REPUBLIC OF MALAWI

MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT

BIDDING DOCUMENTS

FOR

PROCUREMENT OF

CONSTRUCTION OF INTAKE,MAIN CANAL 1 AND PART OF MAIN CANAL 2

PROJECT NAME: SHIRE VALLEY TRANSFORMATION PROGRAM-1

ICB No: **MW-MOAIWD-61737-CW-RFB**

EMPLOYER: MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT (MoAIWD)

COUNTRY: **MALAWI**

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VOLUME III: SPECIFICATIONS

Specification

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1. GENERAL WORKS

1. General Works

1.1. General Information

1.1.1. Introduction

The Government of Malawi is implementing the Shire Valley Transformation Program-1 in Chikwawa District, southern region of Malawi which is being financed by World Bank (WB) and African Development Bank (AfDB). The development objective of the Shire Valley Transformation Program is to increase agricultural productivity and commercialization for targeted households in the Shire Valley and to improve the sustainable management and utilization of natural resources.

Among the five components in this project, the first component, irrigaiton service provision will finance the works, goods and services necessary to develop bulk irrigation and drainage infrasturcure of the SVTP 1. This includes preparation of detailed designs, construction supervision and quality assurance, construction of the physical bulk water conveyance and main distribution system, major drainage and access roads. The component mainly consists of two sub-components: infrastructure development and support to effective and sustainable irrigation management, operation and maintenance.

1.1.2. Location

The project sites are located in Chikwawa District. The location of sections is more specifically described with coordinates in the drawings.

1.2. General Scope of Works

1.2.1. General

The Contract includes the construction of MC1 and part of MC2 from Chainage 6+000 km and up to Lengwe Wild life Reserve. The Contractor shall be responsible for all investigations and calculations necessary to ensure that the Works are sound and fit for their purpose. Dimensions, locations, materials and other requirements expressed in the Contract will be reviewed by the Contractor who will propose for the Engineer's approval such changes as the Contractor considers essential to enable him accept responsibility for the performance of the completed works.

The following requirements shall be adhered to:

(a) Robust solutions and simplicity of operation.

(b) Wherever possible standardization of parts to facilitate spares holding.

(c) Avoidance, as far as possible, of sophisticated, delicate or high tech equipment which could be difficult to maintain under local conditions.

(d) Economy in operation.

(e) Use of equipment and components for which spares are likely to be available for many years to come.

The equipment to be provided shall comply with the General Specification. It is recognized however that there will be instances where full compliance is not possible in the rehabilitation of existing equipment. In these instances the Contractor shall bring the anticipated noncompliance to the notice of the Engineer for his consideration and for instructions to be given.

The Contractor shall be fully responsible for all installations as defined in the Specifications. The Contractor shall provide the services of fully qualified electrical, mechanical and instrumentation supervisors to oversee the installation. The Contractor shall also instruct the Employer's staff in operating and maintenance procedures.

1.2.2. Scope of Works

(a) Earth Work, L=51 km

(b) Canal Structures

- Lining, L=43 km
- Siphon, 3 Nos., L=1795 m

(c) water supply intake and treatment plan for Chikwawa district

1.2.3. Construction Period

36 months after commencement of contruction.

1.3. General Requirements of Preparation

1.3.1. The Site

(a) General

Except where otherwise shown on the drawings or specified herein, the Site shall mean the extent of such public and private lands as is in the opinion of the Engineer necessary or practicable for the construction of the Works. The Contractor shall not use the Site for any purpose not required by the Contract.

(b) Access to Site

Prior to the commencement of any part of the Works, the Contractor shall make temporary access tracks including all necessary temporary diversions and bridge works to the part of the Site concerned, all to the approval of the Engineer.

The Contractor shall maintain such access tracks in a condition suitable for the safe and easy passage of plant and vehicles until they are no longer required for the purpose of the Contract.

The Contractor shall make a record to be agreed by the Engineer of the conditions of the surfaces of any private lands or of any public cultivated or maintained lands over which access to the Site lies before use for access and he shall keep such surfaces in a reasonable state of cleanliness and repair during the execution of the Works. On the termination of the Contractor's use of such access he shall restore the surfaces to a condition at least equal to that obtaining before his entry on them.

For the purpose of this Contract all road tracks, "rights of way", sidewalks and the like, which are not part of the permanent Works, but are required by the Contractor or the Engineer on or near the Site directly or indirectly in connection with the Works under the Contract, will be called Construction Roads. These roads will be regarded as Temporary Works.

The Contractor shall construct all Construction Roads, which shall be of such a standard that they can be normally and safely used in all weather conditions.

The Contractor is not entitled to any reimbursement for the use of the Construction Roads by others than the Employer, personnel and agents of the Engineer and the Contractor, provided that they use it with the approval of the Engineer and directly or indirectly in connection with the Works under the Contract.

The Contractor shall erect and maintain along the site boundary at his own expense suitable and approved temporary fencing and gates to enclose areas of the Works to be carried out and other areas of land as may be necessary to implement his obligations under the Contract to the satisfaction of the Engineer.

(c) Prevention of Surface Erosion

The Contractor shall take particular care at all times to prevent surface erosion on the Site and elsewhere on land which may be affected by his operations and the Engineer may impose such reasonable limitations and restrictions upon the method of clearance and upon the timing and season of the year when clearance is carried out as the circumstances seem to him to warrant.

1.3.2. Site Investigations

The Contractor shall carry out his own investigations at his own expense to draw his own conclusions, particularly in regard to the level of rock, soil type etc. He may if he wishes, subject to the approval of the Engineer, make further explorations at his own expense in order to ensure himself of the adequacy of design of structures.

The Engineer may direct the Contractor to execute further investigations and the Contractor shall be responsible for immediate execution of such works. The effects of any delays caused by the Contractor not executing such instructions promptly will be to his own account.

Prior to carrying out any work the Contractor shall inspect the Site, in conjunction with the Engineer or his Representative to establish its general condition which shall be agreed and recorded in writing, and where, in the opinion of the Engineer or his Representative it is deemed necessary, by means of photography or video recording.

These locations include:

- Contractor's site offices
- Workshop areas

- Routing of construction roads

Details recorded shall include the location of all boundary and survey beacons the conditions of buildings, surfaces, terracing (if any), ditches, roads, tracks, fences, and other information relating to the Site and elsewhere which may be affected by the Contractor's operations.

1.3.3. Climatic Conditions

Malawi, and the Lower Shire Valley in particular, is prone to droughts. The country has experienced severe droughts in the past notable among these occurred during the 1948/49 and 1991/92 seasons. Nearly all the droughts that have taken place in the country have been associated with the El Nino and Southern Oscillation (ENSO) phenomena.

The climate of Shire Valley is characterized by very high temperatures combined with low and erratic rainfall (400 mm to 800 mm) where weeks of dry spells are common during the rainy season. The monthly average rainfall data from 1971 to April of 2015 at Nchalo meteorological station shows that the highest rainfall occurs in January (198 mm).

Temperatures in the Lower Shire Valley are the highest in Malawi. They range from 13.4-37.5 ^{o}C, over even higher. The high temperatures also mean very high evaporation rates, rising from 107 mm in June to 274 mm in October.

1.3.4. Information to be Supplied by the Contractor

Within 30 days of the Letter of Acceptance, the Contractor shall submit to the Engineer for his approval a detailed program in accordance with the Conditions of Contract.

Within 30 days of the Start Date, the Contractor shall submit to the Engineer for approval of drawings for construction and drawins showing details of reinforced concrete structures.

All drawings, technical specifications and other information shall be in English and shall be submitted the number of copies, which is discussed with the Employer and Engineer, for approval. Subsequent to approval being given, the Contractor shall supply the number of copies, which is discussed with the Employer and Engineer, to the Engineer. Drawings and Specifications which have been approved by the Engineer shall not be departed from without the approval of the Engineer to the change.

Approval by the Engineer of drawings, specifications and other information shall not relieve the Contractor from any obligation under the Contract.
All drawings submitted by the Contractor shall bear:

- The title of the Drawing
- The scale
- The date
- The name and references of the Contractor
- A drawing number in a logical sequence
- A revision number (where applicable)

1.3.5. Level Datum

All levels shall be referred to the National Datum and the Contractor shall obtain in writing from the Engineer the location and value of the permanent bench marks to be used to control the works.

Before the commencement of construction work the Contractor shall establish at each site in a position to the approval of the Engineer, a steel datum peg which shall be securely concreted in. The level of this peg shall be established and agreed with the Engineer and all levels used in the construction of the Works shall be referred to this established datum. The correctness of this established datum shall be checked at regular intervals during the construction period and agreed with the Engineer.

1.3.6. Levels and Dimensions

The levels of the ground and the levels and dimensions of existing features shown on the Drawings are believed, but are not guaranteed, to be correct.

Wherever dimensions or levels are marked on the Drawings such dimensions or levels shall take precedence over dimensions scaled from the Drawings. Where no dimensions or levels are shown on the Drawings, instructions shall be obtained from the Engineer.

In the event of discrepancies between the Drawings and the Specification, the Contractor should ask to the Employer and Engineer. The Contractor shall be responsible for all setting out of the works in accordance with the drawings and the Engineer's instructions. On completion of any setting out he shall inform the Engineer who shall, if he considers it necessary, check all such setting out. No work shall commence until the Engineer has approved the setting out, but such approval shall not relieve the Contractor of any of his responsibilities or obligations under the contract.

Where directed by the Engineer, the Contractor shall take such levels and dimensions as may be required prior to the disturbance of the ground for the purpose of measurement. These levels and dimensions shall be agreed in writing before any of the surface is disturbed or covered up.

1.3.7. Units

Metric units shall be used on all drawings and for all calculations, flow capacities, instruments, etc.

1.3.8. Abbreviations

In this Specification the following abbreviations have the meanings hereby assigned to them:

(a) Standards and Organizations

Each and every part of the Works shall be designed, constructed, manufactured, tested and installed in accordance with an internationally recognized Standard, Code of Practice, or Regulation applicable to that part of the Works.

Such standards, etc. shall include:

(1) British Standards (BS)

(2) International Organization for Standardization (ISO)

(3) Other national or international or other authoritative standards equivalent or superior to those designated in the Specifications. The Contractor shall demonstrate to the

Engineer's satisfaction the equivalence or superiority of any item of Works supplied to such alternative standards.

All standards shall be the latest published and shall include amendments which are current at the date of manufacture or construction (as applicable). In the case of category (4) approval must be given in writing by the Engineer, and the Contractor shall familiarize himself with the requirements of these standards. Standards may be denoted by abbreviations indicating the name of the issuing authority, as follows:

ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BS	British Standards
DIN	Deutches Institute for Normung
ISO	International Organization for Standardization
IEC	International Electrotechnical Commission
BSCP	British Standard Code of Practice
BSP	British Standard Pipe (Thread)
CP	British Standard Code of Practice
UK	United Kingdom of Great Britain and Northern Ireland

In the case of conflict between the various regulations, the regulations of the appropriate authority in Malawi shall take precedence.

(b) Dimensions and Units

mm	millimeter
cm	centimeter (1 in. = 2.54 cm)
m	meter
km	kilometer
mm^2	square millimeter
cm^2	square centimeter
m^2	square meter
ha	hectare or 10,000 square meters
l	liter
mgd	million gallons per day
mg/l	milligramme per litre
g/l	gramme per litre
cc	cubic centimeter
m^3	cubic meter

g	gram (1 lb = 453.6 g)
mg	milligram
kg	kilogram
tonne	1,000 kilograms
N	newton
kN	kilonewton
h	hour
l/s	litre per second
m^3/s	cubic meter per second
kg/cm^2	kilogram per square centimeter
kg/m^3	kilogram per cubic meter
kgf	kilogramme force
°C	degrees Celsius
%	per cent
‰	per thousand.

(c) Others

NPSH	Net Positive Suction Head
rpm	Revolutions per minute
A	amp
mA	milliamp
kA	kilo ampere
V	volt
kW	kilowatt
kWH	kilowatt hour
kVA	kilovolt amp
Hz	hertz (cycles per second)
SI	International System of Units
O&M	Operating and Maintenance
IDA	International Development Association
API	American Petroleum Institute
IEE	Institution of Electrical Engineers
MOW	Ministry of Water
DN	nominal diameter
GMS	galvanized mild steel

MDPE	medium density polyethylene
No.	number
NP	nominal pressure
OD	outside diameter
GRP	Glass fibre reinforced polyester
EPDM	ethylene propylene rubber
FSD	full scale deflection
PVA	polyvinyl acetate
NTU	nephelometric turbidity unit
m.a.s.l.	meters above sea level
RSJ	rolled steel joist
HRC	High rupturing capacity
DC	direct current
XLPE	cross linked polyethylene
LV	low voltage
SWA	steel wire armoured
LSF	low smoke and fume
PE	polyethylene
IS	intrinsically safe

1.3.9. Protective Clothing

The Contractor shall provide for the Engineer and his assistants the protective clothing necessary for the proper discharge of their duties on Site.

1.3.10. Language of Correspondence and Records

All communications from the Contractor to the Engineer shall be in the English. All books, time sheets, records, notes, drawings, documents, specifications and manufacturers' literature, etc. shall be in the English.. If any of the aforementioned is in another language a certified translation into English shall be submitted with the documentation concerned.

1.3.11. Contractor's Representation on Site

At least one named responsible senior representative (Agent) of the Contractor shall be immediately available at all times and he shall be on the Site during normal working hours. In the absence of the Contractor's representative a deputy shall be appointed whose name shall be notified to the Engineer at least one day before absence of the Agent and at least three days before any absence exceeding one day. To the Agent (or his deputy) shall be delegated full authority to confer with the Engineer or delegated representative and to take all steps and to issue all those instructions which may be required in an emergency to ensure the safety of all personnel and the Works and of all the Employer's and other property on the Site and in the immediate vicinity thereof.

The Contractor shall provide and maintain at the Site, offices for the use of his representative, to which written instructions by the Engineer can be delivered. Any instructions delivered to such offices shall be deemed to have been delivered to the Contractor. Such offices shall be erected before commencement of the Works.

1.3.12. Personnel

The Contractor shall ensure that at least one senior member of his field supervisory staff, who is experienced in such operations and fluent in English or languages of his labourers, is on site throughout the whole duration of the work.

The Contractor shall also ensure that all necessary skilled artisans for the operation of all his Works are on site throughout the work. The Contractor shall obtain the approval of the Engineer not less than 48 hours before the commencement of the work in respect of each of such personnel. To gain this approval the Engineer may require that such operative is tested in the performance of his duties in the operation of the Works for which he is in attendance. In particular this requirement shall apply to all welders, pipe-cutters and crane operators.

The Contractor shall ensure that an adequate number of labourers are in attendance upon the site during the period of the work.

1.3.13. Assistance to the Engineer

(a) General

The Contractor shall render such assistance with facilities, labour, and materials as at any time may be required by the Engineer's representative directly or indirectly in connection with the works.

The costs of such assistance shall be borne by the Contractor if such assistance is intended for or provided for or specified in the contract; if any assistance is required by the Engineer's representative which is not so intended and not provided for and not specified, then the cost of such assistance shall be borne by the Employer.

The assistance to the Engineer's representative includes, but not by way of limitation, the items in the following sub-chapters.

(b) Protective Items

The Contractor shall provide for the use of the Engineer's Representative and his principals, employees and agents and such other persons as the Engineer authorises adequate protective items such as gumboots, waterproof top-coats, first-aid equipment, life-jackets, hard hats and other safety equipment as required by the Engineer in connection with the Contract.

(c) Care of Public Utility Services

For the purpose of these Specifications public utility services (hereinafter referred to as "public utilities") mean:

(1) Water lines complete (incl. water meter boxes, valve boxes, fire hydrants etc.).

(2) Wire lines complete (telephone wires, poles etc.).

(3) Power lines, both high tension and low tension, complete (masts etc.).

(4) Cable ways.

(5) Street Lighting.

1.3.14. Office Accommodation, Equipment and Services for Engineer

(a) General

Within 2 weeks of the commencement of work on Site by the Contractor, and throughout the execution of the Works, including the Defects Liability Period, the Contractor shall maintain the office accommodation, equipment and services for the Engineer.

(b) Site Office

The Contractor shall provide for the duration of the Contract the following survey equipment.

(1) One modern levels of an approved type

(2) Two levelling staves (metric)

(3) Two 200 m metal measuring tapes

(4) Four 30 m metallic line tapes

(5) Six 10 m retractable pocket tapes

(6) 10 no. ranging rods

The Contractor shall provide all labour and assistance as may be required by the Engineer for checking the Contractor's setting out.

The Contractor shall make available such labour and materials as the Engineer may require for inspections and tests in connection with the works. The Contractor shall provide at his own expense any necessary tackle, test equipment, access, labour, staff and any other thing the Engineer may reasonably require in order that he may conveniently and quickly carry out such inspections as he deems necessary at any time during the execution of the Works and during the Defects Liability Period.

The Contractor should provide the site office for the construction company and the Engineer, and should provide the furniture and office items. The area for the site office should be provided by the Government of Malawi (GoM). The Contractor should build the site office through discussion with GoM about the location of the office. The fence for the site office should be provided, and the area should be provided the enough area to keep the construction materials.

The size of site office: The Contractor should decide the size of the site office and build it through discussion with GoM and the Engineer after decides the member of employee at the construction site.

The item list for the site office: The Contractor should provide the office items depend on the size of the site office, and the items should be provided through discussion with GoM and the Engineer.

1.3.15. Contractor's Yards, Stores and Accommodation for Workmen

The Contractor shall make his own arrangements for all land, yards, stores, workshops, offices, etc. required by him for the purposes of the Contract, and for all services in connection therewith.

The locations of all yards, stores, workshops, offices, etc., shall be agreed beforehand with the Engineer and shall be such as to minimize obstruction and nuisance to the public. In particular, the Contractor shall demonstrate that he will take such measures as are necessary to prevent pollution of the environment from fuel and oil spillages, washing of concrete mixers and the like, in accordance with Clause 1.3.19

The Contractor shall provide and maintain suitable and sufficient shelters and mess rooms for his workmen and supervisory staff as are customary and necessary.

The Contractor shall provide sufficient closets or latrines to the satisfaction of the relevant authority for the use of his personnel. They shall be properly screened and maintained in a clean and sanitary state at all times.

The mess rooms, closets and latrines shall be located in positions to be approved by the Engineer. The Contractor shall be responsible for making all arrangements for the disposal of waste from mess rooms, closets and latrines.

1.3.16. Site for Additional Accommodation

In the event of the Contractor making use of any special or temporary way leave or additional accommodation acquired by him pursuant to the Conditions of Contract hereof or any tip for the disposal of surplus materials, he shall obtain and forward to the Engineer a copy of the written consent of the owner and occupier or Authority having charge of the land in which such way leave accommodation or tip is situated and shall make a record to be agreed by the Engineer of the condition of the surfaces of that land before entering thereon. The Contractor will not be permitted to occupy space in public roads or thorough fares along the route of pipelines nor additional accommodation except with the written consent of the Engineer, which consent will not be given unless the Contractor shall have first obtained the written consent of the Authority concerned and having charge of the road surface.

1.3.17. Security of the Works

Watching of the works shall be provided by the Contractor at his own expense. If the Engineer considers it necessary he will order in writing that additional watchmen be provided, all at the Contractor’s expense.

The Contractor shall provide to the works an adequately supported temporary screen or fence in accordance with local by-laws and to the approval of the Engineer.

All excavation shall be adequately lit at night complete with hazard warning lights to pedestrians and traffic in accordance with applicable Traffic Police Regulations.

Unfenced openings and surface obstructions shall be attended by day and night and shall be adequately lit at night.

1.3.18. Precautions Against Contamination of the Works and the Environment

The Contractor shall satisfy the Engineer that all his personnel working on the Site are medically fit to be in contact with public water supply and his personnel shall undergo any necessary medical tests to show that they are free from any infectious diseases and are not carriers of any such diseases. The Employer reserves the right to call for medical certificates in respect of any employee of the Contractor.

The Contractor shall take all necessary precautions to secure the efficient protection of all waterways against pollution including spillage of oil or concrete mixer wastes, site drainage or any other harmful materials. The Contractor shall seek the Engineer's approval before discharging any substance that may degrade groundwater quality. If nevertheless, such spillage occurs, the Contractor shall clean the waterway at his own expense, and keep the Employer indemnified against any claim arising from such pollution during the execution of the works and the Defects Liability Period.

The Contractor shall be responsible for making all arrangements for the disposal of water from the testing and sterilising of pipelines, water retaining structures and treatment works.

1.3.19. Pipe Laying in Public Roads

Notwithstanding requirements stated elsewhere in the Specification, the Contractor shall comply with the additional requirements of this Clause whenever carrying out any work in connection with pipe laying in or adjacent to public roads, which shall include tracks.

The Contractor shall at all times carry out any work in or adjacent to public roads in a manner to the approval of the Engineer and the responsible authorities and only at such times and during such hours as may be agreed by the competent authority. The Contractor shall obtain any permits from authorities that are required.
At no time shall the Contractor commence work in or adjacent to any public road without the prior approval of the Engineer.

The Contractor shall, when working in or adjacent to any public road, cause the least interference possible to the flow of traffic and shall at all times, except during approved blasting operations, maintain sufficient unimpeded width of the carriageway to permit single lane traffic.

The Contractor shall control the flow of traffic past restrictions caused by his operations by means of stop/go boards or traffic signals positioned at both ends of the restricted section of road. Traffic control shall be to the approval of the Engineer and be in operation at all times and for as long as any restrictions caused by the Contractor's operations exist. They shall be continuously attended by flagmen. Warning signs shall be posted well in advance of any section of restricted road.

All sections of roadway affected by the Contractor's operations shall be bounded by barriers, tapes, bunting or similar means to afford adequate and effective warning to all road users. The Contractor shall at no time string pipes along the carriageway of any public road, unless forced to do so by circumstances, when he shall make arrangements, to the Engineer's approval, for public safety and access.

The Contractor shall arrange his work in or adjacent to public roads in such a way that no continuous length of road restricted by his operations shall at any time exceed 100 m without the written consent of the Engineer.

Some of the pipelines will be laid in areas where narrow streets do not allow the use of mechanical excavators and where the majority of the work will have to be carried out manually. In such areas pipelines will be laid very close to the foundations of buildings and the Contractor is to allow in his rates for all works required to protect buildings and their foundations. The Contractor will be held responsible for all damages caused by him during and arising out of the execution of the Works.

Where pipelines are to be laid close to or in public highways, the Contractor shall ensure that works are properly protected at all times, including the provision of day and night traffic signals when necessary.

1.3.20. Flagging, Lighting, Watching and Traffic Control

The Contractor shall be responsible for watching and lighting the Works and for the flagging and control of traffic and he shall comply with the requirements of the Employer and Police and the relevant authority in these matters.

1.3.21. Closing of Roads

The Contractor shall not close any road unless the Authority having charge of the road surfaces has previously given the appropriate notice or order and without the Contractor having first obtained the written consent of the Police and of the said Authority to close the road. In the event of such consent being refused, the Contractor shall have no claim for any additional payment. In the event of such consent being given, the Contractor shall announce in advance the date of the commencement of the road closure to all statutory local or other authorities, public service undertakers and the public as may be affected by such closure and shall provide fix and maintain all warning signs and diversion notices as may be required by the said Authority by the Police and by the Engineer.

1.3.22. Cleaning of Site

The Contractor shall take particular care and all reasonable precautions to ensure that roads and thorough fares used by him, either for the construction of the works or for the transport of plant, labour and material, are not made dirty as a result of such construction or transport and shall take all necessary and immediate steps to clean them when required or instructed by the Engineer.

Each individual site must be kept clean during the work and must be thoroughly cleaned up on completion.

The Contractor shall control the accumulation of waste materials and rubbish and periodically dispose of legally at an off-site location. All interior surfaces shall be cleaned prior to starting finish work. All areas shall be maintained free of dust and other contaminants during finishing operations.

All trash, debris, unused materials and temporary facilities shall have been removed from the Site. Tools, equipment and construction machinery not needed during the subsequent Defects Liability Period for repair and adjustment shall not remain on the Site. The temporary walkways, parking areas and roadways shall be completely swept and broomed.

1.3.23. Traffic Restrictions

The Contractor shall not run tracked vehicles or tracked Equipment on any public or private road without the written approval of the Engineer and of the responsible authority or owner, and subject to such conditions as each may reasonably require.

The Contractor shall observe all weight and dimensions restrictions which apply to roads and tracks in Malawi and he shall comply with all reasonable restrictions which may from time to time be imposed by the Engineer, Employer, Police, responsible authority or owner. Where damage to roads and tracks is caused by the Contractor this shall be repaired at the

Contractor's expense. In particular the Contractor shall fill potholes in roads with roadstone when these are deepened by his Equipment.

The Engineer shall have the power to restrict the Contractor's use of any roads, or tracks in terms of direction of traffic, speed of traffic, numbers of vehicles or their axle loading in order to preserve such roads or to make them safe for use by the general public.

Where other contractors require the use of these roads or tracks, the Engineer may prescribe times of usage, or impose some other form of control, which shall be established and operated by the Contractor, including the supply of traffic lights, flagmen, traffic cones ordrums, and other controls.

1.3.24. Public Roads

The Contractor shall take every precaution and make adequate provisions to prevent excavated material or other debris from being deposited on public roads, and shall maintain safe use 24 hours per day of all roads through or around any part of the works. No work that will in any way cause inconvenience to the travelling public shall be started until adequate provision, satisfactory to and approved by the Authority concerned and the Engineer, has been made to divert or by-pass traffic in safety and comfort. A road shall only be closed with the written permission of the Authority concerned. All diversions shall be maintained in good condition by the Contractor and shall be at least 6 meters wide where possible. All diversions shall be to the satisfaction of the Engineer, and where existing private or public roads are used as diversions, they shall be maintained and left in a good condition upon completion of the re-routing activity.

The Contractor will be held responsible for any accidents relating to roadways, structures, services, stream crossings and for the proper direction of traffic in a manner approved by the relevant Authority, Police and by the Engineer. It shall be the Contractor’s responsibility to obtain all permissions required.

1.3.25. Temporary Water and Electricity Supplies

(a) Water

The Contractor shall make all necessary arrangements for and shall provide at each Site an adequate supply of water both for the execution of the Works and for the health and safety of his workmen and other persons legitimately on the Works.

The water for the execution of the Works shall be of a chemical and purity standard such that it will not pollute injure or cause any deterioration of the Works, and it shall generally comply with the requirements specified in that section of the Specification dealing with concrete.

(b) Electricity

The Contractor shall make all necessary arrangements for and shall provide any electricity supply required for the execution of the Works. Should the Contractor use a generator, he shall minimize nuisance from noise or exhaust fumes and shall effectively guard against contamination or danger due to spillages of fuel or exposure to vapour.

1.3.26. Power, Water, Sewerage, Drainage, Sanitary Provisions

Where required by the Engineer, at or near the site, including all the facilities, the Contractor at his expense shall arrange for, provide, install and construct everything necessary to adequately ensure:

(a) the supply of potable or non-potable water, whichever is required, for construction, testing and domestic use and all other purposes;

(b) the supply of electricity and other sources of power and light;

(c) the drainage and the disposal of sewage;

(d) the drainage of surface and storm-water.

1.3.27. Contractor’s Temporary Works

The Contractor shall design at his own expense all Temporary Works he may require for the execution of the Works. He shall submit six (6) weeks in advance of any scheduled temporary work, detailed drawings and supporting calculations considered essential by the Engineer.

Within four weeks after submission of the aforementioned drawings and calculations the Engineer shall comment or approve the relevant Temporary Works.

Notwithstanding the approval by the Engineer of any design of Temporary Works, the Contractor shall remain responsible for their efficiency, safety and maintenance, and for all obligations in regard to such works specified or implied in the Contract until the removal of such works.

Unless provided for in the Bill of Quantities expenditures whatsoever dealing with any Temporary Works shall be deemed to be covered by the other rates and prices in the Bill of Quantities and shall not be measured for payment nor be paid for under a separate item.

1.3.28. Other Services

The Contractor shall make his own arrangements for and shall provide and pay for any services required during the duration of the Contract.

1.3.29. Existing Services and Installations

The Contractor shall make himself acquainted with the positions of all existing works such as sewers, water drains, cables and poles for electricity and telephone lines, water mains, oil pipelines etc before any excavation or other work, likely to affect the existing services, is commenced. The Contractor shall liaise with the necessary authorities to whom the existing services belong during the execution of such work. Any work near or on the services shall be done to the complete satisfaction of the respective Authority or its representative and the Engineer.

The Contractor shall take every precaution to ensure that all existing services, pipes, culverts, cables, boundary walls and fences, retaining walls, drainage and irrigation ditches and the like, within and near the line of excavation, are located, supported and safeguarded from damage. Any damage caused to any such services, pipes, culverts, cables, boundary walls and fences, retaining walls, drainage and irrigation ditches and the like attributable to the Contractor's operations, his constructional traffic or his negligence shall be made good by or for the Contractor at his own expense to the satisfaction of the Engineer, owner or responsible authority.

In the event of the owner or responsible authority electing to repair such damage the Contractor shall pay the cost of so doing the work. Should the Contractor fail to pay the cost of the said work within one month of the account being presented, the Employer reserves the right to settle the account and deduct the sum paid by him from monies due or which may become due to the Contractor.

1.3.30. Temporary Removal of Existing Services

If it should become necessary for the proper execution of the work temporarily to remove or divert any existing pipe, sewer, field drain, cable, drainage or irrigation ditch or other service, the Contractor shall obtain permission from the responsible authority or owner and shall carry out the work at his own expense in a manner and at times to be approved by such authority or owner and shall subsequently reinstate the work to the satisfaction of such authority or owner.

In the event of the owner or responsible authority electing to arrange for the temporary removal of an existing service, the Contractor shall pay the cost of his or their doing the work. Should the Contractor fail to pay the cost of the said work within one month of the account being presented, the Employer reserves the right to settle the account and deduct the sum paid by him from monies due or which may become due to the Contractor.

The Contractor's attention is particularly drawn to the requirement to maintain drainage and irrigation ditches in order to avoid any interruption of flow of water therein to the satisfaction of the Engineer, owner or responsible authority and the Contractor shall be deemed to have included in his rates and prices for all temporary works so required.

1.3.31. Permanent Diversion of Existing Services

If in the opinion of the Engineer and/or of the responsible authority or owner it should become necessary permanently to remove or realign any existing pipe, sewer, field-drain, cable, ditch, or other service, other than allowed for in the Bills of Quantities, the Contractor shall obtain permission, where necessary, from the authority or owner and shall carry out and complete the work to the satisfaction of the Engineer and such authority or owner. Payment for such additional work will be made in accordance with the Contract, provided always that the necessity for such permanent diversion has not arisen due to the fault of the Contractor.

In the event of the owner or responsible authority electing to arrange for the permanent diversion of an existing service, the permanent diversion of which has become necessary due to the fault of the Contractor, the Contractor shall pay the cost of his or their doing the work. Should the Contractor fail to pay the cost of the said work within one month of the account being presented, the Employer reserves the right to settle the account and deduct the sum paid by him from monies due or which may become due to the Contractor.

1.3.32. Permanent Support for Existing Services, Etc.

If in the opinion of the Engineer and/or the responsible authority or owner it should become necessary to provide permanent support for any existing pipe, sewer, cable, structure or other thing disturbed, exposed or injured during or after the execution of the Works, the Contractor shall carry out promptly such additional works as the Engineer may require to provide such permanent support. Payment for such additional work will be made in accordance with the Conditions of Contract, provided always that the necessity for such permanent support has not arisen due to the fault of the Contractor.

1.3.33. Authority or Owners May Carry Out Work

Any of the work involving repair, replacement or re-alignment of existing pipes, sewers or other services may be carried out by the responsible authority or owners if they so desire. In such case, the Contractor shall allow them the facilities and assistance they may require and shall bear the full expense of the work except in the case of permanent removal or re-alignment which will be paid for by the Employer, provided that the necessity for such removal or re-alignment has not arisen due to the fault of the Contractor.

1.3.34. Boundaries of Works

The Employer will provide land on which the Permanent Works included in the Contract are to be constructed. Where a drain or pipeline is to be within an existing road reservation the Contractor's working width may be restricted. The existing boundary fences and walls shall not be disturbed without the prior approval of the Engineer and the carriageway shall be left available to traffic.

The Contractor shall not enter upon or occupy with men, tools, equipment and materials any land other than land or rights of way provided by the Employer without the written consent of the owner of such land.

The Contractor shall provide temporary fencing, or immediately install permanent fencing where such is required. Where the Permanent Works do not include fencing (drains and pipelines etc) the Contractor shall submit proposals to the Engineer for fulfilling his obligations under the Contract, and shall obtain the approval of the Engineer.

In the case of way leaves for pipelines outside the built-up area the boundaries of the way leave will be defined by the Employer and the Contractor shall provide erect and maintain in position, from commencement to final completion of the Works, in every section, substantial timber stakes or similar approved markers not less than 1.5 m high indicating the position of the boundary at 100 m or other such intervals as the Engineer may require.

In the event of any boundary or survey mark established for the purpose of land title being disturbed or displaced as a result of the Contractor's operations the Contractor shall forthwith replace the beacon.

The Contractor shall fence the works in a manner sufficient for the protection of the public and livestock and property during the progress of the works and shall satisfy the Employer and the Engineer in this respect.

The Contractor shall erect and maintain adequate safety measures around all trenches and other open excavations in a manner sufficient to provide maximum safety to pedestrians and vehicles at all times.

Temporary bridges with handrails shall be provided across trenches to maintain reasonable and safe access for pedestrians and vehicles to land and property on both sides of trenches. The Contractor shall provide the fences including foundation, concrete posts, and wire chain link as per drawings height of fence 2.7 m.

Also, the Contractor shall provide the metal field gates as per the details on drawing width of gate 4.0 m.

1.3.35. Care of Boundary Walls and Fences

The Contractor shall not cut through or remove any section of any boundary wall or fence without the prior approval of the Engineer who will determine the limits of such cutting or removal.

Approval for the cutting through or removal of boundary walls and fences will normally be limited to those crossing the route of pipelines and the Contractor shall so conduct his operations as to minimize the extent of such cutting through or removal.

The Contractor shall repair and reinstate in a manner similar to the original or by other approved means any wall or fence which he may have cut through or removed with or without the approval of the Engineer or damaged during his operations and all such repairs and reinstatement shall be the Contractor's sole liability and shall be carried out to the satisfaction of the Engineer and the responsible authority.

The Contractor shall at his own expense provide temporary fencing and security measures at all times to protect any affected properties.

1.3.36. Operating and Maintenance Instructions

The Contractor shall submit the number of copies that is discussed with the Employer and Engineer and that is regarding to the comprehensive Operating and Maintenance Instructions to the Engineer for approval.

1.3.37. Inspections by Engineer During Defects Liability Period.

The Engineer will give the Contractor due notice of his intention to carry out any inspections during the Defects Liability Period and the Contractor shall thereupon arrange for an authorized representative to be present at the times and dates named by the Engineer. The Contractor's representative shall render all necessary assistance and take note of all matters and things to which his attention is directed by the Engineer.

1.3.38. Demolition of Contractor’s Temporary Works

The Engineer may at any time before the end of the Defects Liability Period give the Contractor notice in writing to demolish and remove those Temporary Works which are no longer required, whereupon the title to such Temporary Works shall revert to the Contractor. After the demolition and removal of the Temporary Works as required by the Engineer, the Contractor shall level, clear, restore and make good the sites and surrounding ground and fill in all latrines, drains, pits and similar items leaving the whole area in a neat and tidy condition to the satisfaction of the Engineer and any relevant authority.

1.3.39. Advertisements

No advertisements shall be placed on any Site or Works without the written permission of the Engineer.

1.3.40. Contractor’s Compounds

An item is provided in the Bill of Quantities to cover the Contractor’s costs of providing and maintaining the offices, compounds, workshop and housing necessary for the proper Organization and superintendence of the works. The Employer will provide the land required for the compounds.

The Contractor has to submit to the Engineer the layout and design of his compounds showing areas required for workshops, garages, concrete yards, stores, housing etc. for his approval.

The compounds and their contents shall be dismantled and cleared away by the Contractor upon completion of the Contract.

The Contractor shall provide, erect and maintain signboards at locations as directed by the Engineer. They shall be lettered in English and be not smaller than 3 m x 2 m in size. The wording shall be as directed by the Engineer.

1.3.41. Resident Engineer's Office

The Employer will establish his own Engineer’s office in the project area. The Contractor shall provide office rent, furniture and equipment with the approval of the Engineer.

The Contractor shall obtain quotations for various office furniture and equipment to be purchased under this Contract and provide catalogues to enable the Engineer to make his selection of the equipment needed.

The Contractor shall also provide sufficient and regular supply of fresh water, stationery and consumables and other office requisites at his expenses as required by the Engineer and his staff.

1.3.42. Laboratory

The Contractor should provide the laboratory equipments which can check the items shown on below, also should provide the tables, chairs, and etc. The Contractor should report and should get the approval of specifications for the laboratory equipments and other materials mentioned above to the Employer before purchase and provide to the Employer.

> Checking items: Temoperature, pH, SS, Conductivity, Turbidity, Alkalinity, E.coil, Chloride, Calcium, Magnesium, Sulphate, Potasium, Orthophosphate, Nitrite-N, Nitrate-N, Ammonium-N, Fluoride, Iron, Manganese, Salinity

1.3.43. Control of Construction Noise

The Contractor shall employ the best practical means to minimize noise and vibration produced by his operations. These shall include but not be limited to the following:

(a) All vehicles and mechanical plant shall be fitted with effective exhaust silencers and shall be maintained in good and efficient working order.

(b) All compressors shall be "sound reduced" models fitted with lined and sealed acoustic covers which shall be kept closed whenever the machines are in use, and all ancillary pneumatic percussion tools shall be fitted with mufflers or silencers. Dampened bits shall be fitted to percussion tools.

(c) Machines in intermittent use shall be turned off or throttled down when not in use.

(d) All mobile pumps shall be fitted with effective exhaust silencers where appropriate, and maintained in good and efficient working order. Pumps running overnight shall be effectively silenced. Alternatively the Contractor shall use electrically driven pumps if necessary.

(e) All stationary plant shall be screened where possible.

1.3.44. Entry to Private Land

Where it is necessary to enter on privately owned land for the purpose of making temporary road diversions, or for any other reason, the Contractor shall consult the landowner or occupier and his written permission obtained.

The Contractor shall ensure that, in case the landowner or occupier refuses access, the Engineer is informed at least 6 weeks prior to the intended start of work in the area concerned.

Care shall be taken that no undue damage is caused to the land, and at the completion of the work, the land shall be left in a tidy and restored condition to the satisfaction of the landowner or occupier and the Engineer.

1.3.45. Safety Measures and Services

(a) The Contractor shall be responsible for the safety and health of all workmen and other persons in or around the works, to the satisfaction of the Engineer. Such measures shall include, but not be limited to the following:

(1) Provision of proper safety and emergency facilities and procedures; fire, gas and electric shock prevention, stretchers and first aid box together with rescue facilities generally at each place of work;

(2) Adequate supports and braces for all excavations;

(3) Provision of sufficient safety helmets for all staff including the Engineer, his staff, and any authorised visitor to the site;

(4) Safe control of water including the provision of standby plant;

(5) Provision and maintenance of safe, sound ropes, slings, pulleys and other lifting equipment, each having an up-to-date test certificate;

(6) Provision and maintenance of safe, sound mechanical frames, hoists, cranes, and vehicles for transporting materials and personnel, with an up-to-date test certificate for each item;

(7) Provision of good and safe access to the works;

(8) Provision of warning notices to the public in English, warning them of the existence of any dangers related to the works.

(b) The Contractor shall ensure that employees are available at each site to administer emergency first aid in (a) above, and that all employees are aware of their names. The Contractor shall provide for the transport of serious cases to hospital. All medical facilities shall also be to the satisfaction of the regional medical officer to inspect medical facilities at the Site.

(c) The Contractor shall ensure that all his employees are fully conversant with the regulations and emergency procedures, and shall enforce the rule that any employee committing a serious breach of such regulations shall be immediately dismissed from site and shall not be re-employed.

1.3.46. Sanitary Arrangements

The Contractor shall provide and maintain sufficient sanitary conveniences for all operatives and site staff engaged on the works. These shall be in accordance with any requirements and regulations of the Government of Malawi and subject to the approval of the Engineer. The location shall be thoroughly disinfected at the end of the Contract.

The Contractor shall ensure that all operatives and site staff are aware that the sanitary conveniences must be used by all personnel, and the Engineer reserves the right to require the dismissal of any person committing a nuisance on or about the site by failing to properly use the conveniences provided.

1.3.47. Training

The Employer may delegate to the Contractor a team of engineers and technicians to be trained on various sections of the works.

The Contractor shall submit upon request of the Engineer a training program and shall report to the Engineer in writing in monthly intervals detailing the activities and attendance.

The Contractor shall allow for free access to the site of authorized representatives of the sector organizations for inspection of the works upon given notice.

The Employer would be responsible for recruiting staff for the works. A minimum of six weeks prior to the introduction of the works the Contractor shall submit to the Engineer and Employer a training program indicating how he intends to train Employer’s personnel in the operation of the Works. This should comprise but not be limited to:

- formal instruction in a ‘classroom’ type environment,
- formal ‘hands-on’ training on the works itself;
- attendance of Employer’s personnel during pre-commissioning and setting to work;
- a short period of Contractor’s support whilst Employer’s personnel familiarize themselves with the operation of the works whilst under the Supervision of the Contractor.

1.3.48. Connection to Public Services

The Contractor shall be responsible to obtain in time all necessary approvals from the relevant Malawi Authorities to connect the works as described to the services provided by the Malawi Authorities, and in such a manner as required and approved by these Authorities. The costs involved are deemed to be included in the Contract Price.

1.3.49. Public Relations

The Contractor shall designate within his site Organization competent staff whose responsibility shall be to ensure good public relations.

1.3.50. Contractor’s Responsibility for Design

Subject to the requirements of this Specification the Contractor shall be responsible for the general and detailed design of the complete equipment to be provided and for the dimensions and arrangements of the various parts.

The Contractor shall be responsible for the appropriateness of hydrological calculations of the water distribution system on the roads where the actual pipes shall be laid.

The Contractor shall be responsible for checking the dimensions and installation conditions of the existing facilities, existing pipes, any other type of obstacles and for the design of any modifications required.

The design, construction and finish of the complete equipment supplied under this Contract shall be according to first class engineering practice and each item of equipment shall be in every way suitable for continuous operation over the full range of duties.

The Contractor should construct the distribution pipe lines with checking the current condition of the construction area before starting the construction in order to supply the water at the current and new planning distributed area.

The Contractor should make the preparation in order not to make any problem to the construction with checking the existing facilities, pipes, and obstacles or any other facilities need to be revised.

1.3.51. Telecommunications

The Contractor shall arrange for, provide, install construct and maintain adequate and sufficient means of telecommunication for the use of the principals, personnel and agents of the Employer, the Engineer and Contractor on or near the Site.

The Engineer shall be allowed free use of the Contractor's Communication facilities.

1.4. General Requirements of Works

1.4.1. Structural Design

The Contractor shall be responsible for the design of all reinforced concrete structures details and any other details related to connection to existing works or tie-in works.

1.4.2. Program of Performance and Methods of Construction

The Program of Performance shall include but not be limited to the following items:

(a) Proposed dates for starting and completing the construction of the various parts and stages of the Works.

(b) Proposed dates for procuring materials, mobilization of the main plant required to complete the Works.

(c) Proposed hours of Site works for Contractor's personnel.

(d) Proposed system of Contractor's access and work roads and Site plan.

The Contractor shall submit monthly progress reports with the number of copies for the required Program of Performance, which is discussed with the Employer and Engineer. This planning must include the implementation of all the agreements made with the authorities which are involved and responsible for traffic, transport and existing services like water supply, power, telephone, fire fighting, drainage and the followings :

(e) Charts and detailed descriptions of progress, including each stage of design, Contractor’s Documents, procurement, manufacture, delivery to Site, construction, erection, testing, commissioning and trial operation

(f) Photographs showing the status of manufacture and of progress on the Site

(g) For the manufacture of each main item of the Works and Materials, the name of the manufacturer manufacture location, percentage progress, and the actual or expected dates of:

(1) Commencement of manufacture,

(2) Contractor’s inspections

(3) Tests

(4) Shipment and arrival at the Site

(h) Details describing: number of each class of Contractor’s Personnel and of each type of Contractor’s Equipment on the Site

(i) Copies of quality assurance documents, test results and certificates of Materials

(j) Safety statistics, including details of any hazardous incidents and activities relating to environmental aspects and public relations

(k) Comparisons of actual and planned progress, with details of any events or circumstances which may jeopardise the completion in accordance with the Contract, and the measures being (or to be) adopted to overcome delays.

Any consent of the Employer to this planning will not exempt the Contractor of his responsibility to complete the Works within the time as agreed and stated in the Contract.

The Contractor shall take the initiative to inform the local authorities in due time about hisprogram. The Contractor shall attend coordination meetings between the Employer and other authorities and shall supply all relevant information and data in his possession.

The possible simultaneous construction of adjacent works under separate contracts may require the Contractor to adapt his planning to that of other Contractors. The Employer will inform the Contractor in due time about the conditions to be expected during the period of interference of work. Such adaptations as far as are required in the interest of and at the request of Employer shall not entitle the Contractor to additional payments.

For any operations that may result in a safety hazard (eg deep excavation, concrete casting of foundation etc.), the Contractor shall submit in writing the method statements for such operations for approval by the Engineer not less than 30 days prior to the planned commencement of such work.

All materials to enable temporary connections and working arrangements to be made shall be provided by the Contractor.

The Contractor shall allow in his program a period of three weeks for the Engineer to check the details of the Works which the Contractor proposes to order, this period commencing from the receipt by the Engineer of complete information. No Works shall be manufactured or ordered from suppliers until the Engineer has signified approval of the Contractor's proposals.

At least 6 weeks prior to delivery of the Work, the Contractor shall submit to the Engineer for approval a full and detailed program for the erection and commissioning of the Work.

1.4.3. Contractor to Work from Points as Directed

The Contractor shall start the work at such points as the Engineer may from time to time direct.

1.4.4. Contract Drawings

The Contract Drawings shall comprise:

(a) The Drawings listed in the Specifications.

(b) Any modifications to the Drawings approved in writing by the Engineer.

(c) Any drawings that are from time to time issued by the Engineer.

(d) Any drawings that are issued by the Contractor after approval by the Engineer.

1.4.5. Drawings and Documents

The Contractor will be requested to elaborate a Document Submission Schedule showing planned submission dates of Technical Documents and Drawings for approval/review by the Engineer. It will be subject to discussion with agreement of the Engineer. The main purpose will be to enable the Engineer to know in advance, how many drawings of which nature are to be expected when for the approval. This submission schedule will then be considered binding as long as the underlying version of the Program of Performance remains valid.

Subject to the requirements of these Specifications the Contractor shall prepare the detailed design and Working Drawings necessary to execute the works. The calculations and Working Drawings shall be submitted to the Engineer for approval prior to commencement of the relevant sections of the works on site.

The drawing format and deliverables of the design drawings and the document are as follows:

(a) Drawing Format

- (1) Scaling of the drawings : 1/10,000~1/50,000 for general layout, 1/2,000 for the network plans, 1/100 vertical & 1/600 horizontal for profiles of pipeline
- (2) Transmission main drawings : Plan and profiles on the same sheet
- (3) Size : All drawings shall be on A3 size sheets
- (4) Drawings : All drawings should be produced in digital format in DWG.
- (5) Design Report : Description of design including calculations and results in tabular form bills of quantities and cost estimates
- (6) Water Supply system : Tabular form of calculation results shall include 2 sections, outputs for pipes and nodes which shows pipe and node numbers, velocities, ressures and head losses
- (7) General layout plans : 1/10,000~1/50,000 scale drawings
- (8) Plans and Profiles : 1/2,000 scale for plans, 1/100 vertical scale & 1/600 horizontal scale for profiles
- (9) Typical drawings : In proper scale, the drawings for trench cross-sections, house connections, valve chambers, fire hydrants, node details, manholes etc.

All documents shall be produced in English.

All dimensions in drawings, calculations and information furnished in connection with the Contract shall be expressed in metric SI units.

All drawings shall be sized to designations A1, A2, A3, and A4 unless otherwise specifically specified. Sizes A0 and above shall not be used. Each drawing shall carry the project title, the name of the Engineer, the Contractor and the Employer together with the drawing title and number and other relevant data, in the lower right-hand corner.

The Contractor shall submit his drawings and documents to the Engineer for review or approval at least thirty (30) days prior to the planned execution of the work concerned with the said drawings and documents. Manufacturing drawings for items to be fabricated outside the country shall be submitted within one hundred twenty (120) days prior to the planned start of manufacture.

The procedure for the submission, review and/or approval of drawings and documents shall be understood to be as follows; provided that the Engineer shall reserve the right to make any changes to such procedure during the course of the works when the Engineer deems necessary.

When the Contractor is ready to have the Engineer review and/or approve certain drawings and documents, he shall submit the number of clear copies which is made through discussion with the Employer and Engineer, readable copies of the drawings and documents within fourteen (14) days after receiving copies of the drawings and documents from the Contractor, the Engineer will return one copy with one of the following classifications:

(a) "APPROVED” (NO OBJECTION- stamp)

(b) "RESUBMIT AFTER CORRECTION"

(c) "REJECTED".

The Contractor may proceed with the work only upon receipt of drawings and documents which have been approved as shown in (a) above. Copies of all approved drawings shall be maintained at the Contractor's site office.

When returned drawings and documents have been marked as shown in (b) or (c) above the Contractor shall make necessary corrections and/or revisions to the drawings and documents in a timely manner and shall resubmit the number of copies which is made through discussion with the Employer and Engineer for revised drawings and documents until the submitted version is approved (NO-OBJECTION- stamp) by the Engineer.

Any work done prior to the approval of drawings and/or documents shall be at the Contractor's risk.

The Engineer's approval of the Contractor’s Technical Documents shall not relieve the Contractor of the obligation to meet all terms of the Specification and any of the plan which upon delivery to site is found to be incorrect or unsatisfactory, or which fails to perform its duty satisfactorily during commissioning or during the Defects Liability Period shall be replaced to the Engineer's satisfaction.

The Contractor shall be responsible for any discrepancies, errors, or omissions in the drawings and other particulars supplied by him, whether such drawings and particulars have been approved by the Engineer or not, provided that such discrepancies, errors, or omissions be not due to inaccurate information or particulars furnished in writing to the Contractor by the Employer or the Engineer.

The drawing format should be based on the existing designed drawing format.

1.4.6. Working Drawings

If required for the execution of this Contract or requested by the Engineer, the Contractor shall incorporate in the Contract Drawings all openings, ducts, recesses, anchor holes, etc. as required for the mechanical and electrical installations. All related costs are considered to be included in the Contract Price.

The title block shall be as on the Contract Drawings, and shall show in addition the Contractor's name and the descriptive name of the works shown on the drawing. Materials and material standards shall be indicated on the drawings.

Drawings from sub-contractors shall be checked signed and stamped by the Contractor before being forwarded to the Engineer, who shall deal in all respects exclusively with the Contractor.

When the Engineer has approved a working drawing, he shall return a copy marked "Approved" to the Contractor, who shall then insert the date of approval on the tracing and furnish the Engineer with three prints of the working drawings as approved.

Approval of a working drawing by the Engineer will only signify his general approval of the design and shall not make him liable for any error of the Contractor in detail or lack of strength or efficiency of any part. Where errors, deviations and/or omissions are discovered later, they shall be made good by the Contractor at his own expense irrespective of any approval by the Engineer.

1.4.7. Survey Records and As-Built Drawings

After clearing the Site, the Contractor shall take and record levels in the manner directed by and in the presence of the Engineer of the site and works. Such levels, when approved by the Engineer, shall be recorded by the Contractor on drawings and/or schedules, which shall be signed as a true record by the Contractor and the Engineer and shall form the basis of the measurement of the Contractor's work.

Excavation works shall not commence before the Engineer certifies such records.

Before the issue of the Completion Certificate the Contractor shall prepare As-built drawings of all works and installations under the Contract and submit them to the Engineer for approval. All as-built drawings to be of CALC should be provided by a number of copies and format which are made through discussion with the Employer and contractor and the Engineer.

In addition the Contractor shall provide one copy of all As–Built Drawings in digital format agreed with the Engineer and certified virus free. All layouts for the water supply are to be incorporated into the arcView design database.

1.4.8. Record Drawings

Within 4 weeks of the commencement of the Defects Liability Period, the Contractor shall deliver to the Engineer one complete set of record drawings of all works constructed under the Contract. The minimum scales for water pipeline plans shall be complied with the detailed design drawings. All other works shall be at scales used in the Tender Drawings for comparable works or as agreed with the Engineer. The Engineer shall comment on the draft

Record Drawings and within a further 8 weeks the Contractor shall then produce a definitive set in dynamic form which shall be delivered to the Engineer complete with the number of copies that is discussed with the Employer and Engineer.

1.4.9. Working Hours

The Contractor shall perform his construction work only during working hours on construction sites according to the labour law being currently in force in Malawi; (at present: total of 40 hours, distributed over 5 days per week, except on holidays).

In case the Contractor wishes to carry out works outside normal working hours or on Sundays and public holidays, he shall comply with Sub-clause of Conditions of Contract referring to such item.

Work during the Defects Liability Period shall be carried out only after the Contractor has given the Engineer at least 48 hours notice in writing.

1.4.10. Labour and Plant Returns

The Contractor shall include with his monthly reports details of all plant (including their values) and labour force employed on site together with a description of their deployment. The names and trade of hired labourers being local residents are to be shown separately. The Contractor shall also provide a list of all materials intended for use in the permanent works delivered to site.

1.4.11. Photographic Records

The Contractor shall provide photographic records of the execution of the works by having photographs taken at monthly intervals from such points as the Engineer may specify from time to time. The number of such photographs shall be discussed with the Employer and Engineer.

The Contractor shall supply the number of print sets, which is discussed with the Employer and Engineer, including date and description of works to the Engineer.

1.4.12. Photographs

The Contractor shall supply, each month, negatives and four copies of progress photographs, suitably inscribed, of a size not less than 250 mm by 200 mm of such portions of the Works, in progress and completed, as may be directed by the Engineer. The negatives and prints shall not be retouched. The negatives of the photographs shall be the property of the Employer and no prints from these negatives may be supplied to any person or persons without the authority of the Employer or the Engineer. The Contractor shall also provide photograph albums and mounts for mounting photographs.

1.4.13. Working Program

Before commencing trench or structural excavation the Contractor shall record (sketches, photographs) any existing damage to adjacent buildings and structures and notify the Engineer thereof. Failing to do so, the Contractor may become liable to make good such damage at his own expense as it may be considered a result of his activities.

1.4.14. Setting Out

The Contractor shall submit to the Engineer, both the general and detailed methods of complete setting out of the alignments of the various structures, etc. and the calculations for curvatures and the various setting out dimensions there by obtained from the position of the Works. At all times the Contractor shall give the Engineer notice sufficiently in advance but not less than 24 hours of his intention to set out.

The method of surveying shall be to the approval of the Engineer. Field books and tabulated data shall be well maintained and made available for inspection and checking by the Engineer upon request.

1.4.15. Joint Measurement of Works

In the event of the Contractor having to execute any work or provide any material with regard to which he intends to claim extras, or where works are to be covered up, he shall make arrangements to take measurements of the said works or material and shall inform the Engineer accordingly, giving a minimum of 48 hours notice. The Engineer will then join the Contractor for a joint survey. If these measurements are not taken jointly and recorded before the work will be executed, the Contractor's measurement will not be recognized by the Engineer.

The fact that such joint measurements have been made will in no way bind the Engineer to recognize the claim. The Engineer shall at all times have access to the Contractor's diary and may daily check the progress of relevant works, but this shall in no way bind the Engineer to accept the claim nor the value of the work other than by joint measurement.

1.4.16. Works Diary

The Engineer will keep a diary on the Site in which all his remarks, instructions, decisions and the essential details of the Works shall be recorded. The Contractor shall assist in keeping the diary by supplying daily any information on the Works requested by the Engineer.

If required by the Engineer, the Contractor shall read the diary within two days of each daily entry being made and shall sign each entry as having been read by him. The Engineer shall also sign the diary and hand a copy of the signed diary to the Contractor.

If the Contractor does not agree with the diary written by the Engineer in either accuracy or completeness, he shall record his remarks in the space provided therein before signing the diary as having been read by him or shall detail his disagreement in writing to the Engineer not more than seven days after having read and signed the diary. Otherwise he shall be considered to be in agreement with the contents of the diary; however the facts stated therein shall not be by themselves be a ground for any claim for payment under the Contract.

1.4.17. Instructions to be Recorded

The Contractor shall provide and keep permanently on the Site book, which is discussed with the Employer and Engineer regarding required number of copies, wherein the Contractor shall record all instructions relating to concrete work issued by the Engineer. One copy of every entry therin shall be sent to the Engineer on the same day as the entry is made.

1.4.18. Approval of Contractor’s Proposals

The Contractor shall supply to the Engineer the number of copies of the following documentation, which is discussed with the Employer and Engineer, giving details of his proposals for approval, within 4 weeks of the Contract Start Date.

(a) Design and working drawings and data including calculation and erection information.

(b) All technical specifications of all plant and equipment proposed for the works.

(c) Details of dead and live loads imposed by each item of plant on its foundations.

1.5. Materials

1.5.1. Copies of Orders

The Contractor shall provide the Engineer with the number of copies for all orders, which is discussed with the Employer and Engineer, regarding the supply of materials and goods required for the works.

1.5.2. Samples

In addition to specific provisions in the specifications for sampling and testing of materials, the Contractor shall submit to the Engineer, as he may require, samples of all materials, which he proposes to use in the works. When approved, these will be retained by the Engineer.

Samples to be submitted shall be accompanied by an approved form on which all information about specifications, description, location of use, manufacturer etc. is stated.

The Contractor shall submit a “Materials Procurement Program” for all materials and equipment which are deemed to be used in the permanent works indicating dates for sampling, approval, ordering, delivery to site.

The Engineer may reject any materials or goods, which in his opinion are inferior to the samples submitted.

The Engineer's approval of manufacturers or material for the works, whenever required by the specifications, shall not relieve the Contractor of his responsibilities under the Contract.

1.5.3. Testing and Inspection

The Contractor shall provide the number of copies, which is discussed by the Employer and Engineer, regarding a test plan for both the factory and site tests and inspections, for the Engineer's approval. The plan shall consist of a logical step-by-step schedule indicating step, action and reaction. The plan shall be cross referenced to relevant sections of the Specification, Bill of Quantities, and British Standards (or equivalent where applicable), and shall state clearly the test method to be employed, the equipment to be used, the parameters to be measured, and the expected results. On satisfactory completion of the tests etc. the plan shall be completed with the results achieved and shall be retained for record purposes.

The test plan may be sectionalized to suit the plant purchase and manufacturing arrangements, and program. Each section of the plan shall be issued in draft at least 28 days before any testing, inspecting or commissioning takes place. The Engineer will notify his approval or otherwise within 14 days of receipt of the plan. Any portions of the plan which the Engineer disapproves shall be suitably modified before implementation of that portion of the plan. Final copies of the approved plan shall be available for the testing, inspections or commissioning.

The Contractor shall carry out during manufacture all tests specified in the relevant Standards amplified as may be called for in the Specification and Bill of Quantities, and shall forward to the Engineer in the number of duly certified copies, which is discussed with the Employer and Engineer, regarding the test results and certification that the equipment and materials comply with the relevant Standards.

Unless otherwise specified hereafter, the Contractor shall give not less than fourteen clear days notice in writing for the time, date and place of all impending tests so that the Engineer, or his representative may be present to witness such tests. The Contractor shall furnish test certificates in the number of copies for all tests, which is discussed by the Employer and Engineer, whether witnessed or not.

As and when the Engineer is satisfied that any plant is in accordance with the Specification and has passed the prescribed workshop tests, he will notify the Contractor in writing to that effect.

If after inspection or tests the Engineer decides that the plant concerned or any part thereof is defective or is not in accordance with the Contract, he may reject it by giving to the Contractor, within a reasonable time, notice in writing of his decision and the grounds upon which it is based.

(a) Tests

(1) The Engineer may examine and may require testing of any materials or goods to be used in the works at any place inside of Malawi. The Contractor shall give the Engineer unrestricted access to his, his sub-contractors' and suppliers' premises for such purposes at all times.

(2) The Contractor shall afford the Engineer all facilities, assistance, labour and appliances necessary for the convenient examination, testing, weighing or analysis of all materials and goods. The Contractor shall prepare all test samples the Engineer may require.

(3) Tests carried out off the site shall not relieve the Contractor of the responsibility of ensuring that the materials pass any required tests on site and when they are incorporated in the permanent works.

(4) The costs for all tests as prescribed in the Specifications and as directed by the Engineer are to be borne by the Contractor and are deemed to be included in his contract prices.

(b) Test Certificates

(1) The Contractor shall obtain test certificates from his suppliers and forward the number of copies, which is discussed with the Employer and Engineer, regarding such certificates to the Engineer. Such certificates shall certify that the materials or goods have been tested in accordance with the specifications and BS, DIN, KS, and/or ISO standards, and shall give the results of the tests, which have been carried out. With regard to major project equipment, the Contractor shall ensure that the tests are carried out in the presence of the Employer's representative. For this contract, major equipment includes the following:

• Pumps, motors and their control panels;

- Transformer and devices;
- Generators and their control panels.
  In the case of the contractor wishes, the additional equipment might be tested

(2) The Contractor shall provide adequate means on site to identify the materials or goods with their respective test certificates.

1.5.4. Facilities for Engineer to Take Samples

The Contractor shall provide facilities for the Engineer to take samples for testing of any of the concrete or other materials to be incorporated in the Works. Such samples may be taken before or after incorporation into the Works or at any stage during construction at the discretion of the Engineer.

1.5.5. Quality of Materials and Workmanship

The materials and workmanship shall be the best of their respective kinds and to the approval of the Engineer. The words "to the approval of the Engineer" shall be deemed to be included in the description of all materials and workmanship for the due execution of the Works.

All materials to be used in the permanent works shall be new and of the required specifications. The workmanship shall be of the specified quality, all to the approval of the Engineer.

1.5.6. Approval of Suppliers of Materials

Before entering into any sub-contract for the supply of any materials or goods, the Contractor shall obtain the Engineer's approval in writing of the sub-contractor from whom he proposes to obtain such materials or goods. Should the Engineer at any time be dissatisfied with such materials or goods or with the methods of operation carried out at such sub-contractor's works or place of business, he shall be empowered to cancel his previously given approval of such sub-contractor and to specify any other supplier whom he may choose or to approve another sub-contractor for the supply of such materials or goods. The Contractor shall then obtain the said materials or goods from such other supplier and shall bear any additional cost thereof.

1.5.7. Quality Control

The Contractor shall be responsible for his own quality control and shall provide sufficient competent personnel for taking and preparing samples and for carrying out the necessary tests.

1.5.8. Disinfection and Water Quality

Prior to the Tests on Completion, the Contractor shall disinfect all constructed Works which are in contact with the treated water. The structures, tanks, pipes, and etc. shall be filled with water containing a chlorine residual, of a strength to be approved by the Engineer. The chlorine solution shall be thoroughly flushed out before the Works are put into operation. If tests indicate that contamination is present, the Contractor shall search for and remove such contamination, and disinfect and re-test as necessary until the water is shown to be satisfactory.

The Contractor shall ensure that water discharged to waste is not harmful to human, plant or animal life or to the environment downstream of the drain pipe outlet.

1.5.9. Guarding of Moving Machinery

All moving machinery shall be adequately guarded to prevent injury through accidental contact. In particular exposed shafting and couplings shall be protected with suitable guards except where they are in normally inaccessible positions.

1.5.10. Packing for Export

The Contractor shall be responsible for the proper packing, storage and crating and clear identification of all materials or Plant supplied by him or his Sub-contractors, prior to despatch and shipment from its place of manufacture.

All materials shall be packed and marked in accordance with international standards for export from the country of manufacture. All wooden cases shall be proofed with suitable anti-termite solution. Straw or similar organic materials shall not be used for packing.

The materials shall be packed and protected against deterioration in such a manner as to be suitable for transport by sea and overland and for 12 months subsequent storage on site.

All materials liable to deterioration from water or moisture shall be packed in cases with waterproof lining.

All packages shall be clearly and conspicuously marked with the Contractor's identification mark and the Employer's reference mark.

1.5.11. Storage on Site

The Contractor shall construct on the Site a storage compound and storage building where he shall place at his own risk all electrical and mechanical parts, pipe jointing rings and other materials delivered to Site and awaiting erection which are not separately stored (for example at approved pipe stockpiling points). The compound shall be of sufficient size to accept all such parts delivered and awaiting erection.

The storage building shall be weatherproof and shall be of sufficient size to accommodate all items requiring covered storage.

1.5.12. Manufacturer’s Instructions and Recommendations

The Contractor shall keep on site a file copy and shall provide a copy to the Engineer of all Manufacturers' Instructions and Recommendations for handling, storage and use of all materials to be incorporated into the Works.

2. CIVIL WORKS

2. Civil Works

2.1. General

2.1.1. Scope of Work

The technical specifications for Civil Works detailed in generally refer to all civil works such as earth work, temporary work, structure work, etc. These technical specifications shall serve to specify all civil works wherever applicable within the scope of this contract.

2.1.2. Design Standards

All designs shall be based on the followings.

- UBC (Uniform Building Code)
- ACI (American Concrete Institute)
- ASTM (American Society for Testing and Materials)
- ASCE (American Society of Civil Engineers)
- AASHTO (American Association of State Highway and Transportation Officials)
- BS (British Standards)

The design standards adopted shall follow the best modern engineering practice in the field based on any other international standard or specialist literature subject to such standard reference or extract of such literature in the English language being supplied to and approved by the Engineer.

In case of any variation or contradiction between the provisions of the above mentioned Codes and the specifications given along with the submitted bid document, the provision given in this Specification shall be followed.

2.1.3. Summary of Facilities

The facilities for this contract are shown as below;

Structures	Location	b(m)	H(m)	B(m)	Design Elevation(m)		L(m)
					Start	End	
Lining Canal 2	STA06+000 ~ 6+900	2.20	12.60	19.20	135.08	134.90	900
Siphon #4	STA 6+900 ~ 7+120	3.00	8.00	8.00	134.90	134.38	220
Lining Canal 3	STA 7+120 ~ 8+960	2.20	12.60	19.20	134.38	134.01	1,840
Siphon #5	STA 8+960 ~ 9+400	3.00	8.00	8.00	134.01	133.18	440
Lining Canal 4	STA 9+400 ~ 15+520	2.20	12.60	19.20	133.18	131.96	6,120
Lining Canal 5	STA 15+520 ~ 19+940	2.20	12.30	18.90	131.96	131.08	4,420

Lining Canal 6	STA 19+940 ~ 21+860	2.20	11.30	17.90	131.08	130.70	1,920
Lining Canal 7	STA 21+860 ~ 28+160	2.20	11.10	17.70	130.70	129.44	6,300
Lining Canal 8	STA 28+160 ~ 30+620	2.20	10.90	17.50	129.44	128.95	2,460
Lining Canal 9	STA 30+620 ~ 32+788	2.20	10.60	17.20	128.95	128.52	2,168

Structures	Location	b(m)	H(m)	B(m)	Design Elevation(m)		L(m)
					Start	End	
Lining Canal	STA.0+000 ~2+180	8.10	1.80	13.50	128.22	127.56	2,180
Lining Canal	STA.2+180 ~5+220	7.90	1.80	13.30	127.56	126.64	3,040
Lining Canal	STA.5+220 ~5+360	7.80	1.80	13.20	126.64	126.60	140
Siphon #1	STA.5+360 ~6+495	6.20	2.30	6.20	126.60	124.47	1,135
Lining Canal	STA.6+495 ~7+580	8.70	1.80	14.10	124.47	124.20	1,085
Lining Canal	STA.7+580 ~9+320	8.60	1.80	14.00	124.20	123.77	1,740
Lining Canal	STA.9+320 ~10+020	8.50	1.80	13.90	123.77	123.59	700
Lining Canal	STA.10+020 ~12+020	8.40	1.80	13.80	123.59	123.09	2,000
Lining Canal	STA.12+020 ~13+720	8.00	1.80	13.40	123.09	122.67	1,700
Lining Canal	STA.13+720 ~18+020	7.40	1.80	12.80	122.67	121.59	4,300

Specification of Box Culvert in the Main Canal 1

Chainage	G.L Level	Bottom Level	Bank Level	EL 1	EL 2	L1 (m)	H1 (m)	Spec.
6+080	136.65	135.06	138.06	136.70	136.62	44.0	1.0	1.5 x 1.0 x 1
6+394	128.40	135.00	138.00	128.42	128.40	56.0	3.0	3.0 x 3.0 x 1
6+600	125.20	134.96	137.96	125.20	125.18	71.0	3.0	3.5 x 3.0 x 2
7+300	132.76	134.34	137.34	132.20	132.20	44.0	2.0	2.0 x 2.0 x 1
7+648	133.10	134.27	137.27	133.10	132.12	44.0	1.0	1.5 x 1.0 x 1
8+016	133.72	134.20	137.20	131.60	131.58	44.0	2.0	2.0 x 2.0 x 1
8+148	128.26	134.17	137.17	128.20	128.18	56.0	3.0	3.0 x 3.0 x 1
8+434	130.21	134.12	137.12	130.20	130.18	56.0	3.0	3.0 x 3.0 x 1
8+537	126.80	134.09	137.09	126.70	126.68	60.0	3.0	3.0 x 3.0 x 1
9+795	130.20	133.10	136.10	130.10	130.08	44.0	3.0	3.0 x 3.0 x 1
10+200	132.60	133.02	136.02	131.20	131.18	44.0	1.0	1.5 x 1.0 x 1
10+974	128.15	132.87	135.87	128.05	128.03	50.0	3.0	3.0 x 3.0 x 1
11+140	130.80	132.83	135.83	130.70	130.65	48.0	1.0	1.5 x 1.0 x 1
11+340	130.40	132.79	135.79	130.30	130.28	48.0	1.0	1.5 x 1.0 x 1

11+542	123.83	132.75	135.75	123.70	123.68	64.0	3.0	3.5 x 3.0 x 1
11+992	132.61	132.66	135.66	130.10	130.08	56.0	2.0	2.0 x 2.0 x 1
12+336	130.20	132.59	135.59	130.10	130.08	44.0	2.0	2.0 x 2.0 x 1
12+535	130.40	132.55	135.55	130.20	130.18	44.0	2.0	2.0 x 2.0 x 1
12+900	131.73	132.48	135.48	130.40	130.38	44.0	1.0	1.5 x 1.0 x 1
13+554	131.40	132.35	135.35	131.00	131.00	44.0	1.0	1.5 x 1.0 x 1
14+181	124.80	132.23	135.23	124.70	124.68	60.0	3.0	3.0 x 3.0 x 1
14+274	124.60	132.21	135.21	124.60	124.58	60.0	3.0	3.5 x 3.0 x 2
15+120	130.58	132.04	135.04	130.58	130.54	44.0	1.0	1.5 x 1.0 x 1
16+040	128.40	131.86	134.86	138.40	128.38	44.0	3.0	3.5 x 3.0 x 2
16+738	131.38	131.72	134.72	127.80	127.75	55.0	3.0	1.5 x 1.0 x 1
17+820	129.04	131.50	134.50	129.00	129.00	44.0	2.0	2.0 x 2.0 x 1
18+130	131.89	131.44	134.44	130.00	129.90	50.0	1.0	1.5 x 1.0 x 1
18+333	132.00	131.40	134.40	130.00	129.90	50.0	1.0	1.5 x 1.0 x 1
18+628	125.57	131.34	134.34	125.50	125.48	54.0	3.0	3.0 x 3.0 x 1
19+282	124.41	131.21	134.21	124.30	124.28	58.0	3.0	3.5 x 3.0 x 2
20+064	126.20	131.06	134.06	126.00	126.00	50.0	3.0	3.5 x 3.0 x 2
20+597	127.80	130.95	133.95	127.30	127.38	46.0	3.0	3.0 x 3.0 x 1
20+776	129.88	130.91	133.91	129.45	129.42	43.0	1.0	1.5 x 1.0 x 1
21+052	131.20	130.86	133.86	127.30	127.28	50.0	3.0	3.0 x 3.0 x 1
21+480	131.86	130.78	133.78	127.20	127.18	50.0	3.0	3.0 x 3.0 x 1
21+620	131.60	130.76	133.76	127.20	127.18	50.0	3.0	3.0 x 3.0 x 1
22+339	131.20	130.60	133.60	127.00	127.00	50.0	3.0	3.0 x 3.0 x 1
26+560	130.53	129.76	132.76	128.30	128.28	50.0	1.0	1.5 x 1.0 x 1
27+020	130.54	129.61	132.61	127.15	127.12	48.0	1.0	1.5 x 1.0 x 1
27+440	130.18	129.58	132.58	127.10	127.08	48.0	1.0	1.5 x 1.0 x 1
28+300	125.40	129.41	132.41	125.30	125.28	46.0	3.0	6.0 x 3.0 x 3
29+620	129.60	129.15	132.15	125.50	125.48	50.0	3.0	3.0 x 3.0 x 1
30+858	128.90	128.90	131.90	125.30	125.28	50.0	3.0	3.5 x 3.0 x 2
31+500	129.20	128.78	131.78	125.10	125.08	50.0	3.0	3.5 x 3.0 x 2
31+980	128.60	128.68	131.68	125.00	124.98	50.0	3.0	3.5 x 3.0 x 2

Specification of Box Culvert in the Main Canal 2

Chainage	G.L Level	Bottom Level	Bank Level	EL 1	EL 2	L1 (m)	H1 (m)	Spec.
4+360	124.36	126.90	129.50	123.95	123.94	36.0	2.0	3.0 x 2.0 x 2
6+518	117.40	124.40	127.00	117.40	117.38	49.0	3.0	3.0 x 3.0 x 1
6+672	115.80	124.43	127.00	115.80	115.75	49.0	3.0	3.0 x 3.0 x 1
7+135	117.00	124.31	126.91	124.31	124.26	41.0	5.0	3.0 x 5.0 x 2
7+580	117.40	124.20	126.80	117.40	117.36	49.0	3.0	3.0 x 3.0 x 1
7+780	117.76	124.15	126.75	117.76	117.72	49.0	3.0	3.0 x 3.0 x 1
8+180	118.76	124.05	126.65	118.74	118.70	44.0	3.0	3.0 x 3.0 x 1
8+350	119.25	124.01	126.61	119.25	119.20	44.0	3.0	3.0 x 3.0 x 1
8+448	119.50	123.99	126.59	119.50	119.45	44.0	3.0	3.0 x 3.0 x 1
8+720	120.00	123.92	126.52	120.00	119.95	36.0	3.0	3.0 x 3.0 x 1
8+947	120.85	123.86	126.46	120.85	120.80	36.0	2.0	3.0 x 3.0 x 1
9+146	123.60	123.81	126.41	123.60	123.50	36.0	2.0	2.0 x 2.0 x 1
10+024	124.80	123.59	126.19	124.80	124.75	40.0	2.0	2.0 x 2.0 x 1
10+036	125.00	123.51	126.11	125.10	125.05	40.0	2.0	2.0 x 2.0 x 1

Design Information for Bridge Crossings in the Main Canal 1

Chainage	Type	Elevations			Width (m)
		Ground	Canal	Bridge	
6+290	Type-1	139.08	135.02	135.02	4.0m
6+714	Type-1	137.50	134.93	134.93	6.0m
7+464	Type-1	138.75	134.31	134.31	4.0m
8+800	Type-1	142.80	134.04	134.04	4.0m
9+536	Type-1	136.37	133.15	133.15	4.0m
10+035	Type-1	138.94	133.06	133.06	9.0m
10+400	Type-1	136.08	132.98	132.98	4.0m
11+388	Type-1	138.40	132.78	132.78	4.0m
11+909	Type-1	137.24	132.68	132.68	4.0m
12+065	Type-1	134.28	132.65	132.65	4.0m
12+416	Type-1	135.40	132.58	132.58	4.0m

12+673	Type-1	137.66	132.53	132.53	6.0m
13+326	Type-1	137.25	132.40	132.40	6.0m
13+947	Type-1	134.40	132.27	132.27	4.0m
14+838	Type-1	133.78	132.10	132.10	4.0m
15+440	Type-1	133.78	132.98	134.98	4.0m
15+793	Type-1	133.93	131.91	131.91	9.0m
16+760	Type-1	132.01	131.71	131.71	4.0m
17+020	Type-1	135.11	131.66	134.66	4.0m
17+300	Type-1	134.45	131.61	134.61	4.0m
17+480	Type-1	136.93	131.57	134.57	4.0m
18+284	Type-1	134.86	131.41	134.41	4.0m
19+088	Type-1	134.62	131.25	134.25	4.0m
19+685	Type-1	1164.50	131.13	134.13	6.0m
20+560	Type-1	133.61	130.97	133.97	4.0m
20+880	Type-1	133.02	130.89	133.89	6.0m
20+996	Type-1	133.72	130.87	133.87	6.0m
21+136	Type-2	133.40	130.84	133.84	4.0m
21+280	Type-2	132.11	130.81	133.81	4.0m
21+389	Type-2	133.27	130.79	133.79	4.0m
21+820	Type-2	132.58	130.71	133.71	4.0m
22+108	Type-1	134.59	130.65	133.65	4.0m
22+482	Type-2	132.84	130.98	133.58	4.0m
23+148	Type-2	133.18	130.45	133.45	4.0m
23+360	Type-2	132.80	130.40	133.40	4.0m
23+654	Type-2	134.32	130.34	133.34	4.0m
23+860	Type-2	136.70	130.30	133.30	4.0m
24+343	Type-2	139.20	130.21	133.21	4.0m
25+574	Type-2	136.02	129.96	132.96	4.0m
25+948	Type-2	132.26	129.88	132.88	6.0m
26+335	Type-2	132.84	129.81	132.81	4.0m
26+668	Type-2	131.67	129.73	132.73	4.0m
26+905	Type-2	131.12	129.67	132.67	4.0m
27+220	Type-1	131.23	129.63	132.63	9.0m
27+376	Type-1	131.07	129.60	132.60	4.0m

27+694	Type-1	132.25	129.53	132.53	4.0m
28+740	Type-1	130.80	129.32	132.32	4.0m
29+893	Type-1	131.16	129.09	132.09	9.0m
30+390	Type-1	140.00	129.00	132.00	6.0m
32+400	Type-1	130.89	128.60	131.60	6.0m
32+600	Type-1	131.15	128.55	131.55	6.0m

Design Information for Bridge Crossings in the Main Canal 2

Chainage	Type	Elevations			Width (m)
		Ground	Canal	Bridge	
0+040	Type-2	130.53	128.52	128.52	6.0m
0+300	Type-2	129.69	128.46	128.46	4.0m
0+776	Type-2	130.41	128.37	128.37	9.0m
0+888	Type-2	131.17	128.34	128.34	9.0m
1+020	Type-2	130.87	128.32	128.32	4.0m
1+245	Type-2	130.31	128.27	128.27	6.0m
2+150	Type-2	131.71	127.48	127.48	6.0m
2+595	Type-2	129.96	127.39	127.39	4.0m
2+695	Type-2	129.40	127.37	127.37	4.0m
3+040	Type-2	131.60	127.30	127.30	4.0m
3+416	Type-2	131.54	127.22	127.22	6.0m
3+697	Type-2	130.15	127.17	127.17	4.0m
4+097	Type-2	126.60	127.09	127.09	5.0m
4+624	Type-2	130.60	126.98	126.98	4.0m
4+766	Type-2	129.08	126.95	126.95	6.0m
4+974	Type-2	131.35	126.91	126.91	4.0m
9+663	Type-2	130.98	123.86	123.86	4.0m
15+366	Type-2	126.01	122.41	122.41	4.0m
16+436	Type-2	125.37	122.16	122.16	4.0m
16+637	Type-2	124.82	122.11	122.11	4.0m
17+340	Type-2	123.91	121.95	121.95	4.0m
17+800	Type-2				4.0m

2.2. Site Works

2.2.1. Drainage

The drains shall be constructed of precast concrete and asbestos cement pipes as shown on the drawings or described in the Bill of Quantities.

2.2.2. Pipe Bedding

Drainage pipes shall be laid on bedding which is composed of high quality soil without gravels unless otherwise shown on the drawings.

Above the bedding the trench shall be backfilled with suitable material which is discussed with the Engineer.

2.2.3. Laying Pipes for Drainage

Pipes shall be laid in straight lines and at constant gradient between manholes and wash out chambers.

The width of the trench at the crown of the pipe shall not exceed the outside diameter of the pipe plus 300 mm.

2.2.4. Construction of Chambers and Headwalls

Chambers and Headwalls shall be constructed in accordance with and in the locations shown on the drawings or as directed by the Engineer.

2.2.5. Testing Drains, Chambers, etc.

All drains and chambers shall be watertight and clean throughout. Drains shall be tested by the Contractor under a minimum head of 1 m in the presence of the Engineer. Should the pressure fall during a test the Contractor shall locate the leaks and make them good after which the pressure shall be re-applied and the process shall be repeated until the drains are satisfactory.

No drain or other work shall be covered up until it has been seen and approved by the Engineer.

In every case the water used for testing the pipes shall be left in the pipes until they are covered with earth to the top of the trench or a depth of at least 1.2 m over the top of the pipes and until permission is given by the Engineer for the water to be released. If after the Engineer has approved the pipes and has given permission for the trenches to be refilled, the pipes become damaged and lose water from any cause and/or admit subsoil water the pipes shall be uncovered and the defect made good and the pipe retested as before to the satisfaction of the Engineer.

2.2.6. Demolition of Existing Structures

This specification defines demolition of obstructive structures against the construction and deteriorated structures.

The Contractor shall prepare a drawing showing the relevant conditions, Bill of Quantity for the structures to be demolished, and pictures showing the conditions in advance of the demolishment, followed by acquiring an approval from the Employer.

The Contractor shall stop the operation of the object structure for the demolishment or empty the inside of it if it is a building before beginning the demolishment.

The Contractor shall transport reusable/recyclable facilities in the demolishing structures, paying attention not to cause any damage, to a location designated by the Employer.Furthermore, reusable materials from the demolishment for mound need to be utilized while discarding defective materials.

Every puddle, hole, or ditch caused by the demolishment shall be refilled to the surrounding ground level, followed by compaction.

To prevent any deform subsidence, collapse, or damage to a nearby facility, safety facilities such as braces and pillars shall be installed if necessary.

The Contractor shall minimize noise caused by the demolishment and take appropriate measures to prevent dust scattering including watering.

The Contract shall restore any damaged facility due to the demolishment to the original condition.

2.2.7. Safety Assessment

(a) Preliminary Investigation and Analysis of Relevant Data

(1) It is intended for establishing objective, plan, and methods for precise inspection, and safety measures.

(2) Histories and deformation conditions of the objects are analyzed and assessed, and safety inspection data in the facility management department are collected for analysis. Construction problems are intensively investigated and analyzed for cracks and local damages.

(b) Exterior Investigation

(1) The exterior investigation is purposed to figure out the structural safety, appropriateness of the material, and condition of each material of the facility in order to collect base data for field test and location determination. This investigation is to check present conditions for each critical material and supplementary structures, especially for potential safety deterioration. An exterior investigation map is prepared to utilize it for follow-up inspection and maintenance.

(2) To access detailed contents, the investigation is to be conducted as closely as possible to object material.

(3) Basic directions of the exterior investigation
Investigation of present conditions for the entire structure (establishing plan for field survey and temporary selection of various measurement points)
The exterior investigation is arranged and operated depending on the size and environments of the facility.

(4) Main items for the exterior investigation

Inspection Part	Inspection Item	Remarks
Structure	○ Defective part of the structure - Conditions of crack, delamination, exfoliation, differential settlement, erosion, and leakage	

	- Conditions of rooftop and waterproof, and waterproof of the structure's wall ○ Corrosion of concrete walls ○ Conditions of sand and soil settlements ○ Exposed rebar ○ Decoloration of the exterior and interior of wall ○ Cracks in window frame ○ Installation of rooftop ladder	
Various valves	○ Crack and damage on the body ○ Conditions of corrosion and abrasion ○ Fixity and engagement of each driving axis	
Flexible joint	○ Conditions of corrosion and damages ○ Leakage at the engagement part	
Drainage facility	○ Conditions of drain channel on slopes and road (soil and leave settlement) ○ Drainage condition at the upper portion of the structure	
Piping	○ Maintenance of various pipes ○ Damage at the welded portion (cracks, leakage, paint, and corrosion conditions) ○ Other (condition of boundary fence deterioration)	
Landscaping facility	○ Damages on the landscaping facility in the structure - Condition of vegetation protection or damage	

(c) Non-Destructive Concrete Test

(1) The non-destructive test is purposed to figure out rigidity and material characteristics of the structure not damaging its performance or trafficability. In case that the structure has been seriously deteriorated, the test is intended for investigating the degree and cause of deterioration to determine repair or reinforcement of it. For structures with minor deterioration, the test is intended for acquiring basic data to estimate the future deterioration of it.

(2) The following table shows test details, including field conditions for selecting measurement points, in a degree that no damage occurs to the structure.

Items	Description	Instrument	Number of Measurements
Strength of concrete	Rebound hardness test	The instrument and locations of measurements shall be determined in collaboration with the Employer and the Engineer.	
	Ultrasonic wave method		
Investigation of crack depth	Ultrasonic wave angle beam method		
Measurement of reinforcement corrosion condition	Self-potential method		
Rebar survey	Radar method		
Investigation for	Phenol-phtalane		

neutralization depth	method	

(d) Structural Analysis

(1) Purpose

a) Structural analysis is carried out for the load.

b) When any damage assumed to be caused at the construction period is discovered, analyses are carried out for each construction phase to find the cause of damage.

c) Structural analysis is carried out considering the sized of actual structure.

(e) Investigating Cause of Damage

(1) Purpose

a) It is purposed to grasp accurate condition of damage.

b) Time and method of measures are determined.

(2) Procedure of investigating the cause of damage

a) Analyzing the field survey test

b) The cause is assumed through local analysis (if necessary).

c) When the cause of damage is hard to discovered, final results are yielded using relevant information and measurement data based on several assumptions.

(f) Evaluation of Comprehensive Conditions

(1) Structural assessment

a) The design sectional force is assessed.

b) Safety assessment and suggestion of safety rate

c) Comparison of design value and calculation

(2) Status assessment of the structure and determination of safety assessment level

(g) Proposal of Repair or Reinforcement and Maintenance Methods

(1) Purpose
It is purposed to secure the design performance and effective maintenance.

(2) Determination of materials for repair or reinforcement

a) The damaged portion and relevant material are determined through visual inspection and non-destructive test.

b) If necessary, problematic materials for safety and its behavior are investigated through structural analysis and loading test.

(3) Reasonable ways of repair and reinforcement are drawn and proposed.

a) Repair and reinforcement methods are comparatively analyzed, and reasonable ways of repair and reinforcement are proposed

b) The appropriateness of the repair and reinforcement methods is confirmed through structural analysis or experiment.

c) Inspection methods are proposed to confirm the effect of repair or reinforcement against structurally critical or large scale damage.

(4) The repair time and priority are determined, and effective maintenance methods are proposed.

(h) Comprehensive Evaluation

- Overview
  The comprehensive evaluation is based on the assessment of present condition through the exterior investigation, mentioned above, and the endurance evaluation, followed by comprehensive assessment of them.

(i) Comprehensive Evaluation Criteria

Grade of the comprehensive evaluations	Condition and safety	Remarks
A	The best condition without any problem.	
B	Performance is ensured though minor defects are found in supplementary material, and some repair is needed to enhance the durability.	
C	Safety of the overall facility is ensured through minor defects in the main material or wide range of damage in the supplementary material. Repairing the main material is needed to prevent deterioration of performance and rigidity, or simple reinforcement to the supplementary material is required.	
D	Prohibition of using the facility needs to be determined since prompt repair or reinforcement is required due to defects on the main material.	
E	The use of facility should be prohibited immediately due to jeopardized safety of the facility by serious defects on the main material. It should be reinforced or renovated.	

2.3. Earth Works

2.3.1. Condition of Site

Before carrying out any work on the Site, the Site shall be inspected by the Contractor in conjunction with the Engineer to establish its general condition which shall be agreed and recorded in writing, and, where in the opinion of the Engineer it is deemed necessary, by means of photography.

Details recorded shall include the location of all boundary and survey beacons, the condition of buildings, surfaces, terracing (if any), ditches, watercourses, roads, tracks, fences and other information relating to the Site and elsewhere (including storage and stockpiling locations) which may be affected by the Contractor's operations.

2.3.2. Location of Existing Services

The location of any existing services shown on the drawings is approximate only and not necessarily complete. Before carrying out any demolition or excavation for construction purposes the Contractor shall accurately locate in both line and level all existing services within the Site whether indicated on the drawings or not, and furnish the Engineer with 3 copies of the relevant information immediately.

2.3.3. Site Clearance and Topsoil Removal

Site clearance shall be carried out over the areas to be occupied by the permanent Works before beginning excavation or other work, and shall include the clearance of all trees, stumps, bushes and other vegetation and the grubbing out of all roots and the removal of all boulders between 0.01 and 0.2 m^3 volume. The limits of the areas to be cleared shall be as indicated on the drawings or as will be defined by the Engineer.

Following the establishment of ground levels (Clause 2.3.5), the Contractor shall strip topsoil, where indicated on the drawings or as directed by the Engineer to a depth of up to 300 mm. The topsoil so removed shall be deemed to become the property of the Employer and shall be set aside for re-use or disposal as directed by the Engineer.

Topsoil is defined as the surface layer of soil which by its humus content supports vegetation. This layer of soil is unsuitable, due to weathering and vegetable content, as a formation to roads and concrete structures or as a backfill or bedding material. The presence, extent and depth of topsoil that needs removal shall be agreed with the Engineer.

Subject to the requirements of this clause and the Conditions of Contract, all other materials arising out of site clearance will be deemed to become the property of the Contractor, and shall be disposed by him off the Site, or on the site in a manner and place approved by the Engineer.

Where shown on the drawings or directed by the Engineer, trees shall be uprooted or cut down as near to the ground level as possible and all timber shall be deemed to become the property of the Employer. The Contractor shall cut and stack such timber as is salvable as directed by the Engineer.

Bushes, undergrowth, small trees, stumps and tree roots shall, where directed by the Engineer, be grubbed out, burnt and deposited off the site in dumps to be provided by the Contractor. All holes left by the stumps or roots shall be backfilled with suitable material in a manner approved by the Engineer.

The Engineer may require that individual trees, shrubs and hedges are to be preserved and the Contractor shall take all necessary precautions to prevent their damage.

In the case of wayleaves for sewers, pipelines and the like, the area to be cleared shall extend over the full width of the wayleave but the Contractor shall preserve as far as practicable all grass and other vegetation outside the limits of trenches and permanent works within the wayleave and shall not unnecessarily destroy crops or any vegetation whose removal would not be essential to his operations.

Before beginning clearance within any wayleave the Contractor shall give seven days written notice of his intention to the Engineer who will determine the extent and limits of such clearance having regard to the Contractor's requirements, the rate of Contract progress, the reasonable wishes of owners and occupiers, weather conditions and other factors which in the opinion of the Engineer may affect or be affected by the Contractor's proposals.

2.3.4. Erosion

The Contractor shall take particular care at all times to prevent erosion on every site and elsewhere on land which may be affected by his operations and the Engineer may impose such reasonable limitations and restrictions upon the method of clearance and upon the timing and season of the year when clearance is carried out as the circumstances warrant.

2.3.5. Ground Levels

Following the completion of Site clearance and before the commencement of any earthworks or demolition the sites shall be surveyed in conjunction with the Engineer to establish existing ground levels and these agreed ground levels shall form the basis for the calculation of quantities of any subsequent excavation and filling. These levels shall be taken before any topsoil is removed.

2.3.6. Trial Holes

The Contractor shall excavate refill and restore before commencement of any permanent works such trial holes as he may require for the location of existing underground services and obstructions.

