UNITED NATIONS DEVELOPMENT PROGRAMME

CHARQIEH RESERVOIR, PUMPING AND DISTRIBUTION LINES

TECHNICAL SPECIFICATIONS - VOLUME 3

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TECHNICAL SPECIFICATIONS

Part I : General

Part II : Pipelines

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PART 1 - GENERAL

1-A ABBREVIATIONS

Wherever the following abbreviations are used in the specifications or in the plans, they are to be constructed the same as the respective expressions represented :

AC	Asbestos Cement
AASHTO	American Association of State Highway and Transportation Officials
AAMA	Architectural Aluminum Manufacturer's Association
ACI	American Concrete Institute
AFNOR	Association Française de Normalisation
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AWWA	American Water Works Association
AWS	American Welding Society
BS	British Standard
CDR	Council for Development and Reconstruction
CP	Code of Practice
DIN	Deutscher Normausschuss
DTU	Documents Techniques Unifiés
EDL	Electricity of Lebanon
FSS	Federal Specifications and Standards (United States)
gpm	gallons per minute
GRP	Glass Reinforced Plastic
IEC	International Electrotechnical Commission
ISO	International Standards Organization
ITS	Institute of Technical Studies
m	meters
mm	millimeters
m^2	square meter
m^3	cubic meter
NEMA	National Electrical Manufacturers Association

NF	Normes Françaises
UTE	Union Technique de l'Electricité
VDE	Verband Deutscher Electrotechniker

1-B GENERAL

1-B-1 STANDARDS

1- All references to codes, specifications and standards referred to in the Contract Documents shall mean, and are intended to be, the latest edition, amendment or revision of such reference standards in effect.

2- Whenever the Contract Documents require that a product complies with certain Standards or Specifications, the Contractor shall present a certificate from the manufacturer ensuring that the product complies therewith. Where requested or specified, the Contractor shall submit supporting test data to substantiate compliance.

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. The Technical Specifications could refer to one or more standards, but it is still accepted that any international recognized standard, code of practice or regulation could be applicable with the prior consent of the Engineer.

If any clarification or additional information regarding technical aspects, the Contractor must submit a request for information.

1-B-2 EQUIVALENCY OF STANDARDS AND CODES

Wherever reference is made in the Contract including the Specifications, Drawings and Bill of Quantities to specific standards and codes to be met by the goods and materials to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise expressly stated in the Contract.

Where such standards and codes are national or relate to a particular country or region, other authoritative standards that ensure a substantially equal or higher quality than the standards and codes specified will be accepted subject to the Engineer's prior review and written consent. Differences between the standards specified and the proposed alternative standards shall be fully described in writing by the Contractor and submitted to the Engineer at least 28 days prior to the date when the Contractor desires the Engineer's consent.

In the event the Engineer determines that such proposed deviations do not ensure substantially equal or higher quality, the Contractor shall comply with the standards specified in the Contract.

1-B-3 SILENCE OF SPECIFICATIONS

The apparent silence of the specifications, plans or other Contract Documents as to any detail or the apparent omission from them of a detailed description concerning any point, shall be regarded as meaning that only the best general practice is to be used. All interpretations of the specifications will be made by the Engineer on this basis.

1-B-4 LANGUAGE OF CORRESPONDENCE AND RECORDS

All communications from the Contractor to the Engineer shall be in the Arabic or English language. All books, time sheets, records, notes, drawings, documents, specifications and manufacturers' literature etc. shall be in the Arabic or English language.

1-B-5 UNITS

The International System of (metric) Units shall be used throughout the Contract except where otherwise provided.

1-B-6 INTENTION OF TERMS

Where “as shown”, “as indicated”, “as detailed” or words of similar import are used, it shall be understood that reference to the drawings accompanying the Specifications is made unless otherwise stated. Where “as approved”, “as directed”, “as required”, “as accepted”, or words of similar import are used, it shall be understood that the approval, direction, requirement, permission, authorization, review, or acceptance of the Engineer is intended, unless otherwise stated. “Provide” shall be understood to mean “complete in place”, that is, “furnish and install”.

Whenever anything is, or is to be done, if, as, or, when, or where “contemplated, required, determined, directed, specified, authorized, ordered, given, designated, indicated, considered, considered necessary, deemed necessary, permitted reserved, suspended, established, approval, approved, disapproved, acceptable, unacceptable, suitable, accepted, satisfactory, unsatisfactory, sufficient, insufficient, rejected or condemned”, it shall be understood as if the expression were followed by the words “by the Engineer” or “to the Engineer”.

The phrases “or equal” and “or equivalent” shall be construed to mean that material or equipment will be acceptable only when composed of parts of equal quality, or equal workmanship and finish, designed and constructed to perform or accomplish the desired result as efficiently as the named brand, pattern, grade, class, make or model.

1-B-7 INTENT OF CONTRACT

The intent of the Contract is to provide for the construction and completion in every detail of the works described. The Contractor shall furnish all labor, materials, equipment, tools, transportation and supplies required to complete the work in accordance with the plans, specifications and terms of the Contract Documents.

Unless otherwise specified, the Contractor shall allow a minimum of 21 days for approval of drawings and documents by the Engineer.

1-B-8 BILLS OF QUANTITIES

Detailed Bills of Quantities shall be prepared by the Contractor in accordance with the measurement rules described in the preamble and as approved by the Engineer.

1-B-9 OPERATION AND MAINTENANCE MANUALS

The Contractor shall submit to the Engineer for approval draft copies of the Operation and Maintenance Manuals. A separate set of instructions shall be provided for each installation. The Contractor shall incorporate any amendments or additions required by the Engineer in the production of the final Manuals.

The draft O & M Manuals shall be available on site at all times during Tests on Completion for the instructions to be verified. Any modifications found necessary shall be incorporated in the final version.

The Contractor shall supply the final version of the Operation and Maintenance Manuals prior to the issue of the Taking Over Certificate for either the whole of the works or the respective section or part of the works.

The Contractor shall, as necessary, carry out survey work, take measurements, collect details, produce drawings and undertake all other work required to enable him to prepare the manuals.

Operation and Maintenance Manuals shall be supplied written in the English and Arabic languages, and all parts and equipment listings shall be in English.

1-B-10 WORK THROUGH PRIVATE PROPERTY

In order that the necessary easements may be obtained and /or the owners of private property may be served with the requisite notices it shall be an obligation of the Contractor to supply the Engineer from time to time with full information of his program sufficiently in advance of the dates upon which the Contractor will wish to enter upon each parcel of private land.

The Contractor shall consult with Owners and Tenants (if any) and have written approval before entering on their land or cutting through any ditch, bank, hedge, wall, fence or any other form of boundary marking and he shall ascertain and carry out their reasonable requirements as approved by the Engineer in the matter of reinstatement.

1-B-11 PUBLIC UTILITY MAINS AND SERVICES, LOCATING, ETC

It shall be the responsibility of the Contractor to obtain all information available from the Public Utility Authorities regarding the position of mains and services and he shall make this information available to the Engineer as soon as he obtains it.

The absence of such information shall not relieve the Contractor of his liability for the cost of any repair work necessitated by damage caused by him to any mains or services in the course of his work and for the cost of all losses arising from the disruption.

All locating work shall be carried out in advance of further excavation work. The Contractor shall obtain all information and assistance available from the Public Utility Authorities for the

locating of the mains and services and shall agree with the Engineer any trial excavation which may be necessary to confirm or establish these locations.

Any temporary or permanent diversion of mains and services will only be permitted after agreement with the appropriate Public Utility Authority.

1-B-12 PROJECT CONTROL

1- The Contractor shall provide within his site organization a project management section to advise and be directly responsible to the Contractor's Engineer. The duties of the section shall include the following:

   i. Planning and program preparation particularly in relation to the requirements of public authorities and the requirements to maintain water supply disposal services where careful detailed arrangements have to be made and adhered to.

   ii. Planning the execution of the works in a manner which minimizes disruption to the water supply and wastewater systems and will permit the efficient and effective commissioning of the water supply and wastewater systems and its respective components.

   iii. Ensuring adequate water supplies are maintained to all consumers. Also, ensuring all existing wastewater systems are functionning during execution.

   iv. Continuous surveillance of progress and anticipation of factors likely to affect the timely performance of the Contract.

   v. Making proposal for modification to forward planning and to the program at an early stage in the light of factors resulting from (iv).

   vi. Continuous appraisal of the Contractor's methods and routines particularly as to their effectiveness relating to speed of execution and to their effect on the community and property.

   vii. Forward planning for resource requirements taking due account of possible shortages and delays in the arrival on site of materials, plant, personnel, etc. and their mobilization for effective usage.

   viii. Acquisition and process of up-to-date information for progress meetings with the Engineer. The preparation of monthly progress reports including an update of the detailed program and cash flow forecast.

2- The project management section shall be in the charge of a professionally qualified engineer specializing in project management having had at least 10 years experience on similar projects and being versed in modern management techniques. Supporting staff for this section shall be in adequate numbers to carry out their duties and shall be of adequate ability and experience to the Engineer’s approval.

3- Programs shall be based upon C.P.M. networks in precedence format and shall be prepared using a suitable P.C. - based project management software package approved by the Engineer.

4- Reporting shall be in a manner compatible with the Employer’s or Engineer’s requirements.

1-B-13 QUALITY CONTROL

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

1-B-14 MONTHLY CERTIFICATES

Monthly certificates shall be submitted in an approved manner and format. The certificate shall detail the measured value of the work completed on each item of the Works. An item shall constitute a single structure or a component of a system such as a single pipeline or valve complex.

1-B-15 PROGRESS MEETINGS

The Contractor shall arrange progress review meetings, to be chaired by the Engineer, at monthly intervals to coincide with submission of monthly progress submissions.

1-B-16 PROPRIETARY MATERIALS

Material shall be supplied in suitable containers and in appropriate batch sizes for the work to be undertaken.

The following information shall be marked:

i. Storage instructions;

ii. The manufacturer's name;

iii. Shelf life and dates of manufacture:

iv. Material identification;

v. Batch reference number;

vi. Net weight;

vii. Mixing instructions;

viii. Any warnings or precautions concerning the contents and their safe use.

The Contractor shall supply with each consignment of proprietary material delivered to the Site, certificates furnished by the manufacturer or his agent stating:

i. The manufacturer's name and address:

ii. The agent's name and address where applicable;

iii. Material identification:

iv. Batch reference numbers, size of each batch and the number of containers in the consignment;

v. Date of manufacture.

1-B-17 REJECTED MATERIALS

Should any materials or manufactured articles be in the judgment of the Engineer, unsound or of inferior quality or in any way unsuited for the purpose in which it is proposed to employ them, such materials or manufactured articles shall not be used upon the Works but shall be branded, if in the opinion of the Engineer this is necessary, and shall forthwith be removed from the Site.

1-B-18 QUALITY

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.

1-B-19 OFFICES, TRANSPORT, EQUIPMENT AND SERVICES FOR ENGINEER

The Contractor shall provide and properly maintain, for the duration of the Work, the offices for the use of the Engineer, his staff, the Employer and the Employer's Representative. This office shall be constructed, equipped and furnished as directed by the Engineer. These facilities shall be completed and ready for occupancy within sixty (60) days from the date of signing the Contract.

The Contractor shall submit to the Engineer, for approval, details of the offices space to be constructed, equipped and furnished before construction is commenced.

The Contractor shall, at the completion of the Work, supply electricity, water and sanitary facilities for the Engineer's offices. The Contractor shall be fully responsible for the maintenance and operation, including labor and materials, for the offices.

The Contractor shall supply the Engineer with mobile telephones as necessary to enable efficient communication between the contractor and the Engineer's supervision staff.

The Contractor shall also supply the Engineer, for the duration of the work, with 4x4 wheel drive vehicles as necessary to access all different site locations. These vehicles should be powerful enough to withstand all kind of driving conditions, rough roads, natural terrains and tough weathering conditions.

1-B-20 FACILITIES FOR SURVEY AND INSPECTION BY THE ENGINEER

The Contractor shall make available technicians and such labor, materials and safety equipment as the Engineer may require for inspections and survey work in connection with the Works. The Contractor shall provide all necessary tackle, test equipment, access, labor, staff and any other thing the Engineer may reasonably require in order that he may safely,

conveniently and quickly carry out such inspections as he deems necessary at any time during the execution of the Works including the Tests on completion.

1-B-21 INSPECTIONS BY THE 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 a responsible representative to be present at the times and dates named by the Engineer. This representative shall render all necessary, assistance and record all matters and things to which his attention is directed by the Engineer.

1-B-22 APPROVAL

As soon as possible after commencement of the Contract, the Contractor shall submit to the Engineer for his approval a list of his proposed suppliers, sources of materials, construction requirements and proposed standards. No materials, plant or equipment shall be procured for the Contract without first obtaining the Engineer's approval. Samples of materials shall be submitted to the Engineer for approval as required by the Engineer. Materials subsequently supplied shall conform to the quality of the samples which have been approved by the Engineer. No standard, method of manufacture or specification shall be changed without the approval of the Engineer. Where possible plant shall be supplied to the same standards or to compatible standards.

1-B-23 PROTECTIVE CLOTHING

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

The Contractor shall provide any necessary protective clothing and safety equipment for the use of authorized visitors to the site including the Employer and his staff and representatives and those of any relevant authority and who have reason to visit the Site.

1-B-24 SOURCE OF SUPPLY AND QUALITY REQUIREMENTS

All materials, manufactured articles and machinery incorporated in the permanent works shall be new, recently manufactured and shall meet the quality requirements of the Contract. They must, in all cases, be approved by the Engineer prior to their inclusion into the work.

All shipment of materials must be accompanied by a Manufacturer's Certificate of Guarantee or test certificate from an approved independent laboratory when delivered to the site. The independent laboratory shall be approved by the Engineer before any materials are submitted for tests. However, all materials delivered to the Site are subject to additional laboratory testing when requested by the Engineer even though the materials are accompanied by a certificate of guarantee or laboratory test certificate. All costs in connection with certificates of guarantee or laboratory tests and certificates shall be borne by the Contractor. Falsification of such

documents shall be just cause for rejection of the materials and all cost of transportation and handling of the rejected materials shall be the sole responsibility of the Contractor.

In order to expedite the work, the Contractor shall, before placing any purchase order for materials, manufactured articles and machinery to be part of the permanent works, submit for the approval of the Engineer, a complete description of such items, the names of the firms from whom he proposes to obtain such items, together with a list of the items he proposes each firm would supply. No materials, manufactured articles or machinery shall be ordered from any firm without the written approval of the Engineer. When directed by the Engineer or otherwise specified in the Contract, the Contractor shall submit samples for approval.

If it is found after trial that sources of supply for previously approved materials, manufactured articles, or machinery do not produce specified products, the Contractor shall furnish the items from other sources approved by the Engineer.

1-B-25 PRECAUTIONS AGAINST CONTAMINATION OF THE WORKS

The Contractor shall at all times take every possible precaution against contamination of the works.

The Site and all permanent and temporary works shall be kept in a clean, tidy and sanitary condition.

The Contractor shall at all times take measures to avoid contamination of existing water courses and drains by petrol, oil or other harmful materials.

The works shall be kept clean and free from rubbish and remedial works shall be carried out as the work is progressively completed. Before requesting inspection for preliminary or final take-over of the works or any section thereof the Contractor shall inspect the works and assure himself that they are clean and in a satisfactory condition for such inspection, normal usage expected.

1-B-26 ENVIRONMENTAL ASPECTS

The Contractor shall take all reasonable steps to minimize the adverse affects of both the temporary and permanent works on the environment. Before any work commences, the Contractor shall submit an environmental protection plan describing how potential adverse impacts will be mitigated. These adverse environmental impacts could be:

a. Pollution of soil and water due to improper dumping of excavated and construction material, oils used, chemicals/solvents, human wastes.

b. Erosion of soil, sedimentation and drainage due to excavation and bedding.

c. Noise and air (dust, odor) pollution due to operation of machinery and excavation.

d. Traffic increase due to trucks (sand, machinery, equipment) movement and traffic disturbance.

e. Disturbance to recreational, archaeological, touristic sites.

f. Public health and safety due to the operation of the machinery and accidents.

g. Damage to forests, agricultural land, vegetated area and its wildlife habitat.

1-B-27 ACCESS TO PROPERTIES

The Contractor shall not disrupt any private or public access way without first providing alternative arrangements.

Access to properties affected by the Works shall be maintained. Adequate road plates shall be provided for trench crossings.

1-B-28 CONTROL OF DUST

The Contractor shall, throughout the execution and completion of the Works take all reasonable steps to avoid damage or nuisance to persons or property resulting from dust and shall carry out preventative measures, such as spraying the ground with water, and /or soil covering, as instructed by the Engineer.

1-B-29 SAFETY

The Contractor must cover all aspects of site safety during the Works.

1-B-30 PROJECT SAFETY PLAN

Before any work commences on the Site the Contractor shall submit a Project Safety Plan *(PSP)* which shall be specific to the Contract. The plan shall detail the Contractor's site safety organization, his safety rules and procedures and methods of monitoring and enforcing his procedures.

The Project Safety Plan shall cover all aspects of site safety and shall typically include the following:

a. Health and Safety Policy and Primary Objectives:

   The plan shall demonstrate that management of health and safety is an integral part of the management and co-ordination of the project.

b. Organization and Responsibilities:

   A designated competent person shall be specified as the Contractor's Safety Officer with overall responsibility for the establishment, implementation and enforcement of safety procedures and methods of working.

   The Contractor's organization structure and responsibilities with respect to safety shall be detailed.

c. Hazard Identification and Risk Assessment:

   The Contractor shall assess the risks to workers and any others that require access to the site or the works or may be affected by the operations.

   A systematic general examination of each activity and assessment is to include:

- Identification of the hazards present and those hazards their operations will introduce to the site.
- Identification of the people exposed.
- The extent of the risk evaluated after considering the existing control measures.
- Further assessments to be made for new activities.
- Plant and equipment to be identified and those responsible for its provision and maintenance to be defined and designated.
- Review and revision if assessments man no longer be valid or where there has been a significant change.
- Planned review of assessments at regular intervals.
- Inform employees on the nature of the hazard and the risks identified by the assessments, the preventative and protective measures, emergency procedures and the competent personnel.
- Significant findings of assessments to be recorded.

d. Emergency Procedures:

   Effective procedures for contingency in event of serious and immediate danger. All employees shall be able to stop work and immediately proceed to a place of safety if exposed to imminent and unavoidable danger.

e. Cooperation and Coordination:

   All competent persons to liaise and assist in assessing the shared risks and coordinating any necessary measures, primarily by providing information. The Contractor to take full responsibility in coordination arrangements.

f. Capabilities and Training:

   Provision of health and safety training for all employees upon recruitment and on exposure to new or increased risks.

g. Monitoring:

   Scheduled hierarchical audit system conducted by the Contractor. Safety performance to be monitored and measured against the PSP; project procedures for safe systems of work; and specified safety performance standards.

h. Health and Safety Performance Standards to be specified, i.e.:

   - Relevant statutory legislation
   - Standard specifications (BSI/ISO)
   - Approved codes of practice
   - Specific Project Safety Plan Information:
   - <u>Nature of the Project</u>
     - Name of Employer
     - Location

- Nature of construction work to be carried out
- Time scale for completion of the construction work

– The existing environment
  - Surrounding land uses and related restrictions - e.g. premises (schools) adjacent to the proposed construction site.
  - Existing services - e.g. underground and overhead lines.
  - Existing traffic systems and restrictions.
  - Existing structures - e.g. special health problems from materials in existing structures which are being demolished or refurbished, any fragile materials which require special safety precautions, instability problems etc.
  - Ground conditions - e.g. contamination, instability, possible
  - subsidence, underground obstructions etc.

– Existing drawings
  - Available drawings of structure(s) to be demolished or incorporated in the proposed structure(s)

– The design
  - Significant hazards of work sequences.
  - The principals of the design and any precautions that might be needed or sequences of assembly that need to be followed during construction.
  - Detailed reference to specific problems with proposals for managing these problems.

– Construction materials
  - Health hazards where either because of their nature or the manner of their use, particular precautions are required.

– Site wide elements
  - Outline emergency arrangements including access and egress.
  - Positioning of site access and egress points.
  - Location of temporary site accommodation.
  - Location of unloading, layout and storage areas
  - Traffic/pedestrian routes.

- Overlap with other undertaking
    - Consideration of the health and safety issues which arise when the project is to be located in premises occupied or partially occupied by the Employer or other authority.
- Site Rules
    - Specific sites rules which the client or the planning supervisor may wish to lay down as a result of points above or for other reasons - e.g. specific permit to work rules, emergency procedures.
- Continuing liaison
    - Procedures for considering the health and safety implications of work elements
    - Procedures for dealing with unforeseen eventualities during project execution.

1-B-31 HAZARDS

Potential hazards associated with the Sites may include, but will not be limited to the following:

- Any chamber, pipeline, borehole, excavation or other structure (whether above or below ground) not effectively ventilated.
- Compressed air vessels may burst explosively.
- Toxic Fumes and Gases: (generated by combustion engines, chlorine, ammonia, treatment processes).
- Asphyxiating Gases.
- Dangerous Fumes and Gases.
- Chemicals: Chemicals are stored and used in many processes. Most of them are strongly alkaline, acidic, toxic or otherwise aggressive.
- Electricity Cables:

  Buried and overhead cables of all voltage ratings may be encountered.

  Overhead cables of all voltage ratings may be encountered. On operational sites the clearance may be lower than in highways or public areas. Hazards are as for buried cables, with the additional risk of arcing. Arcing may occur from the cables to metal objects or spray.
- Buried services:

  Buried water pipes may be encountered on any operational site. The water may be under very high pressure.
- Moving Machinery:

Any operational plant may contain moving machinery. Much of this is automatically controlled and may start without warning.

There is electrical plant associated with such machinery, carrying the same hazards as electricity cables.

- Noise (high frequency noise)

  Machinery such as engines, turbines, generators, pumps or compressors operating inside buildings may produce very loud noise. High speed machinery may produce high frequency noise. The hazards are possible short and long term hearing damage if ear defenders are not worn.

- Moving Vehicles:

  Any road on an operational site may carry vehicles which are relatively heavy for the class of road. Such vehicles may carry any of the chemicals or sludge's noted above.

  Tractors and other machinery may operate on unpaved areas.

- Contact Lenses:

  In areas where an arc flash can occur (chambers or where welding processes are carried out) wearers of contact lenses can sustain irreparable damage to their eyes. This can occur whether or not safety spectacles arc worn over the contact lenses.

- Confined Spaces

  a. Provide, when work is in progress, radio or telephone communication, or safe visual and oral communication where this is appropriate and background noise levels permit.

  b. Ensure that all electrical tools and equipment are of the appropriate type.

  c. Provide appropriate protective clothing.

  d. Provide hygiene facilities if appropriate.

  e. Ensure that all persons entering or working in a confined space are trained and authorized to enter.

1-B-32 WATER AND ELECTRICITY SUPPLY

The Contractor shall make his own arrangements for procuring water and electricity supplies, at his own expense. Public water and electricity cuts shall, in no way, justify delays in the progress of the work. He shall be solely responsible for ensuring the continuity of the water and electricity supply. For this purpose he shall install the needed number of generators and water tanks that would meet his needs.

1-B-33 SAFEGUARDS TO EXISTING PIPES, CABLES, STRUCTURES

It shall be the Contractor's responsibilities to safeguard by means of temporary or permanent supports or otherwise all existing pipes, cables, structures or other things which would be liable to suffer damage if such precautionary measures were not taken.

Temporary safeguards shall be to the approval of the Engineer and of the Undertaker or Owner concerned.

Permanent safeguards shall be to the approval of the Undertaker or Owner concerned and the Engineer.

1-B-34 CONNECTIONS TO EXISTING PIPES, CABLES ETC.

The Contractor will be responsible for connections between pipes, cables etc. laid by him and existing pipes, cables etc. The Contractor shall submit to the Engineer a drawing showing the details of the connection, and shall state the date on which the particular connection could be made. The work shall not proceed until the Engineer's approval has been given.

The Contractor shall be responsible for joining up to and ensuring complete compatibility with existing pipework, cables, tubing, equipment etc.

1-B-35 CONTRACTOR'S RESPONSIBILITY FOR UTILITY PROPERTIES

At points where the Contractor's operations are adjacent to properties of telegraph, telephone and power agencies or companies, or adjacent to other property, damage to which might result in considerable expense, loss or inconvenience, the work shall not be commenced until all arrangement for the protection thereof have been made. The Contractor shall cooperate with the owners of any underground or overhead utility lines in their removal and rearrangements operations in order that these operations may progress in a reasonable manner and that duplication of rearrangement work may be reduced to a minimum and that services rendered by those parties will not be unnecessarily interrupted.

In the event of interruption to water or utility services as a result of accidental breakage, or as a result of being exposed or unsupported, the Contractor shall promptly notify the proper authority in the restoration of service. If essential public utility service is interrupted, repair work shall be continuous until the service is restored.

1-B-36 SITE ACCESS ROUTES

The Contractor shall satisfy himself as to the suitability of the access routes he chooses for use during the Contract period. The Employer does not guarantee either the suitability or availability of any particular access route and will not entertain any claim in respect of the non-suitability or non-availability of any such route for continuous use during the Contract period. When needed for the execution of the work, the Contractor shall be responsible for constructing and maintaining temporary access routes at his own expense. The Contractor shall submit for the approval of the Engineer his proposal for the access routes he intends to use and build. He

shall be responsible for getting approvals from concerned authorities and/or landowners on the right-of way needed for the construction and use of these access routes.

1-B-37 EXPLOSIVES

When the use of explosives is necessary for the prosecution of the work, the Contractor shall exercise the utmost care not to endanger life or property, including new work. The Contractor shall be responsible for all damages resulting from the use of explosives. The Contractor shall store all explosives in a secure manner marked clearly in Arabic and English "Danger Explosives". Storage shall be in compliance with all local laws and ordinances. It is the Contractor's responsibility to contact the authorities and secure their approval of his proposed method of storage.

Where no local laws or ordinances apply, storage shall be to the satisfaction of the Engineer and, in general, not closer than three hundred (300) meters from the road or from any building or camping area. In no case shall the Contractor store explosives on the Site without prior approval of the local authorities or the Engineer.

Prior to starting any blasting operations, the Contractor shall submit a written comprehensive system of working to be approved by the Engineer. The system shall be approved by the Engineer prior to blasting. Approval of blasting plans shall not relieve the Contractor of his responsibility or liability for the safety of persons and property.

1-B-38 SETTING OUT OF THE WORKS

The Contractor shall prepare detailed setting out drawings and data sheets as necessary and submit them to the Engineer for approval. Any modifications to the setting out drawings or data sheets required by the Engineer shall be made by the Contractor and resubmitted for final approval.

The Engineer will agree with the Contractor the basic information supplementary to that shown on the Contractor's Drawings such as the position of center-lines and base-lines etc. sufficient for the Contractor to locate the Works. Such supplementary information may be provided on drawings, sketches or in writing.

Should it be necessary during setting out or during construction agreed setting out details to be amended, the Contractor shall amend the drawings or data sheets or make new ones for approval as required by the Engineer.

Copies of setting out drawings and data sheets shall be preserved for use by the Contractor in preparing final records and drawings in accordance with the requirements set out elsewhere.

1-B-39 BOUNDARIES OF WORKS

The Employer shall provide the Site upon which the Permanent Works included in the Contract are to be constructed. The existing boundary fences and walls shall not be disturbed without the prior approval of the Engineer's representative and the carriage way shall be left available to traffic.

The Contractor shall not enter upon or occupy with men, tools, equipment or materials and land other than 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 the Contractor shall submit his proposals to the Engineer as to how he intends to fulfill his obligations under the Contract which shall be to the approval of the Engineer.

1-B-40 SHOP DRAWINGS / EXECUTION DRAWINGS

The execution drawings shall be prepared in the same manner stated thereafter in the preparation of the shop drawings.

Where the Contract Documents require the Contractor to prepare Shop Drawings, or where required by the Engineer during the course of the work, the Contractor shall submit to the Engineer Shop Drawings that shall satisfactorily establish actual details of manufactured or fabricated item and of work to be executed. They shall clearly identify materials, dimensions, thicknesses, components, attachments, relation with adjoining work and spaces, and all other pertinent information. Shop Drawings shall clarify and amplify the design drawings and other design requirements and shall, subject to the Engineer's approval, incorporate minor changes in design or construction as may be necessary to suit the requirements of the work. By submitting Shop Drawings the Contractor thereby represents that he has determined and verified all dimensions, relations to existing work, coordination with work to be installed later, coordination with information in previously submitted Shop Drawings and has verified their compliance with all the requirements of the Contract Documents.

The accuracy of all such information is the responsibility of the Contractor and in reviewing Shop Drawings the Engineer shall be entitled to rely upon the Contractor's representation that such information is correct and accurate.

The Contractor shall be responsible for and shall make any alterations in the work due to discrepancies, errors or omissions in the Shop Drawings supplied by him whether or not such Shop Drawings have been approved by the Engineer.

1-B-41 AS-BUILT DRAWINGS

The Contractor shall submit final as-built record drawings to the Engineer for his review by the specified date. After review and approval by the Engineer of the final as-built drawings, the Contractor shall within 10 days thereof, produce a final set of "as-built drawings" and submit to the Engineer the following :

a. One (1) computerized copy of each as-built drawing on CD.

b. 3 prints of each as-built drawing.

1-B-42 LEVEL DATUM

Where possible, construction drawings and all levels used for construction shall be referred to the National Height Datum. The Contractor shall be responsible for obtaining the location of the permanent bench marks. In cases where such bench marks do not exist, the site datum shall be agreed with the Engineer.

Levels of reservoirs, pumping stations, boreholes, pipes, treatment plant and the like shall be referred to the National Height Datum.

Before the commencement of construction works, the Contractor shall establish at each site in a position, to the approval of the Engineer, a steel datum peg which shall be securely concerted in. The level of this pet 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 as agreed with the Engineer.

1-B-43 LEVELS AND DIMENSIONS

Wherever dimensions or levels are not shown on the Drawings, instructions shall be obtained from the Engineer.

1-B-44 BENCHMARKS

Benchmarks in the area of the work shown on the drawings shall be established by the Contractor.

The Contractor shall be responsible for preserving these benchmarks and re-establishing them in case they are destroyed.

The Contractor shall establish at his own expense temporary benchmarks he might need for the execution of the work.

1-B-45 SIGN BOARDS AND SAFETY BARRIERS

The Contractor shall provide two site sign boards in a form and to the specification specified and erect and mount on suitable temporary supports, in positions and at heights as required by the Engineer.

The Contractor shall maintain, alter, move and adapt the sign boards from time to time as instructed by the Engineer. The display of any named Subcontractors or any other information associated with the Works shall be to the approval of the Engineer.

The Contractor shall provide safety barriers to protect the public, in a form and to the specification specified. The safety barriers shall be erected each side of all open trench and other excavations and at such other locations as required by the Engineer.

Sign boards and safety barriers will not be paid for directly but shall be deemed to be included in the rates of other items of the project.

1-B-46 FLAGGING, LIGHTING, WATCHING AND TRAFFIC CONTROL

Where necessary for the safety of the public or where required by the Engineer or his Representative the whole of the Works shall be properly fenced, signed and lighted from half an hour before sunset until half-an-hour after sunrise and at other times when visibility is poor. On all occasions the Works shall be properly flagged. The lamps shall be approved by the appropriate Authority and shall be kept in a clean and proper condition. The position and number of the lamps shall be such that the extent and position of the works is clearly defined and the arrangement shall comply with the requirements of the appropriate Authority. Each site of the Works shall be provided with night and week-end watchmen as may be required.

1-B-47 TEMPORARY WORKS

The Contractor shall be responsible for designing and constructing any temporary works he requires to undertake the construction of the project. These works shall be to the approval of the Engineer. At Contract completion, the Contractor shall be responsible for removing all temporary works and reinstating the site unless the Employer wishes to purchase some of those works at a mutually agreed price and thereby give them the status of permanent works.

1-B-48 CLEANING THE SITE

During the execution of the work, the Contractor shall keep the site clean by removing and carting away to approved dumping sites all rubbish, debris, wastes, etc.

Upon completion of the work and before acceptance and final payment will be made, the Contractor shall clean the Site and property defaced or occupied by him. He shall clear in connection with the Work all rubbish, excess materials, debris, false work, temporary structure and equipment.

All parts of all types of the Work shall be left in a neat and presentable condition and as approved by the Engineer.

1-B-49 CONTRACTOR'S YARDS, STORES AND ACCOMMODATION FOR WORKMEN

The Contractor shall make his own arrangements for all land, yards, stores, workshops, offices etc. and for all services in connection therewith.

The location of all yards, stores, workshops, offices, etc. shall be agreed beforehand with the Engineer and shall be such as to avoid obstruction and nuisance to the public.

The Contractor shall construct on the Site, or at suitable locations, secure storage compounds and storage buildings where he shall store at his own risk all equipment and plant delivered to Site and awaiting erection. The compound shall be of sufficient size to accept all such plant delivered and awaiting erection.

Storage buildings shall be weatherproof and shall be of sufficient size to accommodate all items requiring covered storage.

The storage compounds and buildings shall be completed prior to delivery of any items of plant and equipment.

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. 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 proper disposal of waste from mess rooms, closets and latrines

Materials shall be so stored as to assure the preservation of their quality and fitness for the work. Stored materials, even though approved before storage, may again be inspected prior to their use in the work. Stored materials shall be located so as to facilitate their prompt inspection. Any costs for the use of privately-owned land for storage and/or for the placing of the contractors plant and equipment shall be borne by the contractor. Private property shall not be used for storage purposes without written permission and release of the owner or lessee, and a copy of such written permission and release shall be furnished to the Engineer prior to any use of the land by the contractor.

1-B-50 DUMPING SITES

The Contractor shall remove and cart away all rubbish, excess materials, debris, etc. to dumping sites approved by the Engineer. It shall be the Contractor's sole responsibility to establish the locations of these sites and get the necessary approvals from concerned authorities for using them.

Dumped material shall be spread over the whole area of the dumping site in layers not exceeding 80 cms. In case a dumping site is abandoned, the Contractor shall grade the area in an acceptable manner and to the satisfaction of the Engineer.

1-B-51 DISMANTLED ITEMS

All items dismantled by the Contractor shall be considered the property of the Employer, and they shall be disposed of as instructed by the Engineer.

Part II : Pipelines

PART II: PIPELINES

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PART 2 - PIPELINES

2-A GENERAL REQUIREMENTS

2-A-1 INSTALLATION OF PIPES

2-A-1-1 General

Excavation of any part of the project is not allowed until a full supply of pipes and fittings are available on site.

Before using pipes, special parts and apparatuses should be installed on site and thoroughly cleaned and cleared out from any undesirable element.

During pipe laying, all precautions shall be taken to avoid ingress inside the pipe of any foreign material, dirt or soil.

Pipes are lowered down in the trench with adequate equipment and shall be placed in the right position for the jointing purposes.

Pipes and special pieces and apparatus shall be brought down in the trench carefully avoiding any sudden shocks or falls, etc.

Placing and installing the pipes shall be performed by experienced laborers.

During the course of the work(s) executed within the water table it is necessary to keep the trench bottom dry during the placing of gravel or sand pipe bedding.

Temporary wedges shall be placed to get the proper alignment and at the change of direction. These wedges shall be made of compacted earth heaps or wood pieces. Using stone wedges will not be allowed. However, concrete pipes shall be laid on a temporary basis made from solid materials (exicalibrated stones).

Pipe ends shall be temporarily closed with wooden, plastic flanges or with special pieces during the stopping of the works.

2-A-1-2 Excavation For Pipe Trench

See PART III-1- EARTHWORK.

2-A-1-3 Pipe Installation In Trench

- All pipes and fittings are to be present on site and ready for installation by well trained and professional crew.
- Examine and clean all pipes and fittings before installation. Damaged items are to be removed immediately from site for repair or disposal.
- In case of pipe cutting, use slitting disc type cutter or an air operated saw for larger pipes. After cutting and before assembly, it is essential to fillet or

chamfer the edge of the cut with file. Finally restore the protective coating on the pipe areas affected by the cutting operations if applicable.

- Install pipes to the invert / crown level indicated on the longitudinal profile using proper survey tools.
- Pipes shall not be dragged along the trench bottom.
- Ensure inner and outer coatings are not damaged and pipe is clean.
- Examine the pipe visually against any break of hair cracks, bends, bumps or deflection along pipe length.
- Use proper ropes and protected hooks when handling pipes.
- Use pieces of soft wood when leveling the pipes in the trench. Do not use stones, bricks, etc… this may damage the coating.
- Install joints as specified on the drawings and where needed and as directed by the Engineer.
- Do not leave ends of pipes opened if installations stopped. Use tight lids supplied by manufacture.
- Whenever part or section of pipes, not exceeding 500 meters, is installed in the trench. Submit a written request for pressure testing before backfilling and compacting the pipe trenches.
- Each portion of pipeline shall be a full pipe span, as much as possible in order to reduce to the minimum pipe joints.
- Pipes and fittings laid in trench shall have at least the minimum cover stated on the Drawings.
- Long radius curves in buried pipelines shall be negotiated by deflections taken up in one or more pipes. The deflection in pipeline shall not exceed the specified limits.
- Pipes shall be laid with a minimum gradient of 1 in 500.