2.3.7. Excavation General

Excavation shall be made in open cutting unless tunnelling or heading is specified or approved by the Engineer and shall be taken out as nearly as possible to exact dimensions and levels so that the minimum of infilling will afterwards be necessary.

It shall be the Contractor's responsibility at all times to ensure the stability and safety of excavations and the Contractor shall take all measures necessary to ensure that no collapse or subsidence occurs.

The sides of all excavations shall be kept true and shall where necessary be adequately supported by means of timber, steel or other type struts, walings, poling boards, sheeting bracing and the like. All supports shall be of sound design and construction and shall be sufficiently watertight to permit excavation, concreting and other work to be completed satisfactorily.

Excavations shall be kept free from water and it shall be the Contractor's responsibility to construct and maintain temporary diversion and drainage works and to carry out pumping and to take all measures necessary to comply with this requirement.

In the event of soft or otherwise unsuitable ground being encountered at formation level in any excavation the Contractor shall forthwith inform the Engineer and shall excavate to such extra depth and refill with compacted granular or other approved fill or Grade C15P concrete as the Engineer may require. The requirements of this paragraph shall apply also to the side face of any excavation with which concrete or other work will be in contact except that in the case of a side face the Engineer may alternatively require that the net dimensions of the concrete or work shall be increased.

The Contractor shall not deposit excavated materials on public or private land except where directed by the Engineer in writing or with the consent in writing of the relevan authority or of the owner or responsible representative of the owner of such land and only then in those places and under such conditions as the relevant authority, owner or responsible representative may prescribe.

2.3.8. Excavation in Excess

If any part of any excavation is in error excavated deeper and/or wider than is required the extra depth and/or width shall be filled, at the Contractor's expense, with Grade C15P concrete or compacted granular or other approved fill to the original formation level and/or dimensions as the Engineer may require.

In pipe trenches where the pipe is not bedded on or surrounded with concrete, the excess excavation shall be filled with compacted granular material. Excess excavation in rock trenches shall be filled with Grade C15P concrete up to 150 mm below the pipe invert.

2.3.9. Mechanical Excavation

Mechanical excavation shall be employed by the Contractor only if the subsoil is suitable and will allow the timbering of the trenches or other excavations to be kept sufficiently close up to ensure that no slips, falls or disturbance of the ground take place or there are no pipes, cables, mains or other services or property which may be disturbed or damaged by its use.

When mechanical excavators are used a sufficient depth of material shall be left over at the bottom of the excavation to ensure that the ground at formation level is not damaged or disturbed in any way. The excavation shall then be completed to formation level by hand.

2.3.10. Excavated Materials Suitable for Re-Use

In so far as they may be suitable and comply with the Specification, materials arising from excavations may be used in the Works.

During excavation, the Contractor shall ensure that all material suitable for re-use and which he intends for re-use are kept separate and set aside and protected as necessary to prevent loss or deterioration.

The materials forming the surface and foundations of roads, road verges, tracks and footways shall when excavated, and if required for further use, be carefully separated. All hard materials shall be kept free from soil or other excavated materials.

In particular, during excavation of pipe trenches the Contractor shall ensure that all granular or other approved material suitable for filling around and over pipes shall be kept separate and re-used for this purpose.

Paving slabs, bricks and similar surfaces shall be carefully removed and stacked. Prior to the commencement of excavation the number of badly broken and unsuitable paving slabs, bricks etc. on the line of the excavation shall be agreed with the Engineer.

In verges and other grass surfaces the grass and top soil shall be stripped and separately stacked.

2.3.11. Disposal of Surplus, Demolished or Excavated Materials

All surplus demolished or excavated materials shall be disposed to appropriate distance not exceeding 1 Km of by the Contractor to tips provided by the Contractor and approved by the Engineer.

The Contractor shall not sell any materials arising from excavation, demolitions and the like carried out on the site.

The Contractor shall not deposit excavated materials on public or private land except where directed by the Engineer in writing or with the consent in writing of the relevant authority, owner or responsible representative of the owner of such land and only then in those places and under such conditions as the relevant authority, owner or responsible representative may prescribe.

Surplus material may not be tipped on the site without the written permission of the Engineer. In the event of such permission being granted the Contractor shall observe all conditions attached thereto.

2.3.12. Backfilling of Excavations

All backfilling of excavations shall be thoroughly compacted in layers not exceeding 150 mm compacted thickness and by means which will not damage the Works.

Backfilling of excavations for reinforced concrete structures shall be with suitable material approved by the Engineer.

"Granular material" as backfill is defined as unconsolidated laterite, crushed stone, quarry dust, gravel, sand or similar in which the clay or silt content is not predominant. Topsoil shall not be classified as granular material.

2.3.13. Making Good Subsidence after Refilling

All refilling shall be thoroughly compacted by ramming and any subsidence due to consolidation shall be made up with extra compacted material.

Should subsidence occur after any surface reinstatement has been completed the surface reinstatement shall first be removed, the hollows made up, and then the surface reinstatement relaid.

Any subsidence that occurs adjacent to the Site of the Works which is attributable to the Contractor's activities shall be reinstated to the full satisfaction of the Engineer.

2.3.14. Removal of Timber from Excavations

Timber shall be removed from the excavations before or during the process of refilling except in so far as this removal of timber would be likely to cause damage to adjacent property, structures or structure foundations in which event the Contractor shall leave in the excavation such timbering as he considers necessary or as may be ordered by the Engineer to prevent damage, the proper repair of which the Contractor shall be solely responsible for in the event of any such damage occurring.

Timbering means any form of approved excavation support system or part thereof.

2.3.15. Reinstatement of Surfaces

All surfaces whether public or private which are affected by the Works shall be reinstated temporarily by the Contractor in the first instance and in due course when the ground has consolidated fully he shall reinstate the surfaces permanently.

The temporary reinstatement and maintenance and permanent reinstatement and maintenance of all surfaces of roads, tracks, paths, fields, verges and any other surfaces which have been affected by the operations of the Contractor shall be his sole liability and shall be carried out to the satisfaction of the Engineer and of the responsible authority or owner.

Temporary reinstatement shall be carried out immediately the trenches are refilled.

Permanent reinstatement shall not be carried out until the ground has consolidated completely and the Contractor shall inform the Engineer before carrying out this work. In the event of further settlement occurring after the completion of the permanent reinstatement the Contractor shall forthwith make good the reinstatement to the approval of the Engineer or responsible authority.

For the purposes of temporary and permanent reinstatement in bitumen and murram surfaced roads the surface width of trenches shall be increased by 150 mm on each side of the trench for a depth of 75 mm to provide a solid abutment for the surfacing material.

Reinstatement of murram surfaced roads shall consist of approved "as dug" material placed in one layer 250 mm thick thoroughly compacted by an approved roller and surface blinded with fine material so as to leave a tight closed even surface, all to the satisfaction of the Engineer.

Materials forming the surface and foundations of bitumen and murram surfaced roads, tracks and footpaths may, if they are approved by the Engineer be used by the Contractor in the temporary reinstatement of surfaces. The Contractor shall provide all additional materials necessary for the reinstatement. All materials shall form a surface similar to the adjoining surface. The surface shall be well compacted.

Temporary reinstatement of trenches in bitumen surfaced roads shall comprise a layer of compacted hardcore, of minimum thickness 150 mm, topped with a 75 mm layer of surface material taken from the original surface together with any additional material to form a satisfactory running surface. The surface shall be well rolled and sealed with a coat of approved cold applied bituminous emulsion, applied with an approved sprayer at the rate of approximately 2 liters/m^2. The emulsion shall be blinded immediately with quarry dust or sand approved and then rolled with an 8 tonne roller.

The quality and grade of bitumen shall be suitable for the climatic conditions of the area and shall otherwise conform to BS 434.

Permanent reinstatement of surfaced roads shall be carried out to the approval of the competent authority. In bitumen surfaced roads the top layer of the temporary reinstatement shall be removed to expose the compacted hardcore which shall be topped up and re-rolled as necessary.

Trenches in open ground shall be reinstated to the condition in which the ground was found before excavation was commenced. The final surface of the trench shall be flush with the surrounding ground.

In verges and other grass surfaces and after the refilling has been thoroughly consolidated the topsoil shall be relaid rolled and planted with grass as may be necessary and watered until the grass has become well established. Should the grass fail it shall be replanted as required until a satisfactory growth is obtained.

The Contractor shall take all necessary precautions to ensure that no toxic materials which may cause damage to vegetation or livestock or pollute streams or watercourses are used in any temporary or permanent reinstatement and shall indemnify the Employer against any claims arising out of the use of such materials.

If at any time any trench becomes dangerous the Engineer shall be at liberty to call on the Contractor to restore it to a proper condition immediately.

If the work or reinstatement as carried out by the Contractor is not to the satisfaction of the Engineer and/or the responsible authority and should the Contractor not remedy the defect forthwith any remedial work considered necessary may be undertaken by the Employer and/or the responsible authority at the Contractor's expense.

2.3.16. Forming Banks and Filled Areas

Banks and filled areas shall be made and built up to the levels, dimensions and shapes as shown on the drawings or as may be subsequently directed by the Engineer. Before any filling is started, the ground on which the fill is to be placed shall be stripped of all grass and topsoil and all roots, vegetable matter and other unsuitable substances removed.

The filling to be used in the embankments and filled areas shall be material selected by the Engineer from that arising from surplus excavation, the material being placed according to its nature as shall be directed, that is, coarse hard material may be placed at the bottom with the fine materials and/or soil placed at the top or at the surface.

The fill shall be placed in layers not exceeding 150 mm thick, each layer being thoroughly compacted by an approved roller to the satisfaction of the Engineer.

2.3.17. Restoration of Borrow Areas, Spoil Tips and Quarries

Any spoil tips, quarries or other borrow areas developed by the Contractor for the purpose of the Works shall be finished to safe and fair slopes to the approval of the Engineer.

Where directed by the Engineer these areas shall be resoiled and grassed over or otherwise seeded. Operation of such borrow areas and tips shall be in accordance with the rules and regulations of the appropriate authority responsible for them.

2.3.18. Top Soiling and Grassing

Where required surfaces shall be soiled with fine sifted soil or silt not less than 100 mm compacted thickness which shall be raked and brought to a fine tilth. The Contractor shall supply approved material for this purpose or use the material.

Surfaces required to be grassed shall be planted with approved local grass at a spacing of 200 mm x 200 mm. The grassed areas shall be replanted if the first or subsequent operation is unfruitful or if for any reason the grass is destroyed. Grassed areas shall be watered and attended until the grass has become well established.

The soiling and planting of the grass in slopes shall be carried out immediately the slope is formed and the grass shall be kept weeded and cut until the work is accepted at the time of the Certificate of Completion.

The Contractor shall supply attendance during the Defects Liability Period to ensure that all planted grass is kept weeded and cut, and if necessary watered.

2.3.19. Free Draining Fill

Free draining fill for use as backing to walls shall consist of sound hard stone or broken rock or concrete derived from demolition of structures. The particles shall be roughly cubiform and shall be between 75 mm and 25 mm in size. All smaller particles, dust, rubbish and organic matter shall be excluded.

2.3.20. The Procurement of Equipment at the Construction Site.

The Contractor should procure and use the proper equipment for the excavation (soil and rock), transportation, and etc.

Also, the Contractor should not make any problem to the construction process because of the lack of equipment.

The Contractor should make plan for the procurement of the equipment before commencement of the construction because there will be some problems to procure the proper equipment in the local area.

2.4. General Requirements of Structures

2.4.1. Excavation for Foundations of Structures

The Contractor shall give sufficient notice to the Engineer to enable him to examine foundations well in advance of concrete being placed and no placement shall occur until such inspection shall have been carried out and the formation approved.

If the formation has become weathered prior to the placing of concrete the Contractor shall remove the weathered material and replace it with Grade C15P concrete as directed by the Engineer.

If the Engineer so directs, a bottom layer of excavation of not less than 75 mm thickness shall be left undisturbed and subsequently taken out by hand immediately before concrete or other work is placed. Similarly, where concrete or other materials is to be placed in contact with the side face of an excavation the Contractor shall, if the Engineer so directs, leave undisturbed the last 75 mm thickness of the excavation to that face until it is taken out neatly to profile by hand immediately before the concrete is placed.

Areas of excavation which are to receive a layer of concrete blinding or drainage layer under structural concrete shall be covered with such blinding or layer immediately the excavation has been completed and inspected and approved by the Engineer.

All surfaces shall be free of oil, water, mud or any material which in the opinion of the Engineer is not desirable.

Excavations for foundations and for thrust and anchor blocks shall be to such depth as shown on the drawings or as the Engineer may direct and no concrete or other materials shall be placed until the formation has been examined and approved. Due notice shall be given to the Engineer to enable him to examine the formation well in advance.

2.4.2. Structures Liable to Flotation

Certain structures may be liable to float during the course of construction and it shall be the

Contractor's responsibility to take all necessary precautions to prevent flotation.

Where continuous pumping is necessary to protect the work this shall be maintained at all times. Where flanged pipes are provided in the walls or base of the structure, and are intended for non-potable duty, they shall not be blanked-off until instructions are given by the Engineer to do so.

In the event of pump failure the works for non-potable duty shall be permitted to flood to prevent flotation. If as a result of this action, damage is sustained by recently-placed concrete to an extent which the Engineer considers to be detrimental to the Works, such concrete shall be removed and replaced at the Contractor's expense.

2.4.3. Acceptance Tests

The Contractor shall include in his rates for acceptance tests on completed structures as may be specified or directed by the Engineer. The Contractor shall include for all labour, materials, water and equipment for conducting the tests and for proving the performance of the completed structures.

Water excluding structures shall be watertight and shall prevent infiltration of ground or rain water. Leaks shall be made good to the satisfaction of the Engineer.

Water retaining structures shall be tested. All water retaining structures complete with electrical and mechanical plant installed in position shall be finally tested, before the issue of the Certificate of Completion, under conditions fully representative of operating practice.

All leaks or other faults in structures shall be made good and the repaired structure re-tested at the Contractor's cost.

2.4.4. Backfilling around Structures

Rectangular Structures: The walls of structures for water treatment, chambers and other structures may be designed as being supported by intermediate, ground floor or roof slabs or beams. Backfilling around or loading the walls of such structures shall not take place until the concrete of the supporting slabs or beams has been cured in accordance with the requirements of Section 2.5.

2.4.5. Forming Slopes, Embankments and Cuttings

The slopes of any banking shall be accurately an uniformly dressed off to slopes as directed by the Engineer.

The Engineer may order excavated material to be used in forming embankments or making up low ground. Only suitable material shall be used for such work.

2.4.6. Drainage Layers in Embankments

Gravel for horizontal and vertical layers in embankments shall be hard, clean, washed aggregates of 20 mm nominal diameter.

Any horizontal layers of such drainage gravel shall be laid in one continuous operation on a clean formation and shall be compacted by a method approved by the Engineer.

Vertical gravel drainage layers behind walls shall be placed in lifts in advance to the fill to the embankments, being compacted in layers by the use of light rammers. It shall be kept free from mixing with the filling material by the use of boarding or the like placed between the two materials and raised as the work proceeds.

The Contractor shall include in his rates for sufficient thickness of drainage material to ensure that the minimum thickness at any place is not less than that shown on the drawings.

2.5. Concrete Works

2.5.1 General

This specification covers reinforced structural concrete for use in building and structure, appurtenances, foundations of equipments.

2.5.2 Reference Standards

Reference Standards for concrete works shall follow the Design Standards and detail codes described in Sub-section 1.2. The following codes shall govern the concrete work: Building Code Requirements for Reinforced Concrete (ACI 318) of the latest edition, or approved equal. Other codes, specification, and recommendations referred to in this ACI 318 code shall be interpreted as part of that code.

2.5.3 Submissions of Report on Workability and Consistency of Mixtures

The Contractor shall report concerned on workability and consistency of the concrete mixture for approval of the engineer.

(a) Concrete shall be composed of portland cement, fine aggregate, coarse aggregate, and water. The Contractor may find that an admixture is required for retarding or accelerating the setting and improving the workability of the concrete; however, its use must be approved by the Engineer. These materials shall be combined in such proportions as will result in the specified strength and maximum density and water tightness.

(b) The relative proportions of these materials and the consistency of the mixture shall be at all times subject to the approval of the Engineer. Tests for strength and material requirements shall have been completed and approved before concrete is placed.

2.5.4 Materials

Not less than 90 days before the start of the concrete work at the site, the Contractor shall furnish the Engineer with a written report showing the source, producing company and intended use of the materials required in the work.

The report shall include a description of the proposed methods and the equipment to be used by the producer for the production of the materials and a description of the methods to be used to control and inspect the quality, uniformity, and cleanliness of the product. The source of supply and quality of each of the materials shall be approved by the Engineer and the Engineer's Representative before delivery is started.

(a) Portland cement shall comply with specification for portland cement, ASTM C150-89, Type I and Type III, or equal, with all brands subject to approval. Type III, for high early strength concrete, shall be at the Contractor's option but subject to the approval of the Engineer.

(b) Air entraining admixtures shall conform to ASTM C260, or equal. The Contractor shall furnish to the Engineer's Representative certification that the air-entraining agent has been tested in accordance with ASTM C233, or equal.

(c) Retarding admixtures shall conform to ASTM C494, Type B, or equal. The Contractor shall present to the Engineer test reports from an approved laboratory certifying that the proposed admixture, when used with the cement and aggregates to be used for the project produces satisfactory content, slump, and strength.

(d) Water reducing admixtures shall conform to ASTM C494, Type A, D, or E, or equal. The contractor shall present to the Engineer test reports by an approved laboratory certifying that the proposed admixture when used with the cement and aggregates to be used for the project, produces satisfactory concrete, having the desired properties with respect to time of set, water-reduction, slump, and strength.

(e) Pozzolans, including fly ash: Pozzolanic materials other than fly ash shall conform to ASTM C618, or equal. Fly ash shall conform to ASTM C618, or equal. The Contractor shall present to the Engineer test reports by an approved laboratory certifying that the proposed admixtures when used with the cement and aggregates to be used for the project, produce satisfactory concrete having the desired properties with respect to workability and plasticity, with no adverse reaction.

(f) General Admixtures: Their use shall be optional subject to written approval by the Engineer. Admixtures used in pre-stressed concrete or seawater exposed concrete shall be certified by the manufacturer to be used in a mix, the contractor shall furnish satisfactory to be free of chlorides. When more than one admixture, the admixtures shall be compatible to mix together with the cement and aggregates for the temperature in the worksite. The cost of admixtures proposed for use by the contractor, when allowed, shall be at no change in contract price, except if the Engineer shall require the use of admixtures.

(g) Water shall be clean and free from injurious amounts of oil, acid, alkaline, salts and organic matter, or other deleterious substances.

(h) Aggregate: Fine aggregate and coarse aggregate shall conform to the requirements of ASTM C33, or equal. The nominal maximum size of the aggregate shall not be larger than one-fifth of the narrowest dimension between sides of forms; one-third of the depth of slabs, nor three-fourths of the minimum clear spacing between reinforcing bars, whichever is least. Aggregate shall be graded in accordance with the requirements of ASTM C33, or equal. These limitations may be waved if, in the judgment of Engineer, workability and methods of consolidation are such that the concrete can be placed without honeycomb or voids.

(i) Reinforcement: Reinforcing steel shall be deformed-type hard grade and intermediate grade billet-steel conforming to BS 4449 “Carbon steel bars for the reinforcement of concrete" or equal. Welded wire fabric (mesh) shall conform to ASTM A185-85 for "Welded Steel Wire Fabric for Concrete Reinforcement", or equal.

(j) Curing Materials

- Curing paper shall conform to the requirements of ASTM C171, or equal.
- Polyethylene sheets shall conform to the requirements of ASTM C171, or equal.

- Cotton mats shall conform to the requirements of AASHO M73, or equal.
- Liquid curing compound shall conform to the requirements of ASTM C309, or equal. The clear liquid curing compound shall contain a fugitive dye of sufficient strength to render the film distinctly visible on the concrete for at least four hours but shall leave no permanent discoloration.

(k) Test Cylinder Molds: The Contractor shall furnish a sufficient quantity of re-usable test cylinder molds for adequate sampling.

(l) Floor hardener shall be a sodium silicate or other approved type liquid hardener. Surfaces that are to receive a hardener finish shall not be cured with a liquid curing compound.

2.5.5 Testing

The Contractor shall submit test reports to the Engineer.

No material shall be shipped from its place of manufacture before it has been inspected and approved, unless the Engineer has specifically authorized the inspection to be made elsewhere, or has waived the inspection. Materials shall not be used until approval has been received from the Engineer. Approval of the materials at the producing plant does not constitute a waiver of the Engineer and the Engineer’s right of reexamination at the project site.

(a) Cement shall be sampled at the mill and at the site of the work or at the direction of the Engineer's Representative, and the method of sampling shall conform to that outlined in the ASTM C183-83 for "Sampling Hydraulic Cement" or equal. Test reports to establish compliance with the specifications for each type of cement shall be submitted.

(b) Aggregates shall be sampled at their source and at the site of the work when directed by the Engineer, and test reports to establish compliance with the specifications for each type of aggregate shall be submitted. Moisture content of fine aggregate on the site shall be determined daily before concrete mixing is commenced. The amount of water to be added to each batch shall be adjusted at the direction of the Engineer to allow for the moisture content of the fine aggregate. This test shall be repeated whenever there is reason to believe that the moisture content of the fine aggregate has changed since the previous test was made.

(c) Reinforcing steel shall be sampled at the mill, and test reports to establish compliance with the specifications for each type of reinforcing steel shall be submitted.

(d) Fresh concrete to be placed in stationary formwork shall be sampled as described in ASTM C172-90, "Sampling for Fresh Concrete", or equal.

(e) Slump tests shall be made frequently to control the fresh concrete before its final placement and these tests shall be made in accordance with the ASTM C143-90 for "Test for Slump of Portland Cement Concrete", or equal.

(f) Molded Concrete Test Specimens: One set of four specimens shall be made and tested from each 100 cubic yards of concrete or fraction thereof, or each day's poured, whichever is less. Specimens shall be molded and cured in accordance with the procedure in ASTM C31-90 for "Making and Curing Concrete Compression and Flexural Test Specimens in the Field", or equal, and the mold shall conform to the ASTM C470-87 for "Molds for Forming Concrete Test Cylinders Vertically", or equal.

(g) Concrete Specimen Testing: The standard age of tests shall be 28 days; however, seven day and even three-day tests may be required by the Engineer.

Test specimens for determining when a structure may be placed in service and test specimens for acceptance of concrete shall be tested in accordance with the procedure in ASTM C39-86 for "Compressive Strength of Cylindrical Concrete Specimens", or equal.

The test result shall be the average of the strengths of two 28-day tests, except that if one specimen in a set of four shows evidence of improper sampling, molding, or testing, the test result of that specimen shall be discarded and the resulting test of another specimen of the same set shall be inserted in its place. If two specimens in a set of four show such defects, the result of the tests shall be discarded and the average strength shall be determined from test results of the remaining two specimens. If the average of the strength tests of the specimens for any portion of the work falls below the minimum allowable compressive strength at 28 days required for the class of concrete used in that portion, the Engineer shall order a change in the proportions of the cement and aggregates or the water content of the concrete, or both, for the remaining portions of the work.

If cube specimens are made and tested instead of cylinders, the cube strength shall be 25 percent higher than the cylinder strengths specified in Section 8, "Kind of Concrete, Strength Requirements, and Usage".

(h) Hardened concrete shall be tested when the results of tests of the control specimens indicate the concrete as placed does not meet specification requirements or when there is other evidence that the quality of concrete is below specification requirements.

One or all of the following tests may be required by the Engineer's Representative.

- Concrete test hammers may be used for testing when approved by the Engineer. However, if test results fall consistently below the required compressive strengths for the concrete, cored shall be drilled from the hardened concrete in the questionable area and shall be tested to determine whether the concrete remains in place or is to be removed. The hammer shall be calibrated and testing shall be conducted on surfaces that are smooth and uniform with no rough spots, honeycomb or porous area. The tests shall not be made on sections less than 4 inches in thickness unless it is backed up by a heavy mass placed against the backside. If the surface is rough a grinder shall be used to prepare a smooth surface for testing.
- Cores, when required by the Engineer, shall be drilled and tested in accordance with ASTM C42-84a for "Obtaining and Testing Drilled Cores and Sawed Beams of Concrete", or equal.
- Load Tests : Where core drilled test results indicate that the in-place concrete does not meet specification requirements, a load test shall be conducted in accordance with the applicable section of the American Concrete Institute Building Code (ACI 318), or equal.

(i) Water: Where the presence of deleterious materials is suspected, a mortar test shall be made. The strength at 28 days of mortar specimens made with the water under examination and ordinary portland cement shall be at least 90 percent of the strength of similar specimens made with the same cement and with water of known satisfactory quality. Steps shall be taken in the field to ascertain whether the water in the vicinity meets specification requirements applying to its use in mixing and curing of concrete and in aggregate washing operation : and also whether the soil or water with which the concrete will be in contact contains harmful sulfate concentration.

(j) Admixture: Certificates shall be submitted that the concrete containing admixtures maintains strength increases over a period of at least two years, that drying shrinkage is reduced, that uniformity in mix is maintained, and that an admixture of the exact composition proposed has been successfully employed in work of similar scope for at least five years.

(k) Materials not Mentioned: The testing of all materials not specifically mentioned shall be done by generally accepted methods and standards of ASTM or equal.

2.5.6 Storage

(a) Cement shall be stored in a dry, weather tight, properly vented structure with a wooden floor raised not less than 12 inches above the ground and having adequate provision for prevention of absorption of moisture. Different brands of cement shall be stored separately and shall not be mixed. Notwithstanding and previous acceptance, any bag of cement containing material which has hardened or otherwise deteriorated shall be rejected, and any cement rejected for any cause shall be removed from the site immediately. Cement which has been stored on the site for more than six months, shall not be used in the works and shall be removed from the site.

(b) Aggregate shall be stockpiled in locations providing good drainage and where inclusion of foreign matter will be prevented and the gradation may be preserved. Sufficient live storage shall be maintained to permit separation of shipments from different sources, and to assure placement of concrete at the required rate. Frozen or partially frozen aggregates shall not be used.

- Fine aggregate from different sources of supply shall not be mixed or stored in the same stockpile, nor used alternately in the same class of construction without the approval of the Engineer.
- Coarse aggregate shall be stockpiled in such a manner that it is not contaminated by fine aggregate. Adequate precautions shall be taken to prevent segregation while it is being transported and stockpiled.

(c) Reinforcing steel shall be stored in a manner that will prevent it from being damaged and to preserve the identification of the various pieces. The temperature of the reinforcing shall be kept below 90 degrees Fahrenheit (32 Celsius).

(d) Other concrete materials shall be stored to provide protection from the weather.

2.5.7 Delivery of Materials

Railway cars, barges, or trucks used for transporting portland cement, water, aggregates, and reinforcing steel shall be clean when any of these materials are placed therein. Trucks and other vehicles used to transport materials must be kept clean and free from foreign matter.

They must be in proper working condition and have strong, substantial bodies, which will prevent the loss of materials during transportation.

2.5.8 Kind of Concrete, Strength Requirements, and Usage

(a) All Structural concrete for water retaining structures, unless otherwise specified herein, shall have a minimum compressive strength of 30MPa at 28 days.

(b) All structural concrete for buildings shall have a minimum compressive strength of

24MPa at 28 days.

(c) Lean concrete shall be concrete used for fill material when required by the Engineer's Representative for hopper fills in bin bottoms and for leveling beds. Lean concrete shall attain a minimum compressive strength of 14MPa at 28 days.

(d) Grout: Cement grout and non-shrink grout shall be used at locations shown or specified and shall attain a minimum compressive strength of 300 kg/cm^2 at 28 days.

(e) Control: The strength quality of the concrete proposed for use shall be established by tests made in advance of the beginning of operations, using the consistencies suitable for the work. Trial mix design and testing shall be the responsibility of the Contractor. The contractor shall make trial mixes in the presence of the Engineer.

Test specimens shall be made of each trial mix and shall be tested at 28 days. If the trial mix shall fail to attain the strength and workability required, the Engineer may order further trial mixes to be made until an acceptable mix is obtained.

2.5.9 Proportioning of Concrete Mixes

(a) Measurement of concrete materials shall be by weight on weighing equipment and scales approved by the engineer's representative. Measuring devices shall be as nearly automatic as practicable and shall be so calibrated that the contents of any setting may be readily determined. When measuring devices are not available, the proportions shall be such that the water-cement ratio does not exceed the appropriate value shown in following table.

Maximum Permissible Water-Cement Ratios (Method 3 of ACI 304-73)

Specified Strength, fc, psi (kPa)	Max. Permissible Water-Cement Ratio by Weight*	
	Non-Air-Entrained Concrete	Air-Entrained Concrete
4,000 (27,580)	0.44	0.35
3,750 (25,856)	0.48	0.38
3,500 (24,132)	0.51	0.40
3,000 (20,685)	0.58	0.46
2,500 (17,237)	0.65	0.54

* Including free surface moisture on aggregates, and liquid admixtures.

Fine and coarse aggregates shall be measured separately.

(b) All Structural concrete shall be mixed in such proportions as will result in a workable mix having a minimum cement content of 600.0 pounds per cubic yard (356 kg/m^3) of concrete. The mix shall be designed for a required compressive strength of 3,000 pounds per square inch (20,685 kPa) in 28 days.

(c) Lean concrete shall be mixed in such proportions as will result in a workable mix having a minimum cement content of 200 pounds per cubic yard (119 kg/m^3) of concrete. Aggregate shall be clean, well graded sand and gravel or crushed stone.

(d) Concrete topping shall be mixed in such proportions as will result in a workable mix having a minimum of 100 pounds (45.36 kg) of portland cement to 300 pounds (136 kg) of sand. Aggregate shall be clean, well graded sand.

(e) Grout

- Cement grout shall consist of 100 pounds (45.36 kg) of portland cement to 200 pounds (90.72 kg) of clean, well graded sand. The sand shall contain approximately 25 percent material passing the No. 50 screen. The mortar shall be no wetter than necessary for satisfactory placement.
- Non-shrink grout shall consist of 100 pounds (45.36 kg) of portland cement to 200 pounds (90.72 kg) of clean, well graded sand and shall be mixed with an oxidized, uniformly graded, processed metallic powder blend with a select oxidizing agent.
- A non-shrink grout of fluid consistency shall be used only when authorized by the Engineer's Representative.
- Slump: The proportions shall be such as to produce a mixture which will work readily into the corners and angles of the forms and around reinforcing with the method of placing employed on the work, but without permitting the materials to segregate or excess free water to collect on the surface. The amount of water shall be the minimum necessary to produce concrete of the workability required by the engineer's representative. Slumps shall range as follows:

Description	Maximum	Minimum
Structural concrete (general)	4 inches (10.16 cm)	2 inches (5.08cm)
Lean concrete	4 inches (10.16 cm)	2 inches (5.08 cm)

(f) Durability: Concrete of normal weight which will be subject to potentially destructive exposure (other than wear or loading) such as freezing and thawing, severe weathering of deicer chemicals shall be air entrained and shall conform to the air content limits of the following table as measured by "Test for Air Content of Freshly Mixed Concrete by the pressure method" (ASTM C231), "Test for Air Content of Freshly Mixed Concrete by the Volumetric Method" (ASTM C173), or "Test for Weight Per Cubic Foot, Yield and Air Content (Gravimetric) of Concrete" (ASTM C138) : the water-cement ratio shall not exceed 0.53 by weight.

Total Air Content for Various Sizes of Coarse Aggregate for Normal Weight Concrete (ACI 304-73)

Nominal Max. Size of Coarse Aggregate, In (cm)*	Size Number	Total Air Content, Percent by Volume
3/8 (0.95)	8	6-10
½ (1.27)	7	5-9
¾ (1.90)	67	4-8

1 (2.54)	57	3.5-6.5
1~1 ½ (2.54~3.81)	467	3-6
2 (5.08)	357	2.5-5.5
3 (7.62)	-	1.5-4.5

2.5.10 Ready Mixed Concrete

Where ready-mix concrete is proposed for use, the mixing and transporting equipment and the method of placement shall be subject to approval of the Engineer. Except for materials specified herein, ready-mix concrete shall conform to ASTM Standard C94-90 for "Ready-Mixed Concrete", or equal.

2.5.11 Batching of Materials

(a) General: Batching of materials may be done in either a manual or a semi-automatic plant subject to the approval of the Engineer. A manual plant is one in which batch weights are set manually and materials are batched manually. A semi-automatic plant is one in which batching are set manually, mixes are changed manually, and materials are batched automatically.

Separate bins of compartments shall be provided for fine aggregate, for the different size of coarse aggregate and for bulk cement when used.

The Compartments shall be of ample size and so constructed that the materials will remain separated under all working conditions. Aggregates may be weighed cumulatively in one weigh batcher on one scale in a manual plant and in a semi-automatic plant may be weighed cumulatively in one-weigh batchers on one scale or in separate weigh batchers with individual scales. In a semi-automatic plant, bulk cement shall be weighed on a separate scale in a separate weigh batcher. In a manual plant, bulk cement shall be weighed in a separate hopper that may be attached to a separate scale for individual weighing, or may be attached to the aggregate hopper for cumulative weighing, provided there are separate beams or dials for cement and aggregates. If cement is weighed on the same scale as the aggregates, the cement shall be weighed first and interlock shall be provided to insure that all hoppers are empty and that the scale is in balance before the weighing of the cement is begun. In a semi-automatic plant, the batching controls shall be so interlocked that a new batching cycle cannot be started until all catches are completely empty. The plant shall be arranged as to facilitate the inspection of all operations at all times. Suitable facilities shall be provided for obtaining representative samples of concrete for uniformity tests. Delivery of materials from the batching equipment shall be within one percent for cement, water and admixture, and two percent for aggregates.

(b) Equipment for batching water and admixture shall be provided at the batching plant, or included with the mixer, as required for the type of plant used. A suitable water measuring device shall be provided that will be capable of measuring the mixing water within the specified requirements for each batch. The mechanism for delivering water to the mixers shall be such that leakage will not occur when the valves are closed. The filling and discharge valves for the water batcher shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. Where admixtures are added to the water, a suitable device for measuring and dispensing the admixtures shall be provided which shall meet the approval of the Engineer.

(c) Scales: Adequate facilities shall be provided for the accurate measurement and control of each of the materials entering each batch of concrete. The contractor shall provide standard test weights and any other auxiliary equipment required for the operation of each scale or other measuring device. Periodic tests shall be made in the presence of the Engineer and at his direction. Upon completion of each check test and before further use of indicating, recording or control devices, the Contractor shall make such adjustments, repaired to secure satisfactory performance. The weighing equipment shall be arranged so that the plant operator can conveniently observe all dials or indicators.

2.5.12 Concrete Mixes

Concrete mixers may be either the stationary or transit type. All mixers shall be maintained in a satisfactory operating condition, and mixer drums shall be kept free of hardened concrete. Mixer blades shall be replaced when worn down more than 10 percent of their depth. The use of any mixer that at any time produces unsatisfactory results shall be promptly discontinued until the mixer is repaired. The mixer shall be equipped with adequate water storage, a device for accurately measuring the amount of water stored and a device for accurately measuring the amount of water in each batch. It shall be equipped with a batch meter or other device for accurately recording the number of revolutions for each batch, and an attachment for automatically locking the discharging device so as to prevent the emptying of the mixer until the materials have been mixed the specified minimum time. Upon cessation of mixing for more than 30 minutes, the mixer shall be thoroughly cleaned. Transit mixers shall be operated within the limits of capacity and speed of rotation designated by their manufacturers. Delivery of concrete to the site of work and its discharge from the truck mixer shall be completed within 1/2 hour after the introduction of the mixing water to the cement and aggregates, or the cement to the aggregates, unless otherwise authorized by the Engineer.

2.5.13 Mixing Concrete

Mixing concrete shall be done in a batch mixer of an approved type and size, and one so designed as to positively insure a uniform distribution of materials throughout the mass. All concrete shall be thoroughly mixed, after all materials and water are in the mixer, for a period of not less than 1-1/2 minutes for mixers with a capacity of one cubic yard or less, and not less than two minutes for larger mixers. The mixing time shall be increased when such increase is necessary to secure the required uniformity and consistency of the concrete and shall be at the direction of the Engineer. Excessive over-mixing requiring additions of water will not be permitted. Remixing, re-tempering, or placing concrete or mortar which has partially hardened or has begun its initial set will not be permitted under any circumstances.

2.5.14 Forms

Forms in general shall be suitable and substantial for all structural concrete, and where required, for plain concrete. All required forms, adjustable shores, bracing, column clamps, form ties and other accessories shall be provided.

All formwork will be subject to the Engineer's approval, but responsibility for its safety and adequacy shall remain with the Contractor. All types of forms may be reused if approved as suitable by the Engineer. Forms shall be nailed, bolted, or tied securely together with all required bracing and shoring. Opening with closure panels shall be provided at the bottoms of forms for walls, beams, girders, grade beams, piers, and columns and shall be properly spaced to facilitate inspection and cleaning out of forms. All forms shall be of sufficient strength to support construction loads and the weight of plastic concrete together with moving loads of men and materials. Design, erection, maintenance and removal of all concrete formwork including bracing and shoring shall conform to the requirements of the "Recommended Practice for concrete Formwork" (ACI-347), or equal, unless specified otherwise herein.

Stationary forms for all exposed finished surfaces shall be built of metal, plywood, pressed wood, or dressed tongue and grooved lumber and shall be built, so that when removed, the concrete will be left with a smooth surface, free from offsets, fins, ridges, or other unsightly defects. Forms shall conform accurately to the shape, lines, and dimensions shown on the drawings. All interior and exterior exposed concrete shall be formed with material that will produce surface finishes equal to surfaces produced by new, tight, clean, plastic surfaced plywood. Forms for unexposed concrete may be of sound plank material or sound salvaged plywood. All forms shall be tight to prevent leakage of mortar and shall be constructed and held plumb and true to line. Forms for securely braced, tied, clamped and shored, and shall be fireproofing structural steel shall be so constructed as to insure proper and complete filling and placement, especially in locations of minimum coverage. One half-inch visual check holes shall be provided. A coat of non-staining oil or lacquer shall be applied to protect the form surface material and to facilitate stripping. Form coatings shall be applied to the forms in accordance with the directions of the manufacturer. Where concrete surfaces are to be painted and where other material is to be applied with adhesive directly to concrete (such as soffits and ceilings that are to be plastered), contact surfaces of forms shall be coated with lacquer type sealing coating.

All screeds shall be so constructed as to produce continuous plane surfaces. Screeds shall be set sufficiently ahead of placement of concrete so as to cause no interruption of placing operations, and shall be sturdy and so designed as to leave no undesirable marks prior to placing concrete permanently in the forms. All forms shall be cleaned of wood, shavings, trash, mud, water, and foreign substances, and shall be dampened. All forms shall be thoroughly cleaned before reusing. Studs shall be placed close enough together to prevent deflection of form material and consequent variation in the surface of the concrete.

Slots, chases, recesses and openings in concrete for other work shall be provided. All wall ties, fixtures, frames, sleeves, weld plates, anchors, dowels, nailing blocks, and similar items shall be built into the form construction. Built-in items shall be in their correct locations and securely anchored to the forms.

Concrete shall be blocked out or sleeves shall be installed when pipe or conduit runs through the webs of beams or girders. The type of installation and the location shall be approved by the Engineer's Representative.

Beam and girder forms shall be built so that the sides may be removed without disturbing the bottoms and the centering shall be crowned at least 1/4 inch (6.4 mm) for each 10 feet (3 m). Forms shall not be erected on concrete footings until the concrete in the footings has cured 36 hours. Shoring under beam, girder and slab construction shall be done with approved shores, which are properly braced to support required loads. All column forms shall be properly braced. Forms shall be inspected and approved prior to each concreting operation.

(a) Form Design: The anticipated deflection in the forms due to weight of fresh concrete shall be accurately figured and taken into account in the design of the forms, so that finished concrete members will have true surfaces conforming accurately to desired lines, planes, and elevations shown on the drawings. Forms shall be constructed so that they can be removed without injury to the concrete. Joints shall be sufficiently tight to prevent leakage of grout during placing and shall be arranged vertically or horizontally to conform to the pattern of the design. Forms placed on successive units for continuous surfaces shall be fitted to accurate alignment to assure a smooth completed surface free from irregularities. If adequate foundation for shores cannot be secured, trussed supports shall be provided.

(b) Form ties shall be either pull-through type or snap ties that will break back at least 3/4 inch (19 mm)from surfaces. Wire ties passing through the concrete and wood spreaders may be used after approval of Engineer. Bolts and tie-rods that are to be completely withdrawn shall be coated with grease. Tie rod clamps to be entirely removed from the wall shall be loosened 24 hours after concrete is placed, and form ties, except for a sufficient number to hold forms in place, may be removed at that time. Ties wholly withdrawn from walls shall be pulled toward the inside face.

(c) Filling Tie-Rod and Bolt Holes: Holes left by bolts or tie-rods shall be filled solid within 12 hours after removal of forms, with cement mortar blended to match the adjacent surface. Holes passing entirely through wall shall be filled from the inside face with a device that will force the mortar through to the outside face, using a stop held at the outside wall surface to insure complete filling. Excess mortar at face of filled holes shall be struck off flush.

(d) External corners of columns, girders, beams, foundations, walls projecting beyond overlying masonry, and other external corners not protected by structural steel shall be chamfered by 3/4 inch (19 mm) moldings placed in the forms, unless otherwise shown on the drawings.

(e) Removal of forms shall be in such a manner as to insure the complete safety of the structure. The removal of forms and shores shall require the approval of the Engineer, but the Engineer's acquiescence to removal shall not relieve the Contractor from responsibility for the removal or from the adequacy and safety of formwork and structure. In no case shall supporting forms or shoring be removed until the concrete members have acquired the strength required to safely support their own weight and the load thereon. In no case shall forms used for curing be removed before expiration of curing period, except as provided under the paragraph entitled "Curing".

Normally, formwork may be removed after the following periods have elapsed

- Beam Sides, Walls and Columns (unloaded) - ------------3 days
- Slabs (props left under) ------------------------------------ 10 days
- Removal of Slab Props (unloaded) ------------------------ 14 days
- Beam Soffits (props left under) ---------------------------- 14 days
- Removal of Beam Props (unloaded) ----------------------- 21 days

Care shall be taken to avoid spalling the concrete surface. Wood forms shall be completely removed from under steps and similar spaces. Immediately upon removal of the forms, the surface shall be carefully examined, and any irregularities of the surface shall be treated as directed by the Engineer. Honeycombed portions of concrete shall be cut out to the extent of such defects and the space refilled with concrete or mortar at the direction of the Engineer. Merely plastering over such defects will not be permitted.

If for any reason the formwork moves after the concrete has been placed, thus disturbing the freshly-placed concrete, or if the concrete is found to be out of alignment, the Contractor may be ordered to remove and replace such concrete without extra payment.

(f) Tolerances : Unless other wise specified by the Engineer, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits listed below.

Tolerances for Formed Surfaces

(1) Variation from plumb
- In the lines and surfaces of columns, piers, walls, and in arrises
  - In any 10 ft (3 m) of length 1/4 in (6.4 mm)
  - Maximum for the entire length 1 in (25.4 mm)
- For exposed corner columns, control-joint grooves, and other conspicuous lines
  - In any 20 ft (6 m) length 1/4 in (6.4 mm)
  - Maximum for the entire length 1/2 in (12.7 mm)

(2) Variation from the level or from the grades specified in the contract documents
- In slab soffits, ceiling, beam soffits and in arrises, measured before removal of supporting shores
  - In any 10 ft (3 m) of length 1/4 in (6.4 mm)
  - In any bay or in any 20 ft (6 m) length 3/8 in (9.5 mm)
  - Maximum for the entire length 3/4 in (19 mm)
- In exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines
  - In any bay or in 20 ft (6 m) length 1/4 in (6.4 mm)
  - Maximum for the entire length

(3) Variation of linear building lines from established position in plan and related position of columns, walls, and partitions
- In any bat 1/2 in (12.7 mm)
- In any 20 ftof length 1/2 in (12.7 mm)
- Maximum for the entire length 1 in (25.4 mm)

(4) Variations in the size and locations of sleeves, floor openings, and wall openings + 1/4 in (6.4 mm)

(5) Variations in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls
- Minus 1/2 in (12.7 mm)
- Plus 2 in (50 mm)

(6) Footings
- Variations in dimension in plan
  - Minus 1/2 in (12.7 mm)
  - Plus 2 in (50 mm)
- Misplacement of eccentricity : w percent of footing width in the direction of misplacement but not more than 2 in (50 mm)
- Thickness
  - Decrease in specified thickness 5 percent

- Increase in specified thickness	no limit
(7) Variation in steps	
• In a flight of stairs	
- Rise	+ 1/8 in (3.2 mm)
- Tread	+ 1/4 in (6.4 mm)
• In consecutive steps	
- Rise	+ 1/16 in (1.6 mm)
- Tread	+ 1/8 in (3.2 mm)

* Tolerances apply to concrete dimension only, not to positioning of vertical reinforcing steel, dowels, or embedded items.

2.5.15 Preparation for Placing Concrete

Water shall be removed from excavations before concrete is deposited. Any flow of water shall be diverted through proper side drains and shall be removed without washing over freshly deposited concrete. Hardened concrete, debris, and foreign materials shall be removed from interior of the forms and from inner surfaces of mixing and conveying equipment. Reinforcement, joint material, and embedded items shall be secured in position, inspected and approved before pouring of concrete. Runways shall be provided for wheeled concrete-handling equipment; such equipment shall not be wheeled over reinforcement nor shall runways be supported on reinforcements.

2.5.16 Placing Concrete

(a) General

Concrete shall be placed as near its final position as practicable. Concrete that has attained its initial set or has contained mixing water for more than 30 minutes shall not be placed in the work. Placing will not be permitted when the sun, heat, cold wind or limitation of facilities furnished by the Contractor prevents proper finishing and curing of the concrete. Concrete placing and finishing operations shall be done as quickly as possible. Concrete unless otherwise directed by the Engineer, shall be placed in the forms in horizontal layers not exceeding two (2) feet (0.6 m) in depth for ordinary walls, and shall be poured full depth for beams and girders and for slabs, allowing the concrete to take its natural angle of repose along the pouring line. Concrete shall be thoroughly compacted by rodding, spading, and by mechanical internal vibration, and shall be thoroughly worked around reinforcement and embedded fixtures and into corners and spaces to be filled.

(b) Placing Concrete

Concrete shall be placed in accordance with the "Recommended Practice for Measuring, Mixing and placing concrete". ACI 304, or equal. No concrete shall be placed when the atmospheric temperature is below 2°C (35°F). After concrete has been placed, if the temperature drops below 2°C (35°F), the contractor shall provide sufficient canvas and framework or other types of housing to enclose and protect the structure in such a way that the air surrounding the fresh concrete can be kept at a temperature of not less than 8°C (45°F) for a period of five days after the concrete is placed.

The Contractor shall assume all risks connected with the placing of concrete under the above conditions, and permission given by the Engineer to place concrete under the above conditions will in no way relieve the Contractor of the responsibility for satisfactory results. Should concrete placed under such conditions prove unsatisfactory it will be rejected.

(c) Mechanical internal vibrators shall be used in all formed concrete work, except where tight working space makes hand spading necessary. Systematic spacing of vibrator insertion 12 to 20 inches (30.5 to 50.8 cm) apart shall be established to insure that all concrete is thoroughly consolidated. Vibrators shall have a frequency of 5,000 vibrations per minute and shall be vertically inserted and withdrawn with 5 to 15 second vibration periods and shall be inserted to a depth that will insure penetration into the previous lift. The use of vibration as a method of moving concrete after it has been placed will not be permitted. Fresh concrete shall not be placed on concrete that has become sufficiently hard to cause formation of seams and planes of weakness within the section (cold joints).

(d) Depositing Concrete

Concrete shall not be allowed to drop freely more than three (3) feet (0.9 m) and even then shall not be allowed to hit or contact the sides of forms or reinforcing. Where greater drop heights are required, a tremie or other means approved by the tremie shall be controlled so that the concrete may be effectively compacted into horizontal layers, and the spacing of the tremie shall be such that segregation does not occur.

Pouring of concrete into place will not be permitted, except under such conditions as may be prescribed by the Engineer. If pouring is permitted, the slope of the chute shall be not less than one vertical to three horizontals or more than one vertical to two horizontals. The chute shall be so designed and operated as to prevent segregation of the aggregate and loss of mortar and the discharge end shall be provided with a baffle plate or other device to cause the concrete to drop vertically. The chute shall be thoroughly clean before and after each run. Waste material and flushing water shall be discharged outside the forms.

(e) Earth-foundation Placement

Concrete footings shall be placed upon undisturbed clean surfaces, free from mud and water. A vapor barrier of clear plastic sheeting 0.004 inch (0.1 mm) thick shall be laid over the surface to receive concrete. The contractor shall not allow water to flow over any concrete until the concrete has set at least 24 hours.

(f) Pump Placement

Where concrete is conveyed and placed by pumping, the plant and equipment shall be approved by the Engineer's Representative. Operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, concrete to be used which remains in the pipeline shall be ejected without contamination of concrete or separation of ingredients. After each operation, equipment shall be thoroughly cleaned, and debris and flushing water shall be disposed of outside the forms.

(g) Underwater concreting will not be allowed.

2.5.17 Finishing Concrete

(a) Stationary form concrete

After removal of stationary forms from beams, girders, columns, and foundation walls, or any other exposed surface, the concrete shall be dressed of all irregularities and form marks to bring it to a smooth even surface. If the surface is not smooth and free from irregularities, the concrete shall be rubbed, while green, with a carborundum block until it is smooth. All cracks, voids, and from tie holes shall be puttied with mortar containing the same cement and fine aggregates that were used in the original concrete prior to the rubbing operation.

(b) Slab Finishes

Finished slab surfaces shall be true plane surfaces, with a tolerance of 1/8 inch (3.2 mm) in 10 feet (3 m) unless otherwise indicated. Surfaces shall be pitched to drains. The dusting of finish surfaces with dry materials will not be permitted.

(1) Monolithic Finish

Surfaces to have monolithic finish shall be finished by tamping the concrete with special tools to force the coarse aggregate away from the surface, and then screeding and floating with straightedges to bring the surface to the required finish level. While the concrete is still green, but sufficiently hardened to bear a man's weight without deep imprint, it shall be floated either by hand or mechanical means to a true, even plane with no coarse aggregate visible. Sufficient pressure shall be used on the floats to bring moisture to the surface. After surface moisture has disappeared, the surfaces shall be machine troweled to a smooth even finish. Trowel marks shall be removed by hand steel troweling.

(2) Rough Slab Finish

Surfaces to receive fill and/or mortar setting beds shall be finished by tamping the concrete with special tools to force the coarse aggregate away from the surface, and screeding with special tools to force the coarse aggregate away from the surface, and screeding with straightedges to bring the surface to the required level.

(3) Broomed Finish

Surfaces to have monolithic broomed finish shall be finished as specified for monolithic finish except that the hand steel troweling be omitted. After the machine troweling is completed, the surface shall be broomed with a fiber bristle brush or broom in a direction perpendicular to the main line of traffic.

(4) Abrasive Finish

Surfaces to have abrasive monolithic finish shall be finished as specified for monolithic finish except that before the steel troweling is commenced an abrasive material shall be evenly applied to the surface at a rate of not less than 1/4-pound (0.1 kg) of abrasive material to each square foot of surface. The surfaces shall then be steel troweled as specified for monolithic finish. The abrasive material shall be aluminum oxide so graded that 100 percent of the particles are retained on a No.30 sieve and 100 percent will pass a No.12 sieve, or other similar product.

2.5.18 Cutting and Patching

All cutting shall be neatly done and shall only be done in areas where the structural quality of the member will not be endangered. Permission shall be obtained from the Engineer prior to any cutting or channeling.

For large openings, a saw equipped with an abrasive disk capable of cutting hardened concrete shall be used to circumscribe the area to be opened. The cut shall be made to a minimum depth of one-half (1/2) inch (12.7 mm) on the outside face of walls or top of slabs.

The inner surface of the opening shall be trimmed of all projections to provide an even, but not smooth, surface.

For smaller openings, a portable core-drilling machine or a star drill shall be employed to cut the hole.

Care shall be exercised as the instrument nears the far face of the concrete so the spalling may be held to a minimum. Patching shall be done with the same type and brand of cement and aggregate as was used in the structure. Forms shall be placed on each side of the larger openings and on only one side of the smaller openings.

A wire brush shall be used to remove foreign substance and loose material from the surfaces of the hardened concrete and a slush coat of non-shrink grout shall be painted over the area prior to placing the concrete.

The openings shall be carefully filled with a 1:3 cement and aggregate mortar with enough water to provide a workable mix. No lime or plaster shall be mixed with this filling mortar.

After the areas have been filled and finished and while the concrete is still green, a final coating of cement and water shall be brushed and rubbed into the concrete.

2.5.19 Curing

(a) General

In general, all concrete surfaces shall be cured and curing shall be accomplished by preventing loss of moisture, rapid temperature change and mechanical injury, or injury form rain or flowing water for a period of seven days. Curing shall be started as soon as free water has disappeared from the surface of the concrete after placing and finishing.

Curing of formed under-surface of beams, girders, floor slabs and other similar undersurfaces, shall be accomplished by moist curing with forms in place for the full curing period, or, if the forms are removed prior to the end of the curing period, by other approved means.

(b) Wet Coverings

Unformed surfaces shall be covered with burlap, cotton, or other approved fabric mats kept in intimate contact with the surface, or with sand and dirt and shall be kept continually wet. Where formed surfaces are cured in the forms, the forms shall be kept continually wet. Burlap shall be used only on surfaces that will be unexposed in the finished work and it shall be in two layers. In extremely hot, windy weather, sunshades, windbreakers and fog nozzles shall be used during flat slab finishing operations.

(c) Waterproof Membrane Coverings

Surfaces may be covered with waterproof paper of with plastic sheets lapped four (4) inches (10 cm) at edges and ends, and sealed with mastic or pressure-sensitive tape not less than 1-1/2 inches (38 mm) wide. The membrane shall be weighted to prevent displacement, and tears and holes appearing during the curing period shall be repaired by patching.

(d) Membrane-forming curing compounds shall be one coat of a sodium silicate liquid floor hardener and shall be applied according to manufacturer's instructions. Surfaces damaged by subsequent construction operations within the curing period shall be resprayed at the rate specified above. Membrane curing compound shall not be used on surfaces that are to receive bituminous membrane, or other damp proofing adhesive for application of other material, concrete fill nor on surfaces that are to be painted. Surfaces coated with curing compound shall be kept free of foot and vehicular traffic and other sources of abrasion during the curing period.

2.5.20 Defective Concrete

Any concrete which shall be found defective from any cause shall be cut out and replaced, and the cost of such cutting and replacing shall be borne by the Contractor.

2.5.21 Joints

Joints shall not vary more than 1/4-inch (6.4 mm) from a true line or from their designated position.

(a) Expansion joints shall be so constructed that reinforced corner protection angles, or other fixed metal items, embedded in or bonded into the concrete, shall not be continuous through the joint. Premolded expansion joint filler strips shall be 3/4 inch (19 mm) thick and shall be the full depth of the slab. Premolded expansion joint material shall be preformed strips which have been formed from cane or other suitable fibers of a cellular nature, securely bound together and uniformly saturated with a suitable bituminous binder; or strips which have been formed form clean granulated cork particles securely bound together by a suitable bituminous binder and encased between two layers of bituminous saturated felt and all meeting the requirements of ASTM D1751-83 for "Preformed Expansion Joint Filler for Concrete Paving and Structural Construction", or equal. For expansion joints receiving joint compound the premolded expansion joint filler strip shall be installed below the finished floor with a slightly tapered dressed and oiled wood strip temporarily secured to the top thereof. The wood strip shall be of sufficient depth to form a groove not less than 1/2 inch deep. After the concrete has set the wood strip shall be removed and the joint shall be filled with a hot poured joint sealer. Joint grooves shall be filled approximately flush so as to be slightly concave after drying. Edges of concrete slabs along expansion joints shall be neatly finished with a slightly rounded edging tool.

(b) Construction joints shall not exceed 60 feet (18.3 m) in any horizontal direction unless authorized by the Engineer. Concrete shall be placed continuously so that the unit will be monolithic in construction. At least 48 hours shall elapse between the casting of adjoining units. Construction joints, when required shall be located near the midpoint of spans for beams or girders unless a beam intersects a girder at the center in which case the joints in the girder shall be offset a distance equal to twice the width of the beam and provision for shear shall be made by use of inclined reinforcement. Joints in columns shall be made at the underside of the deepest beams or girder framing thereto. Columns or walls of ordinary height shall be poured at least two hours before any overhead work is placed thereon. Joints not specified shall be so located as to least impair the strength and appearance of the work. Construction joints in wall footings shall be reduced to a minimum. Except where otherwise indicated no jointing shall be made in footings or foundation work without the approval of the Engineer's Representative. Placement of concrete shall be at such rate that surfaces of concrete not carried at joint levels will not have attained initial set before additional concrete is placed thereon. Girders, beams and slabs shall be placed in one operation. A strip of dressed lumber shall be tacked to the inside of the forms at the construction joint.

(c) Caulked joints shall be constructed at the junction of concrete walls, and walls to slabs.

2.5.22 Grout

Grout shall be used for precast units for bedding machinery pads, posts, spouts, conduits, columns and other structural members that are to bear on concrete.

Non-shrink grout shall be used for seating, leveling and bedding precast concrete and structural steel members, machinery supports and other embedded items where intimate contact may be obtained by pressure and where the requisites of non-shrink grout are not required.

2.5.23 Reinforcing Steel

Reinforcing steel shall be as shown on the drawings for sizes, shapes, dimensions and placement. The Contractor shall submit detailed bar lists, bending schedules and drawings to the Engineer for approval.

Columns shall have a deformed type, hard grade, new billet reinforcing.

The identification of the various pieces shall be preserved, and paper identification tags shall be removed just prior to placing the steel. Before being placed, the reinforcing steel shall be free from flaky or scaly rust or coatings of any kind which will destroy or reduce the bond strength and shall be maintained in such clean condition until the concrete is placed. Reinforcing which is appreciably reduced in section shall not be used. Reinforcing shall not be bent or straightened by heating or otherwise in a manner that will cause damage. All shapes required shall be obtained by cold bending. Bars with kinks or bends not shown on the plans shall be rejected.

All reinforcing steel is to be carefully and securely placed in the forms in the correct positions, and sufficient wire supporting devices and ties shall be provided to hold it rigidly in position both before and during pouring operations. Slab bars shall be provided with universal bar bolsters and beam and girder reinforcement shall be supported on beam bolsters.

For supporting the top slab steel #4 bars (or larger when called for) resting on high chairs spaced not over 36 inches (0.9 m) on centers shall be used. One and one-half inch (38 mm) beam bolsters for all beams and two(2) inch (50 mm) beam bolsters for all girders, spacing bolsters not over four(4) feet (1.2 m) on center, starting not over two(2) feet (0.6 m) from the edge of the beam or girder support shall be used. Where bars are in more than one layer, 1-1/2 inch (38 mm) beam bolsters spaced not over four(4) feet (1.2 m)on centers shall be used.

No steel device used in connection with the from work (weld plates excepted), and particularly in foundation walls, shall be left closer than 3/4 inch (19 mm) from any outside concrete surface. All reinforcing steel in slabs resting on the ground shall have a minimum protection of three (3) inches (76.2 mm) and shall be supported on substantial structural shapes firmly driven into the ground and not on bricks and stones, unless there is a vapor barrier required immediately below the bottom of the slab.

All splices shall be so made as to develop the full strength of bar by sufficient lap, by welding or by mechanical connection, a should follow the requirements of section 805 of "Building code Requirements for Reinforced Concrete" of ACI (318).

2.5.24 Temperature, Wind and Humidity

(a) Cold Weather

When the air daily outdoor temperature is less than 5°C (40°F), the temperature of the concrete shall be maintained between 10°C and 20°C (50°F and 70°F) for the required curing period. When necessary, arrangements for heating, covering, work shall be made in advance of placement and shall be adequate to maintain the required temperature without injury due to concentration of heat. Concreting in cold weather shall be in accordance with ACI-304, or equal.

(b) Hot Weather

The Contractor shall be adequately prepared to protect the concrete from the adverse influence of hot weather before the placement of any concrete may begin. Placement of concrete when the air temperature exceeds 20°C (70°F), particularly when the work is exposed to direct sunlight, shall be done taking special precautions to avoid cracking of the concrete from rapid drying.

Forms, particularly metal forms, shall be cooled by sprinkling with water or by protecting them from direct rays of the sun. The temperature of the forms shall not exceed 38°C (100°F).

If requested by the Contractor, and approved by the Engineer, a retardant may be used to delay the initial set of the concrete.

Concrete shall be placed at a sufficient rate so that cold joints are not formed by the rapid set of concrete. Moist curing shall be applied as soon as possible after placement to inhibit the development of shrinkage cracks due to the rapid drying of the surface.

Concreting in hot weather shall be in accordance with ACI-304, or equal.

(c) Rate of Temperature Change

Changes in temperature of the air immediately adjacent to the concrete during and immediately following the curing period shall be kept as uniform as possible and shall not exceed 3°C (5°F) in any one(1) hour or 30°C (50°F) in any twenty-four (24) hour period.

2.5.25 Protection from Mechanical Injury

During the curing period, the concrete shall be protected from damaging mechanical disturbances, such as load stresses, heavy shock, and excessive vibration. All finished concrete surfaces shall be protected from damage by construction equipment, materials or methods, by applications of curing procedures, and by rain or running water.

Self-supporting structures shall not be loaded in such a way as to over-stress the concrete.

2.6. Concrete Lining Works

2.6.1 General

(a) Cement conforms to the specifications of "Materials" in Concrete Works.

This clause applies to concrete lining canal construction.

(b) Relevant specifications conform to the "Earth Works" and "Concrete Works" specifications.

(c) Prior to lining concrete work, a work plan must be submitted to the Engineer for approval.

2.6.2 Materials

(a) Cement conforms to the specifications of "Materials" in Concrete Works.

(b) Reinforcing bars conform to the specifications of "Structural Steel Works" in "Materials".

(c) Sand and Aggregate conform to the specifications of "Materials" in Concrete Works.

2.6.3 Earth Cutting and Filling

(a) Cement conforms to the specifications of "Materials" in Concrete Works.

(b) Earth cutting and filling for concrete lining works conform to "Earth Works" specifications

(c) If the local geotechnical conditions after earth cutting are different from the design conditions, consult with the Engineer.

(d) If the depth of the earth cutting is deep, consideration should be given to the condition of the soil and necessary measures should be taken to prevent safety accidents due to slope collapse.

(e) The temporary drainage facilities in the canal shall have sufficient sizes such that the rainfall and leaked water shall not be stagnated in the waterway during the lining construction, and shall not cause slope failure and ground softening.

(f) Prior to the concrete lining, the surface condition of the canal must be confirmed by the Engineer.

(g) Prior to earth filling, remove the topsoil, such as organic soil, so that the ground and the soil deposited are well bonded.

(h) Where the water is flooded, it must be completely drained and dried before the earth filling.

(i) The earth used for earth filling should be excavated soil. However, it is necessary to consult with the Engineer if it is necessary to replace with high quality soil because it contains harmful substances such as stones, gravel and organic matters.

(j) Do not use excavated soil with high water content to earth filling.

(k) Compaction for concrete lining conforms to the specifications of "Earth Works"

(l) In order to ensure the degree of compaction specified in the design drawing, the type of equipment, layer thickness, number of times of compaction, etc. should be determined and the soil compaction should be made accordingly.

(m) Where compaction using large machinery is difficult, sufficient compaction should be performed using manpower compaction and vibration compaction.

(n) Where there is water leaking on the ground or there is a risk of sliding, consult the Engineer and follow his instructions.

2.6.4 Concrete Lining Construction

(a) Concrete lining work conforms to the "Earth Works" specifications.

(b) Canal concrete lining work is to be done using lining machines, and lining work of mountain ridge drainage canals should be done by manpower.

(c) In lining work, the frame rule should be installed at appropriate intervals so that it can be inspected whether the construction is done as specified in the design, and the slope concrete lining should be installed from the bottom of the canal to the top.

(d) Canal concrete lining work should be applied to the 1/2 section from the center line of the canal section. Adjacent sections should be constructed at least 14 days later.

(e) Wire mesh shall be installed at 1/4 of the lining thickness from the concrete lining surface.

(f) Lining concrete must be sufficiently compacted and the surface to be finished smoothly.

2.6.5 Concrete Joints

(a) Concrete lining work conforms to the "Earth Works" specifications.

(b) Vertical joints of lining concrete shall be installed every 6 m, and the horizontal joints and work joints shall be installed along the centerline of the canal section.

(c) The position of the work joint in the transverse direction shall be the same as the position of the expansion joint.

(d) The joints shall be correctly installed at the locations shown in the drawings and shall not be deformed during concrete works.

(e) Concrete cutting shall be carried out as soon as possible within the extent that the concrete surface is not damaged, so that the initial cracks are induced in advance.

(f) The joint filling material shall be injected in the dry condition of the concrete after two weeks, at which the alkaline component generated during the curing of the concrete disappears.

(g) Apply the primer to the concrete cut surface twice, and then insert the backup material first and sealant next.

(h) The backup material should have the same insertion depth and should be 25-35% thicker than the joint width.

2.7. Concrete for Bridges, Culverts, Siphon Works, Sediments Ejector etc

2.7.1 General

(a) This clause applies to Concrete Bridges, Culverts, Siphon Works, Sediments Ejector Works.

(b) Relevant specifications conform to the "Earth Works" and "Concrete Works" specifications.

(c) When Siphon passes through the river, consult with the Engineer to discuss the construction location, construction order and construction method.

(d) If there is a concern about negative pressure due to an increase in the outside water level during the flood, consult with the Engineer to establish a countermeasure for lowering the outside water level and then construct it.

2.7.2 Materials

(e) This clause applies to Concrete Bridges, Culverts, Siphon Works, Sediments Ejector Works.

(a) .

(b) Cement shall conform to the specifications of "Materials" in Concrete Works.

(c) Reinforcing bars conform to the specifications of "Structural Steel Works" in "Materials".

(d) Sand and Aggregate conform to the specifications of "Materials" in Concrete Works.

2.7.3 Earth Cutting

(a) This clause applies to Concrete Bridges, Culverts,Sediment Ejector and Siphon Works.

(b) Relevant specifications conform to the "Earth Works " specifications.

(c) If the local geotechnical conditions after earth cutting are different from the design conditions, consult with the Engineer.

(d) If the depth of soil cutting is deep, take appropriate measures, such as cutting the soil with a safe slope to avoid slope failure taking into account the soil condition.

(e) The earth cutting shall be of a depth specified in the design book and shall be wide enough to allow the work of the formwork and concrete works.

(f) Where the foundation is weak, appropriate reinforcement methods shall be applied in consultation with the Engineer.

(g) The earth cutting must be carried out in a dry condition with adequate drainage, and the foundation of the structure should always be dry after earth cutting has been completed.

(h) Foundation grounds shall be earth-cut and inspected by the Engineer in accordance with the dimensions and elevation before blinding concrete or foundation laying.

(i) The remaining soil must be transported to the site designated by the Design Book or the Engineer and treated so as not to cause damage such as erosion or burial.

(j) When the finished foundation is a clay layer, measures should be taken to prevent excessive drying.

2.7.4 Concrete Placing

(a) This clause applies to Concrete Bridges, Culverts,Sediment Ejector and Siphon Works.

(b) Relevant specifications conform to the “Concrete Works”, “Form Works” and “Building Works - Reinforcement” specifications.

(c) The Transition part is to work on concrete simultaneously with the Siphon body.

(d) Siphon sidewalls shall be constructed after the siphon floor slab has settled, and the connections between the sidewall and floor shall be roughened to ensure good adhesion, and a copper water stop plate should be installed at the joint.

(e) If the height of the siphon is more than 1.2 m, the upper slab concrete should be placed after the side wall concrete has hardened.

(f) The position of the work joint in the transverse direction shall be the same as the position of the contraction joint or expansion joint.

(g) The water stop plate, expansion joint plate and dowel bar shall be correctly installed at the joints at the locations indicated in the drawings and shall not be moved when concrete placing.

(h) Joints shall be watertight as well as structural safety.

2.7.5 Backfilling

(a) This clause applies to Concrete Bridges, Culverts,Sediment Ejector and Siphon Works.

(b) Relevant specifications conform to the "Earth Works" specifications.

(c) Backfilling should be done after the concrete has reached adequate strength and should be consulted with the Engineer.

(d) The earth used for earth filling should be excavated soil. However, it is necessary to consult with the Engineer if it is necessary to replace with high quality soil because it contains harmful substances such as stones, gravel and organic matters.

(e) Do not use excavated soil with high water content to earth filling.

(f) In order to ensure the degree of compaction specified in the design drawing, the type of equipment, layer thickness, number of times of compaction, etc. should be determined and the soil compaction should be made accordingly. If not specified, the density should be greater than the density of the natural state.

(g) During backfilling and compaction work up to 60 cm above the Siphon body, care should be taken not to place a concentrated load on the siphon barrel, and compaction by a large machine such as a roller or bulldozer is not allowed.

(h) The backfilled surface shall be in harmony with the surrounding ground.

(i) The upstream part of drop structures the canal embankment could be lowered due to rainfall erosion and there is a risk of overflow. Therefore, the corresponding section should be increased.

(j) The downstream part of the drop structures shall be sufficiently protected with a barrier wall, floor protection, etc. to prevent scouring, breakage, etc. before connected to the downstream channel.

(k) In the connection with the transition or lining channel at both ends of the siphon, measures should be taken to prevent penetration passages due to sinking of channel, poor compaction, and scouring.

2.7.6 Subsidiary Facilities and Safety Facilities

(a) This clause applies to Concrete Bridges, Culverts,Sediment Ejector Siphon Works.

(b) Siphon mud valves, manholes, air valves, drain pipes, etc. shall be installed in the locations indicated in the design drawing.

(c) The drain pipe of the mud valves starting from the Siphon drain valve or drainage outlet shall be connected to the nearest drain channel or drainage point indicated by the Engineer.

(d) All subsidiary facilities shall be constructed of materials and shapes specified in the design drawing or technical specifications.

(e) A safety fence, such as a barrier fence, should be installed in the entrance and exit of the siphon to prevent people or animals from falling into the canal and safety accidents.

(f) Measures should be taken to prevent overflow at the entrance of due to accumulation of garbage and obstruction of water flow.

2.7.7 Leakage Test

(a) This clause applies to Concrete Flume, Drop Structures and Siphon Works.

(b) Siphon should be backfilled after leakage test before normal operation.

(c) The leakage testing procedures and methods shall be in accordance with the relevant regulations.

2.9. Structural Steel Works

2.9.1 General

This section covers all structural steel work. Whenever a difference exists between the design drawings and this specification, the drawing shall govern.

(a) Structural steel consists of the steel work for buildings, structures and pipe supports. Structural steel also consists of steel work for the framing of bridge connections between structures and for equipment inside and outside the building as required.

(b) Specification : Unless otherwise indicated, the "Specification for structural steel buildings" of the American Institute of steel construction, adopted June 1, 1989 or approved equal, shall govern the work.

2.9.2 Reference Standards

Reference Standards are referred to in the follows.

ASTM A36	Standard Specification for Carbon Structural Steel
ASTM A307	Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A325b	Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325Mb	Standard Specification for Structural Bolts, Steel, Heat Treated 830 MPa Minimum Tensile Strength [Metric]
ASTM A502-65	Standard Specification for Rivets, Steel, Structural
ASTM F844	Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use

2.9.3 Materials

(a) Structural steel : All structural steel shall conform to ASTM A36 specification or equal.

(b) Bolts and Nuts

- Common bolts shall be 3/4 inch (19 mm) diameter unless otherwise noted, and shall conform to ASTM A307 or equal.
- High-Strength bolts shall be 3/4 inch (19 mm) diameter unless otherwise noted, and shall conform to ASTM A325 or equal. One high-strength bolt assembly shall consist of a heavy semi finished hex head structural bolt and a heavy semi-finished hex nut.
- Rivets shall conform to ASTM A502-65 for "steel structural rivet" or equal.
- Washers : Round washers shall conform to ASTM F844 "plain washers" or equal. Beveled washers shall be square, smooth, and sloped so that contact surfaces of bolt head and nut are parallel. The diameter of the hole of square-beveled washers shall be 1/16 inch (1.6 mm) greater than the bolt size for bolts not larger than one (1) inch (25.4 mm) and 1/8 inch (3.2 mm) greater than the bolt size for bolts larger than one (1) inch (25.4 mm).

2.9.4 Shop Details and Fabrication

(a) The Contractor shall conform to the following shop detail drawings and fabrication requirements unless shown otherwise on drawings.

- All connections which are not detailed or otherwise noted on drawings shall be shop welded and field-bolted AISC Framed Beam connectors, Table III and I. Use the maximum number of rows of Table I for each beam depth use a 1/4 inch (6.4 mm) shop weld "A" shown in Table III for the required number of field bolts.
- Bolts for field connection shall be high-strength bolts in bearing connections unless otherwise noted on drawings. Do not omit paint or galvanizing from the contact surfaces within the joints. Bolt threads need not be excluded from the shear planes.
- End distances shall conform to AISC Specification for Structural steel buildings section J 3.10 without reduction to low stresses, unless otherwise noted on drawings.

- The contractor shall furnish and install erection clips for fit-up of welded connection.
- Ample clearance shall be provided for field erection.
- Double angle members shall have welded fillers spaced in accordance with section E4 of the AISC Specification.
- Gusset plates shall be 1/4 (0.25) inch (6.4 mm) thick minimum.
- Columns have full bearing at splices and at end plates.
- All sharp corners and burrs shall be removed before shop priming.
- Floor plate shall be furnished where indicated on the drawing.
    - Floor plate shall be skid resistant raised pattern plate, 1/4 inch (6.4 mm) thick excluding the height of the raised pattern.
    - Floor plates shall be secured in place by intermittent welding of plate to support beams.
    - Continuous plates shall be plug welded to intermediate support beams.

2.9.5 Welding

Welding shall be in accordance with the American welding society code D1.1-69 "welding in building construction", and code D12.1-61, "Recommended practices for welding reinforcing steel, metal inserts and connections in reinforced concrete construction", or equal.

2.9.6 Qualification of Welders

Before assigning any welder to work covered by this section of the specifications, the contractor shall provide the Engineer with the names of the welders to be employed on the work, together with certification that each of these welders has passed qualification tests using procedures covered in the American welding society standard B3.0, or equal. The contractor shall require any welder to retake the test when, in the option of the Engineer, the work of the welder creates a reasonable doubt as to the proficiency of the welder. Tests, when required, shall be made at the expense of the contractor. Re-certification of the welder shall be made to the Engineer only after the welder has taken and passed the required retest. Welders shall have passed the qualification tests within the preceding 12-months period.

2.9.7 Shop Drawings and Erection Procedures

Shop drawings shall be submitted for approval. Drawing shall show the size, length, and type of each weld. Along with the shop drawings, the contractor shall furnish two copies of detailed erection procedure, including sequence of erection and temporary staging and bracing. Approval of shop drawings shall be interpreted as approval of general methods and arrangement only, and shall not constitute verification of dimensions or quantities. The contractor shall be responsible for the accuracy of fabrication and erection fit-up.

2.9.8 Piece Marking

(a) Each shipping piece shall be clearly marked. The location of the mark shall be on the left-hand end of the piece as detailed. On the erection drawing the mark shall be in corresponding in-place position.

(b) The pipe support number, as shown on the design drawings, shall be a part of the piece-marking on all supports.

2.9.9 Fabrication

Structural steel shall be fabricated and assembled in the shop to the greatest extent possible. Shearing, flame cutting, and chipping shall be done carefully and accurately. Sole plates of beams shall have full contact with the flanges. Fillers under end angles shall not project beyond the back of the angles. Clearance between the ends of spliced web plates shall not exceed 1/4 inch (6.4 mm) where riveting occur near welded joints; the welding shall precede the riveting unless otherwise approved. Assembled pieces shall be taken apart if necessary for the removal of burrs and shavings produced by the reaming operation. Parts not completely riveted in the shop shall be secured by bolts, insofar a practicable, to prevent damage in shipment and erection.

(a) Connections : Shop and field connections may be either riveted, bolted or welded. One-sided or other types of eccentric connections will not be permitted unless shown in detail and approved on the shop drawings. Combinations of rivets and unfinished bolts shall not be used in the same face of any connection. Unfinished bolts shall not be used except where required. Surfaces of joints for riveted or welded connections shall comply with the cleanliness requirements of all joint surfaces and contact surfaces within friction-type joints as outlined in the AISC specifications for structural joints using ASTM A325 bolts, or equal.

(b) Holes shall be cut, drilled, or punched at right angles to the surface of the metal and shall not be made or enlarged by burning. Holes n base or bearing plates shall be provided in members to permit connecting the work of other trades. Holes shall be clean-cut without torn or ragged edges. Outside burrs resulting from reaming or drilling operation shall be removed by a tool making a 1/16 inch (1.6 mm) bevel.

(c) Allowance shall be made for draw in all tension bracing.

(d) Riveting : Rivet heads shall not be caulked, recouped, or double-gunned. In removing defective rivets care shall be taken not to injure the adjacent metal and, if necessary, rivets shall be drilled out. Rivets less than 1/2 inch (12.7 mm) in diameter may be driven cold if approved measures are taken to prevent distortion of the riveted material. When ready for driving, rivets shall be free from slag, scale, and other adhering matter.

(e) Bolts shall be driven accurately into the holes without damaging the thread. Bolt heads shall be protected from damage during driving. Bolt heads and nuts shall rest squarely against the metal. Where bolts are used on beveled surfaces having slopes greater than one in 20 with a plane normal to the bolt axis, beveled washers shall be provided to given full bearing to the head or nut. Where self-locking nuts are not furnished, bolt threads shall be upset to prevent the nuts from backing off. Unfinished bolts transmitting shear shall be treaded to such a length that not more than one thread will be within the grip of the metal. The bolts shall be of the length that will extend entirely through but not more than 1/4 inch (6.4 mm) beyond the nuts. Bolts heads and nut shall be drawn tight against the work with a suitable wrench not less than 15 inches (0.38 m) long. Bolt heads shall be tapped with a hammer while the nut is being tightened. After having been fully tightened, nuts shall be locked.

(f) Welding shall be accordance with the American Welding Society code D1.1-69, "welding in building construction", and code D12.1-61, "recommended practices for welding reinforcing steel, metal inserts and connections in reinforced concrete construction", or equal. All shop welds performed on the main supporting members of the equipment which are subjected to high stress shall be 100 percent X-ray tested. In addition, the Engineer may require other shop and field welds to be X-ray tested. The photographs of all these tests shall be submitted to the engineer thru the Engineer's Representative. The cost of all X-ray test shall be charged to by the contractor.

2.9.10 Erection

Splices and field connection shall be made with high-strength bolts. Welding will be permitted only where shown and approved on the shop drawings. Errors in shop fabrication or deformation resulting from handling and transportation that prevent the proper assembly and fitting of parts shall be corrected as approved or replaced with new materials.

(a) Anchor bolts and anchors shall be properly located and built into connection work. Bolts and anchors shall be preset by the use of templates.

(b) Base plates, and bearing plates shall be provided under columns and bearing plates may be attached or loose as approved on the shop drawings. Base plates and bearing plates shall be supported and aligned on steel wedges or shims. After the supported members have been plumbed and properly positioned and the anchor nuts tightened, the entire bearing area under the plate shall be dry-packed solid with non-shrink grout complying with “2.5.22 Grout” specified in "2.5 Concrete Works”. Wedges and shims shall be cut off flush with the bearing plate, and shall be left in place.

(c) Assembly : The various members forming parts of a completed frame or structure shall be aligned and adjusted accurately before being fastened. Tolerances shall conform to AISC Code of Standard Practice, or equal. Fastening of splices and compression members shall be done after the abutting surfaces have been brought completely in contact.

(d) Bearing surfaces and surfaces that will be in permanent contact shall be cleaned before the members are assembled. As erection progress, the work shall be securely fastened to take care of all dead load, wind, and erection stresses. Splices shall be permitted only when approved. Unless removal is required to continue erection, all erection bolts used in welded construction may be tightened securely and left in place. If erection bolts are removed, the holes shall be filled with plug welds. Welding for re-drilling will not be permitted.

(e) Drift pins may be used only to bring together the several parts and shall not be used in such a manner as to distort or damage the metal.

(f) Gas cutting : The use of a gas cutting torch in the field for correcting fabrication errors will not be permitted on any major member in structural framing. Gas cutting will be permitted on minor members when the member is not under stress, and then only with the approval of the Engineer's Representative.

2.9.11 Damaged Members

Use of members damaged during transportation will be permitted only as approved by the Engineer and the Engineer's Representative. Methods of repairing damaged members must be submitted to an approved by the Engineer or the Engineer's Representative prior to undertaking such work.

Test of repaired members shall be required as deemed appropriate or necessary by the Engineer and the Engineer’s Representative. Unfavorable results of such tests shall be cause for rejection.

2.9.12 Painting

Painting of all structural steel work shall comply with "2.25. Painting Works".

2.9.13 Inspection and Tests

The material to be furnished shall be subject to inspection and tests in the mill, shop, and field. However, inspection in the shop or mill will not relieve the contractor of the responsibility to furnish satisfactory materials.

2.10. Temporary Facility Works

2.10.1 Prefabricated Earth Retaining Works

(a) General

(1) Applied Scope

As the earth retaining is the temporary structure installed for preventing the collapse of the excavated wall or influent sand and earth for the safe and smooth pipeline burial construction, safety and constructability shall be required together with economy. Construction shall be carried out after structures are reviewed on the contractor’s own expense for any place where soil properties are partially different or severe underground water gushes out when this prefabricated earth retaining engineering method is applied to the site.

(b) Materials

- Dimensions of prefabricated engineering

a) It is necessary to shorten the long time to insert earth retaining sheets in the prefabricated earth retaining wall installation. Accordingly, the welding shall be done with ø3.2 m/m welding rods for every cross section by crossing a shape steel (SS41, 50 m/m×100 m/m×100 m/m) and a shape steel (SS41, 60 m/m×60 m/m) internally. Thereafter, a steel plate (SS41, 2.3t, 3.2t) shall be covered in the front and back. Then, a hole shall be made with a drill in 10 cm interval for the welding. Thus, stability shall be increased by making the feeling of uniformity in a secured manner.

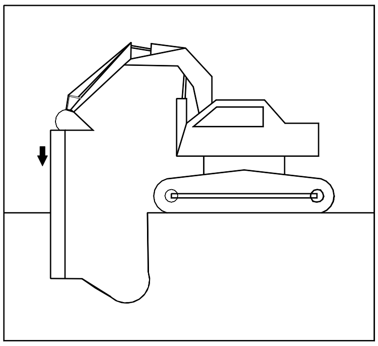
b) For columns, no breakaway shall be allowed by the complete welding and filling with the welding rods after two ø22 m/m holes are drilled in every 15m/m interval as a steel plate (SS41, 8t, 9t) shall be bent to an H shape steel (SS41, 175 m/m×175 m/m×7.5 m/m ×11 m/m).

c) The most important strut shall be able to support the pressure load of 20 tons per piece.

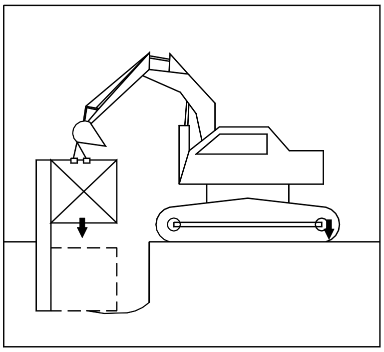
(c) Construction

- Construction sequence of the prefabricated earth retaining and obstacle handling method

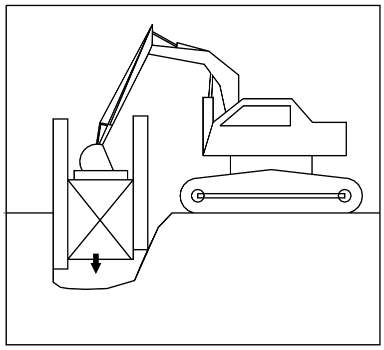
Columns shall be placed in parallel on a flat ground and fix the strut to the column ring in line with the internal excavation width when materials arrive at the site. It is necessary to ensure the columns are placed perpendicularly to the strut at this time.



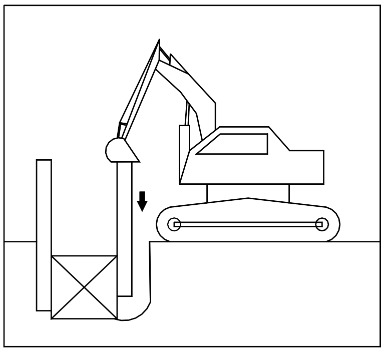
a) Columns shall be erected perpendicularly and two prefabricated columns shall be driven in parallel horizontally because the initially installed columns become reference in excavation works. Both columns shall be alternately pressed by the bucket of a backhoe to secure the erected columns. At this time, a column protector shall be installed on top of columns to protect these columns.



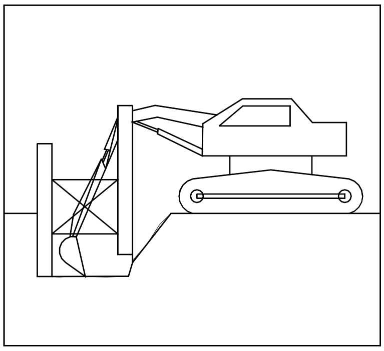
b) The lower panel shall be installed after confirmation to see of the position of panel installation is easy or not. At this time, the installation shall be done after confirmation to see if the initial is located on the expected line and if the opposite panel's interval is right.



c) The assembled columns shall be inserted into the end of panel and the perpendicularity to the excavation direction shall be checked out.

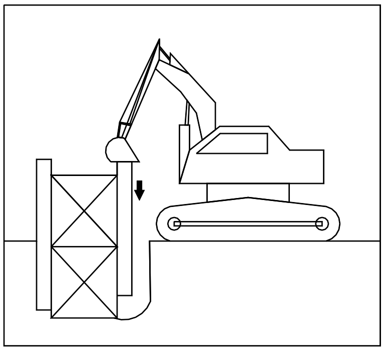


d) Excavation shall be carried out once the panel and columns are assembled and erected. At this time, a panel protector shall be installed on top of the panel for protection.

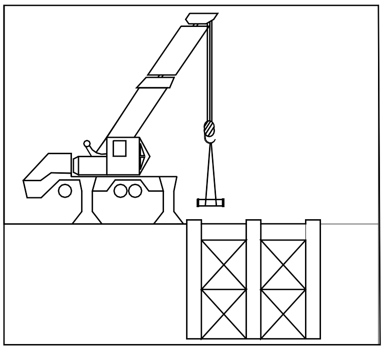


e) Excavation shall be done from the panel bottom in parallel with the panel. Panels and columns can be easily inserted under this excavation method. The pressing sequence shall be done in the order of the panel and column.

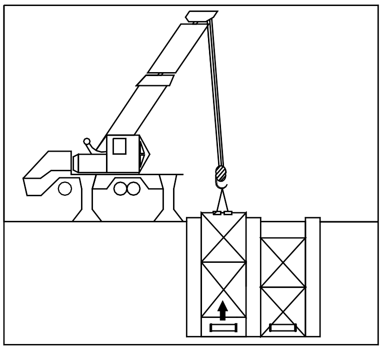
For the mutual relationships between the panel and column, the panel roller shall not be projected from the column bottom. The standard for the one-time press depth shall be followed for columns.



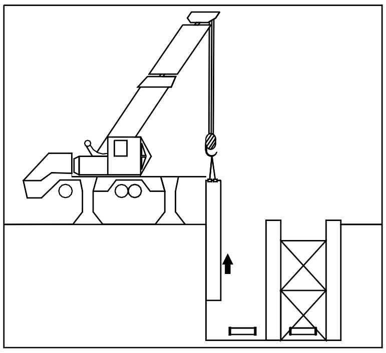
f) The panel backfilling shall be done essentially. Coarse sand is ideal for backfilling, but earth mixed with sand in 15m/m or less may be used when the excavated earth is used, depending on site conditions. The reason is that both panels and columns can be easily pulled out.



g) Backfilling shall be done before panels are pulled out after internal structures are installed. Backfilling process shall repeat backfilling of a certain amount → pulling out panels → suppressing → back filling sequentially. When a lot of backfilling is done at once, it is difficult to pull out panels and columns. It is easy to pull out panels when backfilling is done in a uniform way.



h) Columns shall be pulled out after panels are pulled out first when both panels and columns are pulled out. Especially, a long wire shall be used to keep the angle of a pulling wire 60 degrees or less when excavation is done widely. Attention shall be paid because the strut may cause troubles if it is gradient to one side,



i) The panel connecting ironware connected to the upper and lower panels shall be removed when the lower panel is on G.L. At this time, earth shall be compacted to prevent the lower panel from lowering.

- Cautions during construction

a) The perpendicular materials shall be installed accurately because the excavation depth is shallow when the perpendicular struts are installed.

b) Attention shall be always paid to the prevention of stress in earth retaining panels and struts while re-stress or additional stress is being carried out.

d) Any deformation of materials shall be prevented during the transportation or installation of materials. Tolerance of bending deformation shall be within the defined values in the applicable clauses in the Road Traffic Standard Specifications established by the Ministry of Construction and Transportation.

- Strut beam

Any strut beam shall be constructed for the even support of load.

2.10.2 Water Cutoff Sheet Pile Works

(a) General

(1) Applied scope

Sheet piles shall be applied to the site where general excavation cannot be done when the pipe line is constructed in the river cross section and other river sections.

(2) Reference specifications

Relevant to BS

(3) Transportation, storage and handling of steel sheet piles

a) Loading and unloading

Steel sheet piles shall be handled to prevent any deformation using a crane during their loading and unloading. For the hanging during the loading and unloading, two points of a steel sheet pile shall be tied up with a rope for the handling, but the point at 1/5 from both ends of the pile shall be selected for the point to be tied up.

b) Transportation

No obstacle shall exist for the transportation of steel sheet piles by using equipment and developing a temporary road where it is difficult for a heavy machine to access. Steel sheet piles shall be carefully handled to prevent any shock.

c) Storage

A flat floor with sufficient support on the ground shall be proper in placing steel sheet piles. They shall be placed after the settlement is prevented by improving the ground where any settlement is expected. The height of placement shall be limited to 2 m or less, provided that the number of steps in a floor shall be 5 sheets or less where props shall be supported. At this time, props shall be rectangular woods in 10 cm and their interval shall be within 4 m.

(b) Materials

(1) General materials

Steel sheet piles shall be made of SY30 or better products where interlocking devices are made over the full length. The head of a steel sheet pile has a hole for the connection or removal of a swing rope.

(c) Construction

(1) Preparation of driving

The contractor shall check out equipment in the presence of the construction supervisor before driving and the preparation of driving shall be made according to the construction supervisor’s instruction. Especially, the driving sequence, moving direction of equipment used, and traffic of other heavy machines shall be done after the construction supervisor’s approval.

a) Normal line: The following works shall proceed after the normal line is fixed for the accurate construction of steel sheet piles. The reference points for the normal line shall be installed by measuring the accurate positions in reference to design drawings and the constructed positions shall be corrected by the normal measurements in parallel with the driving.

b) Crane moving: When a crane is moved before or after the driving, the construction supervisor's instructions shall be followed and any crash to the driven piles shall be prevented during the moving.

c) Leader adjustment: The following works shall be done after the leader is supported with props and adjusted perpendicularly after a crane is completely moved. Especially, the condition of each clamp shall be observed and identified at the joint during the leader adjustment, and any defect shall be adjusted.

d) Pile erection: A pile hanging shall be completed before the pile erection and lifted up with the upward speed of about 10 m/min. Tolerance of perpendicularity for a pile shall be 0 when the erection is completed.

e) Capping and leader correction: When the works are completed, the capping shall be done with a cap dedicated to a sheet pile on the driving head together with a diesel hammer, and the leader shall be corrected to make tolerance of perpendicularity become 0.

f) Oiling and check: When the works are completed, oiling and check on the hammer shall be done and works shall proceed after the construction supervisor's approval.

(2) Steel sheet pile driving works

- Piling with a hammer

a) Rotation during the driving: Auxiliary struts shall be installed in advance for the accurate driving of a steel sheet pile to the defined position. A proper spacer shall be used between a steel sheet pile and an auxiliary strut.

b) Test driving: Although whether or not the driving of a steel sheet pile can be done is judged by the N value, the N value may not be applied in many cases, depending on ground conditions, Accordingly, the test driving shall be done in advance to decide the entire conditions. The test driving shall be done after 4 points on a straight line are selected, to review sheet pile specifications, driving method and equipment specifications. If there is any difference from this design document, an alternative plan may be presented and design change can be done after the construction supervisor's approval.

c) Auxiliary works: Auxiliary piles shall be driven in two lines depending on the normal line (in a 10 m interval) and auxiliary struts shall be installed inside auxiliary piles. A 2~5 cm space shall be given to a whole tree where sheet piles are completely interlocked in the internal interval of auxiliary struts. In addition, the installation height of an auxiliary pile shall be done about 30~50 cm higher than that of the driving target of sheet piles to prevent the cap bottom from touching an auxiliary pile when sheet piles are completely driven.

d) If a pile is not inserted into the defined depth only by its weight, it shall be hit lightly by a hammer. The transit observation shall be done during the erection and driving to maintain the proximity of sheet piles and leaders during the erection of sheet piles. As the sheet pile which is first driven becomes the reference for the following driving, the transit observation shall be done to two directions including the normal line and perpendicular direction to prevent any gap in the erected position. If any gap occurs between the sheet pile and auxiliary strut, a spacer shall be inserted to prevent any misalignment in the driving direction of sheet piles. During the driving from the hanging and lifting of a sheet pile, the handling shall be done carefully in consideration of safety on the ground. Especially, efforts shall be made to prevent any crash or shaking.

- Piling with a hydraulic piler

a) General

1) Influences on structures around the site shall be sufficiently identified before construction. If construction is difficult, works shall be done after actions are established under discussions with the construction supervisor.

2) A hydraulic piler shall be in principle used to prevent any settlement or noise around the surrounding ground.

3) The operator shall start working after understanding the related names and operations for the machine operation and identifying any danger.

4) Any load greater than the used load shall not be used because the very large force is given to the machine body during the initial driving of 3 pieces.

b) Installation and dismantlement of a piler (reaction prop)

1) As reaction props receive the full reaction during the piling, additional support or bridge shall be used for preventing collapse to keep ground from settlement when they are installed on any fragile ground.

2) Water drain shall be done well all the time in the installed place.

3) Reaction props shall be placed on the normal line after the normal line for the piling shall be made, and they shall be installed horizontally.

4) As overturn risk exists due to the rising reaction props by reaction to the piling during the piling, the piling shall be done after the reaction weight is loaded on props.

c) Piling works

1) The initial piling shall be done prudently because the precision of first piling by reaction props decides the good or poor precision in the next piling.

2) The piling shall be carefully done for overturn before or after the work, as well as piling position and access to the normal line.

3) Especially, the initial piling shall be sequentially done according to the signals by the instructor under cautions on safety, and any access by others than the related persons shall be prohibited within the range of works.

4) As a piler automatically carries out piling after the initial piling, it shall be done to the right direction while perpendicularity is being checked and no misalignment of gradient is occurring.

5) The piling shall be done by selecting an engineering method in parallel use with the piling method after discussions with the construction supervisor in consideration of neighboring structures if the work cannot be done only by the piler’s capacity during the piling works.

6) When any damage or breakaway in the seaming section during or after the piling of sheet piles, the sheet pile shall be pulled out and driven again in principle, provided that proper actions shall be taken after discussions with the construction supervisor if it cannot be pulled out.

7) If the slop of the sheet piling direction shows difference of a sheet width or more from the top or bottom of the sheet pile, the correction shall be taken with the wedge sheet pile.

8) As the compacted piling may not be done with the piler if a corner sheet pile or wedge sheet pile has to be used, the construction shall be done after the engineering method and equipment are selected under discussions with the construction supervisor if it happens.

9) Water jet (applied if general piling cannot be used)

① The water jet method shall be used in parallel if the piling is difficult due to the solid ground such as the cohesive soil layer in 15 or more of the N value or the layer of sand or layer of sand with gravel in 30 or more of the N value. The driving shall be done after the water pipe is attached to the steel pile in advance.

② Any water necessary for the water jet shall be sufficiently secured not to cause any problem in driving the sheet piles, and a drain channel shall be made.

③ The number and pressure of nozzles shall be enough to blow out substances at the end of the sheet pile. An clogging or impairment of nozzles shall be immediately repaired or reinforced.

④ The connections such as the high pressure hose, band pipe and water induction pipe shall carefully prevent any breakaway due to vibrations in the equipment.

- Strut installation and dismantlement

(1) Struts shall be constructed under the approved drawings.

(2) Struts shall be promptly installed to the defined positions when excavation is done to the position of strut installation, and excavation for the lower section shall be done after the completion of installation.

(3) Struts shall be arranged in response to the site condition to achieve their goal, and their construction shall be done under the comprehensive review on the installation position, time and method.

(4) The dismantlement of struts shall be done from the necessary places sequentially according to the structural works or backfilling progress, and it shall not be done after the load applied to sheet piles is supported by the existing body or backfilling sand and earth.

(5) Struts shall be used by binding two pieces or secured with U bolts and fastening bolts in the perpendicular cross position.

(6) When struts are placed to the gradient direction, they shall be constructed in a method not to provide any excessive load to the connecting struts which have been already installed.

(7) Horizontal tolerance of struts shall be within ±3 cm.

(8) The pressurization to the jack shall be done by the defined pressure, but the pressurization shall be done in a stepwise manner by adding the repeated load to every 0.2 times of the defined pressure, which shall be done with the examination on any deformation of materials during the pressurization.

(9) Materials shall be checked out all the time to see if they are loosened during the test for the next construction after the defined materials are installed. Any deformation shall be

examined in every process for materials which have been implemented, to judge their safety, and the examination performance shall be recorded and kept until the completion of construction.

(10) The dismantling of struts according to the progress of structure placement shall be done after the construction supervisor's approval after the sequence and method of dismantlement are established.

(11) Any material which may cause problems on the safety of earth retaining walls if it is forced to be dismantled shall be cut after the completion of structures.

- Protection of sheet pile head

If the driving is done using an impact hammer like a diesel hammer, the head shall be protected using a cap or cushion. A cap needs to have strength enough to endure severe conditions in use and normally uses cast steel. Strong wooden cushion shall be inserted into the top of cap to ease the impact during the hitting.

- Troubleshooting during the piling of sheet piles

If any stickiness, interlocked piling, head damage or seam section breakaway occurs during the piling of sheet piles, the piling shall be stopped and reporting shall be done to the construction supervisor. Then, the causes shall be clarified to take proper actions after the construction supervisor's approval.

(1) Actions for slope

a) As any slope in a sheet pile during the piling may cause a great obstacle to the next piling due to the greater friction resistance in the seam, the correction shall be made in the following ways.

b) The head of an erected sheet pile shall be pulled with a wire to the opposite direction to the slope.

c) The slope shall be gradually corrected using the earth resistance to the slope direction on the bottom after the interlocking seam on the bottom is cut in a gradient to become shortened.

d) The slope shall be corrected while the hitting is being done in a proper gradient by a hammer.

e) The methods to reduce the seam friction resistance shall be taken, including the coating of lubricant to the seam section, attachment of sand retaining sheet to the end of the seam section, etc.

(2) Interlocked piling

a) The seam friction resistance shall be reduced by correcting the slope.

b) If the ground is fragile, the piling shall be done higher than the planned height to secure more piling space. Then, the piling shall be finished to the defined position.

c) The seam shall be uniformed with the welding or bolt fastening for the seam section with the already installed sheet pile near the sheet pile for the interlocked piling.

d) The seam friction resistance shall be reduced with the coating of lubricant over the seam section.

e) Actions for preventing the flow of sand and earth shall be taken over the seam section.

(3) Drooping and shrinking of construction extension

a) Drooping or shrinking occurs according to the erection and driving circumstances due to the minor space in the seam section. Under this circumstance, the correction shall be made by pushing or pushing to the normal line, but it shall be done with checking on drooping and shrinking for every 20~30 sheets.

- Drawing

(1) Drawing equipment: The drawing equipment shall be selected in consideration of the condition of the piling, lapsed time after the piling, and clip condition.

(2) Installation of furring strips and struts: If the defined structures are completed, the dismantling shall be done after the dismantling plan is established. However, special attention shall be paid to safety accidents, damage to neighboring structures, and weakening of the background during the dismantling, while convenience for the following works are ensured with dismantling and arranging in the order of struts, furring strips and brackets.

(3) The contractor shall manage the site safely all the time to prevent any neighboring facilities from damage. If there is any concern of safety to neighboring facilities, construction shall be done after the construction supervisor’s approval with the necessary actions.

(4) As the design is done under the predicted ground survey based on the ground data implemented at this design for the sheet pile section, any change shall be done in a proper engineering method for the actual ground conditions under discussions with the construction supervisor if the designed ground conditions are different.

- Excavation

(1) The piling shall be done for sheet piles after various underground objects in the neighboring areas are surveyed and checked, and their reinforcing measures are taken before construction.

(2) Excavation shall be done in a stepwise manner with at least 0.3 cm of working space from the installation position of furring strips which will be installed immediately with excavation. If there is any concern of an accident such as the excessive deformation of earth retaining walls or settlement of the surrounding ground during excavation, excavating shall be immediately stopped and the contractor shall take reinforcing actions including the change of engineering under discussions with the construction supervisor.

(3) The contractor shall manage the site safely to prevent entire facilities from any damage. If there is any concern of safety to neighboring facilities, the contractor shall take any necessary action and carry out constructions after the construction supervisor’s approval.

- Backfilling

It shall be done in accordance with ‘2.3 Earth Works’ in this specification.

- Drainage

Any pumping shall not be done rapidly and stability shall be secured in water retaining walls with detailed observations on the internal and external water level changes and wall movements.

- Foundation processing

(1) If underground water excessively gushes out or any hazardous deformation is expected

on neighboring buildings during excavating, the contractor shall establish the foundation processing plan with proper water control for the site conditions and carry out construction after the construction supervisor's approval.

(2) If any circumstance in the aforesaid (1) occurs, the contractor shall stop excavating immediately and inform the construction supervisor of the details and remove any work according to the construction supervisor's instructions.

(3) The contractor shall determine the injecting pressure of grouting within the range of no disturbance to soil properties of the original ground, and carry out the main construction after carrying out the test grouting and confirming no adverse influence on performance and neighboring structures.

2.11. Water Pipelines: Materials

2.11.1. General Requirements

The following pipes shall be used for the works:

The Contractor shall use Steel Pipes for the diameter which is not smaller than 250 mm. (except steel fittings)

The bidder shall submit all quotations of steel pipes for the Local and Foreign Pipes with Bid Documents.

The specifications of all steel pipes shall be fabricated and complied with AWWA standards or related standard approved by Engineer.

The Contractor should provide the steel pipe with the urethane and polyethylene coating which are highly corrosion resistant materials to prevent the steel corrosion.

The water supply pipe is the pressure pipe; therefore, the Contractor should perfectly make the connection between the pipes to prevent the water leak.

When the different type of material need to be connected each other, the flange connection method is recommended; therefore, the Contractor should check the bolt size before the connection.

The pipe should be finished by the same coating materials on the interior and exterior at the connecting point of the each pipe.

In this section, "Pipeline Materials" refers to pipes, pipe fittings, valves, surface boxes and chamber covers, and other such materials as are required for pipelines, mains and pipework at reservoirs and elevated tanks.

All Pipeline Materials shall be suitable for waterworks purposes for the conveyance of water in the conditions prevailing in Malawi and in particular at the location of the Works.

All pipes shall be supplied in accordance with the relevant Standard specified or other Standard approved by the Engineer.

Pipes shall be HDPE and Polyethylene Coated Steel pipe, or the pipes which can be acceptable for water shall be adapted.

All pipes and fittings of any one kind shall be supplied to the same Standard except as otherwise allowed by the Engineer. The Standard, method of manufacture, and specification shall not be changed at any time from that agreed between the Contractor and the Engineer except with the prior written approval of the Engineer.

All valves weighing more than 100 kilograms shall be supplied with two or three lifting eyes fitted in such positions that they hang with their major axes vertical or horizontal as required when suspended from the lifting eyes.

All valves shall be coated with a coating which is complied with BS code or relevant standard including suitable priming on all external body parts, and internal body parts liable to rust or corrode. The coating specification shall not be inferior to BS 4164.

All Pipeline Materials shall be supplied to suit the dimensions shown on the drawings.

The Contractor may supply material to other dimensions subject to the approval of the Engineer, however, the Contractor will be responsible for any redesign or extra design work and construction resulting from the use of material to other dimensions.

Where material to dimensions shown on the drawings is not manufactured the nearest available size above the size shown may be supplied, subject to the approval of the Engineer.

Drawings of all Pipeline Materials shall be submitted to the Engineer within thirty days of the award of Contract and will be returned either approved or with comments within a further thirty days from receipt by the Engineer. Manufacture shall not commence until the Engineer has approved the drawings.

2.11.2. HDPE pipe

(a) General

HDPE pipe is high density polyethylene pipe for the water pipeline.

(b) Standard

- It must be produced by BS or relevant standard approved by Engineer.
- This pipe with the Cu-wire attached could detect its burial depth and location when it was buried.
- The seamed pipe should be produced by relevant to BS or relevant standard approved by Engineer.
- Specific measurement of each product is manufactured by the Standard. Also, it should be submitted the drawing and a preliminary permission before manufacture for the other product.

(c) Summary

Characteristic	Condition
Tensile yielding strength	Over 16.8 N/㎟(200 kgf/㎠)
Waterproof pressure	No leakage, No defect
Degree of muddiness	Up to 0.5 degree
Chromaticity	Up to 1.0 degree
Consumption of Potassium permanganate	Up to 2 mg/l
Reduction of Residual chlorine	Up to 0.7 mg/l

Smell and Taste	None
Creep	No dividedness, No defect
Ash content	0.07%
Anti-Chlorine water	Up to 3 of cubic centimeter of Diameter 0.4 mm
Anti-Stress cracking	Over 240 hours of 50% cracking
Concentration of Carbon	2.0% to

2.11.3. Polyethylene Coated Steel Pipe

(a) General conditions

(1) Scope of application

a) Summary

- This clause shall apply to laying and connection of coated steel pipe which is used outdoor water pipe.

b) This clause shall be complied with all conditions of specifications

c) Main contents

- Bed excavation
- Laying and connection of steel pipe
- Cutting of steel pipe
- Connection with existing pipe
- Backfill

(2) Related clause of specification

The contents related construction of this chapter shall be complied with following clause.

- 22200 Bed excavation
- 24200 Backfill
- 31100 Blending, weighing, and mixing of concrete.

(3) Applying standard

BS standards shall be consisted as a part of this clause within specified scope in this clause. The pipe laying and joint in water pipe work standard will be followd by the related specification.

(4) Documents and reports for submission

The following documents shall be submitted complying with < 01210 documents and reports for submission>.

a) Plan for preparation and close of worksite

The Contractor shall be submitted plan for preparation and close of worksite complying with <05210 preparation and close of worksite>

b) Plan for inspection and test

The Contractor shall be submitted plan for inspection and test before construction complying with <02110 requirements of quality guaranteed>

c) Discussion reports

The Contractor shall be submitted discussion report if required discussion with related authorities, and the report for discussion result with field representative's signature shall be submitted.

d) Construction plan

The Contractor shall be submitted construction plan complying with [3210, detailed drawings, list of material supplier, documents and samples of products, and others] adding followings.

- Plan for cut off and closing existing water pipeline
- Working time and period for cut off the existing water pipeline.
- Plan for welding work
- Safety plan for welding work
- Coating method, procedure and tools.

e) Detailed drawing for construction

The Contractor shall be submitted detailed drawings for construction complying with [3210, detailed drawings, list of material supplier, documents and samples of products, and other documents] adding followings

- Standard drawing for installation
- Construction procedure
- Installation drawing for pipe protectors
- Drawing for temporary structure
- Caution for laying and jointing of pipe

f) Worker's profile

- Welder's profile, photo and qualify certificate shall be submitted before works
- Painter's profile and photo shall be submitted before works

g) Work report

The Contractor shall be submitted daily work report including following contents.

- Date
- Pipe diameter
- Welding point number
- Plumber's name
- Welder's name
- Welding voltage (A)
- Result of welding test
- Preheat temperature
- Post heat temperature
- Specification of welding rod
- Coating condition
- Cleaning condition of pipe
- Other necessaries.

h) Completed building drawing

- The Contractor shall be submitted completed building drawing after completion of

Construction

- Location of laying shall be recorded as a coordinate by transit survey before backfill of pipeline and manifold. The pipe kinds, diameter and location shall be marked on completed building drawing, and location of manifold shall be indicated on ground
- Underground utilities crossing with pipeline shall be marked on longitudinal drawing.
- If the Contractor found underground other utilities which is not marked on drawingor unexpected change the quality of soil under construction, it shall be marked clearly on completed building drawing.

(5) Quality guarantee

a) Skilled Plumber

- The Contractor recruit skilled plumber through examination with supervisor’s attending, and shall control skilled plumbers until completion of construction.
- The skilled plumber shall wear armband during pipe work.

b) Welder qualification

- Welder shall has a technician license issued by Government as a person passed functional examinations complying with BS.
- If there is any welder who has not technician license, he has to examined functional examinations complying with BS at worksite and the person who passed functional examinations at worksite shall be skilled welder after supervisor’s approval.
- The Contractor shall be submitted welder’s profile(experience, photo, and license) and shall control the welders until completion of construction.
- Welder shall has identifying name tag as per functional license to be able to check their proper job performance

c) Cooperation with relevant authorities

- The Contractor shall report to supervisor if underground facilities or utilities which is maintained by other relevant authorities needed to protect or move before starting construction
- The Contractor shall move and install protector for underground utilities through discussion with relevant authorities.
- If there is requirements from authorities for underground utilities, contractor shall report its to supervisor.

(6) Transportation, storage and handling

a) Steel Pipe

- The Contractor shall handle carefully to prevent damage for coating and joints of steel pipe.
- When lifting pipes, safety tools such as nylon sling or rubber coated wire rope shall be used and basically, the hooks has to hang on uncoated parts at the ends of pipe for protection of coated parts
- Prop and support of pipe shall be kept before laying.
- When transporting pipes form storage to worksite, suitable prop shall be put under uncoated part of pipe and when lifting pipes, coating part shall be protected without any damage.
- When moving pipes, do not pull pipe, if it has to be rolling, it shall be used uncoated

part at ends of pipe.

- If workers has to walk on or in coated pipe, it shall be covered coating surface with rubber plate or wore soft slipper.
- Pipes shall be supported with wedge to prevent rolling at storage.

b) Polyethylene tape on exterior of steel pipe

- Materials are transported and kept same as packing condition at factory.
- Storage of material shall be kept apart from fire
- Polyethylene tape shall not be supported with pipes or log, and stacked higher than 2 m.
- Hook, rope and cable etc. shall not be used during transportation of tape, and The tape shall not be rolling or dropping.

c) Welding electrode

- Welding electrode shall always be kept dry condition and do not take it into damp hole having high humidity as bare rod.
- After opening of welding electrode, contractor shall use it after drying in dryer as following table:

Kinds of Welding Electrode	Welding Electrode Conditions	Dry Temperature	Dry Time
Mild steel arc welding electrode	When it passed 12 hours after open (dry) or worried about moisture absorbing in welding electrode	100 ~ 150℃	Over 01 hr.
Low hydrogen type arc welding electrode	When it passed 04 hours after open (dry) or worried about moisture absorbing in welding electrode	300 ~ 400℃	Over 01 hr.

- Dried welding electrode shall be kept in moving dryer heated 100~130℃ to prevent absorbing of moisture. Electrode quantity for 3~4 hr. working has to keep in dryer.

(7) Environmental requirements

a) Environmental conditions

- Welding work will be effected by temperature, moisture so that weather condition shall be checked carefully and shall be took appropriate measures in case of worsening weather.
- Do not start welding when surround temperature of worksite is higher than 35°C or lower than -15°C and when rain, snow or ice is on surface of pipe.

(8) Safety measures

a) The Contractor shall be prepared safety measures during welding works as followings

- Electric shock
- Arc beam
- Scattering of spatter and slag
- Toxic gas
- Explosive gas

- Fire

(9) Cooperation with other work process
The Contractor shall consider other work process to prevent any disruption complying with [02410 discussion and adjustment] before installation work of valves, chambers, other pipeline, and polyethylene coated steel pipe,

(b) Materials (Polyurethane Coated Steel Water Pipe)

(1) Material

a) The quality of steel pipe shall be complied with BS or better than BS.
The Contractor should provide the steel pipe with the ceramic containing composite flake system interior and polyethylene exterior coating which are highly corrosion resistant materials to prevent the steel corrosion

b) Manufacturing method

- Steel pipe shall be 3 layer powder polyethylene coated steel pipe.
- The straight bare steel pipe shall be produced by method of submerged Arc welding and fabricated steel coils or plates complying withBS.
- The bare steel pipe fittings shall be complied withBS.

c) Coating method

1) Pretreatment
Any oil, grease, or other soluble contaminants on interior and exterior of bare steel pipe shall be removed more than Sa2½ of ks M ISO 8501-1 by shot blast or grit.

- Exterior coating
Steel pipe shall be coated 3 layer polyethylene by method of fusion bonded Epoxy powder

• Fusion bonded epoxy powder
On the surface of pre-heated steel pipe, the first coating is thermal spray coating of epoxy powder, the Second coating is thermal spray coating of reformed polyethylene adhesive, and the third coating is the thermal spray coating of polyethylene.

• Coating thickness

Nominal Diameter of Pipe (A)	Coating Thickness (mm)	Remarks
80 – 150	More than 2.0	A thickness of coating is including epoxy powder and adhesive, and the coating thickness of welding place shall be allowed -10% max.
200 – 1000	More than 2.5	
1,100 - 2,000	More than 3.0	
2,100 - 3,000	More than 3.5	

• Coating place and treatment of pipe ends
The non-coated length of pipe end for welding and coating at worksite is as following ;

Nominal Diameter of Pipe (A)	Non-coated Length

Under 700A	150 mm±10 mm
800A ~ 1,100A	175 mm±10 mm
1,200 A ~ 1,650A	200 mm±10 mm
Over 1,800A	250 mm±10 mm

• The ends of external coating shall be treated slopingly.

- Interior coating

• Materials – Name: AM-C-IT

• Gravity: 1.35 ~ 1.55

• Composition: basic material and hardener (weight ratio 3:1)

• Mixture ratio (basic temp. : 25°C)

Item	**Weight Ratio**	**Available Working Time**	**Solidifying Time**	**Remarks**
Ceramic coating (Basic : Hardener)	3:1	Within 120 minutes	Within 30 hours	

The mixture standard of spray work is 100-200cc of thinner (KHM-129M) per 01 kg of ceramic coating material.
If the control of viscosity needed for spray works, the thinner could be adjusted to ±10% according to working conditions.

• Ceramic coating(application)
According to working condition, if ceramic coating(application) was coated by airless spray using airless gun, roller, brush, etc., it shall be coated over 300μm (thickness of dried coating) vertically on surface of pipe

• Fittings
The treatment of coating and painting on the interior and exterior of fittings shall be same quality or better than straight steel pipe.

(2) Sub materials

a) Coated arc welding electrode

1) The quality of coated arc welding electrode shall be complied with BSor better quality, and the following materials shall be used after supervisor’s approval E 4301 Aluminate type electrode E 4316 Low hydrogen type electrode

2) Diameter of welding electrode shall be decided considering thickness of pipe, welding pass, and welding position.

b) Concrete mixing with sand and protector which is used under the pipe shall be complying with『31100 Blending, weighing, and mixing of concrete』.

(3) Material of backfill
Material of backfill shall be complied with『24200 refilling』

(4) Welding equipment

- Alternating current arc-welding machine shall be complying with BS or better quality machine.
- Welding cable shall be complied with BS.
- Welding holder shall be complied with BS.

2.11.4. Corrosion Protection of Steel Pipes

The pipes shall be protected internally in accordance with AWWA C210 and externally AWWA C215 or relevant standard approved by Engineer.

The pipes shall be protected by the materials per clause 2.11.3. The fittings shall be cleaned, primed and coated to the same quality as straight pipes. The equivalent coating material with the coating material on the pipes shall be used in order to prevent the corrosion on the welding parts.

2.11.5. Valves

The valve should be used the water supply purpose, and the flange connection will be required at the pipe connection point. Any type of valves shall meet the standard and bear the pressure stated in this specification and drawings, bill of quantities. Considering poor local condition of maintenance, the valve to be applied have the function of monitoring for mechanical failure continuously or have the easy way to replace the parts.

The Contractor should check the size of the valve and valve chamber which should be provided the enough space for the working area, and then the contractor should start to build.

2.11.6. Gate Valves

(a) General

Valves shall be double flanged wedge gate valves for manual operation suitable for waterworks purposes generally complying with the requirements of BS 5163 or relevant standard approved by the Engineer and suitable for working pressure of 16 bar or other pressure stated in the specification, drawings, bill of quantities.

Gate valves which satisfy the specified conditions of service and duty, but which are manufactured to standards not less than those specified, may be offered. Full descriptive details including detail drawings, which must be annotated in English, shall be supplied on all items whether as specified or as offered alternatives.

If the better valve can be provided, the specifications of the valve can be changed through discussion with the Employer and Engineer.

(b) Construction

Valves up to and including DN 300 shall be of the resilient seal type and valves larger than DN 300 shall have metal seals.

Spindles shall be of the non-rising type and screwed so as to close the valves when rotated in the clockwise direction. The direction of closing shall be clearly cast on the valve cap or handwheel as appropriate.

The valves shall be constructed of the following materials:

body - cast iron

spindle - forged bronze or stainless steel

metal faces and seal - gunmetal.

The valves shall be suitable for an unbalanced head of 16 bar.

Suitable gearing and anti-friction devices such as ball bearing thrust collars shall be provided as necessary to enable opening and closing by manual operation at the pressure stated, using an effort no greater than 26 kg on the tee key or handwheel supplied.

Handwheel shall not exceed 500 mm diameter. A bypass with gate valve forming an integral part of the valve shall be provided where recommended by the valve manufacturer for the pressures specified.

Gearing on valves of DN 300 and less shall be enclosed in a sealed gearbox suitable for buried installation and operated with a tee key. Except where shown on the Drawings, all valves exceeding DN 300 shall be provided with bevel gearing and handwheels.

All valves to be used for washouts and isolating air valves shall have screwed seats.

Extension spindles shall be galvanized or stainless steel adequately supported with cast iron brackets, and of sufficient diameter to prevent any whiplash effect through twisting when being used to operate the valves. The spindles shall be capped for key operation.

Valve caps shall be fitted with hexagonal set screws.

The valves shall be coated with cold applied bitumen conforming to the requirements of BS 3416 (material Type II).

Keys for valve operation shall be of sufficient length so that the valves can be operated by a man standing, but shall not exceed 1.2 m in length, and shall have a detachable cross bar.

(c) Testing

All valves shall be open end tested in accordance with BS 5163, and pressure and materials test certificates shall be submitted to the Engineer for approval.

2.11.7. Butterfly Valves

(a) General

Butterfly valves shall conform to BS 5155/3952 or relevant standard approved by the Engineer and shall be suitable for a working pressure of 16 bar or other pressure stated in the specification, drawings, bill of quantities.

If the better valve can be provided, the specifications of the valve can be changed through discussion with the Employer and Engineer.

(b) Construction

Butterfly valves shall have a high grade cast iron body to BS 1452 designed to the specified working and test pressures. The pressure rating of the valve shall be cast in the valve body.

The disc shall be of high grade cast iron to BS 1452 or nodular cast iron to BS 2789 to the defined working and test pressures. It shall have a convex shape designed to achieve low head loss characteristics. The valve shafts shall be of stainless steel operating in self lubricating bushes in the body.

The valve seat shall be of gunmetal to BS 1400. The sealing ring shall be of high quality nitrile rubber attached to the disc edge by a sectional bronze retaining ring to form a resilient and durable seal.

The valves shall be fitted with handwheel actuators not exceeding 500 mm diameter incorporating gearing to allow opening and closing by manual operation at the pressure stated using an effort no greater than 26 kg on the handwheel supplied.

In all cases, the gearing shall be designed to close the valve, from fully open to fully closed in a period not less than ten minutes with this effort. Actuators shall be designed so as to close the valves when the handwheel is turned in a clockwise direction; the direction of closing shall be clearly cast on the handwheel. Position indicators shall be fitted to all actuators.

Where shown on the drawings or stated in the Bill of Quantities valves shall be electrically actuated with a manual override. Remote actuation shall be provided where shown with visual indication of valve open, valve closed and percentage opening together with fault indication designed and manufactured to the approval of the Engineer.

(c) Performance

A performance curve, relating percentage valve travel, open area and discharge coefficient shall be submitted to the Engineer. The head loss coefficient with valve fully open shall be defined.

(d) Testing

All valves shall be tested in accordance with BS 5155 and pressure and material test certificates shall be submitted to the Engineer for approval

2.11.8. Air Valves

If the better valve can be provided, the specifications of the valve can be changed through discussion with the Employer and Engineer.

Air valve shall be supplied with Double Air Valve (DAV) or Quick Exhaust Valve.

Air valves shall conform to BS code or other codes that are not inferior to BS code.

The pressure meter in the air valve shall be installed in order to check the pressure.

Each air valve assembly shall be suitable for connection to a flange on the pipeline.

Flange sizes are given on the drawings.

At the connection between the air valve and its isolating valve a 3/8" (9.5 mm) BSP tapping shall be made suitable for fitting of a pressure gauge. All tappings shall be sealed by a brass plug and copper compression ring gasket.

Air valves shall be suitable for a maximum operating pressure of 16 bar and shall operate automatically and be constructed so that the operating mechanism will not jam in either the open or closed positions.

2.11.9. Pressure Regulating Valve

(a) Scope

This specification shall be applied to the globe type (including angle) of hydraulically operated and self-acting pressure reducing pilot valve diaphragm for water (and liquid).

(b) General

A pressure regulating valve automatically and constantly reduces pressures from higher first pressure to lower second pressure regardless of variations in the flow or in the first pressure. This valve is a pilot-acting valve which maintains the second pressure to the accurately predefined value. If the second pressure exceeds the predefined pressure, both the main valve and pilot value are completely closed.

If the check function is added and reverse current pressure occurs, the second pressure is accepted in the main valve cover chamber and the valve is closed to prevent any reverse current.

A pressure regulating valve shall use the globe type in a single sheet, and it shall not be operated by any separate external driver such as electricity or compressed air but on its own way by the water pressure in the pipe. In addition, it shall adopt soft sheets to keep air tightness in ANSI Class VI (Drip tight). It also shall apply a diaphragm guide to the upper and lower sections for the protection and smooth operation of a diaphragm.

The pressure regulating valve shall consists of both the main valve and pilot stem.

The main valve stem shall be built in a structure where it can be supported in both the upper and lower sections of the valve by the internal bushing guide. The pilot stem of the pressure regulating valve shall be provided in completely assembled conditions when it is supplied, and it shall not require any separate piping works.

It shall be built in a structure where maintenance and repair can be easily done although the valve is not detached from the pipe for the regular check and maintenance, after the valve is installed to the pipe, and the sheet ring can be replaced, if necessary. In addition, it shall have correction pins for the smooth assembly after the valve is repaired.

The product shall go through the inspections for its operation and water pressure before it is delivered from the factory.

(c) Material and Structure

(1) Main valve body

The material for the main valve body in a globe type (or angle type) shall be made of ASTM A536 for iron cast and ASTM A216-WCB for cast steel in consideration of characteristics for the applied place. In addition, the inside of the main valve in either cast iron or cast steel shall be finished with epoxy coating and thermally processed coating in the thickness of 4 ~ 8 mil (= 0.1 mm ~ 0.2 mm) to prevent corrosion.

(2) Cover

It shall be made with holes where a valve delivery rate indicator or limit switch can be installed on the center, together with 2 or 4 holes where the pilot diaphragm assembly stem can be installed.

(3) Valve stem

The valve stem shall be made on the basis of stainless steel standards.

(4) Trim: Disc Guide, Seat & Cover Bearing)

It shall be made on the basis of bronze.

(5) Spring

Springs to support the closing force of valves shall be made on the basis of stainless steel standards.

(6) Diaphragm

A diaphragm can separate the pressure in the pipe which operates in the lower chamber, from the driving force in the upper chamber. It shall be basically made of nylon reinforced Buna-N® rubber. In addition, the valve chamber shall be made of a single chamber.

(7) Diaphragm assembly system

The diaphragm assembly system shall consist of diaphragm, diaphragm supporting plate, stem, sheet disk, sheet fixing support, and sheet connecting plate.

(d) Pipe Connection and Diameter

(1) Valve diameter and connection method

The valve diameter shall be the size where the supply up to 32 mm (1.1/4") ~ 1,200 mm (48") can be done. The screw type or flange connection shall be applied to diameter up to 80 mm (3"), and the flange connection (ANSI 150#, ANSI 300#) to 100 mm (4") or larger.

(2) Working pressure condition

With regard to working pressure conditions for the valve, the valve shall be able to be used up to 17.2 barg if the main valve material is ductile iron, ASTM A536 ANSI 150#, and up to 27.6 barg if it is ANSI 300#.

(e) Recommended Products

Cla-Val 90-01 Pressure Reducing Valve or equivalent or better products

2.11.10. Flanges

All flanges for new works shall be faced and drilled to conform to the dimensions specified in AWWA C207 or relevant standard approved by Engineer for a nominal pressure of 16 bar or other pressure stated in the Particular Specification. All flange and coupling assemblies shall consist of the required number of bolts, nuts, washers and gaskets (2 washers per bolt). Bolts and nuts shall not be inferior to AWWA C207 and no bolt shall project more than two full threads beyond its nut after tightening. In no circumstances shall the shortening of excessively long bolts by cutting be allowed. Flanges for connection to existing pipework shall be faced and drilled to suit the dimensions of the existing flange.

Gaskets shall be in accordance with AWWA C207, or other specification to the approval of the Engineer.

The contractor should perfectly make the connection between the pipes to prevent the water leak.

The contractor should provide the same size of the flange if the different types of two pipes are connected each other with flange connecting method.

2.11.11. Materials for the Assembly of Flexible Joint

The Contractor shall supply all the lubricants necessary for assembling spigot and socket joints. The lubricant shall be of a kind not conducive to the growth of bacteria and shall be to the approval of the Engineer. The quantity supplied shall be sufficient for the number of joints of each size, together with an allowance of 10% excess over the nett quantity to allow for waste.

2.11.12. Lock-Jointed Pipework

Lock-jointed pipework shall be pipes and socket pipework as specified above but with the additional feature that joints are positively locked against pull-out by bolting into place a circular gland disc bearing on a raised annulus or mechanical lugs on the spigot end. The bolts shall connect the gland disc to a flange or similar feature on the socket end.

Joints depending for tensile security only on toothed inserts in rubber rings shall not be accepted as locked joints for the purposes of this Clause.

Locked joints shall tolerate, during construction and after completion, the same deviation as specified for conventional spigot and socket joints, and watertightness shall be assured by a rubber joint ring, which shall be fully effective whatever the state of compression, tension or deviation in the joint.

Locked joints shall be capable of resisting without damage the same tensile and transverse loads as conventional flanged joints of the same nominal diameter.

Lock-jointed pipework shall be supplied where indicated on the drawings.

2.11.13. Packing and Protection

All items shall be adequately crated or packaged to withstand damage and deterioration due to shipping, handling and storage. Protection shall be provided to prevent damage to flanges, and pipe ends to prevent ingress of foreign matter. The methods of protection and shipping shall be to the approval of the Engineer.

Bolts of the same length and size (and their accompanying nuts and washers) shall be packed together in boxes not exceeding 100 kg gross weight.

Joint rings and gaskets shall be packed in boxes and separate packages shall be provided for each size and description of ring or gasket.

All fittings shall be packed in open sided crates. The Contractor shall supply all necessary materials and equipment for making good, where approved by the Engineer, any damage to coatings of pipes, fittings and valves.

2.11.14. Marking

All Pipeline Materials shall be marked in accordance with BS 4772 and BS 5163 or relevant standard approved by Engineer.

Before shipping all items shall be clearly marked. All crates or packages shall be marked on two sides with indelible paint with the name of the project, the Employer and the Contract number and shall also bear marks indicating the contents.

2.11.15. Handling of Pipeline Materials

The Contractor shall comply with the following requirements:

(a) Pipes shall not be stacked higher than recommended by the pipe manufacturer.

(b) Pipes, fittings and valves shall not be dropped, or allowed to land on sharp or other objects which will cause bends, dents or damage to the coating.

(c) When lifting pipes and fittings special lifting hooks with curved saddles to fit the curvatures of the pipe or fitting shall be used. Alternative types of lifting hooks, clamps, or slings, may be used subject to the Engineer's approval.

(d) Suitable pillows shall be used to protect pipes and fittings under securing chains or other lashings when loads are being transported.

2.11.16. Manufacturer’s Certificates

The Contractor shall furnish the Engineer with a manufacturer's certificate in respect of every consignment of the Pipeline Materials confirming that all items of Plant comprising the consignment comply in all respects with the requirements of the specified Standard and of this Specification.

The original and the number of copies, which is made through discussion with the Employer and Engineer, of such manufacturer's certificate shall be delivered to the Engineer not later than 14 days prior to the intended date of delivery of the Pipeline Materials to Site.

2.11.17. Acceptance of Pipeline Materials on Site

Pipeline Materials will be finally accepted within the Site only when the following conditions have been observed:

(a) All damaged coatings and other repairs have been made good, in accordance with the manufacturer's instructions subject to the Engineer's approval.

(b) All pipes are stacked to the satisfaction of the Engineer, laid on suitable timbers on level ground and properly chocked.

(c) All fittings and boxes are laid out.

(d) The Engineer, or his delegated representative, has carried out a satisfactory inspection.

2.11.18. Inspection and Testing

During manufacture and before despatch from the place of manufacture the Contractor shall allow for inspection of all Pipeline Materials by an inspector appointed by the Engineer. The inspection will include attendance at all pressure and material tests, execution of dimensional checks and inspection of the workmanship and standard of manufacture with scrutiny of evidence of the materials used in the fabrication of the Pipeline Materials.

The Contractor shall arrange for such testing as may be required to be carried out at the place of manufacture according to this Specification. If there are no facilities at the place of manufacture for making the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere.

The Contractor shall supply test certificates and shall furnish and prepare the necessary test pieces and samples and shall supply and provide all test rigs, equipment appliances, labour and any other facility required for inspection and testing.

The Engineer and his inspector shall be allowed full access to all areas at the place of manufacture or elsewhere where testing, furnishing or preparation of materials for the performance and testing of work under this Specification is taking place.

The Contractor shall furnish the Engineer with reasonable facilities and space (without charge) for the inspection, testing and obtaining of such information as he desires respecting the character of material in use and the progress and manner of the work.

2.11.19. Fire Hydrants

Fire hydrants shall be designed and conform fully with BS 750 Type 2, with 'captive' internal valve or it can be changed to other proper type of materials depends on the site situation through discussion with the Employer and Engineer.

Fire hydrants shall be suitable for a maximum working pressure of 16 bar and be subjected to a works hydrostatic test pressure in accordance with the procedures set down in BS 750.

The pressure rating shall be cast into the body of the hydrant.

Inlet flanges to fire hydrants shall be DN 80. The outlet piece shall be screwed 2½" (63.5 mm) diameter BS 750 round thread.

The fire hydrants shall be capable of passing a minimum flow of 34 l/sec at a constant running pressure of 1.7 bars.

2.12. Water Pipelines: Construction

2.12.1. Pipework: HDPE pipe

(a) Piping connection

- PEK piping connections are connected by the fusion method.
- The fusion method is constructed on the process depending on temperature, pressure and time
- For the connection of underground detected pipeline, it is applied to temporary method.

(b) Type of fusion

- Butt Fusion : the method of section to section of pipeline(apply on over 75A diameter)
- Socket Fusion : Insert with inside section of socket and outside section of pipeline(apply on up to 75A diameter)
- Saddle Fusion : Welding with outside section of pipeline and saddle

(c) Storage

- When loading, large diameter pipe should be placed on the first.
- HDPE pipe is very smooth inner and outer surface, so it need to load safely to prevent slipping.

2.12.2. Pipework: Polyethylene Coated Steel Pipe

(a) Checking of construction condition

(1) Checking worksite’s condition
The contractor shall be carried out field survey before starting the work, and it shall be reported to a supervisor immediately if there is any difference between drawing and field survey

(b) Preparation of construction

(1) Contractor shall be submitted to supervisor work plan for cutting-off or disuse of existing water pipeline at least 24 hours in advance of work and it must be approved by relevant authorities. It shall not be started works before receiving written approval of the relevant authorities.

(2) Contractor shall be submitted working plan which is specified working time and duration for minimizing residents uncomfortable due to cut off the water

(3) It shall be checked the specified drawing by workers before removing existing water pipe.

(4) It shall be reported to supervisor for the detail content before starting construction.

(5) It shall be checked and inspected connection parts, necessary tools and equipment before jointing of steel pipes.

(6) It shall be removed sewage and dregs in or on the interior and exterior of the pipe before Jointing of steel pipes.

(c) Bed excavation

(1) The bed excavation including raised bottom and tramping should be complied with 『22200 Bed excavation』.

(2) The bottom of bed excavation should be constructed exactly same altitude as specified on drawing

(3) The bed excavation near by the existing structure shall be installed retaining wall or protection to prevent collapse of foundation structure or any danger.

(4) For the underground utilities, it shall be protected any damage which will be caused by machine excavation work, through previous labor excavation work.

(5) Surplus soil of excavated soils shall be carried out the surrounding area. The soil hich will be use for backfill shall be filed up more than 60 cm apart from the end of the face of slope considering stability of bed excavation.

(d) Steel pipe laying

(1) When arranging pipes, it shall be supported with buffer timber, sandbag, and others under ends of the pipe. So that negligent accident by rolling and damage by pebble and rock for exterior coating of steel pipe by pebble and rock shall be prevented.

(2) After every completion of laying work, it should blocked ends of pipe for prevention of inflow of foreign materials such as soil, dirt, and not be put such as cloth, tool, etc into the pipe.

(3) When laying pipes, it shall be checked the symbol of the pipe, and the symbol, diameter, and manufacturing date marked on the pipe shall be laying toward upper.

(e) Welding joints

(1) General

- Before welding work, it shall be prepared safety measures for preventing of fire and short circuit.
- The joint parts shall not be waterlogged from starting welding to finishing coating
- The Contractor shall be prepared safety measures for avoid damage on the interior coating in pipes, and caution worker's walking.
- The Contractor shall be submitted daily working report to supervisor.

(2) Arc welding

- The surface of welding shall be dried fully and welded after eliminating harmful material by the wire brush.
- The welding materials shall be kept and used after drying in dryer before using it, and the covered Arc welding electrode shall be used keeping in moving dryer (temperature : 100℃ ~130℃).
- The tack welding shall be done simply considering deformation of pipe ends and loaded exactly without excessive burden at the pipe ends. The temporary tack welding shall be removed completely before starting main welding work.
- Depending on the welding work, coating surface shall be protected from damage by the spatter.
- The excess metal of bead shall be less than standard height according to thickness of basic metal. The standard height of the excess metal is as following Table:

Thickness of Basic Metal	Height of Excess Metal
$T \leq 12.7$	Less than 3.2
$T > 12.7$	Less than 4.8

- The width of weaving should not be exceeded three times of welding electrode diameter
- The arc welding should give attention to welding process for equivalent distribution of welding heat in order to minimize deformation and contraction stress of welding face.
- Welding work shall be continuously until completion of 1st welding layer
- The temperature between welding layers shall always be maintained less than 250℃ during welding work, and the measuring of temperature shall be checked on the center of welding part.
- It shall be welded after eliminating and cleaning spatters, slag and etc. on each layer.
- It shall not be welded when its raining, snowing or very cold. but it will be welded by

supervisor's approval if it had protective equipment or preheated sufficiently for welding work.

- The preheat shall be used electric resistance heating method or fixed burner, but when it preheated by burner, it shall not be heated on improvement part directly by the burner.
- The scope of preheat for basic metal shall be 100 mm in front of arc and 100 mm ends of welding lines
- Sub material and temperature required preheat, is as the following Table:

Kind of Steel	Joint	Welding Rods	Plate Thickness (mm)		
			$t < 19$	$19 \leq t < 38$	$38 \leq t < 50$
SS400 SM400 SMA41	Groove	Coated Arc welding	-	10	40-60
		Flux Cored Arc welding Submerged Arc welding	-	10	40-60

Note a) The preheat temperature shall be at least 21° C, if the base metal temperature is below 0 ℃,
b) In case of exceeding 0.44% of carbon equivalent in Mill sheet of steel sheet
c) In case of exceeding 370 of the highest hardness (Hv) in highest hardness test.
d) In case of below 5 ℃

- It shall not be cooled rapidly after welding, and it shall be post-heated, if necessary.

(f) Coated steel pipes cutting

- In case of cutting a pipe, the cutting length and spot shall be fixed exactly and marked on the entire circumference of the pipe.
- The steel pipe shall be cut after peeling 30 cm (width) of coating part from center of cutting line and marking cutting line.
- The pipe shall be cut by the cutters, it shall be cut perpendicularly to the pipe shaft.
- The joints of steel pipe shall be finished carefully same as shape of the end of new pipe, and the cutting part of coated pipe shall be fabricated same dimensions with the new pipe.
- The harmless anticorrosion material sanitarily in order to prevent corrosion of the pipe shall be used on cutting part and it shall be prevented damage or deformation of pipe.

(g) Connection with existing pipes

- Connection construction should be carried out exactly and quickly.
- When connecting to existing water pipe, connection place shall be done prospecting survey in the presence of the supervisor as soon as possible. The existing pipe (location, kind of pipe, diameter etc.) to be connected and other underground utilities shall be checked.
- The Contractor shall have prior discussion with supervisor for construction time, duration, and progress schedule before starting connection construction,

(h) Construction of coated steel pipe

(1) The detailed report for coating method, procedure and tools of steel pipe shall be

submitted to supervisor before starting a construction.

(2) It shall be covered rubber mat or put on clean rubber shoes or slipper to walk on the surface of coated pipe

(3) After finishing welding work, it shall be pretreated for adherence of coating as follows.

a) Eliminate of diffusion hydrogen remained among the welding metal

1) After finishing welding work, it should be neglected more than 24 hours if it used low hydrogen type electrode and more than 14 days if it used illuminate type electrode for primer coating.

2) In urgent case, the weld bead part shall be heated repeatedly until maximum allowable temperature of 600 ° C using gas burner before primer coating with prior approval of supervisor.

b) Cleaning surface of the steel pipe

1) The surface of steel pipe shall be cleaned and dried.

2) The harmful swelling for coating such as slag, spatter and weld bead shall be removed by the electric sander, grinder, wire brush and other tools.

3) The oil, dust and other foreign matters adhere to surface of heated primer shall be removed by the wire brush, solvent naphtha, cleaner etc.

(4) Nano ceramic metallic interior coating

- If preheating needed to prevent dew condensation on the uncoated steel pipe, it shall be heated equally by the infrared rays, heated air, scalding and immersion, etc.
- The coating shall be obtained equal film without foreign matter, coating stains, pinhole and uncoated part. Also, in order to secure the film thickness of the coating product, it shall be coated within specified re-coating time by coating manufacturer.
- The coating product connected by welding shall be left uncoated part considering of welding heat. But uncoating part shall be coated with shop primer of epoxy resin paint.
- The film thickness of the coating products shall be more than 0.3mm.

(5) The exterior tape coating on welding part

a) Primer

1) The primer shall be mixed completely before painting and painted sequentially with specified speed by coating manufacturer. Also, it shall not be any problems for tape adhesion over a long time.

2) The primer shall not be contaminated with impurities such as humidity or dusty before winding the tape after coating.

3) The primer shall be able to use without heating as liquid state, and boned to surface of steel pipe and tape.

4) The primer shall be painted steadily and continuously with specified speed by coating manufacturer for the amount of daily works.

5) The primer shall not be diluted.

6) The primer and tape shall be same contraction, stretching, drying time for a property characteristic.

b) Sealing elements

1) The sealing elements shall be properties being able to work in the climatic condition of above zero and have the following properties.

- color	: Blue/brown
- specific gravity	: 1.39
- draw available	: 720 ㎤/kg
- construction temperature	: 0℃~7℃
- operating temperature	: up to 90 ° C

2) The injection of sealing elements shall be added with the spatula and trowel etc.

3) The sealing elements shall be injected steadily after careful checking of the welding part and also injected by pressing with hands without any empty space.

c) Tape winding

1) The tape shall be winded helically from Min.75 mm inside at the edge of coating.

2) The starting face of tape shall be stated at the direction of 9~ 10 o'clock or 2 ~ 3 o'clock on coated surface.

3) At the beginning time, tape should be pressed equally with the palm after puttingon coating surface of the primer for a length of twice the width of the tape.
Thereafter, it shall be overlapped at least once on the same point after pulling hardy with the weight.

4) After wrapping around, it shall be overlapped 50% from the beginning side of tape, in other words, it shall be located center of the first winded tape and overlapped more than once from the right end of the coating.

5) When replacing tape on the work, overlap of circumferential direction shall be overlapped more than 15 cm at least.

6) If physical damage will be caused by backfill or difference of surrounding soil condition, it shall be reinforced with more than regulation

7) Except absolutely necessary case, workers shall not walk on the coating surface, but it will be allowed to walk after taking safeguard with supervisor's approval for protective method.

(i) Backfill

- The backfill shall be complied with 『24200 backfill』. The compaction thickness of a layer under the pipe shall be less than 20 cm, and on the pipe shall be less than 30 cm. The compaction hardness of each layer shall be compacted more than 95% of the maximum dry density by D compaction.

(j) Construction tolerance

(1) The height of the laid pipe shall be less than 20 mm from the specified altitude

(2) Exterior inspection result for welding part shall be same as followings:

a) Under cut

1) Less than 0.5 mm of depth shall be ignored.

2) The length of undercut between 0.5 mm and 1.0 mm of depth shall be less than thickness of basic metal.

3) The undercut over 1 mm of depth shall not be allowed

b) Over lap
The overlap shall not be allowed.

c) The length and throat thickness of fillet weld part
It should be allowed up to -1.0 mm length and -0.5 mm throat thickness in the range of less 5% of the welding length.

d) Unbalance of the weld bead
Weld bead shall not be extremely bad quality to effect coating work due to uneven weld bead

e) Arc strike
It shall not be Arc strike on surface of basic metal.

f) Crack
It shall not be cracks.

g) Slag, spatter
It shall be removed completely.

(k) Quality control at worksite

(1) The pipe installed to expose and raised bottom of pipe shall be protected to prevent water erosion during the test.

(2) The test plan shall be submitted to supervisor at least 2 days before work, the contractor shall test after preparing pumps, gauges, meters, etc.

(3) The steel pipe shall be coated after completion of welding and all of welding points shall be inspected by supervisor. The contractor shall prepare the equipment required for the inspection. Rejected welding points by supervisor shall be re-inspected after re-work

(4) Test

a) The backfill and the bottom of the water pipe shall be tested complying with BS.

b) Even if passing the test about the steel pipe, contractor shall reconstruct if there is any problems

(5) Inspection

a) The inspection before welding
The contractor shall inspect visually for followings

1) The interval of root, misalignment of the pipe, the discrepancy of the shape.

2) The rust, sediment, oil, moisture of the welding part

3) The tack welding condition complying with regulation

4) The overlap length of bell-end shape shall be secured more than 70 mm.

b) Test items during welding work
The contractor shall be welded completely after checking followings during welding

1) Welding conditions and welding process

2) Standard of electrodes and dry conditions

3) Removing and cleaning status of the slag on each layer for the multi layer welding

4) Proper setting of welding current

c) Inspection After the completion of welding

1) Visual inspection

2) Non-destructive testing

- Butt welded joint pipe shall be performed the radiographic examination complying with the relevant standards.
- In case of difficulties to performed radiographic examination, it shall be performed ultrasonic testing complying with the relevant standard.
- In case of the fillet welded joint pipe for the interior and exterior by bell-end, it shall be inspected every joints for leaking by compressed oxygen (or compressed air) test.

3) Welding deposition status

- The inspection for status of welding deposition shall be followed with supervisor's Instruction.
- The inspection for status of welding deposition shall be inspected using micrometer or vernier calipers.

4) Bonding state test

The test sample shall be collected at any point according to supervisor's instruction and it shall be tested tensile strength after checking a shape of depositing metal.

(6) The Contractor shall be removed completely defective welding points after taking photograph for surround the pipe and checked groove, etc. after that, it shall be tested again for re-welding.

2.12.3. Setting Out

The way leaves, easements or other rights of way for pipelines will be defined by the Employer across any private land and by the Engineer across any land belonging to the Employer or to the Government.

The Contractor shall, where required by the Engineer set out the boundaries of way leaves and mark them as required by Clause 1.3.34.

The Contractor shall, in the presence of the Engineer set out the pipeline alignments in accordance with the drawings, making any changes the Engineer may deem necessary and confirming also, the exact locations of all chambers, valves, air valves, washouts and hydrants, abutments, supports and restraints.

The Contractor shall then submit to the Engineer for approval, at an approved scale, a profile of ground levels after the initial clearing of the way leave, easement or other right of way showing the proposed invert levels and the precise chain ages of all pipeline features.

Following approval and before excavation of the particular pipeline commences, the Contractor shall supply to the Engineer two further copies of the approved profile, incorporating all amendments required by the Engineer.

2.12.4. Pipeline Alignment

The horizontal and vertical alignments of the pipes shown on the Drawings are outline designs only. The Contractor shall, after consultation with the Engineer and relevant statutory authorities, prepare drawings at a suitable scale his proposed route and profile in detail. The Contractor shall identify on the drawings the location and actual level of all services crossing or adjacent to the proposed route. The number of copies which is made through discussion with the Employer and Engineer of the drawings shall be issued to the Engineer for review.

The Contractor shall amend the drawings as necessary to incorporate the Engineer's comments and submit the number of copies which is made through discussion with the Employer and Engineer of the drawings detailing proposed horizontal and vertical alignments to the Engineer for approval. The number of copies which is made through discussion with the Employer and Engineer will be retained by the Engineer for his use.

Setting out shall not commence until the necessary rights of way have been negotiated and notices served through discussion with the Employer or the Engineer.

2.12.5. Examination of Pipes Prior to Laying

Shortly before laying or fixing any valve, pipe or fitting the Contractor shall in the presence of the Engineer carefully examine it to ascertain damage or defect. All damage and all defects revealed by this examination shall be repaired and remedied to the satisfaction of the Engineer or replacement may be required.

The Contractor shall give the Engineer not less than 48 hours' notice of his intention to examine any pipes, etc and the Contractor shall not proceed to lay such pipes until they have been approved as free from damage and defects by the Engineer.

The external sheathing of steel pipes and fittings and the external coating of coated pipes and fittings shall be examined by means of an approved by the Engineer.

2.12.6. Laying Pipes

Immediately before any pipe is lowered into the trench the plug shall be removed from the end of the last pipe laid and the new pipe shall be carefully lowered into the trench in an approved manner.

Each pipe and fitting shall be laid true to alignment curve and gradient in accordance with the drawings or as directed by the Engineer.

Pipes shall be boned to gradient and sight rails shall be provided for this purpose at intervals not exceeding 50 m and at all changes in grade. Pipes shall be laid to a continuous fall to washouts and continuous rise to air valves. No dips or summits will be permitted other than as shown on the drawings unless otherwise instructed by the Engineer. Pipes and fittings laid in trench shall have the minimum cover stated on the drawings or as otherwise directed by the Engineer.

Unless otherwise shown on the drawings long radius curves in pipelines shall be negotiated by deflections taken up in the joints of one or more pipes.

At no time during construction shall the maximum deflection stated by the manufacturer be exceeded.

Pipes laid in trenches shall be laid and firmly bedded on an even and uniform bedding.

Where pipes are not laid on a granular bed, the bottom of the trench shall be smooth and free from stones or other projections. Pipes shall not be dragged along the trench bottom.

Joint holes shall be excavated below the pipe invert and shall be as small as possible and shall be filled in and compacted after the pipes are laid and before the refilling of the trench is commenced. Survey pegs in the trench bottom shall be removed.

Each type of joint shall be made in full compliance with the manufacturer's instructions.

Special care shall be taken to ensure the absolute cleanliness of the pipe ends and joint components and only the recommended lubricants shall be used.

Pipe jointing shall be carried out only by experienced personnel and with close supervision by the Contractor. Further pipe jointing shall not proceed until the previous joint has been inspected by the Engineer. Inspection of the joint by the Engineer shall not relieve the Contractor of his testing responsibilities.

The Contractor shall take all steps necessary to ensure that no dirty water or other extraneous matter is allowed to enter the pipes during or after laying. In the event of dirty water or extraneous matter entering the pipes the Contractor shall immediately carry out the necessary cleaning as may be directed by the Engineer.

As pipe laying proceeds the Contractor shall prove pipelines are free from obstruction by passing through the pipeline a 'badger' which must be kept in the pipes at all times during construction of the pipelines. The 'badger' shall be pulled forward and any obstructions or dirt removed immediately after the laying of each pipe and before the next one is placed in position, so that the barrel of the pipe is left perfectly clean.

The 'badger' shall consist of polyurethane foam with dimensions approved by the Engineer, with suitable attachments to allow for pulling through the pipes.

Except when necessary for jointing, the end of the last pipe laid shall be plugged to the satisfaction of the Engineer and the Contractor shall provide and use a sufficient number of proper plugs for this purpose.

Any damage to the external sheathing or coating or to the internal lining of pipes, fittings, etc. sustained during laying shall be repaired and made good to the satisfaction of the Engineer who shall be afforded facilities of examining and testing any repaired areas of sheathing, coating or lining.

Pipe trenches shall not be backfilled until permission to do so has been obtained from the Engineer. Subject to such permission being obtained trenches shall be backfilled without delay to at least the minimum extent required by the specification in readiness for pressure testing.

2.12.7. Cutting Pipes

Steel pipes, which are suitable for cutting, shall be cut by an approved method. The edges of the cut shall be clean true and square. The use of an oxyacetylene flame cutter will not be permitted in any circumstances.

Pipe shall be cut to provide a clean square profile without splitting or fracturing the pipe wall and with minimal damage to any protective coating and lining. Where necessary, the cut ends of pipes shall be formed suitable for the type of joint to be used and protective coatings and linings shall be made good and the ends of the cut sealed.

2.12.8. In-Situ Welding of Steel Fittings and Flanges

Wherever it is necessary to undertake in-situ welding of steel fittings and flanges the work shall be undertaken under cover, temporary or otherwise. Outside of buildings, the cost of providing such cover shall be deemed included in the Contractors rates. Only suitably qualified welders shall be employed.

Welding procedures used shall comply with ISO 15607 or EN 288-9 or AWWA C206.

Prior to deployment of any welder he shall have satisfactorily undergone an ‘approved testing’ in accordance with EN 287-1 or any other equivalent codes and certification thereof shall be provided to the satisfaction of the Project Manager’s Representative. Each welder deployed shall at intervals of not more than 6 months undergo similar approved retesting and only those who pass such retesting will be allowed to continue to undertake the in-situ welding works.

All testing and retesting will be deemed to be covered in the Contractors rates.

2.12.9. Proprietary Joints and Couplings

Proprietary joints and couplings shall be assembled in accordance with the manufacturer's instructions. The Contractor shall be responsible for obtaining, in advance of any jointing, copies of the manufacturer's instructions at his own expense and shall provide a copy for the Engineer.

The Contractor shall be responsible for obtaining all the necessary special tools, lubricants and appliances necessary for making the joints.

2.12.10. Flanged Joints

Flanged joints shall be made with the gaskets and nuts, washers and bolts provided. Two washers shall be used per bolt, one under the bolt head and the other under the nut. The tightening of the bolts shall be carried out in the sequence and to the torque recommended by the manufacturer. A torque wrench should always be used and in no case shall excessive tightening be exerted on any nut or bolt.

2.12.11. Protection of Joints

All buried flange joints shall be protected externally by painting with an approved bitumen paint and then the joint shall be wrapped using 'Denso' paste, mastic, tape and outer wrap, or similar approved materials all in accordance with the manufacturer's instructions.

All flange adaptors and mechanical couplings shall have a "Rilsan" nylon coating or similar approved protection applied by the manufacturer and no further external protection is required. Where the coatings of flange adaptors and couplings have been damaged in shipping, transport, handling or laying such damage shall be made good in accordance with the manufacturer's instructions.

The Contractor shall supply all tools and materials necessary for compliance with this clause.

2.12.12. Fixing Valves and Penstocks

Valves, penstocks and other fittings shall be securely fixed and where required extension spindles and headstocks shall be properly aligned and fixed in vertical position and valve caps shall be fixed securely using the locking nut. They shall be tested for ease of operation and water tightness. Any damaged protective coating shall be made good and they shall be left clean in all respects.

2.12.13. Thrust Blocks

Concrete thrust blocks shall be formed at bends, tees, tapers and valves in accordance with the typical sections shown in the Drawings or otherwise as directed by the Engineer. The additional excavation shall be made after the bends, etc have been jointed and the concrete shall then be placed with all possible speed. The back of supports and blocks shall abut on to solid undisturbed ground with all loose material being removed before concreting.

The concrete used for thrust and anchor blocks shall be Grade C15P or as shown on the drawings and after placing shall be kept in view for not less than six hours. No pressure shall be applied in any section of main until the concrete has had at least three day's curing.

Flexible joints shall not normally be cast into thrust blocks. However, where the size of thrust block makes this unavoidable, additional flexible joints shall be provided no greater than half the pipe diameter beyond each face of the block.

2.12.14. Anchor Blocks

Anchor blocks to prevent side slips shall be constructed where directed, and in accordance with details provided by the Engineer. Anchor blocks to prevent longitudinal slip shall be constructed where the slope of the pipe is greater than 1 in 10 or as otherwise directed by the Engineer.

External wrap to steel pipes shall be removed where the pipe is in contact with the concrete of the anchor block to ensure satisfactory bond between pipe and block. A strip 100 mm wide of pipe wrap shall be embedded in the concrete at the faces of the block to maintain the corrosion protection of the pipe.

2.12.15. Concrete Surround to Pressure Pipes

Where pipelines pass under streams and rivers or where directed by the Engineer, the section of pipeline under the stream or river and for minimum distance of 2.0 m clear on either side of the bank or edge thereof or such greater distance as the Engineer may direct shall be surrounded with Grade C15P concrete or as shown on the drawings so as to provide a minimum 150 thickness protective surround to the pipe.

Where concrete bedding, or bedding and surround to pipes is to be provided, the excavation shall be taken out to the proper depth to receive the concrete and pipes shall then be laid to line and level and jointed on precast Grade C20P concrete blocks or the strength as shown on the drawing bedded on the floor of the trench. When the pipes have been jointed the trench bottom shall be cleaned and the concrete for the bedding or bedding and surround, shall be carefully placed under and around the pipes. Special care shall be taken to pack the concrete solidly under the pipes throughout their length. All precautions shall be taken to avoid damage to the pipes during the placing of the concrete.

A clean break in any concrete bed, or bed and surround shall be provided for a flexibly jointed pipeline at each joint and shall be formed by inserting a vertical piece or pieces of fibre board or other approved material in the concrete at the pipe joint faces. Flexible couplings shall not be surrounded by concrete unless otherwise directed by the Engineer.

Such joints shall be wrapped and surrounded with well compacted granular bedding material.

Concrete beds, and beds and surrounds, shall be allowed to attain the specified 7 day strength of the concrete before any trench filling is carried out. In order to permit the earliest possible refilling of trenches in all roads, rapid-hardening concrete shall be used for this protection.

2.12.16. Commissioning of Pipelines

(a) General

The rates for installation of pipelines shall include the cost for cleaning (and sterilising in case of water pipes) of pipelines, including the supply of labour, water, any equipment and all materials necessary to complete the work to the satisfaction of the Engineer, including second and subsequent operations, should they be necessary.

(b) Cleaning of Pipelines

All pipelines shall be cleaned by intensive flushing with water to remove all dirt or debris.

(c) Sterilising Water Supply Pipelines

- The water supply pipelines shall be sterilised, after final pressure testing operations have been completed, by filling them with chlorinated water containing at least 5,0 mg/l of free chlorine. Filling of the mains shall be through a metered connection from an existing main. Liquid calcium hypochlorite solutions shall be used for disinfection, subject to the approval of the Engineer.
- The chlorinated water shall remain in the pipeline for a period as directed up to 24 hours. All valves in the system shall be operated at least once during this period.
- Chlorine residual tests shall then be taken at various points along the pipeline. The chlorine residual shall not be less than 2 mg/l. Should the residual at any sampling point fall below this figure, the sterilisation process shall be repeated until no residual falls below 2 mg/l.
- The Contractor shall dispose of the waste chlorine solution in such a manner so as to avoid the pollution of natural waters, streams, reservoirs or natural watercourses.

Then follows the flushing of the sterilised pipelines. The Contractor shall submit his proposed method of disposal of the solution to the Engineer for his prior approval.

2.12.17. Marker Posts

Precast concrete marker posts as detailed on the drawings shall be erected along the line of buried pipelines at intervals and locations as directed by the Engineer and at all gate valves, air valves, hydrants, washouts and changes in direction. Plates shall be fixed to the posts annotated as shown on the drawings and numbered consecutively.

2.12.18. Connections to Existing Pipework

(a) General

The Contractor shall be responsible for connecting pipework laid under the Contract to existing pipework, including detail design of related works and specification of required materials.

The Contractor shall prepare in detail both a program of the work and a schedule of the materials to be used in the work and shall obtain the approval thereto of the Engineer not less than 72 hours before the commencement of the work. The program shall allow for the immediate recommissioning of the existing pipeline as soon as the pipework connections have been satisfactorily completed.

The Contractor shall be responsible for locating the exact line, level and dimensions of the existing pipework and shall agree with the Engineer the precise location of the connection or blanking-off.

(b) Materials

The Contractor shall be responsible for checking the outside diameter of the existing pipework and ensuring that the couplings to be used for making the connections to the existing pipework and the materials used for blanking-off existing pipework are dimensionally suitable. This shall be done by measuring the diameters of pipework and couplings with calipers.

The Contractor shall ensure that all the materials are on site not less than 48 hours before the commencement of the work and shall inform the Engineer not less than 24 hours before the commencement of the work who shall check the materials against the schedule as approved where he deems this necessary.

Any special fittings which are required to carry out the work shall be fabricated under the Engineer's supervision and shall be hydrostatically tested to at least one and a half times the maximum working pressure.

(c) Preliminary Work

The Contractor shall execute all works possible before the commencement of the operation, which shall include:-

(1) Excavation and supports to the excavation.

(2) Blinding with concrete the immediate working areas, but not less than the whole of the bottom of the excavation.

(3) Putting in all drains, or where this is not possible a sump of adequate size from which a pump may operate.

(4) Casting the floor of any chamber which is later to be constructed around any of the works.

(5) Casting the thrust blocks or any other works which may be required by the Engineer.

(6) Exposing and cleaning pipes in readiness for the work.
The Contractor shall complete these works at least 48 hours before commencing the connection or blanking-off and have such works approved by the Engineer not less than 24 hours before the commencement of the connection or blanking-off operation.

(d) Equipment

The Contractor shall prepare a schedule of the equipment which he proposes to have on site either to use, or on standby, or for emergency use and shall obtain the approval of the

Engineer not less than 48 hours before the commencement of the work.

Such equipment shall include:

(1) Excavation equipment

(2) Cutting equipment

(3) Lifting equipment

(4) Pumping equipment (unless a drain is provided)

(5) All tools needed for erection and assembly of the equipment

(6) Safety equipment.
The Contractor shall ensure that all the equipment is on site not less than 24 hours before the commencement of the work and shall inform the Engineer who shall check the equipment against the schedule as approved where he deems this is necessary.

(e) Carrying out the Work

The Contractor shall be responsible for emptying the section of existing pipework on which the work is to be carried out, by a method approved by the Employer and the Engineer.

The Contractor shall take any special precautions necessary to prevent dirt and other foreign matter entering the existing pipelines.

When the Engineer is satisfied that the work is ready he shall give notice that the main is to be recommissioned. When this has been satisfactorily accomplished, the Contractor may dismiss his staff on the verbal instruction of the Engineer.

Within 48 hours of the completion of the work the Contractor shall complete all permanent works required to support the Plant installed during the operation and shall, subject to the requirements of any other clause of the Specification, remove all temporary supports within a further 48 hours after the permanent support works have been approved by the Engineer. The temporary supports shall not be removed before such approval has been given.

2.12.19. Tape Wrapping of Pipes, Valves and Fittings

Where instructed by the Engineer or shown on the drawings, the Contractor shall wrap all buried steel pipe and fittings in the affected lengths of pipeline route by applying a Tape Wrapping System.

If the Engineer requires, the pipe, fitting, and vale can be wrapped by proper tape that is instructed by the Engineer.

All stages of tape wrapping shall be carried out fully in accordance with the supplier's recommendations as approved by the Engineer, and shall be suspended whenever the work is not protected from moist air or precipitation, when dew forms on prepared surfaces or the ambient temperature is outside the limits set by the supplier.

No flames shall be permitted on Site in places where primer or tape is being applied.

Tape shall be applied free of rucks and unevennesses by use of an approved mechanical device which maintains the required tension, achieves a regular overlap of 50% of tape width on pipe barrels, and picks up the release paper on a separate spool.

Tape wrapped pipes shall be carefully moved and stored so that no damage occurs to the applied tape wrapping or the pipe itself before it is finally placed in the trench and jointed.

When all joints have been made, fittings and valves installed, and the pipeline has been tested, but before any backfill is placed (other than fill which is essential to restrain the pipeline during testing) the sockets, unwrapped lengths of spigots, fittings and buried valves shall be made conformable with mastic filler and then wrapped by hand using the petrolatum-impregnated fabric or other materials supplied for this purpose. Care shall be taken that the parts to be wrapped are clean, dry and properly primed, and that the wrapping materials are not contaminated by any soil, water or other material present in the trench or on the operative's hands, gloves or any tools he may use. The hand-applied wrappings shall be placed with at least 50 m overlap on machine-applied tape.

2.12.20. Warning Tiles and Tapes

The pipework including the rising main of the pumping station shall be covered with a warning tape. Tape nominal dimensions shall be 100 mm wide and 0.15 mm thick. The tape shall be made of pigmented low density polythene. The tape shall be la-belled with 40 mm high letters in English and local lanquage stating "DANGER - PRESSURISED PIPING".

2.12.21. Handling and Transport of Pipes and Fittings

The loading, unloading and handling of pipes and fittings shall be carried out using ropes, cranes, lifting beams and slings of approved design, strictly in accordance with the recommendations of the manufacturer and to the approval of the Engineer. Particular care shall be taken at all times to avoid damage of any kind. The use of lifting hooks is not permitted.

The protective cover, discs, etc provided by the manufacturer shall not be permanently removed until immediately prior to installation.

When pipes are loaded for road transport they shall be carefully handled to prevent damage to the coating. When more than one tier of pipes is transported, intermediate cradles shall be used. Pillows shall be provide between lashing (ropes, wires or chains, etc) and the pipes. All cradles and lashings shall be of such widths as to prevent damage to the coating of the pipe, or distortion of the pipes.

All valves shall be handled with care and shall always be transported on timber packings and where possible in the original shipping packing.

In the event of any damage being caused, the Contractor shall be liable for the cost of all repairs or replacements and the costs of any delays. The Engineer shall determine whether the damage shall be repaired (and if it is to be repaired, the manner of such repair), or the damaged piece replaced.

2.12.22. Storage of Materials

The Contractor shall store pipes, fittings and other materials only at places approved by the Engineer and shall at all times provide adequate supervision and, when no activity is in progress at such areas, a watchman to prevent theft or damage. Any damage or theft incurred shall be the Contractor's responsibility.

Pipes shall not be stacked higher than recommended by the manufacturer nor higher than two tiers without the approval of the Engineer. The area on which the pipes are to be stacked shall be free draining. Grass or other vegetation shall be kept cut and suitable timber or cradles shall be provided on which the pipes shall be laid. Secure end stops to all stacks shall also be provided.

Fittings and valves shall not be stacked more than one tier high and they shall be supported off the ground by suitable timbers.

Air valves, rubber joint rings, gaskets, bolts and similar fittings and materials shall be kept in approved locked premises and such fittings and materials shall not be distributed to the trench side until immediately prior to laying, fitting, jointing or assembly thereof. All bolts, nuts, washers, rubber joint rings and gaskets must be stored in a cool location within an approved building. All other fittings and materials shall at all times be stored in the shade under cover and protected from the weather damage and contamination to the satisfaction of the Engineer.

The Contractor shall take any necessary precaution to prevent fire in the storage areas and shall provide and maintain fire breaks and other precautions. He shall also ensure surfacing and drainage of the pipe and valve stockpiling areas so that delivery and handling vehicles can always operate and flood water does not enter the materials.

2.12.23. Stringing of Pipes

Pipes shall be handled and transported. Where pipes, fittings or any other materials are laid out on the site adequate personnel shall be provided to guard and protect them from damage or contamination.

Pipes shall be placed on suitable pillows or other supports approved by the Engineer. End caps shall not be removed until such time as the pipe is to be inspected and laid.

At places where the pipeline route crosses roads, tracks or any other access, and where directed by the Engineer, the Contractor shall so deposit the pipes so that access to the public is not in any way prohibited. Where the pipeline crosses any field or other place frequented by people or livestock similar provision shall be made.

The Contractor may be prohibited from using certain roads and other tracks for the purpose of stringing on account of adverse weather conditions and no extra cost he may incur on this account or for any other road restriction, delay, or any other thing which increases the cost of his haulage will be allowed. The Contractor should note that such restrictions may be imposed due to dust in dry weather, as well as road damage due to wet weather.

2.12.24. Testing of Pipelines

(a) General

Testing for joint leaks shall be performed unless otherwise specified by the purchaser. All welds shall be visually inspected prior to any nondestructive testing, in accordance with ANSI/AWS D1.1, Section 6.14.5, Table 6.1, Visual inspection acceptance criteria for statically loaded nontubular connections.

(b) Hydrostatic test

Tests for leaks in all types of completed welded joints shall be made by hydrostatically testing the entire pipeline, unless the procedures, frequency of tests, and standards for acceptance or rejection of an alternative non-destructive method are approved by the purchaser. If leakage exceeds the amount allowed in the purchaser's specifications, leaks shall be located and weld repaired.

(c) Alternative test

In lieu of the hydrostatic test, the purchaser may approve nondestructive testing of welded joints.

(1) Field-but joint

This joint may be tested by 100 percent radiograph of 10 percent of the joints, using methods and acceptance criteria in API Standard 1104 or Ultrasonic Examination.

(2) Lap joint

Radiographic testing of lap joints shall not be done because of the difficulty inherent in interpreting the results.

Single-welded lap joints may be tested using magnetic particle testing procedures and acceptance criteria as set forth in ANSI/AWS D1.1, Section 6.14.5, Table 6.1 Double-welded lap joints can be tested by shop drilling and tapping for 1/8 in. (3.2 mm) or 1/4 in. (6.4 mm) national pipe thread in the lap or bell end of the pipe.

Apply 40 psi (246 kPa) of air, or other satisfactory gas, into the connection between the two fillet welds.

Paint the welds with a soap solution. Mark any leaks indicated by the escaping gas bubbles.

Close the threaded openings with pipe plugs or by welding them.

(d) Water Pressure Test and Inspection

(1) Water Pressure Test Method

a) Before injecting water for the water pressure test, any pipeline movement during the test should be prevented by refilling the pipeline temporarily

b) Water injection into the pipeline should be done slowly while removing air from inside the pipeline. Smooth air removal should be checked during the water filling as well as any pipe problem. If water leaks at a certain point, it should be appropriately blocked.

c) Residual air in the pipeline should be removed by keeping water filled pipeline at least for 24 hours. Pay special attention to ensure that the lining such as cement mortar is sufficiently saturated before the water pressure test. Standard pressure is maintained for 24 hours to check any problem on the pipeline, and the amount of leakage during the test period is measured.

d) The allowable leakage rate is about 50 to 100l/day per 1 km in case of socket joint pipeline with a diameter of 10 mm as the standard though it may differ depending on type, diameter, and joint method of pipeline.

e) If the above procedures from (1) to (4) are not feasible, the test may be substituted by a pressure hold test.

(2) The pressure hold test can detect pipeline defects or leakage condition by applying pressure to a section of pipeline with a length of about 300 m, which is confined by water control valves or blind flanges, up to the operation pressure, followed by summarizing the pressure change along time in graphs or by reviewing pressure reduction with a electromagnetic recording instrument. The results for about 10 hours

at a pressure of 0.5 MPa (N/mm2) are analyzed.

(3) Test with Hydraulic Tester

a) In case of a joint of cast iron pipe with a diameter of 800 mm or larger, the water pressure test is done inside each joint with a test band in the presence of the Supervisor in principle.

b) For the test band test, the test pressure should be maintained for more than 5 minutes at 0.5 MPa (N/mm2) or above while the water pressure shall not drop below 0.4 MPa (N/mm2). If the pressure is decreasing, it should be reconnected for a new pressure test.

c) Procedures of general pressure test are as follows:

1) After filling the test section with water and leaving it as is for more 24 hours, pressure is applied slowly up to the standard pressure.

2) When the standard pressure is maintained for one hour, the pressure drop shall not exceed 0.02 MPa (N/mm2).

3) When water is supplemented to keep the standard pressure, the leakage rate shall not exceed 1l for the pipeline having a diameter of 10 mm.

4) Before injecting water for the water pressure test, any pipeline movement during the test should be prevented by refilling the pipeline temporarily

5) The pressure test shall be carried out with an interval of 200 mm, and it is recommended to be done in between water control valves.

(e) Radiograph Test

(1) General

a) Radiograph test is carried out at points that the Supervisor requires, and two pictures are taken per point.

b) The shooting point shall be each cross point of welded portion in principle.
However, the Supervisor may designate specific shooting point.

c) The length of each film should be 250 mm or longer, and the radiograph picture is inspected as negative film.

d) If the pipeline has a small diameter so that human cannot enter into it, the test shall be carried out according to the Non-destructive Test of Welded
Section of Pipeline), one-sided picture taking for dual wall.

e) The entire radiograph pictures (negative films) should be arranged with indication of shooting location and submitted to the Supervisor after completing the inspection.

(2) Judgment Criteria for Radiograph Test

Defects on the welded portion shall be judged by BS.

Type 1 defects and Type 2 defects above level 3 shall be considered normal.

(f) Ultrasonic Flaw Detecting Test

(1) General

a) The number of test per one pipe shall be two, and the specific location shall be designated by the Engineer. The standard test length for one location is 30 cm.

However, the number and the length of test may be expanded if the Supervisor recognizes the necessity.

b) Before conducting the test, specific test methods, process, and ways of report preparation shall be approved by theEngineer.

(2) Judgment Criteria for Ultrasonic Flaw Detecting Test

a) Ultrasonic flaw detecting test for the welded joint in the site shall be done according to Comprehensive Ultrasonic Flaw Detecting Test Method Employing Purse Reflection Method on Metal Material related to BS.

b) Defects are determined according to the distinguishable defect indication lengths, which are further divided to A, B, and C values as shown in Table (a) as well as the magnitude areas of echo as shown in Table (b). However, the evaluation shall be made considering following aspects.

1) When an interval of two or more defects, which are assumed to exist at the same depth, is less than a certain defect length, the defect length shall be determined as the interval length plus the defect indication lengths of those two or more defects.

2) The defect length yielded by the above method and another defect length shall be detected on more than two directions, and the bigger value shall become the defect length when those values are not the same.

Table (a) Distinguishing Defect Length in the Ultrasonic Flaw Detecting Test

Distinguishing Defect Length	A	B	C
Above 6 and below 18	6	9	18
10 or above	t/3	t/2	t

t : The plate thickness of main material. When the welding is done with different plate thickness such as angle butt weld, apply the thinner thickness.

Table (b) Defect Evaluation Points for the Ultrasonic Flaw Detecting Test

Defect Length	A or above	A or above to B or below	B or above to C or below	C or above
Area Ⅲ	1 points	2 points	3 points	4 points
Area Ⅳ	2 points	3 points	4 points	4 points

c : Standard for defect evaluation: It is assumed to be normal when the score is less than 3 points according to the preceding section ii) and when the total score for each welded area with a length of 30 cm is less than 5 points in the most densely welded area.

(g) Oxygen Compression Test on the Welded Area

(1) After completing welding works inside and outside the pipe, clean contaminants after completely cooling down, followed by attaching pressure meter on the test hole on a welding point.

(2) After attaching the pressure meter, open the cock of a pressure gas container slowly until the meter gauge indicates 1.5 MPa (N/mm2).

(3) Watch any leaking air for 1 hour while keeping the pressure at 1.5 MPa (N/mm2).
Any leaking point shall be re-welded after cleaning the surface, followed by retest.

(4) After airtight test is completed, remove the pressure meter, and weld the test hole.

(5) If the specified period of airtightness test cannot be observed due to field condition, it should be done according to the direction of Supervisor. For the sections with successful airtight test, take photo records at the portion while keeping the pressure at 1.5 MPa (N/mm2), followed by lodging treatment as directed by the Supervisor.

(h) Magnetic Particle Examination

(1) Scope

a) This procedure is to govern the continuous method of fluorescent magnetic particle & nonfluorescent color contrast magnetic particle examination using the AC Yoke for the steel structure, weldments, fittings, power boilers, pressure vessels and power pipings.

b) This procedure is applied to the items fabricated by welding with the ferromagnetic materials.

c) The materials, shapes, or sizes to be examined, and the extent of the examination shall be based on manufacturing drawing

(2) Surface Conditioning

a) Preparation

1) Satisfactory results are usually obtained when the surfaces are in the as-welded, as-rolled, as-cast, as-ground or as-forged conditions. However, surface preparation by grinding or machining may be necessary where surface irregularities could mask indications due to discontinuities.

2) Prior to magnetic particle examination, the surface to be examined and all adjacent areas within at least 1in. (25 mm) shall be dry and free of all dirt, grease, lint, scale, welding flux and spatter, oil, or other extraneous matter that could interfere with the examination.

3) Cleaning may be accomplished using detergents, organic solvents, descaling solutions, paint removers, vapor degreasing, sand or grit blasting, or ultrasonic cleaning methods.

b) Surface Contrast Enhancement
When nonmagnetic coatings are applied temporarily to uncoated surfaces only in amounts sufficient to enhance particle contrast, it must be demonstrated that indications can be detected through the enhancement coating.

c) If nonmagnetic coatings are left on the part in the area being examined, it shall be demonstrated that indications can be detected through the existing maximum coating thickness applied.

(3) Yoke Technique

a) This method shall only be applied to detect discontinuities that are open to the surface of the part.

b) Magnetizing Method
Alternating electromagnetic yokes shall be used.

(4) Calibration

a) Frequency of Calibration

1) Magnetizing Equipment

• Frequency
Magnetizing equipment with an ammeter shall be calibrated at least once a year, or whenever the equipment has been subjected to major electric repair, periodic overhaul, or damage. If equipment has not been in use for a year or more, calibration shall be done prior to first use.

• Procedure
The accuracy of the unit's meter shall be verified annually by equipment traceable to a nation standard. Comparative readings shall be taken for at least three different current output levels encompassing the usable range.

• Tolerance
The unit's meter reading shall not deviate by more than ±10% of full scale, relative the actual current value as shown by the test meter.

2) Light Meters
Light meters shall be calibrated at least once a year or whenever the meter has been repaired. If meters have not been in use for one year or more, calibration shall be done before being used.

b) Lifting Power of Yokes

1) Prior to use, The magnetizing power of electromagnetic yokes shall have been checked within the past year. The magnetizing power of permanent magnetic yokes shall be checked daily prior to use. The magnetizing power of all yokes shall be checked whenever the yoke has been damaged or repaired.

2) Each alternating current electromagnetic yoke shall have a lifting power of atleast 10Lb (4.5 kg) at the maximum pole spacing that will be used.

3) Each weight shall be weighed with a scale from a reputable manufacturer andstenciled with the applicable nominal weight prior to first use. A weight need only be verified again if damaged in a manner that could have caused potential loss of material.

4) Pole spacing with minimum 3 in. (75 mm) and maximum 8 in. (200 mm) shall be used.

c) Magnetizing Field Adequacy and Direction

1) Magnetic Field Adequacy
The applied magnetic field shall have sufficient strength to produce satisfactory indications, but shall not be so strong that it causes the masking of relevant indications by nonrelevant accumulations of magnetic particles.
Factors that influence the required field strength include the size, shape, and material permeability of the part; the technique of magnetization; coatings; the

method of particle application; and the type and location of discontinuities to be detected. When it is necessary to verify the adequacy of magnetic field strength, it shall be verified by using of the following methods;

• Pie-Shaped Magnetic Particle Field Indicator

The indicator shall be positioned on the surface to be examined, such that the copper-plated side is away from the inspected surface. A suitable field strength is indicated when a clearly defined line (or lines) of magnetic particles form(s) across the copper face of the indicator when the magnetic particles are applied simultaneously with the magnetizing force. When a clearly defined line of particles is not formed, the magnetizing technique shall be changed as needed.

2) Magnetic Field Direction

When a clearly defined line of particles is not formed in the desired direction, the magnetizing technique shall be changed as needed.

d) Wet Particle Concentration and Contamination

Wet Horizontal Units shall have the bath concentration and bath contamination determined by measuring its settling volume.

(5) Examination

a) Preliminary Examination

Before the magnetic particle examination is conducted, a check of the examination surface shall be conducted to locate any discontinuity surface openings which may not attract and hold magnetic particles because of their width.

b) Direction of magnetization

At least two separate examination shall be performed on each area. During the second examination, the lines of magnetic flux shall be approximately perpendicular to those used during the first examination. A different technique for magnetization may be used for the second examination.

c) Method of Examination

The ferromagnetic particles used in an examination medium can be either wet or dry, and may be nonfluorescent. Examination shall be done by the continuous method.

1) Dry Particles

The magnetizing current shall remain on while the examination medium is being applied and while any excess of the examination medium is removed.

2) Wet Particles

The magnetizing current shall be turned on after the particles have been applied. Flow of particles shall stop with the application of current. Wet particles applied from aerosol spray cans may be applied before and/or after magnetizing current is applied. Wet particles may be applied during the application of magnetizing current if they are not applied directly to the examination area and are allowed to flow over the examination area or are directly to the examination area with low velocities insufficient to remove accumulated particles.

d) Examination Coverage

All examinations shall be conducted with sufficient field overlap to ensure 100% coverage at the required sensitivity.

e) Application of Magnetic Particle

1) Dry Magnetic Particle

- Dry magnetic particles shall be applied in such a manner that a light uniform, dust-like coating settles upon the surface of the part while it is being magnetized.
- After application and before turning off current or interpretation, excess dry particles is removed by means of a dry-air current of sufficient force to remove the excess particles without disturbing any particles attracted by a flux leakage field that is indicative of discontinuities. This removal may be accomplished by bulb blowers.

2) Wet Magnetic Particles

Wet magnetic particles shall be applied either by spraying or flowing over the areas to be examined during the application of the magnetizing field current.

f) Excess Particle Removal

Accumulations of excess dry particles in examinations shall be removed with a light air steam from a bulb or syringe or other source of low pressure dry air.
The examination current or power shall be maintained while removing the excess particles.

g) Interpretation

The interpretation shall identify if an indication as false, nonrelevant, or relevant. False and nonrelevant indications shall be proven as false or nonrelevant. Interpretation shall be carried out to identify the locations of indications and the character of the indication.

1) Visible (Color Contrast) Magnetic Particles

Surface discontinuities are indicated by accumulations of magnetic particles which should contrast with the examination surface. The color of the magnetic particles shall be sufficiently different than the color of the examination surface. A minimum light intensity of 100fc (1000 Lux) is required on the surface to be examined to ensure adequate sensitivity during the examination and evaluation of indications. The light source, technique used, and light level verification is required to be demonstrated one time, documented, and maintained on file.

2) Fluorescent Magnetic Particles

The exception that the examination is performed using an ultraviolet light, called black light. The examination shall be performed as follows:

- It shall be performed in a darkened area.
- Examiner shall be in the darkened area for at least 5 min prior to performing the examination to enable their eyes to adapt to dark viewing.
  Glasses or lenses worn by examiners shall not be photosensitive.
- Black light shall achieve a minimum of 1000 ㎼/㎠ on the surface of the part being examined throughout examination.
- Reflectors and filters should be checked and, if necessary, cleaned prior to use. Cracked or broken filters shall be replaced immediately.
- The black light intensity shall be measured with a black light meter prior to use, whenever the light's power source is interrupted or changed, and at the completion of the examination or series of examinations.

h) Demagnetization

When residual magnetism in the part could interfere with subsequent processing or usage, the part shall be demagnetized any time after completion of the examination.

1) The initial field strength used during demagnetization shall be greater than the original magnetizing force.

2) When direct current magnetization has been employed, demagnetization shall be accomplished by repeatedly reversing and progressively decreasing the DC magnetizing current.

(6) Post-Examination Cleaning

a) When post-examination cleaning is required, it should be conducted as soon as practical using a process that does not adversely affect the part.

b) Typical post-cleaning techniques employed are :

1) The use of compressed air to blow of unwanted dry magnetic particle.

2) Drying of wet particles and subsequent removal by brushing, or compressed air.

3) Removal of wet particles by flushing with solvent.

4) Other suitable post-examination cleaning techniques may be used if they will not interfere with subsequent requirements.

(7) Evaluation of Indication

a) All indications shall be evaluated in terms of the acceptance standards of the referencing Code Section.

b) Discontinuities on or near the surface are indicated by retention of the examination medium. However, localized surface irregularities due to machining marks or other surface conditions may produce false indications.

c) Broad areas of particle accumulation, which might mask indications from discontinuities, are prohibited, and such areas shall be cleaned and reexamined.

(8) Acceptance Standards - (ASME 2005 Add.)

a) ASME Sec. A-260

1) Indication will be revealed by retention of magnetic particles. All such indications are not necessarily imperfections, however, since excessive surface roughness, magnetic permeability variations (such as at the edge of heat affected zones), etc., may produce similar indications.
An indication of an imperfection may be larger than the imperfection that causes it; however, the size of the indication is the basis for acceptance evaluation. Only indications that have any dimension greater than 1/16 in.(1.5 mm) shall be considered relevant.

- A linear indication is one having a length greater than three times the width.
- A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.
- Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.

2) All surface to be examined shall be free of ;

- Relevant linear indications;
- Relevant rounded indications greater than 3/16 in.(5 mm);
- Four or more relevant rounded indications in a line separated by 1/16 in. (1.5 mm)

or less, edge to edge;

b) ASME B31.1 136.4.3 - (2004 Add.)

1) Indication which is believed to be nonrelevant shall be reexamined to verify whether or not actual defects are present. Surface conditioning may precede the reexamination. Nonrelevant indications which would mask indications of defects are unacceptable.

2) Relevant indications are those which result from unacceptable mechanical discontinuities. Linear indications are those indications in which the length is more than three times the width. Rounded indications are indications which are circular or elliptical with the length less than three times the width.

3) An indication of a discontinuity may be larger than the discontinuity that causes it; however, the size of the indication and not the size of the discontinuity is the basis of acceptance or rejection.