2-A-1-4 Backfilling Pipe Trenches

See PART III-1- EARTHWORK

2-A-2 CUTTING PIPES

2-A-2-1 General

Before cutting the pipe, it is essential to measure the external diameter at the cutting point with a circumference tape or compass calipers, to check that it is compatible with the intended coupling joint dimensions.

Use hacksaws, manually operated wheel cutter or pipe cutting machine as per manufacturer's instructions. Prepare ends according to the type of joint used and follow manufacturer's

recommendations. Take care not to damage lining of other type pipes associated with main pipes. Repair on site, minor damage, if permitted.

After making the cut, and before assembly, it is essential to fettle / chamfer the edges of the cut with a file.

2-A-2-2 Ductile Iron Pipes

Ductile iron pipes shall only be cut with an approved mechanical pipe cutter in conformity with the pipe manufacturer's recommendations. The use of an oxyacetylene flame cutter will not be permitted. The edges of the cut together with those parts of the pipes from which the coating has been removed shall be given two coats of bituminous paint and the internal lining repaired. When the cut pipe is to be inserted in a "Tyton" type joint it shall be beveled for 10mm at 30° to pipe the axis.

2-A-2-3 Polyethylene

Pipes shall be cut with an approved mechanical pipe cutter and in conformity with pipe manufacturer's recommendations. Where the cut end of the pipe is to be incorporated in a joint the pipe shall be turned down to the correct diameter required for forming the joint by an approved mechanical turning machine. The length of turning shall be sufficient to enable the joint to be properly made the ends of the pipe shall be accurately beveled by mechanical means to the dimensions specified in the manufacturers recommendations.

2-A-3 CONCRETE SURROUNDING PIPES

2-A-3-1 General

All concrete works shall comply with the appropriate requirements of PART III-2- CONCRETE AND MASONRY.

Concrete surround shall be broken at all pipe joints to retain flexibility in the pipeline in case of shallow pipes, except for pipes crossing under watercourse, the concrete surrounding shall be continuous and rigid.

When pipes intersect with other utilities, the pipe shall be surrounded with concrete, the joints at such crossing shall be ridged.

All concrete encasements shall not be executed without the prior approval of the Engineer.

2-A-3-2 Materials

Concrete bedding: cast in situ CLASS "C".

Concrete encasement with reinforcement: cast in situ CLASS "B".

2-A-3-3 Placing Concrete

After placing pipe, place concrete in trench and thoroughly work under the pipe to provide solid and uniform bedding.

Place the balance of concrete on both sides of the pipe simultaneously.

Introduce vertical construction joints in concrete beds, surroundings etc. at the face of pipe joint with compressible board and finish to profile of concrete and pipe. Fill any gap left in concrete with approved resilient material.

2-A-4 RESTORATION OF SURFACE

1- General: Proceed with surface restoration as soon as other practicable works is completed, but in no case more than 10 days after backfilling of the trench and other excavated areas and complete within a further 20 days.

2- Restoration of asphalt, concrete and/or gravel pavements are to be brought back to its original thickness and materials to match the existing pavement. Material and workmanship are to be in according to the local municipality requirements or as directed by the Engineer.

3- Restoration of pavement: Repave to match existing pavements in quality, shape, size and level to a uniform surface finish with existing surface.

4- Restoration of grassed areas: After backfilling is compacted and brought to the bottom of the previous top soil level, spread approved fertilized soil over affected area and seed, Continue fertilizing and watering until grass is restored to its former condition.

5- Restoration of unsurfaced area: Bring backfill to natural ground level, well compacted and distributed evenly.

2-B DUCTILE IRON PIPES & FITTINGS

All ductile iron pipes and fittings to be supplied under this Specification shall be obtained from an approved manufacturer having an ISO9001-2000 TOTAL QUALITY ASSURANCE system based on the latest version of the ISO9001 standard.

2-B-1 SOCKET AND SPIGOT PIPES

Ductile iron socket and spigot pipes shall be centrifugally cast in accordance with the European Standard EN 545-2002.

Each pipe shall be subjected, in accordance with the European Standard EN 545-2002, to a hydrostatic works test at the following pressures:

DN	**Hydrostatic pressure** Bar
60 to 300	50
350 to 600	40
700 to 1000	32
1100 to 2000	25

2-B-2 FLANGED PIPES

Ductile iron flanged pipes shall be manufactured in accordance with the European Standard EN 545-2002. The flanged joint ISO PN 16 or ISO PN 25 whose drilling shall comply with International Standard ISO 7005-2 ISO PN 16 or ISO PN 25 insures the water-tightness.

2-B-3 FITTINGS

The ductile iron fittings shall be sand cast in accordance with the European Standard EN 545-2002.

The water-tightness is insured by the joint, which shall be of the:

- STANDARD push in joint where fittings are used with Socket and Spigot pipes.
- SELF-ANCHORED push in joint where fittings are used with Socket and Spigot pipes and where there is a need to take up the axial forces.
- FLANGED joint where fittings are used with flanged pipes.

Each fitting shall be subjected, in accordance with the European Standard EN545-2002, to a work leak tightness test carried out under a one bar air pressure.

2-B-4 LAYING AND JOINTING

2-B-4-1 Laying

Before Ductile Iron is laid, all dirt and foreign matter shall be removed from inside and all lumps blisters, excess coal tar, oil, grease and moisture shall be eliminated from the surfaces the joints. After the pipe is laid and mounted, care shall be taken to avoid entrance of dirt, water and foreign matter from the trench or from elsewhere by use of tight bulkheads.

2-B-4-2 Jointing

Joints of Ductile Iron Pipes and Fittings shall be of the Push in automatic standard type and where there is a need to take up the axial forces, necessary Self Anchored push in joint shall be used which allows concrete anchor blocks to be dispensed with. Flanged jointing shall be used for pipes inside reservoirs and valve chambers.

2-B-4-3 Lubricant Paste

The lubricant paste shall be a mixing of Vaseline, non soluble in accordance with French standard AFNOR T90 M DOC8. The quantities used in the assembly joints shall be as per manufacturer recommendation. It shall be supplied by the Pipes and fittings manufacturer.

2-B-5 CONNECTING PIECES

All connecting pieces i.e. flexible coupling, flange adaptors, dismantling joint shall be made of ductile iron and shall be supplied from the same pipes and fittings manufacturer.

2-B-6 LININGS AND COATINGS

2-B-6-1 Pipes Internal Protection (Including Welded Flanged Pipes)

Pipes shall be internally lined with sulphate resisting blast furnace slag cement applied by a centrifugal process. The cement mortar lining shall be in accordance with the International Standard ISO 4179-1985 with the thickness given in following table:

	Thickness of mortar	
	Nominal mean Value Mm	**Tolerance Mm**
80 – 300	3.5	- 1.5
350 – 600	5	-2
700 – 1200	6	-2.5
1400 – 2000	9	-3

2-B-6-2 Pipes External Protection (Including Welded Flanged Pipes)

Pipes shall be externally coated with:

- A metallic zinc coating in accordance with the International Standard ISO 8179 Part 1-1995. The quantity of zinc shall not be less then 200 g/m2.
- A bituminous varnish or equivalent (Metallic zinc with synthetic resin) anticorrosive paint which shall be applied over the zinc coating in accordance with the International Standard ISO 8179 Part 1-1995, with a minimum thickness of 100 microns.

2-B-6-3 Fittings Internal And External Protection

The fittings shall be internally and externally protected with a bituminous varnish with a minimum thickness of 70 microns or with an epoxy coating applied by a cataphoresis process ensuring an equivalent protection. The type of the coating depends of the diameter of the fittings.

2-B-6-4 Connecting Pieces Internal And External Protection

The connecting pieces (Flexible couplings, Flange adaptors, Dismantling joint) shall be internally and externally protected with a powder Epoxy coating having a minimum thickness of 150 microns or with a rilsan nylon coating having a minimum thickness of 200 microns. The type of the coating depends of the diameter and the type of the connecting pieces.

2-B-7 HYDROSTATIC PRESSURE TESTING

Pressure pipelines shall undergo a hydrostatic pressure test. They shall be tested in sections not larger than 500 m, or as may be directed by the Engineer, and tests shall be made only on sections which are completed, except for backfilling over joints and fittings which are to be left exposed for inspection. Weights and thrust blocks intended to prevent lateral and vertical displacement of the pipes or specials must be completed and must have attained their design strength before tests are commenced.

Test sections shall be preferably carried out between shut-off or sectioning valves. Where this is not practicable, test sections shall be sealed off by suitable bulkheads, properly braced.

Prior to testing, air shall be evacuated from the line by filling it with water with all valves and taps open. After the first filling and the closing of all valves and taps, the water shall remain in the line for at least 24 hours to allow for absorption, and water being added as required to make up for losses. During this period the Contractor shall inspect the line and all fittings and valves installed on it for leaks. Any leaks found shall be promptly repaired by the Contractor, who shall then proceed with the test, unless otherwise noted on the drawings, in the particular specifications, or by the Engineer, the “Test presssure” measured at the lowest point of the section shall be equal to one of the following values:

For pressure gravity driven pipelines:

1) Test pressure shall be equal to (1.5 x Rated Working Pressure) for rated working pressure equal to or less than 10 kg/cm^2,

2) Test pressure shall be equal to (Rated Working Pressure + 5 kg/cm^2.) for rated working pressures exceeding 10 kg/cm^2 .

For lift pipelines:

Test pressure shall be equal to Rated working pressure plus calculated water hammer surge plus 2 kg/cm^2.

The water hammer surge will be calculated as follows : $\Delta H = \frac{a\ \Delta V}{g}$

where:

ΔH = Water hammer surge

ΔV = design velocity as indicated on the drawings expressed as meter per second.

a = surge velocity expressed as meter per second (a = 1100m/s).

g = acceleration due to gravity in meters per second per second = 9.81 m/s^2.

The pressure shall be slowly raised by pumping to the required "Test Pressure". Pumping shall then be discontinued, the pump disconnected, and the line kept under pressure for at least 30 minutes. For the line to be accepted, the pressure shall not drop by more than 0.2 kg/cm^2 during the said 30 minutes period and there shall be no visible leaks at joints, fittings, valves, etc. Should the drop of pressure exceed this value, the Contractor shall search for the defects causing such pressure drop, shall make all necessary repairs and repeat the test until the section under test meets the requirements. Provided always that all visible leaks must be repaired whatever the loss of pressure. The Contractor shall at his own cost provide all necessary test pumps, pressure gauges, cocks and other accessories and shall make such temporary connections as may be required for filling and testing the line in the manner herein specified.

The water used for pressure testing shall be provided by the Contractor and shall be free from inpurities and of such a quality which will not pollute or injure the pipeline. The Contractor shall be responsible for obtaining the water, transporting it and for its safe disposal on completion.

2-C POLYETHYLENE PIPES

2-C-1 GENERAL TERMS AND CONDITIONS

2-C-1-1 Scope

This specification covers requirements for polyethylene piping system (pipe and fittings) for the supply of water under pressure intended for human consumption both above ground and in buried pipe applications.

2-C-1-2 Engineered And Approved Plans

Construction shall be performed in accordance with engineered construction plans for the work prepared under the direction of a Professional Engineer.

2-C-1-3 Referenced Standards

The most recent ISO standards or European Norms EN12201 / EN12202 or DIN 8074 / 8075 shall apply.

2-C-1-4 Inspections

All work shall be inspected by an Authorized Representative of the Owner who shall have the authority to halt construction if, in his opinion, these specifications or standard construction practices are not being followed. Whenever any portion of these specifications is violated, the Project Engineer or his Authorized Representative shall, by written notice, order further construction to cease until all deficiencies are corrected. A copy of the order shall be filed with the Contractor's license application for future review. If the deficiencies are not corrected, performance shall be required of the Contractor's surety.

2-C-1-5 Warranty And Acceptances

The Contractor shall warrant all work to be free from defects in workmanship and materials for a period of [one year] from the date of completion of all construction. If work meets these specifications, a letter of acceptance, subject to the [one year] warranty period, shall be given at the time of Completion. A final acceptance letter shall be given upon final inspection at the end of the [one year] warranty period, provided the work still complies with these specifications. In the event deficiencies are discovered during the warranty period, they shall be corrected b the Contractor without additional charge to the owner before final acceptance. During the warranty period, the Project Engineer shall determine if warranty repairs or replacement work shall be performed by the Contractor. The decision of the Project Engineer shall be binding upon the Contractor.

2-C-1-6 Qualification Of Manufacturers

The Manufacturer shall have manufacturing and quality control facilities capable of producing and assuring the quality of the pipe and fittings required by these specifications. The manufacturer's production facilities shall be open for inspection by the Owner or his Authorized representative. Qualified Manufacturers shall be approved by the Project Engineer.

2-C-1-7 Approved Manufacturers

Manufacturers must be pre-qualified and pre-approved by the Project Engineer. Products from unapproved manufacturers are prohibited.

2-C-2 POLYETHYLENE PIPES / FITTINGS

2-C-2-1 Raw Materials

The polyethylene compounds used in the manufacture of products furnished under this specification shall be made from compounded pellets obtained by the addition of the correct type and amount of *carbon black* and necessary antioxidants and other additives to protect the pipe during extrusion and assure the life expectancy of the pipe. ***Pipe produced by the addition of black masterbatch to polyethylene is strictly forbidden***. The compound material shall comply with the requirements as specified in EN 12201-Part 1.

Typical material properties as described by the Raw Material Supplier brochure shall be submitted to the project engineer for analysis and verification of compliance. These properties are not to be misconstrued as specification minimums.

All Raw Material used shall be approved and certified ***Pipe Grade Material*** for the transportation of potable water.

2-C-2-2 Polyethylene Pipe

2-C-2-2-1 Pipe Coil

Pipes with OD up to 110 mm shall be supplied in coils where the inside diameter of the coil is 30 times OD. Pressure pipes with OD of 140mm and above shall be supplied in straight lengths. When needed special pipe length can be supplied with the approval between purchaser and manufacturer.

2-C-2-2-2 Marking of Pipe

All pipes shall bear permanent identification markings that will remain legible during normal handling, storage, installation, and service life and that have been applied in a manner that will not reduce the strength nor otherwise damage the products. The marking shall not initiate any defects in the surface and will not provide leakage channels when elastomeric gasket

compression fittings are used to make joints. Both hot tape marking and Ink Jet printing are acceptable.

Marking on pipe shall include the following and shall be applied at intervals of not more than 1.5 meters:

1) Normal size (i.e. 90mm)
2) Standard PE designation (i.e. PE-HD PE 100)
3) The Standard Dimension Ratio (i.e. SDR 11)
4) Marking the product with the applicable standards designation (EN 12201).
5) Production date
6) Nominal pressure rating of pipe (i.e. PN10)
7) Manufacturer's Name
8) Country of production

2-C-2-2-3 Service Identification Stripes

PE Pipes shall be permanently color-coded with stripes for instant identification as potable water service pipes. Stripes shall be provided by co-extruding four (or more) equally spaced blue color stripes into the pipe outside surface. The striping material shall be the same material as the pipe material except for color. ***Stripes printed on the pipe outside surface shall not be acceptable***.

2-C-3 MANUFACTURER'S QUALITY CONTROL

The pipe manufacturer shall have an established quality control program responsible for inspecting incoming and outgoing materials. Incoming PE materials shall be inspected for density, melt flow rate, and contamination. The cell classification properties of the material shall be certified by the supplier, and verified by Manufacturer's Quality Control. Incoming materials shall be approved by Quality Control before processing into finished goods. Outgoing materials shall be checked for:

a) Outside diameter and wall thickness as per EN 12201-Part 2 at a frequency of at last once/hour or once/coil, whichever is less frequent.
b) Out of Roundness at a frequency of at least once/hour or once/coil whichever is less frequent.
c) Quality Control shall verify production checks and test for:
d) Melting Index as per ISO 1133 at a frequency of at least once per extrusion lot.
e) Hydrostatic Strength testing (up to Ø110mm) as per EN 921 at a frequency of at least once per day per line.
f) All fabricated fittings shall be inspected for joint quality and alignment.

2-C-3-1 Permanent Records

The Manufacturer shall maintain permanent QC and QA records.

2-C-3-2 Compliance Tests

Manufacturer's inspection and testing of the materials. In case of conflict with Manufacturer's certifications, the Contractor, Project Engineer, or Owner may request retesting be the Manufacturer or have retests performed by an outside testing service. All retesting shall be at the Contractor's expense, and shall be performed in accordance with the Specifications.

2-C-4 CHARACTERISTICS

2-C-4-1 External Aspect Of Pipes

Pipe surface shall be smooth, free from scoring, pinholes, and other surface defects. Pipe ends must be cut clean and perpendicular to the axis of the pipe. End caps at pipe extremities are required in order to prevent unwanted matter entering the pipe during storage.

2-C-4-2 Engineering Characteristics

The limitation on the outside diameter and ovality shall confirm to PR-EN 12202-2 as follows:

Ovality	OD Max	OD Min	OD
1.2	16.3	16.0	16
1.2	20.3	20.0	20
1.2	25.3	25.0	25
1.3	32.3	32.0	32
1.4	40.4	40.0	40
1.4	50.4	50.0	50
1.5	63.4	63.0	63
1.6	75.5	75.0	75
1.8	90.6	90.0	90
2.2	110.6	110.0	110

The pipes thickness shall depends to the properties used in manufacturing and shall conform to PR-EN 12202-2 and nominal pressures of PN10, PN12.5 and PN16bars for PE80 material and PN10, PN12.5, PN16 bars and PN20 for PE100 material.

STANDARD: PR-EN 12201 - 2/TC 155									
PE 80 MATERIAL									
	PN 10			**PN 12.5**			**PN 16**		
	SDR 13.6 S-6.3			**SDR 11 S-5**			**SDR 9 S-4**		
OD	**E min.**	**E max.**	**ID (*)**	**e min.**	**e max.**	**ID (*)**	**e min.**	**e max.**	**ID (*)**
Mm	Mm	mm	mm	mm	mm	mm	mm	mm	mm
16	-	-	-	-	-	-	2.0	2.3	11.7
20	-	-	-	2.0	2.3	15.7	2.3	2.7	15.0
25	2.0	2.3	20.7	2.3	2.7	20.0	3.0	3.4	18.6
32	2.4	2.8	26.8	3.0	3.4	25.6	3.6	4.1	24.3
40	3.0	3.5	33.5	3.7	4.2	32.1	4.5	5.1	30.4
50	3.7	4.2	42.1	4.6	5.2	40.2	5.6	6.3	38.1
63	4.7	5.3	53.0	5.8	6.5	50.7	7.1	8.0	47.9
75	5.5	6.2	63.3	6.8	7.6	60.6	8.4	9.4	57.2
90	6.6	7.4	76.0	8.2	9.2	72.6	10.1	11.3	68.6
110	8.1	9.1	92.8	10.0	11.1	88.9	12.3	13.7	84.0
125	9.2	10.3	105.5	11.4	12.7	100.9	14.0	15.6	95.4
140	10.3	11.5	118.2	12.7	14.1	113.2	15.7	17.4	106.9
160	11.8	13.1	135.1	14.6	16.2	129.2	17.9	19.8	122.3
180	13.3	14.8	151.9	16.4	18.2	145.4	20.1	22.3	137.6
200	14.7	16.3	169.0	18.2	20.2	161.6	22.4	24.8	152.8
225	16.6	18.4	190.0	20.5	22.7	181.8	25.1	27.8	172.1
250	18.4	20.4	211.2	22.7	25.1	202.2	27.9	30.8	191.3

OD = Outside Diameter
ID (*) = Average Inside Diameter
e = Wall Thickness
PN = Nominal Pressure Ratings in Bar

STANDARD: PR - EN 12201 - 2/TC 155												
PE 100 MATERIAL												
	PN 10			**PN 12.5**			**PN 16**			**PN 20**		
	SDR 17 **S-8**			**SDR 13.5** **S-6.3**			**SDR 11** **S-5**			**SDR 9** **S-4**		
OD	e min.	e max.	ID(*)	e min.	e max.	ID(*)	e min.	e max.	ID(*)	e min.	e max.	ID(*)
mm	Mm	Mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
16										2.0	2.3	11.7
20							2.0	2.3	15.7	2.3	2.7	15.0
25				2.0	2.3	15.7	2.3	2.7	20.0	3.0	3.4	18.6
32	2.0	2.3	27.7	2.4	2.8	20.0	3.0	3.4	25.6	3.6	4.1	24.3
40	2.4	2.8	34.9	3.0	3.5	25.6	3.7	4.3	32.1	4.5	5.1	30.4
50	3.0	3.4	43.8	3.7	4.2	32.1	4.6	5.2	40.2	5.6	6.3	38.1
63	3.8	4.3	55.3	4.7	5.3	40.2	5.8	6.5	50.7	7.1	8.0	47.9
75	4.5	5.1	65.7	5.6	6.3	50.7	6.8	7.6	60.6	8.4	9.4	57.2
90	5.4	6.1	78.8	6.7	7.5	60.6	8.2	9.2	72.6	10.1	11.3	68.6
110	6.6	7.4	96.4	8.1	9.1	72.6	10.0	11.1	88.8	12.3	13.7	84.0
125	7.4	8.3	108.6	9.2	10.3	88.9	11.4	12.7	100.9	14.0	15.6	95.4
140	8.3	9.3	122.8	10.3	11.5	100.9	12.7	14.1	113.2	15.7	17.4	106.9
160	9.5	10.6	140.4	11.8	13.1	113.2	14.6	16.2	129.2	17.9	19.8	122.3
180	10.7	11.9	157.4	13.3	14.8	129.2	16.4	18.2	145.4	20.1	22.3	137.6
200	11.9	13.2	174.9	14.7	16.3	145.4	18.2	20.2	161.6	22.4	24.8	152.8
225	13.4	14.9	196.7	16.6	18.4	161.6	20.5	22.7	181.8	25.2	27.9	171.9
250	14.8	16.4	218.8	18.4	20.4	181.8	22.7	25.1	202.2	27.9	30.8	191.3

OD = Outside Diameter

ID (*) = Average Inside Diameter

e = Wall Thickness

PN = Nominal Pressure Ratings in Bar

2-C-4-3 Mechanical Characteristics

All manufactured pipes shall pass the stress test conforming to the requirements of PR-EN 12202-2 using test method of EN 921/ISO 1167. Stress test shall be the deciding factor in accepting or refusing the pipe.

Produced pipes shall pass the internal pressure test (acceptance test) using test method per EN 921.

PE class	Reqts	Stress	Temp.
PE 100	>100hrs	12.4MPa	20 °C
PE 80	>100hrs	10.0MPa	20 °C

Note: The Contractor must give the Engineer a report specifying that the pipes he will install fits with the specifications described.

2-C-4-4 Effect of temperature on working pressure of PE Pipe

Nominal pressure of PE pipes is the service pressure at 20°C with a service life of 50 years. For the use of Polyethylene pipes at higher temperature (up to a maximum of 60°C) the maximum working pressure according to the following table, should be reduced as shown on the following chart. These values are based on a pipe life time of 50 years.

Permissible Working Pressures For Pipes Transporting Water

Temperature in °C	**Years of service**	**1**	**2**	**3**	**4**	**5**	**6**
		Pressure rating					
		PN 2.5	PN 3.2	PN 1	PN 6	PN 10	PN 16
		Permissible working pressure					
10	1	3.4	4.3	5.4	8	13.4	21.4
	5	3.2	4.1	5.1	7.7	12.8	20.5
	10	3.2	4	5	7.6	12.6	20.2
	25	3.1	3.9	4.9	7.3	12.2	19.5
	50	3	3.8	4.8	7.2	12	19.2
20	1	2.9	3.8	4.8	6.8	11.4	18.2
	5	2.7	3.5	4.3	6.6	10.8	17.3
	10	2.7	3.4	4.2	6.4	10.8	17
	25	2.6	3.3	4.2	6.2	10.4	16.6
	50	2.5	3.2	4	6	10	16
30	1	2.5	3.1	3.9	5.9	9.8	15.7
	5	2.4	3	3.8	5.6	9.4	15
	10	2.3	2.9	3.7	5.5	9.2	14.7
	25	2	2.5	3.1	4.7	7.8	12.5
	50	1.7	2.2	2.7	4.1	6.8	10.9
40	1	2.1	2.7	3.4	5	8	13.4
	5	1.8	2.3	2.9	4.3	7.2	11.5
	10	1.8	2	2.5	3.7	6.2	9.9
	25	1.8	1.7	2.1	3.1	5.2	8.3
	50	1.2	1.5	1.8	2.8	4.6	7.4
	1	1.7	2.2	2.7	4.1	6.8	10.9
	5	1.2	1.5	1.9	2.9	4.8	7.7
50	10	1.1	1.3	1.7	2.5	4.2	6.7
	15	1	1.3	1.8	2.4	4	6.4
60	1	1.2	1.5	1.0	2.9	4.8	7.7
	5	-	1.1	1.4	2	3.4	5.4

Note: These working pressures do not apply for pipes exposed to UV radiation. The effect of such radiation can be eliminated or considerably reduced for up to ten years of service by the inclusion of suitable additives in the molding material.

2-C-5 PIPE CONNECTIONS

There are seven acceptable methods of joining polyethylene pipe with each other and with other pieces such as valves, flanges, etc.

1- Plastic Compression connection

2- Metal (ductile Iron) Compression connection

3- Electrofusion Fittings

4- Flange connection

5- Fabricated Fittings

6- Butt Fusion Welding

7- Special tapping fittings

2-C-5-1 Plastic Compression Fittings for PE Pipes

This type uses mechanical anchoring that holds the pipe in place (clamp ring usually made of Acetalic resin or C-PVC)and a sealing gasket (EPDM or Rubber/food approved) to create a tight grip and prevent water from leaking. Pipes must be pushed inside the fitting without the necessity to disassemble the fittings. The following pipe OD to PN must apply:

- Pipes up to OD = 63mm with pressure rating maximum PN16
- Pipes OD = 75mm up to 110mm maximum PN10. For PN16 applications metal compression fittings or electrofusion fittings should be used.
- Pipes OD >110mm plastic compression fittings are not used. Metal compression fittings or electrofusion fittings should be used.

All fittings must pass the testing requirements of ISO 3458/3459/3501/3503.

2-C-5-2 Metal (ductile iron) Compression Fittings for PE Pipes

When joining polyethylene pipe or for joining polyethylene pipe to another material with metal couplings, those couplings shall be fully pressure rated and fully thrust restrained such that when installed in accordance with manufacturer's recommendations, a longitudinal load applied to the mechanical coupling will cause the pipe to yield before the mechanical coupling disjoins. External joint restraints shall not be used in lieu of fully restrained mechanical couplings. Nominal pressure rating of fittings shall be 16 bar.

Materials used in the manufacturing of steel compression fittings shall conform to the following:

- Body : GGG 400 - DIN 1693 (epoxy coated, see below for detailed reqts)
- Lip Seal : EPDM
- Grip Ring : Ms 58 (dezincification resistant brass)
- Bolts : A2 (stainless Steel)

– All steel compression fittings must be epoxy coated.

2-C-5-3 Electrofusion Fittings for PE Pipes

Electrofusion can be used for all polyethylene pipes irrespective of size and pressure rating as long as pipe and fitting are manufactured from polyethylene resin of the same class and series . It is possible to use fittings with higher pressure rating than pipe, but the opposite is strictly forbidden. Nominal pressure rating of fittings shall be 16 bar.

This type of fittings incorporates electrical heating coil that fuses pipe and fitting by sending an electrical current that heats up the polyethylene material of pipe and fitting at a specific voltage for a specified temperature and duration of time after which pipe and fitting fuse together and become integrated on the molecular level. Manufacturer recommendations for the electrofusion operation must be strictly followed.

Electrofusion machines used in the electrofusion process must be supplied by the same manufacturer of fittings. It strictly forbidden to fuse one manufacturer fitting with another manufacturer machine. Installers of Electrofusion fittings must strictly adhere to both fittings and equipment manufacturer's recommended procedures.

2-C-5-4 Flanged Connections

Flange connections shall be installed in accordance with the Manufacturer's recommended procedure. Flange faces shall be centered and aligned to each other before assembling and tightening bolts. In no case shall the flange bolts be used to draw the flanges into alignment. Bolt threads shall be lubricated, and flat washers shall be fitted under the flange nuts. Bolts shall be evenly tightened according to the tightening pattern and torque step recommendations of the Manufacturer at least 1 hour after initial assemble, flange connections shall be re-tightened following the tightening pattern and torque step recommendations of the Manufacturer. Nominal pressure rating of fittings shall be 16 bar.

Flanged connections shall consist of the following parts/fittings :

- Coupler (Electrofusion)
- Flanged Adaptor

The coupler for jointing plain-end polyethylene (PE) pipe to PE flanged items shall be of the electrofusion type that heats up the PE material of the pipe to the PE material of flanged fitting. Pressure rating of the coupler shall be no less than 16 bar and made of the same PE resin, class and series as the pipe.

The flanged adaptors for jointing plain-end pipe to flanged items shall be of the socket fusion type and made of polyethylene (PE) material of the same class and series as the pipe. Pressure rating of the flanged adaptor shall be no less than 16 bar.

2-C-5-5 Fabricated Fittings

Fabricated fittings shall be made by heat fusion joining specially machined shapes cut from pipe, polyethylene sheet stock, or molded fittings. Fabricated fittings shall be rated for internal pressure service equivalent to the full service pressure rating of the mating pipe. Directional

fittings such as elbows, tees, crosses, etc., shall have a plain end inlet for butt fusion and flanged directional outlets. Part drawings shall be submitted for the approval of the Project Engineer.

2-C-5-6 Butt Fusion Welding

For pipes with diameters larger than 75mm, joints between end of the pipes and fittings may be made by butt fusion, and joints between the main and saddle branch fittings shall be made using saddle fusion using only procedures that are recommended by the pipe and fitting Manufacturer. The Contractor shall ensure that persons making heat fusion joints have received training according to the Manufacture's recommended procedure. The Contractor shall maintain records of trained personnel, and shall certify that training was received not more than 12 months before commencing construction.

Heat Fusion Training Services - Upon request, the Manufacturer must provide training in the Manufacturer's recommended butt fusion and saddle fusion procedures to the Contractor's installation personnel, and to inspectors representing the Owner.

2-C-5-7 Tapping Fittings

Branch connections to the main pipeline i.e. (branch OD 63mm) can be made using either tees or special tapping fittings (saddle fittings). These fittings can be either mechanical type, electrofusion type or metal type (ductile) and should be designed for the connection to polyethylene (PE) pipes

Tapping fittings according to DIN 3543 are provided for welding to PE-HD pipes. They are welded to the main pipe according to the indications of international standards.

Tapping fitting for polyethylene main lines of PVC or PE-HD must have large contact surfaces and particularly for PE-HD special sealing elements in order to limit to a minimum the surface pressure.

When tapping the main pipeline, it is important to adhere to the respective guidelines for the pipe material. Only appropriate drills for the specific purpose, e.g. crown drills with sufficiently dimensioned flutes may be used. The construction of the drill must prevent the milled-out piece from falling into the pipe.

The material of the main pipeline determines the saddle width of the tapping fitting. The minimum width should be 100 mm for mechanically fastened fittings with rubber seals on PE-HD main lines.

2-C-6 INSTALLATION OF POLYETHYLENE PIPE SYSTEM

2-C-6-1 Foundation & Bedding

Pipe shall be laid on grade and on a stable foundation. Unstable or mucky trench bottom soils shall be removed, and a minimum of 100mm foundation or bedding of compacted fine gravel or sand shall be installed to pipe bottom grade. Excess groundwater shall be removed from the trench before laying the foundation or bedding and the pipe. A trench cut in rock or stony soil shall be excavated to 100mm below pipe bottom grade, and brought back to grade with

compacted fine gravel or sand bedding. All ledge rock, boulders and large stones shall be removed.

2-C-6-2 Pipe Laying

a. In case of outdoor temperatures lower than 0°C, it is recommended to lay polyethylene pipes only under application of particular measures. Pipe ends and pipeline elements must be cleared prior to installation, damaged parts must be removed. Cuts are to be executed vertically to the pipe axle with the aid of suitable equipment, e.g. a fine-toothed saw. Cutting of the pipes can be made, too, using a casing cutter for plastic pipes. Burrs and uneven areas are smoothed down using suitable tools, e.g. a shaver or a scraper. The cut ends are then prepared for the jointing method to be used.

b. When lifting pipes with slings, only wide fabric choker slings shall be sued to lift, move, or lower pipe and fittings. Wire rope or chains shall not be used. Slings shall be of sufficient capacity for the load, and shall be inspected before use. Worn or defective equipment shall not be used.

c. Exercise care to keep foreign material and dirt from entering pipe during storage, handling, and placing in trench. Close ends of in-place pipe at the end of any work period to preclude the entry of animals and foreign material.

d. Do not lay pipe when trench bottom is muddy or frozen or has standing water.

e. Use only those tools specifically intended for cutting the size and material and type pipe involved. Make cut to prevent damage to pipe and to leave a smooth end at right angles to the axis of the pipe.

f. Unwinding of pipe coils can be carried out by various methods. Pipes with an outside diameter up to 63 mm can be unwound from the coil in a vertical position whilst securing the pipe end. For larger diameters it is recommended to use an unwinding mechanism. The coils can, for instance, be placed flat onto a rotating wooden or steel cross and be unwound manually or with the aid of a slow-moving vehicle.

The pipes must be unwound in a straight manner without any buckling. Spiral unwinding must be avoided.

When unwinding pipes from drums or coils it is essential to pay attention that the pipe end cannot spring outwards when loosing the fastening. As considerable forces are released, particularly from the large diameter pipes, take the necessary measures of precaution (danger of accident !). Drums should unwound from the top.

When unwinding the pipes, note that the flexibility of the polyethylene pipes is subject to the ambient temperature. At temperatures near the freezing point, pipes exceeding 75 mm of outside diameter are to be warmed, if possible. This can be carried out by pumping warm water through the coil or by using non-pressurized steam or hot air (max. 100° C).

Temperature changes cause alterations of length. This must be taken into consideration when cutting and installing the pipeline. 1 m of polyethylene pipe will elongate by 0.2 mm per °C in case of an increase in temperature and will shorten by 0.2 mm per °C in case of a decrease in temperature.

Temperature of Pipe laying	Smallest Admissible Bending Radius
20° C	25 x d
10° C	35 x d
0° C	50 x d

Note: Directional changes of the pipeline profile are achieved by installing pipe bends. To a limited degree the elasticity of the pipe material can be used to bend the pipe even without pre-warming. The smallest admissible bending radius must, however, not fall below the values given in the table above.

Pipes passing through a wall must be lead through a protective pipe sleeve which, as far as drinking water pipelines are concerned, must be in accordance with the requirements of DIN 1988.

2-C-6-3 Backfilling

Refer to Part III-1- EARTHWORK subsection **"Backfilling Pipe Trenches – Initial Backfill"**.

2-C-6-4 Final Backfilling

Refer to Part III-1- EARTHWORK subsection **"Backfilling Pipe Trenches – Main Backfill"**.

Note: Consulting the Manufacturer during installation phases is recommended to obtain detailed information on the methods and techniques used for proper execution.

2-C-7 HYDROSTATIC PRESSURE TESTING

2-C-7-1 General

During pressure tests on polyethylene pipes, the properties of the material cause elongation of the pipes to take place. The test results can be further influenced by changes in the temperature of the pipe wall while the test is in progress. This is due to the relatively high coefficient of thermal expansion of polyethylene pipes. The temperature rise in the pipe wall causes a drop in pressure. When carrying out the pressure test, it is, therefore, desirable to keep the temperature of the pipe wall as constant as possible to ensure that the temperatures at the start and finish of the pressure test are at the same level. For this reason, particular importance attaches to the temperature measurement.

It is also important to ensure that each pipeline is carefully vented, since air trapped in the line can influence the variation of the pressure drop with time. Due to an effect similar to that of a compressed-air chamber, the rate of pressure drop diminishes, which in turn could conceal an increase in the rate possibly caused by a leak. Any air still in the line - at joints and fittings -

should be dissolved in water during the preliminary test. A pressure drop also results from temperature fluctuations and expansion of the polyethylene pipes.

In order that the often appreciable temperature influences can be largely eliminated, the tests should where possible be carried out at times of day when temperature fluctuations are small. The temperature level should be approximately the same at the start and finish of the test. Preliminary tests are essential in order that the material related elongation of the line can take place. The increase in the volume of a line at a testing temperature of 20°C and at nominal pressure amounts in the case of polyethylene pipes to 1.5 - 2%. This elongation takes place over a period of time, but is almost completed after 12 hours.