4) The following relevant indication are unacceptable;

- Any cracks or linear indications;
- Rounded indications with dimensions greater than 3/16 in. (5 mm);
- Four or more rounded indication in a line separated by 1/16 in. (1.5 mm) or less, edge to edge;
- Ten or more rounded indications in any 6 sq in. (3,870 mm^2) of surface with the major dimension of this area not to exceed 6 in. (150 mm) with the area taken in the most unfavorable location relative to the indications being evaluated.
The Contractor should discuss and make decision of responsibility for the Electric power expense before operate the pressure testing of Pipelines and commissioning of water supply system with the Employer.

2.13. Land Survey, Ground Investigation, Physical Prospecting, and Survey for Condition of Location

2.13.1. Land Survey

(a) General

Every land survey shall be in conformity with the working rules of public survey.
The Contractor shall be equipped with certified land survey equipment to ensure accurate survey in the field.

Surveyors shall be approved by the Supervisor, and the Contractor shall arrange the relevant personnel for smooth land survey performance.

The Contractor shall establish a land survey work schedule in advance of the survey, followed by approval of the construction supervisor.

The Contract shall perform the design confirmation survey among construction surveys to identify any discrepancy in the design documents within 30 days after the construction commencement, followed by submitting relevant documents to the construction supervisor.

The submittals include results of datum and auxiliary point surveys (a pocket register, a calculation book, and a performance chart); pocket books, drawings, and quantity calculation books (calculation of earth volume) of longitudinal and cross sections; and other products designated by the construction supervisor.

The Contractor shall carry out a construction survey for position measurements per process in this project before construction, followed by approval of the construction supervisor.

The submittals include a book of coordination system for the servey positions and a pocket register.

The Contractor shall carry out an inspection survey for the construction locations after the completion of each process in the project, followed by approval of the construction supervisor. The submittals include a book of coordination system for the construction locations and a pocket register.

The Contractor shall maintain the points of datum and surveying facilities for the construction until the construction completion as well as relevant survey products.

Every survey product relevant to this construction shall be signed and sealed by the head surveyor, including survey products for construction, inspection, and completion (pocket registers, calculation books, performance charts, and relevant documents), followed by submitting them to the construction supervisor.

Every accuracy or tolerance shall be determined by the construction supervisor according to the working rules in public survey and considering accuracy requirements for the construction.

The survey datum point shall be based on Topographic Bench Mark Point installed by Malawi governmental organizations.

The plane coordinate system shall be determined as Plane Rectangular Coordinates (TM system) or Global Coordinate System after consulting with the construction supervisor.

(b) Field Survey for Route

Field survey shall be carried out before the route survey along the scheduled route.

For effective survey performance, the field survey shall grasp conditions of survey obstructions, planimetric feature and shape, and traffic means first, and relevant data shall be collected and recorded.

An execution plan for detail surveying shall be established based on the data from the field survey. The work schedule for the survey may be modified if necessary.

The execution plan for detail surveying shall be submitted to the construction supervisor for approval. The submittals include the longitudinal and cross section drawings, relevant drawings and the details of plan such as the scale, the survey methods, and mobilized personnel and equipment.

(c) Selection of Points

Measurement points shall be determined appropriate to the topography of area considering efficiency, convenience, and accuracy of the construction survey as well as maintenance of the datum point and auxiliary points.

The measurement points shall be determined at locations with solid ground and observation convenience while not being interrupted by any natural disaster or traffic flow.

The interval between measuring points shall be distributed uniformly, and the calibration among the points shall be carried out adequately.

(d) Installation of Survey Datum Point

(1) Altitude Reference

The altitude references in the field shall be installed with an interval of about 500 m including the starting and ending points of the route.

The survey method for the altitude references is an amalgamation or combination. It shall start from a nearby Topographic Bench Mark Point installed by a Malawi governmental organization while being amalgamated or combined with another official Topographic Bench Mark Point. However, in case of an amalgamation of Topographic Bench Mark Point installed by a Malawi governmental organization, the bench mark shall be amalgamated with another one to ensure reliability.

(2) Horizontal Control Point

The Contractor shall install more than two horizontal control points at starting and ending point of the construction site (route). If the route is long, additional horizontal control points shall be installed with an interval of 500 m.

The horizontal control point shall be determined by GPS survey, triangular survey, trilateration, and traverse survey with a minimum of three national triangular stations.
In case of the traverse survey, the fixed traverse method shall be used, starting from one base line and joining with another one. The construction supervisor determines other matters according to the accuracy requirement of construction.

Public datum points have been installed for this project. They shall be confirmed by methods specified above Item before using.

The horizontal control points shall be installed at a convenient location, as specified in Section 3.3 in this Specification, in that accessibility is relatively good on solid ground without any obstructions against using equipment such as GPS equipment.

(3) Datum point for semipermanent marker

The Contractor may install and operate datum points of semipermanent marker for the convenience of construction implementation.

However, the location and the survey performance chart for the datum points shall be approved by the construction supervisor before using them.

Datum point for semipermanent marker shall not be used for a prolonged time period more than three months. However, prolonged use of them may be granted when they are proven to be appropriate by re-inspection survey with an approval of the construction supervisor.

(4) Signs for the survey datum points

Altitude references and horizontal control points Altitude references and horizontal control points shall be installed at locations without modifications during construction on solid ground while calibration can be done appropriately. The size, shape, and material for the signs are determined after consulting with the construction supervisor.

Datum points for semipermanent markers The materials and sizes of the datum point stakes for semipermanent markers in the construction site shall be in conformity with the standards shown in Table (a).

(5) Maintenance of datum points or etc.

The Contractor shall specify the installed datum points (for horizontal control and altitude reference) on the drawings, and the survey results shall be reported to the construction supervisor. However, the datum points (for horizontal control and altitude reference) may be installed outside the construction site if necessary with an approval of the construction supervisor.

The Contractor shall maintain the datum points from the initial construction to the completion.

Table (a). Materials and sizes of the datum points for semipermanent markers

Classification	Material	Color	Size (cm)
BC and EC stakes	Wood or plastic	Blue	4.5×4.5×45
IP stake	Wood or plastic	Blue	6×6×60
Center stake	Wood or plastic	Red	4.5×4.5×45
Semi-permanent marker stake	Wood or plastic	White	9×9×75
Stake for longitudinal change point	Wood or plastic	Red	4.5×4.5×45

Horizontal control points and altitude references installed at site shall be marked by an easily distinguishable way, followed by installing protection. A report containing pictures of surroundings shall be prepared and submitted to the construction supervisor for approval.

The report of point shall specify the survey product in details including the time of installation (installer), time of survey (surveyor), address of the point, and overview and specification of the point.

When reinstallation of a datum point is required due to partial loss or damage of the point or ground displacement or an obstruction, the Contractor shall immediately stop using the datum point and report the condition to the construction supervisor for approval of the reinstallation.

The maintenance of reinstalled datum point shall be carried out in an identical way with the existing ones.

(e) General Detail Survey

Following matters shall be checked for detail surveying.

(1) Survey methods, personnel, and equipment shall be secured to satisfy the required accuracy.

(2) Personnel arrangement chart for the surveying shall be prepared.

(3) Survey instrument and equipment shall be inspected and calibrated.

(4) Necessary material for the survey shall be purchased.

(5) Permits and licenses shall be acquired to access the survey sites.

(6) Consultation between relevant authority and the owners shall be done in advance of woods logging and survey obstruction removal.

Expression of calculation during surveying such as coordinates shall be in conformity with the standards specified in Table following.

The tolerance in observation and calculation shall be determined by the construction supervisor according to the working rules of public survey and considering the accuracy requirement of construction.

Classification	Direction Angle	Distance	Altitude	Coordinate Values	Area	Volume
Unit	Sec.	m	m	m	m^2	㎥
Decimal points	1	0.001	0.001	0.001	0.01	0.01

(f) Installation of a Point of Intersection (IP Point)

The existing detail surveying products shall be used. More, IP points are surveyed and installed by GPS or Total Station (T.S.) equipment, Deodolite, and Electronic Distance

Measurement using the installed datum points (for horizontal control and altitude reference) in site.

IP points shall be directly surveyed and installed in site considering surrounding conditions, and the materials and size for the stake shall be in conformity.

However, a referring point may be installed and used at locations that IP point installation is obstructed.

(g) Surveying Center-line

Center-line survey shall be carried out in the site according to the existing detail design document, and a numbered stake shall be installed rigidly in the site. However, a hardware or paint shall be used to indicate the center-line at locations that stake installation is impossible due to a structure or pavement with an advance approval of the construction supervisor.
The interval between measurement shall be 20 m, and plus stakes shall be installed at critical points for the construction such as longitudinal or cross-sectional changing points, a structure installation point, and starting and ending point for a curve (starting and ending point for an easement curve). However, the interval of measurements for a river center-line surveying may be adjusted after consulting with the construction supervisor.
The standards for stakes to be installed at each measurement point shall be according to Table.
Distance measurement shall be accurately done using Electric Distance Measurement (light or electromagnetic wave), T.S. equipment, or GPS. However, a steel tape may be used for measuring a short distance less than 50 m.

(h) Installation Surveying for Temporary Bench Mark

Temporary bench marks (TBM) may be installed at the field, and the altitude of TBM is determined for use by surveying it from an existing altitude reference. However, when a distance mark is available for a river or etc., it may be used as TBM with approval of the construction supervisor. The distance mark shall be surveyed from the altitude reference for confirmation.

A rigid structure may be used to indicate TBM, or a temporary stake for TBM may be installed.

A report of point shall be prepared when TBM is installed, and it shall be kept in the field.

(i) Longitudinal Leveling

Longitudinal leveling determines the altitude of center-line based on the installed measurement point on the center-line as well as center, plus, and referring stakes installed at critical points

Longitudinal leveling is carried out as a direct leveling considering topography and surrounding conditions. In case of an unavoidable case, indirect leveling may be carried out with approval of the construction supervisor.

When the observation point starts from a TBM, the reliability of performance shall be ensured by joining it with another TBM or an altitude reference.

The longitudinal change point and locations of critical structures should be determined by measuring distances from the center point.

The stake for longitudinal change point shall be installed at the longitudinal change point.

In case that stake installation is impossible, it may be indicated by paint or a hardware product.

(j) Cross Leveling

The left and right ranges of cross leveling shall exceed the lot boundary, and they need to be approved by the construction supervisor.

Cross leveling measures heights at altitude changing points or distanced from the center stake that perpendicular to the center-line in the right and left directions at the location of center stake installation.

The ground altitude is measured during a cross leveling by a direct leveling or an indirect leveling depending on the topographic conditions. However, the cross leveling is conducted across a river or on the coast, an appropriate method shall be employed. In those cases, surveying methods other than the direct leveling shall acquire an approval from the construction supervisor.

The scale, drawing standards, and preparation method shall be approved by the construction supervisor when drawings for the longitudinal and cross leveling are prepared based on the surveying.

(k) Surveying Cross Structure

A cross leveling shall be carried out to check whether a cross structure is in line with a water channel or a road direction in its design of inflow and outflow gates or not.

The range of this cross leveling shall exceed the public work's boundaries over 50 m, and it can be extended depending on the topographic conditions. Especially for drainage plans, drainage potential to the terminal draining point shall be confirmed.

A detailed construction drawing shall be prepared in a way that an access road or a water channel confluence is in line with the local topography, considering the results of cross leveling and surrounding topographic conditions.

Other scopes of inspection for critical structures are to be determined by the construction supervisor.

(l) Surveying Underground Facilities

A map showing underground facilities in the construction site shall be prepared for approval by the construction supervisor.

Consultation or permit shall be acquired with the relevant authorities for excavation, move, or modification of the underground facility.

Accurate location of underground facilities accompanied with the construction shall be directly surveyed and stored after acquiring approval from the construction supervisor in advance of refilling or pavement of them. (m) Surveying for Sign Post Installation of Lot Boundaries

Surveying for sign post installation of the lot boundary shall be carried out on the center-line, which is originated from the center point, to determine coordinates of stake points for lot boundary through valid methods, like a radiation method, in order to install the boundary posts.

Boundary line is marked on an obstructive object located on the boundary of the lot by paint or a sprayer according to the boundary survey.

The sign post installation of the lot boundary is done for an interval of 200 m on flat land, 50 m for curved section, and at every pole figures in a mountain or sections with intensive changes regardless of the distance in order to make clear lot boundaries of the road and supplementary road facilities.

Following table that specifies the standards for sign post installation of the lot boundary.

Material	Length	Width (one side)	Above the ground	Under-ground	Back-gound color	Letter mark
Resign	75 cm	10 cm	25 cm	50 cm	Black	White (sunk relief)
Concrete	75 cm	10 cm	25 cm	50 cm	Concrete color	Black (sunk relief)

(n) Arrangement of Survey Products

The survey products shall be arranged according to the following table.

Classifi-cation	Datum point Survey	IP install-ation Survey	Center-line Survey	TBM Installa-tion survey	Longit u-dinal leveling	Cross structure undergro -und facility surveys	Struc-ture Survey	Survey for comple-tion	Survey for lot bounda ry
Pocket register	○			○	○	○	○		
Survey calculation	○	○		○	○		○	○	

book									
Relevant drawings	○	○	○		○	○	○	○	○
Coordinates record book	○			○	○				○
Performance chart	○			○	○		○	○	
Map for referringpoint manage-ment		○	○	○					
Numeric figure file								○	

2.13.2. Ground Investigation

(a) General Scope

This specification is intended for applying to ground investigation to acquire necessary ground information for design and construction of the project. BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

(b) General Affairs of Investigation and Test

The ground investigation during construction shall be carried out in a way that provides overall required data for design confirmation or changes. When a deformation or damage occurs to the structure or when the safety of structure is assumed to be jeopardized due to changes in the surrounding conditions, the ground investigation shall be carried out to find the cause and to prepare measures against the situation.

Tests shall be carried out by qualified engineers for the quality test/inspection or equivalent personnel having the identical experience and capacity, followed by confirmation with the construction supervisor.

When any personnel for the investigation or test need to be changed, it shall be approved by the construction supervisor.

Soil test shall be carried out immediately after sample collection.

If any significant changes in the sample transported into the laboratory is identified or if a test fails or if the sample is insufficient, the situation shall be immediately reported to the construction supervisor before recollecting the sample.

When a collected sample is assumed inappropriate for a certain test, the test shall be stopped by the direction of construction supervisor, or retest shall be carried out after recollecting the sample.

When a test required a prolonged period of time, a supplementary device shall be employed to ensure the accuracy of test results.

A inspection location shall be determined after acquiring approval of the construction supervisor, and its location, depth, and altitude shall be measured accurately. However, geodesy engineers or equivalent personnel shall carry out an investigation with precise survey requirement, followed by confirmation with the construction supervisor.

Type, number, and location of test including in-site tests shall be determined in collaboration with the construction supervisor. Purpose and progress of the test may be modified depending on the local condition after acquiring approval of the construction supervisor

Test agent may conduct a test by acquiring approval of the construction supervisor to promote safety and effective test implementation. As a phase in the test is completed, it should be reported to the construction supervisor stepwise.

Every test shall be conducted in the presence of the construction supervisor. However, if it is not possible, a report for the procedures shall be made and submitted to the construction supervisor before the test, and the purpose of test shall be fulfilled.

Test results shall be prepared in documents, and a relevant report shall be prepared and submitted to the construction supervisor. The report needs to be prepared in A4 size, and pictures showing test procedure shall be attached to it.

The Contractor shall prepare measures to minimize public nuisance when conducting a site quality management test

(c) Surface Geological Survey

Surface geological survey is intended for supplementing existing investigation by grasping overall topography, geological features, rock quality, soil, and ground water.

A geological feature structural map is prepared for faults, flexures, and joints while potential of geological disaster shall be assessed by investigating rock distributions and properties.

During the surface geological survey, following matters shall be indicated on an engineering geologic map, and it shall be submitted to the construction supervisor.

(1) Surface ground: Surface soil, weathering soil, types of sediments (river sediment, alluvial fan deposit, terrace sediment, collapse deposit, and ejecta of volcano) and their distribution, constitutions, thickness, crystalline degree, moist contents, permeability, and mobility

(2) Rock condition: Types of rock, grain size, arrangement of rock forming minerals, pore condition, metamorphic and aeration grades, stratification bedding, foliation, and etc.

(3) Geological structure: Geological distribution, stratification of strata, strike and slope, fault, flexure, joint, crushing zone, alteration zone, and etc.

(4) Underground cavity: Natural cavity (limestone cavern), mine, closed mine, mine in the past, and etc.

(5) Behavior of bedrock: Existence of expansible or movable bedrock and its distribution, existence of potential bedrock collapse due to spring water, and potential of uneven pressure

(6) Surface and ground water: Flow condition of surface water, condition of ground water, water temperature, water quality, constitution of aquifer, level of ground water, relationship between aquifer and geographic feature, and condition of spring water

(d) Soil Test

(1) Preparation of sample

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) Samples for a dynamic test shall be prepared especially carefully not to allow being scattered or moisture evaporating.

c) A test specimen shall have a minimum weight at least for single test.

d) If a sample introduced in the laboratory is considered being scattered or altered such as moisture evaporation, the sample shall be recollected for the test.

(2) Mechanical analysis of soil

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) The temperature/pressure chamber shall not cause any vibration to the water tank. The Contractor shall prepare measures to minimize public nuisance when conducting a site quality management test

(3) Tests for the liquid and plastic limits of soil and coefficient of contraction

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) With an approval of the construction supervisor, a test may be conducted with a natural moist content or a dry condition similar to it. The test conditions shall be recorded in the test log.

(4) Test for Soil Moist Content

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) The representative sample shall be prepared from the core that has not been dried at all.

c) The natural moist content of the transported sample in the laboratory shall be carried out first, and the identical scale shall be used for the soil moist content.

d) The Contractor shall confirm the safety of equipment before the rapid moisture measurement using radiation, and the inspection to the equipment shall be done in the presence of the construction supervisor.

e) The Contractor shall prevent any equipment move or radiation leakage during test.

(5) Test for specific gravity of soil

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) The weight of the specific-gravity instrument shall be measured together with the stopper at all time. The specific gravity is determined as the average of two or more tests while test shall be redone if the deviation of two specific gravities is more than 0.03.

(6) Engineering classification methods of soil

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) The constitution system of soil, which includes the grain property, liquid and plastic limit, and mineral and organic mineral components by laboratory measurements, shall be expressed according to a general classification method

(7) Test for soil compaction

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) In case of test for viscous soil, the dryness of test sample should be checked by the construction supervisor. The moist contents before the test shall be recorded in the test log.

c) The guides of rammer shall be located on the sample surface at all the time while preventing any friction in between the guide and rammer.

d) After compaction, test shall be redone if the thickness of first layer is significantly different to the rule.

e) A minimum of 6 measurements are required for the moist content curve.

f) A new sample shall be used for every test (non-repetitive method) if moisture increase is not applicable for the sample such as clay or if the sample is fragile.
Relevant results should be recorded.

g) When a test is carried out while reducing the moisture content of sample, it should be approved by the construction supervisor.

(8) Soil CBR test

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) A screw jack shall be used as the loading equipment in the test.

(9) Unconfined compression test

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) Strain-controlled type device shall be used for the test.

c) Loading shall be continued until the deformation rate reaches 15 % or above though no clear sign for demolition is identified.

d) Reshaped sample by kneading shall be wrapped by a sheet of vinyl to prevent any change in moisture content, and knead it manually again on the desk while rotating it bit by bit. The manual kneading shall be done more than 300 times.

(10) Tri-axial soil compression test

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) Loading shall be continued until the axial deformation rate reaches 15 % or above though no clear sign for demolition is identified.

(11) Soil consolidation test

a) BS or other equivalent test standards may be employed after consulting with the

Employer and the Supervisor.

b) The consolidation test determines the deformation degree and time while load is applied to it allowing drainage on the axial direction and blocking one side of soil

c) Rowe cell consolidation and permeability test

1) When a major deformation of soft ground is anticipated and when a ground improvement is carried out by horizontal drainage, it shall be conducted parallel with conventional oedometer test in order to determine consolidation properties.

2) The diameters of sample can be 75 mm, 150 mm, or 250 mm. Appropriate diameter shall be determined considering the soft ground improvement and ground purpose for the test.

3) When ch (Rowe cell consolidation and permeability coefficient) is calculated by the test, test shall be done for surrounding Rowe cell consolidation and permeability using free strain. The pore water pressure at the central portion should be recorded.

(12) Soil permeability test

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) In case of a static water level permeability test, the sample tube may be used as is for non-dispersible sample. When the test is done transferring it to the permeability cylinder, the gap should be filled with patching bentonite.

c) When the test is done for non-dispersible sample, the relationship between natural and test directions of permeability shall be recorded.

(13) Direct Soil Shearing Test

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) Pay special attention not to agitate the natural sample.

c. The friction of shearing box shall be minimized.

(14) Soil plaste bearing test

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) Soil plaste bearing test is employed to determine bearing capacity factor for appropriate load on roads, roadbed, and footing foundation.

(15) Soil Unit Weight Test in the Field

a) BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) If the maximum grain size of the object ground for the site unit weight test exceeds the allowable range, Sheet method or other methods approved by the construction supervisor may be employed for the test.

c) Pay special attention to manage test sand, and the sand shall not be used for more than three times if it is standard sand.

d) When the soil as original material shows significant alteration or when the unit weight as standard is changed, the laboratory compaction test shall be repeated to determine the standard dry weight.

(e) Test of Rock

(1) Shaping and preparing test piece and general test

a) Methods to shape and prepare a test piece shall be in conformity with specifications in BS, Suggested method of ISRM: International Society for Rock Mechanics and American Standards for Testing and Materials (ASTM).

b) Three or more test pieces should be prepared for each rock samples that 2 to 3 are taken from each drilling hole for the test.

c) The rock samples should be taken out of the representative ground portion considering its weathering, cracks, orientation, and moisture contents. When they are collected from an unusual portion, it should be clearly indicated.

d) The Contractor should pay attention following factors that may influence the Soil permeability test

1) Shape and size of test piece

2) Finish of the upper and lower bearing sides of the test piece

3) Contact between the pressing face of the compressing equipment and the bearing sides of the test piece

4) Dryness

5) Loading methods such as loading speed and deformation speed

(2) Confined rock compression test

a) Confined rock compression test shall be in conformity with ASTM D 2938 and 3148

b) The test piece should be prepared in a corn shape with a ratio of diameter to height more than 2.0.

c) The diameter of test piece should be larger than NX size.

(3) Rock tensile strength test

a) Rock tensile strength test shall be in conformity with ASTM D 2936 and 3967.

b) The test piece should be a corn shape with a ratio of diameter to height 0.5 to 1.0, and the diameter needs to be larger than NX size.

c) Test may be conducted according to methods suggested by International Rock Dynamics Society. It can be either direct or indirect tensile strength test.

(4) Tri-axial rock compression test

a) Tri-axial rock compression test shall be in conformity with ASTM D 2664.

b) The test piece should be prepared in a corn shape with a ratio of diameter to height more than 2.0.

c) The diameter should be larger than NX size or more than ten times of the maximum rock grain.

(5) Rock elastic save velocity measurement test

a) Rock elastic save velocity measurement test shall be in conformity with ASTM D 2845.

b) The test piece should be larger than NX size, and the length needs to be longer than 5.0 cm.

c) The test piece should have parallel edges that are perpendicular to the measuring axis.

(f) Test Excavation

When a direct inspection is needed for a special ground condition or when specific in-site test is required, the ground may be investigated by a test excavation.

(1) Test excavation plan

a) In advance of a test excavation, a plan should be prepared including following aspects and submitted to the construction supervisor.

1) Location and time of the test excavation

2) Purpose of the test excavation (type and number of a soil or a rock test)

3) Dimension of the test excavation

4) Method of the test excavation (excavation equipment and depth)

5) Safety measures for the excavation

(2) Test excavation

a) A test excavation should be executed in the presence of the construction supervisor.

b) The test excavation should be photographed.

c) The test excavation should be executed at a flat location with good drainage and bearing power.

d) Any potential collapse due to rain should be prevented by applying a waterproof sheet or vinyl sheet during the test excavation.

e) As soon as the purpose of excavation is fulfilled after the test excavation, the site should be refilled with a compaction that exceeds the original level. However, it may be exempted if a follow-up construction is scheduled with an approval of the construction supervisor.

(3) Reporting the test excavation results

a) A report should be prepared to summarize the results after a test excavation, and it should be submitted to the construction supervisor.

b) The report should include the following items.

1) Discrepancy with the design documents and the object ground of the test excavation

2) Ground properties including soil, rock, and ground water level

3) Drawings and pictures showing details of each cross sectional investigation of the test excavation

4) Types and results of each soil or rock test performed after the test excavation

5) Other required items

(g) Drilling

In advance of drilling, the constitution of ground bed, location, and width of a surface of discontinuity, such as fault and crushing zone, and outflow discharge of ground water should be grasped. More, a drilling investigation should be preceded if a field test is required by collecting samples from drilling. A slop drilling may be allowed considering the purpose of investigation and the field conditions.

(1) Types of drilling

The drilling machine type should be of Rotary Drilling with Mud Water Flushing. However, depending on the ground property and the relevant construction method, one of Auger boring, rotary boring, wash boring, or percussion boring machine may be used with an approval of the construction supervisor.

(2) Size, interval, and depth of borehole

a) The size of borehole for a ground investigation should be larger than NX, and the casing should be installed down to the weathered rock to maintain a borehole wall.

b) In case that sample is collected by a thin walled tube from the borehole, the borehole should be 10 mm larger than the outer diameter of the tube. Otherwise, it should be approved by the construction supervisor.

c) When a cross bearing test, a field permeability test, or a pore water pressure measurement is to be carried out in the borehole, the size of borehole should be larger than NX.

d) The interval and depth of borehole should be determined according to the soil survey report. However, an inspection boring around a structure in a limestone region should be carried out after consulting with the construction supervisor since numerous cavities are scattered throughout the region.

(3) Management of boring

a) The Contractor should appoint boring engineers before the boring works, and it should be approved by the construction supervisor. The boring works should be carried out in the presence of the engineers.

b) In advance of boring, leveling should be done from a datum point designated by the construction supervisor, and the relevant boring altitude should be determined and indicated on the ground plan.

c) During boring works, pay attention to the propelling speed, load pressuremeter, pump pressuremeter, volume of water and outflow discharge, and color of drainage, slime condition, and mixture with foreign substances. Any change of them should be recorded along with the relevant depth. Do not ignore a thin stratum.

d) When spring water is identified during boring, measure and record the relevant depth accurately. Moreover, the water level in the borehole should be recorded before starting work daily until the completion of investigation. The normal water level should be determined in consideration of the water level in nearby wells and seasonal water level fluctuation.

e) Cementation should be approved by the construction supervisor.

f) When boring is intended for collection rock or equivalent core samples, works should be carried out paying attention to the following items.

1) Boring should employ a double core barrel with a diameter larger than NX.

Triple core barrel or D-3 Sampler needs to be used in a weathering or crushing zone in order to enhance the core return rate and to collect sample in the original condition.

2) Unless it is unavoidable to prevent an accident during boring, the core should not be damaged by elevating or descending the loader or by repetitive sudden pressure changes.

g) Shape, rigidity, color, grain size, moisture condition, and mixed substances should be recorded after collecting the sample.

h) If the purpose of investigation is fulfilled before reaching the estimated boring depth or if the purpose of investigation is not fulfilled though the estimated boring depth has been reached, it should be immediately reported to the construction supervisor for a follow-up direction.

i) After completion of the boring investigation, arrange surroundings, and close the borehole. When a long-term observation for the ground water level is needed, a protective cap should be applied after consulting with the construction supervisor.

j) For working in a region with anticipated obstruction such as underground facilities, an advance consultation with the relevant authority should be done for the relevant installation depth and location. It should be started after getting approved.

(4) Summary of the results

a) Detailed information from each borehole should be recorded the soil column map of the borehole. The boring engineer and investigator should add following information on the soil column map in the field.

1) Name of the boring investigation and the number of borehole

2) Location and investigation period, names of boring engineers and investigators

3) Coordinates and ground altitude of the borehole (surface altitude)

4) Quantity (depth) and type of borehole

5) Boring machine and its diameter

6) Date of ground water level evaluation and observation

7) Ground stratification

8) Results and depths of the standard penetration test

9) Depth, shape, and length of the collected soil sample

10) Drawings and pictures showing detailed investigation for each cross section of the test ground excavation

11) When a rock test piece is collected, the core collection rate, RQD, name of rock, color, interval and slope of joint, and the roughness of the joint face should be recorded.

b) The engineers should prepare a new soil column map after completing necessary laboratory tests including the field and laboratory test results and relevant annotations.

c) The Contractor should submit the soil column map (final report) with the engineer's sign in a number of copies required by the construction supervisor.

(h) Sampling

(1) Types of sampling

a) For the sampling of soil survey in a shallow foundation, BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) For the sampling of soil survey in a deep foundation and a site penetration test, BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

c) Sampling for non-dispersible specimen for clay and sand ground, BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

(2) Sampling of a disturbed specimen

a) When collection a disturbed sample, it should be put in a plastic bottle or vinyl bag and sealed while paying attention not to change the sample.

b) Sample should be collected from the borehole as a stratum is changed, and it should be carried out with a consistency within an identical stratum.

c) Sampling should ensure recording the name of investigation, date of sample collection, starting and ending dates of the boring, the number of borehole, investigation point, depth, sample number, thickness of the stratum, depth of the stratum change, condition of borehole after boring, ground water penetration location, special aspects during boring, and other references for the soil and rock tests.

(3) Sampling of an undisturbed specimen

a) Collection of sample shall be carried out according to Section called “Sampling of a disturbed specimen” at this section.

b) In case of using a static thin walled tube sampler, a piston rod or a chain should be completely fixed.

c) In advance of press-in of the sampler, the bottom of borehole should be cleaned.

d) The sampler press-in should carry out in a standard speed without interruption, impact, and vibration. The sampler needs to be inserted less than 90% of the effective length of sample collection.

e) It should be collected after completing the tube insertion without immediate rotation. During the drawing process, the sample disturbance (tension release) by suction should be minimized.

f) The samples collected through static piston thin wall tube should be sealed with paraffin, silicon powder, or other sealants, followed by applying a cap on it.

g) A tag showing the name of investigation, the number of borehole, the sample number, the insertion depth, and depth of the collected sample should be attached to the cap.

h) Any gap between the cap and the tube should be sealed using a tape.

i) The sample needs to be protected from extreme temperature change.

j) During transporting and storing the sample, the samples should be protected from damages and impacts.

(4) Test pit

a) The size of the test pit bottom is 1.0 m while the depth is deeper than 1.5 m. Access prohibiting facility or drainage should be installed if necessary.

b) The soil properties on the walls and bottoms of the test pit should be recorded, and a representative portion should be collected as a sample for a test.

c) After completing the test, the test pit should be refilled immediately in a compaction level exceeding the original condition. However, it may be exempted if a follow-up construction is scheduled with an approval of the construction supervisor.

d) The report should contain pictures showing the test process.

(5) Sample for an example

a) The collection location and quantity of the samples for an example should be determined by an engineer, and it needs to be approved by the construction supervisor.

b) The sample for an example should be put in a clear plastic bottle and sealed not to change the moisture content.

c) A label should be attached to the sample for an example, showing the name of investigation, the location of investigation, the number of borehole, the number of sample, the depth of collection, the name of soil classification, N value, and date of collection. No label needs to be applied on the surface of rock example, but a corresponding number should be shown on the rock with an appropriate way.

d) The sample bottle or box should be collected in an example box.

(i) Sounding

(1) Standard penetration test

a) For a standard penetration test, BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) Pay special attention to measure the test depth when a standard penetration test is carried out in a borehole. The construction supervisor may ask retests at a new location with a defined test depth including existing tests.

c) Unless specified otherwise, the interval of standard penetration test should be less than 1.0 m in continuity within an identical soil stratum. However, if the thickness of stratum is less than 50 cm, follow the direction of the construction supervisor.

d) Following items should be recorded on the test results.

1) The starting and ending depths of hitting during test

2) Depiction of the relationship between hitting numbers and accumulated penetration in a diagram

3) The preliminary penetration section (the upper 15 cm) should be excluded from counting as hitting number, N-value, since it is assumed as disturbed portion.
The number of hitting corresponding to 30 cm penetration should be recorded as the N-value.

4) Record the observation results of the collected sample.

(2) Swedish sounding test

a) Swedish sounding test shall be in conformity with SGF Report 1:93E.

b) Calibration results of the cone measuring instrument for the test should be submitted to the construction supervisor for an advance approval.

c) Relevant matters for test location, depth, and pore water pressure measurement should be consulted with the construction supervisor.

(3) Field vane shear test

a) For a field vane shear test, BS or other equivalent test standards may be employed after consulting with the Employer and the Supervisor.

b) Relevant matters for test location, depth, and pore water pressure measurement should be consulted with the construction supervisor.

c) The size of borehole for the field vane shear test should be determined after consulting with the construction supervisor.

(4) Dutch cone penetrometer

a) Dutch cone penetrometer shall be in conformity with JIS A 1220.

b) The corn tester should be of a double tube that is capable of measuring shear resistance and friction on the main face.

c) Results of zero-adjustment for the test corn should be submitted to the construction supervisor for approval.

(5) Piezo cone penetrometer

a) Piezo cone penetrometer shall be in conformity with ASTM D 5778.

b) When using a corn not specified in ASTM D 5778, it should be approved by the construction supervisor.

c) Results of zero-adjustment for the test corn's measurement components should be submitted to the construction supervisor for approval.

d) Relevant matters to the test location, depth, pore water pressure (including dispersion test) should be consulted with the construction supervisor.

e) When measuring pore water pressure of the ground, fully saturated Piezo corn should be used for the test.

(6) Pressuremeter test

a) Pressuremeter test shall be in conformity with ASTM D 4719.

b) The bore diameter of depth measurement should be drilled in a way appropriate to the outer diameter of the bearing portion with as flat finish as possible of the bore wall.

c) Test should be carried out as quickly as possible after boring in order to minimize the softening of bore walls arising from released underground stress and water move.

d) Each part of equipment should be checked, and rubber tension needs to be supplemented to ensure normal condition. The loading portion such as measurement tube is inserted to the specified depth.

e) Results of zero-adjustment for the test pressuremeter should be submitted to the construction supervisor for approval.

f) Relevant matters to the test location (depth) need to be determined after consulting with the construction supervisor.

(7) Water pressure test (field permeability test)

a) As a method to test rock permeability using water pressure, the water pressure test is applied to a ground reinforcement design and construction.

b) A curve for P (pressure)-Q (injection quantity) is prepared based on the water pressure test, and a permeability coefficient and Lugeon value are determined.

c) Flow patterns need to be figured out for each pressure step to judge the hydrological property of the ground.

d) In each pressure step, an identical pressure should be maintained for more than 5 minutes.

e) Each pressure step increases incrementally as 1, 3, 5, 7, 9 kgf/㎠ , and the pressure range may be adjusted by consulting with the construction supervisor.

f) The test sections may be distinguished into Single Packer, which the test is concurrently conducted with a boring investigation, and Double Packer, which the test is carried out after completing the boring investigation.

g) Each Packer method has its own merit and demerit so that determination of test method needs to be done with consultation with the construction supervisor.

(8) Shear test in borehole

a) This test is intended for finding rigidity integer of natural ground in a weathering zone

b) After attaching a shear plate on the bore wall, the shearing force is determined by applying a horizontal pressure and a vertical pressure in order. More, the disturbance to the borehole wall should be minimized for the boring investigation while conducting shear test directly on the borehole wall.

c) After tightly attaching the shear plate on the borehole wall, keep it intact for about 5 minutes.

d) Distinguishing the attachment pressures into 5 steps (5, 10, 20, 30 kgf/㎠), drawing tests are conducted for each pressure step. Two tests should be carried out for the identical pressure while rotating it 90° for the successive test.

(9) Image taking in borehole

a) As an imaging technique for the orientation of a surface of discontinuity, crushing zone, hazardous zone, and geographic boundary, it is further divided into the ultrasonic wave method and the optical methods.

b) For the ultrasonic wave method, water in the borehole is essential as the medium for sound wave propagation.

c) The optical method employs a micro camera that is inserted into the borehole for 360°image taking. Pay attention not to allow that foreign substances are drawn by the equipment when turbid boring water and a transparent tube insertion.

d) Square one calibration should be precisely done to measure the orientation of a surface of discontinuity, and the reliability should be secured comparing it to the actual core (adjustments of depth, direction, and slope)

(10) Water pressure crush test

a) Water pressure crush test shall be carried out by referring ASTM D 4645.

b) Water pressure crush test is carried out to find the initial bearing pressure of the object ground.

c) The initial bearing pressure is determined by crushing borehole with tensile force caused by water pressure after sealing a portion of the borehole with a expandable packer and applying water pressure to the section. The pattern of pressure fluctuation is measured while repeatedly applying and withdrawing pressure to the crushed section for the calculation.

2.13.3. Physical Prospecting

(a) General Scope

This specification shall be applied to the physical exploration intended for surveying ground properties required for construction execution.

(b) General Physical Prospecting

Physical prospecting and inspecting include the seismic profiling, the electrical exploration by electrical resistivity method, electromagnetic prospecting, radar prospecting, electrical and sonic wave inspections, and the object of investigation should be determined in line with the relevant construction objective.

Physical prospecting is intended for investigating the stratification condition and property of strata, thickness, and property of the surface soil or weathered stratum, property of ground and its surface appearance, location and dimension of crushing zone, location and dimension of cavity, and existence of ground water.

Electrical inspection is purposed to get more accurate soil column map and to confirm the properties of strata. Moreover, the sonic wave inspection is intended for calculating P wave and S wave propagation speeds and elastodynamic factors for each stratum.

An image of high resolution can be attained for detecting crushing zone distribution near a

tunnel or underground cavity when precise physical prospecting technologies are combined such as surface radar prospecting, borehole radar, or geotomography.

(c) Seismic Refraction Prospecting

The arrangement of lateral line may be modified depending on local condition after acquiring an approval from the construction supervisor as long as it does not interrupt the objective of survey.

The files at the middle and the end lateral line should be distinguished by size or color, and the relevant signs should be protected from damage. More, the Contractor should check the location and height of datum points.

The Contractor shall use and store test gun powder according to relevant laws and regulations, and it should be protected from theft.

Natural environment such as vegetation should not be damaged. Safety personnel should be arranged to prevent accidents during explosion, and signals should be made by siren or whistle to attract attention.

The explosion hole should be refilled with compaction.

When it is measured at two consecutive lateral points, it should be re-measured.

The measurement results should be summarized in the lateral line arrangement drawing, the time-distance curve, and the cross sectional diagram.

Interpretation details should be clearly expressed on the time-distance curve and the cross-sectional diagram.

When a hammer hitting is used due to local condition, it should be applied considering effective depth for detection (detectable depth) and resolution while minimizing noise to the surroundings.

(d) Electrical Exploration

The arrangement of lateral line may be modified depending on local condition after acquiring an approval from the construction supervisor as long as it does not interrupt the objective of survey.

The arrangement of electrode should be set in line with the exploration goal, and the interval of electrode may be determined appropriately according to the ground depth and electrode arrangement.

The maximum electrode interval should be determined according to the exploration depth.

Unless it is not available due to local conditions, the electrode needs to be progressed in the perpendicular direction of the main direction of anticipated geological structure.

Measurement should be checked by Plot to the resistivity electrode interval curve (ρ-a) or by the control computer, and it should be re-measured by switching electrodes when differentiated values are obtained.

The results of exploration should be summarized as the apparent resistivity curve in cases of the lateral line arrangement drawing and the vertical exploration while the results are summarized as the apparent resistivity cross section diagram in case of double electrode arrangement resistivity exploration. Other analytical results should be arranged in the resistivity isodose line drawing.

(e) Electromagnetic Prospecting

Electromagnetic prospecting may be used to yield the identical resistivity cross sectional information at locations that application of the electrical exploration in Section 3.3 is obstructed such as concrete or asphalt pavement or that inadequate contact of electrode to the earth.

The Contractor should consult with the construction supervisor for the equipment and method before the prospecting, and the results of measurement should be submitted to the supervisor.

The Contractor may change the setting, interval, and total length of lateral line and the interval of the lateral point after acquiring approval of the construction supervisor as long as such change does not obstruct the investigation purpose.

(f) GPR Prospecting

GPR prospecting may be used to search a buried object or to confirm geological features such as heterogeneous zone or crushing zone.

The prospecting makes measurement while moving two transmitting and receiving antennas that are arranged with a certain distance along with lateral line incrementally.

The Contractor shall submit a sectional radar cross section report, which is yielded by computer numeric scale modeling (computerization) of the GPR data, to the construction supervisor.

(g) Electrical Inspection

Excepting the casing insertion area and non-measurable section arising from electrode arrangement, the electrical inspection should be carried out for the entire section.

Electrical inspection should be carried out for both resistivity and self-potential.

Resistivity measurement is done by the double electrode electrical inspection method in principle. The intervals of electrodes should be 25 cm, or 50 cm, or 100 cm, or other distance with the equivalent accuracy.

The records on the lateral line should be done continuously, and the measurement distance should not exceed 50 cm even when the continuous record is not carried out.

When the measurement is impossible due to collapse or etc., the direction of the construction supervisor should be observed.

(h) Sound Wave Inspection

Excepting the casing insertion area and non-measurable section arising from ground water distribution, the sound wave inspection should be carried out for the entire section.

However, the casing insertion needs to be measured if it can be displaced.

The borehole receiver and the start short receiver are used for the receiver, and the borehole receiver should be able to measure one vertical component and two horizontal components.

The direct noise arising from surrounding traffics should be avoided for the measurement.

When the measurement is impossible due to collapse or etc., the direction of the construction supervisor should be observed.

When the diameters of the borehole are significantly different, the Contractor should conduct Boreholes Compensated (BHC) sonic wave inspection that mitigates the impacts of borehole diameter on the velocity by employing more than 2 sets of receivers and transmitters.

(i) Geotomography

Geotomography uses two or more boreholes, in which a transmitting body radiates an elastic wave or electromagnetic wave (radar) to the surrounding medium, and produce images of physical property distribution such as velocity of medium, absorptiveness, or resistivity in 2D or 3D by back calculating the matrix of measured data after measuring propagating wave travel time or amplitude through diverse paths in between two boreholes.

In case of the resistivity tomography, an image of cross sectional resistivity is produced through 2D numeric back calculation after arranging appropriate electrodes to the prospecting purpose.

In case of the electromagnetic prospecting tomography, an image of cross sectional resistivity is produced through reverse calculation of refraction tomography after setting appropriate frequency and measurement distance in line with the object resolution.

Ray Tomography or refraction tomography may be used for Geotomography, and the Contractor should submit the final report to the construction supervisor.

(j) Seismic Prospecting of Borehole Space or Downward Seismic Prospecting

Seismic prospecting of the borehole space is intended for measuring the elastic wave speed (P and S waves) for each depth of the local rock while the downward seismic prospecting is intended for distinguishing rocks and calculating the elastic dynamic factor by measuring velocity for each section according to the relevant depth.

The interval of measurement should be set appropriately according to the local rock condition and the prospecting goal.

S-waves with polarity in the opposite directions are generated for the Seismic Prospecting of Borehole Space or Downward Seismic Prospecting while the S-wave returning time is precisely read by analyzing the amplification and position of S-wave.

Crevice measurement must be conducted for the seismic prospecting of borehole space, and the distance between the receiver and the transmitter should be calculated precisely.

2.13.4. Survey for Condition of Location

(a) Topographic Survey

Influential topographic features need to be analyzed using design documents, topographic map, or aerial photographs, and it should be investigated by site survey.

Unstable geographical features and locations with anticipated disaster, such as Talus, collapsed region and landslide area, and damage area by flood, must be investigated.

(b) Environmental Survey

The environmental survey for the project area and its vicinities performed during designing phase should be repeated at the phase of construction.

The environmental survey is intended for estimating environmental changes arising from construction, establishing environmental preservation measures, and confirmation of their effectiveness, including followings.

(1) Surface and ground water: Conditions of water use, water resources, ground water flow, and possible level changes

(2) Noise and vibration: Potential impacts by noise and vibration

(3) Deformation of ground and structures: Construction with potential impacts on the building, structure, topography and geological features, and deformation of a structure

(4) Disaster: Potential locations and degree of damages from landslide, collapse, earthquake, and flood

(c) Survey for Underground Obstructive Features

Safety construction should be ensured by grasping types, sizes, and depths of existing underground facilities including water supply and sewage pipelines, power and communication cables, underground shaft, and other obstructive features.

For a boring investigation, a map for underground facilities should be acquired from the relevant authority, and their existence needs to be checked by an excavation or physical prospecting. Boring should be done in collaboration with the relevant authorities.

The investigation results need to be maintained to be utilized to protect them for the follow-up construction.

(d) Survey for Spoil Area

When a spoil area is needed to treat waste generated during construction, conditions for transportation need to be investigated including relevant topography, transportation means and distance, traffic regulation of the transportation road, and traffic safety.

Investigations should also be conducted for environmental impact on surroundings, soil change after spoiling, and legal regulations.

(e) Survey for Construction Facilities

Construction facilities are further divided into the ventilation and dust collection, transportation, aggregate and concrete plant, power supply and distribution, water supply and sewage, and temporary buildings.

Following aspects need to be investigated to establish a plan for construction facility.

(1) Topography, geological feature, and climate: Topography, geological feature, and climate with potential of deteriorating facility performance

(2) Surrounding environments: Impacts on surrounding environment arising from noise, vibration, drainage, and traffic flow of the construction equipment

(3) Use of electric power: Capacities of existing and new power cables, frequency, voltage, difficulties in power distribution and supply, required time for power supply, generator, and power consumption for operating construction equipment

(4) Water supply and drainage: Water for compressor, for concrete mix, drinking, and water intake condition for other miscellaneous water uses, treatment of construction water, and discharge conditions for the cleaning water

(5) Transportation of materials and low-grade ore: Access of machineries and materials, construction road to transport the low-grade ore, standard for rails, traffic volume, safety, and conditions of traffic regulation

(6) Construction material: Aggregate for concrete relevant to the construction facilities, not cured concrete, supply channels of other materials, conditions of suppliers and their management, and nearby constructions

(7) Legal and other regulations: Nearby construction

(f) Survey for Compensation

Before the construction commencement, every aspect for compensation should be investigated in details.

Subjects of compensation should include land, building, and vegetation acquisitions for the construction lot, migration of them, violation of various rights (surface right, subsurface right, water right, mine right, and stone quarrying right), decrease of farm profit, and loss of sales.

2.14. Metal Work and Miscellaneous Fittings

2.14.1. General

The Contractor shall be responsible for the detailed design of all items covered by this section of the Specification and their correct performance. The items shall adhere to the general arrangements indicated on the drawings and be to the approval of the Engineer.

The work shall be prefabricated for site assembly without welding. All bolts and nuts shall be assembled with one washer under the head of the bolt and with another washer under the nut. All bolts, nuts and washers shall be galvanized or sheradised.

The Contractor shall submit to the Engineer for his approval number of copies of detailed drawings and specifications which is made through discussion with the Employer and Engineer for all items to be specially fabricated or tailored for the Works and number of copies of manufacturer's drawings and specifications is made through discussion with the Employer and Engineer for standard items. The Contractor shall furnish additional information and calculations if requested by the Engineer.

The Contractor shall allow three weeks for the Engineer to check the details, from receipt by the Engineer of complete information. No items shall be manufactured or ordered from suppliers until the Engineer has signified his approval of the details.

Subsequent to approval being given, the Contractor shall submit a further number of copies of the drawings, specifications and other information which is made through discussion with the Employer and Engineer to the Engineer. Drawings and specifications which have been approved by the Engineer shall not be departed from without approval of the Engineer.

2.14.2. Structural Steel Work

Material for structural steelwork shall comply with BS 4360 and workmanship with BS 449. The steelwork shall be securely fixed to the foundations or buildings and designed to have such strength and stiffness that its deflection and movement under the loads to be applied shall be within tolerable limits.

All bolts and nuts shall comply with BS 3693 except for High Strength Friction Grip Bolts which shall comply with BS 4395.

Mild steel electrodes shall comply with the requirements of BS 639 and High Yield Steel with BS 2540.

All structural steel fabrication shall conform to the requirements of BS 153. The use of High Strength Friction Grip Bolts shall be in accordance with BS 3294.

All structural steelwork shall be hot dipped galvanized after fabrication and shall be fabricated using welded joints where possible for shop joints and bolted joints for field assembly.

Alternatively, structural steelwork may be designed in accordance with the American Institute of Steel Construction Specification for the Design Fabrication and Erection of Structural Steel for Buildings, 1969 Edition and the American Institute of Steel Construction Code of Standard Practice for Steel Buildings and Bridges, 1972 Edition.

2.14.3. Open Mesh Walkways and Covers

Open mesh type walkways, platforms and covers shall be of aluminium or galvanized steel, suitable for a superimposed load of not less than 6kN/m2 and shall comply with the relevant provisions of BS 4592: Parts 1, 2 and 3. They shall be provided with suitable angle kerbing frames fixed to the structural steelwork or concrete (using appropriate tangs cast-in) as appropriate. The kicker plates, for safety purposes, shall also be provided as appropriate.

The walkways, platforms and covers shall include all necessary supports not detailed on the Drawings.

Open mesh panels shall be trimmed with full depth nosing bar along all edges and bolted to each other when in place to help ensure a firm walkway. Panels shall be cut in such a way and fixed so as to provide a continuity of pattern.

Covers shall incorporate a hinged and lockable open mesh access panel with strong durable hinges and heavy duty non-corrodible padlock. Openings for valve keys shall be just sufficient in size for the valve key and shall incorporate a cover hinged only.

All panels shall be securely bolted to the supporting structure. Where the supporting structure is concrete, galvanized mild steel angle curbs shall be provided and securely grouted into rebates left in the concrete such that the tops of the panels are flush with the top of the concrete.

All steelwork shall be hot dipped galvanized after fabrication.

2.14.4. Metal Covers (Top)

(a) This specification is applied to production and installation of various metal covers having iron, non-iron metal, and their secondary products as the main material.

(b) The Contractor should provide and fix 6mm sheet metal access cover with 40x40 angle iron farm with latch and safety lock for valve chamber and reservoir (1.65x2.5) or by drawing.

(c) For the materials for exposed surface metal products, color, surface treatment, painting condition, and durability should be approved by the construction supervisor by submitting required data asked by him/her about the sample product designated by him/her, product data supplied by the manufacturer, and test records.

(d) Every product should be protected from corrosion, deformation, or damage and stored without making a contact with soil or air directly. Any damaged one shall be replaced by a new product. In case of a steel product, the corrosion protection should not be damaged.

(e) The welding rod should be kept in a dry condition, ensuring not to expose it in a high humidity condition. The sheath of rod should not be delaminated by an impact.

(f) Every steel product should be painted with a red lead mixed paint in conformity with BS after priming. However, it may be exempted when the product does not need separate anti-corrosion paint since it is galvanized or powder coated.

(g) Appropriate leakage prevention should be applied for locations with possible storm water penetration such as manhole during production, and accurately fitting neoprene gaskets should be used as specified in drawings.

(h) Manhole cover

(1) Cast iron should be used for manhole to ensure sufficient rigidity to exterior impact, and the shape and size are to be in accordance with the manufacturer's sepcification, drawings, or construction specification.

(2) If letters are engraved on the cover, it should be in conformity with the direction of construction supervisor.

(i) Access Hole

(1) The stainless steel plate for a stainless access hole shall be cold rolled stainless steel plate with a hairline finish

(2) The steel plate for a steel access hole shall be hot-dip gavanizing steel plate (General Purpose).

(3) For hinged access hole, a rubbeer packing with a size of φ12 mm should be used to prevent impacts by opening and closing.

(4) The frame hardware for supporting access holes should be installed with reinforcement to prevent deformation or damage by vertical load.

(j) Trench Cover

A trench cover should bear the larger stress between an uniformly distributed load of 1,220 ㎡ kg/ for a direct load of 3,628 kg.

(1) Steel trench cover

a) Material, shape, and size of the steel trench cover shall be in conformity with the product data of a certified manufacturer Galvanized steel product with bar-type shall be used.

b) The frame hardware for trench should be galvanized steel and installed with reinforcement to prevent deformation or damage by vertical load.

(2) Stainless steel trench cover
The material of stainless steel plate should be in conformity with BS with a thickness of 3 mm or over. Punching hole should be made as specified in drawings to install the frame anchor hardware rigidly. Slippery preventing surface treatment should be done on the surrounding trench cover and others.

(k) Entrance Cover

(1) A rigid entrance cover should be installed according to drawings.

(l) Subsidiary Materials

(1) Joint metal
Every fixing metal should be of non-corrosive material or with an anti-corrosion coating with appropriate size, strength, and material in line with the purpose.

(m) Construction

(1) Installation

a) The anchor plate should be installed at accurate point rigidly. If the location is not accurate or if the installation is defective, a correction should be made after acquiring approval to ensure the equivalent performance with the original one.

b) It should be installed with accurate vertical and horizontal levels, and the steel door needs to be welded on the foundation anchor.

c) Frame hardware should be supplemented rigidly for corners or a overlapped section according to the direction of the construction supervisor.

d) Paint may be applied before installation when it is hard to be done after installation. Any damage on the concrete surface or anti-corrosion coating should be repaired before installation. Construction and installation order may be adjusted not to deteriorate the powder coated portions by site welding.

(2) Field Quality Management
Installation conditions should be inspected after completion. Any color change, contamination, or damages identified during the inspection should be immediately repaired. If repair is not easy, it should be replaced and reinstalled.

(3) Cleaning the installation site

a) Cleaning and protection
Every exposed surface metal finish material should be protected by using appropriate protection medium in line with material and construction process until the completion of the project to prevent color change, contamination, and damages by other type of construction work.
The protective medium should be removed upon the project completion and cleaned.

2.14.5. Galvanising

Where galvanising has been specified the items shall after fabrication be hot dipped galvanized in accordance with BS 729, or where approved zinc coated in accordance with BS 2569 Part 1 to a thickness of 0.15 mm (0.006").

All items to be protected shall be prepared as specified in the above standards.

Articles altered at the manufacturers works in any way after galvanising are to be regalvanized as specified.

Articles subject to minor alterations on site or requiring minor repair on site shall be wire brushed to remove all rust and coated with 3 coats of approved zinc rich cold galvanising compound.

2.15. Scaffold

2.15.1. Materials

(a) General

(1) The material of Scaffold shall be used in accordance with equivalent standards or

regulations to the US or UK standards

(2) Structural steel shall be used for scaffold.

(3) The material for scaffold shall be uniform in section and sectional modulus, and shall have rigidity demanded on construction detail drawings.

(4) Materials being deformed, corrosive and being severe damaged shall not be used.

(5) Materials for scaffold shall be in accordance with construction specification. And in case that there are no problems with the material in structural function, performance, and in feature, the material can be reused.

(b) Steel pipe scaffold

(1) Steel pipe scaffold shall be conformed with the regulation for performance test for temporary facilities.

(2) Floor for pass way shall be conformed with the regulation for performance test for temporary facilities.

(3) Clamp shall be conformed with the regulation for performance test for temporary facilities.

(4) The supporting miscellaneous metals of steel pipe scaffold shall be conformed with the regulation for performance test for temporary facilities.

(5) Wall connection metals shall be conformed with the regulation for performance test for temporary facilities.

(6) In case of using special metal, it shall be confirmed that the metal withstands the imposed stress.

(c) Fabricated scaffold

(1) Fabricated scaffold shall be conformed with the regulation for performance test for temporary facilities.

(2) Working stage shall be conformed with the regulation for performance test for temporary facilities.

(3) Support metals for fabricated scaffold shall be conformed with the regulation for performance test for temporary facilities.

(4) Wall connection metals shall be conformed with the regulation for performance test for temporary facilities

(d) Transfer platform

(1) Transfer platform shall be conformed with the regulation for performance test for temporary facilities.

(2) Wheel for moving scaffold shall be conformed with the regulation for performance test for temporary facilities.

(3) Supporting metal for transfer platform shall be conformed with the regulation for performance test for temporary facilities.

2.15.2. Execution

(a) Execution – General

(1) Construction of scaffold shall be done according to construction plan and drawings.

(2) Construction work shall be done such that suitable method and materials are used in consideration of construction type, size, location so as to be safe and convenient to proceed execution.

(3) Working platform shall be fixed tightly to joist.

(4) In case that the electric cable is adjacent to scaffold, adequate action shall be done not to be damaged.

(5) For weak ground, compaction, concrete placing or laying plate with thickness more than 45 mm shall be done in order not to be settled of column of scaffold.

(6) The connection of columns for more than 3 columns shall be done. If the support metal has been fixed at the bottom foundation, the connection can be omitted.

(7) Scaffold shall not be installed on frozen ground without any alternatives for thawing.

(8) To avoid overturning or buckling of column scaffold shall be fixed to the structure with connection metals.

(9) Connection is done at the cross point between horizontal direction member and vertical member.

(10) For unfolding of the connection, it shall be done by partly sequence.

(b) Construction of steel pipe

(1) The column of scaffold shall be such fixed tightly with brace or horizontal member as not to move or shake.

(2) Column of the scaffold shall be laid on strong foundation to transfer the imposed loads.

(3) The intervals between columns of scaffold shall be smaller than 1.8 m for the wale direction and 1.5 m for joist direction.

(4) In case that the height of column exceeds 31 m, a steel pipe is used at the higher portion than 31 m and tied 2 steel pipes at the lower portion than 31 m in consideration of buckling.

(5) The imposed load at a column shall not exceed 6.8 kN (700 kgf).

(6) The space between wales shall not exceed 1.5 m in vertical, for the first wale from the ground the space can be 2 m for the pass way if buckling does not occur.

(7) In the case that the wale is installed continuously, lapped splices is used and the distance between wales provided lapped splices shall be 100 mm or less, and for the connection between staggered column clamp shall be used.

(8) The location of splices shall be staggered more than minimum 300 mm.

(9) Space between joists in vertical shall be less than 1.5m, and tied with column of staging at cross point between column and whale, and tied with whale at mid-point.

(10) In case of butt laying with work stages, the working stage of joist shall be installed so as that the overhanging portion shall be 100 mm up to 200 mm.

(11) Joist shall be installed so as the overhanging portion to be more than 50 mm.

(12) Diagonal brace shall be installed at an angle of 400 or 600 from horizontal and shall be tied to column or wale, and the space of the brace shall to be crossed at every 15 m.

(13) Cross point between brace and column of scaffold shall be tied with rotational type clamp.

(14) The horizontal brace will be provided at every span, at the height of attached wall metals.

(15) Connection between walls shall be installed at the maximum interval of 5 m for vertical and horizontal, respectively.

(c) Prefabricated scaffolding

(1) In case that total height exceeds 20 m and heavy weight work, the interval of the main frame shall be 1.8 m or less.

(2) The limit of imposed loads is 3.92 kN (400 kgf) for 1.8 m interval of main frame. In case that the interval of main frame is less than1.8 m, load limit can be increased by ratio. If the foundation is firm, the limit of vertical load will be 24.5kN (2,500 kgf) per column.

(3) In case that the passway, entrance, and opening is safe enough for imposed loads, the height and interval of main frame can be increased.

(4) The bottom of the column member of main frame shall use supporting metal and shall be laid on firm foundation in order to transfer the imposed loads to the foundation safely. In case that the foundation is uneven, support metal shall be used for correction.

(5) Wale frame and horizontal member shall be installed at the top of main frame and at every five stages of main frame.

(6) At the edge of scaffold, main frames shall be tied with steel pipe and clamp, and for the opening guardrail shall be provided.

(7) Cross brace shall be provided at every stage and span and the tied portion shall not be failed due to the vibration.

(8) In case that a part of cross brace is removed, horizontal member or wale frame shall be provided instead. But the cross brace at the stage of wall connection shall not be removed.

(9) Wall connection shall be installed 6 m and less in vertical direction and 8 m and less in horizontal direction. In case that the height of scaffold exceeds 4 times of the length of bottom, wall connection shall be provided at every height of 4 times of bottom length with connection metals.

(d) Transfer platform

(1) Prior to fabricate the transfer platform, structure, strength, function, and materials shall be inspected carefully, if there is any defects.

(2) The height of transfer platform shall not exceed 4 times of minimum width of bottom.

(3) In case that the platform is more than three stage, support structure shall be installed or shall be fixed to the structure to prevent from overturning and shaking.

(4) Guardrail shall be provided at top platform and connection area, cross connection area shall be inspected not to be failed while a work.

(5) In case that the guardrail has been removed for work unavoidablely, guardrail shall be installed just after the work.

(6) Break system at wheel shall be provided and it shall be in operation always except moving period.

(7) At inclined slope the working platform of the main frame shall maintain level by using jacks.

(8) Another supports or ladders shall not be used on working platform.

(9) Any concern for droppings, protection roof shall be provided.

(e) Inspection scaffold

Prior to work on the scaffold, inspection shall be done by using inspecting sheet. Any defects founded, scaffold shall be maintained immediately.

(1) Inspection before and after fabrication

- Confirm the materials comply with standard and regulation.
- Confirm any defects due to corrosion, deformation, damage
- Inspect the conformation with installation drawings.

(2) Inspection at bad weather

- Inspection before bad weather

a) Immediately after a strong-wind warning, check wall connection metals, support timber, and so on. If necessary, prevention shall be done for tilting and failing of scaffold, material scattering.

b) Remove or prevention action for protection screen for falling, guard net, boards.

c) Check wall connection, the location of members. If necessary, provide timber support.

- Inspection after bad weather. Check the followings.

a) Check the dropped material on platform.

b) Electric wire.

c) The condition of working boards.

d) The column foundation.

e) Fastened condition of wall connection and clamp

(f) Removal scaffold

(1) Prevention for collapse, falling, drop shall be provision, prior to disassemble and removal.

(2) All scaffold for construction shall be removed until construction completed.

(3) All separated members and connection metals shall not be dropped from scaffold. Remaining structures shall be stable during removal scaffold.

(4) Wall connection metals had better remove later. Especially, the wall connection metal in area which safety facilities are exist shall be removed carefully. If necessary, auxiliary facilities shall be provided.

(5) During removal scaffold the surfaces of buildings and structures shall not be damaged.

(6) The location of joint of column and the removal sequence shall be checked prior to remove the columns and wales.

2.16. Staging

2.16.1. Materials

(a) General material

(1) The material of Staging shall be used in accordance with equivalent standards or regulations to the British Standards

(2) Steel pipe staging shall conform to BS Steel pipe supporting column.

- Inner and outer pipe for supporting column shall conform to BS.
- Other materials besides pipe shall conform to BS.
- The materials for screw and ring shall conform to BS.

2.16.2. Execution

(a) Staging installation

(1) All base line, leveling, elevation shall be established in order that all staging should be installed at exact location. The Contractor shall be responsible for the accuracy of all geometric data related to staging installation.

(2) The type of staging shall be suitable for the function of staging which transfer the imposed loads to the foundation.

(3) Arrangement of staging shall be suitable for installing and removal and the loads shall be transferred safely at joints and connections.

(4) The method of constructing staging shall designed so as not to occur the settlements and the staging has a capacity of supporting the loads shown in drawing which is approved by supervisor.

(5) The staging shall be safe for erosion of foundation, prevented from soil being weak and the loads imposed shall be supported by foundation. The bearing capacity of the foundation shall be conformed that the estimated bearing capacity does not exceed the actual capacity by testing foundation at site.

(6) In case that the staging supported by piles, pile driving shall be done until the piles have the sufficient bearing values, the bearing value shall comply with the value shown on drawings.

(7) If the staging is adjacent to road or cross over road, additional structures shall be provided to resist with impact from road, and the added structures shall not be removed until the staging being removed.

(b) Camper correction

(1) In case of the Engineer's approval, camper strip shall be used to correct the deflection of staging and the expected deflection of structures.

(c) Settlement

(1) To measure the entire settlement of structure, auto display sensor shall be installed at the form adjacent to ground so as to read easily.

(2) Additional dead load shall not be loaded on the staging without supervisor's approval.

(d) Removal staging

(1) The Contractor shall be approved by supervisor prior to the removal of any staging.

(2) To determine the staging removal, the Contractor shall submit the structural calculation or reviewed report, and test result of concrete to the supervisor.

(3) The sequence of removal shall be such detail as to ensure that the imposed loads will be uniformly distributed to the members.

(4) Except in the case of supervisor's special approval, the piles shall be pulled up and the pile foundation area shall be restored to the original state.

(e) Quantity estimation and payment

(1) For quantity estimation, the boundary line is bottom line and exterior line of the concrete member, and the estimation unit is space ㎥ and the detail guide for estimation is as followings.

- Slab at bottom : the space to the bottom of the slab.
- Embankment or excavation : the space to the design ground level.
- No earth work : the space to the original level.

(2) Payment will be done by space ㎥ unit in detail estimate sheet of tender document. Following expenses is included in payment.

- Materials such as container of staging, bracing, material such as binding wire.
- Expense of preparation for staging installation.
- Staging installation, removal and finishing work.
- Other works for staging.

2.17. Waterproof Works

2.17.1. Waterproof : the inside

The Contractor shall provide the material which is made through discussion with the Employer and Engineer for the inside waterproofing.

(a) General

This specification is epoxy waterproof way to prevent corrosion or waterproof

(b) Reference Standards

Followed by the relevant BS.

(c) Material

(1) Primer and Epoxy Waterproof paint

(2) Basis control material (degree of attachment strength is more than 150 N/㎠)

(3) Inspection mechanism (thermometer, hygrometer)

(4) Quality testing (practice 1 time by BS provision)

(d) Construction

(1) Drying thickness is to become 0.7 mm.

(3) After painting basis control material, practice at least 24 hr.

(3) epoxy waterproof layer practice divided twice and finishing layer is the blue.

(4) Total drying thickness is 0.5 mm.

(5) Second coating practice at least 24 hr.

(e) Cleaning and protection.

2.17.2. Waterproof : the outside

(a) General

Using rubber asphalt based material, it is the method of the waterproof for the construction.

(b) Material

- The rubber asphalt waterproof agent should be suitable the British Standard
- The reinforcing agent for enhancing the waterproof layer as a material of glass fiber, synthetic fibers, woven or nonwoven fabric is used.

(c) Construction

(1) Arrangement

- Construction floor remove impurities
- The bad part broken is filled with waterproof mortar with V-cut.

(2) Primer coating

- Apply many times thinner by brush or roller

(3) Material mixing

- Put forward solvent of the material during mixing, Mix 3-5 minutes to put the later curing agent

(4) Coating

- Working twice, become total thickness 2 mm or more using the brush
- Hardens reinforcement Insertion is to prevent the occurrence wrinkles before the lower layer

2.18. Electric Anti-Corrosion Work for the Water Pipeline

2.18.1. Scope

These specifications provide descriptions on materials, equipments, installations and tests required for electric anti-corrosion facilities to extend the lifetime to at least 20 years, which is necessary for the prevention of external corrosion over the buried pipeline.

2.18.2. Reference

(a) National Association of Corrosion Engineers (NACE) of the U.S.

(1) Title: Control of External Corrosion on Underground or Submerged Metallic Piping System. (RP0169-96)

(2) Title: Control of Pipeline Corrosion (June 1981)

(b) Standards and laws of the U.K.
Title: BS 7361 Cathodic Protection (BSI)
Part 1. Code of Practice For Land and Marine Applications.

(c) Ministry of Commerce and Resources of Korea, Public Announcement No. 1993-44: Electric Anti-Corrosion Action Standards for Pipelines

(d) ASTM (America Society for Testing & Material)
A518 Standard Specification for corrosion

(e) Metallic Anti-Corrosion Technology Handbook, Japan Technology Promotion Society

(f) Anti-Corrosion Technology Handbook, Ministry of Construction & Transportation of Korea

(g) Electric Equipment & Technology Standards: Article 263 Electric Anti-Corrosion Equipment

2.18.3. Materials

(a) Magnesium anode

(1) Magnesium anode shall be installed in 9 lb (4.08 kg, 63.5 x 63.5 x 670) in consideration of life.

(2) The elements of magnesium anode shall include BS Standards products or their equivalents with the following tested values.

Element	BS Standards(?)	Other Products	Remarks
Aluminum	Max. 0.01%	Max. 0.01%	
Zinc	Max. 0.03%	Max. 0.05%	
Manganese	Max. 0.01%	0.5~1.3%	
Iron	Max. 0.002%	Max. 0.03%	
Nickel	Max. 0.001%	Max. 0.001%	
Copper	Max. 0.001%	Max. 0.02%	
Silicon	Max. 0.01%	Max. 0.05%	
Magnesium	Residue	Residue	

(3) Magnesium anode shall have minimum open circuit potential of (-) 1.7V or less with an electrode based on copper sulfate.

(4) Anode shall be placed at the center of a bag, which shall be packed in diameter 6” (152.4 mm) x length 30”(762 mm) specification by filling backfill materials around it.

The elements of backfill materials shall include the following;

Material	Percentage of Weight
Plaster	75 %
Bentonite	20 %
Natrium sulfate	5 %

(b) Test Box

(1) Specifications

- Dimension: 230ψ×110L (mm)
- Material: Cast iron

(2) General structure

- The dimension of a test box shall be equal to or larger than the size defined in drawings.
- A tool insert opening shall be made, which enables a test box to be opened using a tool instead of a handle to prevent the box from easy opening.

(3) Components

- Test box • Cable

2.18.4. Installation

(a) General

(1) All the construction works for electric anti-corrosion shall be done in accordance with design drawings and their accurate implementation in accordance with design drawings and specifications shall be confirmed under the supervision of anti-corrosion engineers who have been specializing or completing domestic or overseas anti-corrosion engineering.

(2) Lead cable shall be marked with colors or other methods for their permanent identification.
Electric cables shall be slowly installed and their insulation cover shall not be damaged, and it shall be repaired if it is damaged.

(3) Lead cable for test shall not be exposed to excessively strong heat or light and reference electrode for test shall be positioned on the opposite side of magnesium anode installation.

(4) Every facility with water supply and distribute pipeline shall be protected from corrosion under insulation (100%).

(b) Installation Plan

The constructor shall establish and maintain quality control plans for facility operations to secure the observance of regulations on specifications, and quality control records for every material and construction shall be kept.

(1) Check out if every anode is properly installed

(2) Check out if every test is properly carried out

(3) Check out if every connection is properly constructed

(4) Keep records on every test and measurement

(5) Keep records on every damage, defect and repair

(6) Check out if any facility to be protected contacts other facilities

(c) Construction

(1) Installation of magnesium anode

- Anode lead cable shall be installed 5 M or more in HMWPE 1C-8 ㎣ insulation cable.
- Magnesium anode shall be horizontally installed at least 1 M or more away from the pipeline.
- The gap between anode and cathode shall be installed 1 M or more in 1 set with 2 pieces for anode.
- When the lead cable of anode is connected to the pipeline, it shall be carried out with cad welding, and the re-coating shall be completely done with insulating adhesive epoxy after connection.
- The depth of anode installation shall be equal to or deeper than the bottom of the pipeline.
- The surrounding of anode shall be refilled with fine soil.
- The electric anti-corrosion works shall be done as described in these specifications and drawings, but the quantity of anodes shall be reviewed again for implementation. If any change is necessary, it shall be implemented after the approval by the supervisor.
- The contractor shall test potential per section after construction, based on the installation of a test box. If the result from the potential test is out of the aforesaid standard values, separate measures shall be established and reported to the supervisor.
- If any facility in direct current supply is neighboring or there is any alternating current supply in high voltage, a report for those facilities shall be prepared and presented.
- The contractor shall appoint a person in charge of electric anti-corrosion to carry out the overall construction works in an effort to increase the efficiency of construction after the construction contract is made.

(2) Cad weld

- It is very important to connect electric conductors to structures with connection devices in low resistance to prevent structures from corrosion.
- In using special alloys to minimize thermal influence on steels in the cad weld connection method, copper oxide and aluminum mixtures shall be placed per specification for cad weld metals, and powder igniters in CA-15 and CA-25 types are inserted into the plastic tube floor, and welded metals are placed on them.

(3) Test box

- A terminal to which the lead wire drawn from the pipeline and the lead wire of the reference electrode can be attached shall be built in a test box.

- The size of a text box shall be Ø230 x 110 (mm), which can be easily installed on the ground, and its cover shall be a hinge type.
- Copper sulfate reference electrode (Stelth 2 or others) shall be installed for potential detection in each test box and its life shall be at least 20 years or longer.
- The reference electrode (Stelth 2) shall be installed in a gap of about 60cm from the pipeline, and file soil shall be filled around the reference electrode. The position of the reference electrode shall be the opposite side of the anode installation in the pipeline.
- The electronic marker shall be installed for every lead wire in each test box to check out the position of lead wire for test in the event that the test box is damaged or lost after the completion of construction.

2.18.5. Test

The Contractor shall carry out every test to check out if all the facilities are installed to satisfaction or if they are operating.

The Contractor shall check out all the installed facilities to check out if their marks are consistent with those in the specifications.

(a) Reference potential

The ground potential (natural potential) shall be measured in the pipeline before any anode is connected to the water supply pipeline.

This measurement shall be carried out at the same position as that of measuring potential in the pipeline for the reference electrode defined in the specifications, and their initial measurement shall be recorded.

(b) Output of anode

When the anti-corrosive devices are connected to the pipeline, the full output shall be measured for anode with a low-resistance ammeter which has been certified, and the measurement, date, measured items and measured position shall be recorded.

(c) Potential measurement in the pipeline for the reference electrode

When the installation is completed and the entire anti-corrosion devices are operating, the potential around the electrode shall be measured using a direct current ammeter where scares are marked in 1V or 2V with its internal resistance (strength) 100,000 (ohm)/V or higher, as well as copper-copper sulfate reference electrode and ammeter-voltmeter.

It shall be carried out at the same position as that of measurement for this reference potential, and the measurement, date and measured position shall be recorded.

(d) Measured position

Any measurement shall be carried out at each test box and it may be carried out at any random point, if necessary.

As the reference electrode is buried at the position of each test box, no separate reference electrode is necessary. However, a potable copper sulfate reference electrode shall be used when potential is measured at other points than the position of a test box.

(e) Records of measured results

Any measured result for ground potentials in the pipeline including the initial potential (natural potential) shall be all recorded, if necessary.

If any short is found out from any anode lead wire, reference electrode lead wire or test line during check on the installed anti-corrosion devices, the constructor shall check out its position, correct it, and report it to the supervisor.

The measurement for the ground potential in the pipeline shall be carried out in all the test boxes because it is necessary to decide the degree of anti0corrosion or check out the position of such a short.

2.18.6. Operations of Anti-Corrosive Facilities

(a) Any anti-corrosive facility shall be operating before the final inspection.

(b) The Contractor shall successfully complete the final site inspection in the presence of the maintenance manager in charge of future operations for the anti-corrosive facilities, and then, the contact maintenance manager or its representative shall accept the facility.

2.18.7. Instructions for Operation and Maintenance

(a) The instructions for the opening operations on the stepwise procedures necessary for the start and operation of anti-corrosive facilities shall be presented. These instructions documents shall include the maker name, model number, maintenance guideline, component list, and brief descriptions on entire facilities and their operating points.

(b) Instructions for internal maintenance such as normal maintenance procedures, failure possibility and repair shall be presented, and these instructions documents shall include the drawings for the complete construction of facilities, guidelines on the potential measurement in the pipeline for reference electrode, and the required measurement frequency.

(c) Training course
The Contractor shall carry out training for personnel in charge of operations designated by the supervisor (supervising members). The training period shall be 4 working hours in total, which shall start before the final inspection after the functional completion of facilities.

(d) Performance test report
When the installation and test of facilities are completed, a report shall be presented in a brochure to prepare and record all the performed site test and measurement results in lists. Each test result report shall clarify the final location of the operating devices during this time.

2.19. Water Stop

2.19.1. Water Swelling Rubber Water Stop

Water swelling rubber water stop shall be in conformity with the relevant standards.

Installation surface for the water stop shall be maintained in a clean and dry condition.

The overlapped water stops for joining shall be about 50 mm.

2.19.2. PE Water Stop

The water stop shall be in conformity with Polyvinylchloride Water stop that can seal concrete joints effectively against moist penetration with sufficient rigidity and elasticity.

The water stop shall be produced through a process ensuring dense and uniform material distribution without any pores or other foreign substances. The cross section of the water stop shall be uniform and symmetric throughout the entire length.

The water stop shall be installed at the location as specified in the design document without any twist or bend, and the water stop joint shall be done without any leakage by PVC welding or other methods that have been approved by the Supervisor.

When concrete is applied on the water stop, every foreign substance shall be removed including oil, grease, and dried mortar while filling every portion of the water stop with concrete densely and rigidly.

The water stop shall be installed at every installation and joint on the exterior wall, floor slab, and other specified location.

The water stop shall be installed accurately in its place and fixed not allowing any movement by slightly burying it during concrete application or by other appropriate methods.

The water stop shall be installed to have the same buried portion relative to the both sides of joints.

The water stop shall be installed in a longest possible length, and the waterproofing seal shall be continuous throughout the entire length by appropriate joining.

Concrete shall be applied and compacted in between concrete and the water stop to ensure complete filling and adhesion.

Any damaged or defective or inappropriately installed water stop shall be repaired or replaced by the guidelines of manufacturer.

Water stop shall be joined using an electric heater with temperature regulating function and welding material according to the joining guidelines by the manufacturer. The joint shall have a tensile strength that is 60% of the original material or above with continuity of the water stop and pores. If the water stop joining is obstructive due to field conditions, it should be connected in a way that the waterproof is maintained by using connective material designated by the manufacturer.

Site quality management: The water stop and its joints shall be inspected to check whether there is any defect that can deteriorate the water proof installation effect arising from faulty installation, bubbles, inappropriate adhesion, permeability, cracks, or dislocation or not.

2.20. Drainage and Sewer Works

2.20.1 General

This specification covers general requirements for drainage and sewer work.

2.20.2 Reference Standards

- Reference Standards for drainage and sewerage works shall follow the Design Standards and detail codes described in Sub-section 1.3. All work in this section shall be carried out in accordance with locally applicable standards and codes of practice for material and workmanship or applicable codes and standards.
- Related construction specifications shall comply with the requirements indicated in the following construction specifications described in sub-section 2.3 for Earth Works and sub-section 2.5 for Concrete Works.

2.20.3 Materials

- Concrete pipes, and clay pipes shall confirm to local standards. The contractor shall submit catalogue of pipes and samples for approval of the engineer.
- Un-plasticized PVC pipe shall be of hard variety confirming to ASTM D1785, D2241, D2729. The contractor shall submit catalogue and sample of pipes for various diameters. The pipes shall be straight and shall be fixed with PVC adhesive as recommended by the manufacturer.
- All pipes shall also be provided with specials such as elbows, bends, y-branching, T-branching etc. which shall be of same material and diameter as the pipe.
- Material for jointing concrete pipes shall be Elastometric ring gaskets with sealing compound or caulking material with jute or hemp or asbestos or fiber and cement, Sand mixture of cement mortar. Material for jointing un-plasticized PVC pipe shall be PVC adhesive of manufacturer recommended quality or engineer approved quality.
- Material for jointing Cast Iron Spigot and Socket pipes shall be liquid pig lead or Asbestos fiber as filler material.
- Cracked or chipped or damaged pipes shall be rejected. Such rejected pipes shall be immediately removed away from site by the contractor. The contractor shall not be entitled to claim any compensation (monetary or otherwise) arising out of such rejections.
- Cement and sand shall be of the same quality as of construction specification for "2.5. Concrete Works".
- Cast Iron pipes shall be of soil quality with spigot and socket at one end. The jointing shall be with pig lead and jute or hessian fiber.
- The other pipes shall be approved by the engineer.

2.20.4 Execution for Concrete Pipes

(a) Installation

a) Excavation for pipe trench shall be carried out in accordance with Construction Specification : “2.3. Earth Works".

b) Removal of Unsuitable Material
Where wet or otherwise unsuitable soil incapable of properly supporting the pipe, as determined by the engineer, is encountered in bottom of trench, such material shall be

removed up to the required depth and replaced to the proper grade with selected material and compacted as provided in the specification.

c) Temporary bridges or crossing shall be built or erected in position by the contractor where required to maintain traffic and movement of material and personnel at no extra cost to client.

d) Bell holes shall be excavated accurately to size by hand.

e) Pipe Bedding.

The bedding surface for the pipe shall provide a firm uniform pipe bearing support throughout the entire length of pipe.

Lean concrete of grade fc = 16 MPa at 28 days age shall be laid for bedding where the quality of soil is poor in compaction. However, lean concrete shall not be necessary where the quality of soil is suitable for tamping and consolidation to the required profile. The pipe shall be carefully in the wet laid concrete or in soil, accurately rounded to conform to the lowest on fourth of the outside circumference of the circular pipe when necessary, the bedding shall be tamped.

Associated formwork for lean concrete bedding shall be carried out by the contractor if necessary at no extra cost to Customer.

Bell boles and depression for joints shall be of such length, depth and width as required for properly making the particular type joint as applicable.

f) Pipe Laying and Handling

Pipes shall be protected during handling against impact shocks and free fall. Proper facilities shall be provided for lowering the sections to prevent disturbance of the bed and trench sides.

All bends and special fixtures shall be laid along with the pipe as per drawing.

g) Pipe Joints

- Bell and spigot concrete pipe ends shall be thoroughly cleaned of all dust and undesirable matter and made wet.
- Jute fiber hemp rope shall then be dipped in thick cement slurry.
- The straight end of consecutive pipe shall be inserted in the bell mouth of previous pipe as required and shall be aligned by supporting on previously formed bedding.
- Jute fiber hemp rope thoroughly soaked in thick cement slurry shall then be inserted in between space of bell mouth and straight end of pipe in the form of a ring and caulked with caulking tools and a small chisel until the entire space is thoroughly packed with jute hemp rope.
- Cement mortar of 1 part cement : 2 parts of sand by volume shall then be thoroughly caulked in the space and finished smooth on all along the outer diameter of bell mouth as per drawing with sloped ends to repel any water. Water quantity in the mortar mix shall be such that the consistency of the mortar is suitable for the purpose intended and to the satisfaction of the engineer.
- Completed joint shall then be allowed to harden or set and cured with clean water without disturbing the joint for at least 5 days.
- Alternately concrete pipe joints shall be caulked with elastometric ring gasket which shall be inserted in place of jute or fiber hemp rope and caulked and sealed with

either cement mortar or manufacturer approved sealant in the similar way as mentioned above.

The size of elastometric ring gasket and the material quality shall be as recommended by the manufacturer.

h) Pipe joints at shallow depths shall be protected by a concrete sleeve pipe twice the outer diameter of be 11 mouth of pipe, or by covering the joints with extra thickness of 100 mm thick plain cement concrete as indicated in the drawing or as instructed by the engineer.

(b) Testing

a) The whole or part of underground drainage pipeline system shall be hydrostatically tested at the completion of work to the satisfaction of the engineer and other authorities and shall be retested if necessary until approved.

b) The pipe line shall be hydrostatically tested between manholes or free ends. Short branches between manholes shall be tested as one system with the main drainage line.

c) Lower ends and ends of connections shall be temporarily plugged. Water shall be added during test to compensate for absorption, and the test shall be continued for as long as the engineer may direct.

(c) Backfilling

a) Backfilling of pipe trenches shall not be commenced until after the pipes therein have been tested and passed to the satisfaction of the engineer.

b) Backfilling shall be carried out in layers not exceeding 300 mm, of un-compacted thickness.

c) Compaction density of backfilled soil shall not the less than 95% of maximum dry density of soil when backfilling is carried out for trenches below paved roads, paved areas and adjacent to existing structures.

(d) Test Certificates

When the entire underground pipeline is successfully completed, tested, inspected and approved by the local authorities having jurisdiction over such work, the contractor shall obtain a test certificate from such authorities and shall pay all the necessary fees and taxes as stipulated by the local authorities and shall submit such a certificate in three copies to the engineer certifying that the work has been carried out to comply with regulations approved by the local authorities.

2.20.5 Execution for Unplasticised PVC Pipes

(a) Pipe Handling and Laying

Un-plasticized PVC pipes shall be protected from sources of intense heat and from damage due to impact etc. while handling and laying. So as to ensure that the pipes and fittings are free from cracks and other physical damage.

All bends and special fixtures shall be laid along with the pipe as per drawing.

(b) Pipe Joints

a) Un-plasticized PVC underground pipes shall be joined to the consecutive pipe by using PVC adhesive as recommended by the manufacturer. PVC adhesive shall be coated over one pipe and the adjacent consecutive pipe shall fit in by slip on method and pressed against one another firmly till the adhesive sets and hardens.

b) PVC adhesive shall be of approved make as recommended by the manufacturer. The manufacturer shall submit all relevant technical data on PVC pipes and adhesive meeting the requirements of this specification and the requirement of the works.

(c) Backfilling

a) Backfilling of pipe trenches shall not be commenced until after the pipes therein have been tested and passed to the satisfaction of the engineer.

b) Backfilling shall be carried out in layers not exceeding 300 mm of uncompacted thickness.

c) Compaction density of backfilled soil shall not be less than 95% of maximum dry density of soil when backfilling is carried out for trenches below paved roads, paved areas and adjacent to existing structures.

(d) Test Certificates

The procedure for obtaining test certificates shall be similar to item 7.4 for Concrete Pipe Drainage.

2.20.6 Execution for Cast Iron Spigot & Socket Pipes of Soil Quality

(a) The pipes shall be handled carefully and laid with care to avoid damage and cracks.

(b) The pipes shall be free from all cracks, dents, fractures etc. and shall be straight.

(c) All bends and special fixtures shall be laid along with the pipes as per drawing.

(d) Pipes shall be coated with bituminous materials before laying if specified in the drawings.

(e) Pipe Joints

a) Bell and spigot C.I pipe ends shall be thoroughly cleaned of all loose matter with a wire brush and wiped clean with a dry cloth.

b) The straight end of consecutive pipe shall be inserted in the bell mouth of previous pipe as required and shall be aligned by supporting on temporary supports.

c) Jute fiber or hemp rope shall then be inserted in between space of bell mouth and straight end of the pipe and caulked with a caulking tool and a small chisel until the entire space along the circumference of the joint of the bell mouth is thoroughly packed with the fiber.

d) A clay pocket shall be built up all around the bell mouth to enable pouring of hot liquid lead into the joint without spilling.

e) Lead shall be heated to liquid form in a lead pot using an approved heating source such as blow lamp. Heating shall be done only after obtaining prior permission (fire permit) from the authorities. Liquid lead shall be poured in the hollow clay pocket and care shall be taken to ensure complete penetration of liquid lead into the joint without any air bubbles.

f) After initial cooling and solidification of lead, the clay pocket shall be removed and excess lead chiseled off. The lead shall then be thoroughly packed with a blunt chisel.

g) The final surface of lead joint shall be smooth and clean with slight sloped surface on the outer side.

h) Completed joint shall be perfectly supported from the bottom by packing and temping soil before they are subjected to superimposed load of backfill soil, otherwise the joints are liable to crack due to excessive stresses on the joint.

(f) Testing of C.I Pipe Line

a) Testing of C.I underground pipe shall be done by hydrostatic method at the completion of work to the satisfaction of the engineer other authorities and shall be retested if necessary until approved.

b) The pipeline shall be hydrostatically tested between manhole or free ends. Short branches between manholes shall be tested as one system with the main drainage line.

c) Lower ends and ends of connections shall be temporarily plugged. Water shall be added during test to compensate for absorption or evaporation and the test shall be continued for as long as the engineer may direct.

(g) Backfilling

a) Backfilling or pipe trenches shall not be commenced until after the pipes therein have been tested and passed satisfaction of the engineer

b) Backfilling shall be carried out in layers 300mm of un-compacted thickness.

c) Compaction density of backfilled soil when backfilling is carried out for trenches below paved roads, paved areas and adjacent to existing structures.

(h) Test Certifications

Test certificate obtaining procedures shall be similar to item no. 7.4 as described for Concrete Pipe Drainage.

2.20.7 High Density Polyethylene (HDPE) Pipes

(a) Except where otherwise specified, High Density Polyethylene pipes and fittings shall be in accordance with the following standards :

ASTM D 3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
ASTM F 1055	Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing
ASTM F 1281	Standard Specification for Crosslinked Polyethylene / Aluminum / Crosslinked Polyethylene (PEX-AL-PEX) Pressure Pipe
ASTM F 1282	Standard Specification for Polyethylene / Aluminum / Polyethylene (PE-AL-PE) Composite Pressure Pipe
ASTM F 1962	Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings
ASTM F 2206	Standard Specification for Fabricated Fittings of Butt-Fused Polyethylene (PE) Plastic Pipe, Fittings, Sheet Stock, Plate Stock, or Block Stock
ASTM F 714	Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based

	on Outside Diameter
ASTM F 810	Standard Specification for Smooth wall Polyethylene (PE) Pipe for Use in Drainage and Waste Disposal Absorption Fields

(b) High density polyethylene pipes and fittings for pressure pipelines shall be in accordance with specifications issued WRC as Water Industry Specifications. The manufacturer shall be responsible for all testing and quality assurance procedures and be covered by a third party certificate scheme. Pipes exceeding 90mm nominal diameter shall not be supplied in coils.

(c) All HDPE pipes and fittings for thermal fusion jointing to form an individual pipelines or pipeline systems shall be supplied by one manufacturer unless the Engineer's approves otherwise.

2.20.8 Execution for the Other Pipes

All of the pipe work, pipe handling, laying, jointing, testing, backfilling and test certificates etc. shall be approved by the engineer.

2.20.9 Workmanship

(a) Manufacturer's Recommendations

Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of such recommendations shall be submitted to the engineer prior to installation.

Installation of the item shall not be started until the recommendations are received. Failure to furnish such recommendations shall be one of the causes for rejection of the material.

(b) Installer's Qualifications and Acceptance Criteria for Drainage Work

a) All underground pipe drainage shall be executed by qualified and experienced personnel having valid license issued by the local authorities to execute the work which shall be approved by the engineer if applicable.

b) The Contractor shall procure all the permits and shall pay all fees and charges in connection with this work.

c) The whole drainage work shall comply with the regulations of the relevant local authorities and shall be completed to the satisfaction of relevant local authorities and the engineer if applicable.

d) Drainage pipes in general shall be free from fractures, large or deep cracks and surface roughness. The ends of pipes shall be normal to the wall and to the center line of the pipe. All pipes shall include bends and special fixtures of the same material as per drawing.

2.20.10 Inspection & Tolerances

(a) Inspection & Tolerances for all underground drainage work shall be in accordance with related specification.

(b) Inspection Before Installation

The following inspection shall be made before installation.

a) Assure that materials are of the type specified.

b) Check that pipe to be installed is free of interior bulges, damages, fractures, cracks or splits.

c) Check the grade of excavated trench bottom conforms to drawing after compaction.

(c) Inspection During Installation

a) Verify that pipe bedding & joints are constructed as specified.

b) In cast of underground cable laying, verify that the thickness of sand cushion & the distance between laid cables is maintained as per drawing. Also check that Megger testing of the cables is carried out.

c) Check for coverage of joints with concrete in case pipes are laid at a shallow depth below existing ground.

(d) Inspection after Installation

The following inspection shall be made after installation.

a) Assure the laid position of pipe to conform to drawings.

b) Check that joints are totally leak proof during hydro-testing.

c) Check compaction of backfill material.

2.21. Road works

2.21.1. Earthworks

The earthworks for roads shall be in accordance with the requirements elsewhere in the Specification.

Where the dry density of the natural ground within 0.3 m depth of the formation level is below 90% of the maximum dry density as determined in DIN 18126 or equivalent standard, the sub-grade material shall be reworked and compacted to 90% of the maximum dry density.

Fill below 0.3 m depth under the formation level shall be compacted to 90% maximum dry density. Fill within 0.3 m depth of the formation level shall be compacted to 95% maximum dry density.

When compacting sub-grade sections, particular attention shall be paid to the requirement that the natural sub-grade or the fill shall be compacted with a slight outward slope to ensure good run-off of surface water.

Material excavated out of the road bed which is suitable for use in fill, shall be used for filling as far as this is practicable.

2.21.2. Finish and Protection of Sub-grade

When the sub-grade has been compacted to the required degree, the surface shall have a formation parallel to the finished surface of the carriageway and to the correct levels and cross-section.

The finished surface of the sub-grade shall be approved by the Engineer before any sub-base material is placed. The sub-grade, once it has been finally compacted, shaped and approved, shall be protected and kept well drained.

Plant and materials shall not be stored or stockpiled on the formation. Contractor's traffic shall not be permitted to pass over the completed sub-grade unless otherwise approved by the Engineer. The Contractor shall, at his own expense, repair any soft spots or damage caused to the sub-grade.

2.21.3. Material and Construction of Sub-base

The granular material used in the sub-base shall comply with the requirements specified in DIN 4226. All material shall be placed, spread evenly and compacted, spreading shall be undertaken concurrently with placing. The material shall be spread in one or more layers so that after compaction the total thickness is as required. Compaction of the sub-base shall be to 98% of the maximum dry density in accordance with DIN 18126 or equivalent standard and shall be completed as soon as possible after the material has been spread. Where compacting plant is of insufficient capacity, the sub-base shall be laid in two or more layers. During the construction period the sub-base shall be maintained in such a condition that it will be drained at all times. The outflow shall be diverted away from the construction at all times.

The outflow shall be diverted away from the construction in order to prevent erosion.

2.21.4. Requirements for Compaction

Vibratory compacting plant may be used if approved by the Engineer. The number of passes to be made will be determined having regard to the characteristics of the plant to be employed and the material to be used.

If necessary, test specimens shall be taken to determine the optimum method of compaction. The surface of any layer of material shall, on completion of compaction, be well closed, free from movement under compaction plant and free from compaction planes.

All loose, segregated or otherwise defective areas shall be made good to the thickness of the layer and recompacted.

2.21.5. Material and Construction of Base

The base shall comprise of one of the following:

(a) Selected gravel base

(b) Crushed stone

(c) Cement stabilised selected gravel base

The selected gravel or crushed stone base shall be minimum 150 mm or as required by the existing ground conditions. The base material shall be a well graded material complying with the following requirements:

(a) CBR value after 24 hours soaking shall not be less than 80 %

(b) Liquid limit and plasticity index shall not exceed respectively 25 % and 8 %

(c) The grading limits shall be:

BS sieve size	Percentage by mass passing
75 mm	100
37.5 mm	85-100
20 mm	60-100
10 mm	40-70
5 mm	25-45
600 micron	8-22
75 micron	0-10

The particle size shall be determined by the washing and sieving method of BS812: Part 103

The selected gravel or crushed stone base shall be compacted to 100% of maximum dry density.

Compaction shall take place by watering and rolling until there is no longer any visible movements of the compacted stone material and a stone of the base material when thrown under the roller shall become crushed. A finishing layer of sand shall be rolled in to fill the surface voids.

The cement stabilised selected gravel base shall be minimum 150 mm or as required by the existing ground conditions. The gravel material shall answer to the above specification and be stabilised with 6 - 8% of Portland cement. To obtain a uniform mixture of materials and water, the cement stabilised gravel base shall be manufactured in a pug mill, carried to the place of placement and compacted to 100% of maximum dry density. If the conditions on site allows it and the Engineer approves, the cement stabilised gravel base may be constructed on site by using rotary tillers and water bowsers to obtain a well mixed base.

The compaction requirement remains unchanged, i.e. 100% of maximum dry density.

The material shall be placed and spread evenly, spreading shall be undertaken concurrently with placing. Road base material shall preferably be spread in one layer using a paying machine or similar approved.

The material shall be spread so that after compaction the total thickness is as required. The Contractor shall organise the work in such a way that longitudinal joints against hardened material are avoided as far as possible. If this is not possible then before work proceeds against a longitudinal joint of hardened material, the edge compacted previously shall, if it has been exposed for more than an hour, be cut back vertically to produce a face equivalent to the specified thickness of the layer of properly compacted material.

Compaction of the road base to a minimum of 100% of the maximum dry density shall be completed as soon as possible after the material has been spread. Compaction equipment shall not bear directly on hardened or partially hardened material previously laid other than what is necessary for achieving the specified compaction of the joint. Special care shall be taken to obtain full compaction in the vicinity of both longitudinal and transverse joints and the Contractor shall use special small compactors in addition if necessary or instructed by the Engineer.

Any loose or poorly compacted material in the vicinity of construction joints shall be removed and replaced with fresh material. The surface of any layer of material shall on completion of compaction be well closed, free from movement under compaction plant and free from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the fill thickness of the layer and recompacted. If this cannot be done within 2 hours of mixing, the making good shall comprise the material being broken out to the full thickness of the layer, removed and replaced with freshly mixed material compacted to Specification.

The base shall, immediately on completion or completion, be cured for a period of at least 7 days, unless otherwise approved by the Engineer. Curing shall be achieved either by covering with approved impermeable plastic sheeting adequately secured from being blown off the surface with joints overlapped at least 300 mm and set to prevent egress of moisture or in accordance with Clauses in the Specification dealing with concrete or by spraying with an approved curing compound.

Notwithstanding the above the Contractor shall construct the road base in accordance with the requirements and specification of the relevant Authority or Municipality. The Specification included herein shall be adopted only in the absence of any particular requirements from these authorities.

2.22. Road Works : Asphalt concrete pavement

2.22.1 General

This construction specification covers general requirements for Asphalt Road work.

The Contractor shall be responsible for setting out the center lines of all roads and areas where required in relation to the given base line or lines and reference points as approved by engineer.

All radii at intersection and curves and all details shown on the drawings shall be strictly adhered to and all levels shall be set out from the Bench Marks on the site.

The Contractor shall check and verify the established Bench marks for location and elevation of grade, prior to commencement of setting out work.

The Contractor shall maintain all dimensional details such as width, shoulder, gradient, etc. in accordance with drawings.

2.22.2 Reference Standards

The applicable standards and testing shall conform to the recommendations of ASTM.

ASTM D2166 Standard Test Method for Unconfined Compressive Strength of Cohesive Soils.

ASTM D1556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.

ASTM D4186 Specification for Crushed Aggregate for Macadam Pavement.

ASTM D1195 Represetative Static Plate Load Test of Soil & Flexible Pavement Component.

ASTM D1196 Non Repeatitive Static Plate Load Test of Soil & Flexible Pavement Component.

ASTM D946 Penetration-Graded Asphalt Cement for Use in Pavement Construction.

2.22.3 Submissions by the Contractor

- The Contractor shall submit test-certificates for all materials supplied by the contractor as and when called for by engineer. The Contractor shall also give the details such as source of supply, gradation standards, size of aggregates, details of mix etc.
- For Bituminous or Asphalt road pavements, the Contractor shall submit in advance Job Mix Formula stating all the details such as Grade of Bitumen, flash point, penetration, sieve analysis of aggregates, final temperature of hot mix, curves for gradation of aggregates, final mix proportion, minimum content of asphalt or bitumen per cubic meter of hot mix, etc. This shall be submitted to engineer at least 30 days prior to commencement of work to enable engineer to study the same and for his approval and comments. Approval of the Job Mix Formula by engineer shall not relieve the contractor of his contractual obligations and quality control responsibilities.

2.22.4 Materials

The mixed materials shall be transported from mixing plant to the site of work in clean vehicles and shall be covered with tarpaulins while transportation to prevent loss of heat from the asphalt hot mix (for example) and to minimize contamination due to dust or rains and for general traffic safety purposes while the material is being transported in open trucks or dumpers which have uncovered top side.

Every precaution shall be taken to prevent segregation of mixed material while transporting, loading and unloading.

(a) Materials for Asphalt Concrete Road and Paving

a) Coarse Aggregates for Asphalt Wearing Course Crusher run hard rock shall be with sharp edges. The rock shall be granite rock having uniform color free from fissures and salts to the maximum extent. The crushed rock shall be hard, dense durable, clean and the sizes shall conform in accordance with required gradation.
Gravel if specified shall be river bed gravel and shall consist of natural or artificial mixture of hard pebbles.

b) Fine Aggregates for Asphalt Wearing Course
Fine Aggregates shall be clean, and shall be obtained from either a river bed, pit or sand quarry or shall be fine particles of crushed stone. The size of particle shall not exceed 6 mm.
The fine aggregates shall be sharp edged and shall be free from organic impurities, decomposed material, soil, clay, loam, and other foreign matter and shall generally conform to ASTM D1073. Sea sand shall not be used.

c) Grading of Aggregates
Maximum size of aggregate shall be 13 mm or 20 mm.

d) Bitumen

Bitumen shall be road bitumen conforming to recommendations of ASTM D946 having a bitumen content of not less than 90%. Bitumen having penetration greater than 85/100 shall be used unless otherwise specialty required.

e) Bitumen Emulsion

Bitumen emulsion shall have bitumen content of not less than 60%.

(b) Mechanically Stabilized Crushed Stone and Gravel

Crushed stone and gravel shall consist of a natural or artificial mixture of hard, durable particles of uniform quality. The material shall be free from soft or decomposed particles and excess clay, and shall be uniformly graded so that it can be compacted into hard, dense mass.

(c) Soil for Embankment

Soil for embankment filling shall be generally granular and shall be free from organic decomposed material, humus, clay etc. Heavy clayey soils shall not be used.

(d) Manholes and Street Gullies

Pre-cast concrete chamber rings for manholes and inspection chambers and street gullies shall comply with the requirements of ASTM C 139 ‘Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes’. The concrete shall be made with ordinary Portland cement unless specified otherwise. The unit shall be supplied to the typical details shown on the drawings and to the required dimensions. Cast iron covers and gully gratings and frame shall be of the grades shown on the drawings.

2.22.5 Execution

(a) Excavation/Grading/Leveling

a) In accordance with the cross sectional profile of the road, there shall be cutting and filling involved for road work.

b) Stripping and Spreading of Topsoil

1) All topsoil shall be stripped from areas to be paved, excavated or filled and from other areas as shown in the drawings.
   All organic impurities shall be removed while carrying out stripping of the area for the road or pavement.

2) The depth of the topsoil shall be in accordance with drawings or as instructed by engineer.

c) Excavation

1) Excavation shall conform to limits indicated on the Drawings or specified herein.

2) Excavation shall not be made below grade except where rock or stone masonry is encountered or removal of unstable material as directed by the Engineer.

3) Material removed below grade shall be replaced with approved material thoroughly compacted or as otherwise directed by the Engineer.

   Where excavated material is required for the construction of embankments, for road, etc. and the material encountered in excavation consists of earth, soft rock, and hard rock, the contractor shall construct the bottom of the fills with hard rock, following this with soft rock and finally the earthfill.

Care shall be taken throughout to provide well compacted and void free embankment. The work shall also include stockpiling and rehandling which shall be carried out by the contractor at no extra cost to the Engineer.

d) Borrow Materials

1) Construction method of Embankment shall be done same as in construction specification : “2.3. Earth Works”.

2) Where additional material is required to complete the embankment or fill, the Contractor shall provide it. This borrow material shall be inorganic material approved by the Engineer.

3) The Contractor shall give engineer at least 5 days' notice to permit cross-sectioning before removing borrow material from any approved borrow pit.

e) Filling

1) The soil for filling shall be approved by engineer and prior to being used, shall be given a compaction test to determine its suitability.

2) Fills shall not be started until the area has been inspected and approved by the Engineer.

3) Embankment and fill material shall be free from frost, stumps, trees, roots, sod or muck.

4) Compaction shall be carried out by Vibration roller and macadam roller when required depth, width and strength is obtained.

f) Subgrade

1) Sloped surfaces steeper than 4:1 shall be scarified or stepped and compacted to provide bond with new material. When existing roadways are to be covered with less than 300 mm of fill, the surface shall be scarified and recompacted to the same density as specified for fills.

2) Before starting with clearing and refilling the roadway and shoulders or temporary road shall be drained of all surface water and ground water over the whole width of the road. Dewatering shall be carried out at the Contractor's own expenses.

3) Sub-grade shall be compacted with vibratory rollers and plane steel rollers weighing not less than 10 tons including watering wherever necessary to attain a compaction density of not less than 95% of Max, Dry Density as per ASTM D1556 or D1557. Clay soils and heavy clay sub-grade shall be compacted with sheep’s foot rollers. Watering shall be carried out by the contractor. Final compacted surface shall be slightly trimmed by a grader to the required camber and slope as per drawing and the top level of finished sub-grade shall conform to drawings. Compacted sub-grade shall not be disturbed while trimming with grader blade. Finish tolerance of sub-grade : ±25 mm at any point

g) Base Course

The base course shall consist of the following

1) Crusher run stones which shall be well compacted with intermediate filler material to fill the interstices until there is no movement of the stones under the roller and also to the satisfaction of the Engineer.

2) Mechanically stabilized Gravel and Crushed Stone Base Course :

This base course shall not be constructed on a wet sub-grade or sub-base. The material shall be deposited and spread in lanes in a uniform layer without segregation of size to such loose depth that when compacted, making due allowance for any admixture that is to be blended, the layer will have the required thickness. In the event of any segregation, the material shall be mixed with harrows, blades, rotary tillers etc. to obtain uniform mixture.

Mixing shall continue until the mixture is uniform throughout. When the mixing and blending have been completed, the mixture shall be spread to a uniform depth sufficient to give the required thickness of layer when compacted. Water shall be added in requisite amount while mixing to maintain uniform moisture content of the mix.

The surface shall then be given one pass with roller, after which the surface shall be checked with straight edge and the surface irregularities shall be corrected.

Each layer shall be compacted for full width and depth by rolling with a tire roller or a three wheel power roller weighing not less than 10 tons. Alternate blading and rolling shall be required to provide a smooth, even, and uniformly compacted course true to cross section and grade.

Final Cross section shall be checked for camber by a template to correct all the undulations.

The mix moisture content shall be controlled by draining and aeration when too wet or by adding water when too dry. Finish Tolerance : ±15mm at any point.

3) Water Bound Macadam Base Course

This base course shall not be constructed during wet season overwet sub-base or sub-grade. This base course shall be constructed over already prepared sub-grade or sub-base course. This base course shall be constructed in layers not exceeding 100 mm when compacted. Sufficient coarse aggregates shall be uniformly spread to give the required thickness when compacted with minimum 10 Ton roller.

The voids shall be filled with screenings and the macadam shall be sprinkled with water being followed by the roller. This sprinkling, filling voids with finer materials such as screenings and rolling shall continue until voids are completely filled and the coarse stone firmly set and bonded throughout the depth of the layer.

Should the sub-grade or sub-base at any time become soft or churned up with base course material, the contractor shall, without additional compensation, remove the mixture from the affected portion, re-shape and compact the sub-grade or sub-base and replace the removed section. Coarse aggregates shall not be spread more than 2,000 m² and never more than 150° linear meters in advance of rolling and spreading screenings and brooming.

Tolerance : The surface shall be true to the established grade surface, and shall not vary more than 6 mm in 3 m length from the true profile and cross section.

4) Bitumen Stabilized Base Course

The compacted sub-base top shall be covered with prime coat. Prime coat shall consist of Medium Curing or Rapid curing Cut Back asphalt applied at 1.5 liters per 1 m² at 45℃ temperature.

The sub-base surface shall be totally dry and free from moisture and dust before applying prime coat by mechanical spray. Sand and gravel and hot bitumen shall be premixed in hot mix plant and this mix shall be transported to the site and spread to the site and spread to the desired thickness and width so as to get a compacted thickness as shown in the drawing. The mix temperature at the time of placing shall not be less than 110℃. The mix shall be placed by a mechanical spreader. All cold construction joints shall be chipped before new mix spreading starts.

The hot mix shall be compacted when the temperature of mix is between 90℃ to 70℃.

Initially with water sprayed tire rollers and afterwards with 10T steel road roller.
Thickness of layer shall not exceed 120 mm when compacted.
Rolling shall be carefully done to avoid forming surface cracks due to flow of hot mix when it is very hot whereby rolling at that temperature may cause a slight flow of the mix.

Rolling shall not be carried out when the temperature of the mix is below 70℃ otherwise cold mix may crack.
After final rolling, the surface shall be checked for thru section, camber and gradient.

Corrective measures shall be taken after checking the camber of the road, grade etc.

Tolerance : permissible variation : ±10 mm per 10 meter length.

2.22.6 Asphalt Concrete Work

(a) The Contractor shall place the Asphalt concrete in the locations and in the thickness indicated on the drawings. Compaction by rolling shall be performed in three stages.
Primary rolling, Secondary rolling and Finish rolling.
Other description shall be similar to Bitumen Stabilized base course except for the following.

a) Material used for asphalt concrete shall consist of coarse, and fine aggregates of specified sizes and mix proportions as specified and asphalt.

b) Only dry aggregates shall be mixed hot in the hot mix plant using specified grade of bitumen asphalt depending upon the grade of asphalt to be used for the work.

(b) Each layer of the sub-base and base course shall be compacted to at least 95% of maximum dry density as determined by the test conforming to ASTM D1557.
Surface/dimensional tolerance : ±15 mm for every 6 m length.

2.22.7 Road Machinery & Equipment

The Contractor shall utilize and employ machinery for carrying out road work which shall be in good turning condition.

All the costs of fuel, oils lubricants, water, maintenance, operators, spares and repairs, etc. shall be borne by the Contractor.

Major equipment for various types of work shall meet the basic requirements of specifications and surface tolerances as specified earlier.

2.22.8 Inspection and Test

(a) Inspection
All inspection shall be carried out in accordance with the Inspection and Testing Procedures.

a) Shoulders shall be provided for the road in accordance with the drawings which shall be treated as integral part of the road work.

b) Road camber shall be checked with wooden or metal templates for true camber.

c) All subsequent layers such as sub-grade, sub-base, base course etc. shall be protected from damage due to rains or passing vehicles until the next layer is constructed over the earlier layer.

d) Any repairs, patch work, removal due to failure of field test results etc. shall be carried out by the Contractor as directed by the engineer at no extra compensation to the contractor.

e) The Elevation for curvatures shall be provided as per drawings or as directed by the Engineer.

(b) Workmanship

For all the items listed below, the contractor shall submit a request for inspection to the Engineer at least three days prior to carrying out the work.

a) General Work

Item	Description	Frequency	Allowable Limit
Level	Sub-grade	Every 500 m^2	±3 cm
	Surface of Sub-base and Wearing Coarse	- ditto -	±3 cm
Width	Each course	- ditto -	±3 cm
Thickness	Asphalt Wearing Course	- ditto -	more than specified thickness
	Other Course	- ditto -	- ditto -

b) Paving Work

Item	Description	Frequency	Allowable Limit
Level	Gravel Spreading	Every 500 m2	±2 cm
Thickness	Gravel Spreading	- ditto -	±2 cm

(c) Tests

a) The Contractor shall execute and shall bear all the costs and expenses for all tests.

b) The Contractor shall obtain and submit material test certificates stating the guarantee of quality of factory supplied materials conforming to specified standards of equivalent. Materials such as bitumen shall be certified by the manufacturer/supplier as to the grade of bitumen, and its quality conforming to specified standards.

c) The following quality control tests shall be carried out by the Contractor.
The results from these tests shall be submitted to the Engineer as soon as possible after

carrying out these tests.
Testing laboratory shall be an authorized institute or government body recognized as the standard testing laboratory of repute in the country.
All test charges shall be borne by the Contractor.

Road	Test	Frequency	Allowable Limit
Subgrade	Field Density Test (rd)	Every 100 m	Not less than 95% of rd max
Base Course	Plate Bearing Test (K30)	Every 500 m	Not less than 20 Kg/cm^3
Asphalt Wearing Course	Temperature	Every Truck or lorry	
	Grading of aggregate	Once a month at Point of production	2.5mm sieve : ±15% of the value specified in JOB MIX FORMULA
	Asphalt Content	As per engineer's instructions	±1.2% of the value specified in JOB MIX FORMULA
	Density	Every 500 m	Not less than 95% of the value specified in JOB MIX FORMULA

Marshall Density, Marshall Flow tests for asphalt concrete and specific gravity shall be tested for every 2000 m^2 of road carpet area.
The Compaction tests for asphalt concrete shall be carried out at the rate of one test per 1000 m^2 at the place designated by the Engineer by taking 150 mm diameter core samples at site.

2.23. Access Road Works

The Contractor should make an even and leveled surface of the access road, and should install the drainage pipes across the road. The Contractor should make the access road in the reservoirs area, and the drainage and other miscellaneous construction will be included.

2.24. Vents in the Air Valve Room

Vents should be installed in the air valve room according to the design documents. Copper or stainless steel mesh over #20 shall be installed at the end of vent by using a flange.

The vents in an air valve room located in a river shall be installed above the flood level.

When the vents are installed on a public road, they shall be installed in an inaccessible location in order to ensure stable performance of the pipeline facility.

2.25. Water Bulk Meter

Bulk flow meters for diameters greater than 150 mm shall be inclined in-line turbine type meters to BS 5728, EN 14184-3 and EN 14154 suitable for installation in horizontal or vertical mains unless otherwise indicated on Drawings or in the Bills of Quantities. Each meter shall have a register calibrated in cubic meters, with straight reading counters. The meters shall be capable of measuring accurately +/- 2.5%. For diameters of 150 mm and less, and if so specified, then a combination water meter shall be provided so as to give an accuracy of +/- 2.0%. All meters shall be supplied complete with a removable strainer, and if so indicated on the Drawings with extended registers of the nearest but shorter standard length to that indicated.

End flanges shall be drilled to EN 1092-1, NP 16 or shall be supplied complete with flange gaskets, bolts, nuts and washers.

Domestic (consumer) meters will be of the single jet inferential type, with metal body and unless otherwise called for shall be with a dry dial register capable of measuring to the nearest 0.001 m^3, and having an accuracy of +/- 2% unless otherwise indicated in the Bill of Quantities. The meters shall be manufactured to BS 5728, EN 14184-3 and EN 14154, and shall be subject to the Engineer’s approval prior to ordering. They shall be suitable for both horizontal and vertical location and shall be supplied complete with removable strainer and non return valve.

2.26. Gabions (wall type, for mattress)

2.26.1 Materials

(a) General Materials

- Gabions are made into box shapes in various sizes of iron nets in duplicated twists of pentagonal or hexagonal mesh types using iron mesh rods with strong corrosiveness. They adopt the production where solid stones may be filled in a box.
- An iron wire thicker than the iron wire in the main structure shall be used for the circumferential iron wire in a gabion.
- An iron net shall be twisted and connected in a duplicated manner as well as in a pentagonal or hexagonal shape, so that the disconnection in any area may no cause the entire collapse with the flexibility to endure any form of settlement. The mesh size shall be 8×8~10 cm.
- The internal partitions shall divide the gabion box inside into the same size and the length of each section shall be within 1.5 times as large as the width.
- The connecting iron wire shall be used for assembling and connecting gabions and made from the same material consisting of gabions.
- The filling material shall be solid, dense and durable stone and the large or small components shall be distributed and maintained evenly, which is good with durability as well as proper strength in the rounded or cornered shape.

- Stone shall not include minerals to be discolored or deformed by weathering. It shall not be worried about breaking due to weathering or freezing. The assembly ratio between filling materials shall be good after placement. The compression strength under BS shall be 50 MPa or more and absorption shall be 5% or less. Its specific gravity shall be about 2.5 or more. Regardless of stone color, it may be used if the testing regulations are met, but shale stones or mudstones may not be used.

(b) Quality control and test

- Materials for gabions shall follow testing regulations under the relevant standards as an iron wire with anti-corrosiveness in zinc plated iron wire class 5 or equivalent or better. The sampling shall be taken in the presence of the construction supervisor before use after delivery to the site to take the control testing.
- Gabions shall be able to prevent the loosening due to the mutual connection of mesh in hexagonal shape from the winding and twisting of iron wire net section three and half times as many, as well as in pentagonal shape from the winding and twisting of iron wire net section two and half times as many by the horizontally reinforcing iron wire together with net section iron wire as mentioned before. Gabions shall be made under drawings, as well as division in the unit of 1 m with the woven iron net in hexagonal mesh with the steel wire. General specifications of gabions are shown below.

Division	Net section (cm)	Iron wire		Size (m) (B × H × L)	Remarks
		Area	Diameter (mm)		
Mattress type Wall type	8 × 8~10	Circumferential iron wire	3.4	2.0 × 0.48~0.50 × 6.0 2.0 × 0.28~0.30 × 6.0 1.0 × 1.0 × 1.0 1.0 × 1.0 × 2.0 1.0 × 0.5 × 1.5 1.0 × 1.0 × 1.5	Customized production in case of change in dimension
		Horizontally reinforcing iron wire	3.4		
		Net section iron wire	2.7		
		Connection iron wire	2.2		

- The corner, partition and edge of gabions shall be made into solid circumference to sufficiently maintain the iron mesh structure as well as to prevent the loosening of iron mesh structure.
  1) The iron wire used for edge shall be thicker than that used for mesh.
  2) Both the gabion end panel and partition shall become circumference perpendicularly to the top line. The end panel shall be connected by the dual twisted end finish of the mechanical iron mesh at the circumference of the gabion bottom panel.
  3) The partition shall be connected to the floor by the connection in spiral shape passing through each net frame between the mesh gap and partition panel.
- The seaming iron wire shall be used for the strong connection of gabions, and this iron wire shall have the same characteristics as those of iron wires consisting of gabions,

and the thickness of iron wire shall be 2.2 m.

- Tolerance in dimension for every gabion shall be within 5% of the required size and within 5% of the length.
- River aggregates (solid boulders) and rocky mountain aggregates (blasted rocks or rubbles) may be used for filling material.
- The most appropriate size of aggregates as the filling material shall be larger than the net section and smaller than 1/2 of the gabion height. The size shall be around 80 ~ 150 mmif the gabion height is 0.3 m wall, and around 100~250 mm if the height is 0.5 m wall, and 150~300 mm if the gabion height is 1.0 m wall.
- 85% or more of gross stone weight in wall type gabion shall abide by provisions in General and (H) in Quality Control and Test, and stones to fill small spaces shall not exceed 15%.

- Unit Weight per Stone

Type	Unit Weight (㎏/㎥)	Remarks
Granite	2,600 ~ 2,700	
Basalt	2,700 ~ 3,200	
Andesite	2,300 ~ 2,700	
Sandstone	2,400 ~ 2,790	

2.26.2 Construction

(a) Filter mattress shall be placed on the already completed levee slope and the assembled empty mattress gabions shall be installed within the working range of work equipment (backhoe, etc.)

(b) Drooping shall be prevented due to the input of filling materials by driving the fixing piles on the foundation with iron rods to prevent the installed gabions from bending or unbalancing to one side.

(c) For the installation of binding iron wire to connect the floor mesh and cover mesh to tie up the top cover before the input of filling materials, the connecting iron wire is pulled up by twisting iron wires twice or more on the floor mesh; the installation of the cover mesh is done after the filling stones are filled; and both the floor mesh and cover mesh shall be installed in a more uniform way by twisting and binding the already installed connecting and binding iron wire twice or more in a strong manner to the net section mesh in the cover.

(d) As mattress type of gabions are implemented on the mounding section of a levee in most cases, the partial settlement may occur due to the weight of filling materials despite compaction on the mounding. Accordingly, more filling materials shall be filled than the actual height, while the gap is minimized.

(e) When the foundation is thought to be stabilized after the placement of filling materials, the surface leveling shall be done for the filling materials. And then, the cover shall be placed, where the connection shall be strong for the close tightness between the filling materials and the cover. As the flow of runoff exist on the revetment surface all the time, the cutting shall be shortened as much as possible to prevent any floating objects from being stuck in the connecting iron wire and the cut area shall be bent and inserted into the net.

(f) The gap of the binding section shall be around 20 cm when the partition and cover of gabions are assembled. The material for the binding iron wire shall be the same as that of gabions and its thickness shall be 2.2 mm. The knob of iron wire shall be made twice or more and the connection shall be done in a uniform way for all.

(g) If the foundation is fragile when the wall type gabions are constructed, the ground improvement shall be done or support concrete shall be placed to support the weight of gabions.

(h) If the wall type gabions are constructed, 1/3 out of 1m height of gabions shall be filled, the intermediate iron wire shall be connected to adjust the front perpendicularly, and then, stones are filled and the support iron wire is connected again in about 2/3, and stones are filled up to the top.

(i) The covering of good sand and earth shall be carried out in about 20 cm of the installed area in consideration of the gap ratio of filling materials for the quick rooting and maximizing of vegetation survival after the construction of mattress type gabions, and 15 cm of soil depth for the minimum survival of vegetation shall be secured.

2.27. Fence and Chain link

2.27.1 General

The work under this spec. shall consist of furnishing all labor, tools, materials, Constructional plant, and other items necessary for the complete installation of chain-link fabric fence including gates at the locations indicated on the drawings and as specified herein.

2.27.2 Reference Standards

Reference Standards for fence and chain link shall follow the Design Standards and detail codes described in sub-section 1.2. All work in this section shall be carried out in accordance with locally applicable standards and codes of practice for material and workmanship or applicable codes and standards. Related construction specifications shall comply with the requirements indicated in the construction specifications described in sub-section 2.3 for Earth Works and sub-section 2.5 for Concrete Works.

2.27.3 Materials

(a) General

Materials shall conform to the respective specifications and other requirements specified herein.

(b) Chain-Link Fabric

Chain-link fabric shall be zinc-coated steel wire fabric (galvanized after weaving) that conforms to the requirements of ASTM A-392, or equal. Chain link fabric shall have Class 1 zinc coating-366 grams of zinc per square meter minimum of uncoated wire surface. Chain-link fabric shall be 3.76 mm steel wire woven in a 50 mm mesh.

(c) Posts

Posts shall be of the material, size, and length indicated on the drawings. All steel pipe posts shall have tops provided with covering to exclude moisture. All concrete posts shall be precast.

a) Steel pipe line (or intermediate) post shall be 50 mm in diameter

b) Steel pipe terminal (end, corner, and pull) post shall be 100 mm in diameter.

c) Gate Post shall be steel pipe 150mm in diameter

d) Concrete post shall be precast, reinforced concrete post of the dimension and length indicated. Cement, coarse and fine aggregates, forms, admixtures, and water shall be in accordance with the applicable requirements specified in the Specification entitled in section 2.5 for Concrete Works. Steel reinforcement shall be in accordance with the applicable requirements specified in section 2.5 for Concrete Works.

(d) Top Rail and Bottom Rail

Top rail and bottom rail shall be fabricated from steel pipe 30 mm in diameter.

(e) Bracing

Bracings for terminal (end, corner, pull, and gate) posts shall be fabricated from steel pipe 30 mm in diameter.

(f) Barbed Wire

Barbed wire shall be zinc-coated (galvanized). Barbed wire shall consist of three (3) strands of 2.50 mm wire with 2.00 mm wire four-point barbs spaced approximately 12.7 cm apart. Steel wires shall have a minimum coating of 244 grams of zinc per square meter of surface area on 3.03 mm wire.

(g) Tie Wire

Tie wire shall be zinc-coated (galvanized) steel tie wire conforming to the requirements of ASTM A 112, or equal. The galvanized tie wire shall have a nominal diameter of 2.66 mm (12 gage) and a minimum zinc coating of 244 grams of zinc per square meter (0.80 ounces of zinc per square foot) of uncoated wire.

(h) Miscellaneous Metal Items

Miscellaneous metal items such as tension rods, turnbuckles, stretcher bars, clamps, ends of top rails and bottom rails, bolts and nuts, hook bolts, mounting clips, and stiffener plates shall be as indicated on the drawings.

(i) Gates

Gates shall be swing type as indicated on the drawings, complete with latches, stops, keepers, hinges, and provided with three (3) strands of barbed wire above the fabric.

a) Gate frames shall be constructed of steel pipes 50 mm in diameter welded at all corners. Tension rods with turnbuckles shall be provided to prevent sag or twist. The end members of the gate frame shall be extended above the top horizontal member to accommodate three (3) strands of barbed wire and tension rod. Gate frames shall be zinc coated (galvanized) after fabrication.

b) Fabric shall be the same type as used in the fence construction. The fabric shall be attached securely to the gate frame by tie wires at the top and bottom frame at intervals not exceeding 40 mm and at the side frames by stretcher bars with hook bolts.

c) Hinges shall be of adequate strength for the gate and with large bearing surfaces for clamping in position. The hinges shall not twist or turn under the action of the gate. The gates shall be capable of being opened and closed easily by one person.

d) Latches, stops, and keepers shall be provided for all gates. Latches shall have a plunger bar arranged to engage the center stop, except that for single gates less than three (3) meters wide a forked latch may be provided. Latches shall be arranged for locking. Center stops shall consist of a device arranged to set in the concrete and to engage the plunger bar of the latch of double gates. No stop is required for single gates. Keepers shall consist of mechanical device for securing the free end of the gate when in the full swing position.

(j) Zinc Coating

All steel and iron parts of the fence shall be zinc-coated after fabrication in accordance with the requirements of ASTM A123 of ASTM A 153, or equal, unless otherwise specified.

The minimum weight of zinc coating per square meter of actual area shall be 366 grams.

(k) Compressive Strength of Concrete

Concrete for footing of concrete posts and steel pipe gate post shall have 14 MPa compressive strength after 28 days. Cement, coarse and fine aggregates, admixtures, and water shall be in accordance with the applicable requirements specified in the Specification entitled "2.3. Concrete Works”.

2.27.4 Installation

(a) General

The chain link fabric fence shall be constructed using new materials, in accordance with the details on the Drawings and as specified herein. All work shall be performed in a workmanlike manner satisfactory to the Engineer and the Engineer. The finished fence shall be plumb, taut, true to line and grade, and complete in every detail.

(b) Excavation

Excavation for concrete-embedded items shall be of the dimensions indicated. Post holes shall be cleared of loose material. Waste material shall be spread where directed.

(c) Post Spacing

Posts shall be evenly spaced a maximum of three (3) meters on centers unless otherwise directed. Straight runs between braced posts shall not exceed 30 meters.

(d) Post Setting

Posts shall be set plumb and in alignment. Posts shall be set in pipe sleeves previously installed on the concrete deck and in concrete bases of dimensions indicated elsewhere. When set in pipe sleeves, the space between the steel pipe post and the pipe sleeve shall be filled with molten lead or sulfur compound. When set in concrete base, the concrete shall be thoroughly worked and compacted into the hole so as to be free of voids and finished in a dome. Concrete shall be cured a minimum of 72 hours before any further work is done on the posts.

(e) Top Rails and Bottom Rails

Top rails and bottom rails shall be securely attached to the post by means of malleable iron clamps and bolts before installing the chain-link fabric. Top and bottom rails shall have one rail end fitting each as shown on the drawings.

(f) Chain-Link Fabric

Chain-link fabric shall be pulled taut and secured to the line post, and the top and bottom rails, by means of two (2) strands of 2.66 mm galvanized steel tie wire at intervals of not more than 60 cm on centers. Fabric shall be secured to terminal (end, corner, and/or pull) post and gate post with stretcher bars, clamps, clips, and hook bolts at intervals of not more than 60 cm on centers.

(g) Barbed Wire

Barbed wire shall be installed on supporting arms above the fence posts. The end members of gate frames shall be extended sufficiently above the top member to carry strands of barbed wire in horizontal alignment with barbed wire strands on the fence. Each strand shall be pulled taut and securely fastened to each supporting arm and extended member. The method of securing wires shall be positive and complete.

(h) Gate

Gates shall be hung on gate fittings attached to the gate post as shown on the drawings. The socket for the plunger bar or latch rod shall be set in concrete so that the latch rod will fit perfectly in the socket when the gate is in a closed position. Gates shall be erected to swing in the direction indicated. All hardware shall be secured and properly adjusted for easy operation. Hinges and diagonal bracings in the gates shall be adjusted so that the gates will hang in a level position.

2.27.5 Measurement

The quantity of chain-link fencing shall be measured by the number of lineal meters of chain link fabric fence including gates in place and accepted as required to complete the work.

2.28. Painting Works

2.28.1 General

The work covered by this section includes the requirements for material surface preparation, painting and protection requirements for civil and building works and for such steelwork as is not covered elsewhere in the Specification.

Where not otherwise required by the Specification, or by paint or coating manufacturer's recommendations approved by the Engineer.

The term "paint", as used herein, includes emulsions, enamels, paints, stains, varnishes, sealers, cement-emulsion filter, and other coatings, whether used as prime, intermediate, or finish coats, Surface cleaning and painting not specified in other sections shall be as specified herein.

2.28.2 Reference Standards

Reference Standards are referred to in the follows

ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM ANS/ISO 1522	Paints and Varnishes - Pendulum Damping Test Approved as an American National Standard by ASTM International
ASTM A 120	Specification for Pipe, Steel, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless, for Ordinary Uses
ASTM A 153	Specification for Zinc Coating (Hot-Dip) on lron and Steel Hardware
ASTM A 90	Test Method for Weight of Coating on Zinc-Coated (Galvanized) iron or Steel Articles.
ASTM C 884/C 884M	Standard Test Method for Thermal Compatibility Between Concrete and an Epoxy-Resin Overlay
ASTM D 1006	Standard Practice for Conducting Exterior Exposure Tests of Paints on Wood
ASTM D 1014	Standard Practice for Conducting Exterior Exposure Tests of Paints and Coatings on Metal Substrates
ASTM D 1652	Standard Test Method for Epoxy Content of Epoxy Resins
ASTM D 3168	Standard Practice for Qualitative Identification of Polymers in Emulsion Paints
ASTM D 4142	Standard Guide for Testing Epoxy Resins

2.28.3 Submissions by the Contractor

Samples of each different painting material, properly tagged and marked for identification, shall be submitted to the Engineer for approval.

2.28.4 Materials

Materials shall conform to the respective publications and other requirements specified herein and as shown, and shall be the approved products of manufacturers regularly engaged in the manufacture of such products.

Materials shall be delivered, stored, handled, and installed in a manner to protect them from all damage during the entire construction period. All damaged material shall be replaced by the Contractor at his own expense.

(a) Materials

Paints shall be in sealed containers that plainly show the designated name, formula or specification number, batch number, color, quantity involved, date of manufacture, manufacturer's formulation number, manufacturer's directions, and name of manufacturer, all of which shall be plainly legible at the time of use. Paint containers shall not exceed 20 liters capacity with the exception of containers for emulsion, spraying paints, bituminous paints, stone, cement and road-marking paints which may be of larger capacity. Materials shall conform to the specifications shown in the painting schedule herein and to the requirements herein specified.

(b) Acrylic emulsion paint shall be used for the exterior for concrete masonry unit, cement plaster, and asbestos cement board surfaces. Cement-emulsion filler coat shall be either acrylic base cement-emulsion filler or polyvinyl acetate base cement-emulsion filler. When used in an exterior system, the polyvinyl acetate base cement-emulsion filler coat shall be used only with a polyvinyl acetate exterior emulsion finish paint, and the acrylic base cement emulsion filler coat shall be used with an acrylic exterior emulsion finish paint.

(c) Exterior oil paint shall be ready mixed white and light tints (alkyd resin type).

(d) Zinc coated shall conform to following standards.

ASTM A 120	Specification for Pipe, Steel, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless, for Ordinary Uses
ASTM A 121	Specification for Zinc-Coated (Galvanized) Steel Barbed Wire
ASTM A 123	Specification for Zinc (Hot-Dip Galvanized) coatings on lron and Steel Products
ASTM A 153	Specification for Zinc Coating (Hot-Dip) on lron and Steel Hardware
ASTM A 392	Specification for Zinc-Coated Steel Chain Link Fence Fabric

(e) Paints and varnish shall conform to ASTM ANS/ISO 1522 "Paints and Varnishes - Pendulum Damping Test Approved as an American National Standard by ASTM International", or equal.

(f) Stain shall be commercially available oil type for interior wood surfaces, with shades as selected and approved by the Engineer.

2.28.5 Cleaning, Preparation and Pretreatment

(a) General

All hardware, accessories, machined surfaces, plates, lighting fixtures electrical, telephone, signal and special purpose outlets, electrical receptacles, switches, and similar items in place and not intended to be painted shall be removed, masked, or otherwise protected, prior to surface preparation and painting. Following completion of painting of each space, removed items shall be reinstalled. Such removal and reinstalling shall be done by workmen skilled in the trades involved. Surfaces of all materials to be painted shall be clean and free from loose particles, dirt, and foreign matter before applying the paint or surface treatment. Oil, grease, and other contaminants harmful to paint adhesion shall be removed with clean cloths and an appropriate cleaning solvent prior to mechanical cleaning except when sandblasting is employed. Cleaning and painting shall be so program that dust and other contaminants from the cleaning process will not fall on wet, newly-painted surfaces. Painting shall not proceed until all imperfections, cracks, and holes in surfaces to be painted are repaired in an approved manner. Any painted surface marred or otherwise damaged shall be cleaned, repaired, and repainted.

(b) Concrete, exterior cement plaster and concrete-masonry unit surfaces to be painted shall be prepared by removing efflorescence, chalk, dust, dirt, grease, oil, asphalt, tar, excessive mortar, and mortar droppings, and by roughening to remove glaze. Surface deposit of free iron shall be removed prior to painting. Immediately before coating with cement-emulsion filler, concrete-masonry-unit surfaces to be painted shall be uniformly and thoroughly dampened, with no free surface water visible, by several applications of potable water with a fog spray, allowing time between to spraying for the water to be absorbed.

(c) Wood Surface (Wood and Plywood)

a) General

Wood surfaces to be painted shall be cleaned of dirt, oil, and other foreign substances with mineral spirits. Finished surfaces exposed to view shall be made smooth by sanding. Areas where resin has exuded from the wood shall be scraped clean and sanded prior to application of knot sealer. Recesses, cracks, joints, crevices, and nail holes in the wood shall be filled with glazing putty or plastic wood compound and sanded flush with the wood. Knots shall be surface scraped and thoroughly cleaned, and shall be given a thin coat of know sealer before application of the priming coat. Painting shall proceed only when the moisture content of the wood does not exceed 12 percent.

b) Interior wood surfaces to receive stained or natural finish shall be stained to the approved shade and lightly sanded. Open-grain wood shall be given the same treatment and, in addition, shall be given a coat of paste wood filler, not less than eight(8) hours after the application of the stain. The filler shall be thinned to brushing consistency with mineral spirits, using a stiffer mixture for woods with pores of moderate size. The mixture shall be brushed well into the wood and allowed to stand a few minutes for much of the thinner to evaporate and for the coating to turn dull. However, before the mixture has time to set the excess filler shall be wiped off with rags, burlap, or other suitable material. The first wiping shall be in a direction at right angles to the grain of the wood and shall include a padding or pounding action to pack filler into the wood pores. Final strokes shall be done in the direction of the wood grain. The surface shall then be sanded smooth. Each varnish coat shall be allowed to stand at least overnight to dry and lightly sanded prior to application of subsequent coat.

(d) Ferrous surfaces that have not been shop-coated shall be solvent-cleaned to remove oil and grease. Surfaces that contain loose rust, loose mill scale, and other foreign substances shall be mechanically cleaned by power wire brushing or sandblasting. Minor amounts of residual rust that cannot be removed except by thorough blast-cleaning, and tight mill scale that cannot be removed by applying a sharp knife to any edge, will be allowed to remain. After cleaning, one coat of ferrous-metal primer shall be applied to ferrous surfaces to receive paint.

Shop coated ferrous surfaces shall be stored out of contact with the ground in a manner and location to minimize the formation of water-holding packets, soiling contamination, and deterioration of the paint film. Such metal work shall be protected from corrosion before and after installation by treating corroded areas immediately upon detection. Abraded or corroded spots on shop-coated surfaces shall be wire-brushed and touched up with material similar to the shop coat.

(e) Nonferrous Metal

All nonferrous metal surfaces, such as aluminum alloy (except anodized), copper, zinc-copper-alloy, and zinc-coated surfaces, shall be solvent-cleaned as necessary to remove all oil, grease or other foreign substances. Where galvanized metal is specified, surfaces shall be prepared and finished the same as for zinc-coated metal. All zinc-coated metal shall be protected from corrosion before and after installation by treating cut, scarred, corroded, or abraded spots immediately upon detection; such spots shall be thoroughly wire-brushed, cleaned, and smoothed, and primed with zinc dust-zinc oxide.

(f) Plaster

Surfaces shall be dry, clean, and free from grit, loose plaster, and surface irregularities before paint is applied. When paint is applied, the instrument-measured moisture shall not exceed eight (8) percent.

(g) Asbestos-Cement-Board

Surfaces shall be dry and clean prior to application of the specified first-coat material. Oil and grease shall be carefully removed by the use of mineral spirits. Wire brushing will not be permitted. After the first coating has become dry, and prior to application of finish coats, touch-up coats shall be applied to all suction spots.

(h) Cotton or Canvas Covering over Insulation

Cotton or canvas covering over insulation on pipes, ducts, casings, tanks and other equipment in exposed locations shall be given two coats of alkyd resin type paint.

(i) Preparation of concrete & rendered surfaces for epoxy coatings

Concrete and rendered surfaces shall be thoroughly cured before the application of an epoxy filler primer or paint is begun. All surfaces to be protected with an epoxy paint system shall be prepared as described below, maintaining the sequence of operations indicated.

Areas of concrete contaminated with machine oil or grease shall be cut out as necessary to remove all traces of such substances and shall be made good with an approved epoxy mortar. Areas contaminated with release agent shall be scrubbed with suitable emulsion cleaners and any mould growth shall be treated with water-soluble fungicide. All concrete and rendered surfaces to be coated shall be lightly blast-cleaned to remove the cement-rich surface layer, taking care not to roughen the surface unduly. Grit and detritus shall be removed by vacuum cleaning immediately prior to priming.

Blow-holes and honeycombed areas in the concrete which in the opinion of the Engineer are not capable of being satisfactorily leveled at the primer stage shall be filled with an epoxy mortar supplied by the coating manufacturer for the purpose. Such mortar shall be knifed into the surface to level the area and to leave no excess.

2.28.6 Paint Application

(a) General

Paint shall be applied by skilled painters, following manufacturer's printed instructions and using appropriate methods of application. To prevent formation of skins and loss of volition solvent, paint containers shall be covered when delays in application are encountered. Adjacent work and materials shall be protected by ample drop cloths or other suitable coverings. Spraying equipment shall not be employed in painting motors, electrical controllers, or other equipment where overspraying due to improper masking may be detrimental to equipment operation. Paint shall be thoroughly mixed immediately before use and at frequent intervals during application and shall be applied in proper consistency. The meeting line between colors shall be straight and sharply defined, with no blending, running or gaps. All coats of paint shall be applied uniformly and be free from sags, wrinkles, runs, holidays, smears, dirt, and shall not be defaced by spattered paint.

Paint drops and oversprays shall be removed before dry. The hiding shall be completed and each coat shall be so applied as to produce a film of uniform thickness. Special attention shall be given to insure that edges, corners, crevices, welds, and rivets receive a film thickness equivalent to that of adjacent painted surfaces. Metal or wood surfaces to be painted, and in, on, or adjacent to surfaces to receive water-thinned paints, shall be primed or touched up or both prior to and after application of water-thinned pains. Job mixed aluminum paint shall be used within four (4) hours. Aluminum paint not used within the specified time shall be discarded.

(b) Paint Properties, Storage, Mixing, and Thinning

At time of application, paint shall be protected from exposure of cold weather by storing in shelters to prevent freezing of the paint. Paint shall be thoroughly stirred, strained, and kept at a uniform consistency during application. Paints of different manufacturers or different type shall not be mixed together. Where approved by the Engineer as necessary to suit conditions of surface, temperature, weather, and method of application, the packaged paint may be thinned immediately prior to application if in accordance with the provisions of the manufacturer's directions, but not in excess of one-half (1/2) liter of suitable thinner per four (4) liters of paint. The irregular thinning for any reason shall not relieve the responsibility of Contractor to provide specified film thickness.

(c) Atmospheric and Ambient Conditions

Paint other than water-thinned coatings shall be applied only to materials which are completely free from surface moisture as determined by sight or touch and in which the subsurface moisture is non-existent or within the limits specified when determined by a moisture meter. In no case shall paint be applied to surfaces upon which there is visible frost or ice. While painting is being done, the temperature of the surface to be painted and of the atmosphere in contact therewith shall be maintained at a minimum of 7C° and a maximum of 35C° During periods of inclement weather, painting may be continued be enclosing the surfaces with temporary shelters and applying artificial heat, provided the temperature requirements prescribed above are maintained throughout the drying period. Surfaces to be painted shall be protected from dust and dirt during painting and finishing.

(d) Time Scheduling of Painting

Surfaces that have been cleaned, pretreated, or otherwise prepared for painting shall be given a coat of the specified first-coat material as soon as practicable after such preparation has been completed but in any event prior to any deterioration of the prepared surface. Sufficient time shall elapse between successive coatings to permit proper drying. Paint shall be considered dry for recoating when it feels firm, does not deform or feel sticky under moderate pressure of the thumb, and the application of another coat of paint does not cause lifting or loss of adhesion of the undercoat.

(e) Requirements for specific Paints

a) Interior Emulsion Paint

First coat of interior emulsion paint shall be at such a rate as will effect sealing of the surface.

b) Exterior Emulsion Paint

At least 24 hours shall elapse before applying exterior emulsion paint over filler coat.

c) Signs

Two coats of Traffic Paint shall be applied. Time shall be allowed between coats to ensure drying.

(f) Painting of Above ground Steel Tank

a) Surface Preparation

Surfaces to be painted shall be cleaned of all mill scale and rust by sand blasting, power wire brushing, or other effective methods.

b) Priming

Immediately after surfaces have been cleaned, and before detrimental rusting or soiling can occur, a prime coat of a minimum dry film thickness of 0.025 mm of red lead base paint shall be applied to exterior metal surfaces. After the tank structure has been erected, welded, and tested, all areas on which prime coat has been damaged shall be cleaned and repainted with primer as specified above.

c) Finish Coats, Exterior

Exterior finish painting shall consist of two (2) coats of exterior oil paint, or equal.

(g) Method of Paint Application

a) Rollers for applying enamels shall have a short nap. Rollers for applying paints to masonry surfaces shall be a type designed for that purpose.

b) Brushes used for emulsion paint shall be soaked in water for a period of two (2) hours prior to brushing.

c) First coat of interior emulsion paint shall be at such rate as will effect sealing of the surface. The second coat of interior emulsion paint shall be applied so as to provide a uniform coverage of acceptable appearance.

d) Spray painting shall be done by the use of an air compressor and spray-gun.

(h) Multicolor painting shall be done with the use of compressor and spray-gun. The pressure shall be from 2.0 to 2.8 kg/cm2 for the first coat and 1.75 to 2.46 kg/cm2 for subsequent coats. The distance between the surfaces to be painted and the nozzle of the spray-gun shall be approximately 30cm. Spraying shall be done by gradual moving of spray-gun up and down until the surface has been coated completely.

(i) Bonn tile finish for cement plaster or asbestos cement board surfaces shall be applied by spraying equipment. Each coat shall be sprayed onto the surfaces in accordance with the printed instruction of the paint manufacturer, worked into voids and pores with a brush, and allowed to dry before spray spotting for vailing effect is accomplished. The final coats of clear acrylic resin shall be applied by means of roller or spraying equipment in accordance with the applicable requirements specified in paragraph entitled multi-color Painting. Finish coats shall be free from runs, sags and other defects.

(j) Epoxy coating concrete and rendered surfaces

In addition to the general requirements of this specification, the following conditions shall apply wherever epoxy coating work is being carried out:

The work shall be illuminated to the satisfaction of the Engineer.

Forced-draught ventilation to the approval of the Engineer shall be used wherever required for the needs of personnel or for drying out surfaces.

Operatives shall work in pairs.

The Contractor shall demonstrate all his methods, equipment and materials before any work commences. Sample areas of substrate shall be prepared and coated as required by the Engineer and for his approval.

There shall be strict control of surface cleanliness between primer and epoxy coating and between coats of the same. Vacuum removal of dust and sand-shall be employed and contamination shall be removed as specified in appropriate preparation clauses herein. Where dirt or dust has become trapped in the epoxy coating surface it shall be removed with suitable abrasive paper. The surface being coated shall be free of visible moisture throughout these operations.

Epoxy coating shall be applied only to clean, dry, primed or previously-coated surfaces. Any thick runs or collections of paint shall be removed before they harden.

No fewer than two coats shall be applied over the primer by airless spray, no fewer than three by brush.

Each coat shall be distinctly different in color from the primer or previous coat. The color of the final coat shall be as required by the Engineer.

Each coat shall be seen to have completely covered the preceding coat without misses or pinholes or any areas visibly low in thickness. A high-voltage pinhole detector shall also be used to determine the integrity of the coats.

The manufacturer of the coating shall stipulate primer and epoxy re-coating intervals for all curing temperatures likely to be encountered and these shall be adopted with a maximum tolerance of +4 hours. Where this is exceeded, the surfaces to be re-coated shall first be suitably abraded or treated with solvent to remove gloss and give key.

Wet-thickness gauges shall be used continually by the coating operators to check that sufficient coating is being applied to achieve the desired dry-film thickness.

No priming shall commence until the moisture content of the cemented surface is less than 5% measured by Wet Check moisture meter or other instrument approved by the Engineer.

The primer shall be a low-viscosity two or three-pack epoxy supplied by the manufacturer of the approved epoxy coating material. It shall have complete compatibility and inter-coat adhesion with the first coat of high-build epoxy paint.

The primer shall be applied by suitable nylon bristle brush or spray over the whole area to be coated at such thickness that it may then be squeezed into the pores of the concrete. Any excess shall be effectively removed before application of the high-build epoxy.

The Engineer may approve an alternative application method where the Contractor can demonstrate a suitable technique.

The protective coats shall be of an approved high-build epoxy, 2-pack or 3-pack, completely resistant to the corrosion conditions to be encountered. Certain types of coal-tar epoxy may be approved for this purpose where the Contractor has stated at the time of tendering the type of curing agent and coal-tar, with the percentage content of the latter.

The total dry-film thickness of the paint layer shall have a minimum value of 0.75 mm.

Wherever the paint inspection gauge has been used, and wherever the coating has been otherwise damaged, the surface shall be abraded for 50 mm around such damage and the area shall be touched in with not less than two thick applications to restore the coating integrity and thickness.

Adhesion tests shall be carried out on the cured coating surface using the test equipment supplied under the Contract. The resulting test specimens shall show no indication of poor adhesion to the substrate, residual laitance or intercoat adhesion weakness.

2.28.7 Surfaces Not to be Painted

The following listed items will not required finish painting:

- Concrete and tile floors, unless otherwise directed.
- Aluminum or sized vapor barrier jacketing over insulation on pipes in unexposed locations not requiring color-coding.
- Unexposed interior ferrous surfaces, galvanized or not.
- Factory finish-painted equipment.
- Anodized an aluminum surfaces.
- Other items or surfaces so indicated not to be finish-painted.
- Exposed pre-cast concrete units.
- Concealed and exposed concrete surfaces having concrete sealer finish.

2.28.8 Cleaning

Cloths and cotton waste that might constitute a fire hazard shall be placed in closed metal containers or destroyed at the end of each day. Upon completion of the work, staging, scaffolding, and containers shall be removed from the site or destroyed in an approved manner. Paint spots, oil or stains upon adjacent surfaces shall be removed and the entire job left clean and acceptable.

2.28.9 Quality Control

The Contractor shall provide and maintain quality control for general painting. The Contractor shall ensure conformance to specifications and drawings with respect to construction, workmanship, finish, and functional performance; and record the inspection of all operations, including but not limited to the operations listed herein. Duplicate copies of records of inspection, as well as the records of corrective action taken shall be furnished as required by the Engineer and the Engineer's Representative.

- A check shall be made to insure that all materials comply with the approved samples immediately upon delivery to the site. Materials that do not comply shall not be permitted to be unloaded but immediately removed from the site.

- A list of all surfaces requiring paint shall be prepared, showing the surface preparation, type of paint, color, and number of coats required on each surface as specified. This checklist shall be used to insure that specifications are being followed.
- A check to insure exterior emulsion paint for concrete masonry units is mixed strictly in accordance with the specifications will be made.
- A check to insure cement-emulsion filler is vigorously scrubbed into the concrete-masonry-unit surface as specified, and is used in full strength and not diluted, and to insure that the filler coat and subsequent coat for concrete masonry units shall provide a waterproofed surface against driving rain.
- A check to insure that plaster surfaces are properly aged and dried before the application of oil or vanished base materials will be made.
- A check to insure that coating failures are satisfactorily corrected will be made.

2.28.10 Tests

Method of test for paint, varnish, lacquer and related material shall conform to follows.

ASTM A 90	Test Method for Weight of Coating on Zinc-Coated (Galvanized) iron or Steel Articles.
ASTM C884/C884M	Standard Test Method for Thermal Compatibility Between Concrete and an Epoxy-Resin Overlay
ASTM D 1006	Standard Practice for Conducting Exterior Exposure Tests of Paints on Wood
ASTM D 1014	Standard Practice for Conducting Exterior Exposure Tests of Paints and Coatings on Metal Substrates
ASTM D 1360	Standard Test Method for Fire Retard Paints (Cabinet Method)
ASTM D 1652	Standard Test Method for Epoxy Content of Epoxy Resins
ASTM D 3168	Standard Practice for Qualitative Identification of Polymers in Emulsion Paints
ASTM D 4142	Standard Guide for Testing Epoxy Resins

2.29. Safety Ladder (PE Coating)

2.29.1. Purpose

This specification is purposed to define the production and the purchase of safety ladders required for the basic and execution designs of Sewage Improvement Project.

2.29.2. Scope

(a) Scope of this specification includes production, standards, quality test, delivery, and installation of the safety ladders used in manhole and underground facility.

(b) If manhole and underground facility depth is over 4 m, install safety net in ladder.

2.29.3. Types

Types, standards, shapes, and quantities of the safety ladder and safety net shall be in conformity with the design document and Quantity of Bill

2.29.4. Approval of Production Documents

The Contractor shall submit production documents for the contract item to acquire approval from the construction supervisor before starting production.

2.29.5. Material

(a) The diameter of structural steels should be 18.5 mm to 50.0 mm with a tensile strength of 400 N/mm² or above and a coefficient of expansion of 10 % or above.

(b) The resin should exhibits good durability, chemical resistance, corrosion resistance, and impact resistance.

2.29.6. Production

(a) Composition: The safety ladder is composed of a special structural steel and a polyphrophelen.

(b) Size: The outside dimension of the safety ladder shall be in conformity with the design document.

(c) It should exhibits good durability, chemical resistance, corrosion resistance, and impact resistance by coating polyphrophylene on the special structural steel.

(d) A wave pattern should be applied to the inner portion to facilitate convenient hand gripping.

(e) The surface of horizontal bar that makes a contact with sole should have grooves to prevent slipping.

(f) The location of ladder should be identifiable at night by installing luminous prisms on the upper and lower portions of both sides.

(g) Safety net is mdae by Sus 304 50 mm

2.29.7. Inspection

The inspection shall be in conformity with the safety ladder production specification and the relevant regulations.

2.30. Riverbed Maintenance Works

2.30.1 General

(a) Applied Scope

This specification shall be applied to riverbed maintenance facilities to keep profile and transection in a river while slowing down riverbed slopes to maintain riverbed.

(b) Main Details

- Concrete riverbed maintenance facilities
- Natural riverbed maintenance facilities
- Block riverbed maintenance facilities

(c) Definition of term

- Riverbed maintenance facilities are classified into drop works and streambed works, depending on the size of drop head. They are also classified into concrete types, natural types and block types, depending on the type and materials used. In general, riverbed maintenance facilities consist of main body works, apron works, floor protection works, connecting wall and revetment works, and high-flow plain protection works.
- Drop works refer to riverbed maintenance facilities with large drop head (normally 50 cm or more).
- Streambed works refer to riverbed maintenance facilities without drop head or with very small drop head (normally less than 50 cm).
- Concrete types refer to the most generalized riverbed maintenance facilities whose main material is concrete in their body structure.
- Natural types refer to riverbed maintenance facilities whose main material is natural stone in the body structure.
- Block types refer to riverbed maintenance structures whose main material is block product (including fishway block) in the body structure.

2.30.2 Materials

(a) Stone

- Any stone used for stoke attachment materials shall have 100 MPa (1,000 kg/㎠) or more of compression strength, its absorption shall be less than 5%.
- Any stone for stone masonry shall be hard and solid and its length shall be 30~45cm.
- Cement for wet masonry shall abide by BS Standards or their equivalents or better.

(b) Concrete

- Cement shall follow the related regulations in “2.5. Concrete Works” in this specification.
- Aggregates shall be compliant with BS.

(c) Concrete Block

- Any concrete block shall follow the related regulation in “Concrete Revetment Block” in this specification.
- Any block product (including fishway blocks) shall not have any damage or crack in appearance.
- The compression strength of any block product (including fishway block) shall be 21

MPa (210 kgf/㎠) or more, provided that it may be increased in line with site conditions.

(d) Wooden Pile

- Any pile shall be made of raw pine trees whose skin is completely removed and it shall be a frictional pile without any adhesion.
- Preservation processing shall be done with creosote impregnated for underground and fresh water poles.
- Dimensions shall be applied to the length and diameter as clarified in design drawings.
- Although no adhesion is allowed, adhesion shall be made under the approved method by the construction supervisor if it is stated.
- The end of a wooden pile shall be formed into complete contact to the supporting area or attach the welded steel.
- The head color of a pile shall be the color of the formed or welded steel.

2.30.3 Construction

(a) Concrete Riverbed Maintenance Facilities

(1) Main Body Works

a) General

- The main structure shall consist of concrete and it shall be safe from collapse, activity and sinking.
- The drop head in the main structure shall be determined in compliance with hydrological and structural safety as well as site condition, but it shall be limited within 1.0m. If the drop head height is 1.0m or more, multi-step drop head works shall be planned and the drop head of each step shall be limited within 1.0m.
- The width of levee crown in the concrete body structure shall be at least 1.0m, where the slope in the upstream shall be 1:0~1:0.5 and the slope in the downstream shall be installed slower than 1:0.5.
- The embedding shall be sufficient to prevent riverbed from scouring.
- As the connection between the main structure and revetment may be easily damaged by large flow, the thorough constructions shall be required.

b) Concrete works

- Close attention shall be paid to the construction process to prevent the main structure from collapse due to the cavity under the main structure floor and scouring in the downstream of the apron.
- Concrete works shall be dry construction by cofferdam.
- Any material with large water permeability such as pebbles or gravels shall not be used in the foundation process like other river structures to prevent piping under the foundation bottom due to the penetrated flow, and the accurately driven piles are important if any sheet pile is used for water shielding.
- As the surrounding ground may be weakened during the bed excavation despite the sufficient of bearing capacity in the foundation and the unequal settlement may occur from the weakened ground when the gush-out water is drained, the foundation

processing shall be done sufficiently to prevent them.

- If it is difficult for sheet piles to be driven into the foundation, concrete barrier walls shall be constructed. As the surrounding ground may be weakened by excavation under such a circumstance, any unequal settlement shall be prevented during the refilling.
- During apron works, stone pitching shall be carried out in a proper size, if necessary, to increase dissolved oxygen in the water by aeration and improve water quality, while preventing the drop head by the scouring at the downstream end due to the embedding in a certain depth for the downstream end.
- Stone pitching shall adopt a zigzag alignment rather than a liner alignment, while maximizing aeration effect by the installation of stones in various sizes.

(2) Floor protection works

- Floor protection works shall have the installations under the planned riverbed height after riverbed variations are predicted and riverbed is stabilized in the future.
- If the current riverbed is higher than the floor protection works, the entire downstream bed shall not be excavated but the excavation shall be done from the end of the floor protection works to the proper section, and connected to the current river channel.
- As the floor protection works of the riverbed maintenance facilities are affected by erosion and traction by flow, they shall be continuously maintained after the construction.
- Any matter not mentioned in this section shall follow the related regulations in “Main Body Works of Concrete Riverbed Maintenance Facilities” in this specification.

(3) Connecting revetment works

- The connecting revetment shall be constructed in a structure to prevent shore or levee from scouring due to flow.
- The main structure shall be separated from the connection of the revetment in the riverbed maintenance facilities to make the connecting revetment become a structure to prevent damage to the levee or reservoir channel.
- The connection between the connecting revetment and main structure in the riverbed maintenance facilities shall have the close relationships in a structure to prevent the levee from collapse or reservoir revetment from loss due to the penetrating flow.
- The bottom compaction shall be installed in the front of the revetment in the upstream and downstream of the riverbed maintenance facilities, to prevent them from scouring.

(4) High-flow plain protection works

- A structure with proper coarseness is desirable to reduce the flow velocity while it is being stabilized by the surrounding scouring like the floor protection works.
- The high-flow plain protection works shall be constructed up to the upstream and downstream floor protection work of the drop head works.

(b) Natural Riverbed Maintenance Facilities

(1) General

- Natural riverbed maintenance facilities consist of natural rocks, wooden piles and vegetation, and they shall be safe from collapse, activity and sinking.

- Natural riverbed maintenance facilities shall be constructed in consideration of water quality improvement by aeration, biological habitation or migration in the river, as well as the functions to maintain the riverbed using natural rocks and wooden fence instead of concrete materials.
- Natural riverbed maintenance facilities shall keep the downstream slop slow to about 1:20 to secure the function of rapids, while enabling the migration of fishes, amphibians and reptiles.
- Natural riverbed maintenance facilities shall be constructed in consideration of water flow in the river and size of natural rocks to stabilize flow velocity, as well as functionality of environment and ecosystem.
- Natural rocks and foundations shall be constructed stably to prevent any loss during flooding, and continuous maintenance shall be required in preparation of loss of natural rocks consisting of the main structure after construction.
- Any matter not mentioned in this section shall follow the related regulations in “Main Body Works of Concrete Riverbed Maintenance Facilities” in this specification.

(2) Stone pitching

- Any construction using stones shall be carried out by dry construction with cofferdam.
- Stone pitching shall be done on the even surface of riprap stones and concrete as the foundation works for the main structure.
- No unequal settlement shall occur from the slope of stone pitching after construction, and the longitudinal direction of pitched stones shall be perpendicular to the slope direction.
- If the river flow is fast or the river slope is stiff, the wetted pitching shall be constructed with backfilling using concrete mortar.
- If the river slope is slow, the dry pitching shall be constructed for backfilling using the broken pebbles and gap-filling gravels.
- The foundation of stone pitching shall be constructed strongly to prevent any unequal settlement by the flow penetration.
- As the pitching stones or backfilling pebbles may be removed by flow In case of dry pitching, the seaming section shall be well interlocked by the skilled stone workers.
- Mortar shall be filled in the seaming section after pitching stones are aligned in parallel on the foundation concrete to make the pitching surface even in the wetted pitching.
- Other construction instructions shall follow masonry works and any matter not mentioned in this section shall follow the related regulations in “Masonry Works of Slope Covering Works” in this specification.

(3) Masonry Works

- If the river slop is 10% or more, masonry works shall be constructed for stone masonry on the surface after applying gravels or pebbles on the internal center in the main structure works.
- The dry pitching shall be constructed using gravels or pebbles in the internal center of the main structure in case of small rivers or creeks.
- The wet pitching shall be constructed in any rapid rivers.

- The foundation shall be strongly constructed to prevent any unequal settlement.
- The embedding shall be sufficiently done and the constructed surface shall be made even to prevent the riverbed from scouring.
- The thickness of backfilling concrete shall be constructed in 30~60㎝ or more.
- Attention shall be paid to the prevention of settlement in the filling and backfilling during stone masonry.
- The broken stones shall be laid down as their valleys are interlocked with each other, and 1/10 or more of the stone length shall be interlocked in the seaming section.
- Attention shall be paid to the construction to prevent any projected stone in the pitching for the acute section in the upstream or downstream on the floor of riverbed maintenance facilities.
- The backfilling rubble stones shall be placed in the dry pitching, and the skilled stone workers shall carry out construction for the good interlocking in the seaming section to prevent stones or backing rubble stones from being removed by flow as the gap between stones shall be processed by the gap-filling with small stones.
- Drain works shall be constructed, if necessary.
- Any matter not mentioned in this section shall follow the related regulations in “Slope Covering Works” in this specification.

(c) Block Riverbed Maintenance Facilities

(1) General

- Block riverbed maintenance facilities shall consist of blocks (including fishway blocks) and concrete foundations, which shall be safe for collapse, activity and settlement.
- Matters on excavation of structures and block foundations shall follow the related regulations in “Civil Engineering”.
- The foundation of block riverbed maintenance facilities shall have the foundation concrete in 200~300 mm thickness on the compacted ground to stabilize blocks or the installation of mat on the ground.
- The concrete pool or support pond shall be installed on the bottom of block installation to prevent the bottom from scouring with a role of supports.
- Block riverbed maintenance facilities shall have the downstream slop in about 1:20 to enable migration of fishes.
- As block riverbed maintenance facilities may interrupt migration of fish due to the flowing sand sedimentation, the continuous maintenance efforts will be necessary after construction.
- Any matter not mentioned in this section shall follow the related regulations in “Concrete Riverbed Maintenance Facilities” in this specification.

(2) Concrete block works

- Concrete block construction shall follow the related regulations in “Concrete Revetment Block” in this specification.
- The dry construction using cofferdam is desirable in consideration of mutual connections between blocks if any heterogeneous concrete blocks are used.

- The coarseness coefficient of concrete blocks shall be proper for the current river bed.
- The size of concrete blocks shall be stable for the flow velocity.
- The flexibility of concrete blocks shall be secured.
- Close attention shall be paid to refilling after even excavation on the foundation floor because the installation shall be done horizontally.
- The comparatively good place shall be selected for the foundation. If the installation is done unavoidably on the fragile ground, the surface processing shall be done including the replacement of sand in 1.0 m or more on the top layer.
- Blocks shall be mutually connected and connection nuts shall not be loosened. The connection between blocks shall be filled with mortar to become a strong and uniform structure.
- The habitation and migration of fishes shall be done easily by installing pools or supporting ponds on the block bottom. Gravels shall be placed in the pools and ponds to keep natural conditions.

2.31. Miscellaneous Works

2.31.1 Underdrain system

(a) Applied scope

This specification shall be applied to the installation of the filteration underdrain system in Water Treatment Plant.

(b) General construction

- No epoxy waterproofing shall be done for some of the filter basin floor and wall (up to about 40 cm from the filter basin floor) to prevent the perforated blocks from damage in case of epoxy waterproofing in the filter basin.
- The perforated blocks shall be installed on the installation of support anchors to a certain level in 1~4 cm height from the filter basin floor after the black ink marking to the installation position of the perforated blocks in line with those perforated blocks after the inside of the filter basin is cleaned before the installation of any perforated block.
- Longitudinal tolerance of the lower catchment shall be within ±10mm and tolerance of the level for each side within ±10mm. The level measurement for each water catchment shall be done with a measuring device which is appropriate for specifications from the center line in the basin or it may be checked after water is filled to the defined height in the basin.
- The installation of any perforated block shall be done from the wall where the influent channel is installed. The connection between those perforated blocks shall be done using rubber rings and the sealing in the perforated blocks shall be sealed with sealants.
- Blocks shall be protected from any contaminant such as concrete fragments or scattering dust during construction as they are packed with the protective film to protect those perforated blocks before each perforated block is fabricated.

- The assembling device where the main tabula and auxiliary tabula are connected to long holes shall be used in assembling the perforated blocks.
- If works are done on top of blocks, the top surface of the perforated blocks shall be properly protected all the time. When any equipment like a handcart is used for filling mortar, plywoods or other sheets shall be placed for the use of working areas to distribute the weight.
- When the front water channel and central water channel is designed and constructed in the filter basin, the perforated blocks shall be fastened on the filter basin floor in U-rod (STS 304 fixing anchor) between blocks in consideration of the rising pressure during backwashing. In addition, the fixing anchors and mortar shall bind the walls of the perforated blocks by injecting mortar between blocks.
- Mortar shall be filled to the top space of the perforated blocks and the fastened area with blocks shall not be loosened due to the drying and shrinking of mortar.
- The Contractor shall remove anything to interfere the flow, including any waste or fragments in every pipe of the lower catchment, while accepting and constructing any recommendation suggested by the maker of the perforated blocks unless there is any special reason.
- The Contractor shall take care of any waste, mortar fragment or foreign material in the filter basin’s lower water channels before the installation of the perforated blocks. The perforated blocks shall be protected by covers and others to prevent them from dirt, scattering dust or foreign materials until filter media are put after the perforated blocks are installed and cleaned with a vacuum cleaner or broom.

(c) Trial operation and test

(1) General test

Blowers, pumps and valves shall be completely tested and arranged for tests. The Contractor shall carry out any instructed test, while supplying any necessary thing for tests, including materials, equipment and personnel, provided that the owner shall provide water and electricity necessary for tests and trial operations. The Contractor shall be responsible for any cost for these tests, as well as proper facilities with every problem correction during the tests. In addition, the site test action plan shall be reported to supervisors 10 days before the schedule after discussions with supervisors, so that they may observe the testing site.

(2) Flow distribution test of lower catchment (air)

- The discharge flow distribution test shall be taken to check every orifice in the lower catchment of each filter basin to see it is clogged by any foreign material and if the flow distribution is uniform.
- If any supplementation is necessary, the required corrective actions shall be taken to the satisfaction of supervisors and re-tests shall be taken as well. The lower catchment shall be filled with water to about 30cm height from the top of the lower catchment for the test after the filter media are installed.
- The flow velocity for the test shall be the designed backwashing speed of air and water and this speed shall be kept for 2 minutes while observations are done.
- This test shall be repeated three times. Observations shall be made for every test to see the flow from each orifice and any flow discontinuation or boiling area.
- If problems during the test have to be corrected, subsequent actions shall be taken and the test shall be done again to see if those problems are corrected. The Engineers

from the maker or engineers qualified by the maker shall attend the site tests.

2.31.2 Wheel Washer Facilities Works

(a) General

This specification shall be applied to wheel washers installed at the construction site.

(b) Construction

- The Constructor shall install and operate facilities to completely clean wheels and lower chassis of transportation vehicles accessing to the construction site to carry out this construction.
- The Constructor shall in principle install facilities under discussions with the related organizations after the Engineer’s approval as well as the selection of the most suitable location in installing wheel washers.
- Wheel washer facilities works shall be divided into the installation of wheel washer stations and use of wheel washers. Wheel washer facilities shall be installed in the places that the Engineer has designated. They shall be installed in the reinforced concrete structure of the proper size for cleaning and draining for transportation equipment as shown in drawings. Also, they shall have the installation of power cables and water filling pipes, so that they may have no trouble in cleaning.

3. BUILDING WORKS

3. Building Works

3.1. Definitions

In this Specification, the following definitions shall apply.

3.1.1. Agreement, acceptance

When by or of the Superintendent, these terms shall have the following limitations:

(a) When given in respect of samples of materials, workmanship or proposals for methods of construction submitted in accordance with this Specification, shall not be interpreted as denoting any degree of satisfaction with the materials used in, or the execution of, the structure.

(b) When given in respect of drawings, documents, or schemes called for by the Specification or proposed by the Contractor, is only for conformity with the design concept and design information given in the Contract Documents or contained in subsequent instructions from the Engineer.

3.1.2. Superintendent

The named individual or company engaged to act for and on behalf of the Owner for the purposes of supervising the Contractor, issuing technical information to the Contractor and monitoring the work of the Contractor.

3.1.3. Design calculations

The calculations produced by the Engineer, and by the Contractor for some specialist work.

3.1.4. Drawings

General arrangement drawings (GAs): Plans and sections indicating the layout and dimensions of each floor of the structure. The drawings will be sufficient detail to allow the formwork to be constructed and will show or reference all inserts, cast-in items and holes. GAs may also indicate the locations of concrete grades and finishes.

Reinforcement detail drawings: Drawings showing the layout of the various types of reinforcement used in the construction of the structure.

Reinforcement schedules: Schedules giving the details of each reinforcing bar to be cast into the concrete in accordance with reinforcement detail drawing.

Builders work drawings: Drawings showing coordinated builders work (holes, cast-in services, fixings etc).

Erection drawings: Drawings or sketches indicating any special requirements or methods that the Contactor must use to erect the structure in a safe manner.

As-built drawings: Drawings indicating what was built to be prepared by the Contractor.

Temporary works drawings: Drawings showing necessary formwork, formwork and propping used to construct the structure in a safe manner.

3.1.5. Owner

The individual or company placing the Contract with the Contractor.

3.1.6. Engineer

Where the word 'Engineer' is used in these specification materials and Workmanship, it shall in all appropriate cases be used and construed as the individual or Organization responsible for the design and supervision of the construction of the structure. The item" Approval by the Engineer" shall mean approval in writing.

3.1.7. Formwork

The temporary structure used to support a permanent structure until it is self-supporting.

3.1.8. Framework

The part of the formwork used to give the required shape, finish and support to the poured concrete.

3.1.9. Precast Concrete

Concrete elements cast in formwork and fabricated at a location separate from the final position in the structure.

3.1.10. Site

The designated place where the Contractor will construct the structure.

3.1.11. Spacers

All chairs, blocks, supports and devices of a special nature required to hold the reinforcement in the correct position during concreting.

3.1.12. Structure

The structure comprising any or all of the following elements: columns, walls, slabs, beams, bracing, stairs, foundations, sundry items, and structural timber designed by the Engineer.

3.2. General

3.2.1. Site Clearance and Preparatory Work

(a) Clearing Site

The Contractor shall remove overburden and vegetation, fell trees, cut down hedges and bushes and grub up roots, all as directed by the Engineer. No material or trees shall be removed from the site without prior approval of the Engineer. All rubbish and material unsuitable for re-use must be removed from the site to an approved disposal area provided and paid for by the Contractor and all work that has been disturbed must be made good. All disposal of material shall be carried out in accordance with the environmental legislation in effect in Malawi and to the approval of the relevant environmental authorities.

(b) Felling Trees

Where directed by the Engineer, trees with a trunk exceeding 0.15 m and/or 3.0 m diameter shall be uprooted and holes shall be filled with approved material and well compacted. Rates for removal shall allow for haulage.

3.2.2. Demolitions and Alterations

(a) General

(1) The work shall be carried out in such a manner as to cause as little inconvenience as practicable to the occupants of the premises and adjoining premises and the public.

(2) The debris shall be sprinkled with water to prevent dust arising and all proper screens and protection shall be provided to the satisfaction of the Engineer.

(3) The Contractor must provide all necessary requisite shoring, needling and strutting or other supports incidental to the demolition and/or alteration work and alter and adapt all such temporary works as may be necessary from time to time, and finally clear away and make good all that which is disturbed.

(4) Where materials from the demolitions and dismantling are described as "remove from site" they shall become property of the Contractor. He shall include in his rates for the disposal of such materials together with all associated costs and he shall adjust his rates for any credit, which he is prepared to allow on such materials.

(5) Pits, chambers and tanks to be demolished shall be taken down to a depth of 2 meters below the respective ground or formation level, properly cleaned out and filled with approved material.

(b) A program of the demolitions and alterations shall be drawn up by the Contractor and agreed by all parties affected by the works. Any divergence from this program requires prior agreement from these parties and close liaison shall be maintained through the Engineer.

3.2.3. Excavation and Backfilling

(a) General

(1) The Contractor shall examine the site and familiarise him/herself with the nature of the ground, excavation and shoring methods as well as precautions for safeguarding of buildings and structures to be applied and physical obstructions and conditions on site that may affect his work and prices. His rates shall allow for all operations and costs required and encountered when carrying out the works in accordance with the Contract. Claims due to lack of knowledge of site conditions will not be entertained.

(2) The Contractor shall not execute any earthwork or excavation without having obtained the Engineer's approval of the methods, which he proposes to employ.
He shall not thereafter modify such methods without the Engineer's consent.

(b) Definitions

(1) "Excavation" shall for the purpose of the Contract be deemed to refer to the excavation of all the materials of whatever geological formation, quality, consistency or description. Excavation shall be carried out neatly to the lines and levels, which are specified on the drawings or as instructed by the Engineer.

(2) Excess excavation beyond the specified lines and levels shall be limited to an absolute

minimum making due allowance for working space and the necessary temporary works. The Contractor shall take all possible precautions to prevent slips in excavations and embankments and to protect and support structures, which may be endangered.

(3) Any excess excavation, over break or slip beyond the limits of the specified excavation shall be removed and made good at the Contractor's expense with such material as directed by the Engineer.

(4) Excavation shall be carried out manually if excavation by mechanical means is not reasonably practicable or may endanger or damage structures or property.

(5) Excavated material shall, if in the opinion of the Engineer suitable and required for use on site, be stockpiled or, if possible, immediately placed or shall, if not suitable or required, be removed immediately from site at the Contractor’s expense.

(6) The word "rock", wherever used as the name of a natural materials to be excavated, shall mean only boulders and or solid ledge material which, in the opinion of the Engineer, requires for its removal drilling and blasting, wedging, sledging, barring, or breaking up with a power-operated tool and cannot be excavated with a standard mechanical back – hoe excavator.

(7) Soft or disintegrated material which can be removed with a hand pick (pick axe) or power-operated excavator or shovel, no loose, shaken, or previously blasted material or broken stone in material fillings or elsewhere, and no material exterior to the maximum limits of measurement allowed, which may fall into the excavation, will be measured or allowed as "material".

(8) If rock is excavated beyond the limits of payment indicated on the drawings, specified, or authorised in writing by the Engineer, the excess excavation, whether resulting from over break or other causes, shall be backfilled, by and at the expense of the Contractor.

3.2.4. Excavation

(a) Excavation Rates

(1) The rates for excavation shall include for:

- Excavation in any material other than rock;
- Bulking of excavated material which is suitable for backfilling (structures only);
- Temporary shoring-up of pipe trenches and other excavations;
- Safeguarding of adjacent buildings, structures against any damages;
- Additional excavation to accommodate the temporary supports and all working space necessary to carry out the work together with all subsequent backfilling and compaction using approved excavated material;
- Keeping the excavations clear of all type of water (rain, groundwater, sewage) and all dirt at all times;
- Trimming, compacting and protecting the formation level;
- Formation of all temporary spoil heaps and all double

handling necessary, and carting away excess material to tip;

(2) All surface areas for which items for stripping turf and top soil have been included in the Bills of Quantities and which have been disturbed by the Contractor's work or operations shall be reinstated to the original condition including providing and laying top soil to a minimum thickness of 150 mm, all at the Contractor's expense where

directed by the Engineer.

(b) Trench Excavation

(1) The line and level of trenches shall be as shown on the drawings or as directed by the Engineer. Before commencing excavation, the alignment of the trench shall be pegged out accurately and the ground level shall be agreed with the Engineer. Strong sight rails shall be then fixed and maintained at each change of gradient and at a distance not exceeding 25 m.

(2) Trench excavation shall be carried out by such methods and to such lines, dimensions and depth as required for the proper construction of the works.

(3) Rock excavation shall be carried out to such width and depth to allow a working width of w = nominal pipe diameter (DN) plus 600 mm and to allow placing of foundation and bedding as specified. Any excavation outside these limits shall be considered as over break.

(4) No length of trench excavation shall be started until pipes, fittings, etc. to be laid in that length are available on site.

(5) Any widening or deepening of trench necessary to accommodate curves bends, joints, etc. shall be considered as over break.

(6) Except where otherwise stated, trenches shall be excavated to a sufficient depth to ensure, after consolidation of the backfilling, a minimum cover of 600 mm, measured from ground level to the top of the pipe. Where the Contractor is instructed that the pipeline shall be laid at a lesser depth a concrete bedding (surrounding) shall be provided in accordance with the Engineer's instructions and the drawings.

(7) Subject to any specific requirements of the Contract the backfilling and temporary surface reinstatement of trench excavation shall be commenced and be completed as soon as reasonably practicable after the pipes have been laid and joined. Pipe laying shall follow closely upon the progress of trench excavation and the Contractor shall not permit unreasonably excessive length of trenches to be open while awaiting testing of lines. Further, the Contractor shall keep open only such trench lengths as are required to maintain his progress of Works, which shall generally not exceed 150 m in any one work section.

(8) If the Engineer considers that the Contractor is not complying with any of the foregoing requirements, he may prohibit further trench excavation until he is satisfied with the progress of laying and testing of pipelines and backfilling of trench excavation.

(9) All trench excavation and other work carried out within the limits of any roadway shall be completed as rapidly as possible and not more than half the width of the carriage way shall be obstructed at one time. The Contractor shall provide maintain and operate temporary traffic controls of a type approved by the Engineer.

(10) The rates for trench excavation shall include for working along the line of old pipe trenches or in close proximity to old pipe trenches as the case may be.
Rates should also include for excavations encroaching on and adjacent to service trenches.

(11) Trench excavations in roads and at thrust blocks in all locations shall have vertical sides and be supported as required to ensure safe working.

(12) The Contractor shall at all times take special precautions to prevent settlement in the

vicinity of the trenches. The Contractor shall make good any settlement and repair any damage resulting from such settlement at his own cost and all to be to the satisfaction of the Engineer, the landowner and/or the Road Authority.
This is in no way intended to limit the Contractor's responsibilities.

(13) Road Authority shall mean the authority responsible for road construction and maintenance.

(14) All topsoil shall be carefully placed aside and afterwards replaced in its original position.

(15) Accurate records shall be kept by the Contractor of all services crossed in the course of work. The Contractor shall prepare record drawings showing the location, level and details of the services crossed, and such records shall be given daily to the Engineer.

(c) Trimming Excavation

(1) When excavation to specified levels for the foundation of structures or for pipes or to the specified limits for the face of any structure requires to abut undisturbed soil, the Contractor shall not excavate the last 150 mm until immediately before commencing the constructional work, except where the Engineer shall permit otherwise.

(2) Should the Contractor have excavated to less than 150 mm of these limits before he is ready to commence the constructional works, he shall, where requested by the Engineer, excavate further so as to remove not less than 150 mm of material immediately before commencing the construction work. Any additional work and costs related thereto are considered as over break.

(3) Before commencement of any construction work, all shattered and loose material shall be removed from the excavation by hand so as to ensure that the work rests on a solid and perfectly clean foundation or abuts against solid soil.

(d) Unsuitable Material

(1) The Contractor shall be responsible for forming a sound foundation for pipes supports and pipe bedding structures and he shall make all tests and bring to the attention of the Engineer any inequalities in the bearing capacity of the subsoil. Any additional xcavation ordered by the Engineer to be carried out and the subsequent refilling with suitable material shall be measured and priced at Contract rates.

(2) Should the Contractor fail to comply with the above he shall be responsible for all breakage, fractures, leakages, settlement, etc. that may occur as a result of the aforesaid inequalities of the bearing capacity of the subsoil.

(3) Should the material forming the bottom of any excavation, while acceptable to the Engineer at the time of his inspection, subsequently become unacceptable to him due to exposure to weather conditions or have become soft, loose during the course of the works, the Contractor shall remove such unsound material by hand. Such further excavation shall be held to be over break.

(4) Unsuitable material shall be removed from site and disposed off as instructed by the Engineer.

(e) Supporting Excavation

If required or instructed by the Engineer, all sides of excavation shall be supported to prevent settlement or slip falls of ground, structures and services adjacent to the excavation. Excavation required to provide space for supports and working area as well as slip falls and settlements of ground adjacent to excavation are to be considered as over break. Remedial measures, repairs and related costs encountered due to settlement, slip falls; damages are to be carried out and paid for by the Contractor.

(f) Disposal of Excavated Material

(1) Excavated material, which is not required or is unsuitable for reuse in the works shall be disposed of as directed by the Engineer. The Contractor shall give the Engineer adequate notice of his intention to spoil. Material ordered to be disposed of shall remain the property of the Employer and shall be deposited at places designated by the Engineer.

(2) Subject to any specific requirements of the Contract, the disposal of excavated material within the site shall be at the Contractor's discretion but shall be arranged as to be acceptable to the Engineer and to suit the overall requirements for the construction of the works. The Contractor shall ensure that no excavated material, which is suitable for and is required for reuse in the works, is disposed of outside the site.

(3) The term "excavation" shall be deemed to include for disposing of excavated material in any of the following ways:

- Backfilling to excavation and completed structures, other than trench excavation, using suitable excavated material and including placing in temporary spoil tips and any double handling required;
- Transporting selected excavated material to locations within the site where embankments are to be constructed or where filling around structures is specified to be constructed as embankment including tipping ready for spreading and compacting;
- Disposal of surplus excavated material outside the site;
- Top soil and excavated material suitable for grassing shall be deposited in temporary separate spoil tips within the site;
- Unsuitable material shall be disposed of as approved by the Engineer.

(g) Blasting

Explosives shall be used only with the written permission of the Engineer and under conditions to be approved by him. The Contractor will be required to indemnify the Employer against all claims arising there from in respect of persons, animals, properties and services. Blasting, if required, shall be carried out carefully and in such manner as to avoid loosening or shattering rock beyond the required line of excavation and all loose and shattered rock shall be removed and any voids formed and made good to the satisfaction of the Engineer at the Contractor's expense. Only experienced and qualified personnel shall be employed on this work and the storage of explosives shall conform to the respective regulations. The Contractor will familiarise himself with and conform to any local Authorities regulations concerning blasting.

(h) Existing Services

(1) Notwithstanding any relevant information furnished by the Employer or the Engineer or any public authority, the Contractor shall be solely responsible for ascertaining from his own inspection of the site and from the respective supply authorities and other public or private bodies the position of all pipes and cables whether underground or overhead, within or near the site.

(2) Where excavation is carried out close to or across or below existing sewers, pipes, cables or other services, the Contractor shall, where required, provide temporary

supports or slings. Where such sewers, pipes, cables or other services are damaged, the Contractor shall arrange for and pay any repair works, replacement or costs resulting from such damages.

(3) The Contractor shall allow in his rates for careful dismantling, temporary storing and, upon inspection and decision of Engineer with assistance from the Employer, discarding of existing water installations (pipes, fittings) encountered in the course of excavation works.

(4) Where in the opinion of the Engineer construction of the works cannot be reasonably carried out unless the sewer, pipe, cable, other service is permanently severed or permanently diverted or permanently supported, he will instruct the Contractor to provide all necessary facilities and access for the Government Department or public utility company which shall carry out such works or shall instruct the Contractor to execute these works.

(i) Excavation to be Kept Free from Water

(1) The Contractor shall allow in his rates for excavation for keeping the excavation whether above or below the groundwater table, at all times, free from flooding by storm water, percolating water, subsoil water, sewage water or sewage effluent by pumping, bailing or other means.

(2) No water or sewage effluent shall be discharged into any water course, onto roads, tracks, footpaths, yards or any other area used by vehicular or pedestrian traffic, unless approved by the Engineer. Such permission shall not be granted unless the Contractor has provided efficient settling basins or sand traps to retain all sand and other solids likely to settle. The permission to discharge liquids shall be liable to be withdrawn at any time in the event of circumstances arising and which in the opinion of the Engineer shall make such a discharge undesirable. The Contractor shall have no right to claim in respect of withdrawal of such permission.

(3) The Contractor shall take all precautions to avoid undermining of any part of the works or other properties by pumping or else, but should undermining occur, he shall make good same to the satisfaction of the Engineer at the Contractor's expenses.

(4) In all cases where permission to use existing water courses, sewers, pipes for the discharge of liquids has been granted, it will be under the condition that the Contractor cleans out such facilities after completion of the works at the respective site.

3.2.5. Backfilling

(a) Open Excavation (other than pipe trenches)

(1) Backfilling of the excavations shall not be carried out without the consent of the Engineer.

(2) Excavation shall be carried out in such a manner that material, which is unsuitable for backfilling and compaction, shall be excavated separately and removed from the site.

(3) Examples of unsuitable material for backfilling are the following:

- Materials from swamps, marshes and bogs;
- Vegetable matter, timber or similar material liable to decomposition;
- Materials susceptible to spontaneous combustion;
- Clay or earth having excess liquid content;

- Any kind of soft, non-homogeneous fill material;
- Rock over 100 mm in any dimension.

(4) Material for backfilling shall be deposited and compacted in layers of a maximum thickness of 250 mm and be appropriate to the compaction plant used.
Thickness measured prior to compaction. Compaction shall be so carried out to ensure a value of 95% Proctor is achieved. The compaction methods and plant shall be selected to avoid any damage to the Permanent Works.

(5) Supports to the excavation shall be carefully removed as the filling proceeds, but the removal of such supports shall not relieve the Contractor of his responsibility for the safety and stability of the works.

(b) Forming Slopes, Embankments and Cuttings

(1) The slopes of any banking shall be accurately and uniformly dressed off to slopes as shown on the drawings or as directed by the Engineer.

(2) The Engineer may order excavated material to be used in forming embankments or making up low ground. Only suitable material shall be used for such work.