With the air vents open, it is expedient to fill the line slowly from its deep point, so that the air can escape. As regards the filling of the line, the following empirical values can be recommended:

OD (mm)	Inflow in l / s
63	0.1
90	0.2
110	0.3
140	0.5
180	0.7
225	1.5

2-C-7-2 Execution of Test

The length of the pipeline section to be testing shall be reasonable (less tham 500 m). Ensure all fixed point are surely anchored. Pipes shall be backfilled, joints shall be left exposed for inspection. The test section shall be blanked off with steel blank flanges of adequate thickness supported to resist the end thrust forces and shall be filled from the lowest point with all air valves open.

The correct pre-conditioning of the pipeline is absolutely vital for the acceptance of the main test. This preliminary conditioning serves to bring the pressure time and temperature dependent changes in volume to a steady state, thus ensuring that the results obtained during the main test are reliable.

The preliminary conditioning must be carried out using one and a half times nominal pressure of the pipes, to be checked and corrected if necessary at two hourly intervals. Duration of the preliminary test is 12 hours.

During the main test, it must be taken into consideration that the polyethylene pipeline material may not have completed the expansion process; Therefore, the main test shall be started no sooner than 2 hours after the last pressure increase in the preliminary tests.

Test pressure during the main test is at 1.3 of pipeline section the nominal pressure and the test duration is 3 hours.

For the main test, the results are deemed to be satisfactory when the pressure loss observed from the pressure of the polyethylene pipeline is less than 0.3 bar after the completion of the main test (after 3 hours).

2-D STEEL PIPES AND FITTINGS

2-D-1 PREAMBLE

The scope of this document is to define the technical terms of reference for steel pipes coated internally and externally.

These terms of reference are based on the internationally established standards dealing with bare pipes, external coatings and internal linings.

The quality system of the supplier conforms with ISO 9001 and APIQ1.

2-D-2 STEEL PIPE

2-D-2-1 Product Standard For Steel Pipes

Pipes are spiral seam pipe or butt-welded straight-seam pipes and made in accordance with EN 10224, EN 10217-1, NFA 49 150, DIN 1626 and DIN 2460, BS 534 and BS 3601, or AWWA C200 and with the requirements given hereafter. In case of contradiction between standards and the present terms of reference, the requirements of these terms of reference prevail.

The welding process may be either Submerged Arc Welding (SAW) or Electrical Resistance Welding (ERW).

2-D-2-2 Specification Of The Steel Material

Steel material shall meet the requirements of one of the steel grades listed here below:

	EN 10224	BS 3601	NFA 49150	DIN 1626 DIN 2460	API 5L
1	L 235	360	TSE 235	St 37.0	B
2	L 275	430		St 44.0	X 42
3					X 46
4	L 355			St 52.0	X 52

2-D-2-3 Mechanical Testing

The mechanical tests are performed on one sample pipe per heat for a maximum of 200 pipes (1:200/heat).

The following tests should be made during manufacturing of the pipes. One sample pipe per heat for a maximum of 200 pipes (1:200/heat):

Tensile test: one test piece from the parent metal for outside diameter ≤ 500 mm, plus one test piece transverse to the weld for outside diameter > 500 mm

Weld Bend test (root ≠ / or Face): two test pieces shall be taken from the end of the pipe

Required values are given in the relevant standard for steel material listed in § 2-D-2.2.

Each test is recorded and should be made available to any authorized representative.

2-D-2-4 Hydrostatic Test

All pipes are tested, during manufacturing, for leak tightness. Tests are performed at 90% of the Specified Minimum Yield Strength for a duration of at least 6 seconds. Each test is recorded and should be made available to any authorized representative.

For hydrostatic tests on site, and for under pressure use of pipes, refer to the requirements of the hydrostatic pressure testing of the Ductile Iron pipes.

2-D-2-5 Non Destructive Testing On Welds

All pipe welds are 100% ultrasonically tested prior to the hydrostatic tests during manufacturing and on site.

2-D-2-6 Visual Inspection

All pipes should be inspected outside, and inside for OD≥711mm only.

2-D-2-7 Dimensional Inspection

All pipes should be dimensionally inspected with reference to the required tolerances.

2-D-2-8 Tolerances

- Outside diameter (OD):

  OD ≤ 406.4mm: ± 1%

  OD > 406.4mm: ± 0.75%
- Thickness of the parent material (T):

  OD ≤ 406.4mm: ± 10%

  OD > 406.4mm: T ≤ 14.2 mm: +12% / -8%

  T >14.2 mm: +10% / - 8%
- Ovalisation: ± 1% of the diameter
- Weight of bare pipes:

  ± 10% per pipe

± 7.5% per 10 tons'

- Length:
- Minimum length: 6.0 m
- Maximum length: 14.0 m
- Straightness: 0.2% of the length

2-D-2-9 Ends preparation

Outside diameter at the pipe ends shall comply with the following:

OD ≤ 1600 mm: - 0,8 mm + 2,4 mm

OD ≤ 1800 mm: - 0,8 mm + 3,0 mm

OD ≤ 2000 mm: - 0,8 mm + 3,6 mm

OD > 2000 mm: - 0,8 mm + 4,2 mm

Pipes are either:

- Beveled with an angle of 30° (-0° / +5°) and a root face of 1.6 mm (± 0.8 mm),
- Equipped with lap joints OD ≤ 1600 mm: minimum overlapping is 80 mm.

2-D-2-10 Marking

Pipe markings will indicate, as a minimum:

- The pipe producer,
- Reference product standard,
- Manufacturing reference.

2-D-3 THREE-LAYERS POLYPROPYLENE EXTERNAL COATING

2-D-3-1 Product Standard For Three-Layers Polypropylene Coating

Three-layers polypropylene external coating should be applied on steel pipes conforms to NF A 49711 or DIN 30678 and the requirements given hereafter. In case of contradiction between standards and the present terms of reference, the requirements of these terms of reference prevail.

2-D-3-2 Composition Of The Coating

The three-layers polypropylene external coating consists of:

- One first layer made of Epoxy powder resin film applied to optimize anti-corrosion protection. Its minimum thickness is 50 microns at any points,
- A second layer made of a copolymer to ensure adhesion between layer 1 and 3,
- A third layer made of an extruded polypropylene coating.

2-D-3-3 Thickness of the three-layers polypropylene

Minimum thickness of the three-layers extruded polypropylene coating conforms with:

273 mm < OD ≤ 508 mm: 1.8 mm

508 mm < OD ≤ 762 mm: 2.0 mm

762 mm < OD: 2.5 mm

(OD: outside diameter)

2-D-3-4 Preparation Of The Metal Surface

Prior to the surface preparation and coating, the metal surface shall be examined free of impurities, i.e. rust, oil, dirt etc. which could be detrimental to the coating adhesion to the pipe.

The pipes are dried and preheated in order to obtain a temperature at least 3°C above the critical dew point just before the coating application.

The degree of surface cleanliness is SA 2.5, defined by Standard ISO 8501-1.

The roughness level is from 40 to 80 microns Rz.

2-D-3-5 Routine Testing And Inspection

- Visual inspection: All pipes should be visually inspected.
- Non-porosity test: All pipes should be submitted to the non-porosity test (Holiday's detection tests).
- Cut-back inspection: All pipes are visually inspected at each end.
- Thickness test: Coating thicknesses should be checked on three pipes per production shift, i.e. 3 pipes / 8 hours.

2-D-3-6 Required Properties

The three-layers polypropylene external coating should have the following properties:

- Pull-off strength test:

  Adhesion to support at 23° C: > 750N/5 cm

  Adhesion to support at 80° C: > 200 N/5 cm

- Impact strength at 20° C:

  Punch diameter 25 mm: ≥ 10 Nm/mm

- Penetration resistance under punch load:

  Punch diameter 1,8 mm and Pressure 10 MPa :

  at 20° C ≤ 0,1 mm

  at 80° C ≤ 0,4 mm

- Bendability:

  Radius ≥ 20 D

- Resistance to peeling under negative polarization:

  Average radius of peeling < 10 mm after 7 days at 40° C.

- Electrical non-porosity:

  No defect at 10 000 V/mm.

- Insulation resistance:

  R (100 days) > 108 Ω m²

  α < 0,2/30 Rgr (55 days)

- Elongation at break (PP):

  ≥ 400 %

- Resistance to ultraviolet rays (PP):

  0,75 MFIo ≤ MFI ≤ 1,25 MFIo

  (MFI: melt flow index)

- Heat resistance (PP):

  MFI ≤ 1,50 MFIo

  (MFI: melt flow index)

- Cracking resistance in a surface wetting medium:

  No cracked test pieces after 1 000 h at 50° C.

- First layer Epoxy:

  Thickness: e ≥ 0,05 mm

  Degree of polymerization: Δ Tg = ± 3° C

  Tests should be performed according to NFA 49711.

2-D-3-7 Ends Preparation

Cut-backs are:

- For bevelled pipes:

  150 mm from both ends

- For pipes equipped with lap-joints:

  150 mm from the spigot end

  120 mm from the bell end

External coating is bevelled at the ends.

2-D-4 BITUMEN OR COAL TAR EXTERNAL COATING

Where required or approved by the Engineer and for pipes and fittings of nominal diameters greater than 100mm, the above described polypropylene external coating could be replaced by reinforced bitumen enamel wrapping, or coal tar enamel wrapping or polyethylene wrapped (buried pipes only).

In addition to the suitable above requirements concerning the pipes ends preparation and the preparation of the metal surfaces, surfaces to be protected shall be thoroughly cleaned to remove all scale, rust, grease or other extraneous matter, by acid pickling, abrasive, mechanical or flame descaling.

Reinforced bitumen or coal tar enamel wrapping shall comprise hot applied, mineral filled, bitumen, or coal tar, giving a minimum finished thickness of 3mm. Reinforcement shall comprise an inner layer of 40 grams/square metre glass tissue, spirally wound with overlap, separated from the pipe surface by at least 1mm thickness of enamel, and an outer sheathing of bitumen or coal tar impregnated, longitudinally reinforced, glass fabric spirally wound onto the pipe with overlap, and separated by at least 1mm of enamel from the inner glass reinforcement.

2-D-5 LIQUID EPOXY INTERNAL LINING

2-D-5-1 Product Standard For Liquid Epoxy Internal Lining

Liquid epoxy internal lining applied on steel pipes should conform to NFA 49709 or AWWA C210 and to the requirements given hereafter. In case of contradiction between standards and the present terms of reference, the requirements of these terms of reference of the present specification prevail.

2-D-5-2 Composition Of The Liquid Epoxy Internal Lining

The internal liquid epoxy is a two-compound product - resin and hardener - which polymerizes at high temperature and the application, is carried-out at high temperature. It shall resist to osmotic blistering and it shell have current potable water certification from an internationally

recognized certifying Authority. This certificate shall be enclosed by the Pipe Manufacturer in his offer.

2-D-5-3 Thickness Of The Liquid Epoxy Internal Lining

Thickness of liquid epoxy internal lining measured on a dry film is greater than 300 microns at any point of the surface.

2-D-5-4 Preparation Of The Metal Surface

Prior to coating, the metal surface is free of impurities which could be detrimental to the surface preparation or to the coating adhesion on the pipe.

The pipes are dried and preheated in order to obtain a temperature at least 3°C above the critical dew point just before the coating application.

The degree of surface cleanliness is SA 2.5, defined by Standard ISO 8501-1.

Roughness level is from 40 to 80 microns Rz.

2-D-5-5 Curing The Internal Coating

To obtain a good polymerization of the liquid epoxy, the coated pipes, after being painted, should pass through a post cure oven where the steel temperature is raised and maintained at a temperature by the paint manufacturer.

2-D-5-6 Routine Testing And Inspection

- Surface conditions inspection: The surface conditions of pipes should be checked after blasting.
- Visual inspection of aspect: All pipes should be visually inspected.
- Cut-back inspection: All pipes should be visually inspected at each end.
- Wet film thickness test: Four measurements of thickness on a wet film should be performed for all the pipes.
- Non-porosity test: An electrical non porosity test should be performed on three plates per production shift.
- Adhesion test: Adhesion of the liquid epoxy lining on plates should be checked on one pipe per production shift.
- Dry film thickness test: The thickness of dry films on plates should be checked on one pipe per production shift.

2-D-5-7 Properties Of The Liquid Epoxy Internal Lining

The liquid epoxy internal lining shall have the following properties:

- Electrical non-porosity:

  Wet sponge: 67,5 V
- Cross adhesion test:

  Level 2 NFA 49709 - Appendix C
- Pull-off adhesion test:

  10 MPa NFA 49709 - Appendix C
- Hardness Shore D:

  > 50
- Bending flexibility:

  1% at 23°C
- Immersion test in demineralised water:

  Class 1in accordance with ISO 2409.

Tests are performed according to NFA 49709.

2-D-5-8 Ends Preparation

Cut-backs are:

- For bevelled pipes:

  50 mm from both ends
- For pipes equipped with lap-joints:

  150 mm from the spigot end

  20 mm from the bell end

2-D-6 CEMENT MORTAR INTERNAL LINING

2-D-6-1 Product Standard And Lining Process For Cement Mortar Lining

Cement mortar should be applied using centrifugal spraying process and according to NFA 49701 or DIN 2614 and to the requirements given hereafter. In case of contradiction between standards and the present terms of reference, the requirements of these terms of reference of the present specification prevail.

Fresh mortar is applied using a centrifugal applicator head. The lining is then smoothed and the exceeding water in mortar is expelled by rotating the pipe.

2-D-6-2 Composition Of The Cement Mortar Lining

Cement mortar lining should be made of a mixture of cement, sand and water. It shall be suitable for transportation of potable water.

Cement shall be of the CHF type according to NF P 15-301 or equivalent.

Cement mortar shall be composed so that:

- The S/C ratio (mass of sand in terms of mass of cement) is 2.1 (-0 / +0.3). When CHF cement is used, S/C can be reduced to 1.6.

The E/C ratio (mass of water in terms of mass of cement) shall not exceed 0.42.

In case of pipes used for sewage application, the cement used for internal lining should be sulphate resistant high alumina (similar to the cement lining for Ductile Iron pipes according to EN 598).

2-D-6-3 Thickness Of The Mortar Lining

For high furnace cement, such as the CHF type according to French Standard NF P 15301, the minimum thickness is:

273 mm < OD ≤ 406 mm : 5 mm

406 mm < OD ≤ 610 mm : 6 mm

610 mm ≤ OD ≤ 711 mm : 8 mm

713 mm ≤ OD ≤ 914 mm : 10 mm

(OD : outside diameter)

2-D-6-4 Routine Inspection Of The Lined Pipes

- Visual inspection: All pipes should be visually inspected.
- Thickness inspection: Thickness should be checked on four pipes per production shift.
- S/C and E/C ratio: two determinations per week of production.
- Mechanical resistance: one test per month of production.
- Granulometric curve of the sand: one check per batch.

Tests should be performed according to procedures specified in NFA 49701.

2-D-6-5 Routine testing and inspection

After a 28-day storage, the minimum mechanical characteristics of the cement mortar are:

- Resistance to compression: 35 MPa.
- Resistance to flexural tension: 5 MPa.

2-D-6-6 Ends preparation

Cut-backs are:

- For bevelled pipes:
- 10 mm from both ends
- For pipes equipped with lap-joints:
- No cut-back for the spigot end.

In the bell, cement mortar ends with a rubber ring placed in such a way that the minimum overlapping is achieved.

2-E UPVC PIPES

2-E-1 GENERAL

UPVC pipes and fittings shall comply in all respects with the following standards:

- B.S. 3506 Unplasticized UPVC pipes for industrial uses.
- B.S. 3867 Outside Diameters and Pressure Ratings of Pipe of Plastics Materials.
- B.S. 4514 Unplasticized UPVC Underground Drain Pipe and Fittings.
- B.S. 5481 Unplasticized UPVC Pipe and Fittings for Gravity Sewers.

Approved manufacturers shall supply all pipes and fittings. The nominal length of pipes shall be not less than 6.0 m and not greater than 9.0 m.

UPVC pipes shall be factory tested and shall be subjected to Hydraulic and to Impact (Falling Weight) Tests. The number and selection of samples for testing, the test procedure and the requirements shall all be as specified in the relevant B.S. if so directed by the Engineer. The selection of samples and the Tests shall be witnessed by a representative of the Engineer who shall be informed at least 48 hours in advance of any sampling or testing.

The cost of samples, their transportation to the laboratory, and their testing shall be deemed to be included in the unit rates and shall not be paid for separately.

The diameters measured in mm and indicated on the drawings.

2-E-2 GENERAL PHYSICAL PROPERTIES

Density	1650 kg/m^3 – 1950/m^3
ELASTIC MODULES	
Circumferential flexural	13000 Mpa – 15000 Mpa
Circumferential tensile (for pressure pipes)	10000 Mpa – 12000 Mpa
Longitudinal tensile and flexural	6000 Mpa – 7000 Mpa
MINIMUM ULTIMATE STRAINS	
Circumferential tensile	
Initial	1.4
Long term (50 years)	0.9
Circumferential flexural	
Initial	1.4
Long term (50 years)	0.9

Longitudinal tensile	0.4
Initial (pressure pipes)	0.3
Initial (non-pressure pipes)	
Poison's ratio	0.3
THERMAL EXPANSION	
Longitudinal direction	20 x 10-6 per deg. K
Circumferential direction	
Non-pressure pipe	20 x 10-6 per deg. K
Pressure pipe	15 x 10-6 per deg. K

STIFFNESS

The stiffness of a pipe indicates the ability of the pipe to resist external soil, hydrostatic and traffic loads, and negative internal pressures.

According to British Standard and ISO draft, stiffness is expressed as follows :

$$S = EI / Dm^3$$

Where S = Pipe stiffness N/M2

E = Modulus of elasticity, Pascal

I = Second moment of area per unit length of the pipe wall

Section

In M4 / M

Dm = Mean diameter in M.

2-E-3 HAULING, HANDLING AND STORAGE

Rough handling of pipes shall at all times be avoided, especially at low temperatures. During storage and transport, rigid UPVC pipes shall have as near continuous support as possible at all times, and care shall be taken to avoid damage to pipe by sharp edged angle irons, exposed nail heads, etc.

For long term storage in average ambient temperature, attention shall be paid to stack heights to avoid the possible deformation of the pipe diameters. A maximum height of 1 meter is recommended. For temporary storage on site, care shall be taken to ensure that the ground is level and free front bricks, stones and sharp edges. At high temperatures, rigid UPVC pipes shall be kept in the shade during long term storage. UPVC pipes with spigot and socket shall be stacked with the sockets protruding in alternate layers. Pipes bent, deformed in any way or changed in color shall be rejected and the payment whatsoever shall be made for such pipes.

While transporting, the pipes shall not overhang the vehicle by more than 0.6m. Pipe loads shall not be stacked higher than 2.0 m.

Where pipes are transported one inside another, care shall be taken that :

a. Tile pipes are clean and free from grit.

b. Suitable covering be provided over the exposed ends of the pipes to prevent tile entry of grit during transport.

c. The pipes in the lower layers are not excessively loaded to such a degree as would cause damage or undue distortion.

2-E-4 CUTTING PIPES

Pipes shall be cut with an approved mechanical pipe cutter and in conformity with pipe manufacturer's recommendations. Where the cut end of the pipe is to be incorporated in a joint the pipe shall be turned down to the correct diameter required for forming the joint by an approved mechanical turning machine. The length of turning shall be sufficient to enable the joint to be properly made. The ends of the pipe shall be accurately beveled by mechanical means to the dimensions specified in the manufacturers recommendations.

The cut end shall be beveled as required to suit the form of joint used.

2-E-5 LAYING AND JOINTING

After the excavation and preparation of a section of pipe trench has been completed, it shall be inspected by the Engineer. Just before pipe-laying the trench shall be cleaned of all stones, soil and other debris flat might have fallen therein.

All pipe-laying shall be carried out by experienced pipe-layers, well skilled in this work.

Immediately before being laid, each pipe and fittings shall be carefully examined both inside and outside for any damage, and all dust, dirt and foreign matter shall be removed. Care shall be taken to ensure that they remain clean during laying. The use of a badger will be ordered by the Engineer, if in his opinion, dirt is not being satisfactorily excluded. The badger, on a sound rope, is to remain within the bore of the pipe previously laid and jointed and it is to be drawn forward as the work proceeds throughout the whole length of the sewer. The badger is to be of soft material which will not damage the internal surface of the pipes.

In order to prevent stones and soil from entering the pipe, a suitable cap or plug shall be provided with which the last pipe laid shall be closed when pipe laying is not actually in progress. The plug will be of the screw-up expanding type or of tapered wood.

Where beads are required, performed bends of the desired radii shall be used. Hot bending on site is not permitted.

All joints shall be flexible, with approved rubber rings. Rubber rings shall comply with B.S. 2494 (Elastomeric Joint Rings for Pipework and Pipelines) and shall be of the type designated on the Drawings, or in the Particular Specification, or as directed by the Engineer.

Pipe length and fittings shall be supplied with a chamfer on the spigot end. Where pipes have to be cut to length, the pipe shall be cut square and a chamfer formed on the spigot end using a medium file. Any saw pushing shall be scraped off with a knife. The spigot and socket shall be free from mud or grit, and the ring correctly located in its groove. A lubricant approved by the Engineer shall be applied to the chamfered portion of the spigot before its insertion in the socket.

Pipes shall be laid true to line by means of a line stretched along the sides of the pipes and true to level by means of a straight edge of suitable length kept inside the pipes and pulled forward to pegs boned in at suitable intervals between sight rails set to the proper levels.

2-E-6 MECHANICAL TEST:

Samples of pipes taken from different lots shall be tested in the manufacturer's testing laboratory or any other testing laboratory selected by the engineer/owner and in the presence of representatives of the engineer/owner.

a. The following mechanical tests shall be applied:

   1. Resistance to internal hydrostatic pressure. The method for acceptance and quality tests shall be in accordance with ISO 1167.
   2. And at least one of the following tests shall be applied:

      – Resistance to external blows of UPVC pipes shall be tested in accordance with DIN 3127.

      – Tensile characteristics of the pipes shall be tested in accordance with DIN 3504 and DIN 3502.

b. The following physical tests shall be applied:

   – Vicar softening temperature shall be tested in accordance with ISO 2507.

   – Longitudinal reversion test shall be in accordance with ISO 2505 or DIN 4449.

2-F GRP PIPES

2-F-1 GENERAL

GRP (Glass Reinforced Plastic) pipes shall meet the requirements of the most recent edition of ASTM D 3262 together with the requirements specified herein, GRP pipes and fittings shall be purchased locally provided they conform to these Specifications.

The Contractor shall supply to the Engineer, manufacturer's signed certificates stating that the pipes comply in all respects with the provisions of these Specifications and giving the results of all specified tests.

Other methods for manufacturing of GRP pipes may be proposed but such methods will be subject to the approval of the Engineer. Acceptable alternatives to the filament-wound type of pipe described above include the centrifugally cast type complying with BS 5480 subject to independent evidence of a long record of satisfactory use and subject to the Engineer's approval of the detailed specification.

2-F-2 MATERIALS

2-F-2-1 Appearance

The internal surface of all pipes and fittings shall be smooth, hard, durable and free from all tack, protruding fibers, voids, pits, bubbles, cracks, blisters and foreign matter. The external surface of all pipes and fittings shall be a fiberglass surface mat impregnated with polyester resin and shall be commercially free of resin runs, dry areas, dirt and black marks.

The resin reinforcement and aggregates, when combined as a composite structure, shall produce pipes and fittings that satisfy the performance requirements of these Specifications.

2-F-2-2 Design Requirements

All pipes and joints shall be designed for a minimum working life of 50 years.

Pipelines may run beneath roads and be subjected to maximum loading conditions, therefore, design shall be for the worst surcharge conditions and loading applicable in Lebanon.

The pipe shall be designed to withstand the internal environmental conditions specified below:

pH value	1 to 13
BOD	up to 1000 mg/1
Suspended solids	up to 1000 mg./1
Chloride	500 mg/1

Free NH_3	150 mg/1
Sulphate	1000 mg/1
Temperature	5 to 50 °C
Prevailing temperature throughout sewage medium is:	30 °C
Sewage dissolved H_2S	Up to 20 mg/1
H_2S gas concentrations	Up to 2000 mg/1

The ground and groundwater in which the pipes shall be laid are high in salts and are aggressive.

2-F-2-3 Resins

Resins shall comply with the relevant requirements of BS 5480. Details of all resins to be used in the manufacture shall be provided and shall include all the properties listed in the table herein. The resin system adopted shall be that most suitable to the internal and external environmental conditions and resin properties shall be tested in accordance with the following table.

RESIN PROPERTIES

Property	**Test Method**	**Units**
Liquid Resin		
- Acid Value	BS 2782, BS 3532	mg KOH/g
- Viscosity at 25 deg C	BS 188 &BS 3532	m Pas
- Specific Gravity	BS 3532	
- Volatiles content	BS 3532 &	BS 2782
- Refractive Index	ASTM	D 1045
Cured Resin		
- Heat distortion temperature	BS 3532 Appendix A	deg C
- Glass transition temperature	Differential thermal analysis	deg C
- Tensile strength	BS 2782	MN/m^2
- Flexural strength	BS 2782 & BS 3532	MN/m^2
- Ultimate elongation	BS 2782	
a.Basic resin		%
b.If flexibilised		%
- Barcol hardness	BS 4549 Appendix A	
- Water absorption	BS 2782 & BS 3532	mg

Information supplied on cured resin shall include details of the cure system employed, which shall be the same as that proposed for manufacture of pipes and fittings.

2-F-2-4 Fiber Reinforcement

With the exception of a veil on the inside face of the pipe, all fiber reinforcements used shall be of ECR/ADVANTEX type glass and shall comply with the appropriate standard listed below and shall have a surface treatment compatible with the resin.

BS 3691	Glass fiber roving for the reinforcement of polyester and of epoxy resin system.
BS 3496E	Glass fiber chopped strand mat for the polyester resin systems
BS 3396	Woven glass fiber fabrics for plastic reinforcement
BS 3749	Woven roving fabrics of glass fiber for the reinforcement of polyester resin systems. If a veil is used on the inside face of the pipe, this shall be "C" glass fiber.

2-F-2-5 Aggregates and Fillers

Aggregates and fillers shall comply with the relevant requirements of BS 5480. Silica sand, if used in the manufacture, shall be a minimum of 95% pure silica. The maximum percentage by weight of all aggregates and fillers in the laminate(s) shall not exceed 30%.

No pigment shall be added to any resin used

2-F-2-6 Liner

All pipes and fittings shall have a suitably reinforced resin rich liner to give high corrosion, impact and abrasion resistance. The thickness of this liner shall be determined by the pipe manufacturer, but shall not be less than 1½ mm. No aggregate or fillers shall be included in the liner.

The liner shall consist of two layers, a surface layer and a barrier layer. The surface layer shall be a minimum of 1 mm thick with a minimum of 90% Venylester resin. Any reinforcement in this layer shall be of C type glass or approved suitable synthetic material. The barrier layer shall have 70% to 80% Vinylester resin with ECR/Advantex glass reinforcement.

2-F-2-7 Structural Design

Details of loading and pressures shall be as shown on the drawings. Pipes and fittings shall be designed to these standards for the ground conditions to be encountered. All pipes and fittings shall have a minimum stiffness of 5000 N/m² to accommodate handling and transportation stresses unless specified otherwise.

For buried pipes stiffness shall depend upon depth of cover above the crown of the buried pipe in accordance with the following:

For depths of cover over the pipe more than 6.0 meters or less than 1.5 meters, pipe stiffness shall be minimum 10000 N/m². For depth of cover more than 1.5 m and less than 6.0 meters, pipe stiffness shall be minimum 5000 N/m².

Note: Stiffness factor 'F' shall be calculated as follows:

$$F = \frac{EI}{d^3}$$

where, E = Flexural modulus of elasticity of pipe material in circumferential direction.

$$I = \frac{S^3}{12}$$

S = Wall thickness (m)

d = Mean pipe diameter (m)

Pipe shall have an initial ultimate resistance to longitudinal tensile force per unit of circumference of not less than the following :

DIAMETERS	**RESISTANCE**
Up to and including DN 600	150 N/mm²
Greater than DN 600 up to and including DN 1200	200 N/mm²
Greater than DN 1200 up to and including DN 2400	250 N/mm²

2-F-2-8 Sizes and Tolerances

2-F-2-8-1 Diameter

The diameter of the pipe shall be designated by the nominal internal diameter. The manufacturing tolerance of the internal diameter shall be in accordance with BS 5480.

All deviations from roundness, with the exception of pipe deformation due to its own weight, shall be contained within the tolerances. Deviations in diameter of spigot and sockets shall be kept to the absolute minimum and shall be such that the seal at the joints is not affected.

2-F-2-8-2 Length

Effective length of pipes and tolerance on effective length shall be as specified in BS 5480.

Where it is found necessary to cut or turn down a pipe in order to form a joint, the exposed surfaces shall be fully sealed with a continuous coating of fully cured resin.

2-F-2-8-3 Wall Thickness

Wall thickness shall be as recommended by the pipe manufacturer and to the approval of the Engineer.

2-F-2-9 Fittings

All fittings and collars such as bends, tees, junctions and reducers shall be equal to or superior in performance to pipes of the same classification and shall comply with BS 5480.

The use of metals for any part of these fittings will not be permitted. However, the Engineer may allow the use of fittings of other materials which are commonly used in the construction of sanitary sewers, provided that the design of fittings and pipes are mutually compatible.

2-F-2-10 Joints and Gaskets

Joints shall be of the collar type incorporating rubber rings. All joints shall be capable of withstanding the various tests specified for the appropriate class of pipe and shall withstand a deflection of not less than 1½ degrees in any direction while maintaining the specified test pressures.

Minimum requirements for the rubber rings shall be as specified in BS 2494. Gaskets shall be of a thickness and design to provide watertight joints. The joints shall be qualified before installation with full testing according to ASTM D 4161. At least one test shall be carried out for each diameter. The Contractor shall ensure that the joint gaskets and joint ring are suitable for use in the prevailing climatic soil, ground water and sewage conditions.

All rubber rings shall be of the type that can pass an acid aging test as directed by the Engineer without any noticeable deterioration in the mechanical or chemical properties of the material used.

Flanged pipes shall incorporate an annular gasket at the joints. The gaskets shall cover the full face of the flanging and shall have holes cut in them corresponding to the bolt holes in the flanges. Alternative forms of gasket may be used, subject to the approval of the Engineer. Flanges shall be drilled to BS 4504, metric units, Type PN16.

2-F-2-11 Testing

2-F-2-11-1 Raw Materials

a. Resins

All deliveries of resin shall be checked for consistency by viscosity and reactivity and refractive indices. Resins deviating from these Specifications shall not be used.

b. Glass

All deliveries of glass shall be checked for consistency by dry strength and chemical resistance to 1.0 N sulphuric acid. Pipes shall only be manufactured from batches of glass exhibiting similar strength and chemical resistant properties. Should these properties change due to variations in suppliers, the pipes produced from this glass shall be tested in accordance with the strain corrosion test as if they were different diameter or class. The Engineer may accept test reports of ECR glass as supplied by the manufacturer and testing of pipe factor glass may be dispensed with.

c. Sand or Aggregate

All deliveries of sand or aggregate shall be checked for consistency of grading, moisture content and purity.

2-F-2-11-2 Manufactured Pipe

a. Strain corrosion Test

Control testing shall be carried out during the manufacture of pipes in accordance with Section 6.3 of ASTM D 3262 using the specified test solution. Control tests shall be carried out for each diameter and class of pipe.

In the event regression curves are not available or any changes to the pipe wall and laminate build-up and/or the properties of the raw materials at any time during the manufacture of the pipes, two complete sets of corrosion tests (including a regression curve) shall be carried out in accordance with ASTM D 3681. One set shall use a 10% W/W solution of sulphuric acid maintained at a temperature of 25°C ± 1 C. The other set shall use a 5% W/W solution of sulphuric acid maintained at a temperature of 23 °C.

Strain corrosion tests shall be run on a minimum of 6 samples from each lot of pipe diameter to ensure that they fall above the regression curve values defined by the manufacturer.

b. Hydraulic Tests in Factory

All pipes shall be subjected to an internal hydraulic pressure test at the manufacturer's plant prior to delivery. The test shall be applied to a pressure equal to two times the working pressure or 6 bars of water head whichever is higher. The test pressure shall be applied for a minimum period of 5 minutes without signs of leakage.

All fittings shall be subject to an internal low pressure test at the manufacturer's plant prior to delivery. The pressure test shall be carried out at 0.1 bar and shall be applied for a minimum period of 5 minutes without signs of leakage or distress. Fittings of metric construction shall be manufactured from pipe which has successfully passed the tests defined above.

c. Stiffness

A minimum of one pipe in every 30 pipes, one per shift, or one per production run, whichever is less, shall be tested for stiffness in accordance with ASTM D 2412 "Test

for External Loading Properties of Plastic Pipe by Parallel Plate Loading". A minimum of one pipe for each size shall be tested.

d. Longitudinal Tensile Strength

For pipes with internal diameters of 600 mm and less, a minimum of one pipe in every 1000 pipes manufactured shall undergo a beam test in accordance with ASTM D 3262, Section 8. A minimum of one pipe for each size shall be tested.

e. Curing/Hardness Test

All manufactured pipes shall be subjected to both a Barcol Hardness Test in accordance with BS 4549, Part 1, Appendix A and a commercial acetone test. Both tests shall be carried out on internal and external pipe surfaces.

f. Loss on Ignition

A minimum of one pipe for every 30 pipes, one per shift, or one per production run, whichever is less, shall be tested in accordance with ASTM D 2584. From each test pipe, two samples shall be taken for test.

One sample shall comprise the complete laminate including the liner. The second sample shall comprise the laminate without the liner and shall be split off at the interface between the liner and the structural wall.

g. Other Test and Compilation of Data

Quality control testing shall include thorough checks of all materials to ensure that they comply with the relevant standards and requirements of the Specifications. All pipes and fittings shall also be subject to a complete visual inspection before shipment. Records of all tests and inspections shall be maintained by the manufacturer and two copies of all test certificates shall be forwarded to the Engineer.

In addition, the Contractor shall submit all necessary data and manufacturer's specifications of the GRP pipes and joints, including details of raw materials, pipe design, manufacturing process, laying instructions and all other relevant information required by the Engineer.

h. Test Failure

In the event of a pipe failing the strain corrosion test, two more tests shall be performed: one on a pipe from the previous five pipes and one on a pipe from following five pipes, if any of these two pipes fails, all pipes of that diameter and class which have been manufactured shall be rejected and shall be replaced entirely at the Contractor's expense.

Pipe failing any other test shall be rejected and an additional ten pipes shall then be tested. Five of these pipes shall have been sequentially produced immediately prior to the failed pipe and five immediately following. If anyone of these ten pipes fails, then every pipe shall be tested. Only pipes passing the tests will be accepted.

All pipes and fittings will be subjected to a visual inspection by the Engineer after offloading at Site. All pipes and fittings that have been damaged during delivery shall be repaired and/or replaced by the Contractor and the pipe shall be subject to a further hydraulic test to be carried out by the Contractor as specified herein. Such making good and hydraulic testing at site shall be entirely at the Contractor's expense.

i. Marking and Identification

All pipes, including cut lengths and fittings shall be indelibly marked prior to delivery in the order given below with:

i) The manufacturer's name, initials, or identification mark

ii) The nominal internal diameter in mm

iii) The classification, i.e. pressure rating stiffness (to avoid confusion, pipe rated at 2.5 or 12.5 bars shall be marked 2½ or 12½ and not 2.5 or 12.5).

iv) The date of manufacture.

v) A suitable stamp to indicate that the pipe has satisfactorily passed the required inspection and hydraulic tests at the manufacturer's plant.

These markings may be arranged either in one line or in several lines provided that the order is preserved.

j. Third Party Inspection

All tests shall be supervised and certified by a third party inspection agency approved by the Engineer. All costs for the inspection agency shall be borne by the Contractor and shall be included in the cost of the pipe.

All pipes shall be visually inspected on site prior to installation. The pipes shall be free of defects such as delaminating, air bubbles, protruding or exposed fibers, cracks, air holes, surfaces non-impregnated with resin which can affect, due to their extent, the rigidity and usefulness of the pipe. Defects extent shall be defined by Manufacturer and approved by the Engineer.

The surface of the pipe joints shall be free of all defects and surface irregularities that can affect their integrity. All repairs effected on site shall be agreed to by the Engineer and conducted by qualified personnel from the pipe manufacturer.

2-F-2-12 Loading, Unloading and Transportation of Pipes

GRP pipes are made of delicate elastic materials and, therefore, require special care in loading, unloading and other handling. Nylon lifting strings shall be used for loading and unloading of pipes. Pipes shall not overhang trucks or trailers while being transported and shall be securely tied. Avoid sudden drops or motion while loading and unloading.

2-F-2-13 Storing Pipes, Fittings and Accessories

Pipes shall be stored on flat ground having no stones or debris to prevent any damage to the pipe barrel. It is advantageous to store pipes on timber pieces to facilitate placement and removal of lifting strings. Storage of pipes in heights over 2m shall be avoided. All pipes shall be properly secured to prevent rolling in high winds.

Rubber ring gaskets shall be stored in the shade in the original packing. The store shall be air-conditioned during summer. Gaskets shall be protected from exposure to greases, oils, solvents, or any other petroleum derivatives or chemicals.