(3) Material used shall be spread in layers not exceeding 300 mm depth, each layer being well compacted, to ensure that a value of 95% Proctor is achieved.

(c) Drainage Layers in Embankments

(1) Gravel for horizontal and vertical layers in embankments shall be hard, clean, washed aggregates of 20 mm nominal diameter.

(2) Any horizontal layers of such drainage gravel shall be laid in one continuous operation on a clean formation and shall be compacted by a method approved by the Engineer.

(3) Vertical gravel drainage layers behind walls shall be placed in lifts in advance to the fill to the embankment, being compacted in layers by the use of light rammers. It shall be kept free from mixing with the filling material by the use of boarding or the like placed between the two materials and raised as the work proceeds.

(4) The Contractor shall include in his rates for sufficient thickness of drainage material to ensure that the minimum thickness at any place is not less than that shown on the drawings.

(d) Offensive Matter

The Contractor at his own expense shall deal with any offensive matter found in the excavation immediately. He shall remove, disinfect with chloride of lime or other strong disinfectant and cart away such matter to an approved site for burial or otherwise completely dispose of as necessary. The Engineer may detail other precautions.

(e) Hardcore

Hardcore shall be graded hard limestone or other hard stone from an approved quarry, closely packed with all interstices filled in. When required, the top surface shall be finished to correct levels, irregularities broken off and a smooth surface shall be prepared to receive blinding, building paper or the like.

(f) Stone Revetments

(1) On the face of the revetment all stones shall weigh at least 25 kg and have a depth from the face of at least half the total thickness of revetment stone.

Stones shall be placed with their longest axis perpendicular to the surface.

(2) Closure or bonding stones extending throughout the full thickness of the revetment shall be provided at the rate of at least one closure stone per square meter of pitching. All voids beneath the top 50 mm of revetment stone shall be filled with small stone as the work progresses.

(g) Trial Holes

Trial excavations may be conducted to locate pipes, cables and other services in the path of sewers and water mains. Only trial excavations specifically ordered by the Engineer will be paid for at the Contractor's rate per m^3.

3.3. Concrete Works

3.3.1 General

(a) All concrete works shall comply with the following standards:

(1) BS 8110 Part 1 Structural use of concrete

(2) BS 1881 Testing methods for concrete

(3) BS 5328 Part 1 Guide to specifying concrete

(4) BS 4466 Scheduling, Dimensioning, Bending and cutting of steel

(b) The costs of all tests of concrete and/or its components shall be deemed to be included in the rates.

(c) All equipment employed for concrete works require the approval of the Engineer prior to dispatching to the Project.

3.3.2. Materials

(a) Cement

The cement to be used in the works shall be obtained from an approved manufacturer, and shall comply with the requirements of BS 12.

All cement to be used in works being in contact with water shall be sulphate resisting Portland cement (SRPC) and shall comply with the requirements of BS 4027.

(1) Certificate for Cement

For each delivery of cement, the Contractor shall furnish, free of cost, test certificates as directed by the Engineer, relating to the cement to be used on the work. Analyses of the cement shall be shown.

(2) Storage of Cement

- The Contractor shall provide at his own expense a well ventilated waterproof shed or sheds to store the required amount of cement. Each shed shall have a suitable floor built at such a height that the cement is kept dry at all times. Delivery and stacking shall be arranged in such a way that the various consignments can be used in the order of their delivery. Cement shall not be taken from the shed until immediately before its use in the works.

- Different types of cements shall be stored in separate compartments. If intermixing occurs all cement concerned will be condemned by the Engineer and shall be removed immediately from site.
- No cement, which in the opinion of the Engineer, has deteriorated or hardened shall be used on the works and such cement shall be immediately removed from site.
- Any cement which is stored on site for a period in excess of 28 days shall be tested in accordance with the relevant Standard prior to use.

(b) Natural Aggregate

(1) All aggregates shall comply with the requirements of BS 882.

(2) The fine aggregate shall consist of siliceous natural sand, having hard, strong durable particles and shall come from an approved source. It shall be clean and free from salt or organic matter.

(3) Coarse aggregate shall consist of gravel, crushed gravel, or other approved inert materials of similar characteristics and shall be clean, hard and sound. No material of a shaley or schistous nature shall be used.

(4) Aggregates shall not contain more than 0.5 % by weight of clay. The sulphate content shall not exceed 1 % by weight.

(5) Aggregates shall be screened or washed, if so directed by the Engineer.

(6) Each type and grading of aggregate shall be stored separately in bins of a type and size approved by the Engineer. They shall be provided with flooring of concrete or other approved material having sufficient slope to ensure adequate drainage of surplus water.

(7) The chloride and sulphate content of the aggregate shall be determined and in all cases be considered together with the content in the mixing water.

(8) The combined aggregate should be as coarse-grained and densely graded as possible. The maximum particle size should be so chosen as to be compatible with mixing, handling, placing and working the concrete. Its normal size shall not exceed one third of the smallest dimension of the component to be concreted. With closely spaced reinforcement or small concrete cover, the greater part of the aggregate shall consist of particles smaller than the distance between adjacent bars and between the bars and formwork. Maximum size of coarse aggregates in all cases shall be 20 mm.

(9) The concrete shall contain a certain quantity of ultra fine particles to be properly workable and achieve a close texture. The ultra fines content comprises the cement, the aggregate particles of 0 - 0.25 mm size and such additional material of this particle size range, as it may be necessary to introduce. Such additional material, if any shall consist of natural or artificial mineral substances comprising, as far as possible, a mixture of differently sized particles, which do not soften and do not impair the durability of the concrete. An adequate content of ultra fine material is especially important in concrete which has to be conveyed long distances or, in concrete for thinwalled densely reinforced components and, in waterproof concrete.

(10) After approval by the Engineer, the whole of the aggregate supplied for use on the Works shall be obtained from the approved sources and the quality and grading shall be maintained consistent and equal in all respects to the samples submitted. Should it become necessary to change the source of supply for any of the materials, new tests shall be done to determine the proportions of the materials to be used and adequate

steps shall be taken to maintain the required standard of the materials.

(11) Sieve and sedimentation tests shall be carried out when the first delivery is effected and thereafter at intervals as directed by the Engineer.

(c) Water for Concreting

Water for use in concrete, mortar mixing and curing shall be obtained from an approved source and shall be of a quality as not to affect the setting time, strength, durability of the concrete or mortar, or the appearance of hardened concrete or mortar by discoloration or efflorescence nor the reinforcement at any age of the concrete or mortar.

The water shall be clean, demineralised, blended or unblended with a Ph between 6.0 and 8.0.

On the Engineer's request the water shall be tested in accordance with BS 3148, relevant ministry’s regulations and the following limits are not to be exceeded:

Total dissolved solids (TDS)	not greater than 2,000 ppm
Suspended solids	not greater than 2,000 ppm
Chlorides (C1	not greater than 500 ppm
Sulphates (SO3)	not greater than 1,000 ppm
Alkali (HCO3/CO3)	not greater than 1,000 ppm

Water shall be stored in approved, clean containers which are protected from sun, sand, dust, and organic contamination or from contamination by any other source. Thus:

(1) The water used for mixing or curing of concrete and washing the aggregates shall be clean and free from injurious amounts of oil, acid, alkali, organic matter, or other deleterious substances. No salty water shall be used.

(2) A thorough chemical water analysis shall be done before using a certain water source for concrete mixing and the Engineer shall approve test certificates from an independent laboratory.

(3) When comparative tests are done with distilled water of known quality, any indications of unsoundness, marked change in time of set, or reduction of more than 10% in mortar strength shall be sufficient cause for the rejection of the water under test.

(4) The Contractor shall not take water for use in concrete from shallow, muddy or marshy sources.

(d) Admixtures and Additives

(1) Preliminary strength tests shall be carried out to ensure that admixtures and additives do not adversely affect the concrete to which they have been added.

(2) Additives may be added to the concrete if they do not adversely affect the strength and durability of the concrete and the corrosion protection of the reinforcement.

(3) In no case shall admixtures or additives be added to concrete, cement mortar or grout without the express permission of the Engineer in writing.

(4) Additives and admixtures, if approved by the Engineer, shall be used strictly in accordance with the manufacturers’ instructions.

(5) Chloride based admixtures will not be allowed.

3.3.3. Concrete Mixes

(a) Quality of Concrete

(1) The class of concrete required is specified in the following table, on the drawings and/or in the Bills of Quantities for the particular position of the works to be constructed.

(2) The quantity of water added shall only be sufficient to produce a dense concrete which can be fully compacted without undue difficulty, due allowance being made for the moisture content of the aggregates.

(3) The strength class of concrete shall be as designated in the following Table.

Concrete strength class	Min. Cement Content (Kgs)	Max. Size of Coarse Aggregate (mm)	Max. Water Cement Ration by Weight-	Min. Crushing Strength of Works Test Cubes		Remarks
				7 days	28 days	
				N/mm2	N/mm2	
C15	220	20	-	10	15	For blinding concrete in normal structures and manholes
C25	280	20	0.55	17	25	for blinding concrete in water retaining structures, for R.C. in normal structures
C30	300	20	0.55	21	30	For R.C. in normal structures
C35	370	20	0.55	25	35	For R.C. in water retaining structures and concrete in direct contact with sewage

Minimum requirements for various grades of Concrete using Portland cement to BS 8110 The above properties and crushing strengths are to be considered as the minimum standard that will be accepted in the finish at works. The average crushing strengths should be at least 15% higher than the minimum permissible values given in the above table.

The chloride content of the proposed concrete including chlorides contained in the admixtures shall be limited to that specified in BS 5328: Part 1: 1997, Table 4. The Contractor shall provide evidence of conformity. Calcium chloride shall not be included in any concrete. Precautions shall be taken to restrict the amount of sulphate in the proposed concrete, in accordance with BS 5328: Part 1: 1997, Clause 5.2.3.

Precautions shall be taken to minimize the risk of alkali-silica reaction within the proposed concrete, in accordance with BS 5328: Part 2: 1997, Clause 5.2.4. The Contractor shall provide evidence of conformity. This shall include, but not be limited to, that required by BS 5328: Part 3: 1997, Clause 3.1.

No additions or changes to the fresh concrete shall be made after batching, without prior approval of the Engineer.

Daily maximum and minimum atmospheric shade temperatures shall be recorded using a calibrated thermometer(s) located close to the structure.

(b) Design of Concrete Mixes

(1) Before commencing any concrete work, the Contractor shall design the mixes for the concrete, which he proposes to incorporate in the Permanent Works.
Each mix shall be designed to produce the required class of concrete having a characteristic strength not less than the appropriate value specified above. Each design mix shall fulfil the following requirements:

- The combined grading of coarse and fine aggregate shall be continuous;
- The proportions and properties of the mix shall be within the limits set out for the various classes and types of concrete described in this Specification;
- The water/cement ratio shall be consistent with attaining the average strength but without the ratio exceeding the specified maximum. The aggregate/cement ratio shall be suitable to achieve the minimum workability consistent with proper compaction by the methods specified.

(2) When submitting his proposals for design mixes to the Engineer, the Contractor shall provide, in addition to details of his cement, aggregates and water as specified earlier, details of:

- The proportions in which the dry materials are to be mixed, including the aggregate/ cement ratio, cement per cubic meter of compacted concrete and the sieve analyses of the individual and combined aggregates;
- The water/cement ratio to be adopted;
- The workability of the mix and the range in which it is to be maintained;
- The 28-day individual and average strengths for at least six previously obtained test cubes;
- The individual and average densities of the six cubes;
- The dates on which the cubes were made and tested;
- Any other relevant information.

(3) Following the Engineer's approval of the design mixes, the Contractor shall prepare trial mixes of each class of concrete in the presence of the Engineer's Representative. Each batch shall be not less than 0.5 m^3 of concrete and shall be mixed in the same mixer, which the Contractor proposes to use throughout the construction of the Works. Sieve analyses and moisture content determination shall be done on the aggregates. The batches of concrete shall be mixed as specified herein and tested.

(4) The Contractor shall allow sufficient time in his program for designing and preparing trial mixes and testing test cubes obtained there from.

(5) If during the course of the works the concrete fails to comply with the specified requirements or the source of aggregate or cement should differ from those with which

the preliminary design mixes were carried out, the Engineer will instruct the Contractor to prepare further design mixes, which will be tested in accordance with the above procedure.

3.3.4. Water-Retaining Concrete

(a) Waterproof concrete for components with a thickness of 100 to 400 mm shall be so dense (impermeable) that the greatest depth of water penetration on testing does not exceed 50 mm.

(b) The water/cement ratio shall be not more than 0.50 for components with a thickness of about 100 mm to 400 mm and not more than 0.45 for sections more than that.

(c) The cement content of waterproof concrete of a class less than C 35 shall not be less than 370 kg/m^3. The grading of the aggregate shall be within the favourable range.

(d) Where waterproof concrete is required, the Contractor shall take full responsibility for ensuring that such construction is completely waterproof (crack-free). The minimum allowable design crack width for all water retaining structures is 0.2 mm according to BS 5337. Any leaks appearing during the construction and maintenance period of the Contract shall be completely repaired by the Contractor at his own expense. The method proposed by the Contractor for dealing with shrinkage cracks, leaks, or other defective work shall have no adverse effect on the finished structure. Treatments of internal and external concrete surfaces of water retaining structures, etc. (coatings or toppings) provided in the Bill of Quantities, does not relieve the Contractor of this obligations under the Contract. These treatments shall be considered as an additional step for waterproofing and/or resistance to chemical attack.

(e) Special attention shall be given to the elimination of cracking due the shrinkage of the concrete. In this connection consideration should be given to the following:

(1) Cement content should not exceed 400 kg/m^3;

(2) Reduction of cement content (The minimum cement content is 370 kg/m^3);

(3) Curing of concrete. In this connection it should be understood that if all formwork is left in position for protracted periods, proper curing cannot be carried out;

(4) Provision of construction/contraction of watertight joints at intervals not exceeding 7 m.

(f) Testing for water tightness shall be performed in all water retaining structures

3.3.5. Precast Concrete

Concrete for precast sections shall be Class C25, unless stated otherwise.

3.3.6. Concrete with High Resistance to Chemical Attack

(a) All concrete to be used in water retaining structures shall conform to C35. This type of concrete shall be so dense that the greatest water penetration depth on testing (of at least 3 samples) does not exceed 50 mm. These structures are considered under "strong" chemical attack. The water/cement ratio must not exceed 0.50 for any case.

(b) Concrete, which is exposed to strong chemical attack for a substantial length of time, should be protected against direct access of the aggressive substances. In addition, this concrete should be so composed as is required for strong attack.

(c) Only sulphate resistant Portland cement (SRPC) shall be used for concrete, grout, benching, etc.

3.3.7. Batching

(a) All materials used in the production of concrete shall be measured by weight, except in the case of small quantities of low-grade concrete volume where batching may be used, subject to the Engineer's approval. Coarse and fine aggregate shall be measured separately using approved weigh-batching machines capable of measuring increments of not more than 5 kg.

(b) The concrete mixer shall be fitted with a water tank and a proper device for the accurate measurement and easily controlled adjustment of the quantity of water to be added to the mix. The quantity of water added to each batch shall be accurately measured and so adjusted for changes in the moisture content of the aggregate to maintain the correct water content of the mix.

(c) Where the Engineer has approved the measurement of small quantities of low grade concrete by volume, the gauge boxes shall be accurately calibrated and of robust construction. They shall have closed bottoms, be as deep as practicable in shape and clearly marked for the mix and aggregate for which they are intended.

3.3.8. Concrete Mixing

(a) The Contractor shall include in his rate for making daily tests to determine the grading of the aggregates and the proportions of the various mixes will then be adjusted as required. The quantities shall be arranged to suit the use of approved weigh-batching plant or when approved, gauge boxes.

(b) The mixing of the concrete in the machine shall continue for at least one minute after the last of the ingredients composing the batch have been added.

(c) The concrete shall be placed as soon as possible after having been mixed. If the mixer is stopped for any period over twenty (20) minutes, it shall be washed out before being re-used. In all cases half of the coarse aggregate shall be omitted from the first batch in a clean mixer at the commencement of concreting.

(d) Hand mixing may be allowed where small quantities of concrete are required and where approved by the Engineer. It shall be done on a watertight platform and in such a manner as to ensure a uniform distribution of the materials throughout the mix. Mixing shall be continued until a homogeneous mixture of the required consistency is obtained. When hand mixing is authorised then an extra 10 % of cement shall be introduced into the concrete mix at the Contractor's cost.

(e) Truck mixers can be used if authorised by the Engineer. They shall be of the revolving type, watertight and so constructed that the concrete can be mixed to ensure a uniform distribution. When truck mixers are approved to supply concrete to a distant location, the Contractor shall ensure that the following information is supplied on an approved delivery form:

(1) Type of concrete and ingredients used;

(2) Water/cement ratio;

(3) Type and quantity of approved additives to the concrete mix;

(4) Time of departure from batching plant;

(5) Slump;

(6) Signature of plant manager.

(f) No concrete shall remain in a revolving truck mixer for more than 1 1/2 hours.

(g) The rate of delivery of concrete during concreting operations shall be such as to provide for proper handling, placing and finishing of the concrete as well as the continuous non-stop concreting for the same member or location until its completion.

3.3.9. Transportation of Concrete

(a) Concrete shall be discharged from the mixer and transported to the works by means approved by the Engineer and shall prevent adulteration, segregation or loss of ingredients and ensure that concrete is of the required workability at the point and time of placing. All concrete shall be conveyed from the mixer to the place of deposit in the works as quickly as possible.

(b) Where approved by the Engineer, the Contractor may use a suitable concrete pump for transporting the concrete from the mixer to where it is to be deposited, in which case the specified mix proportions shall be suitably adjusted and agreed with the Engineer. The concrete shall be fed directly from the mixer into the hopper of the pump. Once concreting has commenced the rates of the flow and mixing must be such as to ensure continuous movement of the concrete in the pipe work, which shall have as few bends as practicable. Frequent slump tests shall be carried out at the delivery end to ensure the consistency of workability at the point of placing. All equipment must be thoroughly cleaned at the end of each operation. The water used for this purpose shall be discharged outside the shuttering and clear of all other Works.

(c) Pneumatic placers shall only be used in special circumstances, as approved by the Engineer.

3.3.10. Placing of Concrete

Concrete shall be placed and compacted in the structure in accordance with BS 8110: Part 1: 1997, Clause 6.2.2. Concrete shall be placed and fully compacted so as to avoid cold joints and honeycombing and to minimize segregation, excessive blemishes or other defects in the hardened concrete.

Where kickers are used, they shall be monolithic with the slab, of sound construction and at least 100 mm high. For water-resisting construction kickers shall be cast 150 mm high and monolithic with the slab.

Arrangements for premature stoppage of a pour shall be agreed and in place before work starts. Should premature stoppage of a pour occur, the Contractor shall agree with the Engineer the extent and timing of any necessary remedial work before resumption of placing.

(a) The Contractor shall submit in due time for approval by the Engineer a schedule of the proposed working procedure, indicating time and sequence of concreting sections. Placing of concrete shall start only after written authorisation of the Engineer and with the Engineer's or his representative's attendance.

(b) The Contractor shall keep on site a complete record showing the date when any concrete was placed. This record shall be available to the Engineer at all times.

(c) If ordered by the Engineer, because of better weather conditions, concreting shall be done at night time. In such case sufficient lighting shall be installed by the Contractor at no additional cost to the Employer.

(d) In preparation for the placing of concrete all sawdust, chips and other construction debris and extraneous matter shall be removed from the interior of forms. Struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment, shall be entirely removed from the forms during the progress of the concreting and not buried in the concrete.

(e) Concrete shall be placed in such manner so as to avoid segregation of the materials and the displacement of the reinforcement. The use of long troughs chutes and pipes for conveying concrete from the mixer to the forms shall be permitted only on written authorisation of the Engineer. Open troughs and chutes shall be metal lined. All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete.

(f) The concrete shall be placed promptly, with a minimum of handling, to avoid the segregation of aggregates or the displacement of the reinforcement. Where concrete is being placed, a competent steel fixer shall be in continuous attendance to adjust and correct the position of any reinforcement bars, which may be displaced.

(g) Where placing involves dropping the concrete more than 2 m, it shall not be freely dropped vertically, but must be deposited through sheet metal or other approved pipes.

(h) Concrete shall be placed in horizontal layers not more than 300 mm thick in reinforced concrete and 500 mm thick in mass concrete. Each layer shall be placed and compacted so as to avoid the formation of a construction joint with a preceding layer.

(i) Concrete in girders and walls shall be placed uniformly and brought up evenly in horizontal layers.

(j) The placing of the concrete in walls may be modified after the approval of the Engineer if concreting conditions can be improved and visible joints upon exposed faces can be better avoided.

(k) When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to retain its form, shall be cleaned of laitance, and other objectionable material to a sufficient depth to expose sound concrete. Immediately following the discontinuance of placing concrete all accumulations of mortar splashed upon the reinforcing steel and the surface of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete-steel-bond at and near the surface of the concrete, while cleaning the reinforcing steel.

(l) Pneumatic placers shall only be used with the Engineer's approval. The velocity of discharge shall be regulated, by suitable baffles or hoppers where necessary, to prevent segregation of the concrete, damage and displacement of the reinforcement, embedded items and shuttering.

3.3.11. Compaction of Concrete

(a) All concrete shall be compacted by mechanical vibrators. The vibration shall be carried out with internal vibrators of a type, size and design approved by the Engineer.

(b) The Contractor shall provide a sufficient number of vibrators, including replacement, to properly compact each batch immediately after it has been placed in the forms, and shall at all times have standby vibrators in case of breakdown.

Concreting shall not commence until a sufficient number of vibrators are available.

(c) Vibrating shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn from the concrete slowly. Vibrating shall be sufficiently long and intensive to ensure thorough compaction of the concrete but short enough to avoid its segregation.

Vibrating shall not be continued at any one point to the extent that localised areas of grout are formed.

(d) Vibrating shall not be applied directly on the reinforcement. It shall not be used to work the concrete along the forms of in such a way as to damage the forms or other parts of the structures or displace the reinforcement or other embedded items.

(e) The provisions of this clause shall also apply to precast members except that, if approved by the Engineer, external vibrating or manufacturer's methods of vibrating may be used.

(f) Lean concrete for blinding course may be compacted by tamping.

(g) Once compaction of the concrete is completed, the Contractor shall take all precautions necessary to avoid any disturbance of the concrete from walking upon, wheeling over, or by vibrations of the shuttering in any way until the concrete is thoroughly set and hardened. No traffic of any kind will be permitted on the concrete for a period of at least 7 days. Special care shall be taken to ensure that the reinforcement projecting from the concrete is not disturbed in any way whilst the concrete is hardening.

3.3.12. Resumption of Work at Joints

(a) Concreting shall be carried out continuously up to joints, the position and arrangement of which shall be as indicated on the Drawings or as approved by the Engineer.

(b) When concreting has been interrupted before completion of the pour the surface of the concrete shall be cut away as directed by the Engineer and laitance removed.

(c) The bonding of fresh concrete on or against older concrete, which has hardened, shall be done in the following manner:

(1) When the older concrete is not more than 4 hours old, the fresh concrete shall be placed without further preparation, but half of the coarse aggregate shall be omitted from the first layer of concrete placed.

(2) When the older concrete is more than 4 hours old, the surface of the hardened concrete shall be roughened, wire brushed or, if possible, sand blasted to expose the coarse aggregate without leaving loose particles at the surface. This surface shall be washed.

(3) Before placing the new concrete, a thin layer of cement mortar (slurry) shall be applied to the surface of the older concrete. The mortar shall consist of cement and sand mixed in the proportion contained in the concrete mix, i.e. omitting the coarse aggregate. The fresh concrete shall be placed against the layer of mortar while it is still plastic, but half

of the coarse aggregate shall be omitted from the first layer of concrete.

3.3.13. Weather Conditions

(a) When the shade temperature is above 35°C, special precautions shall be taken during concreting and curing to the satisfaction of the Engineer. In this case, and as far as may be necessary, water and the aggregate should be cooled.

(b) The temperature of fresh concrete must not exceed 30°C.

(c) Concreting shall not be carried out when the shade temperature is above 40°C. It shall then preferably be carried out at night.

3.3.14. Curing and Protection

(a) In hot dry weather suitable means shall be provided to avoid premature stiffening of concrete placed in contact with hot dry surfaces. Where necessary the surfaces, including reinforcement, against which concrete is to be placed shall be shielded from the direct rays of the sun and shall be sprayed with water to prevent excessive absorption of water from the fresh concrete by the surfaces against which it is placed.

(b) During placing and the first stages of hardening, concrete shall be protected against the effects of sunshine, drying winds and rain.

(c) For the purpose of strength attainment, desired impermeability and shrinkage crack prevention, concrete surfaces shall be protected and kept moist. The covering shall be placed as soon as the concrete has hardened sufficiently to support the covering without damage. The type of covering provided shall be that in the judgement of the Engineer is best suited to the conditions.

(d) If, in the judgement of the Engineer it is necessary to use pump, piping, and hose for proper curing, the Contractor shall provide adequate water distribution to all parts or the Works so that complete and efficient curing can be achieved throughout the whole period of construction.

(e) Concrete surfaces shall be protected and cured in the following manner:

(1) The concrete shall be kept moist for a continuous period of at least 14 days after placing by covering it with moist sand, wet sacks, canvass, fiber mats or other satisfactory material capable of retaining the moisture, or by providing a sprinkler system.

(2) Utilising an approved non-bituminous pigmented liquid curing compound of an adequate type. The compound shall be applied strictly in accordance with the recommendations of the manufacturer. This compound shall not be applied on concrete surfaces of movement or construction joints.

3.3.15. Heat of Hydration

(a) The Contractor should take all measures and precautionary actions to allow for proper and sufficient means for transfer of heat evoluted by hydration of cement in the concrete mix, especially in thick sections and massive concrete casting.

(b) These measure and actions shall be proposed by the Contractor for approval of the Engineer.

3.3.16. Testing of Concrete

(a) General

(1) The approval of the Engineer of any materials, proportions or results given under this section shall not relieve the Contractor from his obligations in connection with the requirements for permanent works concrete.

(2) Concrete for testing shall be taken from the point of placing. Sampling shall be carried out and tests made in accordance with an approved procedure.

(3) The Contractor is responsible for the provision of the moulds and assisting the Engineer in taking concrete samples for the execution of the tests and for taking into account the results of such tests in the execution of the Works.

(b) Testing of Fresh Concrete

(1) Compacting Factor Test. This test shall be carried out at the preliminary testing stage and whenever a concrete sample is taken for the making of works test cubes. Values for acceptable factors are indicated in the table following "Slump Test".

(2) Slump Test. This test shall be carried out regularly as an aid to maintaining uniform consistency of concrete during the progress of the Works. Acceptable values of the slump are indicated in the following table:

Purpose	Compaction Factor	Slump [mm]
High-strength concrete sections, paving and mass concrete compacted by vibration	0.78 - 0.85	50 – 75
Normally reinforced concrete sections compacted by vibration. Hand-compacted mass concrete	0.85 – 0.92	75 – 100
Heavily reinforced concrete sections compacted by vibration. Hand-compacted concrete in normally reinforced slabs, beams, columns and walls	0.92 – 0.95	100 - 130
Heavily reinforced concrete sections compacted without vibration and work where compaction is particularly difficult	over 0.95	100 - 130

(c) Testing of Hardened Concrete

(1) General:

Work cubes are to be made at intervals as required by the Engineer and the Contractor shall provide a continuous record of the concrete work. The cubes shall be made in approved 150 mm moulds in strict accordance with the standard.

Six cubes shall be made on each occasion, from different batches, the concrete being taken from the point of deposit.

Each cube shall be marked with a distinguishing number (numbers to run consecutively) and the date, and a record shall be kept on site giving the following particulars: -

- Cube No.
- Date made

• Location in work
• 7-day Test
• 28 day Test
• Date Strength required

Cubes shall be forwarded, carriage paid, to an approved Testing Authority, in time to be tested with three cubes at 7 days and three cubes at 28 days. No cube shall be dispatched within days of casting.

Copies of all work cube test results shall be forwarded to the Engineer and one shall be retained on the site.

If the Strengths required above are not attained and maintained the carrying out of the Contract, the Contractor will be required to increase the proportion of cement and/or substitute better aggregates so as to give concrete which does comply with the requirements of the contract.

The Contractor may be required to remove and replace at his own cost any concrete which fails to attain the required strength as ascertained by work cube tests.

The Contractor must allow in his rates for concrete test cubes for all expenses in connection with the preparation and conveyance to the Testing Laboratory of test cubes and no claim in respect of his not so doing will be allowed.

• Concrete test cube results shall be used to determine the suitability from strength considerations of concrete to be incorporated in the permanent works. Hardened concrete shall be deemed to be unacceptable for the Works should the corresponding test cube results fail to meet the Specification and in this event the Contractor shall take all necessary remedial measures as directed by the Engineer.
• For the making of test cubes the Contractor shall provide a sufficient number but at least 12 nos. of 150 mm standard steel moulds. The costs of assisting the Engineer in taking samples and providing the moulds shall be included in the Contractor's rates for concrete and no additional payment for such assistance shall be made.

(2) Preliminary Test Cubes shall be taken from the proposed mixes as follows:

• For each class a set of 6 cubes shall be made from each of 3 consecutive trial batches. 3 from each set of 6 shall be tested at an age of 7 days and 3 at an age of 28 days.
• The cubes shall be made, cured, stored, transported, and tested in accordance with approved standards.
• At each age of test no cube strength shall fall below the appropriate specified minimum for preliminary strength tests.

(3) Works Test Cubes:

• These cubes shall be made from works concrete samples taken from the point of placing as and when directed by the Engineer. Normally for each grade of concrete, 6 cubes shall be made from concrete taken at random, 3 cubes from each set shall be tested at an age of 7 days and 3 at an age of 28 days.
• Cubes will generally be required at least as follows:

- For every 25 m^3 of concrete placed;
- For each important structural member;
- As otherwise directed by the Engineer.

• The cubes shall be made, cured, stored, transported, and tested as specified.

- A record of such tests identifying the test cubes with the part of the work executed shall be kept on the Site by the Engineer and made available to the Contractor.
- The appropriate strength requirement shall be considered to be satisfactory if none of the strengths of the three cubes tested at each age is below the specified cube strength, or if the average strength of the three cubes is not less than the specified cube strength and the difference between the greatest and the least strengths is not more than 20 % of that average.
- The hardening test gives an indication of the strength of the concrete in the structure at a particular time and thus also gives guidance as to the formwork stripping time.
- The hardening can be determined, in accordance with approved standards, on test specimens or by non-destructive means.
- The specimens for these tests shall be made from the concrete intended for the structural components in question and be stored directly beside or on these components and be cured in the same manner (influence of temperature and humidity). At least three specimens shall be made for the hardening test, but it is advisable to make more specimens so that if the strength determined in the test is found to be inadequate the test can be repeated.
- Components whose dimensions vary significantly from those of the test specimens may attain a different degree of hardening from that of the specimens, e.g. due to differences in heat evolution in the concrete. Due account should be taken of such factors when assessing test results.
- If, due to lack of compressive strength test results, or in the event that there is reason to doubt the strength of concrete in any particular section, it may be necessary to determine the compressive strength of the concrete by taking specimens from the structure or, if authorised by the Engineer, by non destructive testing performed on the finished component or by both methods. In connection with such tests the age and the conditions of hardening (temperature, humidity) of the concrete in the structure shall be taken into account.

3.3.17. Faulty Concrete

Any concrete which falls to comply with these specifications, or which shows signs of setting before it are places, shall be taken out and removed from the site. Where concrete is found to be defective after it has set, the concrete shall be cut out and replaced in accordance with the Engineer’s instructions. On no account shall any faulty, honeycombed or otherwise defective after it has set, the concrete shall be cut out and replaced in accordance with the Engineer’s instructions. On no account shall any faulty, honeycombed, or otherwise defective concrete be repaired or patched until the Engineer has made an inspection and issued instructions for the repair. The whole of the cost whatsoever which may be occasioned by the need to remove faulty concrete shall be borne by the Contractor.

3.3.18. Surface Finish and Treatment

(a) General

(1) Before any concreting commences the Contractor shall submit details and calculations for all shuttering necessary for the carrying out of the work. Any damage due to insufficient strength of shuttering is to be made good by the Contractor at his own expense.

(2) Shuttering shall be so designed and constructed that the concrete can be properly placed and thoroughly compacted and that the hardened concrete while still supported by the

shuttering shall conform accurately to the required shape, position, and level, subject to the tolerance and to the standards of finish specified.

(3) The rates for concreting shall include shuttering and for all types of cutting and waste and for forming of 25 mm x 25 mm chamfers at all exposed arises or as otherwise indicated on the Drawings.

(4) The qualities of finish shall not be inferior to those hereafter described. If minor porosity is evident on removing shuttering, the Engineer may approve a surface treatment by rubbing down with cement and fine aggregate mortar of the same richness as in the concrete in that particular portion of the Works.
This treatment shall be carried out immediately after removing the shuttering.

(b) Shuttered Surfaces

(1) All surfaces of concrete, especially those exposed to view, including all precast structures, shall be cast against steel or planed timber formwork. All visible edges shall be chamfered as ordered by the Engineer.

(2) Where necessary and ordered by the Engineer, the surface shall be rubbed with a carborundum stone or an abrasive of equal quality to remove form marks and projections, thereby leaving a smooth, dense surface without pits or irregularities.

(3) Any surfaces, irrespective of the shuttering employed, which show honeycombing, voids or air holes, shall be made good to the satisfaction of the Engineer. Cutting back the concrete behind the reinforcement or to such depth as is required and/or the Engineer may specify, and any other repair, shall not be started without the inspection and approval of the Engineer. Resin grouting or other approved suitable materials may be applied.

(4) All concrete surfaces shall be protected against damage and disfigurement and the Contractor shall remove all blemishes and repair all such damages to the satisfaction of the Engineer.

(5) All costs for making good honeycombed and defective concrete and repairing damaged surfaces shall be deemed to be included in the rates for concrete inserted in the Bills of Quantities.

(c) Surfaces Not Requiring Shuttering

(1) All upper surfaces of concrete shall be thoroughly worked during the placing operation to produce a smooth finish free from water, coarse aggregate and air pockets or honeycombs.

(2) The Contractor shall be required to prepare tests or samples under the direction of the Engineer, and the method and manner of finish, the choice and selection of the aggregate and other features affecting the work, shall be approved before any further work is done.

(3) The surfaces shall be formed by placing an excess of concrete within the formsm and removing or striking of such excess with a wooden template. The surface shall then be tamped to an even finish, aided where indicated by approved floats to give a dense surface with a minimum of cement and fine materials. The tamping shall not be done to the extent of bringing an excess of fine materials to the surface. The use of mortar topping shall only be permitted when indicated on the Drawings.

(4) The final finish of concrete surfaces shall be executed in the following ways, as shown

on the Drawings and/or Bills of Quantities or as directed by the Engineer:

- Rough finish: Shall consist of levelling and screeding concrete to produce a uniform and plain surface for structural members such as lean concrete, subsequent stages of construction, bonded concrete, surfaces with mortar topping and paving.
- Scratched finish: As before, but the surface shall be roughened before the final set to increase the future bond between structural members.
- Floated finish: After the concrete has been struck off, the surface shall be floated with a fine or rough wooden plasterer's float. Cork floats may be used. This finish shall be used on tops of foundations, columns, beams and all normal structural members.
- Trowelled Finish: In line with the above, the final trowelling shall be carried out after floating using a steel trowel to produce a finished surface free of trowel marks, uniform, smooth in texture and appearance. This finish shall be used for floors surface of water retaining structures as well as for floors where specified and/or directed by the Engineer.
- Broom or belt finish: In line with the above, the surface shall be finished to produce a non-skid, coarse transversal score texture. This finish shall be used for slabs of pedestrian access and in other locations where specified and/or directed by the Engineer.

(d) Treatment with Chemical Hardeners

(1) Where specified in the Bill of Quantities, the surface of slabs requiring high wearing resistance shall be treated with chemical hardeners. Only approved materials from recognised manufacturers withstanding medium to heavy stress and strain and resistant to chemicals, which have been approved by the Engineer may be used. The application of chemical hardeners shall be in strict accordance with the manufacturers' instructions.

(2) After the curing of concrete slabs with broom finish or other finish already executed, the surfaces are to be washed and brushed down with water to clean all dirt, oil, grease and dust, and then allowed to dry before application of the chemical hardener.

(3) The hardener is to be poured on the totally dry slab and spread evenly with a broom. When the hardener has been fully absorbed, but before the slab is dried out, all surplus material is to be swilled off. Second and third coats are applied similarly.

3.3.19. Damp Proof Protection

To protect surfaces of footings, tie walls, tie beams, column necks against aggressive soil, all surfaces of concrete in contact with earth shall be protected by the use of cold bitumen solution type D complying with BS 743 applied in two coats to give uniform and impervious finish.

3.3.20. Joints in Concrete

(a) General

(1) The Contractor is referred to the various types of joints required in the various structures and which are indicated in the drawings.

(2) Only those joints itemised in the Bill of Quantity or specifically ordered by the Engineer will be measured and paid for as separate items otherwise they are deemed to be included in the rates for concrete.

(3) The cost of the joints shall include for all labour and materials in forming the joint as

shown on the drawings including, where required:

- Shuttering, notching for passage of reinforcement if necessary and cutting for passage of water stop;
- Waterston and jointing;
- Expansion joint filler;
- Formation of grooves and sealing with approved sealing compound;
- 20 mm dowel bars, 1 m long, with sleeve and packing, where shown on the drawings;
- Adequate grout checks.

(b) Construction (Day) Joints

(1) Concrete bond across the joint shall be effected by removing the surface laitance and exposing the aggregate on the joint face as soon as the concrete has hardened. The surface shall be thoroughly washed with clean water prior to the resumption of concreting.

(2) The proposed position of the construction joints shall be submitted to the Engineer and approved by him before construction of each separate structure is commenced. A joint shall be made wherever concreting is finished for the day, or whenever concreting is stopped for any reason.

(3) All joints of water retaining structures shall be made watertight by introducing 20 cm wide rubber water stop bar placed and fixed in the middle of the section width. The rubber water stop (or metallic if required) shall have the approval of the Engineer for its type and quality.

(4) The cost of construction joints shall be deemed to be included in the rates for concrete.

(c) Movement Joints

(1) Movement joints, if required, shall be constructed in the positions as shown on the drawings or as directed or approved by the Engineer.

(2) Movement joints are measured separately and items are included in the Bill of Quantities for the various joints in each of the structures.

(3) Where indicated on the drawings, dowel bars shall be positioned across the joint. They shall have sawn ends and shall be provided with and secured to steel cradles on each side of the joint. They shall be placed with the midpoint of the longitudinal axes intersecting the plane of the joint at right angles, half the length of the bars being suitably coated to prevent bonding. Fitted over the coated length shall be a loose cardboard or plastic sleeve, closed and packed with glass fiber for a depth of 75 mm at the end of the bar remote from the joint.

(4) Where shown on the drawings or as directed by the Engineer, joints shall be sealed on one or both faces as required. On the face or faces requiring sealing, a groove of the shape and dimensions shown on the standard joint details shall be formed. Not earlier than fourteen days after the placing of the concrete, or when otherwise directed by the Engineer, the groove shall be cleaned, dried if necessary, primed and filled with a suitable approved mastic sealing compound to the underside of the chamfers. The sealer shall be prepared and applied strictly in accordance with the manufacturer's instructions.

(5) Partial contraction joints (for water retaining structures only) to be proposed by the contractor for the approval of the Engineer with a maximum span of 7.0 m.

(d) Joint Sealing

This section covers the work involved in delivery and placing of jointing material and joint sealing in concrete structures.

(1) Jointing Materials

- Expansion joints shall be filled with an approved jointing material, which shall be compressible and resistant to weathering and extrusion.
- The jointing material shall be kept back from the face as indicated in the joint detail drawings, formed recesses shall be primed and sealed with an approved sealing compound.
- The Contractor shall be held responsible for the quality of all materials, including the adhesion of the joint sealing. Joint sealing, which are too soft, too brittle or which lack the prescribed adhesion and resistance shall be replaced by the Contractor at no extra cost. The approval of material by the Engineer does not relieve the Contractor of his obligations under the Contract.

(2) Synthetic Joint Sealing Material

- All joints of concrete members shall be sealed with mastic as specified and/or as directed by the Engineer.
- The Contractor shall select permanent elastic, synthetic mastic sealing compound, which has a high degree of extensibility, optimum elastic force and good adhesion to concrete. Products consisting of one or two components, on the basis of polysulphite liquid polymer, silicone rubber and polyurethane or others, may be used; however, only proprietary materials (made by fully recognized manufacturers), which are resistant to aging, oxygen, irradiation with ultra-violet light, water, oil, grease, chemicals and biodegradation and which have been approved by the Engineer may be used.
- Concrete grey mastic shall be used for joints in exposed concrete areas. Joints in concrete areas not exposed to the eye may be filled with dark coloured mastic.
- The mastic shall be stored in sealed containers in a dry and cool place prior to use, strictly in accordance with manufacturer's instructions.
- Mastic sealing compound used for expansion joints in water tanks shall be:
  - Physiologically absolutely safe, i.e. it shall not contain any substances, which may be considered a substrate for water bacteria;
  - Resistant to any detergents used in water tanks;
  - Complying with the health requirements for potable water.
- Mastic sealing compound used for expansion joints of sewage tanks, sewers and any other structural elements exposed to the effect of chemicals (e.g. varnishing unit, oil traps etc.) shall be resistant to chemicals such as alkali, acid and solvents etc. and to biodegradation resulting from attack by bacteria normally present in sewage and sewage sludge.

(3) Workmanship

- The joints shall be prepared and primed as indicated by the manufacturer of the sealing compound.
- The depth of the joint sealing shall be as indicated on the drawings, but at least 20 mm or equal to the width of the joint. In case of bevelled joint edges, the sealing

shall only be placed between the parallel joint faces.

- In compliance with the instructions of the manufacturer, the mastic sealing shall be applied - within the time span specified after priming and from top to bottom in vertical joints - with a sealing gun equipped with a nozzle fitting the width of the joint. Surplus material must be removed before hardening of the mastic.

3.3.21. Water Bar (Water Stops)

(a) This Specification covers all work involved in furnishing and placing of preformed water stops and joint sealing strips for sealing of joints in concrete members.

(b) All joints must be watertight and must be provided with water bars, as shown in the Drawings and specified in the Bills of Quantities, and - where indicated - with joint sealing strips.

(c) The profile of the water bar for expansion and contraction joints shall have a centre tube with an external diameter equal to the width of the joint. Joints in base slabs may have an external flat water bar as indicated on the Drawings.

(d) Construction joints in water retaining structures etc., shall be provided with water bars as specified.

(e) Special water bars with incorporated steel strips may be used for expansion and/or contraction joints of water tanks.

(f) Prior to commencement of the relevant work, the Contractor shall submit to the Engineer, samples, test certificates and placement instructions issued by the manufacturer of all proposed water bars and joint sealing strips.

(g) The Contractor is responsible for the quality of all materials. The approval of materials by the Engineer does not relieve the Contractor of his obligations under the Contract.

(h) Pre-formed water bars and rubber joint sealing strips shall consist of permanent elastic material and being resistant to aging, oxygen, irradiation with ultra-violet light, water, oil, grease and chemicals.

(i) Water bars used for expansion and contraction joints of sewage tanks, sewers and other structural elements exposed to the effects of chemicals shall be resistant to attack from alkali's acids and solvents.

(j) Only materials agreeing with the requirements of the specification shall be delivered for use in the works, these may be elastomeric water bars made of artificial rubber (chloroprene-neoprene).

(k) Vulcanising of water bars may be done at the site. Vulcanising of elastomeric water bars requires great care and should where practical be done at the factory. A waterproof gluing shall not be permitted. Al necessary equipment for vulcanizing shall be provided by the Contractor.

(l) All required fittings for intersections, crossings, tees and junction pieces shall be supplied by the manufacturer. Site fabrication of such pieces shall not be allowed, unless suitable vulcanising equipment is provided and methods and equipment are approved by the Engineer.

(m) The Contractor shall make a visual inspection of all water bars prior to placing operations to ensure that they have no defects or damages (air bubbles, deformations, cuts, holes, brittle parts, etc.). All water bars shall be stored in a cool place and not be exposed to the sun.

(n) For joint sealing strips types of elastomeric rubber only shall be used.

(o) Workmanship

(1) The water bars shall be placed in such manner as to ensure that their two flaps are securely embedded in either side of the adjacent concrete members. They shall be properly fastened to avoid movement during placement and compaction of the concrete. The use of nails shall not be permitted; only special stirrups or other constructions approved by the Engineer shall be used. Great care shall be exercised during placement and compaction of concrete around the water bars to ensure that the concrete completely encloses the water bars.

(2) The compressible jointing material for expansion joints, shall be glued to the face of the completed member to avoid slipping during concrete work of the second member. Consideration shall be given to adequate thickness of the concrete cover enclosing the reinforcement of the concrete members, especially those adjoining the jointing material. For the perfect functioning of expansion joints perforation of the jointing material by internal vibrators must be avoided.

(3) Vulcanising work on water bars shall be kept to an absolute minimum. All vulcanising shall resist a bending test without formation of cracks along the seams. Diameter of the bending roller in the bend test is 50mm.

3.3.22. Tolerances of Concrete Construction

(a) General

The following tolerances of concrete constructions after completion of the work shall be permitted. All concrete work shall be executed in the required dimensions, shapes, position and level shown on the drawings. The Engineer may apply other tolerances if required.

(b) Dimensions

Tolerance for dimensions of columns, walls, beams slabs: - 0 mm / + 10 mm and for Holes, Cast in-items etc. (Where not otherwise specified):

- Position in relation to grid lines +- 4mm
- Level +- 6mm
- Dimensions of holes +- 6mm
- Dimensions of steel parts +- 1mm

(c) Concrete Cover to Reinforcement

- Concrete cover of 30 mm: - 0 mm / + 5 mm
- Concrete cover of 35 mm: - 0 mm / + 10 mm
- Concrete cover of 50 mm: - 0 mm / + 10 mm

3.3.23. Cement Mortar and Grout

(a) General

Cement mortar and grout under bearing plates and to fill in pockets shall be composed of cement, fine aggregate (natural sand) and water. If required, admixtures and/or additives shall be used. All components shall comply with the requirements of the Specifications for concrete.

(b) Strength

(1) The compressive strength of mortar and grout, which must in all cases be determined on three specimens, shall in preliminary tests and in quality control tests conform to the following requirements:

- Lowest compressive strength for each specimen: 25 N/mm²
- Lowest limit for the average compressive strength for each series of specimens: 30 N/mm²

(2) The compressive strength of mortar and grout is determined on specimen (diameter 10 cm, height 12 cm) at an age of 28 days.

(c) Mixing

(1) Mixing of mortar and grout shall be done in an approved mechanical mixer, the amount of water added being just sufficient to give the consistency and workability desired for the use to which they are to be put. Mixing shall be carried out as specified for concrete.

(2) Hand-mixing will only be permitted when very small quantities are required and the approval of the Engineer has been obtained.

(3) All mortar and grout must be in their final position in the structures within 30 minutes.

(4) Grout and mortar shall be composed of one part cement and two parts well graded sand or as approved by the Engineer.

(5) Shrink-resistant grout shall be used under heavy machinery equipment, subject to vibrating, reciprocating and pulsating movement and to set structural steel and precast concrete members and in all members where shrinkage inherent in normal cement grout cannot be tolerated. Non shrink grout shall be obtained as a pre-mix ready requiring only the addition of water to produce a free flowing grout which, when cured, will completely fill the pockets in which it has been placed. The grout shall be so formulated to provide high resistance to the long-term effects of machinery operating stresses. The grout shall be obtained from a manufacturer approved by the Engineer.

(6) Shrink resistant grout shall be free from iron compounds, which can result in rust staining and subsequent corrosion and expansion.

(d) Workmanship

(1) Grouting shall not be carried out until the steelwork or equipment has been finally levelled and plumbed, the bases being supported meanwhile by steel wedges.

(2) Immediately before the operation of grouting, the entire area covered by the bearings, including pockets for holding down bolts, and a sufficient extra area around to prevent contamination, shall be thoroughly cleaned by washing with water from hose pipes, compressed air, etc., and all dust, loose and deleterious matter shall be removed. All surplus water shall then be dried off by mopping and the use of compressed air and the surfaces left damp. Freshly mixed mortar as directed, of suitable consistency, shall then be introduced to fill the pockets for the holding down bolts and the space beneath the bearing plates. The mortar shall be well punned into the space, working from one side with suitable punners until the mortar appears on the opposite side and every care shall be taken to ensure that the entire void is filled, giving complete support to the bearings

over the entire area, without air holes, etc. To ensure this, wooden screeds shall be introduced around the edges of the grouting space to contain the mortar during the punning operations, any mortar which may foul the treads of bolts, nuts, or affect their bearing on washers and plates shall be carefully removed without disturbing the mortar already placed and, on completion of the operation, the edges of the mortar shall be trimmed. The whole shall then be covered with wet sacks or hessian which shall be kept continuously damp for a period of not less than 7 days, after which they shall be removed and all loose, adherent or projecting mortar liable to reduce the efficiency of the bearings carefully removed. After 28 days all holding down and other bolts shall be tightened as directed.

3.4. Form Works

If the Contractor intends to use a wooden formwork construction, all timber shall be of sound wood and well seasoned. Other types of formwork construction, e.g. steel or tubular steel scaffolding may be used.

Reinforced concrete shall not be poured directly against an excavated face, but only against suitable formwork.

All concrete especially that exposed to view including all precast concrete members shall have fairfaced finish. Steel shuttering or plywood panels approved for concrete works may be used if they are free from defects likely to detract from the general appearance of the finished surface. Joints between boards and panels shall be horizontal and vertical or as directed by the Engineer.

3.4.1 Design of Formwork and Forms

(a) The Contractor shall submit to the Engineer for approval, details of the formwork intended to be used before commencement of the works.

(b) The submission of such details shall not relieve the Contractor of responsibility for the sufficiency and strength of the formwork and forms.

(c) It is the Contractor's responsibility to dimension the footings in a way that settlement of the subsoil under concreting loads will be kept small and symmetrical.

(d) Settlement of formwork and footings is to be measured and recorded while concreting. Provisions shall be made to permit the compensation of unexpected settlements and the uniform release of the formwork by means of hydraulic jacks or at least wedges.

3.4.2. Construction Requirements for Forms

(a) Forms shall be of such quality and strength that they maintain rigidity throughout placing and vibration of concrete. Within the allowable tolerance the finished concrete shall coincide in the required shape, position and level with the drawing.

(b) In order to prevent adhesion of concrete, forms shall be oiled with form oil approved by the Engineer. The oil shall be applied according to the recommendations of the manufacturer. Form oil shall be of such quality that it will not discolour the surface of exposed concrete. Care shall be taken to prevent the reinforcement from being contaminated.

(c) Forms shall be thoroughly wetted on both sides in advance of placing the concrete. Standing water in the forms will not be permitted. Joints shall be sufficiently tight to prevent leakage of grout.

(d) All dirt, chips, sawdust and other foreign matter shall be thoroughly removed from between the forms before any concrete is placed. Where the inside of the bottom of the forms is inaccessible, the lower form boards shall be left loose so that they may be removed for cleaning out extraneous material immediately before placing concrete.

(e) In water retaining structures, the use of internal ties as anchorages within the forms is prohibited.

(f) Where it is required in non-water retaining structures to use internal ties, their position and the filling of cavities shall be approved by the Engineer, especially in case of exposed concrete. Ordinary wire ties shall not be permitted.

(g) The specification for forms shall apply with equal force to metal forms. The metal used for forms shall be of such thickness that the forms remain true to shape. Metal forms which do not present a smooth surface or line up properly, shall not be used. Special care shall be exercised to keep metal forms free from rust and grease.

3.4.3. Removal of Formwork and Forms

All formwork shall be removed without undue vibration or shock and without damage to the concrete.

No formwork shall be removed without the prior consent of the Engineer and the minimum periods that shall elapse between the placing of the concrete and the dismantling of the formwork will be as follows:-

• Beam sides, walls and inclined columns (unloaded)	3 days
• Slab soffits (props left under)	7 days
• Beam soffits (props left under)	14 days

Removal of props (subject to 7 days concrete cube strength being satisfactory):-

• Slab Soffits	14 days
• Beam Soffits	21 days

For design requirement, walls of closed tanks should not be subjected to any lateral forces before the final hardening of the roof slab due to the propping action induced by the slab.

If the contractor wishes to take advantage of the shorter times permitted for beam and slab soffits when props are left in place, he must so design his framework that sufficient props as agreed with the Engineer can remain in their original position without being moved in any way until expiry of the minimum time for removal of props. Removal and repropping is not permitted.

The above times may be reduced in certain circumstances, at the discretion of the Engineer, provided an approved method is adopted at the Contractor's expense to ensure that the required concrete strength is obtained before the forms are removed.

The top of retaining walls shall be adequately supported with stout taking props at intervals as required by the Engineer. The props are not to be removed until 14 days after casting. After removal of formwork all projections, fins, etc., on the concrete surface shall be chipped off and made good to the requirements of the Engineer.

(a) The removal of formwork and forms shall be executed in accordance with the BS8110 (Table 6.2). The specified number of days between placing of concrete and removal of formwork and forms shall closely be adhered to. Depending on curing and weather conditions longer times may be necessary if the strength of the concrete is still low. In no case shall the removal of formwork and forms be done without the approval and direction of the Engineer.

(b) The removal shall be carried out in such a manner that the concrete is not disturbed or in any way damaged.

(c) Any required repairs of concrete shall be done only after inspection by the Engineer.

3.5. Reinforcement

3.5.1 Certificates for Reinforcement

All deliveries of steel reinforcement shall be accompanied by the manufacturer's certificate giving the results of tests carried out in accordance with the requirements of the relevant standard. The Engineer may require the Contractor to submit samples of steel from each delivery to an approved Authority for testing, the costs of all samples and tests shall be deemed to be included in the Contractor's rates for reinforcement.

3.5.2. Material

(a) Mild Steel Bars: Main round steel bars - yield stress minimum 250 N/mm2, according to BS 4449

(b) High Yield Bars: Deformed steel bars - yield stress minimum 460 N/mm^2, according to BS 4449

(c) Steel Fabric: Hard drawn welded wire fabric - according to BS 4483 Reinforcing drawings and bar bending schedules shall, unless otherwise indicated or provided on the drawings, be prepared by the Contractor and checked and approved by the Engineer.

Special attention should be paid to hooks, splices, bending radii, anchorage lengths and concrete cover.

3.5.3. Storage and Protection

(a) All reinforcing steel shall be stored on elevated platforms or other supports and must not be laid on the ground. It shall be stored in an orderly manner to facilitate inspections, each diameter and quality being kept separate.

(b) Reinforcing steel shall be protected at all times from damage and, when placed in the structure, shall be free from dirt, loose mill and rust scale, paint, oil and other foreign substance.

3.5.4. Bending

(a) Steel reinforcing bars shall be cut and bent by competent workmen. They shall be bent cold to templates that shall not vary appreciably from the shape and dimensions shown on the Drawings. All sharp bends shall be avoided and in no case shall the bending radius be less than 80 mm for reinforcing bar diameters less than 20 mm and 200 mm for reinforcing bar diameters equal or larger than 20 mm and less than 28 mm.

(b) Distance from the forms shall be maintained by means of stays, blocks, ties, hangers, or other approved supports. Blocks for holding reinforcement from contact with the forms shall be of suitable material of approved shape and dimensions. Special distance holders may be used for waterproof concrete of water tanks, etc. The holders shall be short enough to permit their ends to be covered with concrete. Reinforcing bars shall be securely wired together in such a manner that they will maintain their exact designated position during placing of concrete. The ends of all wires shall be turned into the concrete away from the face.

3.5.5. Splicing

(a) All steel bars for concrete reinforcement with a total length of less than 12 m shall be furnished in the full length indicated on the Drawings. Steel bars with splices shown on the Drawings shall be spliced and steel bars with a total length exceeding 12 m may be spliced as given on the Drawings and as directed by the Engineer.

(b) Welding of steel bars shall only be carried out if authorised by the Engineer.

3.5.6. Fixing of Reinforcement

Reinforcement shall be accurately bent to the shapes and dimensions shown on the drawings and schedules and in accordance with B.S. 4466. Reinforcement must be cut and bent cold.

Reinforcement shall be accurately placed in position as shown on the drawings and before and during concreting shall be secured against displacement by using No. 18 S.W.G. annealed binding wire or suitable clips at intersections. Reinforcement bars shall be supported by concrete or metal supports, spacers or metal hangers to ensure the correct position and cover.

Binding wire is to be cut at the ends and bent back neatly. On no account is binding wire to be left protruding from the reinforcement towards the formwork. Where bars are joined longitudinally they shall be lapped for a minimum length of fifty diameters unless otherwise indicated on the drawings or in the bending schedule.

Welding may be permitted but for mild steel bars only and under approved conditions. Tack welding may be permitted where mild steel bars cross each other. But welding of the ends of bars in line wherever stress is transferred across the section is not permitted.

No concreting shall be commenced until the Engineer has inspected the reinforcement in position and until his approval has been obtained. The Contractor shall give two working days notice of his intention to concrete.

The Contractor is responsible for maintaining the reinforcement in its correct position, according to the drawings, before and during concreting. During concreting a competent steel fixer must be in attendance on the concreters to adjust and correct the positions of any reinforcement that may be displaced. The vibrators are not to come into contact with the reinforcement.

Where reinforcement projects from a concrete section of the structure and this reinforcement are expected to remain exposed for some time, it is to be coated with a cement grout to prevent rust staining on the finished concrete. This grout is to be brushed off the reinforcement prior to the continuation of concreting.

3.5.7. Position and Correctness of Reinforcement

Irrespective of whether any inspection and/or approval of the fixing of the reinforcement has been carried out as above, it shall be the Contractor's sole responsibility to ensure that the reinforcement complies with the details on the drawings or schedules and is fixed exactly in the positions shown therein and in the position to give the prescribed cover.

The Contractor will be held entirely responsible for any failure or defect in any portion of the reinforced concrete structure and including any consequent delay, claim, third party claim, etc where it is shown that the reinforcement has been incorrectly positioned or is incorrect in size or quality with respect to the detailed drawings or schedules.

3.5.8. Spacer Blocks

Spacer blocks of approved size and shape made of concrete similar to that used in the surrounding construction and fixed to the reinforcement or formwork by No. 18 Standard Wire Gauge set into the spacer blocks, or other approved means, shall be provided where necessary to ensure that the required cover is obtained. The Contractor is to include for providing sufficient spacer blocks in his prices for steel reinforcement.

3.5.9. Concrete Cover to Reinforcement

Unless otherwise directed, the concrete cover to reinforcement bars in any face shall be:-

• Foundation against earth face	50 mm
• Foundation against blinding	50 mm
• Columns, Tank walls and Ground Slabs	40 mm
• Beams and other walls, tank roofs	30 mm
• Slabs	25 mm

3.5.10. Fixing Fabric Reinforcement

The fabric shall be free from scale, rust, grease or other substance likely to reduce the bond between the steel and the concrete and shall be laid with a minimum lap length of thirty diameters and bound with No. 18 S.W.G. annealed binding wire.

In all ground slabs, unless otherwise specified, a single layer of square mesh steel fabric shall be placed at a depth of 50 mm below the surface of the concrete. Sufficient wire ties shall be provided to ensure that the fabric is held down securely.

3.5.11. Cast-in Items, Chases, Holes, etc in Concrete

The contractor shall be responsible for the co-ordination with the Sub-Contractors for incorporating cast-in items, pipes, electrical conduits, fixing blocks, chases, holes and the like in concrete members as required and must ensure that adequate notice is given to such Sub-Contractors informing them when concrete members incorporating the above are to be poured.

No opening chases holes or other voids shall be formed in the concrete without the prior approval of the Engineer. Details of any item to be permanently built into the concrete shall be submitted to the Engineer for his approval before being placed.

Unless otherwise instructed by the Engineer, all electrical conduits to be positioned within the reinforced concrete shall be fixed inside the reinforcement cages of beams and columns and between the top and bottom steel layers in slabs and similar members

3.5.12. Approval of Reinforcement

(a) No concrete shall be placed until the reinforcement has been checked and approved by the Engineer. The Contractor shall give a minimum period of notice of 24 hours before the scheduled commencement of concreting in order to allow the Engineer time to carry out a full and detailed inspection of the reinforcement.

(b) If in the Engineer's opinion additional reinforcement is required, this shall be placed as directed by the Engineer.

3.6. Blockwork-Plastering

3.6.1 Pre-cast Concrete Blocks, Sandcrete Blocks

(a) Precast concrete blocks and sandcrete blocks shall be manufactured locally with aggregates, sand and cement in an approved vibrating pressure machine. The mix proportions shall comply with DIN 1045. The sand shall have the following grading:

Sieve Size [%]	Passing [% per weight]
2.4	- 100
1.2	95 - 100
0.6	25 - 85
0.3	5 - 50
0.15	0 - 10

(b) The blocks shall be hard, sound, with sharp well defined arises, and shall be 40 cm long by 20 cm high by the specified thickness, unless otherwise instructed by the Engineer. The sandy bricks shall be 25 cm by 12 cm by 6 mm of uniform colour and shall comply with the relevant Malawi Standard Specifications.

(c) Immediately after moulding, the blocks shall be placed on a clean level pallet and shall be cured by being continuously sprayed with water or other approved means.

(d) For a sample out of twelve blocks, randomly selected, the average compressive strength shall not be less than 3 N/mm2, and no block out of the twelve shall be less than 2.4 N/mm2. If these requirements are not met, the whole batch from which the twelve blocks were selected will be rejected.

3.6.2. Workmanship

(a) All block work shall be set out and built to the respective dimensions, thickness and heights as shown on the drawings.

(b) All blocks shall be carefully handled to prevent damage and protected as necessary. No cracked, chipped or broken block will be used in the works.

(c) In dry weather, the suction rate of all concrete blocks shall be adjusted by wetting before being used, and the tops of walls left unfinished shall be wetted before work is recommenced.

(d) All blocks shall be well buttered with mortar after being laid and all joints shall be thoroughly flushed up as the work proceeds.

(e) Block work shall be carried up in a uniform manner, no one portion being raised more than one meter above another at one time. All perpends, quoins etc., shall be kept strictly true and square and the whole properly bonded together and levelled round at each floor or agreed height. Bats shall not be used except where required for bonds. A full joint of mortar is to be made where block work abuts concrete or masonry.

(f) Jambs of openings in hollow block walling shall be built-in solid blocks.

(g) Stainless (galvanized) steel anchor ties to connect block walls to concrete columns shall be dovetail slots, with prior approval of the Engineer.

3.7. Mortars and Plasters

(a) The mixes of mortars and plasters for block work, plastering and for external rendering shall be as per the following table:

Designation	**Mix Proportions**		
Cement Mortar	Cement (Vol.)	Lime (vol.)	Sand (vol.)
i	1	1/4	3
ii	1	1/2	4
iii	1	1	5
iv	1	2	8

(b) The ingredients for cement mortars shall be measured in proper gauge boxes on a boarded platform, the ingredients being turned over twice dry and twice whilst water is added through a sprinkler rose. Alternatively, mixing may be by means of an approved mechanical batch mixer.

(c) Cement and sand mortar mix shall be used within 2 hours after starting addition of water, any amount of mix remaining should be collected and disposed.

(d) Mortar plasticiser shall be of an approved make and shall be used in the proportions and manner recommended by the manufacturer. The proportions of the mortar mix shall if necessary be adjusted in accordance with the manufacturer's recommendations.

(e) Where coloured mortar or rendering is specified the pigment shall be of an approved manufacture and shall not be injurious to other ingredients of the mortar. It shall be mixed with care to ensure even colouring throughout the mixture and a sufficient quantity shall be made to ensure completion of an area of rendering in one operation.

3.7.1 Finishing

(a) The preparation of the surfaces for plastering, includes raking out joints of concrete surfaces or block work to form key, dubbing out all uneven surfaces as required, temporary rules and boards, working around pipe clips and other similar obstructions, working behind pipes.

(b) All surfaces are to be finished true and smooth.

(c) External angles, where not protected by metal angle beads, shall be properly formed rounded angles to 10 mm radius unless otherwise directed.

(d) All joints between block walls and concrete members, all routes of electric or sanitary piping should be covered by 20 cm wide metal lath strip; this will be included in the rates.

(e) The prices shall include for 1 m x 1 m sample panels if so directed by the Engineer.

(f) Plasters and Mortars shall be to the grades and mix proportions specified.

(g) Plastering to internal walls and surfaces shall be composed of the layers, as hereafter detailed, to make up the complete thickness of 15 mm.

(h) Backing coat shall consist of approximately 10 mm thick cement mortar Grade "C" and scratched to form key.

(i) Finishing coat shall consist of a 5 mm thick layer mortar Grade "C" and finished with a steel float to approval.

(j) Cement rendering shall be cement mortar Grade “A” and shall be applied in two or three coats. Undercoats shall not exceed an average thickness of 10 mm and finishing coats an average thickness of 6 mm. Two-coat rendering shall be to a total thickness of 16 mm and three coats rendering to a total thickness of 25 mm.

(k) Where rendering is to be applied to concrete surfaces such faces shall be suitably treated to provide an adequate mechanical key for the rendering.

(l) The surface of brickwork block work or masonry to be rendered shall be thoroughly prepared before the first undercoat is applied by raking out the joints to form an efficient key for rendering.

(m) Surfaces shall be thoroughly brushed down to clean off all dust and loose material. Particular attention shall be paid to the removal of mould oil or other deleterious substances prior to rendering. Each undercoat shall be scored to form an adequate key for subsequent coats. The surface of block work shall be thoroughly wetted with fresh water before rendering is applied.

(n) Each rendering coat shall be kept moist for at least 48 hours and then given adequate time to dry out thoroughly before the application of any subsequent coats. The surface shall then be wetted immediately before the application of any further coat.

(o) The finishing coat shall have a steel float finish to true planes and regular curves and to an even and polished surface. Arises shall be rounded and in true alignment and a hollow fillet shall be run at internal angles.

(p) The finished rendering shall be protected and cured as specified for concrete.

3.8. Glazing

3.8.1. Materials

(a) Clear plate glass shall be of a quality as locally available and as directed by the Engineer.

(b) Clear plate glass shall be to the thickness given on the drawings and the Bills of Quantities.

(c) Wired reinforced glass shall be 7 mm thick.

3.8.2. Workmanship

(a) The glass shall be cut to sizes with a small clearance and shall be installed in accordance with the manufacturer's drawings and recommendations as approved by the Engineer.

(b) The glass shall be cleaned inside and outside and all cracked and broken glass replaced before handing over the Works.

3.9. METAL ROOF WORKS

3.9.1. General

3.9.1.1 Application

Any general engineering method not in this section shall be done in accordance with common installation engineering methods.

3.9.2. Material

3.9.2.1 Material

(a) Light metal plates

(1) Quality specifications
Light metal plates shall be light corrugate plates, templates or semi-lard band templates, and the designation of their types shall be done in accordance with specifications on drawings or construction specifications.

(2) Thickness of plate

Table 15030.1 shall be the standards for the thickness of plates and the designation of their types shall be done in accordance with drawings or construction specifications, provided that Type B shall be applied when there is no provision on drawings or construction specifications.

Table 15030.1 Thickness of Light Metal Plates

Type	Type A	Type B	Type C
Thickness	0.6 mm	0.5 mm	0.4 mm

(b) Fixing ironware and others

(1) Types of fixing ironware

The fixing ironware of light metal jointing plates shall include light metal nails, stainless steel nails, brass nails or cadmium plated iron nails and galvanized iron nails.

(2) Length of fixing nails

The length of fixing nails for flat plates or strap plates shall be 24 ~ 30 mm.

(3) Fixing ironware for corrugate plates and others

The fixing ironware for corrugate plates and ribbed templates (hereinafter referred to as 'Templates') shall be done in accordance with Table 15030.2 and their types shall abide by provisions on drawings or construction specifications, provided that Type B shall be applied if there is no provision therein.

Table 15030.2 Fixing Ironware (for Wooden Purlins)

Type	For small corrugate plates (mm)		For large corrugate plates (mm)	
	Type A	Type B	Type A	Type B
Nails	4 ψ × 50	3.5 ψ × 40	4.5 ψ × 50	4 ψ × 40
Screw nails	5 ψ × 40	4 ψ × 30	6 ψ × 50	5 ψ × 40

(4) Hook bolts

If a purlin is made of steel, hook bolts (diameter 4~5 mm), hanging plates (thickness 1.2 mm, width 20 mm) and clip (thickness 2 mm, width 25 mm) with others shall be used.

(5) Shape of fixing ironware

Fixing ironware shall be selected, which is suitable for corrugate shape, and washers shall have thickness and diameter suitable for the diameter of fixing ironware. In addition, their supports shall adopt felt materials having the same diameter as washers, where rubber or asphalt in thickness 2 mm or more is penetrated.

3.9.3. Installation

3.9.3.1 General

(a) Jointing and lapping engineering method

The jointing and lapping engineering method shall be done in accordance Table following:

Division Engineering Method	Lapping Section	Jointing Section	Plate End
Standard Engineering Method	Radius is interlocked and lapped according to materials and plate thickness.	Clamp joint, 12~15 mm is applied to the lapped width, unless it is otherwise provided on drawings or construction specifications.	Lapped to the inside.
Special Engineering method	In accordance with drawings, construction specifications or approval by the person in charge. Template jointing shall be done in accordance with the predefined engineering method.		

(b) Lapping of flow direction

The lapping width of flow direction for corrugate plates shall be done in accordance with drawings or construction specifications, provided that it shall be done in accordance with Table 15020.2 if there is no specific provision.

(c) Jointing of Width Direction

The jointing of width direction shall be done in accordance with drawings or construction specifications, provided that it shall be done in accordance with Table following, depending on the roof pitch if there is no specific provision.

Pitch	Less than 3/10	3/10 or more	4/10 or more
Engineering Method	Soldering	Clamp joints, watertight painting for jointing sections	Dual clamp joints, watertight painting for jointing sections

(d) Lifting of plates

For the standard for the joint of flow direction, the effective lifting shall be made in 25 mm or more for strap plates and flat plates, 18 mm or more for templates, and 9 mm or more for corrugate plates.

(e) Arrangement of clamps

When a plate is attached to the base, light metal clamps (width 25 mm) shall be used and the binaural piece shall be attached in the interval for the arrangement of fixing ironware, which is a piece per every 450 mm. However, instructions by the person in charge shall be followed for the reinforced templates and the interval for the arrangement of shorter plates shall not exceed 450 mm.

(f) Bending of plates and clamps

The bending of plates and clamps shall be done in accordance with this Construction Standard Specifications 16000 (Metallic Construction).

(g) Wooden floor

When the floor is wooden, the insulation shall be in principle done with asphalt roofing or neutral coal tar.

(h) Steel frame floor

When the floor is steel frames, the insulation painting shall be done for the contact of purlins and joint plates.

(i) Floor of mortar or concrete

When the floor is mortar or concrete, the insulation shall be done with asphalt waterproofing layers.

(j) When fixing ironware other than light metals is used

When fixing ironware other than light metals is used, the insulation painting shall be done for any area exposed to rainfall.

(k) When watertight characteristics are necessary

Watertight engineering methods such as brazing, watertight caulking or watertight painting shall be applied to any place necessary for watertight characteristics for joints and nailing spots.

(l) When fixing with nails or bolts is done

When fixing with nails or bolts is done, flexibility shall be given for temperature of plates by enlarging holes a little more.

(m) Joint of clamps

Light metal clamps shall be used to fix the plate end and the joint of clamps shall be done in accordance with drawings or construction specifications, provided that butt joint shall be applied if there is no specific provision and 2 light metal (or cadmium / galvanized iron) nails shall be driven per 450~500 mm interval.

3.9.3.2 Various Engineering Methods

(a) Flat joint

(1) Size of joint plates
Flat plates or strap plates shall be used for joint plates, where 4 planes shall be clamp joint. The standard width for a sheet of a plate shall be around 450 mm.

(2) Jointing of joint plates
Watertight painting for dual clamp folding shall be the standard for the joint of jointing plants. Watertight painting on water caulking shall be done during clamp folding.

(b) Lozenge jointing

About 450 mm shall be the standard for a side of a sheet for the jointing plate, and the jointing section shall be done with dual clamp folding and watertight painting.

(c) Strap plate jointing and ribbed seam jointing

(1) Jointing of joint plates
The jointing of longitudinal direction for jointing plates shall be lifted bending, pushed

bending, inserted bending and valley lapping. When ribbed seam is used, the lifted section shall be 40 mm or more for waterproofing.

(2) Fixing of strap plates

Strap plates shall be fixed on the floor per about 450 mm and anything with clamp jointing shall be jointed with clamps and the lapping shall be done with nailing or bolt fastening.

When any wooden ribbed seam is used, fixing may be done with anti-corrosive light metal nails only for the lifted section of 25 mm or more to the side.

(3) Consideration for expansion and shrinkage

Space shall be placed in consideration of expansion and shrinkage by narrowing down the bottom end of ribbed seam or hooked attaching to the jointing plates, where temperature variations are severe.

(d) Jointing of corrugate and flat plates

(1) Fixing

Fixing for the jointing of corrugate plates and flat plates shall be done on the ridge of valleys. The standard interval shall be done in accordance with Table 15030.5, when the plate thickness is 0.5 m. The interval shall be made 1.3 times as large as those of Table 15030.T for plate thickness of 0.6 m, and 0.8 times as large for plate thickness of 0.4mm.

The area with less snow (maximum snowing of 3 cm or less) or the minor structure without concern of damage by storm may increase the interval by 2 times.

Distance of Flow Direction		**About 450**	**About 600**
Distance of Width Direction	Large valley	4 valleys (300)	3 valleys (230)
	Small valley	8 valleys (250)	6 valleys (190)
	Template	About 300	About 200

(2) Lapping of width direction

Lapping of width direction for corrugate shall be 2 valleys for small valleys and 1.5 valleys or more for large valleys, and the number of valleys shall be instructed by the person in charge for templates.

(3) Lapping of flow direction

Lapping of flow direction shall be done.

(4) If fixing is done to the roof sheets

Although corrugate plates shall be fixed on purlins in principle, they may be fixed to the roof sheets when roof sheets in thickness 18mm or more are used.

3.9.3.3 Engineering Method for Each Section

(a) Wrapping of roof ridge

(1) Wrapping plates

Strap plates shall be applied to wrapping plates, if possible, and the jointing shall be reduced. The joint shall be clamp folding or clamp attachment.

(2) Roof sheets shall be used in around 100 mm for shaped wrapping sheets on the roof bridge for the interface to top of sheets in jointing corrugate plates and templates

during the jointing of corrugate plates and templates. The top on the roof sheets shall keep valleys lifted up and the weathered slope shall be attached.

(3) For the jointing of flat plates

For the jointing of flat plates, the top shall be lifted up in 20 mm or more and the wrapping to the bottom of wrapping plates for the roof ridge shall be made.

(4) For the jointing of ribbed seam

For the jointing of ribbed seam, the top of jointing plates shall be lifted up in 40 mm or more and their corners shall be finished in watertight engineering. The wrapping plates shall be lapped in about 7 5mm on the roof ridge in accordance with the jointing of corrugate plates.

(b) Joint end

(1) For the jointing of corrugate plates and templates

For the jointing of corrugate plates and templates, the lapped weatherboards shall be lifted up in 120 mm or more to the wall side in accordance with the wrapping engineering for the roof ridge, and wall sheets shall be lapped in about 75mm.

(2) For the jointing of flat plates

For the light metal flat plates or strap plates in the jointing of flat plates, the top shall be lifted up in 40 mm or more, and wall sheets shall be fixed in clamp folding or clamp fixing.

(3) For ribbed seam roofing

Any ribbed seam roofing shall be done in accordance with 3.3 (Engineering Method for Each Section).

(c) Gable side and end

(1) For the jointing of corrugate plates and templates

For the jointing of corrugate plates and templates, the shaped weatherboard in line with corrugate plates and templates shall be lapped in 100 mm or more.

Both ends shall be done with clamp strap attachment. When gable plates are wrapped, weatherboards shall be folded and attached along the valley of gable sheets, and the weathered slope shall be fixed with clamps and lowered 15 mm or more from gable plates.

(2) For the jointing of flat plates

For the jointing of flat plates, the bottom shall be fixed in dual clamp folding and clamp fixing to the top of gable wrapping plates fixed with clamps in accordance with 3.3 (Engineering Method for Each Section).

(3) For the jointing of ribbed seam roofing

For the jointing of ribbed seam roofing, the wrapping plates for the ribbed seam roofing and wrapping plates for gables shall be done with the eared clamp folding and clamp fixing.

(d) Joint with walls

(1) For the jointing of corrugate plates and flat plates

For the weatherboards in jointing corrugate plates and flat plates, the weathered slop shall be attached to the top, lifted up 100 mm or more to the walls, and the appropriate weathered slop (0.2 or more) shall be attached along the jointing plates. 1.5 valleys for large valleys and 3 valleys or more for small valleys shall be lapped. The weatherboards shall be lapped about 100 mm for flat plates with the proper weathered slop at the end.

(2) For the jointing of flat plates
For the jointing of flat plates, the weathered slop on the top shall be attached and lifted up 25 mm or more, so that the weatherboards are lapped and attached in accordance with 3.3 (Engineering Method for Each Section) C-1) or lifted up 50 mm or more for the fixing to the walls with clamp folding or clamp fixing, or lifted up about 40 mm with the attachment of weatherboards to the inside in 50 mm.

(3) For the jointing of ribbed seam roofing
For the jointing of ribbed seam roofing, it shall be lifted up 40 mm or more by the clamp fixing, which shall be fixed by the eared clamps with the weatherboards lifted up 75 mm or more, or the weatherboards (about 60 mm) with the weathered slops shall be lapped and attached.

(e) Edge of eaves

(1) For the jointing of corrugate plates and templates
The edge of eaves for the jointing of corrugate plates and templates shall be projected about 30 mm and fixed from the bottom with clamp fixing, where the nailing shall be done to the sheets of eaves near the top. The wrapping boards for eaves shall be done with the clamp folding to the bottom plates in 120 mm or more and the rivet jointing in light metal shall be done for the elements.

(2) For the jointing of strap plates
For the jointing of strap plates, the edge of eaves shall be finished with clamp and the placing plates (bottom plates) may be omitted.

(3) For the jointing of flat plates
For the jointing of flat plates, the throating shall be attached and the edge of eaves shall be wrapped down or the clamping folding shall be done onto the top of the eave end plates fixed to the clamps.

(4) For the jointing of ribbed seam roofing
For the jointing of ribbed seam roofing, the edge of eaves shall be fixed with clamps and both the jointing plate bottom shall be fixed with the clamp folding with the use of 60 mm~100 mm wide strap plates as the placing plates whose upper corners are fixed with clamps.

(f) Side valley

(1) Engineering method for side valley
When any side valley is placed, the throating shall be attached to the top of corrugate plates and lifted up 60 mm or more, and the eared clamp folding shall be done with the bottom plates which are inserted and lapped 40 mm or more into the roof sheets.
The roof plates shall be lapped down 25 mm or more to the side of valley with the clamp fixing. The side of walls shall have the attachment of weathered slops on the back, lifted up 100mm or more, and the wall plates shall be lapped down 75 mm or more.

(2) For the jointing of corrugate plates
For the jointing of corrugate plates, the roof plates shall be folded down along the lifting of the roof corrugate plates in 1.5 valleys for small corrugate plates and 50 mm or more for large corrugate plates. Or, 2 valleys for small corrugate plates and 1.5 valleys or more for large corrugates shall be lapped and inserted into the bottom of roof plates, and the weatherboards shall be fixed with the eared clamp folding and clamps to

the corrugate plates.

(g) Jointing of roof valleys

(1) For the jointing of flat plates
For the jointing of flat plates, both ends of corrugate plates shall be folded to roof plates with clamp folding or lifted up 40mm or more, and both the jointing plates and their ears shall be all done with watertight engineering method by the clamp folding.

(2) For the jointing of corrugate plates and templates
For the jointing of corrugate plates and templates, the bottom plates shall be elongated and extended to be lapped and inserted into the bottom of roof plates as long as the lapped section along the roof pitch in accordance with the preceding clause, and the roof plates shall be fixed with the watertight engineering method.

3.10. Metalwork

3.10.1. Materials

(a) Structural steelwork shall comply with recognized standards for general structural purposes.

(b) Bolts, washers etc. for use with structural steel shall be black bolts. Fastenings, including bolts, for use with materials having a galvanized finish shall be sheradised or have an alternative approved protective metal coating.

(c) Before ordering or fabricating any item of metalwork, the Contractor shall submit to the Engineer for his approval shop drawings showing all details and dimensions required for fabrication, assembly and erection. Fabrication shall only commence after the approval of the Engineer has been obtained.

(d) Angles, channels, flats and all standard steel sections shall be to the sizes given on the drawings.

(e) Angles or channels used for framing of openings in concrete structures or for guides shall be provided with steel fixing lugs securely welded to the frame or guide prior to galvanizing.

(f) All steel shall be treat corrosion protection

3.11. Ladders, Stairs, Handrails and Open Flooring

(a) Unless otherwise stated, all steelwork shall be hot dip galvanized.

(b) Steel runged ladders shall conform to international safety standards and as amplified by the details given in the Bill of Quantities or as shown on the drawings.

(c) Safety hoops and stringer extensions shall be included where required for safety, unless specifically excluded by details given in the Bill of Quantities or on the drawings.

(d) Suitable support stays shall be provided for fixing the ladder to the supporting structure so that there is a minimum of 200 mm clearance behind the rungs. These connections shall be of the type, which bolt to the supporting structure.

(e) Handrails and stanchions shall be safe and stable and properly fixed to the concrete.

(f) Handrails shall be prefabricated of steel pipes of DN 50 or 65 mm nominal bore, cut to lengths and fixed by welding to the stanchions. Hand railing and fixings shall be designed to withstand a horizontal force at handrail level of 740 N/mr.

(g) Stanchions shall be as the handrails made of 50 or 65 mm nominal bore shank and be 1200 mm high. They shall be set in sockets cast in the concrete and grouted in non-shrink grout. Spacing shall be a maximum 1.500 mm. Side palm type of fixing will only be used where shown on the Drawings or approved by the Engineer.

(h) Open mesh (Grid Cover) or chequer plate flooring shall be of mild steel. The thickness of plate or construction of open mesh shall be of adequate strength to bear the load of not less than 5 kN/m2.

(i) In addition to the requirements of strength a minimum overall chequer plate thickness of 7 mm and an open mesh minimum member thickness of 3 mm shall be allowed.

(j) Where a welded construction is used to open mesh flooring the welding shall be continuous, heavy and on both edges of a joint.

(k) Metal flooring shall in all cases be supported by a properly formed and secured steel kerbing running continuously throughout the length supported. The flooring shall be provided with proper and adequate lifting handholds and where used on suspended supports adequate clips shall be used to prevent any movement of the flooring.

(l) Mild steel plating, open mesh and kerbing shall be hot dip galvanized after cutting, manufacture and complete fabrication.

(m) Where metal flooring is placed adjacent to a clear opening it shall include a 100 mm high kicking plate along the full length of the opening. Rates for such flooring shall include for kicking plate as described.

(n) Chequer plate covers over cables/pipes passage in transformer/generator rooms shall be non-slip pattern type and shall be set flush in mild steel frames provided with lugs for building in.

(o) The work is to be carried out as detailed on the drawings and/or as specified. All working drawings shall have the approval of the Engineer before fabrication.

3.12. Doors and Windows

3.12.1. Materials

(a) Steel doors shall be of the hollow metal type constructed in standard profiles and sheet steel.

(b) The doors shall be provided with buffer strips fixed all around the frame.

(c) Windows and frames shall be manufactured of anodised aluminium, to the dimensions given on the Drawings. They should generally be supplied with one horizontally sliding sash complete with sash-bolt unless shown otherwise.

(d) All windows shall be designed to withstand wind pressures and to be dust proof.

(e) Openings in windows shall be provided with an aluminium fly-screen mesh. In offices the glass shall normally be 5 mm thick clear sheet glass.

3.12.2. Installation

(a) Doors and windows shall be installed plumb and true to line and shall operate smoothly.

(b) Doors and windows shall be such that glazing or re-glazing on site is possible without the need to remove the outer frame from the structure of the building.

(c) The Contractor shall submit details of manufacture including sections of all members and no orders shall be placed until such details have been approved by the Engineer.

(d) Weather stripping shall be made from material compatible with aluminium, be resistant to deterioration by weather conditions.

(e) All doors and windows shall be protected after installation and handed over in a clean and perfect condition on completion of the works.

3.13. Protection

3.13.1. General

(a) The work detailed in this section refers only to protection applied at the manufacturer's works prior to delivery. The protection required subsequently is covered in Section Paintwork.

(b) All paints shall be obtained from one approved manufacturer, and applied strictly in accordance with the manufacturer's instructions. The source of supply shall not be altered without the Engineer's approval. The colour of the paints used shall be of different shades.

(c) After welding and fabrication, all weld areas shall be thoroughly cleaned and touched up as specified with the appropriate priming system.

3.13.2. Repair of Damaged Coatings

Any damage to the protective coating shall be made good as soon as possible, and shall not be left until the time of general finish painting. Damaged areas shall be cleaned down to bright metal by power wire brushing or sanding and feathered of to the surrounding area.

A new protective system shall then be applied generally following the requirements of the system originally applied, modified if necessary to comply with the recommendations of the manufacturer of the protective materials used.

3.13.3. Types of Protection

Unless otherwise specified on the Contract Drawings the various types of protection shall be applied as detailed below:

(a) Type A (hot-dip galvanized to give a minimum coating weight of 1200 gm/m2):

- All ladders, staircases, guardrails, guardrail standards, safety cages and open steel flooring and small bore pipe work;
- All small metalwork such as pipe supports, steel flooring supports and safety chains.
- All steelwork, which is in contact with potable water, or is in close proximity to potable water.

(b) Type B (zinc rich epoxy primer and heavy-duty epoxy coal tar):

- All steelwork, which is in contact with sewage, or is in close proximity to sewage, or is buried in the ground.

(c) Type C (zinc rich epoxy primer):

- All steelwork in buildings or otherwise which is exposed to the weather.

(d) Type D (metallic lead primer applied by brush to a minimum thickness not less than 75 μm):

- All steelwork, which is in buildings but protected by cladding.

(e) Type E (hand or tool cleaning to remove rust, grease etc. for all steel work, which is to be encased in concrete).

3.14. Painting

3.14.1. General

(a) Paint exposed exterior and interior plumbing, heating and electrical equipment, apparatus, conduits, pipes and fitting, supports and hangers and all other unfinished surfaces of mechanical and electrical work.

(b) Equipment In Finished Rooms: Paint wall grilles and diffusers, door louvers, panel board fronts and other equipment having a factory finish, occurring in rooms other than storage, mechanical and custodial.

(c) Work includes field painting of exposed bare and covered bare and covered pipes and ducts (including color coding), and of hangers, exposed steel and iron work, and primes or factory painted metal surfaces of equipment installed under mechanical and electrical work, except as otherwise indicated.

(d) “Paint” as used herein means all coating systems materials, including primers, emulsions, enamels, stains, sealers and fillers, and other applied materials whether used, as primer, intermediate or finish coats.

(e) Surfaces To Be Painted: Except where natural finish of material is specifically noted as a surface not to be painted, paint exposed surfaces whether or not colors are designated. Where items or surfaces are not specifically mentioned, paint the same as similar adjacent materials or areas. If color or finish is not designated, Architect will select these from standard colors or finishes available.

Following categories of work are not included as part of field-applied finish work.

(1) Concealed Surfaces: Unless otherwise indicated, painting is not required on surfaces such as walls or ceilings in concealed areas and generally inaccessible areas, foundation spaces, furred areas, utility tunnels, pipe spaces, duct shafts and elevator shafts.

(2) Finished Metal Surfaces: Unless otherwise indicated, metal surfaces of prefinished aluminum, anodized aluminum, stainless steel, chromium plate, copper, bronze and similar finished materials will not require finish painting.

(3) Operating parts: Unless otherwise indicated, moving parts of operating units, mechanical and electrical parts, such as valve and damper operators, linkage, sinkage, sensing devices, motor and fan shafts will not require finish painting.

(d) Following categories of work are included under other sections of these specifications.

(1) Shop Priming: Unless otherwise specified, shop priming of ferrous metal items is included under various sections for structural steel, metal fabrications, hollow metal work and similar items.

(2) Unless otherwise specified, shop priming of fabricated components such as architectural woodwork, wood casework and shop-fabricated or factory-built mechanical and electrical equipment or accessories is included under other sections of these specifications.

(e) Do not paint over any code-required labels, such as Underwriter’s Laboratories and Factory Mutual, or any other equipment identification, performance rating name, or nomenclature plates.

3.14.2. Quality Assurance

(a) Codes and Standards: Work and materials shall conform to regulations of Fire Department, safety color coding in conformance with OSHA and all other regulatory ordinances having jurisdiction. Conform to the most stringent requirements and authorities having jurisdiction.

(b)Single Source Responsibility: Provide primers and other undercoat paint produces by same manufacturer as finish coats. Use only thinners approved by paint manufacturer, and use only within recommended limits.

(c) Coordination of Work: Review other sections of these specifications in which prime paints are to be provided to ensure compatibility of total coatings system for various substances. Upon request from other trades, furnish information or characteristics of finish materials provided for use, to ensure compatible prime coats are used.

3.14.3. Submittals

(a) Product Data: Submit manufacturer’s technical information including paint label analysis and application instructions for each material proposed for use.

(b) Samples: Prior to beginning work, Architect will furnish color chips for surfaces to be painted. Use representative colors when preparing samples for review. Submit samples for Architect's review of color and texture only. Provide a listing of material and application for each coat of each finish sample.

(1) On 300 mm x 300 mm hardboard, provide two samples of each color and material, with texture to simulate actual conditions. Resubmit samples as requested by Architect until acceptable sheen, color, texture is achieved.

(2) On actual wood surfaces, provide two 100 mm x 200 mm samples of natural and stained wood finish. Label and identify each as to location and application.

(3) On concrete masonry, provide two 100 mm square samples of masonry for each type of finish and color, defining filler, prime and finish coat.

(4) On actual wall surfaces and other exterior and interior building components, duplicate painted finishes of prepared samples. Provide full-coat finish samples on at least 9.2 square meter of surface, as directed, until required sheen, color and texture is obtained; simulate finished lighting conditions for review of in-place work.

3.14.4. Delivery and Storage

(a) Deliver materials to job site in original, new and unopened packages and containers bearing manufacturer's name and label, and following information:

Name or title of material

Manufacturer's stock number and date of manufacturer.

Manufacturer' s name

Contents by volume, for major pigment and vehicle constituents

Thinning instructions

Application instructions

Color name and number

(b) Store materials not in actual use in tightly covered containers. Maintain containers used in storage of paint in a clean condition, free of foreign materials and residue.

(c) Keep storage area neat and orderly. Remove oily rags and waste daily. Take all precautions to ensure that workmen and work areas are adequately protected from fire hazards and health hazards resulting from handling, mixing and application of paints.

3.14.5. Job Conditions

(a) Do not apply paint in rain, fog or mist, or when relative humidity exceeds 85 percent, or to damp or wet surfaces, unless otherwise permitted by paint manufacturer's printed instructions.

(1) Painting may be continued during inclement weather if areas and surfaces to be painted are enclosed and within humidity limits specified and allowed by paint manufacturer during application and drying periods.

3.14.6. Products

3.14.6.1. Materials

(a) Material Quality: Provide best quality grade of various types of coatings as regularly manufactured by acceptable paint materials manufacturers. Materials not displaying manufacturer's identification as a standard, best-grade product will not be acceptable.

(1) Proprietary names used to designate colors or materials are not intended to imply that products of named manufacturers are required to exclusion of equivalent products of other manufacturers.

(b) Color Pigments: Pure, non-fading, applicable types to suit substrates and service indicated.

(1) All exterior colors and interior deep tone colors shall be ground in at the factory. Shop mixing is not permitted. Colors as selected by the architect, and subject to modification on the job at the Architect's discretion.

(2) content in pigment, if any, is limited to contain not more than 0.06 percent lead, as lead metal based on the total nonvolatile (dry-film) of paint by weight.

(3) This limitation is extended to interior surfaces and those exterior surfaces, such as stairs, decks, porches, railings, windows, and doors which are readily accessible to children under seven years of age.

3.14.6.2. Materials List

(a) Submit complete and detailed list with Painting Contractor's signature of the materials proposed for use on the work before ordering materials. Obtain Architect's approval before proceeding. Materials shall be the best quality of their respective kinds and suitable for the intended purpose, equal to or exceeding the following products, which are hereby set as standards.

(WP) Acrylic Emulsion water thinned coating, flat finish.

(EAE) Exterior Acrylic Enamel: A 100% acrylic latex water thinned coating with extra mildewcide, flat finish, conforming to Federal Spec. #TTP1SC, "Exterior Vinyl Bond Acrylic Masonry Paint" .

(ASE) Interior Acrylic Semi-Gloss Enamel: A vinyl acrylic water thinned, semi-gloss.

(AFE) Interior Acrylic Flat Enamel: 100% acrylic latex, water thinned washable flat finish.

(EP) Epoxy Paint: An epoxy polyester solvent thinned, two-component coating, semigloss finish.

(RIP) Rust Inhibitive Primer: An alkyd mineral spirit thinned, satin finish primer.

(BF) Block Filler: A vinyl acrylic latex, flat finish.

(PS) Primer Sealer: PVA vinyl acrylic water thinned, flat finish primer.

(ARE) Alkyd resin enamel: Industrial enamel.

(CS) Concrete Stain: A chemical stain in water solution.

(TMP) Traffic Marking Paint: Traffic and Zone Marking Paint.

(FR) Fire Resistance Paint: acrylic urethane finish coating shall be applied on two coats of Fire Resistance Paint on Red Lead Paint or recommended Primer by Supplier.

Supplier should submit approved Certification of Fire resistance Test granted from relevant Authorities.

3.14.7. Execution

3.14.7.1. Inspection

(a) Applicator must examine areas and conditions under which painting work is to be applied and notify Contractor in writing of conditions detrimental to proper and timely completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to applicator.

(b) Starting of painting work will be construed as Applicator's acceptance of surfaces and conditions within any particular area. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions otherwise detrimental to formation of a durable paint film.

3.14.7.2. Surface Preparation

(a) General: Perform preparation and cleaning procedures in accordance with paint manufacturer's instructions and as herein specified, for each particular substrate condition.

(1) Provide barrier coats over incompatible primers or remove and reprime as required. Notify Architect in writing of any anticipated problems in using the specified coating systems with substrates primed by others.

(2) Remove hardware, hardware accessories, machined surfaces, plates, lighting fixtures, and similar items in place and not to be finish-painted, or provide surface-applied protection prior to surface preparation and painting operations. Remove, if necessary, for complete painting of items and adjacent surfaces. Following completion of painting of each space or area, reinstall removed items.

(3) Clean surfaces to be painted before applying paint or surface treatment. Remove oil and grease prior to mechanical cleaning. Program cleaning and painting so that contaminants from cleaning process will not fall onto wet, newly-painted surfaces.

(4) Cementitious Materials: Prepare cementitious surfaces of concrete, concrete block and cement plaster to be painted by removing efflorescence, chalk, dust, dirt, grease, oils, and by roughening as required to remove glaze.

(5) Determine alkalinity and moisture content of surfaces to be painted by performing appropriate tests. If surfaces are found to be sufficiently alkaline to cause blistering and burning of finish paint correct this condition before application of paint. Do not paint over surfaces where moisture content exceeds that permitted in manufacturer's printed directions.

(6) Clean concrete floor surfaces scheduled to be painted with a commercial solution of muriatic acid, or other etching cleaner. Flush floor with clean water to neutralize acid, and allow to dry before painting.

(b) Wood: Clean wood surfaces to be painted of dirt, oil, or other foreign substances with scrapers, mineral spirits, and sandpaper, as required. Sandpaper smooth those finished surfaces exposed to view, and dust of f. Scrape and clean small, dry, seasoned knots and apply a thin coat of white shellac or other recommended knot sealer, before application of priming coat. After priming, fill holes and imperfections in finish surfaces with putty or plastic wood-filler. Sandpaper smooth when dried.

(1) Prime, stain, or seal wood required to be job-painted immediately upon delivery to job. Prim edges, ends, faces, undersides, and backsides of such wood, including cabinets, counters, cases, panels.

(2) When transparent finish is required, use spar varnish for backpriming.

(3) Backprime paneling on interior partitions where masonry, plaster, or other wet wall construction occurs on backside.

(4) Seal tops, bottoms, and cut-outs of unprimed wood doors with a heavy coat of varnish or equivalent sealer immediately upon delivery to job.

(c) Ferrous Metals: Clean ferrous surfaces, which are not galvanized or shop-coated, of oil, grease, dirt, loose mill scale and other foreign substances by solvent or mechanical cleaning.

(1) Touch-up shop-applied prime coats wherever damaged or bare, where required by other sections of these specifications.

(2) Clean and touch-up with same type shop primer.

(d) Galvanized Surfaces: Clean free of oil and surface contaminants with non-petroleum based solvent.

3.14.7.3. Materials Preparation

(a) Mix and prepare painting materials in accordance with manufacturer's directions.

(b) Maintain containers used in mixing and application of paint in a clean condition, free of foreign materials and residue.

(c) Stir materials before application to produce a mixture of uniform density, and stir as required during application. Do not stir surface film into material. Remove film, if necessary, and strain material before using.

3.14.7.4 Application

(a) General: Apply paint in accordance with manufacturer's directions. Use applicators and techniques best suited for substrate and type of material being applied.

(1) Paint finishes are scheduled.

(2) Provide finish coats which are compatible with prime paints used.

(3) Apply additional coats when undercoats, stains or other conditions show through final coat of paint until paint film is of uniform finish, color and appearance. Give special attention to insure that surfaces, including edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.

(4) Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Paint surfaces behind permanently-fixed equipment or furniture with prime coat only before final installation of equipment. Paint interior surfaces of ducts, where visible through registers or grilles, with a flat, non-specular black paint.

(5) Paint back sides of access panels, and removable or hinged covers to match exposed surfaces.

(6) Finish exterior doors on tops, bottoms and side edges same as exterior faces unless otherwise indicated.

(7) Sand lightly between each succeeding enamel or varnish coat.

(8) Omit first coat (primer) on metal surfaces which have been shop-primed and touch-up painted, unless otherwise indicated.

(b) Scheduling Painting: Apply first-coat material to surfaces that have been cleaned, pretreated or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.

(1) Allow sufficient time between successive coatings to permit proper drying. Do not recoat until paint has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure, and application of another coat of paint does not cause lifting or loss of adhesion of the undercoat.

(c) Minimum Coating Thickness: Apply materials at not less than manufacturer's recommended spreading rate, to establish a total dry film thickness or, if not indicated, as recommended by coating manufacturer.

(d) Roof Flashing: Paint all exposed roof flashing that is not stainless steel.

(e) Mechanical and Electrical Work: Painting of mechanical and electrical work is limited to those items exposed in mechanical equipment rooms, in occupied spaces and equipment on roof.

(f) Mechanical items to be painted include, but are not limited to, the following:

Factory pre-painted diffusers at public spaces.

Piping, pipe hangers, and supports.

Heat exchangers.

Tanks.

Ductwork, insulation.

Sprinkler covers and pipes.

Motor, mechanical equipment, and supports.

Accessory items.

(g) Electrical items to be painted include, but are not limited to, the following:

Rooftop equipment.

Panel Boards in public spaces.

Conduit and fittings.

Speaker grilles.

Switchgear.

(h) Prime Coats: Apply prime coat of material which is required to be painted or finished, and which has not been prime coated by others.

(1) Recoat primed and sealed surfaces where there is evidence of suction spots or unsealed areas in first coat, to assure a finish coat with no burn-through or other defects due to insufficient sealing.

(i) Stipple Enamel Finish: Roll and redistribute paint to an even and fins texture. Leave no evidence of rolling such as laps, irregularity in texture, skid marks, or other surface imperfections.

(j) Pigmented (Opaque) Finishes: Completely cover to provide an opaque, smooth surface of uniform finish, color, appearance and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness or other surface imperfections will not be acceptable.

(k) Transparent (Clear) Finishes: Use multiple coats to produce glass-smooth surface film of even luster. Provide a finish free of laps, cloudiness, color irregularity, runs, brush marks, orange peel, nail holes, or other surface imperfections.

(1) Provide satin finish for final coats, unless otherwise indicated.

(l) Completed Work: Match approved samples for color, texture and coverage. Remove, refinish or repaint work not in compliance with specified requirements.

3.14.8. Field Quality Control

(a) The right is reserved by Owner to invoke the following material testing procedure at any time, and any number of times during period of field painting:

(b) Engage services of an independent testing laboratory to sample paint being used. Samples of materials delivered to project site will be taken, identified and sealed, and certified in presence of Contractor.

(1) Testing laboratory will perform appropriate tests for any or all of following characteristics: Abrasion resistance, apparent reflectivity, flexibility, washability, absorption, accelerated weathering, dry opacity, accelerated yellowness, recoating, skinning, color retention, alkali resistance and quantitative materials analysis.

(c) If test results show that material being used does not comply with specified requirements, Contractor may be directed to stop painting work, and remove non-complying paint; pay for testing; repaint surfaces coated with rejected paint; remove rejected paint from previously painted surfaces if, upon repainting with specified paint, the two coatings are non-compatible.

3.14.8.1 Clean-up and Protection

(a) Clean-Up: During progress of work, remove from site discarded paint materials, rubbish, cans and rags at end of each workday.

(b) Upon completion of painting work, clean window glass and other paint-spattered surfaces. Remove spattered paint by proper methods of washing and scraping, using care not to scratch or damage finished surfaces.

(c) Protection: Protect work of other trades, whether to be painted or not, against damage by painting and finishing work. Correct any damage by cleaning, repairing or replacing, and repainting, as acceptable to Architect.

(d) Provide “Wet Paint” signs as required to protect newly-painted finishes. Remove temporary protective wrappings provided by others for protection of their work, after completion of painting operations.

(e) At completion of work of other trades, touch-up and restore all damaged or defaced painted surfaces.

3.14.9. Extra Stock

Deliver stock of maintenance material to the Owner’s representative. Furnish maintenance material matching products installed, packaged with protective covering for storage and identified with appropriate labels.

Paint: Five (5) gallons of each of the paint colors.

3.14.10. Color Sections

Color Schedules: Colors and finishes and textures to be used shall be determined and directed by Architect. Color schedules will be furnished to the Contractor, well in advance of scheduled start of painting and finishing work.

3.14.11 Schedule of Paint Treatments

(a) General: Paint abbreviations refer to those noted previously in Part 2, Material List.

No. LOCATION	MATERIALS
1. Exterior & Interior Aluminum	Shop Coat: As specified in respective metal Ferrous Metal, Millspec section. Prime Coat: (RIP) Finish: Two coats (ARE)
2. Exterior & Interior Metal	Prime Coat: recommended Primer Finish: Two coats (ARE)
3. Factory Prefinished Metal	Finish: One coat (ARE)
4. Interior Exposed Smooth Concrete & Plaster where noted for water paint coating system. Including : Fascia, Soffits, Walls of Bldgs., Exposed Concrete Beams, Exposed Concrete Retaining Walls	Primer & Finish Coat: (WP) per manufacturer's recommendation
5. Exterior Plaster,& Concrete where noted for paint Including: Ceilings, Plaster Soffits and as indicated.	Prime Coat: (EAE) Finish: Two coats (EAE)
6. Interior Smooth Concrete & Gypsum Board Where	Scheduled. Prime Coat: (PS). Finish: Two coats (ASE or AFE).
7. Interior Masonry Where Scheduled.	Prime Coat: (BF). Finish: Two coats (ASE or APE).
8. Interior Smooth Concrete & Gypsum Board where noted for epoxy.	Prime Coat: (PS). Second Coat: (EP #371 Enamel). Finish: (EP #370 Clear Glaze).
9. Interior Masonry where noted for epoxy.	Prime Coat: (BF). Second Coat: (EP #371 Enamel). Finish: (EP #370 Clear Glaze).
10. Interior Wood for opaque finish.	Prime Coat: recommended primer Finish: Two coats Alkyd resin enamel (ARE)
11. Exterior/Interior Traffic Pavement Marking	One Coat Traffic Paint, minimum dry film thickness of 2.5 mils (.063 mm).
12. Interior Structural Steel Members Steel	Prime Coat: Red Lead Paint

Beams and Girders Miner Steel Members	Finish: as per Manufacture's Specification 1.5Hr Fire Resistance Paint: (FR) 0.5Hr Fire Resistance Paint: (FR)

3.15. Spray Painting

3.15.1. General

The decorative spray painting shall include aqueous born tiles in acrylic copolymer emulsion as the main ingredient with excellent water-proofing, hiding power and alkali-proofing, acrylic born tiles with acrylic resin with excellent color holding power and anti-pollution as the main ingredient, epoxy born tiles as epoxy emulsion in the middle painting type as the main ingredient, and elastic born tiles with the water-proofing to cracks together with excellent elasticity and anti-shock as the external finishing material for the light and foamed concrete.

(a) Painting method

The table shall be applied, depending on the type and intended use of the spray painting.

Painting Method	Floor	Painting Times		
		Lower Painting	Middle Painting	Upper Painting
Aqueous born tile (internal)	Mortar, concrete surfaces	1	1	2
Acrylic born tiles (internal and external)	Mortar, concrete surfaces	1	1	2
Epoxy born tiles (internal and external)	Mortar, concrete surfaces	1	1	2
Elastic born tiles (internal and external)	Mortar, concrete surfaces	1~2	1	2

3.15.2. Materials

Not applicable

3.15.3. Construction

(a) Aqueous born tile spraying works

Following table shall be applied to standards for the work process, mixing ratio of diluting materials, drying time and paint amount in aqueous born tile spraying works.

Process		Details	Mixing ratio (mass ratio)	Surface processing	Drying time	Paint amount (kg/m^2)
1	Floor processing	Table at 3.15.1				
2	Lower painting (1st time)	Acrylic emulsion primer	100		Within 8 hours	0.08
		Water	0~20			
3	Floor putty	Unsaturated polyester putty	100		Within 1 hour	
		Diluting material	0~3			
4	Grinding	Grinding paper p180~p240				
5	Middle painting (1st time)	Aqueous middle painting pattern paint	100		Within 24 hours ~3 days	0.9~1.2
6	Upper painting (1st time)	2 fluid type polyurethane paint	100		Within 24 hours ~ 7 days	0.12
		Polyurethane diluting material	0~20			
7	Upper painting (2nd times)	2 fluid type polyurethane paint	100		Within 24 hours ~ 7 days	0.12
		Polyurethane diluting material	0~20			

(b) Acrylic born tile spraying works
Table shall be applied to standards for the processes, mixing ratio of diluting material, drying time and paint amount in the acrylic born time spraying works.

Process		Details	Mixing ratio (mass ratio)	Surface processing	Drying time	Paint amount (kg/m^2)
1	Floor processing	Table at 3.15.1				
2	Lower painting (1st time)	Transparent acrylic resin	100		Within 6 hours	0.08
		Acrylic diluting material	0~20			
3	Middle painting (1st time) (Middle painting pattern)	Middle painting pattern paint	100		24 hours ~ 3 days	0.9~1.2
4	Upper painting (1st time)	Acrylic resin paint	100		24 hours ~ 3 days	0.23 ~ 0.35
		Acrylic diluting material	0~10			
5	Upper painting (2nd times)	Acrylic resin paint	100		24 hours ~ 3 days	0.23 ~ 0.35
		Acrylic diluting material	0~10			

(Note) Aqueous acrylic pattern paint may be used instead of middle painting pattern.

(c) Epoxy born tile spraying works

Table shall be applied to standards for the processes, mixing ratio of diluting material, drying time and paint amount in epoxy born tile spraying works.

Process		Details	Mixing ratio (mass ratio)	Surface process ing	Drying time	Paint amount (kg/m^2)
1	Floor processing	Table at 3.15.1				
2	Lower painting (1st time)	Transparent epoxy emulsion	100			0.08
		Water	0~10			
3	Middle painting (1st time) (Middle painting pattern)	Epoxy emulsion pattern spray paint	100			1~1.5
4	Upper painting (1st time)	Acrylic urethane resin paint	100		24 hours ~ 3 days	0.23 ~ 0.35
		Designated diluting material	0~10			
5	Upper painting (2nd times)	Acrylic urethane resin paint	100		24 hours ~ 3days	0.23 ~ 0.35
		Designated diluting material	0~10			

(Note) Acrylic resin enamel may be applied to the inside of upper painting.

(d) Elastic born tile spraying works

Table shall be applied to standards for the processes, mixing ratio of thinner, drying time and paint amount in elastic born tile spraying works.

<table>
<tr><th colspan="2">Process</th><th>Details</th><th>Mixing ratio (mass ratio)</th><th>Surface processing</th><th>Drying time</th><th>Paint amount (kg/m^2)</th></tr>
<tr><td>1</td><td>Floor processing</td><td colspan="5">In accordance with 18015</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Lower painting (1st time)</td><td>Elastic acrylic emulsion transparent</td><td>100</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">0.08 ~0.1</td></tr>
<tr><td>Water</td><td>010</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Middle painting (1st time) (pattern)</td><td>Elastic middle painting patter floor material</td><td>100</td><td rowspan="2"></td><td rowspan="2">24 hours</td><td rowspan="2">1.3~1.7</td></tr>
<tr><td>Water</td><td>10~20</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Middle painting (2nd times) (Pattern)</td><td>Elastic acrylic pattern paint</td><td>100</td><td></td><td rowspan="2">24 hours</td><td rowspan="2">1~1.5</td></tr>
<tr><td>Water</td><td>0~10</td><td></td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Middle painting (3rd time) (pattern)</td><td>Elastic acrylic pattern paint</td><td>100</td><td></td><td rowspan="2">24 hours</td><td rowspan="2">1~1.5</td></tr>
<tr><td>Water</td><td>0~10</td><td></td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Upper painting (1st time)</td><td>Elastic acrylic urethane resin paint</td><td>100</td><td rowspan="2"></td><td rowspan="2">Within 24 hours ~ 3 days</td><td rowspan="2">0.23 ~ 0.35</td></tr>
<tr><td>Designated diluting material</td><td>0~20</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2">Upper painting (2nd time)</td><td>Elastic acrylic urethane resin paint</td><td>100</td><td rowspan="2"></td><td rowspan="2">Within 24 hours ~ 3 days</td><td rowspan="2">0.23 ~ 0.35</td></tr>
<tr><td>Designated diluting material</td><td>0~20</td></tr>
</table>

(e) Cautions

(1) Works shall be done after any gap or scratch shall be filled and adjusted with aqueous putty, epoxy putty, elastic putty, etc.

(2) Works shall be avoided for any spray paint using water when ambient temperature is 5^oC or lower because cracks may occur during the works.

(3) Aqueous born tiles shall be only possible for internal use but improper for external application.

(4) Ambient temperature of 5^oC or higher shall be proper for painting or hardening and surface temperature shall be higher than dew point temperature to avoid the dewing of moisture.

(5) The diluting ratio for the 1st time upper painting shall be increase for the sufficient absorption into the middle painting surface because bubbles may occur during the spraying works in winter or low temperature.

(6) Works shall be done under the sufficient ventilation and respiratory protection equipment shall be worn during any work in the sealed space.

(7) The uniform mixing in the predefined ratio shall be applied to the 2 fluid type spray paint.

3.16. Cement Liquid Waterproofing

3.16.1. General

(a) Any cement waterproofing material shall be mainly used under the wet environment because its use under the dry environment has the degradation of strength and cracks, and causes defective adhesiveness.

(b) It may not be applied to any place where structures are moving or have vibrations around them, because of concern of cracks in the waterproofing layer.

(c) The sufficient protection shall be done until the complete hardening because of concern of cracks in the waterproofing layer by the dry contraction in the curing process.

3.16.2. Floor Conditions

(a) Waterproof floor shall be flat.

(b) No dent or crack shall exist.

(c) No stagnant water shall exist on the floor.

(d) No oil, dust, contaminant or rust to hinder adhesiveness shall exist.

3.16.3. How to Process the Floor

Attention shall be paid to the following items during the waterproofing works.

(a) Any jointing section shall be done with the V cutting, water cleaning, filling of cement mortar or waterproofing material painting, and then finishing with cement mortar.

(b) The section of ironware (form tie) for the forms fixing shall be cleaned, where cement mortar shall be filled or waterproofing material is applied, and then finishing shall be done with cement mortar.

(c) Any crack shall be done with the V cutting, where finishing is done with cement mortar and polymer cement mortar filling.

3.16.4. Mixing of Waterproofing Material

(a) Each material of mortar and cement shall be accurately weighted and mixed in the predefined mixing ratio.

(b) The mixing between cement and waterproofing material or between waterproofing material and water shall be done by the accurate weighting in weight or volume according to the mixing provision by the maker.

(c) Mixing of waterproofing material

1) The waterproofing material shall be accurately weighted, where water is poured for the use with the dilution to the predefined concentration.

2) The mortar with the mixing of waterproofing material shall be done with the dry mixing in the predefined mixing ratio of cement and sand, and then, the dilution liquid of waterproofing material shall be put and the sufficient mixing shall be done in the predefined ration.

3) When the waterproofing material is mixed with mortar or concrete, the sufficient mixing shall be done in the predefined mixing ratio to the used cement amount with the dilution liquid of waterproofing material.

(d) The general sequence and method for the powder waterproofing material shall be done in the following 3 ways, although each material shall be put and mixed in the sequence, method and mixing ratio as designated by the maker.

1) Water is poured and mixed in the predefined dilution after the waterproofing material to cement is mixed uniformly in the predefined ration.

2) Water is poured and mixed in the predefined dilution after the waterproofing material and water are poured and sufficiently mixed to cement.

3) Cement or sand is mixed after waterproofing material is mixed and melted to water first in the predefined ratio in case of water soluble powder waterproofing material.

3.16.5. Painting of Waterproofing Material

(a) Floor processing

(1) Any soil, dust, sand, pebble and/or laitance on the floor shall be removed with chisels, wire brushes or brushes. Any stray hay, nail or wire which is deeply stuck on the mother object shall be dug out to the sufficient depth. Any defect or crack or other flaws to mortar or concrete shall be removed and repaired to become the strong mother object with sufficient strength, and then, the construction for waterproofing layers shall be done.

(2) The predefined actions shall be taken for any place under progress of dried cracks in the mother object or with concern of defect on the waterproofing layer.

(3) The waterproofing construction shall be done after the complete cleaning in water washing or other methods after surface processing.

(4) The alkalinity shall be neutralized in the mother object, especially when the waterproofing material affecting alkalinity is used.

(5) When mortar is applied to floor for the installation of weathered slop, the position of water drop opening and height of upper water shall be accurately defined, no stagnant water shall exist in the corners in a certain slope for good flow, and the sufficient attachment shall be applied to floor.

(b) The 1st layer waterproofing works shall be done in consideration of the drying time after the surface processing is completed, and the protective pressing shall be applied after the completion of the defined layers.

(c) The cement waterproofing material shall be constructed in 2 ways.

(1) Pasting of waterproofing cement: The waterproofing cement paste shall be applied to floor, which is mixed with cement, waterproofing material and water.

(2) Painting of waterproofing solution: The waterproofing solution shall be painted, which is diluted or melted with waterproofing material to water.

(3) Waterproofing mortar applying: Cement, sand, waterproofing material and water are mixed and applied.

3.16.6. Process for Waterproofing Layer

(a) Pasting of waterproofing cement

The waterproofing cement paste shall be flatly applied in a certain thickness under the predefined mixing and concentration.

(b) Painting of waterproofing solution

When waterproofing solution is painted, floor cleaning shall be sufficiently done, and then, painting shall be done in the uniform amount and speed. Especially, detailed painting shall be applied to any bent area, concave section, cornered section or edge.

(c) Applying of waterproofing mortar

Waterproofing mortar shall be sufficiently mixed in the predefined mixing ratio and the waterproofing solution painting or waterproofing cement is applied. Then, it shall be constantly and flatly applied considering the hardening time.

(d) Mortar for the protective pressing to waterproofing layer

When joints are made to prevent drying and contraction cracks on the surface of the pressing mortar if the protective pressing to waterproofing layer is done under drawing or special specifications, drawings or special specifications shall be applied to the depth, width, and intervals for the horizontal and vertical section for joints. If there is no specific provision in the special specifications, 6 mm depth, 9 cm width and 1mm interval shall be applied.

(e) Drawings or special specifications shall be applied to the construction times of waterproofing layers.

Type Process		**Cement waterproofing**	
		Type 1	**Type 2**
1st layer		Waterproofing cement paste	Waterproofing cement paste
2nd layer		Waterproofing solution	Waterproofing solution
3rd layer		Waterproofing cement paste	Waterproofing cement paste
4th layer		Waterproofing solution	Waterproofing solution
5th layer		Waterproofing cement paste	Waterproofing cement paste
6th layer		Waterproofing solution	Waterproofing mortar
7th layer		Waterproofing cement paste	
8th layer		Waterproofing mortar	
Division of application	Indoor	○	○
	Underground	○	○
	Water tank	○	○
	Rooftop *	○	○

Legend * : Applied to the section for sun shielding or rooftop drain ditch

(Note) 1 : The protection and finishing per type of each waterproofing layer shall be done in accordance with special specifications.

2 : Two types including Type 1 and Type 2 exist in the cement liquid waterproofing layers and polymer cement waterproofing layers, and the free selection and application may be done depending on the intended use.

3.17. Floor, Wall, and Ceiling Finishes

3.17.1. Materials

(a) Materials used in the mixing of mortars and plasters for finishing to internal surfaces shall be as specified for mortars and plasters.

(b) Glazed wall tiles shall be of a minimum thickness of 6 mm and to the colour and pattern as instructed by the Engineer.

(c) Ceramic floor tiles (non-slip) shall be 300 mm x300 mm minimum thickness of 8 mm and to the colour and pattern as instructed by the Engineer.

(d) Granite slabs for entrance steps shall have a minimum thickness of 30 mm for treads and 30 mm for risers. Colour and dimensions shall be as indicated on the drawings, in the Bill of Quantities, or as instructed by the Engineer.

(e) Terrazzo tiles shall have a minimum thickness of 25 mm, colour and pattern shall be as indicated on the drawings, in the Bill of Quantities, or as instructed by the Engineer.

(f) Acoustical tile shall be made from mineral fiber having a density of 136 kilograms per cubic meter and not less than six (6) mm thick with fissure design. The size of the acoustical tile shall not be less than 30 cm by 30 cm.

3.17.2. Workmanship

(a) The wall tiles shall be matched for colour before fixing. The surface to be tiled shall first be rendered with one undercoat 10 mm thick. The tiles shall be set in cement mortar, approximately 5 mm thick. The joints shall be regular and finally grouted with white cement. External corners shall be rounded using specially rounded tiles.

(b) Unless otherwise stated all floor tiles are to be well soaked before laying, laid to an approved pattern on a 40 - 45 mm thick bed of mortar Grade "C" and finally jointed and pointed in matching colour cement grout.

(c) Skirting tiles shall have a coved base and rounded top edge. The skirting tiles shall match the floor tiles both in colour and texture and shall be secured to the plaster by an approved adhesive.

(d) Immediately after laying the tiles, paving shall be cleaned off and a 25 mm thick protective layer of sawdust, renewed from time to time as necessary, shall be laid over the whole surface. On completion the sawdust shall be cleaned off and the tiling given a final coating with an approved polish.

(e) Ceiling Suspension System : Metal suspension system shall be installed in accordance with the installation procedures as outlined in Section entitled Metal Suspension System.

(f) Acoustical tiles shall be attached to or installed on the suspended ceiling by means of suitable fasteners such as nails, screws, or other approved fastening devices. Tile arrangement shall be as directed by the Engineer.

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4. BUILDING MECHANICAL WORKS

4. Building Mechanical Works

4.1 Building Mechanical General Provisions

4.1.1. General

Material and installation is the responsibility of the Contractor.

4.1.2. Summary

(a) Scope of Application
This Division of Specifications Covers furnishing and installing plumbing, heating, entilation, air conditioning (HVAC). All general requirements in General specification Division 1 apply to this section.

(b) Related Work
The work mentioned below shall be provided, but not limited. The Contractor shall complete the related work immediately when so required by the Employer, including this contract.

(1) HVAC Equipment installation

(2) HVAC Piping work

(3) Duct work

(4) Plumbing work

(5) Plumbing Fixture

(6) Others necessary work

4.1.3. Codes and standards

(a) Standards, codes and regulations by National, Provincial, City and utility compasies regulations. The following standards apply :

(1) ANSI – American National Standards Institute

(2) ASHRAE–American Society of Heating Refrigerating and Air Conditioning Engineers

(3) ASME – American Society of Mechanical Engineers

(4) ASTM – American Society for Testing and Materials

(5) SMACNA – Sheet Metal and Conditionitng Contractors National Association

(b) Laws, Codes and regulations shall prevail except where Work indicated on drawings and Specifications exceed legal requirements regard to quality and quantity

(c) Construction Documents do not detail certain Project requirements. The Contractor shall be responsible for detailed engineering work required for performance of work

4.1.4. Submittals

(a) All work under this division shall be executed in a thorough professional manner by competent and experienced workmen licensed to perform the Work specified

(b) All work shall be installed in strict conformance with all manufacturers requirements and recommendations. All equipment and materials shall be installed in a neat and professional manner and shall be aligned, leveled, and adjusted for satisfactory operation.

(c) All material and equipment shall be new, shall be of the best quality and design, shall be current model of the manufacturer, shall be free from defects and imperfections and shall have markings or a nameplate identifying the manufacturer and providing sufficient reference to establish quality, size and capacity. All material and equipment of the same type shall be made by the same manufacturer whenever pracicable

4.1.5. Quality assurance

Plans and specification shall be complied with.

4.1.6. General responsibilities

(a) Final project documents

(b) Once Work has been completed deliver drawings as modified at site and diskettes to Owner

(c) Coordinate with Owner′s Construction Manager and other trade Work to be performed to avoid conflicts or delays during construction.

(d) The Contractor is responsible for receiving, unloading, storing, and protecting owner furnished items (buy out)

(e) The Contractor′s responsibility is to comply with all specifications, project drawings applicable standards.

(f) The Contractor′s Site Manager shall be present at site every time mechanical Work is being done.

(g) All tests shall be made in the presence of the appropriate Owner′s Construction Manager and Construction Supervision Company or their consultants.

(h) Label HVAC Equipment with a 15 cm stencil, permanent black paint, Number units as shown on drawings. Locate labels for each unit near its disconnection.

(i) Where drawings indicate equipment furnished by others, the Employer or other Sections of Specifications shall provide. The Contractor shall make final connections, provide shut-off valves, traps and other necessary components for complete installation.

4.2. Heating and Air Conditioning

4.2.1. General

The Contractor is fully responsible for taking care of and maintaining equiment furnished by the Employer and for material and installation supplied by the Contractor′s own.

4.2.2. Summary

(a) This Section includes : Heating, ventilation and air conditioning systems.

(b) Related Sections and Work :

(c) Summary of Work: General procedures related to products furnished by the Employer.

(d) Comply with other Sections when applicable.

4.2.3. Certifications

(a) Each piece of equipment shall be furnished with capacity ratings certified by the relevant Authorities.

(b) Energy management system control certifications shall be filed by the Employer.

4.2.4. Submittals

(a) Complete enclosed start-up reports and forward to Owner′s Construction Manager and Owner′s Construction Supervision Company.

4.2.5. Warranty

(a) After acceptance by the Employer, the Contractor shall furnish materials and labor warranty for components supplied under this Section.

4.2.6. Energy saving controls

(a) Controls designed by the Employer shall be the only one accepted.

(b) All heating, ventilation and air conditioning system/equipment shall use type Controls specified by the Employer, unless otherwise specified.

4.2.7. Air exhaust and injection fans

(a) These shall be horizontal type composed basically of the following elements:

(1) Cabinets completely made of top-quality galvanized sheet.

(2) Airflow shall be as specified on drawings and back pressure shall be the one pertaining to conduit system and system interior back pressure.

- All fans shall comply with respective drawings.
- During two-years warranty, the Contractor may be required to perform some or all of the above readings to demonstrate that systems are operating properly during each season. The Contractor shall make additional adjustments and corrections as required during warranty period ensuring proper operation of fan.

4.2.8. Execution

(a) Equipment installation

(1) Install equipment at locations indicated on drawings. Installation procedures shall comply with these Specifications and with manufacturer′s instructions as well as the local regulations.

(2) Energy management equipment shall be installed under approval and supervision of the Engineer, and Mechanical Contractor shall coordinate installation, testing and completion dates in cooperation with Refrigeration Contractor. Mechanical Contractor shall be responsible for any additional fees imposed by Refrigeration Contractor for extra labor and expenses for negligence on the part of Mechanical Contractor.

(3) Label equipment with 150 mm black permanent paint stencil. Number units as indicated on Drawings. Locate label for each unit so it can be read from the doorway, roof hatch or other accessible means

(b) Piping installation

(1) General

- The installation and materials used for all piping system shall conform to the Regulations and By-Laws of all Local Authorities having jurisdiction over the installation.
- The Mechanical Contractor shall apply for and obtain all necessary permits and certificates for Work to be carried out and for Work done from the government Authorities, and shall pay all fees and charges incurred herewith, unless otherwise specified.
- The Mechanical Contractor shall immediately after the award of the contract prepare and submit to Design Consultant for approval the shop drawings showing the exact locations and runs of pipe-work, the layout and setting up of equipment and the arrangements of connection of the Improvement of Water Supply System various pipelines to the equipment. Such shop drawings shall also include details and methods of supports, anchors, sleeves, etc.
- Pipe runs and locations shown in the drawings are approximate and intended to indicate the general runs and locations only. The exact runs and locations of all pipelines shall be determined at site. Shop drawings.
- All pipes shall be installed clear of one another or close to walls, floor slabs, beams, columns, etc., a minimum distance of 50 mm shall be maintained between the surface of the pipe or its insulation and the nearest surface.
- Provision shall be made for thermal expansion or contraction of the pipes when the pipes are installed on the exterior.
- Where pipes pass through walls or floors, approved pipe sleeves shall be provided. These sleeves shall extend through the full finished thickness of the walls or floors, and shall be secured to the walls or floors against movement.
- Pipes shall be installed in continuous length as long as practicable. Pipe joints shall be so located for ease of inspection and maintenance.
- The jointing of remaining short lengths of pipe to form one long length will not be permitted.
- Pipes installed in pipe shaft in ceiling spaces or between walls shall have the positions of all joints carefully located to ensure that any length of pipe may be removed with minimum disturbance to other pipes or building structure.
- All pipes, fittings, valves and accessories shall be cleaned both internally and externally before assembly or installation and likewise before putting into service.
- The internal areas of all pipes shall be maintained throughout their full lengths and no internal projection or restriction will be permitted where fittings or branch pipes are jointed.

- All pipe runs shall be so sloped to ensure the elimination of air lock and to facilitate the draining of the pipes for repair.
- Provision shall be made for venting at the high points and draining at the low points of all piping systems.
- Square elbows shall not be used in any piping systems except where specifically permitted by the Engineer. Round elbows of easy sweep may be used where spaces are limited but wherever possible easy sweep bends shall be used.
- All pipe lengths shall be cut with standard pipe cutters and threaded with standard threading machines and both reamed and cleaned before assembly.
- All galvanized steel pipes up to 50mm diameter may be screw-jointed using Cotton yarn, Teflon, Compond as a sealing compound. For 65mm diameter and above all joints shall be connected by groove coupling.
- All black steel pipes shall be butt welded.
- Connection of smaller diameter pipe to larger diameter pipe shall be done in the following manner. Galvanized Steel Pipe Must be by means of proper galvanized fittings. Black Steel Pipe By means of proper fittings or butt-welding.
- All connections of pipes to equipment and appliances shall be arranged with unions or groove coupling so that disconnection may be done without dismantling the pipework.
- Adequate numbers of union or groove coupling shall be provided for long runs of piping to acilitate removal of pipes for inspection and repair.
- Union shall be provided for all screwed branch-off pipes at the down stream side immediately after the isolating or control valves.
- Flexible connection shall be used where differential movement may occur between two sections of pipe-work or where excessive expansion or contraction may occur.
- All pipes installed in hollow walls, underground or inaccessible locations shall be jointed by means welding and subject to test before covering up.
- Pipes shall pass through wall at right angles.
- Sleeves shall be placed in walls through which pipes pass to extend 25 mm on each side. Sleeves in floors shall finish 30 mm above finished floor level and shall be of alvanized pipe with a concrete curb.
- After completion of testing and insulation the space between sleeves and pipe shall be firmly packed with approved fire resistant materials.

(2) Welding

- The welding of steel pipes, elbow and accessories shall be effected by means of electric arc or gas welding, using rods of such composition that the welds produced by them will have the same analysis as the steel in the pipe, elbow or accessories.
- Pipe ends shall be prepared for welding by beveling to the required angle.
- During welding, the ends of the pipe shall be held together and duly matched by means of suitable jigs.
- Where required by the Engineer, welders engaged on the Work covered by this Mechanical contractor shall demonstrate their proficiency by the performance of test welds equivalent to the Work- and the Mechanical Contractor shall bear the cost of such tests.

(3) Pipe Support and Fixings

- Unless otherwise stated, all pipe hangers and supports shall be of steel construction adjustable for height and shall be prime coated with two layers of rust preventive paint and finished with two coats of paint of the same color as the pipe.
- Vertical pipe risers passing from floor to floor shall be supported to each floor by clips or U-bends attached to the pipes.
- All vertical pipe risers shall have foot elbows or steel structure supports at their lowest points.
- The supports shall permit appropriate movement for expansion and contraction in the desired direction and prevent transmission of vibration.
- Clips, rollers, hangers and supports shall be fabricated from mild steel or approved material nd have sufficient strength to support the pipes and it contents.
- Where pipe and clamp are of dissimilar materials, an approved gasket shall be installed between pipe and saddle.
- Pipe-work shall be installed with a minimum 80 mm clearance from all electrical conduits, rays and troughs and from finished floor, and 50 mm clearance from other parts of the building structure and any adjacent pipe-work.

(4) Piping Testing and Cleaning

- All water piping shall be hydraulically tested to one and half times the working pressure before putting into service. The test pressure shall be maintained for a minimum duration of 24 hours.
- All compressed air piping shall be tested to two times the working pressure. Special care shall be taken to protect controls during the pressure test.
- All water piping, except air, shall be flushed with clean water before final finishing and putting into service.
- Water pipe-work and water tanks for drinking purpose shall be flushed with clean water and sterilized with chemical containing chlorine before putting into service.

(c) Insulation

(1) Pipe Insulation

- Type of materials
  - The insulation of all steam, chilled and hot water pipe-work shall be carried out using preformed section pipe insulation. The insulation shall be glass wool or same and above material equal. The density of the section shall be at least 24 kg/㎥.
  - The sectional insulation shall have a thermal conductivity of not greater than 0.036 W/m k at 24C.
- Thickness of Pipe Insulation
  - The thickness of pipe insulation with glass wool or, same and above material insulation having the thermal conductivity k = 0.036/m。K at 24。C and the thickness shall be as follows:

Pipe Nominal Diameter	Thickness of Insulation
25 mm	40 mm
32~65 mm	40 mm

80 mm~200 mm	40 mm
Condensate drain pipe for all sizes	25 mm

(2) Method of insulation

- All pipe joints and fittings shall not be insulated until th e Engineer has inspected the services and pressure tests have been carried out. Straight pipe may be insulated prior to hydraulic testing of pipe-work.
- The surface to be insulated shall be thoroughly cleaned of all dust, scale, dirt or grease and dried immediately before applying the insulation. Where the pipe's anti-rust paint has been removed, another coat shall applied.
  - Straight Pipes - The section of insulation shall be snapped over the clean pipe surface at its approximate location and then firmly butted against the preceding section and seated with approved barrier sealant.
  - Bends and Tees - Bends and tees shall be insulated by preformed sections fittings insulation. Alternatively, PVC fitting covers of appropriate size shall be fitted over the section and sealed in place with PVC tape. The annular spacing between the bare pipe and the PVC cover shall then be filled with urethane foam. The foam shall have a thermal conductivity equivalent to that specified for the fiber glass insulation.
  - Flanges - The length of insulation shall be stopped in front of flanges sufficiently to allow easy withdrawal of bolt for inspection or replacement of parts. The insulation shall then be completed by cutting an appropriate length and size of pipe insulation and fitting it round the parts as required. The piece shall be as closed fitting as aluminum fixing band.
  - Valves - Valves shall be insulated using same of piping insulation.
  - Hangers, Sleeves – Piping supported hanger or roller, in sleeve shall be finished fire stop material or the same material as close piping insulation.

(3) Sealing of Joints

All segments of pipe insulation shall be firmly butted against the preceding sections and the joints shall be sealed with a butt strip. The butt strip shall be finished to finish tape with a minimum width of 40 mm.

(4) Finishes

- Finish of piping insulation according to related drawings.
- All the valves in Mech. Room and AHU Room shall be insulated by glass-wool insulation with white PVC colour sheet.
- Exposed pipes in sales area and inside area shall be insulated by suitable insulation with glass cloth, and painted with in white on surface of insulation or covered by white protecting cover. Exposed pipes in outside area Area shall be insulated by suitable insulation with vapour barrier and white polypropylene cover Concealed pipes shall be insulated by suitable insulation with vapour barrier.

(5) Insulation of Factory Assembled Equipment

The factory assembled equipment such as Packaged Air Conditioners (PAC) etc. shall be insulated as recommended by the manufacturers and as specified on drawings. This insulation shall be applied at the manufacturers factory, and only as necessary on site during or after installation. Should this insulation appear inadequate in the opinion of the Employer and Engineer, he reserves the right to call for partial or complete removal and repair or replacement by the Contractor at no extra cost to the Employer.

(6) Drain Piping

Pipes - All condensate drain pipes shall be insulated as per insulation of the chilled and hot water pipes with 13 or 25 mm thick insulation. The floor traps to which these condensate drain pipes flow shall also be equally insulated including the horizontal soil/waste pipes and vertical pipings.

4.3. Plumbing

4.3.1. General

Material and installation is the responsibility of the Contractor.

4.3.2. Summary

This section includes:

(a) Water piping. (Compressor AIR Piping)

(b) Sanitary and industrial drainage

(c) Storm drainage.

(d) Condensate piping.

(e) Valves.

(f) Facuet

(g) Flashing.

(h) Traps.

(i) Pipe cleanout.

(j) Pressure reducing valve.

(k) Floor drains.

(l) Submersible pump

(m) Sump pit

(n) Testing.

4.3.3. Reference

(a) American National Standards Institute (ANSI):

(1) ANSI B16.22 - Wrought Copper and Copper Alloy Welded Pressure Joints.

(b) American Society for Testing and Materials (ASTM):

(1) ASTM A74 - Cast Iron Pipes and Joints.

(2) ASTM B135 - Seamless Bronze Tube.

4.3.4. Submittals

Submittals as indicated in Section 01300.

4.3.5. Water piping system

(a) Cold and Hot water piping above ground level

(b) Seamless copper water tube cold drawn. (c) Joints with wrought copper pressure accessories. Make joints using silver solder by capillary and continuous string. Where welded copper tubes with welded ends must be connected to brass tubes threaded ends, use a cast brass adapter by same manufacturer. Do not use pre-tin plated accessories. Joined with accessories of the same material and manufacturer, threaded joints sealed as indicated by manufacturer. If under any circumstances, these pipes are joined with accessories of other material (brass, galvanized iron, etc.), the Contractor shall verify if type of thread matches the one of piping. For suspended piping exercise proper care to avoid arrows, Mechanical Contractor shall coordinate with Structure Contractor and pipe manufacturer to place tension, reinforcements, etc.

(1) Quote alternative in stainless steel pipe with correspondent accessories;

(2) Hot and cold water pipes in underground level: Polypropylene separate lining steel pipes shall be applied for hot and cold water underground piping. Do not join under floor. If joints are necessary, bring pipes above floor near a wall, make joints there and place pipes back under floor.

(3) Make pipe connections to parts and equipment with seamless copper and copper alloy tubes., (ASTM B135).

(4) Insulation

- Type of materials
  The insulation of all domestic cold/Hot water lines, condensate piping, and drain lines for sanitary equipments shall be carried out using preformed section pipe insulation, The insulation shall be glass wool or same and above material equal, The density of the section shall be at least 24 kg/m^2 The sectional insulation shall have a thermal conductivity of not greater than 0.036 W/m °k at 24°C
- Thickness of Pipe Insulation
  The thickness of pipe insulation with glass wool or, same and above material insulation having the thermal conductivity k = 0.036/m °k 24 °C and the thickness shall be a follows

Pipe Nominal Diameter	Thickness of Insulation
Up to 50 mm	40 mm
65 mm to 100 mm	40 mm
Condensate drain pipe for all sizes	25 mm

(5) Piping in walls or partitions shall be located considering necessary spaces for allowing free expansion or contraction due to temperature changes, to avoid stressing and damaging pipes, accessories and welding. Therefore it is a rule that embedding points

between pipes and their surroundings shall be avoided throughout all the route of inlay stretches. For suspended pipes, joints or rigid embedding shall be avoided. Suspended pipe elements shall always have an articulation of their joints to walls or slabs.

(6) In exceedingly long runs, proper expansion joints shall be applied in order to contribute to pipe movement.

(7) Hot water system shall be supplied from hot water storage tank in mech. Room Detailed specifications for installation of cold water pipe to connect to the tank shall be specified by tanks′ manufacturer.

(8) Where given greater thermal expansion piping will be subjected to, they shall have expansion joints made with the same materials and accessories used for installation, and they shall be installed in strict accordance to drawings and specification.

4.3.6. Sanitary and Industrial drainage

(a) CASTIRON Piping: for sanitary drainage use.

(b) Underground pipes shall be supported by sand bed and covered by 10 cm above sand on the pipe ridge with selected and compacted field on the above layers.

(c) Suspended installation: CASTIRON Pipes will be supported from their heads with hanger. The pipe body will be fixed by hanger apart not more than 1.5 m to avoid pipe bending. In long runs, Cleanout will be used according drawings and specification.

(d) Piping materials and accessories:

(1) All discharge pipes shall be bell-and-spigot and outlet, where such piping is joined with other materials, use an adequate transition piece ensuring proper finish. Vents pipes shall be used PVC (VG2).

4.3.7. Condensate piping

(a) Provide condensate piping system for all equipment as shown in drawings.

(b) Condensate piping shall be connected to sump tank located the nearest.

(c) Insulation : Rigid glass fiber or same and above material equal, 24 kg/m^3density, hermal conductivity of not greater than 0.036 W/m °k 24 ℃, minimum of 25 mm thick with white finish.

4.3.8. Valves

All general shut-off valves for 50 mm dia, below shall be valve box, cover, valve body and valve stem, 10 kg/cm^2 series bronze body ASTMB-62. And for 65 mm dia, above shall be 10 kg/cm^2 series cast-iron body They shall be preferably hidden, located in shaft or ceilings with access door using 1.5 mm thick stainless steel cover, 0.20 x 0.20 m.

4.3.9. Flashings

Flashing for pipes going through outside wall, roof, floor slab shall be the Contractor's responsibility with whom must be coordinate and shall guaranty watertightness. Refer to details on drawings.

4.3.10. Trap

Provide each floor drain with individual trap to each washing basin and similar fixtures.

4.3.11. Pipe cleanouts

Castiron pipe shall be used. Furnish castiron pipe cleanouts as indicated on drawings.

4.3.12. Pressure reducing valve

When the water system static pressure is greater that 5 kg/㎠, a pressure reducing valve shall be furnished, placed at indicated on drawings, before supplying fixtures and shall be located in an accessible place. Set pressure in accordance with equipment specification. The Contractor shall verify the supply pressure together with the Manager.

4.3.13. Floor drains

(a) Drains (generally floors) shall be in accordance with drawings. Install as indicated on drawings and it made of brass.

(b) Floor drains piping shall be installed with trap in individual piping in order to prevent small bug and sewage gas.

4.3.14. Execution

(a) Coordination

Before installation, location of drain inlets shall be coordinated with Refrigeration Contractor and etc, confirming or adapting locations indicated on drawings.

(b) Piping installation

(1) Install piping neatly and parallel with, or perpendicular to, lines of the structure. Install pipe hangers to maintain accurately aligned piping systems, adequately supported both laterally and vertically. Where practical, connect two or more vents together and extend as one vent through roof. Make vent connections to pipes by appropriate use of 45 wyes bends except that tees may be used on the vertical pipes.

- Install soil, waste, and vent pipe with grade of 20 mm per meter where possible and required by code, and not less than 10 mm per meter.

(2) Conceal piping if possible spaces of no ceiling and above ceiling in sales area, stockrooms with ceilings, vestibules, garden center with ceilings and office areas.

(3) When required by code or local regulations extend condensate drain piping from units with condensate discharge.

(4) Cap pipe openings during construction.

(5) Identification of Potable and Nonpotable Water: Identify potable and nonpotable water systems by color markings or metal tags in accordance with the Engineer′s instructions.

(c) Piping insulation

(1) Refer to detail drawings

(2) Method of insulation

- All pipe joints and fittings shall not be insulated until the Engineer has inspected the services and pressure tests have been carried out. Straight pipe may be insulated prior to hydraulic testing of pipe-work.

- The surface to be insulated shall be thoroughly cleaned of all dust, scale, dirt or grease and dried immediately before applying the insulation. Where the pipe′s anti-rust paint has been removed, another cost shall applied
  - Straight Pipes – The section of insulation shall be snapped over the clean pipe surface at its approximate location and then firmly butted against the preceding section and seated with approved barrier sealant.
  - Bends and Tees – Bends and tees shall be insulated by preformed sections fittings insulation. Alternatively, PVC fitting covers of appropriate size shall be fitted cover the section and sealed in place with PVC tape. The annular spacing between the bare pipe and the PVC cover shall then be filled with urethane foam. The foam shall have a thermal conductivity equivalent to that specified for the fiber glass insulation.
  - Flanges – The length of insulation shall be stopped in front of flanges sufficiently to allow easy withdrawal of bolt for inspection or replacement of parts. The insulation shall then be completed by cutting an appropriate length and size of pipe insulation and fitting it round the parts as required. The piece shall be as closed fitting as aluminum fixing band
  - Valves – Valves shall be insulated using same of piping insulation.
  - Hangers, Sleeves – Piping supported hanger or roller, in sleeve shall be finished fire stop material or the same material as close piping insulation
  - Exposed pipes in inside area shall be insulated by suitable insulation with vapour barrier, and painted with in white urethane coating on surface of insulation or covered by white protecting cover. Exposed pipes in outside area. Area shall be insulated by suitable insulation with vapour barrier and polypropylene cover

(3) Sealing of Joints

All segments of pipe insulation shall be firmly butted against the preceding sections and the jonints shall be sealed with a butt strip. The butt strip shall be finished to finish tape with a minimum width of 40 mm

(4) Finishes

- Finish of piping insulation according to related drawings.
- All the valves in Mech. Room shall be insulatated by glasswool insulation with white PVC colour sheet
- All the surfaces of insulation of exposed pipes shall be covered by polyproplene sheet made of Unflamable and of white colour.

(d) Pipe Testing

(1) Test piping before installing equipment and before insulation is applied, using specified methods and conditions. Subject piping to test for not less than 24 hours under inspection by the Engineer. Make necessary replacements and repairs and repeat tests until entire system is accepted as satisfactory. Work includes testing equipment. After installation of equipment, operate systems, clean out scale, dirt, oil, waste, and foreign matter, and correct additional leaks. Test underground piping prior to backfilling.

(2) Test plumbing drainage systems under 3 m static head. Test water supply and return systems under 10 kg/㎠ hydrostatic pressure.

(3) Sterilize domestic water system to meet requirements by the relevant standards. Flush system thoroughly of dirt and foreign matter, then fill with water treated with 50ppm of chlorine. During filling process, open valves and faucets several times to assure treatment of entire system. Leave treated water in system for 24 hours, after which time, system may be flushed; if residual chlorine is not less than 10ppm, repeat flushing. After sterilization, receive approval by the relevant Authorities on samples of water in system.

(4) Condensate Piping: Upon completion of condensate system, contact Owner′s HVAC Department.

4.4. Plumbing fixtures

4.4.1. General

Material and installation is the responsibility of the Contractor.

4.4.2. Summary

This Section includes:

(a) Piping and joints.

(b) Plumbing fixtures and trim.

Related Sections:

(a) Section – Plumbing Services piping.

4.4.3. Piping and fittings

(a) Supply brass fittings and piping in connection with plumbing fixtures; polished chrome-plated where exposed to view.

(b) Supply and place tight-fitting escutcheons of chrome-plated wherever pipes pass through floors, walls or ceilings.

(c) Provide required water, waste, soil, and vent connections to plumbing fixtures and equipment, together with fittings, supports, fastening devices, cocks, valves and traps, leaving all in complete working order.

4.4.4. Plumbing fixtures

(a) The drawings and/or specifications indicate type of plumbing fixtures and model number, and are based on the specific descriptions, manufacturerss and models indicated Subject to compliance and equirements, supply sanitary fixtures from one of the following manufacturers.

(b) Provide new plumbing fixtures, first quality, free from flaws or chips. Support each fixture in rigid manner which permits no perceptible movement of fixture by manually applied forces. If reguired, seal space between fixtures and floor or walls with silicone sealant.

(c) Furnish each fixture complete with required trim; Exposed piping and trim shall be of polished chrome-plated brass. Furnish each fixture with chrome-plated angle stop valves having metal-to-metal seats.

(d) Provide flow-limiting device with lavatory.

(e) Flush Valves: Subject to compliance and compatible with plumbing fixtures as scheduled on Drawings. Provide flush valves that do not exceed code requirements for maximum volumes per flush.

(f) Provide trim, as required, to permit scheduled lavatory to be installed for handicap use.

(g) Provide bolt caps with retainer clips on water closets.

4.4.5. Execution

(a) Installation

(1) Sanitary fixtures and accessories shall be installed level and connected at locations indicated on drawings. The Contractor shall protect fixtures from damage during construction.

(2) Installation procedures shall conform to specifications and with manufacturerʹs instructions which the Contractor state in writing prior to beginning of installation.

(b) Adjustment and cleaning

(1) Prior to final acceptance, inspect faucets, flush valves, closure valves and other similar devices to determine that they operate properly and appropriate quantities of water are discharged. Correct any deficiency following the Engineer's instructions.

(2) Remove any foreign matter from fixtures and accessories, including labels. Use only cleaners recommended by manufacturers. Do not use abrasive elements or acid.

4.5. Fire Fighting Systems

4.5.1. Fire Fighting Standards, Codes and Regulations

Use BS or ISO

4.5.2. Portable Fire Extinguisher

(a) General

(1) Technical requirements which are not described in this standard erection procedure shall be applied in accordance with the concerned Malawi Laws and Regulations.

(2) Fire extinguishers which are approved by the Government of Malawi.

(3) Equipment and materials shall be suitable for the function of fire extinguisher.

(b) Installation

(1) Fire extinguishers which are suitable for the occupancy hazard fire class shall be provided.

(2) Travel distances for portable fire extinguisher shall not exceed 20 m and for wheeled type shall not exceed 30m.

(3) Fire extinguisher shall be located at floor or place where is not higher than 1.5 m from the floor, and "fire Extinguisher" label shall be provided at place where occupant can find it easily.

(4) CO_2 or Halon fire extinguisher shall not be intalled at basement floor, closed space with no window or opening of which the floor area is smaller than 20 m^2, but automatic expelling extinguisher can be installed.

5. MECHANICAL WORKS

5. Mechanical Works

5.1 General specifications Mechanical works

5.1.1 General

The Technical Specifications for the Mechanical Works detailed in generally refers to all machinery components, mechanical equipment, pump sets, control systems etc. These Tech. Specifications shall serve to specify all mechanical works wherever applicable within the scope of this Contract.

5.1.2 Standards

The Mechanical Works shall comply as a minimum with International Standards ISO, EN or BS Standards* named as I.S., with the respective Codes of Practice and Standards generally used for water supply and waste water facilities in foreign countries, adapted to the local conditions, shall be used as an alternative subject to written approval by the Engineer. For example:

BSCP:	British Standard Code of Practice
EN:	European Standard
BS:	British Standard
ASTM:	American society for testing materials
AWWA:	American Water Works Association
IEC:	International Electrical Commission
BSP:	British Standard Pipe (Thread)
CP:	British Standard Code of Practice
UK:	United Kingdom of Great Britain and Northern Ireland
ISO:	International Organization for Standardization
SI:	International System of Units

Other national or international or other authoritative standards equivalent or superior to those designated in the Specifications.

The Contractor shall demonstrate to the Engineer's satisfaction the equivalence or superiority of any item of Plant supplied to such alternative standards.

5.1.3 Quality Standard

When a certain piece of equipment is planned to be applied, the product of a certain manufacturer, that manufacturer must be clearly marked. The purpose is to set up a quality standard, structure type and acceptable reference. Generally, a definite manufacturer for the respective item of plant shall be given in the Schedule of Particulars. The term of “or equal” for manufacturer shall not be applied.

All the equipment and materials provided by the Contractor shall be new, modern, of good quality, faultless, with long service span and low maintenance.

5.1.4 Equipment Guarantee

The Contractor must ensure the Guarantee period of 2 years commencing from the date of successful take-over of the Plant. During the guarantee period, the Contractor shall maintain the equipment and carry out at least two overall inspections. During the guarantee period, in case of failure of any equipment or poor manufacturing, the Contractor shall be responsible for repairing and recovering smooth operation without delay, once he has been informed. If the Contractor fails to recover operation within 14 days, the Employer reserves the right to dispose by himself. The expenses shall be compensated by the Contractor with no rejection.

5.1.5 Design of Plant

(a) General

The names of the manufacturers of materials and equipment proposed for incorporation in the works together with procedures, performances, capacities, certified test reports and other significant information pertaining to the same, shall be furnished when requested for consideration by the Employer, who shall have power to reject any parts which, in his opinion are unsatisfactory or not in compliance with the Specification and such parts shall be replaced by the Contractor at no extra cost to the Employer.

The design, construction and layout of the plant and equipment shall be such as to ensure safety, simplicity and ease of operation, plus economy in maintenance. The plant shall be new, of sound workmanship and robust design.

The general mechanical design of the roller gate and particularly that of bearings, contacts and other wearing parts shall be governed by the need for long period of service without frequent maintenance and attention by the owner being necessary. Design aspects offering long service life should be highlighted in the tender submission.

The roller gate shall operate with minimum noise and vibration. All rotating parts shall be truly balanced both statically and dynamically so that when running at normal speeds and any load up to the maximum there shall be no vibration due to lack of balance. Full speed shall be less than the first critical speed.

All component parts shall be manufactured to a strict system of tolerances and complete interchangeability of similar parts is required. All wearing parts shall be readily available in Malawi. If not, they shall be listed in the tender as additional mandatory spares and sufficient spares for a period of two years priced within the schedules.

All warning signs, notices, other signs, labels and the like shall be provided by the Contractor.

(b) Plant Fixing

All fixings shall be sized to suit the loading and duty of the attached item.

Fixing to brick work or block work shall be made in the bricks or blocks and not in the joints. In external and damp situations equipment shall be secured to brick work and block work by round headed stainless steel woodscrews and plastic wall plugs. Other indoor fixings shall be secured with stainless steel anchor bolts. Mounting fixings shall comprise straps or external lugs. Accessories mounted in fixed equipment shall incorporate slotted fixing holes.

All equipment shall be fixed with purpose-made clamp brackets, or proprietary fixing bolts. Plugs or shot bolts shall not be used without the written approval of the Employer.

(c) Labelling

All labelling shall be in English. Each main and auxiliary item of Plant shall have permanently attached to it in a conspicuous position a rating plate of weather- resistant material. The Manufacturer's name, type and serial number of Plant, details of the loading and duty at which the item of Plant has been designed to operate shall be engraved on each plate. Where the Plant may have its rating plate in an inconvenient position (e.g. submersible pumps) then the Contractor shall supply an additional plate summarizing the particulars, which shall be fixed in a suitable location on the operating platform.

The labels shall be of non-corrode metal embossed with the lettering with black letters on white background and shall be fixed with brass or stainless steel screws. The labels shall be conspicuous and consistently located relative to the equipment to which they apply so that they can be read from the normal operating positions.

All safety signs shall comply with ISO 3864 or equivalent.

Plant which may start automatically shall carry labels (minimum size 200 mm x 100 mm) incorporating a hazard warning symbol and the following wording in black letters with yellow background:

"WARNING - THIS GATE IS REMOTELY/AUTOMATICALLY CONTROLLED AND MAY START AT ANY TIME"

(d) Shafts, Couplings & Gearboxes

The drive coupling shall be rated to transmit the maximum rated motor power output. All transmissions and couplings shall be erected true to line. The coupling shall correct minor angular and positional misalignment without allowing resultant "strain energy" stressing of either driver or driven shaft. The coupling shall be key located on each shaft, and easily removable.

Shafts shall be of high tensile steel or stainless steel. To reduce stress concentrations, section changes on the shaft shall be properly radiused at the root of any steps and keyways shall be internally radiused or gradually run out. The shaft shall have first critical speed well above maximum operating speeds. Where separate items of interconnected plant such as motors, couplings, gearboxes and similar items depend upon correct alignment for satisfactory operation then each and every items shall be positively located in its correct operational position by means of dowels, locating pins, fitted bolts or other approved means to ensure that correct realignment can be easily achieved when reassembling the items after removal for overhaul.

Where fitted bolts, spigots or other means for precise location are not employed in the assembly of the plant, locating dowels shall be fitted on completion of erection and alignment. Fitted bolts shall be identified by means of stainless steel tags installed under the bolt head.

Standard enclosed gear boxes for machines shall be obtained from an approved manufacturer. Couplings shall be of the flexible multi-pin and bush type. Bosses shall be a tight fit on the shafts and secured with hand fitted stainless steel keys.

Belt and chain drives shall be provided with separate independent means for adjustment of tension and alignment.

All Gear box housings shall be of rigid high-strength close grained cast iron and shall be complete with ventilation opening and oil level gauge.

The transmission of power shall be achieved by means of precision helical gears and the gearbox designed for a guaranteed life span of at least 100,000 hours.

The gear box shafts shall be solid forgings of the parallel type, precision ground and made from heat treated hardened and tempered chrome-molybdenum alloy steel.

(e) Vibration

Mechanical vibration levels at duty point conditions shall be in accordance with the requirements of ISO 2372 for range of vibration severity.

(f) Guarding of Shafts

All rotating shafts, couplings, gears, flywheels, bolts, drives etc shall be fully guarded to BS 5304 or equivalent.

(g) Bearings

Bearings must be capable of taking all radial and axial loads resulting through the normal and extreme conditions. Class of fit, bearing clearance classification shall be indicated in the technical schedules.

(h) Materials

All materials utilized in the Plant shall be the most suitable for the duty concerned and shall be new and of first class commercial quality.

Particular attention shall be paid to material selection to minimize corrosion due to atmospheric conditions, contact with or submersion in corrosive liquids, electrolytic action of dissimilar metals, or any other causes which may reasonably be associated with the overall performance of the Works.

(i) Welding

Before starting the welding of pipe joints the Contractor shall submit for the Employers approval details of the equipment, methods and materials he proposes to use, including make and size of electrodes, number of runs and current strength.

In all cases where welds are liable to be highly stressed before fabrication commences, the Contractor shall supply the Employer with detailed drawings of all welds and weld preparations proposed. No such welding shall be carried out before the Employer has signified his approval.

Welded components containing highly stressed fusion welds shall be stress relieved prior to machining. A smooth neat finish, by careful grinding if necessary is required on all exterior welding and shall be free from pitting or slag inclusions.

Radiographic examination or other non-destructive testing of welds may be ordered by the Employer and the Employer may witness such tests.

Other welds shall be subject to dye or magnetic particle penetrant testing.

Evidence of the valid certification of the welding personnel may be requested by the Employer where necessary in accordance with BS 4872 or equivalent.

(j) Nuts, Screws, Washers, Bolts and Anchors

Nuts, screws, washers and bolts shall comply with the relevant requirement of the following ISO standards unless other wise specified:

(1) ISO 272

(2) ISO 885

(3) ISO 888

(4) ISO 4759

Bolting for pipes and fittings shall comply with ISO 7005/2 except that spheroidal graphite iron bolts for use with pipes and fittings shall be steel, galvanized to ISO 1459; ISO1460; ISO1461 or equivalent or sherardized to BS 4921 Class I or equivalent.

All bolts, nuts and washers which are liable to become submerged during the operation of the plant shall be nickel-chromium stainless steel. (Minimum quality 316 S13 to BS 970 or equivalent) All other threaded fixings, washers etc. shall be hot dipped galvanized to ISO1459, ISO1460 and ISO1461.

One washer shall be provided under each bolt head and nut. Bolt clearance holes shall be drilled, never flame cut.

(k) Special Tools

Any special tool provided for maintenance of the Plant in each town shall be identified within the tender and supplied and handed over to the Employer on completion of the Works. Prior to handover the Employer and Contractor shall examine tools which have been used during plant erection to ensure that they are not damaged and are in good condition.

The recommended optional tools, including any special tools, gauges, jigs or extractors which may be required for maintenance of the Plant shall be set out in the appropriate schedule. A suitable lockable box shall be provided for each town to contain all tools provided.

(l) Lubrication

The initial changes of oils, greases, electrolyte and similar materials necessary for the correct setting to work and operation of the plant shall be included in the Contractor’s price. All lubricants shall be readily available within Kinshasa.

A complete schedule of recommended oils and other lubricants shall be furnished by the Contractor, for approval by the Employer. The number of different types of lubricants shall be kept to a minimum. In the case of grease lubricated roller bearings for electric motors a lithium base grease is preferred. A draft of this schedule with trade names, purpose, viscosities, etc. container size and life, and the name of the manufacturer (preferably one only) and his local Contractor shall be incorporated in the draft operation and maintenance instructions.

When more than one special grease is required at a site a grease gun for each special type shall be supplied for that site and permanently labelled.

Oil sumps shall be fitted with oil level indicators of the sight glass type or, where this is not practicable with dipstick indicators which shall show the level at all temperatures likely to be experienced in service. The normal maximum and minimum levels at 40 degrees C shall be clearly visible in the sight glass from the normal access floor adjacent to the particular item of plant.

All lubrication systems shall be designed so as not to present a fire hazard and particular care shall be taken to prevent leakage of lubricant.

The Contractor shall supply flushing oil for each lubrication system when an item of plant is ready for preliminary running, and a sufficient quantity of the approved lubricants for setting to work for the commercial operation of the plant for one year after issue of the Taking-Over Certificate.

(m) Color Coding For Water Supply

Pipes, valves, pumps, compressors etc shall be colour coded in accordance with below. The coding shall indicate the contents of the pipelines, purposes of the valves etc, and show whether or not the fluids being handled are dangerous.

Tape banding of pipes, of the appropriate colour, shall be spaced at 3 m intervals and at every valve or junction, direction of flow arrows shall be provided together with process stream contents.

Lagged pipework shall be colour coded prior to lagging. Lagging surface shall be continuously colour coded.

Stainless steel shall not have any paint system applied to its surface but imperfections and heat affected zones shall receive a suitable treatment to give a high quality uniform surface appearance.

COLOUR	BS 4800	WATER
Yellow Light Brown	10E53 08C35	Natural Gas Fuel Oil
Light Blue Dark Blue	20E51 20D45	Compressed Air Instrument Compressed Air Process
Dark Green Olive Green Light Green+	14C39 12D45 14E51±	Raw Water. Partially treated water Potable Water
Dark Brown Black	06C39 00E53	Filter wash water etc Consolidated Sludge
Red Grey	04E53 8I325	Casings, Flues etc. Motors, Gearboxes, Transmissions Structural Steel, Frameworks.

(n) Protection & Packaging

(1) Cleaning and Protection at Place of Manufacture

- Parts shall be cleaned prior to testing at the Manufacturer's Works. Parts subject to hydraulic test shall be tested before any surface treatment. After testing all surfaces shall be thoroughly cleaned and dried out prior to surface treatment.

- Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventative lacquer or high melting point grease before the parts are packed. A sufficient quantity of the correct solvent for removal of the protective compounds shall be supplied and packed with each particular part.

(2) Protection. Packing and Transportation

- Prior to dispatch from the Contractor or Manufacturer’s premises all Plant shall be adequately protected by painting or by other approved means for the whole period of transit storage and erection, against corrosion and incidental damage.
- The flanges of the pipes, valves and fittings shall be protected by wooden discs attached by means of service bolts (which shall not be used at Site) or by other approved means. The sleeves and flanges of flexible couplings shall be securely tied. Cases containing rubber rings, bolts and other small items shall not normally weigh more than 50 kg gross.
- All items of Plant shall be clearly marked for identification against the packing list.
- All crates, packages etc., shall be clearly marked with a waterproof material to show the weight and where the slings should be attached and shall also have an indelible identification mark relating them to the packing lists.

5.1.6 Design of Piping Works

(a) References

Pipes and fittings shall comply with the relevant provisions of the appropriate ISO Standard or equivalent as set out below:

(1) Steel pipes, specials and fittings	BS 534, 3600, 3601, 1640, 1965
(2) Metal arc welding of steel pipes	BS 2971
(3) Screwed pipes & fittings for pressure	ISO49, BS1256. ISO65
(4) Purposes for water, air and oil	ISO445
(5) Copper pipes and fittings	ISO 2016, BS 2871
(6) Pipe Flanges	ISO 7005/2/3
(7) Rubber hoses for use with compressed air	ISO 2398
(8) Pipe supports of fabricated steel	BS 3974

Materials and coatings used shall be unconditionally resistant to the conveyed fluids.

(b) General

Each pipe, fitting and casting shall bear clear and durable markings showing the nominal diameter, class or schedule, type, year of manufacture and the manufacturer's name or trade mark. Marking on pipe lengths shall always be at the same end. Painting of data will be acceptable for all pipe material.

Pipes and fittings shall be compatible and have equal or higher pressure ratings as specified.

Pipes, fittings and appurtenances shall be installed in full conformance with the manufacturer's recommendations.

When cutting of pipe is required, the cutting shall be done by machine in a neat and workmanlike manner without damage to the pipe, coating or lining. Cut ends shall be smooth and at right angles to the axis of the pipe. Pipe ends to be used with rubber joints shall be beveled and filed or ground smoothly to conform to the manufactured spigot end.

The Contractor shall furnish and install transition pieces at all locations when one type of pipe joins a second one.

At the conclusion of the work the Contractor shall clean all piping and pipelines.

(c) Pressure Rating

Pipework and fittings shall be suitable for a safe working pressure equivalent to the maximum working pressure of the system. The safe working pressure of pumping mains shall be the closed valve head of the pump plus the maximum suction static head. The pipework shall also be rated for the maximum surge pressures generated in the system.

(d) Design

All machinery stations shall be provided with flexible joints, flange adaptors or unions such that upon renewal of plant minimal disturbance of pipework is required.

The pipework system shall be so designed to ensure that anchorage at blank ends, bends, tees and valves may be kept to a minimum. The Contractor shall provide and install all anchor blocks and mechanical ties required to support and accommodate system thrust loadings unless otherwise stated.

There shall be a sufficient number of mechanical joints to enable mechanical plant and valves to be disconnected from built-in pipework. Such joints shall be tied, as required to counter hydraulic loadings and shall not be allowed to sustain the weight of any pipework.

Flanges shall be drilled off centres.

Pump suction bell mouths shall be standard castings.

The use of gusseted bends shall only be permitted upon approval by the Employer. Where space allows all bends shall be even curvature manipulated bends and where short radius bends are required the use of carbon and alloy steel welding fittings to BS 1640 Part 3 or equivalent shall be permitted.

Tee pieces on pump manifolds shall have a radial branch to enable a more streamlined flow from branch to body. Short radius tee pieces are permitted where there are space limitations and the consequent head toss is insignificant. Due allowance shall be made to provide reinforcement in the vicinity of branches etc.

Puddle flanges shall be provided on all pipes where they pass through pumping station walls. The Contractor shall provide and ensure a gas tight seal at the penetration.

Pump suction and delivery manifolds shall be provided with a drain valve and a station isolating valve.

Where pipes pass through a concrete wall or structure they shall, where space permits project from the external face(s) of the structure by 300 mm for pipes with nominal bores of 500 mm or less and by 500 mm for pipes with nominal bores in excess of 500 mm and the surface of such pipes shall be prepared to the approval of the Employer to ensure a satisfactory bond between pipes and concrete.

Flat top eccentric tapers shall be used to connect suction pipework to pump flanges.

(e) Velocities

Allowable velocities in pipes will be related to the fluid type and shall comply with the following.

Fluid	Minimum	Maximum
Raw water	0.5 m/s	2.0 m/s
Air	N/A	15.0 m/s
Sludge	N/A	1.5 m/s

(f) Handling

Care shall be taken during loading, transporting, and unloading to prevent injury to the pipes, fittings, or coatings. Under no circumstances shall pipe or fittings be dropped or rolled against one another. All pipes or fittings shall be examined and no piece shall be installed which is found to be defective.

If any defective pipe or fitting is discovered after it has been installed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipe and fittings shall be thoroughly cleaned before installation.

Special handling of pipes and fittings shall be in accordance with the manufacturer's instructions.

All pipes shall be bundled or packaged in such a manner as to provide adequate protection for the ends, threaded or plain, during transportation from the manufacturer to the Contractor. All special provisions for ocean shipment shall be provided.

(g) Inspection

The quality of all materials, the process of manufacture, and the finished piping shall be subject to inspection and approval by the Engineer by an independent testing laboratory selected by the Employer, or by other representatives of the Employer. Such inspection may be made at the place of manufacture or at the site after delivery, or at both places, and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipes may have been accepted as satisfactory.

Inspections, at point of manufacture, will require the Contractor's and manufacturer's cooperation. The cost of foundry or factory inspection of piping approved for these

works will be in accordance with the program set forth under the Provisional Sums.

When any routine chemical analysis fails to meet the requirements of these specifications or when any specified test fails to meet the requirements, all pipe in the same sampling period shall be rejected, except that any pipe that is subsequently re- tested and is judged acceptable, may be accepted.

All pipes, and appurtenances will be inspected by the Engineer upon delivery to the site and those pieces, not conforming to the requirements of this specification, will be rejected and must be immediately removed from the site by the Contractor. The Contractor shall furnish all labor necessary to assist in inspecting the material.

On completing the installation, the inside of the pipe shall be carefully cleaned of tools, scrap, dirt and debris. The Engineer will make a full and complete inspection of all lines before acceptance and the Contractor shall fully flush out the lines with water and air prior to inspection.

(h) Flanged Joints

Flanged joints shall be furnished complete with gaskets, bolts and nuts.

Gaskets shall be cut to the proper size so that no part protrudes. Prior to application of gaskets, the face of the flanges shall be thoroughly cleaned.

All gaskets supplied with each flange fitting shall be styrene butadiene rubber conforming to BS 2494 or equivalent. Thickness of gasket shall be 3 mm.

Flange assembly bolts shall be standard hexagon head machine bolts with hexagon nuts. Threads shall conform to ISO 68, "ISO General Purpose Screw Threads-Basic Profile". Material for bolts and nuts shall be steel conforming to ASTM or BS or other internationally accepted standards, and shall have a minimum yield strength of not less than 226 N/mm^2. Steel bolts and nuts shall be galvanized. Bolts and nuts for intermittent or continuous underwater pipe work shall be Type 304 stainless steel.

Bolts and nuts for stainless steel flanges shall be stainless steel and type of stainless steel shall be the same as the flanges.

Bolts in flanged joints shall be tightened alternately on opposite ends of joints diameters, in rotation around the flange and evenly.

The bolts shall not protrude more than 3 mm beyond the nuts. Should the bolts protrude more than 3 mm, the bolt ends shall be machined cut and refinished.

Mating dimensions of flanges, nominal diameter 80 mm to 1,800 mm shall conform to dimensions shown on the following FLANGE SCHEDULE. Mating dimensions and thicknesses of flange, nominal diameter 65 mm and smaller shall conform to ISO, ANSI, or BS or internationally accepted standards and the working pressure of the flange shall be 0.98 MPa.

NOMINAL DIAMETER			**DIAMETER BOLT DIAMETER**		
DN	D	C	NUMBER	d	
80	200	160	8	19	16
100	220	180	8	19	16
150	285	240	8	23	20
200	340	295	12	23	20
250	400 (405)	355	12	28	24
300	445 (460)	410	12	28	24

350	520	470	16	28	24
400	580	525	16	31	27
450	640	585	20	31	27
500	715	650	20	34	30
600	840	770	20	37	33
700	910	840	24	37	33
800	1025	950	24	40	36
900	1125	1050	28	40	36
1000	1255	1170	28	43	39
1100	1355	1270	32	43	39
1200	1485	1390	32	49	45
1400	1685	1590	36	49	45
1500	1820	1710	36	56	52
1600	1930	1820	40	56	52

• Definitions : DN - Nominal diameter of pipe
D - O.D. of flange
C - Diameter of bolt circle
d - Diameter of bolt holes
() - Only for steel flange

• Note: Bolt holes shall straddle the vertical center line of the flange.

(i) Steel Pipe

(1) General

All welding shall be in accordance with the welding under the provision unless otherwise specified.

(2) References

The following standards are referred to:

• BS 4622	Grey Iron Pipe Fittings
• BS 1965	Carbon Steel Pipe Fittings
• BS 4360	Rolled Steel for General Structure
• BS 1387	Carbon Steel Pipes for Ordinary Piping
• AWWA C200	Steel Water Pipe 6 Inches and Larger
• AWWA C206	Field Welding of Steel Water Pipe Joints
• AWWA C208	Dimensions for Steel Water Pipe Fittings
• AWWA C210	Liquid Epoxy Coating System for the Interior and Exterior Steel Water Pipe
• AWWA	Manual Steel Pipe Design and Installation M11
• ASTM A283	Low and intermediate Tensile Strength Carbon Steel Plates

(3) Pipes

Steel pipe shall be fabricated from steel sheets or plates and shall be arc welded or electric-resistance welded, shop fabricated, tested and cleaned.

Steel sheets or plates shall have a minimum yield point not less than 226N/mm^2 and shall conform to the following materials.

- BS 4360
- BS 1387
- ASTM A283 Grade D

Fabrication of steel pipe shall be in accordance with BS 1387 or AWWA 200. The weld shall be of reasonably uniform width and height for the entire length of the pipe and shall be made by automatic means except that with approval of the Engineer, manual welding by a qualified procedure and welder may be used.

All longitudinal seams or spiral seams and shop girth seams of pipe shall be butt welded. The maximum allowable number of shop seams shall be one longitudinal seam and three girth seams per length of pipe. The longitudinal seams shall be staggered on opposite sides for adjacent section. No reinforcing ring, plate or saddle shall be provided on the exterior or interior of pipe. The length of pipe shall be six (6) meters or smaller unless otherwise specified.

(j) Flexible Joints and Couplings

(1) General

All flexible joints and couplings shall be designed for a minimum working pressure of 0.98 MPa unless otherwise specified and to the maximum designed working pressure.

(2) References

The following standards are referred to:

• BS 4360	Rolled Steel for General Structure.
• BS EN 1563	Spheroidal Graphite Iron Castings.
• BS EN 1562	Blackheart Malleable Iron Castings.
• BS 2494	Elastomeric seals for joints in pipe work

(3) Mechanical Flexible Joints

- Mechanical flexible joints shall be closer joint, rubber type and designed to withstand any forces or any combination of forces due to expansion and contraction, shear deflection, distortion and other forces to the pipeline.
- Mechanical flexible joints shall be designed and manufactured to meet the operating conditions and design requirements, as enumerated and tabulated below:
- Two (2) meters depth of earth cover the unit weight of which is 2.0 ton/m^3 plus a 20 ton truck loading.
- Minimum shear deflection of 100 mm.

(k) Pipe Hangers and Supports

(1) General

Hangers and supports shall be of approved standard design where possible and shall

be adequate to maintain the supported load in proper position under all operating conditions.
Pipe hangers and supports shall be designed based on pipe weight including water and maximum support spacing which are tabulated in the following table.

NOMINAL PIPE DIAMETER (mm)	PIPE WEIGHT PER 1 METER (kg)	MAXIMUM SUPPORT SPACING		
		STEEL PIPE (m)	DUCTILE CAST IRON OR CAST IRON PIPE (m)	PVC PIPE (m)
40 & smaller 50	10 15	2.0 2.0	1.5 1.5	1.0 1.0
65	20	2.0	1.5	1.5
80	25	2.0	1.5	1.5
100	40	4.0	1.5	1.5
125	50	4.0	1.5	2.0
150	65	4.0	1.5	2.0
200	110	4.0	1.5	2.0
250	150	4.0	1.5	2.0
300	200	4.0	1.5	2.0

(2) Materials

All overhead hangers shall be provided with turnbuckles and supported by threaded hanger rods from inserts in the concrete. Overhead hangers, turnbuckles hanger rods and inserts shall be galvanized steel conforming to BS 4360 or equivalent unless otherwise specified. Hanger rods shall be machine threaded and rod sizes shall conform to the following Table.

PIPE DIAMETER (mm)	HANGER ROD DIAMETER (mm)
80 and smaller	10
100 to 150	12
200 and 250	16
300	19

Where support is from walls or columns, welded steel brackets with U-bolts shall be provided. U-bolt sizes shall conform to the following table.

PIPE DIAMETER (mm)	U-BOLT DIAMETER (mm)
80 and smaller 100 to 125 150 and 300	10 12 16

Wherever practicable, PVC piping and chemical feed piping shall be supported by channel supports.
Threads for all nuts, bolts and rods shall conform to ISO 68 "ISO General Purpose Screw Threads - Basic Profile”.

(l) Pipe Installation

(1) General

This section covers the installation of all pipe and fittings except all pipe and fittings in the ground.

- Piping shall be installed to the required lines and grades and as closely as possible to walls, ceilings, columns and other structural parts so as to occupy the minimum of space, and all offsets and fittings required to accomplish this must be furnished. All dimensioned pipes and fittings shall be installed before fitting make up pieces, and the whole shall be joined so that no stress or strain is created in the lines and associated equipment due to forcing parts into position.
- When installation is not in progress, including lunchtime, the open ends of the pipe shall be closed by a watertight plug or other approved means. Flotation of pipe shall be prevented. Good alignment shall be preserved during installation. In the event interference develops between piping and other appurtenances the Engineer will decide which work is to be relocated regardless of which was first installed.
- Changes in direction shall be made using proper fittings. Piping shall run parallel and at right angles to walls, unless noted otherwise.
- Temporary bracing and supports shall be provided to adequately support the pipe during its installation and care shall be taken in placing piping to prevent damage to the pipe lining or pipe coating or to adjacent structures or equipment. Supporting piers and blocking shall be in place before temporary supports and bracing are removed.
- All piping shall have a sufficient number of flanged joints to allow convenient removal of piping. Threaded piping shall have a sufficient number of unions to allow convenient removal of piping.
- Systems shall be arranged with low points and drains to permit complete drainage of the system. Fill connections for the purpose of testing shall also be provided on closed system when required.

(2) References

The following standards are referred to:

- AWWA MANUAL
- M11 Steel pipe design and installation
- M23 PVC Pipe Design and Installation

(3) Steel pipe

- General

Steel pipe shall be installed in accordance with AWWA M11.

All work shall be in full conformance with the manufacturer’s recommendations.

The lining and coating shall be protected at all times. All repairs shall be the responsibility of the Contractor.

Where steel pipe passes through wall sleeves, the sleeves shall be caulked with sealing compounds recommended by the pipe manufacturer and approved by the Engineer.

- Flanged Joints

Same as previous Clause “5.1.6 (h)” Flanged Joints.

- Screwed Joints

All threads for screw joints shall be clean, machine cut, and all pipes shall be reamed before erection. Each length of pipe as erected shall be up-ended and rapped to dislodge dirt and scale.

Screwed joints shall be made up with good quality thread compound and applied to the male thread only. After having been set up, a joint must not be backed off unless the joint is completely broken, the threads cleaned, and new compound applied. All joints shall be airtight.

No close right and left hand nipples shall be used. All nipples shall be of such length that the correct size of pipe wrench can be used on them when in place.

- Welded Joints

Welding shall be in accordance with the Clause “5.1.5(i)” Welding.

- Flexible Joints

During transportation, handling, storing and installation, any deflection, contraction, expansion or any other transformation of the flexible joints shall be avoided. Extreme care must be made to prevent any scarring or nickling of the joints from bearing on sharp objects.
All flexible joints shall be installed true to the lines and levels and the Contractor shall maintain the joints in the same condition as shipped from the manufacturer. Disassembling the joints at the site shall be avoided unless otherwise directed by the Engineer. The Contractor shall not remove any protective ribs, shipping protection or other devices provided to the joints before jointing work is completed.

(m) Pipeline Identification

Pipework shall be colour coded as defined Colour Coding For Water Supply.

To assist in process tracing direction of flow, arrows shall be applied using adhesive tape. Where pipelines are lagged tape shall be applied to both the external lagging and the pipe.

5.1.7 Valves and Actuators

(a) General

Valves shall be suitable for use with water or water works sludge at all temperatures of up to 30°C and at high humidity.

All valves shall have following marking and they shall be designed cast in raised letters upon some appropriate part of the body.

- Name and mark of manufacturer
- Year of manufacturing, 11 (means 2011)
- Working pressure, NP10 (means 0.98 MPa)
- Arrow direction for valves designed for one-way flow only.

Valve ends shall be flanged ends except where otherwise specifically specified elsewhere. Where flanged ends are used, mating dimensions and drilling shall be in accordance with the flange schedule specified in Clause "5.1.6 (h)" Flanged Joints.

Thickness of flanges shall conform to internationally accepted standards, or the Contractor shall determine the flange thickness and shall submit his design calculation.

All materials which will be specified hereunder shall conform to ASTM, BS, or other internationally accepted standards.

Valves shall be equipped with hand lever, hand wheels, chain or hand, pneumatic or electric operators. Unless otherwise specified, manual operation valves shall have hand wheels. Valves shall open by turning to the left or counter clockwise. Operators shall have arrows cast thereon to indicate the direction of rotation for opening the valve.

All pipe connection openings shall be capped to prevent the entry of foreign matter prior to installation.

Valves 50 mm in size and smaller shall be all bronze, unless otherwise specified, except for hand wheels which shall be of cast or malleable iron, provided with screw ends.

(b) Valves

(1) General

Valves shall be suitable for their application and media being passed and installed in such a manner as to allow ease of operation and maintenance.

The use of dissimilar metals in conjunction in a corrosive environment shall not be permitted, e.g. steel pipes and non-ferrous valves.

Valves used in water treatment process plant shall be suitable for use with the chemicals associated with the process, e.g. chlorine, coagulants, polyelectrolyte, lime, etc.

Valves and penstocks located outside buildings shall be provided with a locking device where operation will be critical to the process or plant being controlled or isolated.

Valve gearboxes shall be provided where necessary to allow handwheel operation at maximum differential pressure. Gearboxes are to be fully enclosed.

All valves shall be capable of drip-tight isolation of the free end of an unsupported pipe and be capable of manual operation under maximum head conditions.

Valve selection shall be as follows unless otherwise specified.

- Pump Isolation - Wedge Gate Sluice or Knife Edge Gate or Flanged Butterfly.
- Water Control/Isolation - Butterfly, Ball, Eccentric Plug, Globe, Axial Sleeve or Roll Seal.
- Sludge Control - Eccentric Plug or Knife Edge Gate. Chemical Dosing - Diaphragm or Ball.
- Slurry lines (e.g. Lime) - Wireless Diaphragm. Sampling - Diaphragm or Ball.
- Non-return or reflux valves shall be fitted downstream of all pumping plant. Where indicated in the specification that the valves have to close within a designated surge transient return time they shall be suitably rated for that condition by the use of spring assistance.

Valves up to 40 mm inclusive shall have screwed socket-welded or flanged ends according to service conditions and pipework layout.

Valves larger than 40 mm shall have flanged ends unless otherwise specified.

Sluice valves to BS 5163 or equivalent for PNI6 Double Flanged Cast Iron, Wedge Gate Valves for Waterworks shall be provided as boundary valves on all elements of the process stream.

Sluice valves installed within the confines of building shall be type A and those installed within valve chambers or underground shall be type B. They shall have bodies of high quality cast iron and those above 300 mm shall be fitted with renewable body seat rings of gunmetal. The wedge shall be of cast iron with renewable wedge face rings of gunmetal and the non-rising spindle shall be of manganese bronze.

All sluice valves shall be fitted with hand wheels unless otherwise specified. Stem caps shall be provided on all valves detailed for key operation and shall be secured with socket headed set screws.

Sealing shall be so arranged that replacement can be accomplished with ease and shall not require the removal of the valve from the pipeline. Unless otherwise specified stem sealing shall by toroidal ‘O’ ring seal. Where a conventional stuffing-box arrangement is specified, the packing shall be non-asbestos.

The dimensions of a gate valve fitted with a by-pass valve shall not exceed the basic dimensions set down in BS 5150 or equivalent and BS 5163 or equivalent.

Valves of 600 mm nominal diameter, or larger shall be fitted with a wedge re jacking screw and locknut.

(2) Testing

• General

The manufacturer shall notify the Engineer at least thirty working days prior to factory tests. The Engineer reserves the right to witness all tests.

• Performance Tests

Each valve, gate and appurtenance shall be shop-operated three times from the fully closed to the fully opened position, and the reserve, under a no-flow condition, to demonstrate that the complete assembly is workable.

• Leakage Tests

Valves, gates and appurtenances shall be shop-tested for leaks in the closed position. With the valve in the closed position, hydrostatic pressure as directed by the Engineer shall be supplied to one face of the disc for the full test duration at the working pressure. The length of test shall be at least 5 minutes and there shall be no indication of leakage past the valve during the test period.

• Hydrostatic Tests

Valves specified shall be hydrostatically tested. Hydrostatic tests shall conform to the following:

With the valve disc in a slightly open position, internal hydrostatic pressure equivalent to 150% of the specified working pressure shall be applied to the inside of the valve body of each valve for a period of 10 minutes. During the hydrostatic test, there shall be no leakage through the metal, the end joints, or the valve shaft seal; nor shall any part be permanently deformed. While undergoing testing, the valve body shall be struck with a hammer several times.

• Field Testing

When the valves, gates and appurtenances have been completely installed and as soon as operation conditions permit, they shall be given a field test by the Engineer to demonstrate that they have been suitably installed, that they meet all requirements, are in good operating condition and are, in every way, adequate for the service intended.

(3) Painting

All valves, gates and appurtenances, unless otherwise specified, shall have an interior ferrous port, except finish or bearing surface, painted with two (2) coats of epoxy paint or coal tar epoxy paint having total minimum dry film thickness of 0.4 mm. Material of the said epoxy paint or coal tar epoxy paint shall conform to AWWA C210 or shall be certified by the recognized public health authorities for linings in potable water service.

(4) Gate Valves

• General

The following Gate valves shall be specified hereinafter:

Gate Valves, Normal Pressure Service, NP 10 (50 mm to 500 mm) Gate Valves, High Pressure Service, NP 16 (50 mm to 300 mm) Resilient-seated Gate Valves (80 mm to 300 mm)

Bronze Gate valves (80 mm and smaller) Stainless Steel gate Valves (15 mm to 300 mm)

• Reference

The following standards are referred to:

BS 5163	Sluice Valves for Waterworks
ASTM B 584	Bronze Casting
AWWA B115 10kgf/cm2	Sluice Valves for Waterworks
AWWA B120	Resilient Seated Gate Valves for Waterworks
AWWA C210	Liquid Epoxy Coating System for the Interior and Exterior of Steel Water Pipelines
AWWA C213	Fusion-bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
AWWA C500	Gate Valves, 3 through 48 in. NPS, for Water and Sewage Systems
AWWA C509	Resilient-seated Gate Valves, 3 through 12 NPS, for Water and Sewage Systems
BS 5163	Metric Specification for General Purpose Cast Iron Wedge Gate Valves.