Gasket lubricant shall be carefully stored to avoid damage to the container. Partially used buckets shall be properly resealed to prevent contamination of the lubricant. If the lubricant is contaminated by any foreign substance it shall be abandoned.

2-G TEST OF DISINFECTION OF POTABLE WATER PIPES AND RESERVOIRS

Provide equipment, gauges, temporary connections, chlorine and water needed for flushing and disinfection after all work has been completed.

Before commencing disinfection, flush main until effluent is clean and then clean as directed by the Engineer. 1 to 2 times volume of pipe is usually required for such flushing.

After closing all pipeline's exit, the Contractor shall fill pipelines with clean water mixed with chlorine dose of 20 mg per liter. Wait for 24 hours, then measure residual chlorine by taking a sample to the lab and perform a bacteriological test in the presence of the Engineer. If any harmful signs appear, disinfection process must be redone and another test must be taken until the test gives a results acceptable to the Engineer.

After the completion of the work, the Contractor must fill the reservoirs with clear water mixed with chlorine dose of 20 mg per liter and,

1- Wait for 24 hours, then measure residual chlorine by taking a sample to the lab and perform a bacteriological test in the presence of the Engineer. If any harmful signs appear, disinfection process must be redone and another sample must be taken until the test gives a results acceptable to the Engineer.

2- Wait for an additional 48 hours and check if the water level stays as it was. If not, the Contractor has to fix the reservoirs on his own expense and restart the test

The cost of these tests are considerd to be included in the unit rates of the materials and works related to the pipes and reservoirs mentioned in the Bill of Quantities.

2-H FINAL CLEANING AND INSPECTION

Before the works are accepted by the Engineer, the entire pipe system, including all structures, shall be thoroughly cleaned by flushing or by passing a brush, sphere or other suitable tool through it, or by any other approved method, to ensure that it is clean, and free of obstructions and that pipe runs are perfectly straight. Before taking over, the pipeline will be finally inspected by the Engineer.

2-I ACCESSORIES

Refer to Part IV- MECHANICAL WORKS.

Part III : Civil and Architectural Works

Part III-1 : EARTHWORK

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PART 3.1 - CIVIL & ARCHITECTURALWORKS: EARTHWORK

3-1-A EARTHWORK (GENERAL)

3-1-A-1 DESCRIPTION

This work shall consist of clearing and grubbing, stripping, removal of unsuitable soil, excavation, fill and backfill, and other specified works related to the earthwork.

3-1-A-2 GENERAL REQUIREMENTS

Prior to any excavation in the streets, a license request together with all detailed drawings showing the locations of the excavations and a written commitment to restore the street to its initial condition shall be submitted to the Engineer.

Excavation in streets and roads shall not commence without written approval from the Engineer.

Before the commencement of any earthworks or demolition the sites shall be surveyed as necessary in conjunction with the Engineer's representative to establish existing ground levels.

The Contractor shall not start any earthwork before getting the Engineer's approval on the cross sections.

The Contractor shall correct all disapproved cross sections and resubmit them for approval.

The Contractor shall excavate, refill and restore in advance of his program such trial holes as he may require for determining the nature of the subsoil and the location of existing underground services and obstructions.

The Contractor shall ensure that there are no pipes, cables, mains or other services or property which may be disturbed or damaged by its use. He will take all precautions not to damage these services and restore these services if damaged on his own expense.

3-1-A-2-1 Explosives

The Contractor shall at all times take every possible precaution and comply with the Explosives Laws of Lebanon and regulations relating to the handling, transporting, storing and use of explosives and shall at all times when engaged in blasting operations post sufficient warning flagmen to the full satisfaction of the Engineer's Representative. The Contractor shall also provide a special proper store for explosives in accordance with local regulations and shall provide experienced men with valid blasting licenses for handling explosives to the satisfaction of the Engineer and the authorities concerned.

The Contractor shall at all times make full liaison with and inform well in advance and obtain such supervision and permission as is required from the Police and all Government Authorities, public bodies and private parties whosoever concerned or affected by blasting operations.

Blasting shall only be carried out on those sections of the Works for which permission in writing shall have been given by the Engineer and the relevant authorities and shall be restricted

to such hours and conditions as may be prescribed. Blasting within 10 meters of existing water mains will not be permitted.

Blasting shall be carried out so as not to weaken an existing structures or the foundations or ground adjacent to the existing and proposed works. The Contractor shall take all necessary precautions to prevent loss injury or accident to persons or property and shall be entirely liable for any accident or damage that may result from the use of explosives.

The Contractor shall submit to the Engineer for his approval a method statement including details of the intended drilling patterns, depths of holes, the amounts of explosives at each location, and the method or sequence of setting off what he proposes to use.

3-1-A-2-2 Clearing & Grubbing

3-1-A-2-2-1 Description

This work shall consist of clearing, grubbing, removing and disposing of all vegetation and debris within the limits specified. This work shall also include the preservation from injury or defacement of all vegetation and objects designated to remain.

3-1-A-2-2-2 General Requirements

The areas to be cleared and grubbed shall be as shown on the Plans, as designated in the Specifications or as directed by the Engineer. The Engineer will designate all trees, shrubs, plants and other things to remain. The Contractor shall preserve all things designated to remain.

Before carrying out work, 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 which may be affected by the works.

In the case of wayleaves for pipelines, the boundaries of the wayleave 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 1.5m high indicating the position of the boundary at 50m or other such intervals as the Engineer may direct. In the event of any boundary or survey mark established for the purpose of land title being disturbed or displaced, the Contractor shall forthwith replace the beacon. Where necessary the Contractor shall employ the services of an approved licensed surveyor for the purpose of setting out boundaries.

Before beginning clearance in any area the Contractor shall give seven days written notice of his intention to the Engineer who will determine the extent and limits of such clearance.

All surface objects and all trees, stumps, roots, sod and vegetable matter, other protruding obstructions, not designated to remain shall be cleared and grubbed.

Within the limits of clearing and grubbing, all stumps, roots 4 cm in diameter or larger, buried logs, and all other objectionable material shall be removed 90 cm below the existing ground surface or subgrade, whichever is deeper.

Except in areas to be excavated, stump holes and other holes from which obstructions are removed shall be backfilled with suitable material and compacted to 90% of Maximum Dry Density.

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

Topsoil shall be set aside for re-use or disposal off site as directed by the Engineer.

Trees to be removed shall be uprooted or cut down as near to the ground level as possible.

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

Materials arising out of site clearance shall be disposed by the Contractor off the Site, or where approved by the Engineer on the Site in a manner and place approved by the Engineer.

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

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

The Contractor shall take 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.

3-1-B EXCAVATION

3-1-B-1 EXCAVATION IN GENERAL

3-1-B-1-1 Description

This work shall consist of all excavation for structures, chutes, canals, pipelines, trenches, culverts, headwalls, basins, gravel traps, manholes, inlets, retaining walls, roadways and other specified works.

3-1-B-1-2 Classification

All excavation will be classified as one of the following :

- Common Excavation Common excavation consists of the excavation and disposal of all materials of whatever character encountered in the work except rock.
- Rock Excavation Rock is defined as a sound and solid mass, layer, or ledge of mineral matter in place and of such hardness and texture that it cannot be effectively loosened or broken down by ripping in a single pass with a late model tractor-mounted hydraulic ripper equipped with one digging point of standard manufacturer's design adequately sized for use with and propelled by a crawler-type tractor rated between 385 and 410 net flywheel horsepower operating in low gear.

  In areas where the use of the ripper described above is impracticable, rock is defined as sound material of such hardness and texture that it cannot be loosened or broken down by a manual drifting pick.

  Boulders and detached stones having a volume of 0.75 cubic meters or more shall be classified as rock.
- Unclassified Excavation "Unclassified Excavation" shall be that volume of excavation consisting of the removal of all materials regardless of their physical properties.

3-1-B-1-3 General Requirements

Excavation in public streets is subject to the following:

- Decree-law No. 68 dated 9/9/1989
- Decree-law No. 98 dated 9/9/1989
- Circular issued by the Prime Minister's Office No. 6/95 dated 13/3/1995

Excavation shall be made in open cutting unless tunneling 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.

The Contractor shall ensure the stability and safety of excavations and shall take all measures necessary to ensure that no collapse or subsidence occurs.

Except where described in the Contract or permitted under the Contract excavation shall not be battered. 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. Supporting excavation cost shall be deemed included in the excavation unit rate.

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.

3-1-B-1-3-1 Excavation in Excess

In the event of unsuitable ground being encountered at formation level or if the formation is damaged or allowed to deteriorate, the Contractor shall forthwith inform the Engineer. The Contractor shall excavate to such extra depth and refill with compacted granular or other approved fill or Class D concrete as the Engineer may require. With respect to the side face of any excavation against which concrete or other work will be in contact the Engineer may require that the net dimensions of the work be increased.

If any part of any excavation is in error excavated deeper and/ or wider than what is required, the extra depth and/or width shall be filled with Class D concrete or compacted granular or other approved fill to the original formation level and/or dimensions as the Engineer directs on the contractor’s expense.

In pipe trenches where the pipe is not bedded on or surrounded with concrete, excess excavation shall be filled with compacted granular material. Excess excavation in rock trenches shall be filled with Class D concrete up to 100 mm below the pipe invert.

3-1-B-1-3-2 Excavated Materials Suitable for Re-use

No excavated material suitable for re-use shall be removed without the approval of the Engineer.

During excavation, the Contractor shall ensure that all material suitable 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.

During excavation, 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.

3-1-B-1-3-3 Damages Caused to the Surface of Roads

Where the surface of the road damaged either by the concentration of traffic caused by an open excavation, by subsidence or other causes arising from the operations of the Contractor. The Contractor shall permanently reinstate the whole of the surface to its original condition.

3-1-B-1-3-4 Safety of Excavations

The Contractor shall ensure that excavation and reinstatement are maintained in a safe condition and shall take immediate action to remedy any deterioration which renders the works unsafe. If in the opinion of the Engineer any excavation or reinstatement is in a dangerous condition the Contractor shall immediately remedy the defect. Should the contractor fail to carry at the reinstatement promptly, the work may be carried out by others at the Contractor's expense.

3-1-B-1-3-5 Mechanical Excavation

Mechanical excavation shall be employed only if the subsoil is suitable and only in such manner which will allow adequate support of the equipments.

3-1-B-2 EXCAVATION FOR STRUCTURES

3-1-B-2-1 Description

This work shall consist of all excavation for structures, gravel traps, chutes, basins, culverts, headwalls, manholes, inlets, retaining walls or other structures, and other excavation for structures.

3-1-B-2-2 General Requirements

The Contractor shall notify the Engineer a sufficient time in advance of the beginning of any excavation for structures which so that the Engineer may observe the cross-sectional elevations and measurements taken of the existing ground and structure. Any materials removed or excavated before these measurements have been taken and approved by the Engineer will not be paid for.

The foundation shall be excavated to the outlines of the footings as shown on the Plans or as required by the Engineer and shall be of sufficient size to permit the placing of the full width and lengths of the footings shown with full horizontal beds. Rounded or undercut corners and edges of footing will not be permitted.

The excavation shall be carried out to the elevation shown on the plans or as established by the Engineer. No concrete shall be poured prior to the approval of the excavation by the Engineer. Overdepth excavation below the footing elevation approved by the Engineer and overwidth excavation beyond the lateral limits for footings shown on the Plans or directed by the Engineer, shall be backfilled with the same class of concrete designated for the footing and

shall be poured monolithically with the footing. No payments will be made for unauthorized overdepth and overwidth excavation and the concrete backfill shall be at the Contractor's expense.

Where rock bottom is secured the excavation shall be done in such manner as to allow the solid rock to be exposed and prepared in horizontal beds or properly serrated for receiving the concrete. All loose and disintegrated rock and thin strata shall be removed.

Where unstable material or other unsuitable material is encountered below foundation elevation of reinforced concrete structures, the Contractor, at the direction of the Engineer, shall excavate such unstable material and replace with suitable and stable backfill material or blinding concrete as shown on the Plans or directed by the Engineer. The foundation stabilization, necessary depth of excavation and suitability of the proposed backfill material shall be approved by the Engineer prior to the Work.

Suitable and practically watertight cofferdams, or other watertight equipment and materials to maintain a waterfree excavation shall be used whenever water-bearing strata are encountered above the elevation of the bottom of the excavation. They shall be sufficiently large to give easy access to all parts of the foundation form and shall be of dimensions not less than those for which payment for excavation is made and shall be deemed included in the excavation price.

If cofferdams have to be used, then cofferdams shall be constructed so as to keep the excavations free from earth, water, ice, or snow and to permit the excavations to be carried to depths up to 1m below the foundation elevations shown on the plans. They shall be substantially braced in all directions, and of such construction as will permit them to be pumped free of water, and kept free until the concrete has been placed. They shall be such that leakage can be kept out of the concrete or masonry. Unless otherwise shown on the plans or agreed upon with the Engineer, cofferdams and all sheeting or bracing shall be removed after the completion of the concrete or masonry. When the bottom is of sandy or porous material which will not, in the opinion of the Engineer, permit the footing to be poured in the dry, it shall be sealed with concrete so that it may be pumped dry. The cement content water / cement ratio and the maximum coarse aggregate size will be submitted to the Engineer prior to the work. A seal course shall not be used unless shown on the Plans or authorized in writing by the Engineer. If in the opinion of the Engineer, the necessity for a seal course is due to inadequate or improper cofferdam construction, he may order the removal and/or reconstruction of the cofferdam, or permit the placing of a seal course at the Contractor's expense. Other satisfactory methods of sealing out the water may be approved.

After the seal course has set, the cofferdam shall be cleared of water and the work completed in the dry. When weighted cribs are employed and the weight utilized to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal. Cofferdams shall be constructed so as to protect green concrete against the damage from a sudden rising of the stream and to prevent damage to the foundation by erosion.

The provision of dewatering equipment and all operations required to maintain a water free excavation shall be carried out and considered subsidiary to the items of structural excavation.

Maintenance of natural waterways and allowance for the passage of surface water during construction is the Contractor's responsibility and any damage occurring in this respect shall be corrected at the Contractor's expense.

3-1-B-2-2-1 Excavation for Foundations of Structures

The Contractor shall give sufficient notice and sufficient time in advance to the Engineer to enable him to inspect and approve foundations in advance of placement of the permanent work. The Engineer may withdraw his approval if work is not commenced within 48 hours or the formation is subsequently allowed to deteriorate.

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

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

Surfaces against which permanent works are to be placed shall be kept free of oil, water, mud or any material.

No concrete or other materials shall be placed until formations have been approved. Adequate notice shall be given to the Engineer to enable him to examine the formation.

3-1-B-2-2-2 Rock Surfaces Under Concrete Structures

3-1-B-2-2-2-1 Concrete Placed Directly on Rock

Rock under concrete structures shall be prepared by picking, barring, and wedging or other methods which will lease the rock in as sound a condition as may reasonably be expected according to the rock quality.

Rock surfaces shall be thoroughly cleaned by compressed air and water jet or such means as the Engineer may direct before concrete is placed.

3-1-B-2-2-2-2 Concrete Placed on Capping Layer

Where instructed the excavation shall be taken down to a depth of 1.0 m below the underside of the structure and the excavation backfilled with capping materials to the required formation level.

Capping material shall be an approved granular material.

The material shall be compacted in 150mm layers to achieve a density of not less than 95% maximum dry density determined by the Moisture - Density curve of the material.

3-1-B-3 EXCAVATION FOR PIPE TRENCHES

3-1-B-3-1 Description

This work shall consist of excavation for pipes laying to the required line and grade.

3-1-B-3-2 General Requirements

Pipe trenches shall be excavated to the typical cross-sections shown on the Drawings, and in no case shall the trench width up to the level specified exceed that shown on the Drawings. The Contractor shall ensure that at any point the width of the pipe trench is sufficient to permit the pipeline to be laid, jointed, bedded/surrounded and backfilling to be placed and compacted around the pipeline to the Engineer's satisfaction. The minimum trench width for each trench type shall be computed according to the data given on drawings.

In order to ensure a rapid execution, a mechanical crane or shovel is necessary to avoid a major disturbance in the road traffic.

The trench invert level and the trench width shall, at any location, be at the proper level and trench width of the proper dimensions to allow for sand and/or concrete bedding or surrounds as shown on the Drawings and directed by the Engineer.

If required by the Engineer, the extraction of backfill materials by means of mechanical engines shall be stopped at a level higher than that of the determined excavation bottom. As for internal walls, the mechanical digging shall stop before reaching the limits of the outline, so as to prevent the engine claws from breaking up the bottom and the walls. The excavation shall then be completed by manual means. The bottom of the trench shall be well levelled and have its longitudinal profile parallel to the pipe.

Where welding or jointing of pipes and/or accessories is required to be done in the trench, the same shall be widened and/or deepened to form bell-holes of sufficient size as directed by the Engineer's Representative so as to easily permit the proper execution of all welding, connecting and fixing works in all their stages, all necessary repairs to the pipe and coating, and for the thorough inspection of all these operations.

The length of trench to be kept open at one time shall be determined by the Engineer and shall in no case be exceeded. The maximum length of open trench shall be 150 meters or the distance necessary to accommodate the amount of pipe installed in a single day, whichever is the greater. Should there by any danger that trenches may erode, then sections shall be left unexcavated for as long as possible and the laying and backfilling of pipelines shall follow excavation as soon as possible.

The excavated material shall be placed alongside the trench (at least 500 mm away from the trench edge) in such a manner as not to interfere with the work and to prevent its falling into same.

Should any part of a trench be excavated, in error, deeper than required, the extra depth shall be filled up with concrete, solely at the Contractor's expense.

Trench formations shall be in undisturbed ground. Where in the opinion of the Engineer, the formation is unsuitable for bearing, extra excavation shall be carried out under the direction of the Engineer and the level made up again with sound soil material carefully compacted or with concrete. This work shall be paid for by the Employer provided that the unsuitability of the

formation is not due to the method of working of the Contractor, in which case the Contractor shall carry out the work at his own expense.

In confined areas, where the passage of excavating equipment is impossible, or where the Engineer's Representative deems the use of such equipment impracticable or undesirable for any reason whatsoever, trench excavation shall be done by hand. All requirements specified above shall apply to trench excavation by hand. No extra payment shall be made for works in confined areas. All excavation, whether in confined or unconfined areas, shall be paid for at uniform rates as specified hereafter.

If, in the opinion of the Engineer, there is undue delay in testing the pipelines; removing surplus material; general tidying up of areas where pipes have been laid; partial restoration of maintenance of surfaces; or similar operations, then the Engineer may order that no further trenches shall be opened until the outstanding work has been carried out to his satisfaction and the Contractor shall have no ground for a claim against the Employer on this account.

No work will be started on the laying of pipes or bedding in any section of trench, until the trench formation of that particular section has been approved by the Engineer.

Once the pipeline section has been tested and the bedding and surround approved by the Engineer, the trenches shall be backfilled by layers as specified hereafter. Each layer shall be separately compacted and any subsidence resulting from insufficient compaction shall be the Contractor's liability and he shall forthwith add the necessary extra material which shall then be thoroughly compacted.

Unless otherwise specified, items for trench excavation shall apply to all kinds of soil, including rock, and the excavation will be measured for payment in linear metres measured along the centreline of the pipeline. The cost of trench excavation shall be deemed to include for excavation, drilling and blasting, to the required width and depth to underside of pipe barrel, finishing the trench bottom as specified by removing unstable materials (rock, boulders and hard spots), digging boreholes where required, removing excavated material and storing it alongside the trench for backfilling whenever permitted, removal of material that may result from land slides, removal of loosened earth or rock, removal and disposal of all excess spoil to any distance, supporting and stabilizing trench walls either by timbering or shoring, dewatering as and where required if no specific items have been provided in the Bill of Quantities.

3-1-B-3-3 Dumping of backfill materials

Backfill materials shall be directly transported by trucks outside the site and discharged at locations approved by the Engineer. The road shall be thoroughly cleared from any backfill material.

As for roads maintained by the municipality, having favorable width and condition, backfill materials could be placed, upon the prior approval of the Engineer, on both sides of the trench; the blocks and stones close to the sidewalk, the sand and the earth free from stones next to the road center line, so as not to impede the traffic.

3-1-B-3-4 Precautions relating to other utilities

The contractor shall take all necessary precautions to protect the installations in the trench.

In order to choose a good location for the installations, the contractor shall use a device to detect the cables before digging trenches, or dig by hand, probing holes at his own expenses.

During excavation works, if the contractor notices a slight water leak from existing pipes he shall immediately notify the Engineer and the competent authorities.

If he encounters electrical or telephone cables or other pipe works, he shall take necessary measures to protect them. The contractor remains entirely responsible before competent authorities for eventual damages.

The contractor shall not demolish, remove or repair any other utility (rainwater pipes, telephone cables,...) existing in the trench, but in the presence of the Engineer and the competent authority or upon their approval.

In case these damages occur (breaking of a water pipe, telephone cable, electrical cable, drain pipe, etc...), the contractor is bound to repair them immediately at his own expense (providing materials and labor).

3-1-B-3-5 Water drainage

The contractor shall effectively have at his disposal from the beginning of works all necessary equipment to avoid any water flow and ensure a good drainage.

The excavations shall be kept dry during the works period and eventually during the period the Engineer deems necessary.

Water encountered in the excavations, whether resulting from aquifers or any kind of infiltration, shall be drained towards sumps and then discharged by the contractor.

When pumping water from the excavation, the contractor shall take all necessary measures to prevent soil erosion and undermining, as well as necessary measures to maintain the structures' stability.

The contractor shall be responsible for any damage caused by water to foundations or works.

He shall afford any eventual repair.

3-1-C NATURE AND ORIGIN OF THE MATERIALS

3-1-C-1 GENERAL REQUIREMENTS

The materials intended for the construction of the various work, will be supplied by the Contractor and will come from extraction sites that will have to be accepted by the Engineer and must comply with the Technical Specifications.

The approval of the Engineer does not relieve the Contractor from his responsibility as to the quality of materials furnished to the site.

Any change as to the source of the material will have to be approved by the Engineer. Furthermore, the Engineer has the right during the works, to ask for a change of source in the event the quality is not in compliance with the present specifications.

All material must satisfy the French Standard AFNOR and DTU documents, American Standards ASTM or British Standards BS.

3-1-C-2 GENERAL POINTS ON THE QUARRIES

The limestone quarries must be homogeneous, joint free with convenient stratification and little bedding to obtain material of the required quality.

The Engineer will accept or refuse the quarries in a period of 15 days following the Contractor's request. The Contractor must, at his own expense carry out several drillings and trenches that will enable the Engineer to appreciate the quality of the proposed materials.

The cost of searching for a quarry deposits and testing it shall be on the expenses of the Contractor.

If during the works, the excavated material no longer conforms to the required quality, or if the volume of the usable proportion is insufficient, the Contractor must, at his own expense, search for other sites conforming to the specifications.

3-1-C-3 QUALITY AND PREPARATION OF BORROWED MATERIALS

3-1-C-3-1 Norms

All materials shall satisfy with AFNOR, DIN, ASTM or BS norms.

3-1-C-3-2 Material Gradation

– Material of sand and limestone quarries :

The filter material shall be obtained by sieving natural sand in provenance from the sand quarries. The drain material shall be obtained by crushing rocks in provenance from the quarries. These materials shall have a continuous gradation.

– In case of filter and drain materials acting as protection against washing of another material, they shall respect the following conditions:

1- $\frac{d_{15}F}{d_{85}M} < 5$ F for the filter or the drain

M for the material to protect

Note: in case of fine granular soil, this criteria is not valid for filter material. The gradation of filter materials shall be between 0 and 5 mm.

– $2 < \frac{d_{60}}{d_{10}} < 8$

– Less than 5% of elements < 80 microns and d_{15} (sand) > 0.1 mm.

– In case of a draining material, the gradation should range between from 1 to 4 cm and less than 5% of elements < 80 microns.

3-1-C-3-3 Rockfill paving, Rockfill, Drain and Filter Materials

Rockfill, drains and filter materials must have sufficient hardness to be discharged in bulk and manipulated by power machines without being broken or disintegrated. They must be homogeneous, freeze resistant, unaffected by water or air and shouldn't contain neither earthly nor organic components, nor soluble components. They must be of a minimum specific weight of 2.6 t/m^3.

3-1-C-4 CRITERIAS FOR THE CHOICE OF LIMESTONE QUARRIES

3-1-C-4-1 Studies and Testing Before Choosing the Limestone Quarries

The Contractor must carry out the following works.

3-1-C-4-1-1 Geological study on the limestone quarries

The Contractor must present a geological report giving the following estimations :

a. The geological formation of the quarry including covering and homogeneity.

b. The apparent quality of the rock.

c. The rate of fractures and their maximum width.

d. The method of preparation of the quarry (removal of altered materials).

e. The method of extraction and exploitation to obtain the best possible blocometric breakage (blasting plans, drilling equipment, explosives, loading and transportation).

3-1-C-4-1-2 Laboratory Test

The Contractor must take 6 rocky samples coming from the materials extracted from the quarry to be the object of laboratory tests. These tests must lead to the following results :

- Micro-Deval attrition test(> 20)- AFNOR P18-572
- Los Angeles Abrasion Test (< 30)- ASTM C131
- Porosity (< 10%)
- Unconfined compression strength (350 kg/cm^2)
- Chemical nature of the material
- Volume weight (>2.6 T/m^3)

These tests much show that the material components are at least 50% from limestone origin.

3-1-C-4-2 Choosing the Limestone Quarries

In the light of the geological report and the laboratory results, the Engineer shall give his approval for the use of the Quarry proposed by the Contractor. His approval does not affect the responsibility of the Contractor.

3-1-D FILL AND BACKFILL

3-1-D-1 FILL AND BACKFILL IN GENERAL

3-1-D-1-1 Description

This work shall consist of all fill and backfill for structures, chutes, canals, pipelines, culverts, headwalls, basins, manholes, inlets, retaining walls, roadways and other specified works.

3-1-D-1-2 General Requirements

Backfilling whether in foundations or in pipe trenches 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.

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

Temporary reinstatement and permanent reinstatement of all surfaces affected by the operations of the Contractor shall be carried out and maintained to the satisfaction of the Engineer and the responsible authority or owner.

Temporary reinstatement shall be carried out immediately after the trenches are backfilled.

Permanent reinstatement shall not be carried out until the ground has consolidated completely. 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 make the reinstatement good to the approval of the Engineer or responsible authority.

Unless otherwise specified in the drawings or by the Engineer, for the purposes of temporary and permanent reinstatement in bitumen and 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 surfaced roads shall be carried out to the approval of the relevant authority.

The responsible authority shall have the right to carry out permanent reinstatement at the Contractor’s expense.

Excavation in open ground shall be reinstated to the condition in which the ground 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 backfilling has been thoroughly consolidated, the topsoil shall be relaid rolled and planted with grass or other vegetation as-directed by the

Engineer as may be necessary, and watered until the grass has become well established. Should the planting fail it shall be replanted as required until a satisfactory growth is obtained.

If at any time any reinstatement deteriorates, the Contractor shall restore it to a proper condition immediately.

Should the Contractor not remedy the defect to the Engineer's satisfaction, any remedial work considered necessary may be undertaken by the Employer and/or the responsible authority at the Contractor's expense.

All trees, shrubs and plants shall be carefully transplanted and shall be returned to their original location after the refilling of the excavations. Return of old or mature trees may be waived in cases where the age of the tree makes return impracticable.

Top soil shall be carefully set aside and replaced at the surface of the backfilling.

The trenches shall be refilled and rammed solid as specified in the Contract and shall not be topped up above the original surface level to allow for settlement.

If any trench becomes dangerous the Engineer may call upon the Contractor for its reinstatement at three hours' notice and failing this to have the work done by others at the Contractor's expense.

3-1-D-2 COMPACTION OF EARTHWORK

3-1-D-2-1 Description

This work shall consist of the compaction of earthwork by rolling or tamping or any combination of these methods in accordance with the requirements for the Moisture Range and Type designated or ordered by the Engineer.

3-1-D-2-2 General Requirements

Each layer shall be compacted to a density between 90 and 95 % of the maximum density. This maximum density shall be determined by the AASHTO T 180-93, method D test or equivalent Standard Test for cohesive soils, by the ASTM D 2049 test or equivalent Standard Test for cohesionless soils.

In case where borderline materials are encountered, both the above mentioned tests will be utilized and the test which results in the higher laboratory maximum density shall be used as a standard to which the field density is compared.

Each layer of earth fill shall be compacted by approved tamping or sheepsfoot rollers, pneumatic tired rollers, or other mechanical means as requested by the Engineer and depending on the soil nature.

At locations where it would be impractical because of inaccessibility to use such compacting equipment, fill layers shall be compacted to the specified requirements by hand directed compaction equipment.

Whenever fill is placed adjacent to structures or at locations where it is not practicable to use a roller, the fill material shall be well tamped by the use of mechanical rammers or tampers.

Each layer shall be compacted to a density equal to or greater than obtained under the above rolling procedure for the type of compaction designated. Each layer must be approved by the Engineer before the next layer is placed. When the quantity of work is small, a hand tamper may be used with the permission of the Engineer.

At the time of compaction, the moisture content of the soil shall be within the moisture range as defined in the Test Methods. When the moisture content of the soil does not fall within the required moisture range, water shall be added and thoroughly mixed with the soil, by approved methods or the material shall be aerated, whichever is needed to adjust the soil to the specified moisture content before compaction.

3-1-D-3 BACKFILL FOR STRUCTURES

3-1-D-3-1 Description

This work shall consist of backfilling with suitable excavated or borrowed material (Selected Fill and Backfill), uniformly distributed and thoroughly compacted, around structures, chutes, culverts, manholes, retaining walls, or other structures.

3-1-D-3-2 General Requirements

Structure backfill shall not be placed until the structure has been inspected by the Engineer and approved for backfilling. In general, no structure shall be subjected to the pressures of backfilling or to live loads until three(3) days after the expiration of the period designated for the removal of forms. At the direction of the Engineer, this period may be extended if subnormal curing conditions exist. Backfill, placed around culverts, abutments and piers, or a particular structure as designed by the Engineer, shall be deposited on both sides to approximately reach the same elevation at the same time. Special care shall be taken to prevent any wedging action against the structure. The slopes bounding the excavation shall be stepped when necessary, to prevent such wedge action. Whenever backfill is placed in back of or over arches, culverts or rigid frames, the fill shall be first placed midway between the ends of the structure, working equally both ways from the center of the structure toward the ends.

The material shall be placed in layers and compacted by means of suitable equipment, or by tamping with mechanical tampers or hand tampers. Each layer shall be compacted to a density equal to or greater than ninety five (95) percent of the maximum density determined by AASHTO T 180-74, Method D. Each successive layer shall contain only that amount of material which will ensure proper compaction, but in no case shall any layer be greater than twenty (20) centimeters (compacted measurement) in thickness. When backfilling and compacting around retaining walls, extreme care shall be exercised to prevent forward movement of the wall. If not specified elsewhere or indicated on the plans, the backfill around structures shall be completed to the level of the original ground or to the finished ground level, whichever is lower unless otherwise specified.

3-1-D-4 BACKFILLING PIPE TRENCHES

3-1-D-4-1 Preparation of the excavation bottom

The excavation bottom shall be shaped according to the pipe's slope, and must not be loosened. However, if it is loosened, the initial bearing capacity shall be restored by compacting or by any other means.

3-1-D-4-2 Laying bed

Generally, the laying bed shall be executed with selected materials (as described below) except for a sandy soil where it is possible, upon the Engineer's approval, to use the excavation bottom that has been leveled and made compact as a laying bed. The theoretical thicknesses of the bed under the pipe works shall be at least equal to 10 cm. Nooks shall be performed in order to facilitate couplings connections. The laying bed shall enable the loads to be uniformly distributed on the support surface. It shall be necessary to lay pipes in such a way that the pressure is not concentrated in one area.

If the laying bed is located in a drain zone or in a pumping zone, it is necessary to prevent the materials of the laying bed from being carried away towards neighboring soils or inside the drainage equipment.

The preparation of the laying bed should not damage an eventual external protection of the pipe works.

The laying bed thickness under the pipe shall be at least equal to 10 cm + 1/10 of nominal diameter in cm, for the pipe works.

3-1-D-4-3 Sand fill protecting layer (initial backfill)

Use only selected fill, sand or other approved material complying with following:

Standard Sieve No. #	**% Passing**
¾	100
# 4	25-100
# 16	10-75
# 40	5-30
# 100	3-10
# 200	0-5

Initial backfill shall be used as bedding material underneath the pipe, and for filling around the pipe and above the top of the pipe (to the dimensions indicated on Drawings) compacted to 95 % of proctor maximum dry density by a compacting machines suitable for trench width.

Material around the pipes shall be compacted with proper tools as recommended by the manufacture, and as directed by the Engineer.

In general, the initial backfill should be sand fill. However where required by the Engineer, the initial backfill could be granular material (or granular with high sand content) according to the recommendations of the concerned pipe supplier.

3-1-D-4-4 Concrete Encasement

In some particular cases (narrow trench not allowing a normal compacting, repartition of loads to be improved, pipes located near foundations, etc...), pipes may be encased partially or totally with concrete. The casing operation shall be performed according to the details indicated on the drawings and to the indications of the Engineer.

The concrete coating shall consist of plain or reinforced concrete, depending on the cases and according to the instructions given by the administration.

The minimal thickness of the encasement shall be equal to 1/4 the nominal diameter with a minimum of 10 cm.

3-1-D-4-5 Main Backfill

Material excavated from the trenches are suitable for compaction and can be used as main backfill over sand protecting layer around the pipes, otherwise use material with a maximum size of 50 mms, well graded and suitable for compaction and approved by the Engineer.

- Backfill shall be laid and well compacted in layers not exceeding 200 mm thick. compacted to 95 % of proctor maximum dry density by a compacting machines suitable for trench width.
- Do not use heavy compactors over pipe trench until there is 600 mm (or as required by the pipe supplier) cover over the pipe.
- If the cover over the top of the pipe is less than 600 mm (or as required by the pipe supplier), use concrete encasement as specified on the drawings and directed by the Engineer.
- When backfilling to pipes with concrete beds and surrounds, do not start backfilling before 24 hours or allow heavy compactors and traffic over the pipes before 72 hours of placing concrete.
- Use temporary crossing over the trench to prevent damaging the pipes.

3-1-D-5 SPECIAL BACKFILLS

3-1-D-5-1 Execution Of Rocks Paving

The rocks in accordance with the required specifications for this particular zone shall be placed to the maximum possible position in its final locations. The finishing of the rock paving demands individual arrangement of each block by means of a heavy mechanical equipment for

the big blocks and by hand equipment for the smaller blocks, in a manner that a linear and plain surface is obtained free of any knobs.

If necessary, in some locations that the contractor should proceed with filling the voids between the big blocks by hand width a smaller size in order to obtain a consistent and compact volume.

The contractor must take all necessary measures to ensure safety and security of the site while paving with big chunks of rocks.

3-1-D-5-1-1 Rockfill

These backfills are discharged and leveled by bulldozer in slightly horizontal layers of 100cm after compaction. The biggest blocks, not bigger than 70 cm, are evenly distributed in the mass.

The equipment used and the number of operations must provide a good compaction with results being at least equal to those obtained with an 8 tons per linear meter of width vibrating roll, of a vibration frequency of 1500 to 1800 cycles per minutes with 6 operations at a 1.8 km/h speed.

The faces should present a certain aspect of unity. For that, the Contractor proceeds to a classification of block facings of same size. The blocks are sorted out at the quarry and prepared for the fill layer.

3-1-D-5-1-2 Filters and Drains

These backfills are unloaded avoiding any segregation and are leveled by a bulldozer in slightly horizontal layers of 15 cm after compaction. The equipment used and the number of operations must provide a good compaction with results being at least equal to those obtained with an 8 tons vibrating roll per linear meter of width, of a vibration frequency of 1500 to 1800 cycles per minute at a 1.8 km/h speed (6 to 7 passes). Alternatives leading to the same degree of compaction could be proposed by the Contractor and submitted to the Engineer for approval.

3-1-D-6 RIPRAP

3-1-D-6-1 DESCRIPTION

This work shall consist of furnishing and placing one (1) or more layers of riprap on a prepared surface in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the Engineer.

3-1-D-6-2 MATERIALS

Riprap shall consist of aggregate, from hard, durable, quarried or natural stone having an apparent specific gravity of not less than 2.4, and the absorption shall not exceed 5 percent.

The stone shall be free of weak laminations and cleavages, and shall not disintegrate on exposure to water or weathering. The aggregate shall be round or angular.