• Gate Valves, Normal Pressure Service, Class NP 10 (50 mm to 500mm)

Gate valves, normal pressure service, working pressure of 0.98 MPa shall be pipe body, bronze-mounted, non-rising stem (NRS) type gate valves and shall be designed and manufactured in accordance with AWW C500, BS 5163 or AWWA B115 and in addition shall conform to the following requirement:

Stem shall be of cast, forged or rolled bronze or copper alloy or mantensitic series stainless steel. Stem sealing shall be of stuffing box or O-ring type. Packing for the stuffing box shall be made of nylon. Asbestos or hemp of jute packing materials shall not be used. O-ring stem seals shall have a minimum of two (2) “O” ring seals, of which at least one (1) shall be above the stem collar and replaceable under full working pressure while the valves is in fully open position.

- Gate Valves, High Pressure Services, Class NP 16 (50 mm to 300mm)

  Gate valves, high pressure service, design working pressure of 1.568 MPa shall be pipe body, bronze-mounted, non-rising stem (NRS) type gate valves and shall be designed and manufactured in accordance with BS 5163 or other international accepted standard.

(5) Butterfly Valves

- General

  The following butterfly valves shall be specified hereinafter:

  Butterfly Valves, Class NP 10

  Butterfly Valves, Class NP 16

  Toothed Vane Rotary Control Valves

  Wafer Butterfly Valves (50 mm to 600 mm).

  All valves shall be equipped with manual operators with hand wheels unless otherwise specified.

- References

  The following standards are referred to:

BS 1452	Gray Iron Casting
BS EN 1563	Spheroidal Graphite Iron Casting
AWWA C504	Rubber-seated Butterfly Valves
BS 5155	Butterfly Valves
ISO 5752	Metal Valves for use in flanged pipe systems – face to face and centre-to-face dimensions

- Butterfly Valves - Class NP 10

  Valves shall be double flanged, pipe body, rubber- seated butterfly valves, and shall be designed and manufactured basically in accordance with AWWA C504 or BS 5155 and in addition shall conform to the following requirements.

  Valves shall be designed to be leak tight in both directions at a maximum working pressure of 0.98 MPa and at a maximum differential pressure of 0.98 MPa across the valve disc, and shall be suitable for a maximum velocity of 4.8 m/sec and for throttling service.

  Each shaft shall be a one-piece unit extending completely through the valve disc, or of the “stub shaft” type, which comprises two separate shafts inserted into the valve disc hubs. If of “stub” construction, each stub shaft shall be inserted into the valve disc hubs for a distance of at least 1.5 times the shaft diameter.

  Materials of shaft shall be either austenite series stainless steel, Type 304 or 316, or high yield strength mantensitic series stainless steel.

  If high yield strength martensitic series stainless steel such as Type 403, 420, 431 and others are used for the valve shaft, allowable torsional shear stress, not exceeding 25% of yield strength of the material used, shall be applied for design of valve shaft diameter.

  Valve discs shall be made of stainless steel casting and shall be of design with no external ribs transverse to the flow. The design of disc shall withstand full differential pressure across the closed valve disc without exceeding a working stress, equivalent to 20% of tensile strength of the material used.

  Rubber seats shall be applied to either the body or the disc, shall be of synthetic rubber, and may be reinforced. Rubber seats of valve 700 mm in diameter and larger shall be of a design that permits removal and replacement at the site of the installation. Rubber seats shall be clamped, mechanically secured, or bonded to the body or disc. Rubber seats shall mate with stainless steel seating surface. Clamps and retaining rings for rubber seats shall be made of stainless steel and hardware used with clamps and retaining rings shall be stainless steel.

Valves shall be fitted with sleeve type bearings contained in the hub of the valve body. Valves, 350 mm in diameter and larger shall be equipped with either one or two thrust bearings, which shall hold the valve disc securely in the center of the valve. Sleeve and other bearings fitted into the valve body proper shall be made of self-lubricated materials that do not have a harmful effect on potable water or rubber.

A shaft seal shall be provided where shafts project through the valve bodies for actuator connection. Shaft seals shall be designed for the use standard V-type packing; O-ring seals; O-ring-loaded, U-cup seals; or a pull-down packing. If O- rings are used, they shall be contained in a stainless steel or bronze removable recesses. If stuffing box and pull-down packing gland are used, the design of the valve and stuffing box assembly shall permit adjustment or complete replacement of packing without disturbing any part of the valve or actuator assembly except packing gland follower.

Gland or gland assemblies shall be made of stainless steel or bronze. Packing shall be made of resilient, non-metallic material suitable for potable-water service which shall not contain asbestos.

• Butterfly Valves, Class NP 16

Valves shall be double flanged, pipe body, rubber- seated butterfly valves. Valves shall be designed leak tight in one direction at a maximum working pressure of 1.568 MPa, and shall be suitable for a maximum velocity of 3.0 m/sec and for throttling service.

Valves shall conform to all provisions specified in the previous sub-section, (iii) Butterfly Valves, Class NP 10, except the following items and in addition shall conform to the following requirements.

Valve bodies shall be designed to withstand the maximum working pressure specified and a maximum differential pressure of 0.98 MPa. Minimum thickness of valve body shall be calculated without exceeding a working stress equivalent to 20% of the tensile strength of the materials used.

Valve shafts shall be of high yield strength mantensitic series stainless steel such as Type 403, 420, 431 and others and valve shafts made by precipitation series stainless steel may be acceptable. Allowable torsional shear stress, not exceeding 25% of yield strength of material used shall be applied for design of valve shaft diameter.

Valve discs shall be designed to be off-centered. Rubber seats of valve shall be of a design that permits removal and replacement at the site of the installation without removing shafts from the valve body.

• Wafer Butterfly Valves

Valves shall be cast pipe body, rubber-seated butterfly valves, and shall be designed and manufactured basically in accordance with BS 5155 or equivalent international standard and in addition shall conform to the following requirements:

Valves shall be designed to be leak tight in both directions at a maximum working pressure of 1.568 MPa and at a maximum differential pressure of 0.98 MPa and at a maximum velocity of 4.0 m/sec and for throttling service.

Each shaft shall be a one-piece unit extending completely through the valve disc, or of the “stub shaft” type, which comprises two separate shafts inserted into the valve disc hubs. If of “stub”construction, each stub shaft shall be inserted into the valve disc hubs for a distance of at least 1.5 times the shaft diameter.

Valve shafts shall be of high yield strength mantensitic series stainless steel such as Type 403, 420, 431 and others and valve shafts made by precipitation series stainless steel may be acceptable.

Valve discs shall be made of stainless steel casting and shall be of centered design with no external ribs transverse to the flow. The design of disc shall withstand full differential pressure across the closed valve disc.

Rubber seats shall be spool shaped rubber seating applied to the body and shall be made of EPDM or Buna-N (NBR).

Allowable stress, not exceeding 20% of yield strength of allowable stress, not exceeding 30% of yield strength of stainless steel shall be applied for design of major parts of valve.

All valves shall be equipped with manual operators with hand wheels unless otherwise specified.

(6) Check Valves

• General

The following check valves shall be specified hereinafter:

Swing Check Valves (50 mm to 600 mm)

Bronze Swing and Lift Check Valves (50 mm and similar)

Stainless Steel Check Valves (15 mm to 300 mm)

Tilting Disc Check Valves (50 mm to 1,500 mm)

Wafer Check Valves (50 mm to 1,200 mm)

Spring Loaded Lift Check Valves (25 mm to 400 mm).

Spring Loaded Lift Check Valves (25 mm to 400 mm).

All check valves except tilting check valves, wafer check valves and spring loaded lift check valves mentioned above shall be constructed so that disc, seat, seat rings and other internal working parts which may become necessary for repairs shall be readily accessible, removable and replaceable without use of special tools and removing the valve from the line.

• References

The following standards are referred to:

BS 5150	Cast Iron Gate Valves
ASTM B 584	Bronze Castings
API 594	Wafer Check Valves
AWWA C508	Swing-Check Valves for Waterworks service, 2 in. (50.8 mm) through 24 in. (609.6 mm) NPS.

• Swing Check Valves (50 mm to 600 mm)

Swing check valves shall be cast iron body and disc, and bronze seating type. The valves shall be designed and manufactured in accordance with AWWA C508. Working pressure shall be 0.98 MPa.

Valves shall be suitable to operate in a horizontal or vertical position with flow

upward and when fully open, valves shall have a net-flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

Valves shall be furnished with hinge arms, levers and springs or weights and also furnished with a by-pass pipe and by-pass valve.

• Bronze Swing and Lift Check Valves (50 mm and smaller)

Bronze swing and lift check valves shall be designed and manufactured for a working pressure of 0.98 MPa. Valves shall be equipped with screwed ends.

Swing check valves shall be suitable to operate in a horizontal or vertical position with flow upward. Lift check valves shall be suitable to operate in a horizontal position with flow upward when fully open. Both of swing and lift check valve shall have a net-flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

Valves shall be bronze body, screwed bonnet and disc. Valves shall be designed to have bronze seating or resilient seating. Resilient seats shall be made of Teflon.

• Stainless Steel Check Valves (15 mm to 300 mm)

Stainless steel check valves shall be straightway, swing type and designed for handling acid. Valves shall have metal to metal seating. Working pressure shall be 0.98 MPa.

Valves shall be suitable to operate in a horizontal or vertical position with flow upward and when fully open, valves shall have a net-flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

Unless otherwise specified, major parts of the valve such as body, bonnet, disc, hinge with hinge pin and other parts which may contact with handling liquid shall be made of Type 316 stainless steel casting.

• Tilting Disc Check Valves (50 mm to 1,500 mm)

Tilting disc check valves shall be pipe body and disc, and bronze or stainless steel seating. Valves shall be designed for a working pressure of 1.568 MPa and shall be suitable for operation in a horizontal pipeline.

Body shall be two (2) piece construction bolted together. Seat rings shall be mounted on both valve body and disc and shall be made of bronze casting conforming to ASTM B 584 or Type 304, 403, 420 or other stainless steel. Mating surfaces of body seat and disc seats shall be machine finished. Hinge pin shall be of stainless steel specified above. Bushings of hinge pin shall be bronze casting or aluminium bronze casting.

Body shall be provided with suitable hand holes for cleaning and by-pass pipe with valve. Pivot pin housing shall be fitted with ball check grease fittings.

Dash pots shall be furnished with valves and designed to have valve opening and closing speed control devices.

• Wafer Check Valves (50 mm to 1,200 mm)

Wafer check valves shall be dual plate, two spring-loaded, semi-circular plates type. The valves shall be designed and manufactured in accordance with API 594, or other internationally accepted standards.

Valves shall be designed to fit between two pipe flanges and for working pressure of 1.568 MPa.

Valve body and plates shall be Type 316 stainless steel. Bronze casting plates may be permitted. Hinge pin, stop in and springs shall be of Type 316 stainless steel. Valves shall have resilient seating in the valve body unless otherwise specified. Seat materials shall be Buna-N (NBR).

Unless otherwise specified, the spring shall be high Torque type.

- Spring Loaded Lift Check Valves (25 mm to 400 mm)

Spring loaded lift check valves shall be cast iron body, spring loaded, center guided disc type with flanged ends. Valves shall be designed for a working pressure of 0.98 MPa.

The valves shall be suitable to operate in a vertical position with flow upward and shall consist of body, disc, upper guide, disc guide, reverse flow guide disc, spring and by-pass valve.

Body seat ring shall be bronze casting accurately threaded and screwed into the body. Disc shall have synthetic rubber seat bolted to the disc. Disc, upper guide, disc guide and by-pass valve shall be of bronze casting conforming to ASTM B584. Spring shall be Type 304 stainless steel.

(7) Globe Valves

- General

The following globe valves shall be specified hereinafter:

Angle hose valves (10 mm to 100 mm)

Hose bibs (13 mm to 25 mm)

Stainless steel globe valves (15 mm to 300 mm).

- References

BS 5159	Faucets and Ball Taps
ASTM B 584	Bronze Castings.

- Angle Hose Valves (10 mm to 100 mm)

Angle hose valves shall be bronze body Y-Gloss valves with renewable composition discs. Valves shall have rising stem and screwed ends with stainless steel replaceable quick couplings cap. Working pressure shall be 0.98 MPa..

Discs shall be hard but sufficiently resilient to maintain tight seal within the pressure and temperature range and have high flexural and impact strength. Discs shall be made of Teflon or other materials approved by the Engineer.

Disc holder shall be made of bronze casting conforming to ASTM B 584.

- Hose Bibs (13 mm to 25 mm)

Hose bibs shall be bronze body globe valves with renewable composition discs. Valves shall have rising stems, screw-in bonnet, screwed inlet and hose coupling outlet. Working pressure shall be 0.74 MPa. Valves shall be designed and manufactured in accordance with BS 5159 or equivalent and shall be swivel nose faucet, faucet with hose coupling or lawn faucet.

Stem with disc and disc nut shall be bronze, bronze casting or copper. Disc shall be medium soft composition as recommended by the manufacturer for the intended use.

(8) Diaphragm Valves

Diaphragm valves shall be of the weir or straightway type as noted, with cast iron body, resilient reinforced rubber diaphragm and cast iron bonnet. They shall be fitted for spoked hand wheel operation.

The valves shall be used in water, air, and weak chemical service lines.

The reinforced rubber diaphragm shall be connected to a spindle actuated compressor so that it will be lifted to provide an adequate water-way for minimum pressure loss.

Further, the diaphragm shall be forced tight against the body even when the compressor is lowered. The diaphragm shall seal the bonnet compartment and working parts from the fluid stream. The diaphragm shall be capable of ready replacement without removing the valve body from the pipeline.

The valve shall be protected against corrosion with a minimum 3.0 mm thick of neoprene lining suitable for the service intended and consistent with associated piping unless otherwise noted.

(c) Valve Operators

(1) General

Operators shall be capable of seating, unseating and rigidly holding the valve disc in any intermediate position under the maximum design unbalanced head and water velocity noted.

Means for holding the valves in intermediate positions shall be furnished.

The operating mechanism of butterfly valve, plug valve and ball valve operators shall incorporate worm gears of bronze and worms of hardened steel operating in a lubricating bath totally enclosed in a sealed water tight gear case.

All valves shall be equipped with adjustable mechanical stop-limiting devises to prevent over travel of the valve disc in the open or closed position.

Operator housing, supports and connections to the valve shall be designed with a minimum safety factor of five (5) based on the ultimate strength, or three, based on the yield strength, of the material used.

Extension stem for valves shall be galvanized seamless steel pipe Schedule 80 with pinned coupling.

Support housing for extension stem shall be seamless steel pipe specified above, schedule 40 with reinforcing steel ribs if required.

Each rising-stem shall be provided with stem guard. The stem guard shall be galvanized seamless steel pipe specified above, Schedule 40. The guard shall be of sufficient diameter and length to permit full travel of the threaded stem without obstruction. Top of the guard shall be closed galvanized steel cap.

The stem guides shall be so constructed that when properly spaced they will hold the stem in alignment and yet allow it enough play to permit easy operation.

The guides shall be spaced in accordance with the manufacturer’s recommendations for each stem size. The guides shall be adjustable with respect to the bracket to provide proper concentric alignment with the stem, and shall be so designed that alignment will be maintained after adjustment. Brackets shall be attached to the wall by sufficient anchor bolts to prevent twisting or sagging under load.

Each floorstand unit shall be provided with a position indicator to show the position of the valve disc at all times.

Manual operator shall require an input force of not greater than 178 N pull on either hand wheel or crank. Hand wheels shall be of cast iron, clearly marked with an arrow and the word “open” and “close” cast in relief on the rim. Hand wheel shall be of the spoke type only. Webbed or disc type shall not be used.

All operators, whose pipe center line is less than 2.0 meters above the operating level shall be of the hand wheel type, unless noted otherwise.

All operators, whose pipe center line is more than 2.0 meters above the operating level, shall be of the chain operated type with chain sufficiently long to reach to 0.9 meters above the operating level, unless noted otherwise.

(2) Manual Operators

• Manual Operators for Gate Valves

Manual operators for gate valves, 500 mm and smaller including resilient-seated

gates, NRS type shall be wrench nuts and hand wheels type without gear ratio. OS&Y rising stem type resilient-seated gate valves shall be equipped with hand wheels without gear ratio. The wrench nut shall be 35 mm square at the base with taper 1 to 20 on each side to top of nut, and 63 mm high.

• Manual Operators for Butterfly Valves and Ball Valves

Manual operators for butterfly valves and ball valves shall be essentially an integral part of a butterfly valve. The rated torque capability of each operator shall be sufficient to seat, unseat, and rigidly hold in any intermediate position the valve disc it controls under the maximum operating condition. All valves shall be equipped with an adjustable mechanical stop-limiting devices to prevent over-travel of the valve disc or ball in the open and closed positions. Operator housings, supports, and connections to the valve shall be designed with a minimum safety factor of five (5), based on the ultimate strength, or three (3), based on the yield strength, of materials used.

All gears operators shall be self-locking and designed to transmit two (2) times the required operator torque without damage to the faces of the gear teeth. Each manual operator shall be equipped with a position indicator which shall read both in percent (0 – 100%) with minimum graduation of 5% and in degrees (0 – 90 degrees) with minimum graduation of 5 degrees. The graduation shall be engraved on operator cover plate.

• Gearing

Gears shall be of steel, or bronze, accurately machines with cut teeth, and smooth running with suitable shafts in bronze sleeve bearings or roller bearings of ample size.

All gears and bearings shall be enclosed in a cast-iron housing. Fittings shall be provided so that all gears and bearings can be periodically lubricated. For remotely operated valves, the operator shall be supplied with a cast-iron pedestal, machined and drilling to receive the gear housing and drilled for bolting to the operating floor.

(3) Electric Valve Operators

• General

Two (2) types of electric valve operators such as Type A, integral control type and Type B, standard type shall be specified hereinafter.

Each type electric valve operator shall be furnished in weather-proof construction. The motor shall operate on 400 volt, 3-phase, 50 Hertz, service for open-close and throttling service.

Each type electric valve, operator shall be mounted by the valve manufacturer, tested and adjusted prior to shipment. All electric valve operators shall be designed and manufactured in accordance with AWWA C540 and shall be Limitorque SMB type or other type approved by the Engineer.

Electric valve operator, Type A shall be integral control type and shall include, but not be limited to, the electric motor, reversing magnetic starter, limit switches, torque switches, space heaters, valve position potentiometer if specified, push-button station, shop wiring, gear case and a declutch hand wheel to allow manual operation of the valve.

The valve control units shall have pushbutton stations furnished in enclosures suitable for flush panel mounting or field mounting as required. The stations shall include pushbuttons, status lights, and a selector switch all as required.

Electric valve operator, Type B shall be standard type and include, but not be limited to, the electric motor, reversing magnetic starter, limit switches, torque switches, space heaters, valve position potentiometer if specified, shop wiring, gear case and a declutch hand wheel to allow manual operation of the valve.

• Electric Valve Operators for Butterfly Valve

Gear Case shall be of cast iron. Flanges for motor attachment and pedestal attachment shall be integrally cast, fully machine and template drilled.

Motors for electric valve operator shall be capable of producing not less than 1.5 times the required operator torque.Any gearing in direct association with the electric motor shall be totally enclosed and shall operate in a lubricant.

Operator shall include an adjustable torque or thrust-limited switch capable of stopping the power to the motor when the valve has reached the stops in the open or closed position or when an obstruction has been encountered in either direction of travel. Torque switches shall be factory set to satisfy the calculated value corresponding to the maximum operating conditions.

Limit switches shall be geared to the drive mechanism and in step at all times whether the unit is operated electrically or manually.

The switches shall be of the adjustable type capable of being set to trip at the fully open or fully closed valve positions or at any point between.

All electrical inter-connections between limit switches, torque switches, indicator lights, and so forth, shall be factory- wired and ready for operation.

All gearing used in connection with limit switches shall be factory-lubricated. Operator shall be provided with a position indicator to show the position of the valve at all times. The indicator shall read in percent (0 – 100%) with minimum graduation of 5%.

Operator shall be equipped with a handwheel for manual operation.

The hand wheel shall be connected so that operation of the motor will not cause the handwheel to rotate and the operation of the handwheel shall not cause the motor rotor to rotate.

The handwheel shall be engaged by an exterior lever or an automatic clutch. The action of the lever shall also declutch the motor if there is no device to accomplish this automatically when the power supply to the motor ceases.

Should the power return to the motor while the handwheel is in use, the design of the unit shall prevent the power from being transmitted to the handwheel.

An arrow and the word “open” and “close” shall be placed on the handwheel to indicate direction of resultant valve movement. Lettering shall be in the English language.

(d) Strainers and Sight Glasses

The following strainers and sight glasses shall be specified hereinafter:

(1) U-Type Strainers

U-type strainers shall be quick open-and-close type strainers. Strainers shall consist of body, removable body cover plate, mesh cage and yoke with bolt. Strainers shall be constructed so that mesh cage shall be readily accessible, removable, and replaceable without use of special tools and removing the strainer from the line. Removable body cover plate shall have air vent plug and be fixed to the body by means of yoke and bolt. Body shall have drain plug.

Mesh cage shall consist of inner mesh cage and outer perforated metal cage. Unless otherwise specified, inner mesh size shall be 40. The strainers shall have flanged ends, and working pressure shall be 0.98 MPa for nominal size 50 mm and smaller and 0.735 MPa for nominal size 65 mm to 150 mm.

(2) Y-Type Strainers

Y-type strainer shall consist of body, removable body cover plate, mesh cage. Strainers shall be constructed so that mesh cage shall be readily accessible, removable, and replaceable without use of special tools and removing the strainer from the line. Removable body cover plate shall be screwed type for nominal size 50 mm and smaller and flanged type for nominal size 65 mm to 200 mm. Mesh cage shall consist of inner mesh cage and outer perforated metal cage. Unless otherwise specified, inner mesh size shall be 40. The strainer shall have flanged ends and working pressure shall be 1.568 MPa.

(3) Sight Glasses

Sight glasses shall consist of flanged body and two sight glasses with glass holders. If specified, sight glass shall have colored plastic balls. Working pressure shall be 0.98 MPa.

Body for chemical service and for general purpose shall be Type 316 and 304 stainless steel casting respectively.

5.2 Detailed Specifications Mechanical Equipment

5.2.1 Centrifugal Pumps

(a) General

Pumps supplied shall be capable of satisfying the performance requirements as specified. Prime considerations for the selection of pumps will be efficiency, reliability, trouble free operation and low maintenance requirements.

Pumps shall be quiet in operation and free from vibration. Preference will be given to pumps with lower revolving speed. Casings, unless otherwise stated, shall be of best quality closed grained cast iron and capable to withstand all pressures that may be produced due to normal operating and pressure surges.

Pumps shall be mounted on base plates or suction stools manufactured of cast iron. The pumps shall be accurately aligned and located by dowels or machined spigots. Holes shall be provided in the base plates or stools for foundation bolts.

The pump shafts shall be of adequate size to avoid the possibility of fatigue failure and shall be shock and corrosion resistant. The pump shaft and elements shall be adequately designed to assume a rigid support of the impeller and to rotate without whip, vibration or undue deflection at all operating speeds and under all operating conditions. The impellers shall be designed to give a non-overloading characteristic over the range of duties stated.

All pumps, where applicable, shall be of the same manufacturer's design. All pumps shall be complete, with motor, gearbox, bearings, couplings, pressure gauge on the pumps delivery, as well as flushing connections on the pumps delivery and vacuum on the pump suction.

The pumps to be applied have the function of convenient test run for checking of equipment and replacing the parts easily at all times.

(b) References

The following standards are referred to.

• BS EN ISO 14691	Flexible Couplings
• ISO 3555 Class B	Testing Methods for Centrifugal Pumps, Mixed Flow Pumps and Axial Flow Pumps
• BS 1452	Gray Iron Casting
• ASTM B 584	Bronze Castings
• ISO 3555	Centrifugal mixed flow and axial pumps-Code for acceptance test - Class B.
• BS 292	Ball Bearings
• ISO 3555 Class B	Testing Methods for Centrifugal Pumps, Mixed Flow Pumps and Axial Flow Pumps
• ISO 2858	End Suction Centrifugal Pumps
• ASTM B 584	Bronze Castings
• BS 1452	Gray Iron Castings
• ISO 2858	End-suction centrifugal pumps (rating 16 bar) Designation, nominal duty point and dimensions
• ISO 3069	End-suction centrifugal pumps - Dimensions of cavities for mechanical seals and for soft packing

It shall be the Contranctor's responsibility to comply with the requirements of all Codes and Standards which are applicable to meet the Specification.

The following Codes and Standards from s part of the Specification : International Organization for Standardization(ISO)

- ISO 2858 End-suction centrifugal pumps (rating 16 bar) – Designation, nominal duty point and dimensions

The edition or revision of the Codes and Standards shall be the edition current at the EFFECTIVE DATE of the AGREEMENT.

The Contractor shall advise COMPANY of any changes to Codes and Standards after the EFFECTIVE DATE. The Contractor shall comply with COMPANY instruction to comply with any changed Codes and Standards.

The Contractor shall advise of conflict among any referenced Codes and Standards and any technical specification and COMPANY will determine which shall govern.

(c) Pump Performance

The pump head versus flow characteristic shall be stable, rise continually to close valve head and be non-overloading.

The closed valve head shall be a minimum of 110% of the duty head.

The Contactor shall select the most economic pumps given the constraints of the operating parameters, as operating costs will be considered in association with the capital costs in the tender evaluation.

Characteristic and system curves for the pumps against the various static heads shall be supplied with the bid. When tested through their complete range of workable heads at the manufacturer’s works the pumps shall give results which conform to the stated duty points. The curves shall be presented at a reasonably large scale and shall also show pump efficiency and kW loading.

Where pumps are working in multiple parallel operations they shall operate satisfactorily on the system curve regardless of the number of pump sets running and not approach run out condition.

The system design and pump curves shall illustrate the design conditions with operational efficiencies and power demands illustrated on the systems curve or envelopes and shall take account of at least the following conditions

(1) the full range of static heads occurring in the works

(2) the various possible combinations of parallel pump operation

The net positive suction head required (NPSHR) curve for the full range of operation shall be submitted and shall be compatible with the available to enable the pump to operate, without cavitations over the full range of flows at all liquid levels.

Pump motors shall be rated a minimum of 10% higher than the maximum power required by the pump across the whole of its operating duty.

Where pump sets are fitted with flywheels for surge control reasons, the pumps motors and associated starters shall be suitably sized to cater for the increased starting torque requirements.

The Contractor shall provide with the bids, sales brochures for the plant offered and shall include technical details of materials of construction, thrust bearings, lubrication and sealing.

(d) Materials and Workmanship

(1) General

All materials shall be of the highest grade, free from defects and imperfections, of recent manufacture and unused, and of the classification and grades designated. Material not specifically described shall conform to the manufacturer's standard for the applicable part in the service intended.

All materials, supplies, and articles, not manufactured by the Contractor, shall be the products of recognized reputable manufacturers. The products of firms other than those specified herein will be accepted when it is proved to the satisfaction of the Engineer that they are equal in strength, durability, usefulness, and convenience for the purpose intended.

The Contractor shall furnish to the Engineer for his approval the names of the manufacturers of all machinery and other equipment which he contemplates incorporating in the work, together with performance capacities and other relevant information pertaining to the equipment. Samples of materials shall be submitted for approval when so directed. Equipment, materials, and articles installed or used without such approval shall be at the risk of subsequent rejection.

All wearing or erodible materials associated with water pumps shall be compatible with potable water and not impart taste, odour, colour or toxicity. Internal coatings shall be approved for use with potable water and external coatings if not specified shall be capable of withstanding continuous severe condensation. The paint manufacturer shall confirm and guarantee the suitability of his product for the working environment.

Workmanship shall be of the highest grade and in accordance with the best modern standard practice.

Liberal factors of safety shall be used throughout the design and especially in the design of all parts subject to alternating stresses or shock. For pumps, the maximum units stress due to maximum operating conditions shall not exceed the values given in the following table, with the exception of the pump shaft in which the combined torsional and axial stress shall not exceed seven (7) percent of the tensile strength of the material.

Item	Stress in Tension	Stress in Compression
Cast Iron	14.7	73.5
Plate Steel	88.2	88.2

For other materials used in the construction of the pump, the maximum stressed in tension or compression due to the most severe operating conditions shall not exceed one-third of the yield point or one-fifth of the tensile strength of the material. The maximum unit working stresses in shear shall not exceed 14.7 N/mm^2 in cast iron, nor more than 60 percent of the allowable stresses in tension for other materials.

(2) Pump Casing

The pump casing shall be high grade cast iron to BS 1452 (Double suction volute pump) cast steel (Single suction volute pump) or equivalent and be abrasive resistant, capable of taking shock loads and incorporate lifting eyes located for removal of the pump. Lifting eyes shall be collared, certified, tested and marked individually with identity number and Safe Work Load. Test certificates shall be provided. Suction and delivery branches shall be incorporated in the casing and include tappings for pressure gauges. Drain plugs shall be provided at the lowest point of the casing and automatic air release valves complete with isolating cocks and bleed lines, to the bedplate tundish, shall be provided on each stage of the pump. Flanges shall comply with BS 4772, ISO 2531 or equivalent and be drilled to suit the adjacent pipework. A suitably rated pressure gauge shall be provided with each pump set. The gauges shall be suitably damped internally to prevent damage through system pressure surges.

Pump casings and discharge pipework up to and including the isolation valves and

non- return valves, shall be rated for the maximum closed valve head developed; including the maximum suction pressure, or 16 bar, whichever is the greater.

(3) Impeller

Impellers on potable water applications shall be high grade bronze. On raw water applications the impeller shall be stainless steel or equivalent.

The impeller(s) shall be keyed and positively secured to the pump shaft and shall be designed so that there is no tendency for any parts to unlock due to reverse rotation of the pump.

Hydraulic balancing holes in the impeller will only be accepted on end suction overhung impeller water pumps and where the impeller is suitably reinforced to minimize stress concentrations.

(4) Casing Wear Rings

Removable wearing rings shall be provided on the pump casing. Casing wear rings shall be locked to prevent rotation by dowel or similar approved method. Ease of replacement shall be a major design criterion. The wear rings shall be of bronze casting conforming to ASTM B 584 or better and designed such that hydraulic pressure aids the sealing of the ring into the pump casing. Casing wear rings shall be incorporated on all rotating/stationary interfaces.

(5) Bearings

• Thrust Bearing

The axial thrust generated shall be taken by an appropriate thrust bearing arrangement. Thrust bearing arrangements incorporated into the motor housing are not permitted. Setting of thrust bearings shall account for dynamic loading.

• Rolling Element Bearing

Ball or roller bearings shall comply with BS 292 or equivalent and shall be sealed for life. They shall be rated to give a minimum life of 70,000 hours at maximum load without replacement. Bearings shall be protected by water throwers and lip seals.

• Submersible Bearings

Submersible bearings shall be of the water lubricated type with corrosion resisting outer shell and internal lining of high resilience and abrasive resisting properties. The shaft should be protected locally with shaft sleeves to ensure that particles in suspension in the water do not cause premature wear.

Intermediate support bearings shall be housed in a spider arrangement spigot to the discharge column flanges to ensure concentricity. The upper water lubricated bearings shall be maintained in a lubricated condition particularly on pump start up, in order to avoid dry running of the bearing.

• Plain/Bush Bearings

Bush bearings, where utilized, shall be in bronze or equal, split for easy maintenance and positively locked to prevent rotation.

(6) Sealing

• General

The means of sealing shall be soft packed gland.

- Soft-Packed Gland

Gland packing shall be graphite impregnated Polytetraflouroethylene (PTFE), of approved manufacturer. Asbestos based packing will not be permitted.

The gland design shall incorporate the following:

A tapered "lead in" at the mouth of the gland entry to facilitate packing replacement and obviate the risk of damage on assembly.

The surface finish of the adjacent metal parts shall be0.4 m CLA on the shaft gland sleeve and 1m CLA on the stuffing box bore.

Where running clearances are excessive, the packing shall be protected by an independent ring of suitably robust material which reduces the clearance to a minimum.

The packing must not be used as a bearing.

All studs, dowels and adjustable nuts shall be manufactured from stainless steel, Lantern rings shall be of gun metal or bronze and shall be split for ease of' removal.

Pumped water supplies to the lantern ring shall be free from abrasive solids.

- Seal/Gland Drainage

Seal/gland drainage shall be collected in a collecting tray formed integrally with the pump casing stuffing box. The tray shall not extend high enough to submerge the gland in the event of drain hole blockages. Drainage shall be piped to the bed plate tundish located at the non-driven end of the pump.

(7) Pump Shaft

- Shaft Sleeves

Where shafts are exposed to the process fluid and where they pass through the sealing gland they shall be fitted with sleeves of bronze or stainless steel, positive driven and which extend through the stuffing box. Bronze casting shall conform to ASTM B 584 or better. Type of stainless steel shall be 304, 420 or others. The finish of the sleeve at the seal faces shall be highly polished (15 microns). Where a pump is drawing water from a river intake stainless steel sleeves shall be fitted.

The diameter of the sleeve shall not be taken into account when calculating shaft stiffness.

- Balance

The whole of the rotating assembly, including impeller locking key(s) but excluding the impellers shall be dynamically balanced as an integral component. The impellers shall be dynamically balanced separately and then assembled to the shaft, to form without further adjustment, a dynamically balanced whole.

(8) Mounting

- Horizontal Mounting

Horizontal pump sets shall have the pump and motor mounted on a common bedplate of cast iron or fabricated steel which shall incorporate machined reference surfaces to permit levelling of the assembled pump set on its foundation. The bedplates shall be fully supported on sets of steel packers and shims which shall be not less than 80 mm wide or twice the width of the bedplate frame and drilled for positive location. Not more than one packer and two shims shall be used at each location point.

The pump shall be mounted on and bolted to the bedplate and unless positively located be dowelled in its final position with not less than 0.75 mm, of brass shimming between the pump and bedplate. The motor shall not be dowelled until after final alignment on site has been checked and approved by the Employer's Representative. Dowel pins shall be Grade A in accordance with BS 1804 Part 3 or equivalent.

• Vertical Mounting

Close-coupled pump sets complete with motor shall be mounted on a rigid stool incorporating the coupling, coupling guards and thrust bearing where applicable.

Where the design requires the pump to be mounted on a separate floor below the drive motor because of the possibility of pump room flooding or for the purposes of locating motors adjacent to switchgear, shaft driven pumps shall be provided. The shaft may be open or enclosed and shall incorporate intermediate steady bearings as determined by the transmitted power, speed, length and diameter. Intermediate shaft lengths shall not exceed 3m and shall run below their first critical speed, vibration free.

The shaft shall be supported such that the weight of the shaft is not transmitted to the pump and motor bearings. A thrust bearing assembly shall be incorporated into the drive motor stool to take the weight of the shaft and include all necessary ventilation and cooling coils if required.

Each intermediate shaft shall be independently supported and designed such that there is no transmission of vibration between supports via walkways, support steelwork etc.

The Contractor shall be responsible for the provision and erection of all support steelwork for the support bearings and shall undertake vibration studies as required to ensure that vibration effects are not transmitted to the supporting structures and/or buildings which may impart resonance effects to those structures/buildings.

The support stool shall be manufactured from either close grained cast iron or fabricated steel. The stool shall be founded on a separate foundation plate permanently bolted and grouted to the structural floor; the motor stool shall be located relative to the motor by a machined spigot flange and to the foundation plate by the same or dowel pins together with the necessary number of securing bolts. The upper face of the motor stool shall not be less than 600 m above the finished motor room floor level.

The intermediate bearings shall be self-aligning ball or roller type housed in Plummer blocks fixed and dowelled to the supporting steelwork.

Lubrication points or support bearings, universal joints, sliders, etc. shall be readily accessible from permanently fixed access platforms provided under the contract or piped to ground level unless otherwise specified.

After manufacture and assembly, including setting pre-load in the universal coupling bearings, the shaft assembly shall be dynamically balanced.

(9) Couplings

• General

Couplings shall be provided to permit the removal of drive shafts, bearings, etc. without removing the pump or motor. Couplings between the thrust bearing and motor shall be accommodated within motor/support stools.

Couplings shall be of the pin and buffer type unless otherwise specified.

• Coupling Alignment

After coupling alignments the Employer shall witness and accept the machine alignments which shall be recorded in accordance with BS 3170 or equivalent.

(10) Rating Plates

Rating plates shall be fitted to all pumps, be manufactured and fixed by corrosion resistant material (excluding brass) and include full details of the pump including size, type, serial number, best efficiency, duty point flow, head, speed, NPSH and the closed valve head.

The weight of the pump set, motor and bedplate or stool shall be marked on the pump set data plate.

(11) Guarding

All machine enclosures shall be safeguarded in accordance with BS 5304 or equivalent and with guards fixed to either the pump set bed plate or motor stool whichever is appropriate. Couplings shall be totally enclosed.

Shaft guards shall extend the whole length of the shaft and include hinged access doors at lubrication/inspection points for couplings, bearings, sliding joints, etc. Mesh sizes or apertures in the guard shall not exceed 12 mm diameter or 12 mm square.

(12) Lifting Brackets

Integral lifting brackets, shackles and lifting eyebolts shall be manufactured from stainless steel with minimum ultimate tensile strength of 540 MN/m^2, and certified in accordance with BS 4278 or equivalent. Both bolt and hole shall be permanently marked, preferably by punching, with the diameter and thread form used. All eyebolts shall be of the collar type.

5.2.2 Submersible Pumps

(a) General

Submersible pumps shall suit the duty or capacity specified in the Bid Drawings The pump shall be direct driven by a close-coupled electric motor. The maximum pump operating speed shall be 1800 RPM.

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the specified flow range without surging, cavitation, or vibration.

The pumps shall not overload the motors for any point on the maximum speed pump performance characteristic curve within the limits of stable pump operation as recommended by the manufacturer to prevent surging, cavitation, and vibration, as well as throughout the entire pump operating range.

The service factors for the motors shall not be applied when sizing the motors. To ensure vibration-free operation, all rotating components of each pumping unit shall be statically and dynamically balanced.

The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided.

In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the limits set forth in the latest edition of the Hydraulic Institute. Excessive vibration shall be sufficient cause for rejection of the equipment.

All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection, and operation.

All units shall be so constructed that dismantling and repairing can be accomplished without difficulty.

(1) Casing

The casing shall be of close-grained cast iron to the requirements of ASTM A48 Class 40 designed for maximum heat transfer to the surrounding liquid. The casing shall be fitted with renewable wear rings

(2) Impeller

The impeller shall be constructed of close-grained cast iron, ASTM A48, Class 30 or better to the manufacturer's standard grade, preferably secured to the 316 stainless shaft by keying. The pump shall be provided with a separate, removable suction plate constructed of the same material as the casing.

(3) Shaft

Shaft seals shall be doubled and selected for a long service life. The choice of face material shall be suitable for the pumped media and to the recommendation of the seal manufacturer. However, it is envisaged that as a minimum the inner mechanical seal shall be constructed with a solid block carbon rotating seal face and a solid block silicon carbide stationary seal face.

(4) Fasteners

The pump-set shall be fitted with a stainless steel lifting handle designed for simple, safe and speedy removal of the pump-set using a permanently installed stainless steel lifting chain and shackle. Eyebolts shall be stainless steel. It shall be provided with stainless steel built in strainer.

(5) Motor

Motor housing shall be cast iron and hermetically sealed, squirrel cage induction type in oil filled chamber. Power shall be 400V, three phase, 50 Hz.

Motor and pump shaft to be integral, and provide waterproof, oil resistant, grounded, flexible power cord. Motor shall non-overloading throughout entire pump curve.

Capable of running dry for extended periods without damage to motor or seal

Provide motor of totally submersible design, enclosure IP 68 or equivalent.

(6) Motor lead cable:

Conductors shall be copper stranded wire. Jacket shall be Vinyl or neoprene. Terminal head grommet shall be Epoxy sealed Buna - N.

(7) Discharge connector (with guide rail, lifting device)

The guide rail system design shall be such that the pump will be automatically connected to the discharge piping when lowered into place on the discharge connection. The pump shall be easily removable for inspection or service, requiring no bolts, nuts, or other fasteners to be disconnected, or the need for personnel to enter the wet well.

Intermediate guide brackets are recommended for rail lengths over 6meter. Guide rails are part of the pump package and shall be supplied by pump supplier.

The discharge connector shall be manufactured of cast iron, ASTM A48 Class 30. It shall be designed to adequately support the guide rails, discharge piping, and pumping unit under both static and dynamic loading conditions with support legs that are suitable for anchoring it to the wet well floor.

The face of the inlet discharge connector flange shall be perpendicular to the floor of the wet well.

The pump design shall include an integral self-aligning sliding bracket.

Sealing of the pumping unit to the discharge connector shall be accomplished by a single, linear, downward motion of the pump.

The entire weight of the pump unit shall be guided to and wedged tightly against the inlet flange of the discharge connector, making metal to metal contact with the pump discharge forming a seal without the use of bolts, gaskets or O-rings.

Lifting chains, either galvanized or stainless steel, is suitable for removing and installing the pump unit.

5.2.3 Coarse Raked Bar Screens

(a) General

Front raked coarse bar screens shall be installed at the head of the inlet treatment plant. Each screen shall have bar spacing of 60 mm.

The rack shall consist of a number of 316 grade stainless steel bars of tapered section supported on a framework, which shall be fixed to the channel walls. Each bar shall be individually supported at the bottom and at a point above top water level in the channel. The bar rack shall be inclined in the direction of flow.

water shall be prevented from passing around the sides or underneath the screen by heavy

5.2.4 Fine Screens

(a) General

The screens shall consist of continuous basket of linked stainless steel mesh mounted in the inlet channel at an angle (75~90 degrees). Debris and suspended solids present in the wastewater flows shall retained by these mesh baskets. Each end of the mesh baskets shall be connected to a drive chain which is driven by chain wheels. Each chain shall be driven by a sprocket on a common shaft and a flange mounted geared motor. The screens shall be designed to prevent long fibers from passing through and shall be able to cope with a significant amount of gravel and grit.

At their upper turning point the perforated plates shall be continuously cleaned by a high speed rotating brush which shall remove the screenings from the perforated plates. The cleaning action shall be supplemented by an integrated spray bar that jets the screenings from the panels from inside to outside.

Screenings shall be transported along the launder trough via the flow of wash water, to the screenings handling plant for disposal into skips.

The screens shall be designed so as to facilitate safe inspection, cleaning, lubrication and repair to ensure safe and satisfactory operation under all service conditions. The screens shall be able to tilt by means of a pivot out of the channel to allow the sections normally located below the coping level to be inspected and maintained.

Screen must be a through flow type. Each Screen must be consist of head sprocket, frame screen basket and foot sprocket attached on chain of two sides, driving device of 2.2 m/min to operate the screen, water sprinkling device for screen cleaning, housing, take-up device, and control panel.

It must be included motor-operated valve which can supply and block quantity of water of water sprinkling device, Submerged parts in the water and chain of screen must be a oilless lubricate type that don't contaminate drinking water.

All parts of the screen must stand against external force that may be come from manufacture, transportation, installation, operation and maintenance. And it must be manufactured to keep normal operation of the 760 mm head loss.

(b) Frame

Steel structure screen frame must be a single-body type (two-post type), and support the upper part and the lower part. The lower screen frame must be manufactured strongly by steel structure of minimum 10 mm thickness, and stiffener and cross-support must be equipped for strength. The lower screen frame must be attached by the more than 2 points of same length.

The carrier chain guide must be made of steel and driving distance should not exceed 6mm to prevent basket from trapping.

Lifting ring must be attached in the upper part. Also, in the part of lower frame, equipment for lifting and supporting must be considered in preparation for installation and removal.

(c) Basket

Wire screen must be a diameter 2 mm of STS304 wire, space 20 mm mesh type, and clamp which fix screen basket must be consisted of basket lip manufactured by pultrusion and end plate manufactured by compression molding. Inner part of lip must be filled in order to prevent flotation effect.

Also, basket lip must be manufactured in same size in order to prevent from torsion, sagging and the inflow of trash by reduction of gap between baskets.

(d) Chain

Side bar of carrier chain must be made of stainless steel of more than 10mm thickness. Diameter of chain roller must be more than 125 mm and its of chain pin must be more then 40mm.

Chain bushing and pin must be made of stainless steel, and roller must be made of MC NYLON, and drive must be matched to the sidebar

(e) Driving device

Driving reducer must be cyclo reducer and have anti-friction type bearing. Gear must be located in the strong case for promotion of oil- bath lubrication, and, oil must not leak in every case.

(f) Sprocket

Head and foot shaft must be a stainless steel. Foot shaft must be fixed strongly at screen main frame.

All bearing must have oilless bushing, and bearing which is used on the water must have proper lubricate ring. Head shaft bearing must be able to adjust vertically and fixed strongly, in order to prevent from movement.

(g) Shaft and bearing

Head and foot shaft must be a stainless steel. Foot shaft must be fixed strongly at screen main frame.

All bearing must have oilless bushing, and bearing which is used on the water must have proper lubricate ring. Head shaft bearing must be able to adjust vertically and fixed strongly, in order to prevent from movement.

(h) Housing

Housing must be attached by bolt at head part, and cover water sprinkling device and trough. Housing must be a stainless steel of more than 2 mm thickness and be able to make waterproof.

Waterproof packing must be installed in order to access to cleaning water vessel, and inspecting window and door must be installed. The rear housing must be able to cover behind of screen head part entirely, and must be made of plate of 2 mm thickness.

Upper part of housing must be fixed at screen head part by bolt, and lower part of housing must be removable easily in order to approach at basket chain of basket.

(i) Water spray device

Wash water shall be used to supply the screen spray nozzles to facilitate removal of screenings.

Spray water from device must be scattered on the whole of screen. Debris and cleaning water must be discharged through the trough in the bottom. Spray water header must be included ON/OFF auto-operated valve of minimum 80 mm diameter.

An isolating valve, solenoid valve, pressure reducing valve (to eliminate spray) and in line strainer shall be fitted.

The wash water shall be discharged into trough from the site washwater system at a minimum pressure between 3 and 5 bar

(j) Guide rail

The Guide rail for frame fix is installed through water channel well, and must be manufactured enough strength for screen operation and head loss

(k) Test and inspection

Driving device of screen must be assembled at the factory before site installation. The performance test must be conducted by no-load running with the site condition at the factory.

The result above performance guarantee must come out, even if performance test at the factory is conducted with disadvantage condition in comparison with site condition. And suitability of site installation and operation must be checked.

Site inspection : After site installation Screen load-test must be checked a smooth operation.

5.2.5 Roller Gates

(a) General

The Technical Specification contained herein shall be used for the mechanical construction of the roller gate, which involves with all accessory facilities including gate leaf, guide frame and actuator.

The Contractor shall comply with all contract documents as well as the technical instruction.

STRUCTURE & QUANTITY

STAINLESS STEEL PLATE GIRDER TYPE ROLLER GATE :

- ROLLER GATE : 3.5 M (B) x 3.5 M (H) x 2 SET

- ROLLER GATE : 3.0 M (B) x 3.0 M (H) x 11 SET

- ROLLER GATE : 3.0 M (B) x 2.5 M (H) x 5 SET

- ROLLER GATE : 2.5 M (B) x 2.5 M (H) x 16 SET

- ROLLER GATE : 2.0 M (B) x 2.0 M (H) x 26 SET

- EMERGENCY GATE : 1.0 M (B) x 1.0 M (H) x 14 SET

(b) Technical Items

<SUBJECT TO DESIGN REQUIREMENTS>

FORM	STAINLESS STEEL PLATE GIRDER TYPE ROLLER GATE
QUANTITY	5.0 M (B) x 3.0 M (H) x 1 SET (CLEAR SPAN x CLEAR HEIGHT) HANDLE TYPE ACTUATOR MOTOR 10TON
	3.5 M (B) x 3.5 M (H) x 2 SET (CLEAR SPAN x CLEAR HEIGHT) HANDLE TYPE ACTUATOR MOTOR 8TON
	3.0 M (B) x 3.0 M (H) x 11 SET (CLEAR SPAN x CLEAR HEIGHT) HANDLE TYPE ACTUATOR MOTOR 8TON
	3.0 M (B) x 2.5 M (H) x 5 SET (CLEAR SPAN x CLEAR HEIGHT) HANDLE TYPE ACTUATOR MOTOR 8TON
	2.5 M (B) x 2.5 M (H) x 16 SET (CLEAR SPAN x CLEAR HEIGHT) HANDLE TYPE ACTUATOR MOTOR 6TON
	2.0 M (B) x 2.0 M (H) x 26 SET (CLEAR SPAN x CLEAR HEIGHT) HANDLE TYPE ACTUATOR MOTOR 5TON
	1.0 M (B) x 1.0 M (H) x 26 SET (CLEAR SPAN x CLEAR HEIGHT) HANDLE TYPE ACTUATOR MOTOR 1TON

1. DESIGN CONDITIONS

- STRUCTURE

  THE STEEL MADE PLATE GIRDER TYPE ROLLER GATE WITH THE SKIN PLATE ADJACENT TO THE LOWER REACHES

- WATERTIGHT MECHANISM

  WATERTIGHT IN ALL DIRECTIONS

- MECHANISM

  HANDLE TYPE POWER ACTUATOR MOTOR & MANUAL

- WINDING SPEED

  0.3 m/min ± 10 %

- POWER

  AC 60 Hz 3 Φ 380 V

- OPERATION

  OPERATION AT WORK SITES

2. ALLOWABLE STRESS

< STEEL>

- SS304 (IF THE THICKNESS < 40 m/m)

(1) AXIAL TENSILE STRESS (AGAINST THE PURE CROSS-SECTION AREA) 1,050 kg/cm²

(2) BENDING STRESS: TENSILE FORCE OF THE BEAM (AGAINST THE PURE CROSS-SECTION AREA) 1,050 kg/cm²

(3) SHEARING STRESS (AGAINST THE TOTAL CROSS-SECTION AREA) 600 kg/cm²

- SS400 (IF THE THICKNESS < 40 m/m)

(1) AXIAL TENSILE STRESS (AGAINST THE PURE CROSS-SECTION AREA) 1,200 kg/cm²

(2) BENDING STRESS: TENSILE FORCE OF THE BEAM (AGAINST THE PURE CROSS-SECTION AREA) 1,200 kg/cm²

(3) SHEARING STRESS (AGAINST THE TOTAL CROSS-SECTION AREA) 700 kg/cm²

<ACTUATOR>

The tensile stress calculated by the rated torque of the motor shall have the safety factors as below and the tensile stress calculated in the maximum torque of the motor shall not be greater than 90% of the yield stress of the material used.

* SAFETY FACTORS OF THE MATERIAL USED

TYPE	TENSILE STRENGTH	COMPRESSIVE STRENGTH	SHEARING
STRUCTURAL ROLLED STEEL(SS, SM)	5	5	8.7
CARBON STEEL FORGING(SF)	5	5	8.7
MACHINE STRUCTURAL CARBON STEEL(SC)	5	5	8.7
CARBON STEEL CASTING (SC)	5	5	8.7
STAINLESS STEEL (STS)	5	5	8.7
GRAPHITE CAST IRON (GC)	10	3.5	10
BRONZE CASTING (BC)	8	8	10
AGAINST THE STATIC LOAD OF THE WIRE ROPE SWITCH	8		
PLATE LINK CHAIN	6.5		

The bearing stress of the axis shall be determined based on the following table.

TYPE	BEARING STRESS (kg/Cm²)		
	ROTATING PART		HOLDER
	ACTUATOR	LINK	
BRONZE CASTING (BrC) PHOSPHOR BRONZE CASTING (PBC) LEADED TIN BRONZE CASTING (LBC)	70 -100	150 - 200	
OILLESS BEARING 500 SP (HB : > 210)	< 250	< 250	< 500

<MATERIALS USED>

The materials of construction are required to meet the quality requirements stated below or better qualities.

These materials shall be recorded in the specification and the warranty, and shall be evaluated by bills.

Gate Leaf and Guide Frame

(1) SKIN PLATE : STS 304

(2) RUBBER

Material Quality : NEOPRENE

Tensile Strength : > 150 Kg/Cm²

Flexibility (When being destructed) : > 300 %

Absorptivity : < 5% at maximum

Hardness : 40 - 80° (SHORE)

Specific Gravity : 1.1 - 1.4

(3) Contact Surface of Main Rail Roller : STS 304

(4) Main Rail Beam : SS 400

(5) Rubber Contact Surface : STS 304

(6) Concrete Protection Plate : STS 304

(7) GUIDE BEAM : SS 400

(8) BOLT NUT & WASHER : STS 304

(9) MAIN ROLLER : SSC 13

(10) MAIN ROLLER METAL : OILLESS METAL

(11) MAIN ROLLER SHAFT : STS 304

(12) SIDE ROLLER : STS304

(13) SIDE ROLLER METAL : OILLESS METAL

(14) SIDE ROLLER SHAFT : STS 304

(15) SIDE ROLLER BRACKET : STS 304

(14) RACK BAR BRACKET : STS 304

Actuator (Power Handle Motor Type)

(1) Control Running Gear, Casing Body : GC 200

(2) Gear Reduction Pulling Up Body : GC 200

(3) Rack bar : SS 400

(4) Bolts : STS 304

(5) Cover : STS 304

<DETAILS OF GATE LEAF>

- The skin plate shall be vertically installed to outside and the lower end shall have a proper slope.
- The gate leaf shall be sufficiently solid and structured to be safe against vibrations and impacts.
- The side of the gate leaf shall be structured in which its profile is reduced.
- The plate thickness of the gate leaf shall be at least 6 m/m and that of the shape steel shall

be at least 5 m/m.

- The bending of the gate leaf shall be within 1/800.
- In calculating the intensity of the gate leaf, the welding quality deterioration factors should be sufficiently considered.
- The seal rubber shall be structured in which both seals are available and the seal rubber on the side shall be shaped to cope with the elasticity of the gate leaf due to temperature changes and also with the movement of the gate leaf toward left and right.

  The seal rubber of the upper and lower parts should be able to cope with the movement by curvature changes of the gate leaf into the horizontal direction.

  The sealing rubber material shall be synthetic rubber and its structure shall be easy to be replaced while the material of the pressure plate and the bolt nut should be STS (stainless steel) with the replacement of the seal rubber taken into consideration.
- The main roller shall be a cantilever type and two rollers shall be installed on each side so that the roller and the axis could be easily separated from the gate leaf.
- Two side-rollers on each side shall be installed and the elasticity due to temperature changes should be taken into consideration for allowing gaps among guide metals.
- The surface of the roller should be formed as an arc so that it would not contact only one side even when the gate leaf bends due to the load of the water pressure.
- A dust sheat is required in order for foreign substances to get into the bush of the roller.
- The materials of main rollers, side rollers, metal bearings of the sheave should be oilless metal.
- The bracket of the gate leaf that is connected to the rack bar for the actuator should be installed as on the center line of the gate leaf as possible.

<DETAILS OF GUIDE FRAME>

- The guide beam shall be sufficiently solid against the pressure of the roller that is transferred from the gate leaf in order for the pressure to be transferred to the concrete from the lower flange, and the bearing and shear strength should be reviewed.
- In addition, the surface to which the main roller contacts shall be in the form of H-beam welded with stainless steel, and the anchor and the bolt for installation controls that are locked onto the initial concrete shall be installed hard in order not to cause any trouble when the secondary concrete pouring is carried out.
- The main surface of the roller rail should be stripped and finished, and the material should be 10+% harder than that of the roller.
- The roller rail beam should be calculated by Andree’s formula and be greater than the standard marked on the drawings provided for bidding at least.
- The watertight plates on the side and on the upper part shall be efficiently structured not to cause any trouble to the edge seal, and there should be sufficient room to cope with the elasticity of the gate leaf.
- The profile of the main roller rail beam shall be installed within ±2 m/m against the

overall length and ±0.5 m/m against the leg length.

- The rubber contact plate for the upper part supports shall be installed ±3 m/m against 10 m overall length and the contact plate of the seal rubber on sides shall be installed ±3 m/m against 10 m overall length.

<DETAILS OF THE ACTUATOR (Power Handle Motor Type)>

- The actuator type shall use lock bars, which makes it a handle-type.
- The material of each part shall meet the capacity of the actuator and the specifications, and shall be sufficiently solid for operations.
- Ensure to inject appropriate amount of gear oil inside the gear box so as to make it work properly.
- Make the gears precisely processed, treat the contact surface with heat, use the ball bearing to increase the efficiency.
- There should be a centrifugal break attached which works only on the way down in order to make it automatically drop.
- A disc plate break should be used as an power transmission device.
- The pulling-up speed and the actuation force should be made to meet the specifications of the actuator.
- The actuator is composed of a spur gear, a sprocket and a motor in a form which has the winding speed control device is attached that uses the centrifugal force electrically powered (manually as well).
- The gate positioner shall have a far-field manipulating device built inside and the upper and lower limit device should be structured to discretionally control the gate positioning from outside.
- The motor used for the actuator is a totally-enclosed special squirrel-cage type, which works at full voltage starting while the starting current is restricted to be less than 5.5 times of the rated current.

  The starting voltage of the motor should be greater than 200% as to the full-load torque and the maximum torque should be less than 300% as to the full-load torque.
- There should be a safety system designed in order for the hoist to work each of the motor control and the manual control separately.
- The rack bar shall have the gap among pins consistent in order for the rack bar made of the general rolled steel (SS400) to fit together perfectly with the sprocket gear, and should be solid enough to bear the load of the actuator.
- There should be a safety device for the rack bar and the gear box against the overload including the torque switch.
- The brake must have anti-reverse function to control only when closing the door, and install it on the single shaft.
- The centrifugal brakes should be operated only when closing the door, and it should be controlled by the centrifugal brakes at a rotation speed of 2 to 3 times faster than that of

the single shaft. It is possible to open the roller gate in a short time without stopping by turning the handle continuously by the brake means and the clutch means and to open the roller gate by simple operation of the clutch lever even when the roller gate is closed.

- The continuously variable transmission is to be of a structure in which the electric/manual switching can be smoothly operated even when the actuator is in operation. When operating the actuator, it should be a device that facilitates the mechanical safety improvement and the mode switching operation by automatically switching to the power mode simultaneously with the operation of the motor when operating the power switch in the manual mode.
- The overload prevention device is installed in the reducer and it should be structured to cut off the power of the motor by sensing the overload due to the foreign material when opening and closing the roller gate. Also, it should be able to control the torque according to the conditions of overload such as size, weight and water pressure of the rollergate.

<TOOLS>

The contractor should provide a full set of the tools could have the standard tools stipulated in the tool list attached to the contract and any part of the facility equipment installed, disassembled and inspected.

<PROCESSING>

- It is required to use the auto-gas in cutting different types of steels and the end should be finished flat.
- The steel quality should remain the same as it was when transformed. It is required to use the press roller to get the plate bended and processed and it is prohibited to use such tools as hammer and the like to get it deformed.
- It is required when welding to electrically get it welded and comply with the approved welding specifications stipulated in the manufacturing drawing.
- It is required to prevent twist or excessive residuals of the local stress when welding. And, it is principle to keep the downward welding.
- Only those holding qualification licenses over class 2 are allowed to work as welders.
- The manufacturing drawing should have such prerequisites stipulated on as welding sites, welding type, welding method, welding measures, separations between factory welding and site welding, whether or not to get the mechanical stress eliminated, separations between auto welding and manual welding, and so forth.

  The on-site welded joint shall be carried out on the spot which would have as little constraints as possible against the mechanical stresses and combinations.

- If the welding shall be carried out on multi-layers, it is required to have any slag or spatter completely removed and check if there is any defect on the layer prior to moving to the next layer for welding.

  It is required in speed welding to get gouging complete before starting welding.

- It is required to get an approval from the professional engineer for the shape of the butt welded joint of the skin plate.

- It is required to butt-weld and speed-weld the joint of the mainly intensive parts while it is also required to pay a special attention not to get the welded joints crossed.

It is also required not to have the welded lines get too close, and ensure to make it keep away over 5 times and 100 m/m from the rear of the plate at least.

<CONVEYANCE AND INSTALLATION >

According to the general provision of the specifications, the contractor should provide the conveyance plan prior to conveyance that includes the conveyance method, upload and download method and so forth, and also the on-site installation plan prior to installation that includes on-site assembly, installation orders, installation method, operation instructions of the machines to be used and so forth.

<PAINTINGS>

GATE LEAF

1) CLEANING

It is required to use sanding, electrically working tools, disc sander and the like or acid treatment to completely remove the foreign substances.

ROLLER, PIN, SHEAVE

(1) Coat the actuating components of the machine with the rust preventive oil.

(2) CLEANING

It is required to use sanding, electrically working tools, disc sander and the like or acid treatment to completely remove the foreign substances.

(3) PRIMARY COATING, COVER COATING.

ACTUATOR

(1) Coat each part of the actuator with the grease.

(2) PAINTINGS

○ PRIMER TREATMENT

It is required to use sanding, electrically working tools, disc sander and the like or acid treatment to completely remove the foreign substances.

○ PRIMARY COATING

ZINC RICH PRIMER (Organic 20+μ)

It is principle not to apply coating under following conditions.

(1) When the temperature is below 5℃.

(2) When the humidity is over 85%.

(3) When it looks like rain before the coating gets hardened and dried.

(4) When the surface of the steel is damp.

(5) When bubbles may occur due to the blazing sun.

(6) When the conducting film is not fully dried in the case that the coating overlaps.

(7) When the supervisory service admits that it is improper.

Those spots welded on sites shall not be coated each by 50m/m and after the on-site welding it shall be coated as instructed above.

The supervisory service consults with the coating contractor to determine the color of the coating above.

It is principle that the coating is inspected at each stage by the supervisory service and when it is unqualified, it should be re-coated.

<INSPECTION>

Inspections shall be carried out on materials, standards, welds, interim test, completion test and the items that the supervisory service requires.

- The material inspection includes such material quality and standards inspections as steels, wire ropes, seal rubber and the performance inspection of the actuator and other necessary components. And, the test inspection by an authorized institution or a manufacturer that the supervisory service approves can be equally accepted as an legitimate inspection.
- The weld inspection shall be visually carried as to improvements, gaps, cleanings of the welded surfaces before manufacturing. During manufacturing, complete removing of the slag on each layer and the first lay removing of the gouging shall be inspected.
- Non-destruction inspection shall be carried on the joint welds of main materials. And, the qualifying grade is as follows.

Factory welding joint: Qualifying Grade 2

- Trial assembly inspections shall be carried on gate leaf, guide frame and actuator.

All rollers, brackets and seal rubbers shall be taken onto the gate leaf and the actuator shall be no-load operation.

Other than the provisions stipulated in the technical specification hereof, the measure tolerances when the trial factory assembly is carried are as follows.

(1) Measure Tolerance of Each Part

$$\mathrm{E} = \pm\frac{E0}{2}(1+\frac{L}{10})$$

Yet, it shall not be over ± 20 m/m.

Here, Eo : In the case that the length is 10m, the standard tolerance (m/m)

L : Length of the Material (m)

Also, The measure of L is as follows.

Common measures such as width and height : ± 8 m/m

Center Distance : ± 6 m/m

Measure related to Watertight : ± 4 m/m

(2) Warpage against Entire Distance

Common Structural Part : 1/1000

Machine Processing Part : 1/2000

<Completion Test>

After completing the on-site installation, the completion test shall be carried out as follows.

- Assembly Inspection
  - (1) Gate Leaf Assembly Inspection
  - (2) Gide Frame Assembly Inspection
  - (3) Actuator Assembly Inspection
- OPERATION INSPECTION
  - (1) CONDITIONS
    - ○ No-Load
    - ○ Load before Filling with Water
  - (2) TIME
    - ○ BEFORE OPERATING
    - ○ DURING OPERATING
  - (3) TEST ITEMS
    - ○ ACTUATOR OPERATING CONDITION
    - ○ WATERTIGHT STATUS
    - ○ VIBRATION
    - ○ NOISE
    - ○ TEMPERATURE UP

(c) Various Standards Application

Following laws and regulations shall be applied in addition to the technical specifications hereof.

- British Standard, ISO

- Technical Specifications of the Sluice Steel Pipe (Japan Water Steel Pipe Association)
- Standard Specifications for Concrete
- Other Related Laws and Regulations

6. ELECTRICAL WORKS

6. ELECTRICAL WORKS

6.1. General

The work to be performed consists of power supply to electrical equipment, furnishing main electrical panels, local control panels, lighting panel boards, auxiliary equipment and materials and their installation in all sites. Services to be provided shall include all technical engineering, the supply, testing before shipment, transportation, insurance, storage, installation, testing at each site, documentation, and commissioning of equipment, the provision of tools and spare parts and the training of operations staff for Shire Valley Transformation Program 1.

The Contractor shall design, supply, install and test all items of equipment provided for the Works. All equipment and materials including tools, accessories and spare parts shall be new and unused of first class quality, free of manufacturing defects and imperfections and shall meet the requirements of the specifications.

The Contractor shall provide complete and functioning electrical equipment that meet current applicable standards and best practice including all engineering and accessories, necessary for reliable performance under the site conditions.

6.2. Standards and Regulations

The requirements of these specifications are minimum requirements for all supplies and performance. Except as provided in the specifications, design, all materials, equipment, performance, and the fabrication and testing thereof shall conform to the relevant ISO standards or the applicable standards from the following standards and regulations, as may be approved by the engineer.

1)	International Electro technical Commission	(IEC)
2)	Institute of Electrical and Electronics Engineers	(IEEE)
3)	American National Standards Institute	(ANSI)
4)	National Electrical Manufacturers Association	(NEMA)
5)	American Society for Testing and Materials	(ASTM)
6)	European Standards	(EN)
7)	International Organization for Standardization / Open System Interconnection	(ISO/OSI)
8)	International Telecommunication Union	(ITU)
9)	International Society of Automation	(ISA)
10)	Other standards or regulations approved by the Engineer	

The latest revision or edition of the applicable standards shall apply. All materials and workmanship not fully specified herein or covered by an approved standard shall be of such kind as is used in first class work and suitable for the climate of the project area.

Also particulars not described in this specification shall conform to the specification prepared by government agencies or related organization such as rules and regulations of the local enforcing authority, and requirements of the local power company.

6.3. Electrical Power Supply System

One complete lot of electrical power system shall be designed, supplied and installed by the contractor under this section for operating gates, pumps, valves, instruments and other equipment. Power supply shall be taken from distribution lines of local utility companies as Electricity Supply Corporation of Malawi (ESCOM).

The 3-phase 4 wire supply of 400V, 50Hz shall be used for power circuits, and the single phase 2 wire of 230V, 50Hz shall be supplied for lighting, indication, convenience outlet, control sources and similar small power circuits.

6.4. Name Plates

All major items of equipment shall be provided with a securely fastened nameplate showing the maker's name, model, serial number, year of manufacture, main characteristic data of the respective equipment and further relevant information specified in the applicable standards or necessary for the proper identification of the equipment involved.

The Contractor shall also supply and install label plates and other labeling (of the screw-on type) for control panels and other places where required for operational, functional and safety reasons.

The labeling, size of the plates, available language and their location shall be subject to approval of the engineer.

A sample label-plate (with indication of the material used) with lettering shall be submitted for this purpose. The sizes of the plates shall be standardized wherever possible.

6.5. Packing, Delivery and Storage

6.5.1. Packing

All equipment shall be carefully packed so as to withstand the duration of transport whether by sea or land including packing list in a waterproof envelop. Electrical equipment shall be fully protected against moisture during transit and storage. All items of material shall be clearly marked for easy identification against the packing list

All cases, packages etc., shall be clearly marked on the outside to indicate the total weight, to show where the weight is bearing and the correct position of the slings and shall bear an identification mark relating them to the appropriate shipping documents.

Cases which cannot be marked as above shall have metal tags with the necessary marking on them. The metal tags shall be securely attached to the package with strong steel wire or equivalent.

The shipping mark shall consist of information such as consignee, contract number, port of destination, item number, if applicable, package number in sequence and quantity per package, description of contents, gross weight, cubic measurement.

The finished surface of the equipment and the portion embedded in concrete shall be protected by rust preventive means.

The Contractor shall be entirely responsible for ensuring that the packing is suitable for transport of electrical equipment.

6.5.2. Delivery

The Contractor shall deliver all facilities including contractor's equipment provided under this section to the site in adequate time for its preparation and erection according to the construction time schedule.

The Contractor shall have responsibility of inspect the cargoes at the site upon arrival of the cargoes and shall report in writing the particulars, quantities, conditions, and damages of equipment to the engineer.

6.5.3. Storage at Site

The Contractor shall be responsible for the adequacy of all protection. The Contractor shall arrange at his own expense for covered storage or other protection of all materials and equipment against corrosion and mechanical damage. Any corrosion or damage that may occur to any item of the facilities shall be made good before that item is to be installed at the site.

All cases containing important machinery and electrical equipment shall be stored in the warehouse which shall be provided by the Contractor.

6.6. Tests and Inspection

6.6.1. General

During the manufacturing, the construction and after the installation work of each item of the facilities in this section, the contractor shall perform the tests as described in the test procedures to establish the accuracy of assembly and to prove the adequacy of the materials and workmanship.

The Contractor shall give to the engineer written notice of the data of the tests not less than 14 days in advance.

The Contractor shall provide professional staff, tools, meters, materials and other necessary to carry out tests and shall be fully responsible for the tests.

Any defect observed during the tests shall be repaired and improved by the contractor and be tested until it fulfills the specifications. It shall be considered acceptable until it has successfully complied with the specifications.

All cost for any tests required in this section and to repair in result of testing shall be deemed to be included in the appropriate prices of the Bill of Quantities.

All parts which are not consistent with specifications and drawings shall be changed without delay without additional cost from the Employer.

6.6.2. Material Inspection and Test

All materials, parts and assemblies thereof, entering into the plant shall be tested, unless otherwise indicated, according to the best commercial method for the particular type and class of work.

Witness tests and inspection of material may be made at the place of manufacture by the engineer unless otherwise specified. Such witnessing and inspection will be conducted so as to interfere as little as possible with manufacturing operation. The Contractor shall however comply with any reasonable request made by the Engineer concerning the method of test or correction of defective workmanship.

The testing of the specimens shall be carried out by the Contractor at his own cost and expense and shall be performed in accordance with the approved test procedure instructions.

6.6.3. Workshop Tests

All items of equipment shall be assembled in the shop prior to shipment and tests shall be performed by the contractor as may be required to demonstrate to the satisfaction of the engineer the adequacy of the equipment.

All electrical equipment and systems shall be tested completely and detailed in the contractor's workshop. All tests required by the codes and standards as well as all tests of manufacture shall be performed.

Test programs for workshop test including test procedure shall be approved by the Engineer prior to the start of the tests.

6.6.4. Site or Routine Tests

The Eontractor shall take out the equipment from their packing and shall inspect the equipment for damage due to delivery. The Contractor shall repair or replace any damaged portion of the equipment subject to approval of the Engineer.

During the construction and after the installation of each item of equipment, control device, piping system etc., tests shall be performed as specified in this section, to establish the accuracy of the assembly and to prove the adequacy of the equipment and the workmanship. All tests shall be made upon approval of the engineer.

6.6.5. Test on Completion

After any section or the whole of facilities under this specification has been fully installed, adjusted, tested and approved and parts under other sections for operating the plant are fully installed, the Contractor shall conduct the tests on completion in the presence of the engineer to demonstrate that the facilities has been correctly installed, all necessary adjustment and setting made, and is free from vibration and leakage under load, and meets the specification in all respects.

Insulation resistance test and continuity test shall be done during / after installation cables which are witnessed by the Engineer. The results should be recorded and submitted to the Engineer.

6.6.6. Test and Inspection Reports

Unless otherwise specified, the Contractor shall submit to the engineer all tests and inspection reports in accordance with following manners.

Place of test or Inspection	Number of report	Submitting time after the test
Manufacturer's shop	Discuss with the engineer	Before 14days for testing, and Before application for shipment
Site	Discuss with the engineer	After approval of the engineer

6.7. Spare Parts and Tools

6.7.1. Spare Parts

The Contractor shall supply spare parts for maintenance and repairs which are goods for a period of not less than three years operation. The items of spare equipment and parts to be supplied shall be equal or better than those recommended below but not be limited to.

All the spare parts and equipment shall be supplied with respective service manuals by contractor, and shall be clearly marked with its description and purpose on the outside of the packing, ready for long-term storage indoors.

Common parts and spare parts shall be interchangeable

1) Electrical materials
   a) MCCB and ELCB : 3 pieces per each type used in panel
      - MCCB (4P 225AF, 4P 50AF, 3P 30AF, 2P 30AF), ELCB (2P 30AF)
   b) General fuse & VT primary fuse : 20 pieces (each)
   c) Indicator lamp : 20 pieces
   d) SPD (Power, Signal, CCTV) : 3 pieces (each)
   e) Transducer (V, A, PF, KW) : 3 pieces (each)
   f) Motor protection relay : 3 pieces
   g) AS, VS and S/S : 3 pieces (each)
   h) Power capacitor & M.C : 3 pieces per each type used in panel
2) Remote Terminal Unit
   a) CPU and Power Supply : 2 pieces
   b) D/I Module (16P) : 2 pieces
   c) D/O Module (16P) : 2 pieces
   d) A/I Module (16P) : 2 pieces
3) Sensors
   a) Flow Meter : 1 Set
   b) Water Level Sensor : 1 Set
4) Any other recommended spare parts and accessories by the Contractor and/or manufacturers.

6.7.2. Tools

The tools required for assembly, disassembly, maintenance or adjustment, shall be part of the supply. Sets of tools shall comprise at least the following but not be limited to.

1) Integrated set with tools of 10 class: 1 set
2) Screwdriver set : 1 set
3) Digital Multi-tester : 1 set
4) Any other recommended tools by the Contractor and/or manufacturers.

6.8. Electrical Panels

All electrical panels such as main distribution panel located indoor of control house, local control panels for control of various gates and lighting panel board for supply small power to the control house shall be made of steel or stainless steel, self-standing or wall attached type for installation, weather proof enclosure type and sealed in accordance with this specifications and detailed design document.

Manufacturing drawings and document including material and parts list shall be prepared and commence manufacture by the contractor after approval of the Engineer. The parts list shall clearly indicate the dimensions and manufacturing company.

6.8.1. Drawings and Documents to be Submitted

The Contractor shall submit manufacturing drawings and documents for approval before manufacturing. One original and three copies of manufacturing drawings and documents should be submitted to the Engineer for approval with following offers.

5) Manufacturing schedule charts

6) Manufacturing drawings
   - c) Single line diagram and three lines diagram
   - d) Out line and arrangement drawing of each panel
   - e) Equipment assembly drawing inside of panel
   - f) Foundation drawing and view details of each panel side
   - g) Sequence diagram and catalogues of equipment

7) Manufacturing specification and data sheets

8) The list of material to be supplied and testing guide book after manufacture

9) Delivery documents
   - a) The list of various materials and parts to be supplied
   - b) The guide book for operation and maintenance
   - c) Spare parts and tools list
   - d) Performance test guide book after field installation
   - e) The characteristics and handling manual of circuit breaker and protective instruments
   - f) Final manufacturing drawings and documents including catalog of various equipment to be used.

10) Equipment accessories and miscellaneous

11) The list of material to be supplied and testing guide book after manufacture

6.8.2. Structure and Equipment of Electrical Panels

1) Main distribution panel
   a) Structure of panels
      - Material and type: free-standing type of steel plates for indoor construction
      - Thickness : (Door) 3.2t, (The others) 2.3t
   b) Size : Refer to drawings
   c) Channel base frame : 100mm x 50mm x 5t

2) Local control panel
   a) Structure of panels
      - Material and type: free-standing type of stainless steel plates for outdoor construction
      - Thickness : (Door) 2.0t, (The others) 1.5t
   b) Size : Refer to drawings
   c) Channel base frame : 100mm x 50mm x 5t

3) Lighting panel board
   a) Structure of panels
      - Material and type: wall mounted type of stainless steel plates for indoor construction
      - Thickness : (Door) 2.0t, (The others) 1.5t
   b) Size : Refer to drawings

4) All materials and types will be applied in accordance with the enclosure classification specified elsewhere specifications, international standards and or codes.

5) The cable power and control wiring shall be entered from bottom side or approved by the Engineer.

6) Materials to be used

   All materials and devices to be installed shall be new brand and approved type for location and purpose before starting manufacture or ordering of equipment.

7) Instrument and control devices shall be easily accessible and capable of being removed from the panels for maintenance purposes

8) Hook shall be attached to the top of free-standing panels for hauling. Bolts for assembly shall be supplied for channel base and installation of panels.

9) Auxiliary devices

a) Panels shall be included bus bar to supply power to branch circuits as well as bus bar for grounding.

b) All panels shall incorporate a common internal copper earth bar of 3t x 25mm onto which all panels earth connections shall be made.

c) Space heating element with thermostatic control shall be included in each panel.

d) The panel shall contain adequate capacity of various circuit breakers in number required for the equipment including more than one spare feeder with the low voltage circuit breaker.

e) The source pilot light shall be visible from outside without opening the door and/or window, which shall have integral lock and master key.

f) All panels shall contain internal power sockets and door-operated internal lighting with LED lamp for saving energy, and be clearly labeled with the circuit title at front, with an additional label inside the panel.

g) All panels shall be vermin-proof. All cable entries to equipment shall be sealed against vermin as soon as possible after installation and connecting-up of the cables to the approval of the Engineer.

h) All panels shall be provided with a natural air circulation ventilation system for prevent temperature rise of inside panels.

i) Panels shall be mounted on an approved form of anti-vibration mounting whenever necessary.

10) Electrical instruments and meters

a) AC Volt meter

- Applicable standard : industrial standard, for indoor
- Type : wide angle type
- Rated voltage : refer the detailed drawings
- Rated frequency : 50Hz
- Accuracy class : ± 1.5 %

b) AC Am meter

- Applicable standard : industrial standard, for indoor
- Type : wide angle type
- Rated frequency : 50Hz
- Accuracy class : ± 1.5 %
- Am meter on motor circuit is protected type with ample over lode scale from the impact of the starting current and ensure of long life

11) Low voltage transformers

a) Voltage transformer

- Type	:	resin mold type
- Primary voltage rating	:	refer the detailed drawings
- Rated frequency	:	50Hz
- Accuracy class	:	1.0 grade

b) Current transformer

- Type	:	resin mold type
- Voltage rating	:	refer the detailed drawings
- Primary current rating	:	refer the detailed drawings
- Secondary current rating	:	5A
- Rated frequency	:	50Hz
- Accuracy class	:	1.0 grade

- Current transformers shall be capable of withstanding without damage the peak and rated short-time currents of their associated equipment

12) All instruments and meters shall be heavy-duty, dust-proof, industrial type suitable for extreme shock and severe vibration applications

6.8.3. Installation of Panels

1) All local control panels shall be rigidly constructed on the wall of adequate location of each site in accordance with drawings, this specification and/or approved location by the Engineer, unless otherwise specified.

2) The wall-mounting panels shall be anchored to the inside wall with anchor bolts and, if necessary, it shall be installed to withstand violent vibrations. Also, panels shall be constructed after coordinate balance of horizontal and vertical conditions.

3) All electrical equipment mounted in or on switchgear, panels and desks, shall have readily accessible connections and shall be wired to terminal blocks for the reception of external cabling.

6.9. Emergency Power Generation

1) Diesel engine generator set shall be installed completely for emergency power supply to intake gates and small power system of control house. The design shall be in accordance with IEC specifications and/or related international standards unless otherwise specified.

2) Technical characteristics shall include followings;

a)	Speed	:	1,500 rpm
b)	Cos	:	0.8
c)	Voltage, Frequency	:	400V, 3-phase, 50Hz
d)	Generator	:	3-phase synchronous alternator, 1,500 rpm
e)	Electrical power	:	20kW 25kVA
f)	Overload capability	:	10 percent for transient load response

3) The following drawings shall be submitted to the engineer for approval of manufacture.

a) Generator set arrangement drawing

b) Perspective view of generator set arrangement

c) Installation drawing

d) Cooling system diagram

e) Air system and exhaust system diagram

f) Fuel system diagram

g) Lubrication oil system diagram

h) Electrical equipment list with generator set wiring diagram

4) In addition, the following documents shall be submitted to the Engineer.

a) Set of operation instructions / operation manuals

b) Engine, alternator and governor description

c) Specification of all fluids and lubricants

d) Parts lists with detailed exploded views for all parts

e) Spare parts catalogue

f) Drawings of all electrical systems including operation panel

5) Diesel Engine

a)	Operation method	:	four stroke cycle
b)	Combustion method	:	direct fuel injection
c)	Engine mounting	:	resiliently to steel frame and skidded base
d)	Battery voltage for all systems	:	24V DC

6) Alternator

a)	Electrical power	:	suitable for the purpose
b)	Insulation class	:	F, tropicalized with anti-humidity insulation
c)	Battery voltage for all systems	:	24V DC

d) Control panel : mounted type

7) Accessories for Diesel Generating Set

Diesel generating set shall be installed and delivered with compatible tools and kits by the Contractor.

8) Engine Room Ventilation and Vibration

Sufficient fans shall be supplied to ensure the adequate ventilation of the engine room. Also, the engine generator set shall be designed and installed on anti-vibration pads to minimize vibration and noises.

6.10. General Description of Cables

1) Power and control cables of 0.6/1 kV shall be used with copper conductors according to IEC 60502 unless otherwise specified in the specification and shall be conformed the followings:

   a) Single or multi-core, PVC insulated, with overall PVC sheath

   b) The insulation of cross-linked polyethylene type (XLPE)

   c) Stranded conductor of annealed copper wires applied helically

   d) Over sheath with Extruded layer of flame retardant PVC compound

2) Bare copper conductor is for grounding and lightning protection system for electrical equipment.

6.11. Cabling and Wiring

Various types of cable and wire are to be applied for the works by each type of services and functions.

Electrical cables and wires in accordance with international standard shall be used for electrical facilities except otherwise specified.

The Contractor shall provide the complete cabling and wiring with all required cables, wires, and other specialized cables specified. He shall also deliver and install all required auxiliary items including cable trenches, cable ducts, trays, conduits, connector, terminal boxes, watertight bushings, etc.

The Contractor shall be carefully installed without damage of covering material of all cables and wires.

The Contractor shall be responsible for wiring, laying and furnishing control, signal and power cables and wires which are necessary for the required operation.

All wiring in the control panel shall be of PVC insulted stranded copper conductor, the cable and all connections shall be fixed at the terminal block by screws. The insulating material shall be used flame retardant PVC over sheath in accordance with IEC standards

All external wiring between the control panel and electric equipment, flow switch, etc. shall be multi-core cross linked polyethylene insulated, PVC sheathed for 0.6/1kV cable.

All wiring shall be carried out in according to wiring diagram so that arrangement of wiring is consistent with the equipment.

All power and control cable conductor shall be of copper and have minimum cross sectional area of 2.5mm².

Compression type terminal shall be used and ring number identification shall be used and be put on both ends of the cables.

All cables and wires except BC shall be clearly labeled on insulated surface of them.

6.12. Phase and Color of Cables

The standard phase arrangement when facing the front of panel shall be R-S-T-N and R-N-S from the left to right, from top to bottom and front to back for AC three phase and single phase circuit, and P-N from left to right, P-N from top to bottom and front to back for DC polarity.

Marked color of each AC phase shall be black for phase 1, red for phase 2, blue for phase 3 and white for neutral phase.

The Following color shall be provided on cables and wires in order to identify by approval of the Engineer

Description	Phase and Polarity	Color
1) AC–Three phase 4 wire:	First phase	Black
	Second phase	Red
	Third phase	Blue
	Neutral	White
2) DC:	Positive	Red
	Negative	Blue
3) Grounding wire		Green

Sample of secondary wiring, terminations and terminal blocks shall be submitted by contractor for approval before commencement of the works, if requested by the Engineer.

6.13. Conduit and Accessories

The installations of all conduits and conduit fittings shall also be compliant with local regulations and IEC standards, unless otherwise approved by the Engineer.

Conduit shall be used for the cable and wiring between the control panel and various electrical equipment.

When conduits buried underground, shall be installed at least more 0.6m below ground surface. But, it shall be entered the ground more 1.2m where high pressure of heavy load is expected.

6.13.1. Rigid Metal Conduit

All conduit and conduit fittings shall be thread steel conduit with enclosure classification. All conduits run in any circuit are to be completed before any cables are pulled in.

Metal conduit shall be galvanized, rigid steel with threaded ends. It shall be galvanized inside and outside and of a minimum thickness of 2.3 millimeters and have a minimum inside diameter of 16 millimeters

In case of it is cut metal conduit in the field, cutting edge shall be smoothened after each cut using saw or pipe cutter not to be damaged the cover of electrical cable or wire.

6.13.2. Rigid Nonmetallic Conduit

All nonmetallic conduits shall be flame retardant, resistant to impact and crushing, resistant to distortion from heat under conditions likely to be encountered in service, and resistant to low temperature and sunlight effects.

For use underground, the material shall be acceptably resistant to moisture and corrosive agents, and shall be of sufficient strength to withstand abuse, such as by impact and crushing, in handling and during installation.

Also, in this purpose shall be permitted to be installed underground in continuous lengths from a reel.

All cut ends shall be trimmed inside and outside to remove rough edges.

6.13.3. Flexible Metal Conduit

Flexible metallic conduit shall be used where relative movement is required between the conduit and connected apparatus.

Flexible conduit may be used where necessary for vibration or flexibility purposes; they should be tight with appropriate fittings.

Flexible metallic conduit shall not be used in the followings.

1) In any hazardous location

2) Where subject to physical damage

3) Underground or embedded in poured concrete or aggregate

4) Where rubber covered conductors are exposed to oil, gasoline or other materials having a deteriorating effect on rubber.

6.14. Installation Works

6.14.1. Preparatory Works

1) General

The preparatory works shall be conducted to prepare for the installation of electrical equipment. All expenses necessary for the preparatory works shall be included in the contract price.

Survey and investigation of sites

Before commencement of the installation works, if contractor desire, survey and investigation may be made at each job site to obtain information such as road condition, site condition, related civil and mechanical works condition.

2) Transportation and storage

Transportation shall mean carrying the electrical equipment and materials to each job site by vehicle capable of transporting equipment and work personnel.

Storage shall mean keeping and protection of various electrical equipment and materials in the each site.

6.14.2. Installation Works

1) Installation of equipment

The equipment and facilities shall be installed in accordance with the drawings and this specification. All tools and consumable materials necessary for the installation works shall be provided by the Contractor at his own expense.

2) Materials furnished with equipment and installation

Materials furnished with equipment shall include power cables, control cables, wires, electrical conduit pipes, various electrical panels as main distribution panel and local control panels, lighting facilities with accessories and so on.

The materials shall be rustproof and shall be equal to or more than the approved standard by the Engineer.

The cable and wiring materials shall have ample voltage and current capacity for electrical equipment.

The outdoor cable shall be of the waterproof type. This cable shall also be able to withstand high temperatures due to direct sunlight without detriment to its original functions.

Cables and wires shall be embedded into underground, conduit pipe or installed in cable tray, exposed state. No cable connection shall be permitted in conduit and underground while jointing fixtures shall be suitable at terminal.

Embedded underground shall be provided for the grounding works, hand hole and incoming power cable and the others of sites. Cable laid in the ground should not connect in the ground except in the hand hole or box.

The cover of hand hole shall be material by cast iron and impermeable structure, and shall be durable ones to withstand possible pressure from heavy things such as vehicle, trucks etc.

6.15. Underground Cables

Underground cable installation shall be carried out according to the following methods:

Appropriate deep and 50 cm wide space shall be prepared, then filled and stamped with 10cm thick bed sand.

Cable shall be laid down on the bed sand and must not be subject to stress. Sand shall be filled up to 10 cm above the cable.

All steps of excavation, filling sand, laying down cables and final filling shall be inspected by the engineer.

Backfill shall be done after covering the underground line with PVC warning tape, 300 mm wide and 0.5 mm thick, over a location 30 cm above underground line to be buried.

Cables crossing under road and crossing bridge shall be protected by steel conduit pipe.

6.16. Grounding Systems

All electrical equipment shall be properly grounded and bonded, and grounding wires fro m the equipment shall be provided.

Grounding works shall follow requirements of the Malawi electrical regulations or internationally accepted work standards related to grounding type and structure unless otherwise specified.

1) Ground rods and wire
    a) The materials of ground rod and wire shall be in accordance with the specification and detailed drawings.
    b) Ground rods of full copper rod 18 mm or more in diameter and 2.4 m in length.
    c) Ground wire shall be green colored poly vinyl insulated ground wire with properties of flame retardant, moisture resistant and abrasion resistant (GV).
    d) The wire to be installed in underground shall be connected by bare copper (BC) wire having equivalent or more thickness of cross sectional area of ground wire to ground rods.
2) Ground connectors
    a) Connectors can be used with compression type without cutting each conductor.
    b) All connections of conductors on equipment shall be performed with pressure type connectors and threaded bolts, screws and snap-rings / washers.
    c) The conductor shall be passed for measurement test of the resistance for grounding, and necessary measuring and material test.
3) The grounding resistance to be measured shall in no case exceed resistance value of 10 ohms in accordance with relevant standards. Where this value cannot be obtained, the contractor shall additionally be equipped with ground rods.
4) All grounding works shall be installed under attendance of the engineer, and report the measured grounding resistance value to the Engineer in writing after completion.
5) The Contractor shall supply complete grounding system. Accurate buried location of equipment such as conduits, cable, ground rods and manholes shall be marked in the as built drawing and shall be submitted to the Engineer.

6.17. Lighting and Socket Outlets

6.17.1. General

The Contractor shall design, manufacture, supply, install and test a complete lighting and convenience socket outlet system for the electrical works.

Electric power of lamps and socket outlets shall be fed from the local control panel. Local control panel, lighting fixtures, socket outlets and all related materials shall conform to the specified international standards.

Installation and type of lighting and socket outlets shall comply with the specifications and detailed drawings unless otherwise approved by the Engineer.

6.17.2. Lighting Fixtures

All complete lighting fixtures and fitting shall be installed in the buildings after approval of the Engineer. The location, capacity of lamp and type of lighting fixtures and fittings are shown on the detail drawings.

Indoor and entrance lighting fixtures shall be installed compact fluorescent light with adequate illumination for saving energy and electrical cost. All lighting fixtures shall have lamp holders in accordance with the related standards.

The PVC insulated wire 600 V, 2.5 mm^2 will be used for connection from circuit breaker of control panel to lighting fixtures.

6.17.3. Switches

The Installation and setting of single or double switch is shown on the drawings. All switches for lighting fixtures and fitting shall be set inside of wall with appropriate height from the floor surface. Moreover Switch box of inside wall shall be strong and screwed to the box so that not easily pulled out.

6.17.4. Convenience Socket Outlet

The location for installation of socket outlets shall be in accordance with wiring diagram and detailed drawing as shown on the drawing.

Socket outlets types with functions of 250 V, single-phase, 13 A for general-purpose outlets and special tools shall be provided.

All complete socket outlets shall have grounding terminal and connected grounding system for safety. The earth-connected convenience socket outlets shall be installed at suitable locations to use portable tools, hand-lamps and any other electrical works for purpose of operation and maintenance.

7. SCADA SYSTEM

7. SCADA SYSTEM

7.1. General and Objectives

The Supervisory Control and Data Acquisition System (SCADA) shall be installed as part of the Shire Valley Transformation Program 1 to increase capabilities of the water resource management organizations to reduce the natural hazards and to improve irrigation efficiency.

The main objectives of SCADA system for integrated monitoring and operation in the irrigation infrastructures are as followings:

1) To minimize the hazards expected from the flood and drought damage due to climate change
2) To improve irrigation efficiency and reduction of the operational costs
3) To provide, analyze and record data on rainfall, water levels, equipment, storages and discharges for supporting decisions and operation activities.

7.2. Scope of Works

The works to be performed consists of making provision for the installation of **SCADA** system especially during construction of bifurcation point and in consultation with the supervising engineer, on the secondary canal offtakes.