3-1-D-6-3 GRADATION REQUIREMENTS

Small size riprap gradation shall be as follows :

SIEVE OPENING SIZE IN CENTIMETERS	PERCENT PASSING (By weight)
20	100
15	50
10	0

Medium size riprap gradation shall be as follows :

SIEVE OPENING SIZE IN CENTIMETERS	PERCENT PASSING (By weight)
40	100
30	50
20	0

3-1-D-6-4 CONSTRUCTION REQUIREMENTS

3-1-D-6-4-1 Subgrade Preparation

The Contractor shall, as a part of this work and prior to the delivery of the material for the riprap, prepare the bed surface by sprinkling, blading, rolling, and lightly scarifying where necessary, until the proper slope is obtained for pipe riprap placing. However, in the process of shaping the bed, the originally compacted crust or top portion of the bed shall be disturbed as little as possible. When completed and ready for riprap construction, the bed shall be well compacted, smooth, hard and uniform, all irregularities having been bladed out and rolled down.

3-1-D-6-4-2 Placing

The material shall be so handled as to avoid segregation. If an aggregate spreader causes segregation in the material or leaves ridges or other objectionable marks on the surface which cannot be eliminated easily or prevented by adjustment of the spreader operation, the use of such spreader shall be discontinued and replaced.. All segregated material shall be removed and replaced with well-graded material. No “skin” patching shall be permitted.

Riprap shall be placed to grade in a manner to insure that the larger rock fragments are uniformly distributed and the smaller rock fragments serve to fill the spaces between the larger rock fragments in such a manner as will result in well-keyed, densely placed, uniform layers of

riprap of the specified thickness. Hand placing will be required only to the extent necessary to secure the results specified above.

All humps and depressions and thickness deficiencies exceeding the specified tolerance of five (5) centimeters shall be corrected by removing the defective work or by adding new material as directed by the Engineer.

3-1-D-6-5 SMALL SIZE RIPRAP WITH BITUMINOUS MASTIC

3-1-D-6-5-1 Description

This work shall consist of furnishing and placing one (1) or more layers of riprap, on a prepared surface, and to fill the joints between the stones with sand-asphalt mastic in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the Engineer.

3-1-D-6-5-2 Materials

3-1-D-6-5-2-1 Gradation Requirements

Riprap shall consist of aggregate, from hard, durable, quarried or natural stone having an apparent specific gravity of not less than 2.4, and the absorption shall not exceed 5 percent. The stone shall be free of weak laminations and cleavages, and shall not disintegrate on exposure to water or weathering. The aggregate shall be round or angular.

Small size riprap gradation shall be as follows.

SIEVE OPENING SIZE IN CENTIMETERS	PERCENT PASSING (By weight)
20	100
15	50
10	0

Sand-asphalt shall consist of a hot-laid mixture of asphalt and mineral aggregates conforming to the requirements below:

AASHTO SIEVE	PERCENT PASSING
1/2 inch	100
3/8 inch	80 to 100
No. 4	55 to 75
No. 10	32 to 47
No. 40	16 to 26
No. 80	10 to 18
No. 200	4 to 10

Asphaltic binder 16 % by weight of the aggregates

3-1-D-6-5-2-2 Physical Requirements for Sand-Asphalt

Mineral Aggregates

Mineral aggregates for "sand-asphalt" shall consist of fine aggregates, and filler material if required. When the grading of the available aggregates is deficient in material passing the AASHTO No. 200 sieve, mineral filler shall be added as approved by the Engineer. Mineral filler shall consist of finely divided mineral matter such as rock dust, including limestone dust, slag dust, hydrated lime, hydraulic cement, or other suitable mineral matter.

The combined mineral aggregate shall meet the following physical requirements:

- Loss of Sodium Sulfate Soundness Test (AASHTO T 104) 10 percent maximum
- Loss of Magnesium Sulfate Soundness Test (AASHTO T 104) 12 percent maximum
- Loss by Abrasion Test (AASHTO T 96) 40 percent maximum
- Thin and elongated pieces, by weight (larger than 1 inch, thickness less than 1/5 length) 5 percent
- Friable Particles (AASHTO T 112) 0.25 percent maximum
- Sand Equivalent (AASHTO T 176) determined after all processing except for addition of asphalt binder 45 minimum
- Plasticity index (AASHTO T 90) 3 maximum

Asphalts

Asphalts for "sand-asphalt" shall be petroleum asphalt cement, grade 60-70 penetration, conforming to the following requirements:

Designation	Test Method	Requirement
Penetration, 25 degrees C, 100 grams, 5 seconds	AASHTO T 49	60-70
Viscosity at 135 degrees C	ASTM E 102	100
Flash point (Cleveland) open cup, degrees C	AASHTO T 48	232.2
Ductility at 25 degrees C	AASHTO T 51	100
Solubility in organic solvents, percent	AASHTO T 44	99.5

The asphalt shall be prepared by the refining of petroleum. It shall be uniform in character and shall not foam when heated to 176.7 degrees Celsius.

Job-Mix Approval

At least thirty (30) days prior to the date he intends to begin production of plant-mix "sand-asphalt" mixtures, and after receiving approval of the aggregates from the Engineer, and after receiving the approval of the source of asphalt, the contractor shall make written request for the approved job-mix formula from the Engineer.

The job-mix formula shall combine the mineral aggregates and asphalt in such proportion as to produce a mixture conforming to the following composition limits by weight:

	PERCENT
Total Mineral Aggregates	88 - 84
Asphaltic Binder	12 - 16

When tested according to the Marshall method, the bituminous mixture shall conform to the following requirements:

Stability (kilograms)	700 minimum
Flow (millimeters)	2.4 - 4.0
Voids in total mix (percent)	3.0 - 5.0
Voids filled with asphalt (percent)	70 - 80

All trial mixes shall be prepared and tested by the Contractor. Results will be submitted to the Engineer and, if necessary, direct the Contractor to readjust the Plant to maintain conformity to the job-mix formula. If, during production, the grading of the aggregates alters, the mix shall be redesigned and the plant readjusted as outlined above.

The assistance of the Engineer in the preparation of the job-mix formula in no way relieves the Contractor of the responsibility of producing a bituminous mixture meeting the requirements of the specifications.

Preparation of Sand-Asphalt Mixture

Dried aggregate as specified for bituminous construction shall be combined in the plant in the proportionate amounts as approved. Asphalt shall be introduced into the mixture according to the job-mix formula.

The initial mixing time will be designated by the Contractor. Mixing time may be increased by the Engineer if additional time is necessary to obtain a homogeneous mixture and satisfactory coating.

The temperature of the asphalt, except for temporary fluctuations, shall not be lower than fourteen (14) degrees C below the temperature of the aggregate at the time the two (2) materials enter the mixer or plug mill.

3-1-D-6-5-3 Construction Requirements

3-1-D-6-5-3-1 Subgrade Preparation

The Contractor shall, as a part of the work and prior to the delivery of the material for riprap and sand-asphalt mixture, prepare the bed surface by sprinkling, blading, rolling, and lightly scarifying where necessary, until the proper slope is obtained. However, in the process of shaping the bed, the originally compacted crust or top portion of the bed shall be disturbed as little as possible. When completed and ready for riprap and sand-asphalt construction, the bed shall be well compacted, smooth, hard and uniform, all irregularities having been bladed out and rolled down.

3-1-D-6-5-3-2 Placing

The material shall be so handled as to avoid segregation. If an aggregate spreader causes segregation in the material or leaves ridges or other objectionable marks on the surface which cannot be eliminated easily or prevented by adjustment of the spreader operation, the use of such spreader shall be discontinued and replaced.. All segregated material shall be removed and replaced with well-graded material. No “skin” patching shall be permitted.

Riprap shall be placed to grade in a manner to insure that the larger rock fragments are uniformly distributed and the smaller rock fragments serve to fill the spaces between the larger rock fragments in such a manner as will result in well-keyed, densely placed, uniform layers of riprap of the specified thickness. Hand placing will be required only to the extent necessary to secure the results specified above.

All humps and depressions and thickness deficiencies exceeding the specified tolerance of five (5) centimeters shall be corrected by removing the defective work or by adding new material as directed by the Engineer.

After placing the stones for riprap as described above, in surfaces and thicknesses approved by the Engineer, the Contractor shall fill all the joints between the stones with the approved sand-asphalt mastic.

At least thirty (30) days prior to the date to begin placing of plant-mixed “sand-asphalt” mixtures, and after receiving approval of the sand-asphalt job-mix from the Engineer, the Contractor shall make written request for the approved method of transport and placement of the sand-asphalt from the Engineer. No mixture shall be placed prior to the Engineer’s approval of the Contractor’s methods and procedures for placing the mixture.

All mixed material shall be delivered to their final location in time to permit the mixture to be placed during daylight hours.

All bituminous mixtures shall be delivered to their final location at a temperature between 139 degrees C - 163 degrees C. Mixtures delivered at lower temperatures shall be discarded.

3-1-D-6-5-3-3 Weather Limitations

Sand-asphalt mixtures shall be placed only when the air temperature is four (4) degrees C or above, and when the weather is not foggy or rainy and when the existing surfaces free are free from moisture.

3-1-E TESTS ON MATERIALS

3-1-E-1 TEST METHODS

3-1-E-1-1 Moisture - Density Curve Test

A Moisture - Density Curve (AASHTO T 180-93, Method D or equivalent standard) will be determined for each type of soil to be used in the construction of the work to determine the Maximum Density, the Optimum Moisture content and the Moisture Range required of the soil for satisfactory compaction. The field density and actual Moisture Content of the compacted embankment shall be determined by field curves according to AASHTO T 191 or equivalent standard.

3-1-E-1-1-1 Maximum Density

The Maximum Dry Density as determined by the Moisture-Density curve shall be the density to which the Field Density is referred for comparison or percentage for each type of soil used in the work.

3-1-E-1-1-2 Optimum Moisture

The Optimum shall be the moisture content corresponding to the Maximum Density on the Moisture - Density curve.

3-1-E-1-1-3 Moisture Range

The Moisture Range shall be the limits of moisture content of each type of soil with the Optimum moisture as a reference.

3-1-E-1-1-4 Field Density

The Field Density shall be the density of the compacted fill determined by the Field Density Test.

3-1-E-1-1-5 Moisture Content

It is the percentage of moisture in the specimen based on oven dry mass of soil. The Moisture Content shall be the actual moisture content of the soil in the compacted embankment at the time of compaction.

3-1-E-1-2 Relative Density Test

For cohesionless free draining soils for which impact compaction will not produce a well-defined Moisture-Density relationship curve, the test for the Relative Density of Cohesionless Soils (ASTM D2049 or equivalent Standard) shall be used to determine the relative density.

Relative density is defined as the state of compactness of a soil with respect to the loosest and densest states at which it can be placed by the laboratory procedures described in ASTM D2049 or equivalent Standard. The Field Density and actual Moisture Content of the compacted embankment shall be determined by field tests according to AASHTO T 191-93 or T 238-86 or equivalent Standards.

3-1-E-1-2-1 Relative Density

The Relative Density as determined by the Relative Density Test shall be the standard to which the Field Density is referred for comparison for each type of cohesionless soil used in the Work.

3-1-E-1-2-2 Field Density

The Field Density shall be the density of the compacted fill determined by the Field Density Test.

3-1-E-1-2-3 Moisture Content

It is the percentage of moisture in the specimen based on oven dry mass of soil. The Moisture Content shall be the actual moisture content of the soil in the compacted fill at the time of compaction.

3-1-E-2 GENERAL PRESCRIPTION

The Contractor shall keep a constant control on the works by mean of tests, under the control of the Engineer. These tests shall be done in a laboratory site fit with equipment and staff personnel in order to accomplish the necessary tests specified below and before without delay. The list of equipment and staff will be submitted to the approval of the Engineer.

The Contractor can eventually subcontract a part of the test to specialized laboratories.

The Contractor has to submit to the approval of the Engineer, the laboratories as well as the list of test to subcontract.

The approval of the Engineer to undertake the tests in these laboratories does not relieve Contractor from his responsibility.

If the Engineer refuses to give his approval to accomplish certain tests outside the working field, the Contractor will have to undertake them in the field laboratory and equip it in consequence.

If during the works, the Engineer is not satisfied by the progress of the tests, as planned by the Contractor, he can ask the Contractor to modify his arrangements.

The necessary tests and samplings should be undertaken according to the recommendations of the French, American and British specifications or others agreed by the Engineer.

The Contractor must take into consideration all the necessary expenses for:

1. The samplings (undertaken by the field staff or by a specialized laboratory).
2. The transportation of the samplings from the field to the laboratory.
3. The conservation and treatment of the samples before the tests.
4. The tests and the result reports.

The number and types of tests listed below and above are provided for the control and good execution of the Contract. The Engineer could require other tests or increase the frequency of the tests and their number, if doubting their conformity with the specifications. The Contractor will have to undertake these supplementary tests on his expenses, without any claim or price revision.

3-1-E-3 TESTS ON BORROWED MATERIALS

All borrow material for the construction will be tested before use. The Contractor must submit to the Engineer as soon as possible and at the latest 15 days after the date of the notification of the contract, a detailed program and the time program of the tests.

3-1-E-3-1 TESTS AND SAMPLING RELATIVE TO THE FILTERS, DRAINS AND ROCKFILL MATERIALS

a. On quarry refer to related paragraph above.

b. During execution:

The necessary tests for the approval of the filters and drains materials are:

- Sieve analysis
- Specific gravity
- Proctor (When necessary)
- Compression tests on original rocky materials.

It is necessary to undertake a series of tests per 200 m^3 of filter, drain and rockfill and when requested by the Engineer.

3-1-E-3-2 TESTS AND SAMPLING RELATIVE TO THE INITIAL BACKFILL, MAIN BACKFILL AND SELECTED FILL AND BACKFILL

a. On quarry refer to related paragraph above.

b. During execution:

The necessary tests for the approval of these materials are:

- Sieve analysis
- Specific gravity
- Proctor.
- Plasticity Index (When necessary)

It is necessary to undertake a series of tests per 100 m^3 of initial backfill, Main backfill and Selected Fill and Backfill and when the request by the Engineer.

3-1-F WIRE ENCLOSED RIPRAP (GABIONS)

3-1-F-1 DESCRIPTION

This work shall consist of the installation of wire-enclosed riprap (gabions) in the locations designated on the plans.

3-1-F-2 MATERIALS

3-1-F-2-1 Aggregate

Aggregate for riprap shall be hard, durable, quarried or natural stone having an apparent specific gravity of not less than 2.4, and the absorption shall not exceed 5 percent. The stone shall be free of weak laminations and cleavages, and shall not disintegrate on exposure to water or weathering. The aggregate shall be round or angular and not less than 95 percent of the stone shall be retained on a screen having 3 inch square openings.

3-1-F-2-2 Wire-enclosed Riprap (Gabions)

Gabions shall be constructed of wire mesh. The wire mesh shall be made of galvanized steel wire having a minimum size of 0.120-inch diameter (U.S. Wire Gage No.11). The tensile strength of the wire shall be in the range of 60,000 to 85,000 psi, determined in accordance with ASTM A392. The minimum zinc coating of the wire shall be 0.80 oz./sq.ft. of uncoated wire surface as determined in accordance with ASTM A90.

Selvedge, tie, and connection wire shall meet the same strength and coating requirements specified above for wire used in the wire mesh.

3-1-F-2-3 Fabrication

The wire mesh shall be twisted to form hexagonal openings of uniform size. The maximum linear dimension of the mesh opening shall not exceed 4-1/2 inches and the area of the mesh opening shall not exceed 8 square inches. The mesh shall be fabricated in such a manner as to be non-raveling. Non-raveling is defined as the ability to resist pulling apart at any of the twists or connections forming the mesh when a single wire strand in a section is cut.

Gabions shall be fabricated so the sides, ends, lid, and diaphragms can be assembled at the construction site into rectangular baskets of the specified size. Gabions shall be of single unit construction-base, lid, ends, and sides shall be, either woven into a single unit or one edge of these members connected to the base section of the gabion in a manner that strength and flexibility at the point of connection is at least equal to that of the mesh.

Where the length of the gabion exceeds its horizontal width, the gabion shall be equally divided by diaphragms of the same mesh and gauge as the body of the gabions, into cells the length of which does not exceed the horizontal width. The gabion shall be furnished with the necessary

diaphragms secured in proper position on the base in a manner that no additional tying at this junction will be necessary.

All perimeter edges of the mesh forming the gabion shall be securely clip bound or selvedges so that the joints formed by tying the selvedges have at least the same strength as the body of the mesh.

Selvedge wire used through all the edges (perimeter wire) shall not be less than 0. 148-inch diameter (US. Wire Gage No. 9) and shall meet the same strength and coating specifications as the wire mesh.

Tie and connection wire shall be supplied in sufficient quantity to securely fasten all edges of the gabion and diaphragms and to provide for at least four cross connecting wires in each cell whose height is equal to the width and at least two cross connecting wires in each cell whose height is one-half the width of the gabion. Cross connecting wires will not be required when the height of the cell is one-third the width of the gabion. Tie and connection wire shall meet the same strength and coating specifications as the wire used in the mesh, except that it may be as much as two gages smaller.

In lieu of tie wire, two gauge galvanized hog rings may be used to connect adjacent baskets and to secure basket lids. Spacing of the hog rings shall not exceed 6 inches.

Vertical joints in the completed work shall be staggered at approximately 1/3 or 1/2 the length of the full baskets.

3-1-F-2-4 Installation

The gabions shall be placed on a smooth foundation. Final line and grade shall be approved by the Engineer.

Each gabion unit shall be assembled by binding together all vertical edges with wire ties on approximately 6 inch spacing or by a continuous piece of connecting wire stitched around the vertical edges with a coil about every 4 inches. Empty gabion units shall be set to line and grade as shown on the plans or as directed by the Engineer. Wire ties, hog rings, or connecting wire shall be used to join the units together in the same manner as described above for assembling. Internal tie wires shall be uniformly spaced and securely fastened in each cell of the structure.

A standard fence stretcher, chain fall, or iron rod may be used to stretch the wire baskets and hold alignment.

The gabions shall be filled with stone carefully placed by hand or machine to assure alignment and avoid bulges with a minimum of voids. Alternate placing of rock and connection wires shall be performed until the gabion is filled. After a gabion has been filled, the lid shall be bent over until it meets the sides and edges. The lid shall then be secured to the sides, ends and diaphragms with the wire ties or connecting wire in the manner described above for assembling.

Part III-2 : CONCRETE & MASONRY

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PART 3.2 - CIVIL & ARCHITECTURAL WORKS: CONCRETE & MASONRY

3-2-A CONCRETE

3-2-A-1 DESCRIPTION

Concrete shall consist of a mixture of cement, water and aggregates without air-entraining or water-reducing admixture unless specified otherwise.

Precautions are required to minimize the risk of alkali aggregate reaction. The Contractor shall demonstrate the adequacy of his proposals when he supplies details of his mix design. Unless otherwise agreed, when calculating the cementitious alkali contribution the maximum cement content in the schedule shall be used.

When calculating the alkali contribution of cement replacements Method A of Clause 3.8 of BS 5328 Part 4 shall be used.

3-2-A-2 CONCRETE MATERIALS

3-2-A-2-1 Cement

The types of cement to be used are in general: cement type P for ordinary concrete, cement type PA-S 32.5 for hydraulic concrete and sulfate resisting cement type P-RMS or P-RSS for concrete exposed to sulfate attack. The cement classes should be as defined by the Lebanese norms LIBNOR. However the Engineer has the right to impose the use of any type of cement in any type of concrete and in any structure according to the concrete exposure and other conditions.

3-2-A-2-1-1 Mixing of Cements

Only one (1) type or brand of cement shall be used in any one structural member. Mixing of types or brands will not be permitted.

3-2-A-2-1-2 Tests and Acceptance

Cement shall be tested for conformance with Lebanese Norms or AASHTO M 85 or British Standard 12 and shall have a compressive strength of standard cement mortar samples at twenty-eight (28) days of not less than two hundred fifty (250) kilograms per square centimeter. All cement is subject to the Engineer's approval and shipments of cement shall be accompanied by a manufacturer's Certificate of Guarantee and/or laboratory test certificate. The Engineer reserves the right to order a retest of the cement at any time. Approval of a cement quality shall not relieve the Contractor of the responsibility to fabricate concrete of the specified strength. The Contractor shall bear all costs in connection with the Certificates of

Guarantee and laboratory tests. When tests of factory or field tests subsequent to the original approval tests show that the cement does not comply with the specifications, the entire consignment from which the sample was taken will be rejected and the Contractor shall immediately remove the rejected material from the site and replace it with cement, which meets the required specifications.

3-2-A-2-1-3 Storage

Storage capacity shall be sufficient to meet the requirements for 30 (thirty) working days unless in the opinion of the Engineer the supply from the manufacturer is so limited that more storage capacity is necessary. Cement shall be stored in moisture-proof storage sheds in such a manner that the oldest is used first. Neither stale, caked nor reclaimed or re-sacked cement shall be used. The Contractor shall not store cement in areas subject to flooding.

Cement remaining in bulk storage at the mill prior to shipment for more than six (6) months or cement stored in bags in local storage by the Contractor or a vendor for more than three (3) months after shipment from the mill, may be retested before use and will be rejected if it fails to meet any of the requirements of these specifications.

3-2-A-2-2 Aggregates

3-2-A-2-2-1 Fine Aggregates

Fine aggregates shall conform to AASHTO M6 and shall consist of natural sand of sand equivalent of more than 80%, or, if approved by the engineer, crushed rock having hard and durable particles having similar characteristics: 100% passing 5 mm sieve, 65% to 85 % passing 1.25mm and 5% to 10% passing 0.15 mm sieve. The percentage of particles passing the 0.08mm. sieve should be less than: 3% for natural sand and 5% for crushed sand. The fine aggregates shall not contain harmful materials such as iron pyrites, coal, mica, shale or similar laminated materials such as flat and elongated particles or any materials which may attack the reinforcement in such a form or in sufficient quantity as to adversely affect the strength, durability and texture of the concrete.

3-2-A-2-2-2 Coarse Aggregates

Coarse aggregates shall conform to AASHTO M80 and shall consist of gravel, crushed gravel, or crushed stone free from coating of clay or other deleterious substances. It shall not contain harmful or any other materials in such a form or in sufficient quantity as to adversely affect the strength and durability of the concrete. If necessary, coarse aggregate shall be washed to remove deleterious substances or for consistency of concrete color.

3-2-A-2-2-3 Combined Aggregates

Combined aggregates are composed of a mixture of coarse aggregates and fine aggregates. They shall be used only in proportions with the prior approval of the engineer. In no case shall materials passing No. 200 (0.075 mm) sieve exceed 3% by weight of the combined aggregates.

3-2-A-2-3 Water

All sources of water to be used with cement whether for mixing or curing of concrete, or compaction of backfill around the concrete structures, shall be approved by the Engineer. If at any time during construction, water from an approved source becomes unsatisfactory, the Contractor shall provide satisfactory water from other main sources.

Water shall be free from injurious quantities of oil, alkali, vegetable matter and salt as determined by the Engineer. The water shall be reasonably clear and shall contain not more than one quarter (0.25) percent solids by weight. Water shall comply with the requirements of AASHTO T26 and BS 3148. If the specific conductance is less than 1500 micro ohms per centimeter the total solids contents requirement may be waived.

3-2-A-2-4 Admixture

Where directed by the Engineer, all the necessary additives shall be used (Air Entrained Agent, plasticizers, protection of concrete in contact with water from the evaporation of lime, waterproofing,…). In particular a retarding admixture set shall be used. The admixture proposed for use shall be approved by the Engineer before it is incorporated into the Work. The admixture shall be Type D as specified in AASHTO M 194.

3-2-A-3 ASSEMBLY AND HANDLING OF MATERIALS

3-2-A-3-1 Assembly of Aggregates

Aggregates shall be assembled in such quantities that sufficient material approved by the Engineer is available to complete any continuous pour necessary for structures. The batching site shall be of adequate size to permit the stockpiling of sufficient, non segregated materials, having proper and uniform moisture content to ensure continuous and uniform operation. Aggregates shall enter the mixer in a manner approved by the Engineer and in such a manner to ensure that no matter foreign to the concrete or matter capable of changing the desired proportions is included. In the event two (2) or more sizes or types of coarse or fine aggregates are used on the same project, only one (1) size or type of each aggregate may be used on one (1) continuous concrete pour.

3-2-A-3-2 Stockpiling of Aggregates

All aggregates shall be stockpiled before use in order to prevent segregation of material, to ensure a uniform moisture content, to provide uniform conditions for proportioning plant control and to aid in obtaining concrete that is uniform as to materials and moisture content.

The use of equipment or methods of handling aggregates which results in the degradation of the aggregates is strictly prohibited. Bulldozers with metal tracks shall not be used on coarse aggregate stockpiles. All equipment used for handling aggregates shall be approved by the Engineer.

Stockpiling of aggregates shall be in the manner approved by the Engineer and in addition, every precaution shall be taken to prevent segregation. Segregation shall be prevented by making no layer higher than one and one-half (1.5) meters and if two (2) or more layers are required, each successive layer shall not be allowed to "cone" down over the next lower layer.

Aggregates shall not be stockpiled against the supports of proportioning hoppers and weighing devices.

Aggregates shall be stockpiled and protected at locations which preclude contamination by brackish groundwater during periods of high water or contamination from other sources which might detrimentally affect the aggregates. Contaminated aggregates shall not be used in the concrete.

When required, the aggregate stockpiles shall be sprinkled with water, twelve (12) hours prior to use, to maintain a moisture content in the aggregate equivalent to the water absorption value of the aggregate as determined by AASHTO T 84 and AASHTO T 85.

3-2-A-3-3 Segregation

Segregated aggregates shall not be used until they have been thoroughly remixed and the resultant pile is of uniform and acceptable gradation at any point from which a representative sample is taken. The Contractor shall remix aggregate piles when ordered by the Engineer.

3-2-A-3-4 Transporting of Aggregates

If aggregates are to be transported from a central proportioning plant to the mixer in batch-boxes or dump trucks, such equipment shall be of sufficient capacity to carry the full volume of materials for each batch of concrete. Partitions separating batches shall be approved by the Engineer and shall be adequate and effective to prevent spilling from one compartment to another while in transit or being dumped.

3-2-A-3-5 Cement Storing And Stockpiling

Cement in storage or stockpiled on the site shall be protected from any damage by climatic conditions. Methods of storing or stockpiling shall be approved by the Engineer. Cement shall be transported to the mixer in the original sacks. Each batch shall contain the full amount of cement for the batch. Batches where cement is placed in contact with the aggregates may be rejected unless mixed within one and one-half (1-1/2) hours.

3-2-A-4 COMPOSITION OF CONCRETE

3-2-A-4-1 Requirements

The mix proportions shall be selected to ensure that the workability of the fresh concrete is suitable for the conditions of handling and placing, having regard to the structural element being constructed.

In the event of sulphate exposure precautions requiring lower cement content than those required for normal conditions the latter requirements shall prevail.

The maximum cement content in any mix shall not exceed 500 kg/m3 for normal structures and 450 kg/m3 for liquid retaining structures.

In all cases of mix proportioning, the added water shall be included with due allowance for the moisture contained in the aggregates and shall be the minimum consistent with the workability requirements.

3-2-A-4-1-1 Strength

The characteristic strength of concrete means that value of the 28 day below which 5% of all possible test results would be expected to fall.

3-2-A-4-2 Mix Proportions & Measurement for Proportioning Materials

The Contractor shall be responsible for the design of the concrete and shall consult with the Engineer as to mix proportions at least forty-five (45) days prior to beginning concrete work. The actual mix proportions of cement, aggregates and water shall be determined in accordance with BS5328 Parts 2, 3 and 4, by the Contractor under the supervision of the Engineer.

The Contractor shall, in the presence of the Engineer, prepare trial mixes for each class of concrete required for the project, made with the approved materials to be used in the work. The proportions of the trial-mixes shall be such as to produce a dense mixture containing the cement content specified and meeting the plasticity requirements and one hundred fifteen (115) percent of the strength requirements specified for the designated classes of concrete. If the materials supplied by the Contractor are of such a nature or are so graded that proportions based on minimum cement content cannot be used without exceeding the maximum allowable water content, the proportions will be adjusted so as to require the least amount of cement which will produce concrete of the required plasticity and workability without exceeding such allowable water content. No additional payment will be made for increased quantity of cement. Test cylinders shall be made from the trial-mixes.

The Engineer will review the Contractor's trial-mixes and break the test cylinders at seven (7) and twenty-eight (28) days. The Engineer will then determine which of the trial-mixes shall be used. If none of the trial-mixes for a class of concrete meets the specifications, the Engineer will direct the Contractor to prepare additional trial-mixes. No class of concrete shall be prepared or placed until its job-mix proportions have been approved by the Engineer.

The approval of the job-mix proportions by the Engineer or his assistance to the Contractor in establishing those proportions, in no way relieves the Contractor of the responsibility of producing concrete which meets the requirements specified in these specifications.

All costs connected with the preparation of trial-mixes and the design of the job-mixes shall be done by the Contractor, including all laboratory tests and the breaking of the test cylinders.

The limiting values which shall govern for each class of concrete are as follows:

- The cement content specified herein shall be determined from a yield test in accordance with AASHTO T 121.
- Concrete for Structures: Cement, water and aggregate sizes requirements for the various classes of structural concrete are specified in the following table:

Schedule for the specification requirements of designed mixes					
The mixes below shall be supplied as designed mixes in accordance with the relevant clauses of BS 5328: Parts 2, 3 and 4.					
1. Mix reference (Class of concrete)	A	B	C	D	E
2. Minimum Compressive Strength at 28 days (Kg/cm^2)	300	250	200	200	400
3. Nominal maximum size of aggregate, mm	20	20	40 or larger by approval	20	10
4. Types of aggregate:Coarse AASHTO FineAASHTO	M80 M6	M80 M6	M80 M6	M80 M6	M80 M6
5. Minimum cement content, kg/m^3	350	300	200	200	400
6. Maximum free water/cement ratio	0.55	0.55	0.60	0.60	0.55
7. Maximum cement content, kg/m3	375	350	250	250	450
Other Requirements					AEA

Note: AEA – Air Entrainment Agent

The minimum compression strength is the strength measured on test cylinders. The seven (7) day compressive strengths shall not be less than seventy-five (75) percent of the required twenty-eight (28) day strength.

The ultimate compressive strength of the concrete shall be determined on test specimens obtained and prepared in accordance with AASHTO T 23 and AASHTO T 126, except that only six (6) inches [one hundred fifty-two (152) millimeters] by twelve (12) inches [305 millimeters] cylinders shall be used for compression tests. The Contractor shall furnish single use cylinder molds conforming to AASHTO M 205, or when approved by the Engineer, reusable vertical molds made from heavy gauge metal.

3-2-A-4-2-1 Changes in Proportion

As the work progresses, the Engineer reserves the right to require the Contractor to change the proportions from time to time if conditions warrant such changes to produce satisfactory results. Any such changes may be made within the limits of the specifications at no additional compensation to the Contractor.

3-2-A-4-2-2 Measurement for Proportioning Materials

3-2-A-4-2-2-1 Cement

Cement shall be measured by weight. The measurement shall be accurate to within two (2) percent throughout the range of use.

3-2-A-4-2-2-2 Water

The mixing water shall be measured by weight. The measurement shall be accurate to within one (1) percent throughout the range of use.

3-2-A-4-2-2-3 Aggregates

The aggregates shall be measured by weight. The measurement shall be accurate to within one-half (1/2) percent throughout the range of use.

3-2-A-4-3 Concrete

3-2-A-4-3-1 Porous Concrete

Porous concrete shall be composed of ordinary Portland cement and 37.5mm single size aggregate complying with B.S 882, 1201: Part 2.

The ratio of aggregate to cement shall be 8:1 by volume or 10:1 by mass.

The concrete shall be mixed by machine or by hand to a uniform color and consistency before placing. The quantity of water used shall not exceed that required to coat all of the aggregate particles without forming excess grout.

The concrete shall be compacted by hand when total thickness does not exceed 40cm, otherwise it shall be compacted by rollers. The placement for roller compaction shall be in layers but shall not exceed 40cm in thickness per layer.

Permeability shall range between 1×10^{-2} and 1×10^{-3} meter/sec.

Compressive strength: 105 Kg/cm².

Contractor shall demonstrate the permeability of porous concrete in place by an effective field testing method that is approved by the Engineer. Contractor shall also install a laboratory on site for testing the permeability of concrete on samples before any placing of porous concrete. The permeability test method shall be approved by the Engineer.

3-2-A-4-3-2 Cyclopean Concrete

Cyclopean concrete shall consist of Class "C" concrete containing large embedded stones. The embedded rubble stones shall be of approved quality, sound and durable, and free from segregations, seams, cracks and other structural defects or imperfections tending to destroy its resistance to the weather. It shall be free from rounded, worn, or weathered surfaces. All weathered stone shall be rejected. The stone shall be kept free from dirt, oil, or any other injurious material which may prevent proper adhesion. The largest dimension of any rubble

stone shall not exceed 20 centimeters. The distance between two adjacent rubble stones or between a rubble stone and the form shall not be less than 5 centimeters.

The stone shall be carefully placed-not dropped or cast-so as to avoid injury to the forms or to the partially set adjacent masonry. All stones shall be washed and saturated with water before placing. The total volume of the stone shall not be greater than one third of the total volume of the portion of the work in which it is placed.

3-2-B SPECIAL TYPES OF CONCRETE

3-2-B-1 AIR ENTRAINED CONCRETE

Concrete where specified shall include an approved air-entraining agent capable of producing a 5% air-entrainment with a tolerance of 0.5%.

The mix shall be purposely designed having regard for the nature of grading of the aggregates and air-entraining agent being used.

Preference shall be given to the use of air-entraining agents which can be administered in fixed calibrated amounts through a dependable mechanical dispenser or sachet and which are added to the mixing water.

Frequent air meter tests shall be carried out and the consistency of the air-entrainment maintained to the above tolerances by adjustments in the mix, as may be necessary.

3-2-B-2 CONCRETE IN BENCHING

Concreting for benching in manholes, pumping stations and works structures shall consist of class B concrete (Grade C25) concrete unless otherwise specified. It shall be placed with low workability to the approximate shape required and, while still green, shall be finished with not less than 20 mm of Grade C25 concrete to a steel trowel led finish and to the contours indicated on the Drawings.

3-2-B-3 READY MIX CONCRETE AND CENTRAL MIXED CONCRETE

3-2-B-3-1 Description

"Ready-Mixed Concrete" and "Central-Mixed Concrete" shall consist of a mixture of cement, water and aggregate, without air-entraining or water-reducing admixture. The terms ready-mixed or central-mixed concrete shall include transit-mixed concrete and all will be referred to hereinafter as ready-mixed concrete.

Ready-mixed concrete may be used in the construction of all work, when approved by the Engineer.

Ready-mixed concrete may be manufactured by previously approved commercial plants or by other approved plants furnished for the work.

Approval of any ready-mixed concrete plant will be granted only when an inspection of the plant indicates that the equipment, the method of storing and handling the materials, the production procedures, the transportations and rate of delivery of concrete from the plant to the point of use, all meet the requirements set forth herein.

Permission to use ready-mixed concrete from any previously approved plant may be rescinded at any time upon failure to comply with the requirements of the specifications.

Ready-mixed concrete shall be mixed and delivered to the point of use by means of one of the following combinations of operations:

Mixed completely in a stationary central-mixing plant and the mixed concrete transported to the point of use in a truck mixer or tank agitator operating at agitator speed, or when approved by the Engineer, in non-agitating equipment (known as "Central-Mixed Concrete").

Mixed completely in a truck mixer at the batching plant or while in transit (known as transit-mixed concrete).

Mixed completely in a truck mixer at the point of use following the addition of mixing water (known as truck-mixed concrete).

A Computerised delivery note to be issued from the batching plant with each transit mixer. Copies of all delivery notes shall be submitted to the Engineer and shall include at least the following information:

1. Name of supplier, serial number of ticket and date.
2. Truck number.
3. Name of Contractor.
4. Name of contract and location of site.
5. Grade of concrete.
6. Specified workability.
7. Type and source of cement.
8. Source of aggregate.
9. Nominal maximum size of aggregate.
10. Time of loading at supplier’s works.
11. Quantity of concrete.
12. Arrival and departure times of truck.
13. Time of completion of discharge.
14. Extra water added with the approval of the Engineer.

3-2-B-3-2 Materials

All materials used in the manufacture of ready-mixed concrete shall conform to the requirements of "Concrete section".

3-2-B-3-3 Equipment

3-2-B-3-3-1 General

Equipment shall be of the type and number as outlined in the Contractor's Program of Work, as approved by the Engineer.

3-2-B-3-3-2 Check Tests

The Engineer may, from time to time, make slump tests of individual samples of the concrete at approximately the beginning, the mid-point and end of discharging the load. If the slumps vary by more than the allowable tolerance as specified in the specifications, the mixer or agitator shall not be used unless the condition is corrected to the satisfaction of the Engineer. All mechanical details of the mixer or agitator such as water measuring and discharge apparatus, condition of the blades, speed of rotation of the drum, general mechanical condition of the unit and clearance of the drum shall be checked before further use of the unit will be permitted.

3-2-B-3-3-3 Inspection

Mixers and Agitators shall be examined periodically for changes in condition due to accumulation of hard concrete or mortar or to wear of blades. The mixers shall be cleaned at intervals approved by the Engineer. The pick-up and throw-over blades in the drum or drums shall be repaired or replaced when they are worn down twenty (20) millimeters or more. The Contractor shall:

Have available at the job site a copy of the manufacturer's design, showing dimensions and arrangements of blades in reference to original height and depth, or provide permanent marks on the blades to show points of twenty (20) millimeter wear from new conditions. Drilled holes of six (6) millimeter diameter near each end and at midpoint of each blade are recommended.

Truck mixers and agitators of the revolving-drum type must be equipped with a hatch in the periphery of the drum shell of such design as to permit access to the inside of the drum for inspection, cleaning and repair of the drum and blades.

3-2-B-3-3-4 Composition of concrete

The composition of ready-mixed concrete shall conform to the requirements of "Concrete section".

3-2-C REINFORCING STEEL

3-2-C-1 DESCRIPTION

This Work shall consist of furnishing and placing reinforcing steel in accordance with the specifications and in conformity with the plans.

3-2-C-2 MATERIALS

3-2-C-2-1 Reinforcing Bars

3-2-C-2-1-1 Type

All reinforcing bars shall be of a deformed type in accordance with AASHTO M 31, except that plain bars may be used where specifically indicated on the drawings.

3-2-C-2-1-2 Quality

All steel reinforcement shall be of type FE E40 (min Fy=4,000k/cm2) (deformed), except for ties and stirrups which shall be of type FE E24 (min Fy=2,400k/cm2) (plain). The type of steel to be used shall be as mentioned on drawings.

3-2-C-2-2 Certification and Identification

3-2-C-2-2-1 Certification

Three (3) copies of a mill test report shall be furnished to the Engineer for each lot of billet-steel reinforcement bars proposed for use on the project. The mill test report shall be sworn to for the manufacturer of the steel by a person having legal authority to bind the manufacturer and shall show the following information:

The process or processes used in the manufacture of the steel from which the bars were rolled.

Identification of each heat of open-hearth, basic oxygen or electric furnace and/or each lot of acid Bessemer steel from which the bars are rolled.

Chemical and physical properties of the heat from which the bars were rolled.

3-2-C-2-2-2 Identification

The bars in each lot shall be legibly tagged by the manufacturer and/or fabricator before being offered for inspection. The tag shall show the manufacturer's test number and lot number or other designation that will identify the material with the certificate issued for that lot of steel.

The fabricator shall furnish three (3) copies of a certification which shows the heat number or numbers from which each size of bar in the shipment was fabricated.

3-2-C-2-2-3 Inspection and Sampling

The sampling and testing of reinforcement bars may be made at the source of supply when the quantity to be shipped or other conditions warrant such inspection. Bars not inspected before shipment will be inspected after arrival on the work. Test samples obtained at the destination of the steel shall be duplicate bars not less than one (1) meter in length and bars from which such samples are taken shall be replaced at the Contractor's expense. The Engineer reserves the right to resample and inspect all reinforcement steel upon its arrival at the work site.

All reinforcement bars shall be free from detrimental dirt, mill scale, rust, paint, grease, oil or other foreign substance, fins or tears. The Contractor will not be required to remove slight rusting which discolors the metal, but he shall remove all loose mill scale and scales rust. Brushing to clean blue metal will not be required. There shall be no evidence of piping or visual flaw in the test specimen or on the sheared ends of the bars.

Supports. Metal supports, approved by the Engineer, shall be provided and used to retain the reinforcement at proper distances from the forms. Supports under horizontal bars slabs shall be spaced at not more than eighty (80) diameters of the bar. All reinforcement shall be so rigidly supported and fastened that displacement will not occur during construction. Reinforcing steel shall be inspected in place and must be approved by the Engineer before any concrete is deposited.

3-2-C-2-2-4 Welded Wire Fabric

To be used for the reinforcement of concrete shall conform to the following requirements:

3-2-C-2-2-5 Dimensions

Welded steel wire fabric shall conform to the size and dimensions shown on the plans.

3-2-C-2-2-6 Properties

Wire fabric furnished shall conform to the requirements for "Welded Steel Wire Fabric for Concrete Reinforcement," AASHTO M 55.

3-2-C-3 CONSTRUCTION REQUIREMENTS

3-2-C-3-1 Protection and Storage

Reinforcing steel shall be protected at all times from damage. Reinforcing steel shall be stored above the ground on platforms, skids, or other supports. It shall be stored in such a manner and adequately marked to facilitate inspection and checking. When placed in the Work, the reinforcing steel shall be free from dirt, detrimental scale, paint, oil or other foreign substance.

3-2-C-3-2 Cutting and Bending

All cutting and bending of reinforcement bars shall be done by competent workmen and with equipment approved by the Engineer. Unless shown otherwise on the plans or unless written approval is obtained from the Engineer, all reinforcement bars shall be cut and bent in an on-site fabrication shop.

Bent bar reinforcement shall be cold bent to the shapes shown on the plans, and unless otherwise provided on the plans or by written authorization of the Engineer, bends shall conform to the following requirements:

D = 6d for five (5) millimeter through twenty-two (22) millimeter bar sizes

D = 8d for twenty-four (24) millimeter through twenty-eight (28) millimeter bar sizes

D = 10d for thirty (30) millimeter and over bar sizes

Where D = Minimum pin diameter around which a bar may be bent d = Bar diameter

3-2-C-3-3 Placing, Supporting and Fastening

All reinforcing steel shall be accurately placed and, during the placing of concrete, firmly held by approved supports in the position shown on the plans. Reinforcing bars shall be securely fastened together. Reinforcement placed in any member shall be inspected and approved before any concrete is placed. Laying or driving bars into the concrete after placement will not be permitted. All horizontal reinforcement shall be supported on metal supports or spacers as approved by the Engineer. The use of small stones or wood blocks for supporting reinforcement will not be permitted. The reinforcement shall be held securely in place at the proper position and spacing as indicated on the plans by the use of wire ties at bar intersections and tying to the supports and spacers. The adequacy of the supports and ties to secure the reinforcement properly shall be subject to the approval of the Engineer.

3-2-C-3-4 Splicing

Splices shall be avoided at points of maximum stress. They shall, where possible, be staggered, and shall be designed to develop the strength of the bar without exceeding the allowable unit bond stress. Unless otherwise shown on the plans, bars in the bottom of beams and girders, and in walls, columns, and haunches shall be lapped a minimum of twenty (20) diameters and bars near the top of beams and girders having more than thirty (30) centimeters of concrete under. The bars shall be lapped a minimum of thirty-five (35) diameters to make the splice. In no case shall bars be lapped less than thirty (30) centimeters.

3-2-C-3-5 Couplers

Couplers for reinforcement shall be either Standard Swaged Splices or Type II Alpha Couplers manufactured by CCL Systems Limited, Cabco House, Ewell Road, Surbiton, Surrey England, KT9 7AH, UK, or similar approved. Where bars of different diameters are to be joined a CCL Reducer Sleeve or similar shall be used.

Couplers shall be suitable for the type and size of reinforcing bars and shall be capable of developing 115% of the characteristic strength of the smaller of the reinforcing bars being joined in both tension and compression. Couplers shall be installed in accordance with the manufacturer's recommendations. Square twisted reinforcing bars shall not be used with couplers.

3-2-C-3-6 Reinforcing Bar Trusses

Bar trusses shall be placed, supported and secured in proper position before beginning the placement of the concrete. Unless the bar trusses are so designed and fabricated with outstanding legs to be in contact with the forms they shall be supported on metal supports and spacers. If the weight of the trusses causes the supporting legs of trusses to indent into the forms, bar supports shall be used as auxiliary support for the truss legs.

3-2-C-3-7 Mesh Reinforcement for Structures

Mesh reinforcement shall be of the sizes and spacing of bars and sheets as shown on the plans. The sheets of mesh shall be lapped as indicated on the plans. The method of placing the mesh and securing it in proper position shall be approved by the Engineer.

3-2-D CONCRETE STRUCTURE CONSTRUCTION

3-2-D-1 DESCRIPTION

This Work shall consist of furnishing and placing Portland cement concrete for structures and incidental construction in accordance with the specifications and in conformity with the lines, grades and dimensions as shown on the plans or established by the Engineer.

3-2-D-2 CONSTRUCTION REQUIREMENTS

3-2-D-2-1 Falsework

Detailed plans for falsework and centering shall be prepared by the Contractor and submitted to the Engineer for approval. The plans must be approved by the Engineer before the Work is started.

Falsework and centering shall be designed and constructed to provide the necessary rigidity to support all loads placed upon it without appreciable settlement or deformation. Falsework columns shall be supported on wood or metal bases when it cannot be founded on rock, shale, or thick deposits of other compact material in their natural bed. Falsework shall not be supported on any part of the structure, except the footings, without the written permission of the Engineer. The number and spacing of falsework columns, the adequacy of sills, caps and stringers and the amount of bracing in the falsework framing shall be subject to approval of the Engineer.

Falsework and centering shall be designed and constructed to support the total anticipated loads with a deflection not to exceed two one-thousandths (0.002) of the falsework span. The Contractor shall submit calculations to support this requirement for all spans over three (3) meters and other spans if requested by the Engineer.

All timber shall be of sound wood, in good condition and free from defects that might impair its strength. If the vertical members are of insufficient length to cap at the desired elevation for the horizontal members, they shall preferably be capped and frames constructed to the proper elevation. Ends of the vertical members shall be cut square for full bearing to preclude the use of wedges. If vertical splices are necessary, the abutting members shall be of the same approximate size, the ends shall be cut square for full bearing and the splices shall be scabbed in a manner approved by the Engineer.

The Contractor shall provide means for accurately measuring settlement in falsework during placement of concrete and shall provide a competent observer to observe and correct the settlement.

In designing forms and centering, concrete shall be regarded as a liquid. In computing vertical loads, a weight of twenty-four hundred (2,400) kilograms per cubic meter shall be assumed, and not less than thirteen hundred and sixty (1,360) kilograms per cubic meter shall be assumed in computing horizontal pressure.

The Engineer may refuse permission to proceed with other phases of the work if he deems the falsework unsafe or inadequate to support properly the loads to which it will be subjected.

The review or approval of falsework plans by the Engineer or permission to proceed with the work shall not relieve the Contractor of the responsibility for successful erection or satisfactory results.

3-2-D-2-2 Formwork

Forms shall be mortar tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incidental to the construction operations, including vibration. Forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber. They shall be designed to permit easy removal without injury to the concrete. Form lining such as smooth, exterior grade plywood or other approved material shall be used for all formed surfaces. The Contractor shall submit samples, specifications and other pertinent information thereon to the Engineer and secure his prior written permission to use the form lining.

Form lining material shall not bulge, warp or blister, nor shall it stain the concrete. Form lining shall be used in the largest practicable panels to minimize joints. Small panels of the lining material shall not be permitted. The joints in the lining shall be tight and smoothly cut. Adjacent panels of form lining shall be so placed that the grain of the wood will be in the same general direction (all horizontal or all vertical). Thin metal form lining will not be permitted. Undressed lumber of uniform thickness may be used for backing for form lining. Wooden ply form, of adequate thickness, which is properly supported, may be used in lieu of the lined forms specified herein.

Forms shall be maintained after erection to eliminate warping and shrinkage. They shall be checked for dimensions and condition immediately prior to the placement of concrete. The Engineer may at any time require the revision or reconstruction of forms and may refuse permission to place concrete within the forms until they are satisfactorily constructed. If, at any period of the work during or after placing the concrete, the forms show signs of sagging or bulging, the concrete shall be removed to the extent directed by the Engineer, the forms brought to the proper position and new concrete placed. No allowance will be made to the Contractor for such extra work.

Metal forms may be used and are subject to the same requirements and approvals specified for wood forms. The specifications for wood forms with respect to design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse and oiling, also apply to metal forms. The metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins of other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or do not line up properly shall not be used. Care shall be exercised to keep metal forms free from rust, grease or other foreign matter. Under such circumstances the continuance of use of the metal forms will depend upon satisfactory performance and their discontinuance may be required at any time by the Engineer. Steel panels with metal frames and wood or combination facing which leave permanent impressions or ridges will not be approved.

The inside of all forms shall be oiled with a light, clear, paraffin base oil that will not discolor or otherwise injure the surface of the concrete.

The oiling shall be done where possible after the completion of the forms and prior to placement of reinforcement.

Unless otherwise directed, the exterior side of all forms shall be painted with an approved, good quality high gloss white oil base enamel prior to placing concrete. When complete coverage is not obtained with one (1) coat, the Engineer will order additional coats as he deems necessary to obtain complete coverage. Forms shall be repainted when ordered by the Engineer.

Shrinkage cracks shall be closed by moistening the forms with water prior to concrete placement.

Forms that are to be reused shall be thoroughly cleaned and roiled and, if necessary, shall be reconditioned by revision or reconstruction. Unsatisfactory lumber will be condemned by the Engineer, and shall be removed from the site.

The width and thickness of the lumber, the size and spacing of studs and wales shall be determined with due regard to the nature of the work and shall be sufficient to ensure rigidity of the forms and to prevent distortion due to the pressure of the concrete.

Form bolts, rods or ties shall be made of steel. They shall be the type which permits the major part of the tie to remain permanently in the structure. They shall be held in place by devices attached to the wales capable of developing the strength of the ties. The Engineer may permit the use of wire ties on irregular sections and incidental construction if the concrete pressures are nominal and the form alignment is maintained by other means. The ties shall be removed on all exposed surfaces. The ties shall be removed to a depth of at least fifteen (15) millimeters below the concrete surface. Wire ties shall be cut back at least six (6) millimeters below the concrete surface. The cavities shall be filled with cement mortar composed of one (1) part by volume of cement and two (2) parts of sand and the surface left sound, smooth, even and uniform in color. Sufficient white Portland cement shall be mixed with the cement in the mortar, so when dry, the color will match the surrounding concrete. Form ties will not be permitted through forms for handrail. Pipe spreaders shall not be used unless they can be removed as the concrete is placed, as determined by the Engineer. Wood or metal spreaders shall be removed as the concrete is placed. The use of cofferdam braces or struts that extend through the forms for any concrete section will not be permitted except in unusual situations and then only with the approval of the Engineer.

Where the bottom of the forms is inaccessible, the lower form boards shall be left loose or other provisions made so that extraneous material may be removed from the forms immediately before placing the concrete.

Unless provided otherwise on the plans or directed by the Engineer, all exposed edges shall be beveled by using dressed, mill-cut, triangular molding, having twenty (20) millimeter sides.

All curved surfaces shall be formed with approved plywood or steel.

When instructed by the Engineer the Contractor shall submit formwork drawings and calculations to the Engineer in advance of the concreting.

Formwork shall be of such accuracy, strength and rigidity as to carry the weight and pressure from the concrete to be placed on or against it. together with all constructional wind or other loads likely to be imparted to it, without producing deformation of the finished concrete in excess of the specified tolerances.

Formwork shall be sufficiently tight without plugging to prevent loss of grout during the vibration of the concrete. When required by the Engineer joints between formwork facing boards shall be sealed with foam rubber sealing strips or other approved material.

Faces of formwork shall be clean, free from projecting nails adhering grout and other imperfections or defects. Formwork shall be treated with approved mould oil before positioning. The contractor shall prevent reinforcement or steelwork from being contaminated by the oil.

Formwork, which as a result of prolonged use or general deterioration or is otherwise in the opinion of the Engineer unsuitable shall not be used.

Through-bolts or ties will not be permitted in liquid-retaining structures. The Contractor shall use only such bolts or ties as are capable of being removed in whole or in part so that no part remaining embedded in the concrete shall be nearer the surface of the concrete than the specified thickness of cover to the reinforcement.

Beam soffits shall be erected with an upward camber of 5 mm for each 3 meters of span.

Top formwork shall be counterweighted or otherwise anchored against flotation.

Boxes for forming holes shall be constructed so as to be easily removable without damaging the concrete during removal. They shall be properly vented to permit the escape of entrapped air, and shall be capable of being sealed, subsequently to prevent the loss of grout.

On all external arises of the concrete 25 mm chamfers shall be formed.

Any openings provided in formwork for inspection and for cleaning-out shall be formed so that they can conveniently close before the placing of concrete.

All props shall be supported on adequate sole plates and shall not bear directly on or against concrete. They shall be capable of being released gently and without shock to the formwork. No appliance for supporting the formwork shall be built into the permanent structure without the Engineer's prior approval. Props for upper level support shall be placed directly over those at lower levels. Props shall only bear upon work sufficiently mature to carry the load.

Formwork shall be such as to allow for its removal without damaging the concrete and in the case of suspended floors for the removal of the beam sides and slab soffits without disturbing the beam-bottom boards and their props.

Before concreting, the areas which are intended to receive the concrete shall be cleaned by jetting with compressed air and all water and extraneous material removed.

Where timber is used for formwork it shall be properly cured free from warp straight, clean and free from loose knots.

Where metal forms are used for formwork they shall be of the type strengthened by intermediate ribs or cross bracing.

Moving formwork man be used if the Engineer sees it appropriate.

3-2-D-2-2-1 Sawn Formwork

Sawn formwork shall be properly designed and constructed of closely-jointed Sawn boards sheet metal or other approved material. It shall produce a standard of finish free from substantial voids, hones-combing or other large blemishes. There shall be no loss of grout.

3-2-D-2-2-2 Wrought Formwork

All exposed concrete shall be formed by wrought formwork.

Wrought formwork shall produce a high standard of finish with a hard smooth surface with true clean arises. Only minor surface blemishes shall be permitted. The face in contact with the concrete shall consist of framed plywood or metal panels or other approved material. Joints between boards and/or panels shall be arranged in a uniform pattern.

3-2-D-2-3 Tolerances

Unless otherwise indicated on the Drawings, the tolerances of the finished concrete with respect to the dimensions shown on the Drawings shall not exceed the limits set out in the following Table. Formwork shall be constructed to ensure completed work within the following tolerance limits:

Departure from established alignment	0.5 cm
Departure from established grade	0.5 cm
Variations from plumb or specified batter in lines and surfaces of columns, piers and walls	0.5 cm in 3 meters, if exposed 0.5 cm in 3 meters, if backfilled
Variations from level or indicated grade in slabs, beams, etc.	0.5 cm in 3 meters, if exposed 0.5 cm in 3 meters, if backfilled
Variation in cross-sectional dimensions of columns, piers, slabs, walls, beams	-0.5cm, + 0.5cm
Variations in slab thickness	-0.5cm, + 0.5cm
Footings : Plan Dimensions	-0.5cm, + 0.5cm
Eccentricity	2 percent of footing width, not exceeding 5 cm
Reduction in thickness	2 percent of specified thickness

3-2-D-2-4 Removal Of Forms And Falsework

To facilitate finishing, forms on handrails, ornamental work and other vertical surfaces that require a rubbed finish shall be removed as soon as the concrete has hardened sufficiently that it will not be injured as determined by the Engineer. In determining the time for the removal of forms, consideration shall be given to the location and character of the structure, weather and other conditions influencing the setting of the concrete.

If removal of forms or falsework is not controlled by beams or cylinders cured with and under the same conditions as the structure, the following periods, exclusive of periods when the temperature is less than four (4) degrees C, for releasing of forms and supports shall be used as a minimum:

- Arch Center 14 days
- Centering Under Beams 14 days
- Supports Under Flat Slabs 14 days
- Floor Slabs 14 days

- Vertical Wall Surfaces 24 hours
- Columns 24 hours
- Sides of Beams 24 hours
- Top Slabs R.C., Box Culverts 14 days

If high early strength cement is used, the time limits may be decreased as determined by the Engineer.

When form and falsework removal is controlled by beams or cylinders cured with, and under the same conditions as the structure, the release of falsework in load or movement carrying members shall not occur until the concrete has reached its specified strength. In no case shall release be permitted in less than seven (7) days.

Methods of form removal likely to cause overstressing of the concrete shall not be used. In general, the forms shall be removed from the bottom upwards. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

In general, arch centering shall be struck and the arch made self-supporting before the railing or coping is placed. For filled spandrel arches, such portions of the spandrel walls shall be left for construction subsequent to the striking of centers, as may be necessary to avoid jamming of the expansion joints. In arch structures of two or more spans, the sequence of striking centers shall be as specified or approved.

Immediately after the removal of the forms, all fins caused by form joints and other projections shall be removed and all pockets cleaned and filled with a cement mortar composed of one (1) part by volume of Portland cement and two (2) parts sand. Sufficient white Portland cement shall be mixed with the cement in the mortar, so that when dry, the color will match the surrounding concrete. Patches shall be moistened prior to mortaring to obtain good bond with the concrete. When directed by the Engineer, the Contractor shall at his own expense, substitute an approved epoxy grout for the Portland cement mortar or provide an epoxy bonding agent to be used in conjunction with the Portland cement mortar. If, in the judgment of the Engineer, rock pockets are of such extent or character as to materially affect the strength of the structure or to endanger the life of the steel reinforcement, he may declare the concrete defective and require the removal and replacement of that portion of the structure affected. The resulting surfaces shall be true and uniform. Portions of the structure which cannot be finished or properly repaired to the satisfaction of the Engineer shall be removed.

3-2-D-2-5 Mixing and Transporting

3-2-D-2-5-1 Mixing

Concrete shall be mixed in quantities required for immediate use. Concrete shall not be used which has developed initial set or is not in place one-half (1/2) hour after the water has been added for non-agitated concrete or if agitated, the concrete must be in place one and one-half (1-1/2) hours after the water has been added. Retempering concrete by adding water or by other means will not be permitted. Concrete that is not within the specified slump limits at the time of placement shall not be used and shall be disposed of as directed by the Engineer.

The Concrete may be mixed at the site of the work, in a central-mix plant, or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials, except water, are in the drum. Ready-mixed concrete shall be mixed and delivered in accordance with requirements of Section 3.3 "Ready-Mixed Concrete and Central-Mixed Concrete".

When mixed at the site of the Work or in a central-mixing plant, the mixing time shall not be less than fifty (50) seconds nor more than ninety (90) seconds. Four (4) seconds shall be added to the specified mixing time if timing starts the instant the skip reaches its maximum raised position. Mixing time ends when the discharge chute opens. Transfer time in multiple drum mixers is included in mixing time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein.

The mixer shall be operated at a drum speed as shown on the manufacturer's nameplate on the approved mixer. Any concrete which, in the opinion of the Engineer, is mixed more or less than the specified time shall be discarded and disposed of by the Contractor at his expense. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic meters, as shown on the manufacturer's standard rating plate on the mixer; except that an overload up to ten (10) percent above the mixer's nominal capacity may be permitted when approved by the Engineer, provided concrete test data for strength, segregation and uniform consistency are satisfactory, and provided no spillage of concrete takes place.

The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first fifteen (15) seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as may restrict the free flow of materials into the drum.

3-2-D-2-5-2 Central-Mixing

Plants for concrete shall comply with the following requirements, in addition to those set forth above:

3-2-D-2-5-2-1 Cement

Means provided for storing cement shall be as approved by the Engineer. The Contractor shall clean all conveyors, bins and hoppers of unapproved cement before starting to manufacture concrete for the work.

3-2-D-2-5-2-2 Aggregate

Coarse and fine aggregate to be used in concrete shall be kept in stockpiles and bins apart from aggregate used in other work. Aggregates shall come from a source approved by the Engineer. The Contractor shall clean all conveyors, bins and hoppers of unapproved aggregate before starting to manufacture concrete for the work.

3-2-D-2-5-2-3 Consistency

The Contractor shall be responsible for producing a concrete that will be of the proper consistency when delivered to the job site.

3-2-D-2-5-2-4 Hauling

Mixed concrete from the central-mixing plant shall be transported in truck mixers, truck agitators, non-agitating trucks having special bodies or other approved containers.

3-2-D-2-5-2-5 Time of Haul

The time elapsing from the time water is added to the mix until the concrete is deposited in place at the site of the work shall not exceed thirty (30) minutes when the concrete is hauled in non-agitating trucks, nor more than ninety (90) minutes when hauled in truck mixers or truck agitators.

3-2-D-2-5-2-6 Delivery

The Contractor when supplying concrete from a central plant shall have sufficient plant capacity and transporting equipment to ensure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing and finishing of the concrete. The method of delivery and handling the concrete shall be such as will facilitate placing with a minimum of re-handling and without damage to the structure or the concrete. Methods of delivery and handling for each site shall be approved by the Engineer. The Engineer may delay or suspend the mixing and placing of concrete at any site for which he considers the Contractor's delivery equipment inadequate, until such time as the Contractor provides additional approved delivery equipment.

3-2-D-2-5-3 Transporting

Concrete shall be transported to the place of final deposit by approved means.

Barrows, spades and other equipment used in the process of transporting concrete shall be thoroughly cleaned before each day's work or after a long interruption and they shall be free from hardened concrete.

Concrete shall be transported as soon as possible after mixing. by methods which will prevent the segregation, loss or contamination of the ingredients.

Bridging for traffic over reinforcement shall be provided so that the reinforcement is not distorted, damaged or displaced.

Where approval is obtained for concrete to be conveyed by chutes. These shall have a slope (not exceeding 1 vertical to ' horizontal) such as to ensure a continuous flow of concrete. Additional water shall not be introduced to assist the flow. If deposition is to be intermittent the

chute shall be arranged to discharge into a storage hopper. In no case a clear fall of more than 1 m be permitted at the discharge end of the chute.

Where approval is obtained for pumping the concrete, the pump manufacturer's recommendations as approved by the Engineer shall be followed. The pumps used shall be of adequate capacity and power to ensure delivery of a continuous supply.

Wherever transport of concrete is interrupted for any period of over half an hour the chutes, pumps, pipes and any other means of distribution shall be thoroughly flushed out and cleaned. These shall also be flushed out immediately prior to resumption of concreting and shall be kept free from hardened concrete. All washing water used shall be discharged outside the formwork and clear of any freshly placed concrete.

3-2-D-2-6 Handling, Placing, Concrete and Compacting

Concrete shall not be placed until forms and reinforcing steel have been checked and approved by the Engineer. The forms shall be clean and free of all debris before concrete is placed. The method and sequence of placing concrete shall be approved by the Engineer.

The external surface of all concrete shall be thoroughly worked during the placing by means of tools of an approved type. The working shall be such as to force all coarse aggregate from the surface and to bring mortar against the forms to produce a smooth finish, substantially free from water and air pockets, or honeycomb.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. Concrete shall not be deposited in large quantities at any point in the forms and then run or worked along the forms, thus causing segregation of the materials.

The concrete shall be deposited in the forms in horizontal layers and the work shall be carried on rapidly and continuously between predetermined planes agreed upon by the Contractor and the Engineer. Keyways shall be formed between layers.

Where steep slopes are required for placing concrete with chutes, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement. Chutes and the use of chutes must be approved by the Engineer.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. The water used for flushing shall be discharged clear of the concrete already in place.

Concrete shall not be dropped in the forms a distance of more than one and one-half (1-1/2) meters, unless confined by approved closed chutes or pipes and care shall be taken to fill each part of the form by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and worked around the reinforcement without displacing the bars. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement.

Unless otherwise directed, the concrete shall be compacted with suitable mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate compaction.

Vibrators shall be of an approved type and design.

Vibrators shall be so manipulated as to work the concrete thoroughly around the reinforcement and embedded fixtures and into corners and angles of the forms. Vibrators shall not be used as a means to cause concrete to flow or run into position in lieu of placing. The vibration at any

point shall be of sufficient duration to accomplish compaction, but shall not be prolonged to the point where segregation occurs.

Concrete shall be deposited in water only with the permission of the Engineer and under his supervision. The minimum cement factor of the class of concrete being deposited in water shall be increased ten (10) percent without further compensation and the slump shall be approximately fifteen (15) centimeters. When depositing in water is allowed, the concrete shall be carefully placed in the space in which it is to remain in a compact mass, by means of a tremie, bottom-dumping bucket, or other approved method that does not permit the concrete to fall through the water without adequate protection. The concrete shall not be disturbed after being deposited. No concrete shall be placed in running water, and forms which are not reasonably watertight, shall not be used for holding concrete deposited under water.

Pumping will not be permitted from the inside of the foundation forms while concrete is being placed. If necessary to prevent flooding, a seal of concrete shall be placed through a closed chute or tremie and allowed to set.

When casings are used in drilled shafts, the casing shall be smooth and well-oiled and shall extend sufficiently above the grade of the finish shaft to provide excess concrete to be placed for the anticipated slump due to the casing removal. When the casing is to be pulled**,** the concrete placed in the casing shall have such a slump and be of such workability that a minimum amount of vibrating will be required.

No concrete work shall be stopped or temporarily discontinued within forty-five (45) centimeters of the top of any finished surface, unless such work is finished with a coping having a thickness less than forty-five (45) centimeters in which case the joint shall be made at the under edge of the coping.

Concrete in simple slab spans shall be placed in one (1) continuous operation for each span, unless otherwise indicated on the plans or approved by the Engineer. For continuous slab spans, concrete shall be placed in the sequence shown on the plans, except that with the approval of the Engineer, consecutive placement may be combined in a single placing operation to cover from one end of a unit to the other.

Concrete in simple or continuous T-beam spans may be placed in one (1) continuous operation, or when shown on the plans or approved by the Engineer, may be placed in two (2) separate operations; first, to the top of the girder stems, and second, to completion.

The concrete in arch rings shall be placed in such a manner as to load the centering uniformly.

Arch rings, preferably, shall be cast in transverse sections of such size that each section can be cast in a continuous operation. The arrangement of the sections and the sequence of placing shall be as approved by the Engineer, and shall be such as to avoid the creation of initial stress in the reinforcement. The sections shall be bonded together by suitable keys or dowels. When permitted by the Engineer, arch rings may be cast in a single continuous operation.

Before concrete floors are placed on steel spans, the centering under the spans shall be released and the spans swung free on their supports unless otherwise indicated on the plans. The operation of placing the concrete in any floor slab shall be continuous until complete, except where joints are provided on the plans or authorized by the Engineer. When a special sequence or method of concrete placing operations is indicated on the plans, or designated by the Engineer, this sequence or method shall be followed.

The method used for transporting concrete batches, materials, or equipment over previously placed floor slabs or floor units or over units of structures of continuous design types shall be

subject to approval by the Engineer. Trucks, heavy equipment and heavy concentration of materials will be prohibited on floor slabs until the concrete has attained its design strength.

Where concrete is to be placed in lifts greater than 2.5 m high it shall be placed by suitable tremie pipes. Shutters for lift heights greater than 3 m shall incorporate windows in suitable places to allow placing and vibration.

3-2-D-2-7 Hot Weather Concreting (for temperatures above 20°C)

Concreting shall not be permitted if its temperature at placing is in excess of 38°C. In order to maintain the temperature of the concrete below this value the following precautions shall be taken wholly or in part as instructed by the Engineer:

All aggregate stockpiles, water lines and tanks as well as the mixer shall be protected from the direct rays of the sun.

Coarse aggregate shall be cooled by constant watering where possible.

Mixing water shall be cooled by the addition of ice to the storage tanks where necessary.

Rapid-hardening cement shall not be used.

Where the above precautions are inadequate concreting shall be carried out during the cooler parts of the day or during the night as may be directed by the Engineer.

When the air temperature is above 20°C loss of mixing water by evaporation shall be considered in arriving at the amount of water to be added to the mix. To maintain the water/cement ratio within permissible limits an approved water-reducing agent shall be included in the mix.

The maximum water/cement ratios may be increased with the Engineer's permission by 0.05 (or 2.5 litres/50 kg of cement) during mixing, but on no account shall water be added to concrete once it has left the mixer.

In order to reduce premature drying of the concrete during transporting and placing, all chutes, formwork and reinforcement shall be cooled by watering when possible, or shall otherwise be protected from the direct rays of the sun.

As soon as possible after concreting, the formwork shall be stripped and the surface of the concrete shall be treated.

Where drying winds are encountered, wind shields shall be positioned as necessary to protect exposed surfaces of the curing concrete.

3-2-D-2-8 Wet Weather Concreting

Concreting during periods of constant rain shall not be permitted unless aggregate stockpiles, mixers and transporting equipment, and the areas to be concreted are adequately covered.

During showery weather, the Contractor shall ensure that work can be concluded at short notice by the provision of stop ends. On no account shall work be terminated before each section, between one stop end and another is complete. Adequate covering shall be provided to protect newly placed concrete from the rain.

3-2-D-2-9 Cold Weather and Night Concreting

No concrete shall be mixed, placed or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated and such night work is approved by the Engineer.

Unless authorized in writing by the Engineer, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches five (5) degrees C. When directed by the Engineer, the Contractor shall enclose the structure in such a way that the concrete and air within the enclosures can be kept above fifteen (15) degrees C for a period of seven (7) days after placing the concrete. The Contractor shall supply such heating apparatus as stoves, salamanders or steam equipment and the necessary fuel. When dry heat is used, means of maintaining atmospheric moisture shall be provided.

When directed by the Engineer, all aggregates or mixing water or both, shall be heated to a temperature of at least ten (10) degrees C, but nor more than twenty-one (21) degrees C the aggregates may be heated by steam or dry heat.

The temperature of the concrete shall be not less than fifteen (15) degrees C at the time of placing in the forms. In case of extremely low temperature, the Engineer may, at his discretion, raise the minimum limiting temperature for work, aggregates and mixed concrete. Salt, chemicals or other material shall not be used to prevent freezing.

3-2-D-2-10 Joints

3-2-D-2-10-1 Construction Joints

Wherever the work of placing concrete is delayed until the concrete shall have taken its initial set, the point of stopping shall be deemed a construction joint. So far, the location of construction joints shall be as shown on the plans, but if not shown on the plans, they shall be planned in advance and the placing of concrete carried continuously from joint to joint. The joints shall be perpendicular to the principal lines of stress and in general be located at points of minimum shear.

Where dowels, reinforcing bars or other adequate ties are not required by the plans, keys shall be made by embedding water-soaked beveled timbers in soft concrete. The key shall be sized as shown on the details, or as directed by the Engineer, which shall be removed when the concrete has set. In resuming the Work the surface of the concrete previously placed shall be thoroughly cleaned of dirt, scum, laitance or other soft material with stiff wire brushes and if deemed necessary by the Engineer, shall be roughened with a steel tool. The surface shall then be thoroughly washed with clean water and painted with a thick coat of neat cement mortar, after which the concreting may proceed.

3-2-D-2-10-2 Expansion Joints

Expansion joints shall be constructed at the locations of the materials and to the dimensions shown on the plans.

Preformed expansion joint filler for concrete, bituminous type conforming to AASHTO M33 shall be placed in the joint. The joint filler shall cover the full depth minus the thickness required to place the bituminous putty at each joint. One face of the filler shall be held rigidly in place against the face of the concrete previously cast, while fresh concrete is placed against other face of the filler.

3-2-D-2-10-3 Contraction Joints

Contraction joints shall be constructed at the locations, of the materials and to the dimensions shown on the Plans or as directed by the Engineer.

3-2-D-2-10-4 Cold Joints

When the continuous placement of concrete in any structural member is interrupted or delayed, for any reason, for a period long enough for the previously partially placed concrete to take its initial set, the Engineer shall declare such joint a cold joint and the Contractor shall immediately remove the previously partially placed concrete from the forms. No extra payment will be made for the initial placement or the removal of concrete which is wasted because of a cold joint. The Engineer may suspend all or any part of subsequent concrete Work until he deems the Contractor has corrected the cause of the cold joint occurrence.

3-2-D-2-11 Holes, Cavities and Fixing

Holes shall be accurately marked and boxed-out for before concreting operations commence. No holes shall be formed after the concrete has set. Where bars, if placed to specified spacing would foul holes of size less than 250 mm x 250 mm. The full length of the bar shall be moved to one side unless otherwise indicated on the Drawings. For holes exceeding 250 mm x 250 mm, the bars shall be cut on site and lapped with additional equivalent bars.

Wherever possible, the Contractor shall build in all pipe work, Ironwork, and steelwork which passes through walls and floors. The pipe work, ironwork, and steelwork shall first be thoroughly cleaned and freed from any deleterious matter. Every care shall be taken to ensure that it is thoroughly encased in concrete.

Bolts, hooks and other fixings shall be embedded in concrete, or holes shall be drilled and fitted with threaded expanding anchors to receive the bolts. The Contractor shall ensure that bolts, hooks and fixings are accurately positioned Holding down bolts for machinery shall be set to template.

Where brick or stonework is to form a facing to the concrete or where the end of a brick or stone wall butts against a concrete face, galvanized metal ties of approved manufacture to BS 1243 shall be incorporated.

3-2-D-2-12 Finishing

All top surfaces, such as the top of retaining walls, curbs, abutments, rails, etc., shall be treated by tamping and floating with a wooden float in such a manner as to flush the mortar to the surface and provide a uniform surface, free from pits or porous places. The surface thus obtained shall be troweled to produce a smooth surface and brushed lightly with a damp brush to remove the glazed surface.

Unless otherwise shown on the Drawings, all exposed concrete surfaces shall be smooth finish with epoxy paint and shall be free from honey-combing, fins, projections and air-holes. After removal of the forms, the Contractor, at his own expense, shall make good faulty surfaces by filling them with cement and sand (1/2 by vol.) mortar and rubbing them with a fine carborundum stone.

Immediately after the curing period, the Contractor shall repair all minor shrinkage cracks identified by the Engineer. Repairs shall be made as directed by the Engineer using an approved water resistant, high modulus low viscosity epoxy.

Unless otherwise provided on the plans, all true and even surfaces, obtained by use of a form lining, which are of a uniform color, free from stone pockets, honeycomb, excessive depressions or projections beyond the surface shall be considered as acceptable surfaces and a rubbed surface finish will not be required, except as follows:

The above provisions for surface finish shall not preclude requiring the use of a dry carborundum brick for straightening molding lines, removing fins, etc., or requiring a rubbed surface finish on all portions of the structure which do not present an acceptable surface even though a form lining is used.

3-2-D-2-13 Curing and Protection

All concrete shall be cured for a period of time required to obtain the full specified strength, but not less than seven (7) consecutive days beginning immediately after placement. Curing shall be done according to one of the following pertaining methods:

3-2-D-2-13-1 Water Curing

All surfaces, unless sealed by metal forms or submerged, shall be water cured including those surfaces which have previously had liquid curing membrane applied. For construction joints or other surfaces where no liquid membrane is specified, water curing shall begin within one (1) hour of placement. Where liquid membrane is placed, water curing shall begin within four (4) hours of placement.

For structure decks and slabs, the Contractor shall provide sufficient water and equipment to keep the surface of the concrete continually damp until the membrane curing is applied. The water shall be applied with a nozzle that so atomizes the flow that a mist and not a spray is formed. The moisture from the nozzle shall not be applied under pressure directly upon the concrete and shall not be allowed to accumulate on the concrete in a quantity sufficient to cause a flow or wash the surface.

Surfaces to be water cured shall be covered with wet sand, cotton mats, double thickness burlap or other equivalent absorbent material. The absorbent material shall cover the concrete

surface completely. The material shall be completely saturated with water and kept continuously saturated throughout the curing period. After initial saturation, all surfaces shall be covered with polyethylene sheeting meeting requirements of ASTM C-171 or other approved impervious material. The sheeting shall be weighted or secured to prevent moisture loss. However, the surfaces of the concrete shall be readily available for inspection of the Engineer. The sheeting shall be in good repair. Sheeting that contains holes or is otherwise damaged shall be rejected by the Engineer. The Contractor shall be responsible for thoroughly inspecting and monitoring the concrete surfaces throughout the curing period. Additional water shall be added to any areas which are not still saturated. Inspections by the Contractor shall be conducted at least twice per day for the duration of the curing period and more often if ordered by the Engineer. The Engineer shall be advised of the inspection schedule and may accompany the workman to verify the acceptability of curing.

3-2-D-2-13-2 Membrane Curing

Except for construction joints and surfaces sealed by metal forms, liquid membrane shall be used as follows:

On wood formed vertical surfaces, forms shall be stripped as soon as practical and liquid curing membrane applied immediately except that those areas being rubbed or finished during the curing period shall be kept wet until finishing is complete when clear liquid curing membrane shall be uniformly applied.

On metal formed surfaces, with or without wood lining, liquid curing membrane shall be applied if the Contractor elects to strip the forms within the curing period.

The curing membrane used shall be in accordance with the requirements specified for curing membrane material, AASHTO M 148 Type 1-D. The curing membrane shall be applied in two (2) applications. The rate of each application of curing compound will be -as prescribed by the Engineer with a spreading rate per application of one (1) liter of liquid per five (5) square meters of concrete surface. If the concrete is dry or becomes dry, it shall be thoroughly wet with water and the curing compound applied just as the surface film of water disappears. During curing operations, any unsprayed surfaces shall be kept wet with water. Any curing membrane material on construction joints and/or reinforcing steel shall be completely removed before the following concrete pour.

Hand operated spraying equipment shall be capable of supplying a constant and uniform pressure to provide uniform and adequate distribution of the curing membrane at the rates required. The curing compound shall be thoroughly mixed at all times during usage.

No traffic of any kind will be permitted on the curing membrane until the curing period is completed, unless the Engineer permits the placement of concrete in adjacent sections in which case the damaged areas shall be immediately repaired as directed.

3-2-D-2-13-3 Cold Weather-Curing

When concrete is being placed in cold weather, it shall be placed in accordance with the requirements provided in section “Cold weather and night concreting”.

When concrete is being placed and the air temperature may be expected to drop below five (5) degrees C, during the curing period, the Contractor shall provide suitable measures such as

straw, additional burlap, or other suitable blanketing materials and/or housing and artificial heat curing to maintain the concrete temperature between ten (10) degrees C and thirty-two (32) degrees C as measured on the surface of the concrete. The surface of the concrete shall be kept moist by the use of an approved moisture barrier such as wet burlap or polyethylene sheeting. The moisture barrier shall be maintained in intimate contact with the concrete during the entire curing period. After the completion of the required curing period, the Contractor shall remove the curing and protection in such a manner that rapid cooling of the concrete will be prevented.

When concrete is placed in cofferdams and subsequently flooded with ground water, the above curing conditions may be waived providing the surface of the water is not permitted to freeze.

3-2-D-2-13-4 Steam Curing

Precast concrete members shall be cured for not less than seven (7) days by water or by steam curing, at the option of the Contractor. Steam curing for precast members shall conform to the following provisions:

After placement of the concrete, members shall be held for a minimum four (4) hours presteaming period. If the ambient air temperature is below ten (10) degrees Celsius, steam shall be applied during the presteaming period to hold the air surrounding the member at a temperature between ten (10) degrees and thirty-two (32) degrees Celsius.

To prevent moisture loss on exposed surfaces during the presteaming period, members shall be covered as soon as possible after casting or the exposed surfaces shall be kept wet by fog spray or wet blankets.

Enclosures for steam curing shall allow free circulation of steam about the member and shall be constructed to contain the live steam with a minimum moisture loss. The use of tarpaulins or similar flexible covers will be permitted, provided they are kept in good repair and secured in such a manner to prevent the loss of steam and moisture.

Steam at the jets shall be low pressure and in a saturated condition. Steam jets shall not impinge directly on the concrete, test cylinders, or forms. During application of the steam, the temperature rise within the enclosure shall not exceed five (5) degrees C per hour. The curing temperature throughout the enclosure shall not exceed sixty-five (65) degrees C and shall be maintained at a constant level for a sufficient time necessary to develop the required transfer strength. Control cylinders shall be covered to prevent moisture loss and shall be placed in a location where temperature is representative of the average temperature of the enclosure.

Temperature recording devices that will provide an accurate continuous permanent record of the curing temperature shall be provided. A minimum of one temperature recording device per sixty (60) meters of continuous bed length will be required for checking temperature.

Members in pretension beds shall be detensioned immediately after the termination of steam curing while the concrete and forms are still warm or the temperature under the enclosure shall be maintained over fifteen (15) degrees C until the stress is transferred to the concrete.

Curing of precast concrete will be considered complete after termination of the steam curing cycle.

All newly placed concrete for precast concrete piles, both conventionally reinforced and prestressed, shall be cured by steam as provided above except that piles with a designation of "Corrosion Resistant" shall be kept continuously wet for their entire length for a period of not less than seven (7) days including the holding and steam curing periods.

3-2-D-2-14 Making Good

The cement mortar used in filling recesses in the concrete formed by hobbins in connection with formwork shall contain an approved expanding admixture.

3-2-E PRECAST CONCRETE

3-2-E-1 PRECAST CONCRETE

This section includes the work for furnishing and installing precast concrete structures. Reinforcement shall be in accordance with detail shown on plans.

Precast concrete units shall be manufactured with air-entrained concrete. The maximum size of aggregate shall be 1.9 cm. The minimum cement content shall be 350 kilograms of cement per cubic meter of concrete. The final finish surface shall be smooth. Precast units shall be true to line, plane and dimensions in accordance with the following special requirements:

3-2-E-1-1 Plant Requirements

The units shall be manufactured in an approved area or enclosed building under the Engineer's control and inspection with guaranteed provision to meet the requirements for curing and protecting the concrete as specified.

3-2-E-1-2 Forms

Metal of tight rigid construction, true to shape, and with smooth finish shall be used.

The forms shall be oiled in any approved manner. Re-use of old, worn, or misshapen forms, will not be allowed.

3-2-E-1-3 Vibration

Vibrators shall be provided and used as directed by the Engineer. Prolonged vibration shall be avoided in order to prevent surface finish susceptible to crazing. Units showing surface checking or crazing will be rejected.

3-2-E-1-4 Protection And Curing

The units shall be cured either by steam or water for a sufficient length of time for the concrete to obtain the minimum compressive strength.

3-2-E-1-4-1 Steam Curing

Two to four hours after the concrete has been placed and attained the initial set, the first application of steam shall be made. Forms shall be removed after the units have been steam cured for 24 hours.

The steam shall be at 100% relative humidity to provide moisture for proper hydration of cement. The steam shall be directly applied onto the concrete. During application of steam the

ambient temperature shall increase at the rate not to exceed 4.4° C per hour until a minimum temperature of 54° C is reached.

When discontinuing the steam application, the ambient temperature shall be decreased at the rate of 4.4° C per hour until a temperature of -6.7° C above the atmospheric temperature has been attained. The concrete shall not be exposed to temperature below freezing for a minimum of 6 days after casting.

3-2-E-1-4-2 Water Curing

The units may be water cured with water, saturated material or other acceptable or approved methods that will keep the units moist for a period of 5 days. Under no condition will the use of curing compounds be permitted.

Concrete delivered in outside temperature lower than 4.4° C shall arrive at work having a temperature not less than 15.6° C nor greater than 32.2° C. Water and aggregates shall be heated if necessary but the water shall not be heated above 60° C. The use of direct heating torch in mixer shall not be approved.

3-2-E-1-4-2-1 Testing and Sampling

Representative test specimens of the concrete shall be taken by the Engineer. No precast units will be shipped to the project until the test specimen cured show a compressive strength equal or superior to the concrete type required strength.

3-2-E-1-4-2-2 Inspection

All precast units shall be subject to inspection at the point of manufacture and any units showing defects or damage before the completion of the project shall be removed and replaced at the expense of the Contractor.

3-2-F SAMPLING & TESTING

3-2-F-1 GENERAL REQUIREMENTS

3-2-F-1-1 Sampling & Testing

All concrete, aggregate, cement and water shall be sampled and tested during construction as frequently as deemed necessary by the Engineer. All test samples shall be supplied by the Contractor at his expense. Samples shall be obtained in accordance with AASHTO T 23, T 141, T 2, T 127 and T 26. All costs connected with manufacturer's Certificates of Guarantee, laboratory analysis and all subsequent testing for material acceptance shall be borne by the Contractor

The Contractor shall provide on the Site equipment, staff and labor for carrying out the sampling and testing and he shall carry out any or all of these tests at such times and with such frequency as may be requested by the Engineer.

All equipment shall be calibrated and checked from time to time as the Engineer may require.

The Contractor shall provide all samples required by the Engineer. Those samples to be tested in an off site laboratory shall be carefully forwarded by the Contractor to an approved laboratory. Results of laboratory and site tests shall be kept on site and copies of all test reports shall be forwarded in duplicate to the Engineer.

Frequency of tests and the number of samples required will be governed by the results of the previous tests the quality of the materials revealed during the tests and the uniformity of that quality. Should it become evident that the quality of concrete is deteriorating the Engineer may require additional samples to be taken and test cylinders to be made and tested to determine the cause.

3-2-F-1-2 Quality Control

Compliance with the specified characteristic strength shall be based on tests on cylinders at an age of 28 days. For major structures the frequency of sampling shall be initially three samples taken each day for five days of concreting and thereafter at a frequency of one sample per 10m³ of concrete but not less than one sample for each day concreting.

For minor structures the frequency of sampling shall be one sample per 20 m³ but not less than one sample for each day concreting. For mass concrete works and concrete works at pipeline appurtenances sampling shall be at on average of one sample per 50 m³.

A minimum of 3 test cylindres shall be made from each sample.

Where materials are of an unfamiliar grading or type, or where directed by the Engineer compression tests shall be carried out at 7 days and adjustments made in advance of the main control methods outlined above.

Cylinders test results will be examined individually in 10 consecutive sets of four and the standard deviation and mean strength of each set calculated. The concrete mix proportions will only be acceptable if all of the following requirements are complied with :

i. Not more than two results in 40 are less than the characteristic crushing strength.

ii. No value of the average for any set of four results is less than the characteristic strength plus one-half of the design margin.

iii. When 40 results have been obtained and the mean strength and standard deviation are calculated, the mean strength minus 1.64 times the standard deviation shall be greater than the characteristic strength.

Where the results do not conform to the above requirements the following action shall be taken :

Adjustments to the mix shall be made to obtain the strength required.

In the case where any result is less than 80° of the characteristic strength, the structural implications shall be considered and action taken as ordered by the Engineer.

For those Prescribed Mixes required to be tested, requirements (i) and (ii) only still be applicable.

3-2-F-1-3 Concrete Compression Tests

The Engineer will make and cure the cylinders from concrete as mixed for the work, which will be tested in accordance with AASHTO T 22 after seven (7) and twenty-eight (28) days. Test specimens shall be made and cured in accordance with AASHTO T 23. These specimens will be the basis for acceptance of the concrete in the structure.

They also provide means for checking the adequacy for laboratory mixture proportions for strength. If the average of the strength tests of the specimens falls below the minimum allowable compressive strength at seven (7) or twenty-eight (28) days, the concrete mix shall be redesigned. In the determination of the average compressive strength of the specimens, no cylinder specimen shall have a strength less than eighty-five (85) percent of the allowable strength.

The Engineer will take a total of four (4) cylinders from each day's run of concrete at each structure site. Two (2) cylinders will be for the seven (7) day test and two (2) cylinders for the twenty-eight (28) day test. All four (4) specimens are to be taken from the same batch. The Contractor shall give the Engineer full cooperation and, when requested by the Engineer, labor assistance in preparing the cylinders. When directed by the Engineer, the Contractor shall transport the cylinders from the structure site to the laboratory.

The Engineer may make additional test cylinders to ascertain the effectiveness of the methods by which the structure is being cured and also to determine when the structure may be placed in service. These cylinders shall be cured in the field in the same manner as the concrete placed in the structure, and the Contractor shall protect the cylinders from all damage.

The Contractor shall take every precaution to prevent injury to the test cylinders during handling, transporting and storing. He will be held solely responsible for any test failures caused by improper handling and transportation, or any other cause which may be detrimental to the test cylinder.

In order that the test cylinders may be transported from field to laboratory undamaged, the Contractor shall provide a minimum of two (2) approved metal boxes. [One (1) for the Contractor's use and one (1) for the Engineer's use.] Boxes shall be of such size to receive a minimum of six *(6)* test cylinders and leave space for sawdust packing around all surfaces of the cylinders. Boxes shall be approved by the Engineer. The Contractor shall, when directed by

the Engineer, provide as many additional boxes as may be required by the remoteness and/or magnitude of the concrete work.

When test cylinders fail to meet minimum strength requirements, the Engineer may require core samples to be taken to determine the acceptability of such structures. The contractor shall, at his own expense, furnish all equipment required for such core samples.

3-2-F-1-4 Loading Tests

The Engineer may permit that a loading test be made on the works or any part thereof for one or more of the following reasons:

Failure of "Site Cylinders" to attain the strength requirements.

Premature removal of formwork.

Overloading of structure during construction.

Improper compaction and/or curing of concrete.

Any other circumstances attributable to alleged negligence on the part of the Contractor, which, in the opinion of the Engineer, may result in a structure being of less than the required strength.

If the results of the test are not satisfactory, the Engineer will direct that the part of the work concerned be taken down or removed and reconstructed to comply with the Specification, or that such other remedial measures as he may think fit be taken to make the work acceptable.

The Engineer may instruct the Contractor to take out cylindrical core specimens from the structures concerned and have them tested. The cutting equipment and the method of doing the work shall be to the Engineer's approval. The specimens shall be dealt with in accordance with BS 1881. Prior to testing, the specimens shall be available for examination by the Engineer.

3-2-G WATER RETAINING STRUCTURES-SPECIAL CLAUSES

The design, detailing materials and workmanship shall comply with the requirements of BS 8007.

3-2-G-1 MAKING GOOD

The cement mortar used in filling recesses in the concrete formed by bobbins in connection with formwork shall contain an approved expanding admixture.

3-2-G-2 CONSTRUCTION JOINTS IN WATER RETAINING STRUCTURES

Waterstop not less than 150 mm wide shall be built into all construction joints in external walls and construction. Construction joints shall only be formed at positions approved by the Engineer.

3-2-G-3 WATERTIGHTNESS OF STRUCTURES

The Contractor shall be responsible for the watertightness of structures and any remedial measures necessary. Where detailed on the Drawings the surfaces of concrete shall be coated with a waterproof coating.

In the event that a structure designed and specified to be water retaining fails to satisfy the watertightness tests, the Contractor shall undertake such remedial works as are necessary and are approved by the Engineer. In certain situations the Engineer may permit the provision of an internal waterproofing coating in compliance with the specification. Where such a coating is permitted it shall be applied to the whole of the internal water retaining face.

3-2-G-4 WATERPROOF COATINGS

Waterproof coatings shall be applied only where shown in the drawings or where instructed by the Engineer.

Coating shall be chloride free and suitable for contact with potable water (in case of potable water retaining structure) and sulfate resistant in case of wastewater retaining structure.

The system shall be applied in accordance with the manufacturer's recommendations. Prior to application, the surfaces shall be prepared and all cracks, porous patches and generally defective areas shall be cut-out and made good.

The system shall provide a waterproof coating without impeding the breathing of the structure.

Expansion joints shall be formed in the waterproofing system by the use of compatible sealants as recommended by the manufacturer.

The system shall be cured for a period of not less than 7 days.

3-2-G-5 HYDROPHILLIC RUBBER SEALER

Hydrophillic rubber sealer shall be co-extruded from chloroprene and hydrophillic rubbers into a cellular strip approximately 25 mm x 7 mm thick which expands as it absorbs water. The strip shall incorporate an expansion delay coating to prevent activation during setting of the surrounding concrete.

Hydrophillic rubber sealer could be applied to the perimeter of all pipes to be built into concrete structures to existing concrete walls and slabs at or below water levels which have been demolished and require extension, and to other locations as indicated on the Drawings.

The strip sealer shall be bonded to the pipe diameter or on to the face of demolished structures on to which new concrete is to be placed so as to be at least l00 mm from the wall surface. Where dowel bars are incorporated in bonding new concrete to old, the sealer shall be placed above the dowel bars on the "wet" side of the structure. Bonding shall be accomplished using proprietary neoprene or epoxy adhesives to ensure the sealer is not disturbed during placement of the concrete.

The application shall be in accordance with the manufacturer's recommendations.

3-2-H DEMOLITION & REMOVAL

3-2-H-1 DESCRIPTION

This work shall consist of the complete demolition and removal of a whole, not partial, structural concrete and miscellaneous concrete structures as indicated on the plans or as ordered by the Engineer. All demolition material shall be removed from the work site to approved dumping site.

3-2-H-2 DEMOLITION DETAILS

Care shall be exercised in the demolition so as not to damage neighboring structures designated to remain in place.

3-2-H-3 STRUCTURAL CONCRETE REMOVAL

3-2-H-3-1 Description

This work shall consist of the removal of a section or segment from a structural concrete elements and other concrete removal indicated on the Plans or ordered by the Engineer. All removed material shall be removed from the work site to approved dumping sites.

3-2-H-3-1-1 Removal Of Structural Concrete

All concrete shall be removed to a pay line shown on the Plans or to sound surface as determined by the Engineer. Reinforcing bars and miscellaneous material shall be removed as part of this work unless the Plans or the Engineer specifically direct otherwise. Surfaces from which structural concrete has been removed shall be cleaned, except that surfaces not designated to come in contact with new concrete placements need not be cleaned.

Chipping hammers shall weigh no more than 20 kg with the bit and muffler removed. The hammer shall deliver no more than 1600 blows per minute. The Contractor shall provide the Engineer information from the hammer manufacturer that these requirements are not exceeded. The air pressure used to power the hammer shall not exceed 759 KPa measured at the air compressor. An air pressure gauge in proper working condition shall be provided. Only sharp chisel point bits shall be used. All bits determined by the Engineer to be dull shall be sharpened or replaced. If the Engineer determines that the Contractor's operations are resulting in damage to concrete that is to remain, the Contractor shall make immediate corrections. These corrections shall include the use of a lighter chipping hammer if so ordered by the Engineer.

3-2-H-3-1-2 Materials

Materials used in this work shall conform to the following requirements:

Sandblasting Sand: No. 40 Boiler Slag Grit or

No. 2 Sandblast Sand

3-2-H-3-1-3 Construction Details

General care shall be exercised in removing concrete so as not to damage material designated to remain in place. Reinforcement designated to remain in place shall be cleaned in a manner satisfactory to the Engineer. Saw cutting of concrete shall be performed only where indicated on the Plans or where ordered by the Engineer.

All concrete surfaces which require cleaning, after the concrete removal has been performed, shall be thoroughly sandblast cleaned, or abraded by other mechanical means satisfactory to the Engineer. After blast cleaning, the surface shall be air blown or vacuum cleaned. Air-blowing may be used on vertical or overhead surfaces. Vacuum cleaning will be required for all other surfaces.

For any structural concrete removal item, where a hammer size limitation is specified on the Plans or in the Specifications, the Engineer may order the Contractor to use a lighter hammer than that specified, if, in his opinion, the hammer being used is destroying concrete that should remain.

3-2-I CONCRETE GROUTING MATERIAL

3-2-I-1 SCOPE

This specification covers a grouting material for use in grouting anchor bolts, dowels and other miscellaneous items in concrete.

3-2-I-2 GENERAL

The material shall be a non-metallic, non-shrink grout which, when mixed with water, will harden rapidly to produce a permanent anchoring bond. It shall contain no metals nor rust or corrosion promoting agents. The color shall be light gray matching approximately the color of hardened concrete.

3-2-I-3 MATERIAL REQUIREMENTS

The material when prepared in accordance with the manufacturer's instructions shall be of a tolerable consistency. It shall also have the following properties:

The material shall exhibit no shrinkage on setting but may exhibit slight expansion of no more than 0.40%.

Compressive strength - Two-inch cubes of this material when cured as shown shall have the following minimum compressive strengths:

Cure	**Strength**
24 hour air cure @ 23° C	27.6 MPa/Min.
7 day air cure @ 23° C	41.4 MPa/Min.
7 day air, 10 day water submersion	41.4 MPa/Min.
7 day air, 24 hour, 10% NaCl solution submersion, 25 cycles freeze-thaw	41.4 MPa/Min.

The material shall have a minimum initial set of 30 minutes.

Pull-out strength - T15 concrete reinforcement bar grouted 15 cm deep in 2.2 cm hole in saturated surface dried concrete shall have a pull-out strength of 4500 kg.

The material shall contain not more than 0.05% chlorides or 5% sulfates. The material shall withstand 25 cycles of freeze-thaw (10% NaCl) with a maximum loss of 4%.

3-2-J REHABILITATION OF RESERVOIRS

3-2-J-1 DESCRIPTION

The following specifications include procedures, materials and workmanship for the rehabilitation of existing reservoirs. Rehabilitation works will include, but will not be limited to structural repairs and general building rehabilitation. Repair works may include the following:

- Repairs to cracked concrete.
- Sealing joints and cracks to prevent leakage.
- Sealing of pipe penetrations including replacement of some pipes.
- Repairs to damaged concrete.
- Repairs and replacement of corroded reinforcement.
- Removal and replacement of plaster and rendering.
- Major structural demolition and reconstruction.
- Internal and external tanking and waterproofing.
- Earthworks.
- Replacement of miscellaneous metalwork, access ladder covers and the like.
- Painting.
- Cleaning and general restoration.

The procedure for the rehabilitation of reservoirs shall be for the Contractor to first undertake an initial Site Survey. This survey will determine the general nature and condition of the site, the structure, pipework and ancillaries. Based upon the results of this survey, the Engineer together with the Contractor shall plan and undertake a detailed structural inspection/survey. This detailed survey will identify the extent and nature of any defects which in the opinion of the Engineer needs to be rehabilitated or repaired. The Engineer will instruct the Contractor as to the extent and method of rehabilitation or repair to be implemented. In the case of major defects, the Engineer may instruct the demolition and reconstruction of the structure either in whole or in part.

Only structural repairs are defined beneath for reservoirs.

3-2-J-2 SITE SURVEY

The Contractor shall record the existing conditions of the site, the structure and its associated equipment and shall produce dimensioned drawings of the structure comprising plans and sections at a scale of not less than 1:100 and dimensioned plans and layouts of any existing mechanical and ancillaries.

The drawings and condition survey shall be supported by photographs and shall be submitted to the Engineer for approval within 10 days of the survey. The cost of this work is considered to be included in the unit rates of the bill of quantities.

3-2-J-3 STRUCTURAL SURVEY

The Engineer together with the Contractor's engineer accompanied by adequate support staff shall inspect the structure to assess its condition and determine the scope of the rehabilitation work. The survey shall include a cover meter survey and rebound hammer survey of concrete surfaces.

Structural surveys may need to be undertaken in stages involving a number of visits by the Engineer and Contractor. The scope of work may be amended by the Engineer, as necessary, to incorporate the findings of the surveys.

To facilitate the structural surveys it may be necessary to remove existing plastering and rendering, clean the structure, excavate to expose buried surfaces, provide temporary accesses and scaffolding, and carry out water tightness testing or other preparatory work. The preparatory work to be undertaken will be instructed by the Engineer after receipt from the site survey. Further instructions may be issued by the Engineer during the course of the detailed survey and the rehabilitation works. The cost of this work is considered to be included in the unit rates of the bill of quantities.

3-2-J-3-1 Cover Meter Survey

Cover meter surveys shall be carried out using normal methods and equipment. On plane members the direction of reinforcement with least cover shall be determined. The cover meter head shall he moved across the surface of the concrete along a line in a direction perpendicular to the direction of reinforcement with least cover and with the head oriented in the direction which enables the cover to that reinforcement to be measured. The lines along which the cover meter head is moved shall be approximately 500 mm apart. The cost of this work is considered to be included in the unit rates of the bill of quantities.

3-2-J-3-2 Rebound Hammer Survey

Rebound hammer for testing the hardness of concrete shall be carried out in accordance with International codes and standards as instructed by the Engineer. The cost of this work is considered to be included in the unit rates of the bill of quantities.

3-2-J-4 ACCESS

The contractor shall provide suitable and safe means of gaining access to all repair areas to enable the works to be carried out and the Engineer to carry out surveys inspections.

3-2-J-5 CONTRACTOR'S METHOD STATEMENT

Prior to commencing rehabilitation the contractor shall submit for approval a detailed method statement which shall include.

- A program detailing the proposed sequence and duration of each item of work.

- Details of any necessary disruption to the operation of the works and the contractor's proposed methods of providing any temporary service.
- Details of all detailed method statements.
- Details of all materials to be used in the rehabilitation works together with all necessary technical documents, catalogues and samples.
- Descriptions of any items including pipework, mechanical and miscellaneous work related to rehabilitation including proposed schedule of design, procurement and delivery.

The cost of the preparation of the method statement for reservoirs rehabilitation should be considered to be included in the unit rates of the bill of quantities.

3-2-J-6 CONCRETE REMOVAL

3-2-J-6-1 General

Where existing concrete is to cut out it shall be removed over the areas defined by the Engineer. The contractor shall ensure that the cutting out is done in such a manner so as not to cause permanent damage to the surrounding structure.

Where practicable, concrete shall be removed by disc cutting, grinding or similar cutting methods and not by percussive tools.

Where percussive methods are approved by the Engineer, the size and power of tool shall be the minimum appropriate.

Before removing any concrete the Contractor shall provide and erect any temporary propping necessary to ensure the safety of the structure.

The Contractor shall be liable for making good of his own expense any damage arising from cutting out.

Where concrete is to be removed the surface of the concrete over the area to be removed, shall be cut by a grid of straight lines using a disc cutter or similar and the concrete removed by chiseling or by percussive tools.

3-2-J-6-2 Removal of Unsound Concrete

1. Removal for concrete replacement. The minimum depth of removal shall be the greater of the following :
   a. A depth no less than 1cm and not greater than the distance from the rearmost point of exposed reinforcement to sound concrete.
   b. The depth necessary to reach sound concrete.

Should the removal depth exceed 15 cm, the Project manager may order supplementary anchoring as part of the replacement procedure. The sides of the cavity shall be made at a slight angle, so that the width of the base of the cavity is greater than the opening at the surface, thereby providing a key.

2. Removal for patching material replacement. Feather edges shall not be permitted. The minimum patch depth shall be 1 cm as measured from the theoretical plane of the original concrete surface.

3-2-J-6-3 Corroding Reinforcement

Where the reinforcement bars are corroded, concrete shall be removed to a depth of 25mm behind and along the actively corroding bars until a continuous length of 50 mm of bar which is free from active corrosion is exposed.

The Contractor may be directed by the Engineer to supplement or replace the existing bars with new bars. Bars to be replaced shall be cut out and not removed by burning.

Replacement reinforcement shall be adequately fixed and tied in position such that it will not be displaced during the subsequent reinstatement works.

Where corroding reinforcing bars are to be retained they shall be brushed and cleaned by grit blasting or other method approved by the Engineer and submitted by the Contractor. Cleaning shall be carried out in such a way to include the hidden faces at the backs of bars and at the intersection of bars. Abrasives shall be new, clean and dry and of a grade suitable for the preparation of steel to the qualification required above. The exposed reinforcement shall be thoroughly washed down with clean water.

3-2-J-6-4 Surface Cleaning

Cleaning of structures shall be undertaken to remove all dirt or other contaminants, previous coatings, paint, moss, plant growth and the like, as directed by the Engineer. Cleaning shall be by methods that cause no damage to the existing structure. The Engineer may instruct a change in the method if the method adopted causes damage to the surface or is otherwise unsuitable or ineffective.

Where instructed by the Engineer cleaning shall be by:

a. Grit blasting (wet, dry or vacuum blasting).

b. High pressure water jetting, steam cleaning employing wax free detergents together with power scrubbing as necessary.

Before cleaning begins, the contractor shall remove all surface attachments from the areas to be cleaned or from positions that obstruct access. Unless otherwise directed. All inserts and fixings which have been cast in or mortared into pockets or otherwise attached to the concrete shall be protected or removed from the area to be cleaned.

Before cleaning commences, trials shall be carried out on areas at typical locations to the approval of the Engineer.

3-2-J-6-5 Reinforcement Protective Treatment

Where directed by the Engineer reinforcement shall be coated with a polymer modified cement based primer or slurry coat prior to reinstatement of the concrete. All exposed surfaces of the bars shall be coated with the primer within 3 hours of cleaning. Any reinforcement remaining uncoated at the end of a 3 hours period shall be recleaned.

3-2-J-7 CONCRETE REPAIR METHODS

Defective concrete shall be cut out and reinstated by either a proprietary repair method or in the case of large volumes, by recasting with new concrete. Any defective or corroded reinforcement will either be cleaned and protected by a corrosion protection system or replaced.

Concrete repair methods shall include, but shall not be limited to, the following:

- Hand application of resin based mortars
- Hand application of cementitious mortars.
- Sprayed concrete and mortar
- Recasting with concrete

The Contractor will determine and submit to the Engineer the extent of the concrete to be removed and will select the appropriate repair method and material of repair depending upon the nature and extent of the defect. Repair methods and materials of repair shall be submitted to the Engineer's approval.

In general hand applied resin based mortars and cementitious mortars will be used for patch repairs to areas of less then 0.5 m² and depths less then 100 mm. Re-casting into formwork will be used for the reinstatement of large volumes and sprayed concrete (Gunite) will be used to cover large areas.

3-2-J-8 REINSTATEMENT OF CONCRETE

3-2-J-8-1 General

Prior to placing repair materials in any section of the works, all profile guides, formwork and reinforcement shall be fully fixed and cleaned over the entire area of the proposed repair. All dust, debris and loose material shall be removed from the area of the repair.

Plant and tools used for mixing, transportation and spraying of repair materials shall be kept clean and free from accumulated deposits of repair material.

Repair materials shall be mixed and applied in accordance with the manufacturer's recommendations as approved by the Engineer. The entire contents of a pack (or any other type of container) shall be mixed at one time.

Transportation of the repair materials to the point of application shall be such as to prevent contamination, segregation or loss of fine constituent materials.

Repair materials shall be placed in position in as short time as possible after mixing and within times stated in the manufacturer s recommendations. The repair material shall be placed in layers not exceeding those recommended by the manufacturer and approved by the Engineer.

Repairs shall not proceed if the air temperature or concrete substrate temperature is 5°C or less, or such higher temperature as may be recommended by the manufacturer and shall cease if the air temperatures falls below this minimum.

Repair may proceed at low temperatures if specific planned and approved procedures are implemented. These may include:

a. Provision of heated tenting which envelopes the repair area and produces an environment with a sustainable air temperature in excess of the minimum.

b. Where approved by the manufacturer warming materials and the substrate to a temperature above 5°C. The method of warming shall be such that the materials are not damaged and are not caused to dry out in the case of cement based repair materials.

c. Insulating the completed or partially completed repairs in accordance with good practice for winter concreting.

In general the concrete reinstatement patching shall be done as follows:

1- Horizontal or essentially horizontal locations. Concrete or approved patching material shall be used. Class A concrete shall be placed only at locations where removal depths average out greater than 8 cm. Patching material shall be placed only at locations where removal depths average out less than 8 cm. Average depths shall be determined by a measurement procedure acceptable to the Engineer.

2- Vertical or essentially vertical locations. Concrete or approved patching material shall be used. Concrete shall be restricted to the depth limitations noted for horizontal locations. Average depths shall be determined by a measurement procedure acceptable to the Engineer.

3- Overhead. Approved patching material shall be used. Lift thicknesses shall not exceed 2 cm, unless formwork or anchoring devices are employed.

3-2-J-8-2 Materials

Where the repair system comprises two or more materials the Contractor shall ensure that the repair materials are compatible and shall submit to the Engineer certificates provided by the manufacture confirming that the proposed repair materials are compatible.

Where possible repair materials, other than replacement concrete, shall be pre-batched.

All materials shall be mixed, applied and cured in accordance with the manufacturer's recommendations as approved by the Engineer or as otherwise instructed by the Engineer.

3-2-J-8-3 Formwork

Formwork necessary to reform arises, profiles, rebates, soffits, and the like shall be so constructed that it remains true to line and level under the loads and pressure imposed by the repair materials.

Formwork shall be struck without causing damage to the repair materials, and the contractor shall be responsible for determining the age at which the repair material attains a sufficient strength to support its self weight and any other loads which may be imposed thereon.

All profiled guides and formwork shall be coated and/or adequately treated such that they do not absorb water from the repair mortar and do not discolor/contaminate the repair mortar or surrounding concrete.

3-2-J-8-4 Epoxy Mortar

3-2-J-8-4-1 Description

Epoxy mortar is a blend of high strength aggregates bonded together with epoxy resin, designed for speedy and permanent repairs, to concrete. The mortar shall provide shrinkage-free hardening and abrasion and impact-resistance. The mixed material is applied to a suitably prepared and primed surface. It is supplied as a three pack material in pre-weighed quantities ready for on site mixing and use.

3-2-J-8-4-2 Preparation of Concrete Surface

The surface to be prepared will be sandblasted after which it will be thoroughly cleaned and dried prior to epoxy bonding course.

All grease, chemical contamination, dust, cement, laitance, and loose concrete must be removed by scrabbling or light bush hammering to provide a sound substratum.

3-2-J-8-4-3 Priming Surfaces

Surfaces to be repaired shall be primed with an epoxy primer. The epoxy mortar shall be applied when the primer starts to gel but is still tacky, normally between 30 minutes and one hour. If the concrete has absorbed the primer, or the primer has dried, a second primer coat should be applied.

3-2-J-8-4-4 Technical Properties

The contractor shall submit catalogues from manufacturers for approval of the Engineer. It shall conform to the following properties:

	NORMAL TYPE	**L.P. TYPE**
Compressive strength	70-80N/mm^2	50-60N/mm^2
Flexural Strength	20-25N/mm^2	15-20N/mm^2
Bond Strength to concrete	2-3N/ mm^2	2-3N/mm^2
Young's Modulus	27.000N/mm^2	27.000N/mm^2
Mixing Ratio	1 part epoxy to 3 parts silica sand	

where: Normal type : Have storage conditions above 0°C, max. 25°C.

L.P. type : Have storage conditions above 10°C, max. 35°C.

3-2-J-8-4-5 Application

The mixed material should be applied to the surface with a steel trowel, ensuring that it is pressed firmly into cracks to ensure positive adhesion. Epoxy coatings shall be kept dry and above 16°C.

3-2-J-8-4-6 Safety

For health and safety, the instruction of the epoxy manufacturer should be followed.

3-2-J-8-5 Epoxy Resin Bonding Agent

3-2-J-8-5-1 Description

Epoxy resin bonding agent is a solvent-free bonding agent, based on selected epoxy resins. After application to old concrete surfaces, it shall provide a perfect bond for new concrete. It is supplied as a two component bonding agent ready for mixing with a slow speed electric drill.

3-2-J-8-5-2 Preparation of Concrete Surface

All surfaces must be clean, free from standing water and all loosely adhering particles. Cement laitance must be removed and the surfaces to be treated must be roughened.

3-2-J-8-5-3 Technical Properties

The contractor shall submit catalogues from manufacturers for approval of the Engineer. It shall conform to the following properties:

- Compressive Strength 60-70N/mm^2
- Flexural Strength 30-35N/mm^2
- Tensile Strength 8-20N/mm^2
- Bond Strength to Concrete 2.5-3N/mm^2 (concrete failure)

3-2-J-8-5-4 Application

The mixed material should be applied to the surface by brush, roller or spray, ensuring that it is well brushed in on damp surfaces. New concrete should be poured within specified time when the material is still tacky.

3-2-J-8-5-5 Safety

For health and safety, the instruction of the epoxy manufacturer should be followed.

3-2-J-8-6 Cementitious Mortars.

Cementitious mortars shall be high strength polymer rich proprietary products which produce a dense durable mortar that exhibit minimum shrinkage on drying.

The polymer shall be acrylic, styrene-butadiene rubber or similar polymer which is durable in damp or wet conditions.

Cement shall comply with the Specifications except that cement to BS4027 shall not be used.

The mortar shall exhibit high bond strength and excellent adhesion and shall be free of chloride compounds.

The total chloride content of the mortar arising from the cement, aggregate and any other source shall not exceed 0.1% of chloride ion by mass of cement. The chloride content of the cement shall be determined in accordance with BS EN 196-21 and that of the aggregate in accordance with BS S 12: Part 1 17. The use of calcium chloride is prohibited.

It shall be non toxic suitable for contact with drinking water and it shall demonstrate excellent resistance to long term water immersion.

The minimum strength properties measured in accordance with BS 6319 at 28 days shall be as follows:

Compressive Strength	50 N/mm^2
Tensile Strength	5 N/mm^2
Flexural Strength	10 N/mm^2

3-2-J-8-7 Sprayed Concrete

Sprayed concrete shall be microconcrete (Gunite) material.

The material shall be a proprietary pre-batched microconcrete supplied by a manufacturer who operates quality assurance procedures approved by the Engineer. It shall be cementitious with graded non-reactive aggregate modified with polymer. super plasticisers and silica fume and pre-bagged in the required proportions. Only water shall be added to the mix on site.

The water cement ratio shall not be less than 0.32 or greater than 0.45 and shall comply with the manufacturer's instructions.

The proportion of silica fume shall not exceed 10% by mass of cement.

The total chloride content shall not exceed 0.1% mass of cement. Calcium chloride or admixtures containing chloride salts shall not be used. The chloride content of the constituents of the mix shall be determined as follows:

– Cement	- BS EN 196-21
– Aggregate	- BS 812: Part 117
– Admixtures	- BS 5057: Part l

Maximum aggregate size shall be 3 mm.

There shall be no expansion agents contained in or added to the repair material.

The material shall exhibit excellent adhesion to the existing concrete and shall exhibit low shrinkage.

It shall have low water absorption and shall demonstrate excellent resistance to long term water immersion.

The minimum strength properties at 28 days shall be as follows:

Compressive strength	45 N/mm^2
Flexural strength	10 N/mm^2
Adhesive Strength	3 N/mm^2

There shall be no change in source or type of material. manufacturer supply, mix proportions or method of mixing without the approval of the Engineer. Such approval will only be given after further site trials have been carried out to the satisfaction of the Engineer.

3-2-J-8-8 Concrete

Concrete used in recasting shall comply with the specification to give a 28 day characteristic strength of 35 N/mm^2.

Approved water reducing additives, superplasticizers, accelerators, may be used subject to satisfactory testing and the Engineer's approval.

3-2-J-8-8-1 Priming

Concrete surfaces within the repair area shall be treated with a suitable bonding aid or primer which is compatible with the repair material.

Priming coats or bonding aids shall be thoroughly worked into all hollows and crevices in the prepared surface and around the reinforcement if required.

If at any time the primer or bonding aid completely dries out before over-laying, the repair surface shall be re-prepared generally by complete removal of the dried primer or bonding aid or as specified by the manufacturer of the repair materials.

When using cementitious based repair mortars the concrete substrate shall be thoroughly wetted to obtain a saturated surface dry condition. Any surplus water shall be remoisted before reinstatement begins.

3-2-J-8-8-2 Filling Resin Based and Cementitious Mortar

Mortars shall be applied in self supporting layers and in any case not exceeding the thickness specified by the manufacturer of the mortar.

Each layer shall be thoroughly worked and compacted into the repair zone and around or between reinforcing bars. The technique employed shall ensure that no air is entrapped and that full contact with the primed substrate is achieved.

Successive layers shall be applied as soon as the preceding coat has become sufficiently stiff to support the weight of the additional build-up layer but is still adequately tacky to provide bonding. The time between layers shall be in accordance with manufacturer's recommendations. If sagging occurs the material shall be completely removed and reapplied at a reduced thickness.

If at any time the last layer applied completely dries out before over-laying, the surface shall be prepared according to the manufacturer's recommendations.

The final build-up layer within a repair shall not be less than 10 mm thick and shall be leveled off or profiled to produce a smooth finish.

The repair shall be cured by the method and for the period recommended by the manufacturer of the repair system. During this period the temperature of the material shall not be allowed to drop below the minimum specified by the manufacturer and the repair shall be shaded from direct sunlight. Curing membranes shall only be permitted where they are recommended by the manufacturer.

3-2-J-8-8-3 Filling Sprayed Concrete

Delivery equipment shall be demonstrated to the satisfaction of the Engineer in site trials. The equipment shall deliver a conical uniform discharge stream of uniformly mixed material at the proper velocity from the discharge nozzle at all heights of the work.

Once placed, the applied material shall be capable of being profiled and steel trowel finished to a high standard without detrimental effects.

3-2-J-9 SPECIFIC WORKS

3-2-J-9-1 Crack Repairs

Cracks requiring repair shall be categorized by the Engineer as follows:

- Live cracks.
- Major cracks.
- Stable structural cracks.

- **Repair of Live cracks**

Live cracks shall be chased out using a grinding machine to a minimum depth of 30mm and width of 15 mm.

The rebate shall be cleaned of loose material, primed and filled with a gun applied polyurethane sealant onto a debonding tape within the rebate.

- **Repair of Major Cracks**

Cracks classified by the Engineer as major live cracks shall be repaired by cutting out and subsequent restatement of the concrete.

Reinstatement shall be in accordance with the Engineer s instructions. A joint bridging strip shall be applied over the crack where instructed by the Engineer.

Where the Engineer instructs the concrete shall be cut out over sufficient width and depth to enable examination and any repairs to the reinforcement.

- **Repair of Stable Structural Cracks**

Stable structural cracks shall be filled with proprietary materials applied by pressure injection such that the crack is completely sealed.

Materials shall be polyurethane resin, epoxy resin or liquid silicate. Polyurethane foam may be used as directed by the Engineer for crack sealing in wet conditions.

The material shall exhibit low viscosity and good adhesion to dry or moist concrete. On curing, the material shall form a hard mass impermeable to water.

3-2-J-9-2 Repair around pipe penetrations

Leaks around pipe penetrations, shall be repaired as follows:

1. Where pipes are in good condition the contractor shall chase out a 20 x 20 mm rebate around the pipe and fill the rebate with gun application of elastomeric polyurethane mastic sealant and provision of a butyl flashing ring.
2. Where pipes must be removed and new pipes installed the contractor shall break out and remove the existing pipe. The new pipe shall be installed complete with a puddle flange, and concrete shall be placed from both sides of the wall. The contractor shall ensure a good bond will he formed between old and new concrete.

3-2-J-9-3 Repair of leaking joints and Cracks

Repairs to leaking joints and cracks shall where directed by the Engineer be made on the internal water face using a proprietary joint bridging strip, with a minimum thickness of 2 mm and made of an inert flexible strip such as Hypalon (By Dupont) or equivalent material.

The adhesive shall be an epoxy resin compatible with the concrete and the flexible strips suitable for use in damp conditions. Full contact between the flexible strip and the concrete shall be ensured by means of a roller.

Surface preparation shall be by grit blasting or other approval method to remove all laitence and in accordance with the manufacturer’s requirements.

3-2-J-9-4 Refurbishment of Roof Structures

Where directed by the Engineer, all existing internal and external roof screeding, rendering and debris shall be removed from the roof and any defective concrete repaired.

The installation of new waterproofing memebrane, thermal insulation and concrete protection of the roof of the reservoir shall be done if required by the Engineer and with the same material used for new reservoirs and described elsewhere.

3-2-K NEOPRENE PADS

3-2-K-1 GENERAL

Elastomeric supports must comply with the following criteria:

1. To be of simple design under normal execution procedures.
2. To permit:
    a. Horizontal displacement due to any cause,
    b. Rotation of the support due to bending under permanent loads, working loads and the effects of hydraulique shrinkage and thermal phenomena, without building liable stresses outside the elastomeric support.

The elastomeric support can fill all the substrate surface of the wearing walls /or/ only a part of this surface; the unoccupied surface. In this case must be filled by a compressible material to avoid the intrusion of concrete grout between the various elements of the elastomeric support.

3-2-K-2 MATERIAL AND APPLICATION

The elastomeric support is generally constituted by a non-hooped elastomeric polychloroprene (neoprene) which under various movements and loads will sustain deformation, transmitting to the underneath wearing walls, vertical and horizontal efforts.

3-2-K-2-1 Eveness Of The Wearing Substrate

The substrate wearing surface must be evened to avoid any accidental contact outside the designed contact surfaces; anyhow the wearing zones must be made horizontal.

The Contractor must furnish to the Engineer all necessary justifications concerning the elastomeric support and the procedures for the execution of the wearing surface.

3-2-K-2-2 Minimal Characteristics

The following minimal characteristics must be submitted by the Contractor for the Engineer's approval:

Maximal constraint which varies with the type of material used (around 30 bars /or/ 3 MPa for the non-hooped polychoroprene = neoprene)

Minimal constraint to be obtained and which is needed to respect the condition of non-slipping of the elastomeric support on its substrate (around 15 bars or 1.5 MPa for the non-hooped polychloroprene = neoprene)

This condition may result for the elastomeric support to have a maximal dimension implicating sometime the impossibility to design a continuous linear elastomeric support. Thus needing to consider the use of strips or pads of elastomeric material.

A continuous break of ties must be then insured between the pads by incorporating between the pads of neoprene of a compressible material (polystyrene type) and making the joints between pads and polystyrene water tight to avoid concrete grout intrusion.

3-2-K-2-3 Minimal Thickness Of The Elastomeric Support

The required thickness of the neoprene support shall depends on the loads, the amount of sliding and permissible rotations.

The Contractor shall submit technical certificate from the manufacturer to the Engineer allowing him to control and approve the chosen sizes and thickness of the elastomeric support.

The minimal thickness is conditioned by two factors:

The maximal distortion of the neoprene (α) which must not exceed $\alpha \leq 0.5$ radians.

The thickness must be large enough to permit rotation of the support avoiding contact in the maximum compression corner zones.

3-2-K-2-4 Determination Of The Horizontal Stresses

As an example, horizontal stresses may be controlled by the following formula (DTU.20.12)

$$H = G \times S \times \frac{U}{e}$$

e = thickness of the support

S = surface of the support in contact with the substrate

G = Transversal elasticity coefficient of the neoprene (around 0.8 to 1.3 MPa or 8 to 13 bars depending of the neoprene quality)

U = displacement

The admissible displacement (U) in relation with the thickness (e) can be first estimated as follows:

Thickness (mm) e =	5	10	15	20
Displacement (mm) U =	2.5	5	7.5	10

3-2-K-2-5 Other Approved Elastomeric Support

The elastomeric constituting the pad may be a mix vulcanised based on Ethylene - Propylene - Diene - Monomer (E.P.D.M) which has the following average characteristics:

A shore hardness of	60 ± 5
Specific weight	1.06 ± 0.02 g/ml
Ultimate resistance (rupture)	≥ 15.0 MPa
Maximum elongation (Rupture)	$\geq 400\%$

Tearing resistance	≥ 15.0 MPa
Permanent deformation after 24 hours at	70oC ≥ 20%
Module "G" of transversal elasticity	0.8 ± 0.1 MPa

3-2-K-2-6 Compression Sollicitation

The admissible load over an elastomeric linear pads support depends of the dimensions and number of elastomeric pads constituting the support.

The average admissible constraint on every single pad is obtained for example by using the following formula

average = $1.2 \times \beta \leq 5$ MPa

Where β (form factor) = $\frac{a \times b}{2xt(a+b)}$

t = thickness of the elastomeric support

a,b = dimensions (in plan) of the elastomeric support

3-2-K-2-7 Special Dispositions

In case the horizontal effort is greater than the value of friction of the interface between the elastomeric support and the substrate, the following dispositions must be taken by the Contractor:

If not otherwise specified by the Engineer the Contractor may stick the pads to avoid uncontrolled displacement when setting the different elements.

A special glue approved by the Engineer must be laid on the primed substrate and on the back side of the pad. After a maturation time, the pad shall be applied on the glued substrate with force.

3-2-K-3 SLIP MEMBRANE

This slip membrane is constituted generally

- A protection sheet
- A slip plate around 3mm thick
- A silicone lubrication or similar
- An elastomeric pad recovered with special slipping cover adhering to it.

This system fulfills most of the usual functions of elastomeric support as:

- Uniform distribution of vertical loads
- Horizontal displacement by slipping of the supported construction over it.

This system will permit under small thickness, wide horizontal displacement with minimum limitation of the horizontal stresses transmitted and after the displacement it does not exercise any underpinning stress on the construction at the contact interface.

The Contractor is asked to submit all technical specifications to the Engineer for approval before any purchase of the material.

3-2-L CONCRETE FLOOR FINISHING

3-2-L-1 GENERAL

Concrete floor finishing consists of a cast in place concrete slab, having the surface colored (optional) and imprinted with pattern (optional) and textured (optional).

The related works that the contractor should complete are as follow:

- Preparation work, including sub-grade preparation, finish grading, setting of forms and screeds, and furnishing of reinforcement.
- Provide and place all concrete
- Provide and apply color hardener
- Provide and apply imprinting tools in the proper pattern
- Grout imprinted joints.
- Outside edges of slabs shall be left uncolored except where indicated to be colored on drawings.

3-2-L-2 PRODUCTS AND MATERIALS

Concrete mix design:

The concrete shall have minimum compressive strength of:

- 4,000 psi in severe freeze-thaw areas
- 3,500 psi in moderate freeze-thaw areas
- 3,000 psi in non-freeze areas.

Portland cement shall conform to LIBNOR depending on soil conditions. Aggregates shall conform to ASTM C 33. Mixing water shall be fresh, clean and potable. In freeze-thaw areas only, an air-entraining agent complying with ASTM C 260 shall be used to achieve an entrained air content for the particular concrete mix used in accordance with the published recommendations of the Portland Cement Association and The American Concrete Institute. No admixtures containing calcium chloride are permitted.

Reinforcement for slabs shall have the same reinforcement as an ordinary concrete slab in the same situation.

3-2-L-3 EXECUTION

Installation procedure:

- The area to receive concrete floor finishing shall have the sub-grade prepared as for any concrete slab on grade.
- The form work shall be installed and the slab thickness shall be as required by the Engineer.

- Provide reinforcement when specified.
- Control joints or expansion joints shall be provided.
- Color hardener shall be applied evenly to the plastic surface by the dry-shake method. It should be applied in two or more shakes, floated after each and troweled only after the final floating.
- While the concrete is still in the plastic stage of set, the imprinting tools shall be applied to make the desired impression to the surface.
- After initial curing, the impressions shall be grouted.

3-2-M EXPOSED CONCRETE

3-2-M-1 DEFINITION

Exposed concrete with texture can be obtained by using a face structured surfaces. These surfaces should be able to avoid unaesthetic defects and irregularities that might occur in smooth finish concrete.

This structured surface should be made of Polystyrene-coated with a hardened surface, and then formed to the required surface. They should be lined using a separation foil.

This lining foil should last for several applications without the risk of staining and coloring of the concrete. This foil should also be able to provide perfectly sealed and smooth concrete surfaces.

3-2-M-2 TECHNIQUE

The structured surfaces or the form elements should be cut at the construction site, joined glued or nailed to the supporting wood shuttering. Concrete should be vibrated thoroughly.

Lining foils should also serve as separation allowing the structured form elements to be stripped off the hardened concrete at any desired time.

It is recommended that the form elements be left in place until the construction work is finished to maintain the cleanliness of the structured surfaces. These form elements should have a glass fiber reinforced backside to ensure dimensional stability.

This form elements should have this specified dimensions:

- Structure thickness 3mm max
- Backside thickness 2mm min
- Total thickness 5mm
- Total weight 3kg/sqm

3-2-N CONCRETE BLOCK MASONRY

3-2-N-1 DESCRIPTION

This work shall consist of concrete blocks laid in cement mortar.

3-2-N-2 MATERIALS

3-2-N-2-1 Concrete Masonry Units

Concrete masonry units shall be of approved manufacture and shall be formed in a press.

Blocks shall be well and evenly formed with true corners and unbroken arises, and shall be carefully handled and stacked.

Unless otherwise specified, The Contractor shall provide standard units with nominal dimensions of 400 x 200 mm and thickness to be standard 100, 150, or 200 mm as indicated on the drawings.

- Solid Block: Blocks shall be deemed to be solid if it does not contain formed holes or cavities other than those inherent in the materials.
- Hollow Block: Blocks shall be deemed to the hollow if the cavities which pass through the blocks is between 50 and 75% of the total volume of the blocks calculated from the overall dimensions.
- Fairfaced Blocks: Blocks for use as fairfaced shall be selected blocks from each delivery to the approval of the Engineer.
- Tests: Blocks for non bearing walls shall comply with the following:
- Average minimum compressive strength of 12 blocks not to be less than 30 kgs/cm^2 of gross area for hollow blocks and 35 kgs/cm^2 for solid blocks in accordance with best local practice and supplied by a manufacturer approved by the Engineer conforming to BS 12 and natural aggregates to BS 882.

Load bearing walls shall comply with BS CP. 111

Blocks should remain intact when dropped on to a hard surface from a height of 1 m. Should any sample of blocks fail to pass the above compressive strength tests above or meet the above requirements, the whole delivery will be rejected removed from the site.

The cement and aggregate of the concrete blocks shall be so proportioned as to meet, when tested at the age of 28 days with the cells placed vertically, the requirements of the ASTM designations.

3-2-N-3 MASONRY ACCESSORIES

Unless specified otherwise, galvanized wire netting: to be 22 SWG of galvanized mesh complying with BS-1085 shall be used in interior partition walls, in addition to providing ties with ends bent to 90 degrees angle to form hooks not less than 50 mm long.

3-2-N-4 MORTAR

Mortar for bedding and jointing shall be composed of 1 part of ordinary Portland cement to 4 parts of sand by volume.

Lay masonry units with full mortar coverage on horizontal and vertical faces, butter ends with sufficient mortar to fill head joints and put into place.

Cure unit masonry construction by keeping wet for at least 5 days.

The materials of mortars shall be measured out in their correct proportions and shall first be thoroughly mixed together in a dry state by turning them over upon a clean wooden stage until they are of a homogeneous appearance in consistency and color. Clean water shall then be added while the mixture is being turned over until it attains a suitable consistency. Mortar is to be mixed in small quantities as required and must be used within one hour of mixing. Plasticizer shall be added in accordance with the manufacturer's recommendations as approved by the Engineer.

The mortar shall be used immediately after it has been mixed. No mortar which has commenced its first set shall be used, or mixed up again. Mortar shall, where possible in hot weather, be protected from too rapid drying action by covering with impervious material such as polyethylene film.

Mixing by hand will be allowed only if the Engineer gives specific approval. Mixing by machine using the same sequence of operations described above shall be carried out whenever possible.

3-2-N-5 GENERAL REQUIREMENTS

Block work shall be set out and built to the respective dimensions shown on the drawings and shall comply with the following code of practice BS 5390 Part 1, BS 5628 Part 1.

Build chases and recesses as shown and as may be required by the Engineer. Provide not less than 200 mm of masonry between chase and jamb of openings, and between adjacent chases and recesses.

Blocks shall be soaked in water before use. The top of walls where work has been left off shall be thoroughly wetted before work is recommenced.

Walls shall be bonded in accordance with best constructional practice. Where required for bond, block shall be carefully cut to size.

Courses shall be properly leveled.

Proper masonry units shall be used for all windows, doors, bond beams, lintels, pilasters, etc., with a minimum of unit cutting. Where masonry unit cutting is necessary, all cuts shall be neat and regular exposed in the finished work and shall be cut with a power driven abrasive saw. Use full units without cutting whenever possible

Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint widths and to properly coated openings. Avoid the use of less than half size units at comers, jambs and whenever possible at other locations.

Lay-up walls with the exposed face plumb and true to line with courses level, accurately spaced and coordinated with other work.

Mortar joints shall be straight, clean and uniform in thickness unless otherwise specified or detailed on the plans, joints shall be approximately 10 mm thick.

No slashing or grouting of a joint will be permitted, nor shall a joint be made by working in mortar after the units have been laid.

Joints between blocks shall be filled solid with mortar and shall be of regular thickness of 5 to 10 mm. The blocks shall be laid in level courses and bonded so that each vertical joint is midway above the face of the block below, except at junctions and piers where a bond of not less than 100 mm shall be provided. The walls shall be raised in lifts not exceeding three meters in height in any one day, and truly vertical.

Walls shall be carried up regularly and no portion shall rise more than one meter above adjacent portions and at such changes in levels work shall be raked back.

The framing of all openings must be in reinforced concrete.

For walls higher than 3m and longer than 4m, the Contractor shall make sure to construct a 20x40cm continuous column at the end of the 4m length. All walls must be chained at the lintel level and related to the main structure. Walls shall be fixed to the ceiling with a steel profile in order to prevent falling under seismic effects.

Joints of exposed block work shall be raked out and neatly flush-pointed in the same mortar. The whole of the visible faces of the walls shall be left perfectly clean and all surface mortar and droppings shall be removed before they have set.

Clean exposed concrete masonry unit by dry brushing at the end of each day's work and after find pointing to remove mortar spots and droppings.

3-2-N-6 FAIRFACED BLOCK WORKS

Where shown on the drawings, walls with fairfaced finish shall be on both sides of selected blocks pointed with a neat flush joint as specified and approved.

3-2-N-7 ANCHORING MASONRY WORK

The Contractor shall:

- Support masonry walls to concrete structure with clip anchors as detailed.
- Provide anchors in every other course of concrete walling.
- Provide anchors as detailed at intersection of concrete block walling.

3-2-N-8 TOLERANCES

a. Alignment of columns	:	max. 3 mm from true line.
b. Variation from unit to adjacent unit	:	1.5 mm maximum.
c. Variation from plane of wall	:	6 mm/3 m and 13 mm/6 in or more.
d. Variation from plumb	:	6 mm per story non-cumulative 13 mm in two stories or more..
e. Variation from level coursing	:	3 mm/m; 6 mm/3 in; 13 mm maximum.
f. Variation of joint thickness	:	2 mm/m.
g. Maximum variation from cross sectional thickness of walls	:	± 6 mm.

3-2-N-9 PARTICULAR SPECIFICATIONS

3-2-N-9-1 Block works 10 cm Thick

The Contractor shall provide, store and build masonry hollow blocks with the following requirements as shown on construction drawings.

Masonry concrete hollow blocks manufactured of cement and crushed aggregate + sand 1.5 mix (300 kg cement to one meter cube of crushed aggregate + sand).

Nominal dimension	:	100 x 200 x 400 mm.
Moisture content	:	< 8% by weight
Cavity	:	Approx. 50% of the total volume of the blocks calculated from the overall dimensions
Compressive strength	:	50 kgs/cm^2
Description	:	The blocks shall be sound, dense, true to shape, uniform in size, straight edges, without any chipping, cracking or other damages resulting from transportation, unloading and storage

Installation and erection

The blocks shall be laid as shown on drawings in true and regular courses on a full bed of mortar min. 10mm thickness, exclusive of any key of the jointing surface of the blocks.

All keys are solidly filled.

Where blocks are against concrete they shall be tied there to by means of approved wire mesh. The contractor shall provide and build into the concrete work patent galvanized steel dovetailed channel grooves and shall build in min. 2 mm thick fishtailed ties which shall fit closely in the grooves and shall generally be embedded in blockwork 150 mm, in every two courses.

All horizontal joints shall be properly level. The vertical joints shall be lined and quoins, jambs and other angles plumbed as the work proceeds.

All walls shall be plumbed vertical.

Standard sizes blocks shall be used. Broken blocks shall be used except where required for bonding purposes.

Blockwork fitting into backs of frames shall be so placed as not to distort alignment of such items. The backs of all frames shall be well buttered up with mortar. Carefully paint around metal frames to detail using an approved sealant.

Where units are to receive glazed wall tiling on render, joints shall be racked 10 mm deep to receive render.

3-2-N-9-2 Block works 15 cm Thick

The Contractor shall provide, store and build masonry hollow blocks with the following requirements as shown on construction drawings.

Masonry concrete hollow blocks manufactured of cement and crushed aggregate + sand 1.5 mix (300 kg cement to one meter cube of crushed aggregate + sand).

Nominal dimension	:	150 x 200 x 400 mm.
Moisture content	:	< 8% by weight
Cavity	:	Approx. 50% of the total volume of the blocks calculated from the overall dimensions
Compressive strength	:	50 kgs/cm^2
Description	:	The blocks shall be sound, dense, true to shape, uniform in size, straight edges, without any chipping, cracking or other damages resulting from transportation, unloading and storage.

Installation and erection

The blocks shall be laid as shown on drawings in true and regular courses on a full bed of mortar min. 10mm thickness, exclusive of any key of the jointing surface of the blocks.

All keys are solidly filled.

Where blocks are against concrete they shall be tied there to by means of approved wire mesh. The contractor shall provide and build into the concrete work patent galvanized steel dovetailed channel grooves and shall build in min. 2 mm thick fishtailed ties which shall fit closely in the grooves and shall generally be embedded in blockwork 150 mm, in every two courses.

All horizontal joints shall be properly level. The vertical joints shall be lined and quoins, jambs and other angles plumbed as the work proceeds.

All walls shall be plumbed vertical.

Standard sizes blocks shall be used. Broken blocks shall be used except where required for bonding purposes.

Blockwork fitting into backs of frames shall be so placed as not to distort alignment of such items. The backs of all frames shall be well buttered up with mortar. Carefully paint around metal frames to detail using an approved sealant.

Where units are to receive glazed wall tiling on render, joints shall be racked 10 mm deep to receive render.

3-2-N-9-3 Block works 20 cm Thick

The Contractor shall provide, store and build masonry hollow blocks with the following requirements as shown on construction drawings.

Masonry concrete hollow blocks manufactured of cement and crushed aggregate + sand 1.5 mix (300 kg cement to one meter cube of crushed aggregate + sand).

Nominal dimension	:	200 x 200 x 400 mm.
Moisture content	:	< 8% by weight
Cavity	:	Approx. 50% of the total volume of the blocks calculated from the overall dimensions
Compressive strength	:	50 kgs/cm^2
Description	:	The blocks shall be sound, dense, true to shape, uniform in size, straight edges, without any chipping, cracking or other damages resulting from transportation, unloading and storage.

Installation and erection

The blocks shall be laid as shown on drawings in true and regular courses on a full bed of mortar min. 10 mm thickness, exclusive of any key of the jointing surface of the blocks.

All keys are solidly filled.

Where blocks are against concrete they shall be tied there to by means of approved wire mesh. The contractor shall provide and build into the concrete work patent galvanized steel dovetailed channel grooves and shall build in min. 2 mm thick fishtailed ties which shall fit closely in the grooves and shall generally be embedded in blockwork 150 mm, in every two courses.

All horizontal joints shall be properly level. The vertical joints shall be lined and quoins, jambs and other angles plumbed as the work proceeds.

All walls shall be plumbed vertical.

Standard sizes blocks shall be used. Broken blocks shall be used except where required for bonding purposes.

Blockwork fitting into backs of frames shall be so placed as not to distort alignment of such items. The backs of all frames shall be well buttered up with mortar. Carefully paint around metal frames to detail using an approved sealant.

Where units are to receive glazed wall tiling on render, joints shall be racked 10 mm deep to receive render.

Part III-3 : WATERPROOFING

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PART 3.3 - CIVIL & ARCHITECTURAL WORKS: WATERPROOFING

3-3-A FLEXIBLE WATERPROOFING PVC SHEETS 2 MM THICK

3-3-A-1 DESCRIPTION

This work shall consist of furnishing and placing flexible PVC sheets 2 mm thick on prepared surfaces in accordance with the Specifications, and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the Engineer.

3-3-A-2 MATERIALS

Waterproof membranes shall consist of uniform flexible sheets of two (2) mm minimum thickness.

3-3-A-2-1 Physical Requirements

The waterproofing PVC sheets shall comply with the following specifications at 20 °C:

Weight	2.80 kg/m^2
Thickness	2 mm
Tensile strength at rupture	17 daN/cm
Elongation %	170 %
Bursting Test (C.T.G.R.E.F.)	> 12 Bars
Hydrocarbon resistance	Good
Chemical resistance	Very good
Satisfactory for potable water	Good (Excluding Chlorinated Water)

The Contractor shall provide all adhesives, tapes and welding material recommended by waterproofing sheets manufacturer for bonding to substrate (if required), and for waterproof sealing of joints between membrane and flashing, adjoining surfaces and projections through membrane. The Contractor shall also provide all types of flexible sheet material and accessories for flashing and welding as recommended by waterproofing sheet manufacturer.

Each side of the waterproof membrane shall be protected by one layer of heavy duty geotextile sheets, in accordance with the Contract Drawings and Specifications.

3-3-A-3 CONSTRUCTION REQUIREMENT

3-3-A-3-1 Manufacturer's Instructions And Recommendations

At least thirty (30) days prior to the date he intends to order the waterproofing sheet materials the Contractor shall make written request for approval of: the brand of materials and method of installation he intends to apply, from the Project Manager.

The written request shall include all necessary manufacturer's instructions and recommendations relevant to the physical properties of the proposed sheets, the methods of storage, handling, laying, jointing, attachment, and protection. No ordering of waterproofing sheet material shall be effected before obtaining the written approval of the Project Manager on the above.

3-3-A-3-2 Subgrade Preparation

Unless other subgrade preparation is called for on the plans or appears as a pay item in the Bill of Quantities, the Contractor shall, as a part of the work and prior to the delivery of the material for the waterproof membrane, prepare the bed surface by sprinkling, blading, rolling, and lightly scarifying where necessary, until the proper slope is obtained. However, in the process of shaping the bed, the originally compacted crust or top portion of the bed shall be disturbed as little as possible. When completed and ready for waterproof membrane construction, the bed shall be well compacted, smooth, hard and uniform, all irregularities having been bladed out and rolled down.

3-3-A-3-3 Placing

The waterproof sheets shall be unrolled directly on the bearing surface, generally constituted by a layer of heavy duty geotextile sheets. Waterproof sheets shall be overlapped to a minimum of twenty centimeters, and shall be welded on site by means of a thermoplastic soldering machine to seal the membranes and ensure water tightness to these joints, all in accordance with Manufacturer's instructions and recommendations. The strength of the welding shall be at least equal to that of the sheets.

Installation shall be scheduled to minimize period of exposure of sheet waterproofing materials.

Equipment and vehicles shall not be operated on the fabric. Damaged fabric shall be repaired, at the Contractor's expense, by placing new fabric over the damaged area in a manner that meets the overlap requirements for horizontal placement. Vertically placed fabric shall be replaced in its entirety.

3-3-B GEOTEXTILE SHEETS

Geotextile sheets shall be of the non-woven heavy duty type, needle punched or needle entangled and shall consist of long chain polymeric filaments of polypropylene, polyester, nylon or any material approved by the Engineer. The fabric shall be a stable network of fibres, which retain their positions relative to each other. The geotextile sheets shall meet the following requirements:

Property		Test reference
Grab strength	: 500N	NFG 38.014
Elongation, Minimum (at peak load) %	: 65/57	NFG 38.014
Puncture strength	: 1500N	NFG 38.019
Permeability m/sec	: $5.5x10^{-3}$	NFG 38.016
Surface weight	: 390 Gr/m^2	NF EN 965
Thickness under 2kPa	: 2.0 mm	NF EN 964-1

Geotextiles shall be furnished in rolls wrapped with protective covering to protect them against ultraviolet radiation and abrasion. Torn wrappers shall be repaired within 48 hours, using an approved protective covering. Each roll of fabric shall be marked or tagged to identify the manufacturer, type, length, width, and production identification number.

3-3-C BITUMINOUS PUTTY

3-3-C-1 PUTTY FILLER

Putty filler must have a consistent, semi-rigid and compatible with flexibility inside the joint. Before fillings the joints must be dry and clean and the concrete surfaces in contact with putty must be primed with compatible material with the putty.

Putty must be of type "IGAS" or similar with bituminous base or rubber having the following characteristics:

Density	: 15
Flexibility at 20°	: null
Adhesivity of cohesiveness	: 3 daN
Maximum elongation under service	: 10%

Excellent adhesivity when laid on cement.

Another type could be used which is the elasto-plastic type conforming to the following requirements:

Black colour

Temperature for use	: 100°C to 130°C
Stable at	: -30°C to 60°C
Penetration at 25°C	: around 55°C
Softening temperature	: around 145°C
Practical elongation	: 10%

Non-toxic

The selection of which type to be used shall be approved by the engineer.

3-3-C-2 APPLICATION OF THE SEALANT

Before proceeding with filling the joint, the Contractor shall complete the following works:

- Widening the joint by grinding or sawing when the joint width is less than required.
- Cleaning by grinding and brushing the sides of the joint all along its length.
- Final cleaning shall be done by blowing air immediately before starting the filling.

The putty is applied at a temperature ranging between 100°C and 130°C. It shall be filled in the joint from the bottom up. In case the putty spreads slowly when applied, especially in horizontal joints, more material is immediately added until the joint is completely filled.

3-3-D WATERSTOPS

3-3-D-1 GENERAL

Waterstops shall be PVC type or Vulcanized Caoutchouc class A (rubber water stop) and shall be installed where shown on the drawings or where directed.

The Contractor shall furnish the waterstops and all materials and equipment for splicing waterstops, for fastening waterstops to the forms and to the supporting reinforcing bars, and for completing the installation of the waterstops.

The Contractor shall provide suitable support and protection for the waterstops during the progress of the work and shall repair at the Contractor's expense any damaged waterstops, which in the opinion of the Engineer, have been damaged to such an extent as to affect the serviceability of the waterstops. All waterstops shall be protected from oil, grease and curing compound.

3-3-D-2 MATERIAL

PVC waterstops shall be fabricated from a compound, the basic resin of which shall be domestic virgin PVC. No reclaimed PVC or manufacturer's scrap shall be used. The compound shall contain all additional resins, plasticizers, stabilizers, or other materials needed to ensure that, when the material is compounded, the finished product will have the required physical characteristics listed in the ASTM or similar.

3-3-D-3 FABRICATION

All waterstops shall be moulded or extruded in such a manner that any cross section will be dense, homogeneous and free from porosity and other imperfections.

3-3-D-4 INSTALLATION

Installation of the waterstops shall be in accordance with these specifications and the manufacturer's recommendations. The location and embedment of waterstops shall be as shown on the Plans, with approximately one-half of the width of the waterstop embedded in the concrete on each side of the joint.

In order to eliminate faulty installation that may result in joint leakage, particular care shall be taken that the waterstops are correctly positioned and secured during installation. All waterstops shall be installed so as to form a continuous watertight diaphragm in the joint unless otherwise shown.

Adequate provision shall be made to completely protect the waterstops during the progress of the work.

Concrete surrounding the waterstops shall be given additional vibration, over and above that used for adjacent concrete placement, to assure complete embedment of the waterstops in the concrete. Larger pieces of aggregate near the waterstops shall be removed by hand during embedment to assure complete contact between the waterstop and the surrounding concrete.

Where splices are required between waterstops of different sizes, the splices shall be made as recommended by the manufacturer of the waterstop.

3-3-E WATERPROOFING PROTECTIVE COATING FOR WATER RETAINING STRUCTURES

3-3-E-1 DESCRIPTION

This coating shall be a surface-applied material which waterproofs and protects concrete in depth and shall be suitable for use in water retaining structures. It consists of rapid-hardening Portland cement, specially treated quartz sand, and a compound of active chemicals. It is supplied in powder form and needs only to be mixed with water prior to application.

3-3-E-1-1 Preparation Of Substrate

All concrete to be treated with this coating must be clean and have an "open" capillary system. Laitance, dirt, grease, etc. should be removed by means of high pressure water jetting, wet sandblasting or wire brushing. Faulty concrete in the form of cracks, honeycombing etc. should be made good. Surfaces must be carefully pre-watered prior to the application of the coating. The concrete surface must be damp but not wet.

3-3-E-1-2 Mixing

The powder material is mechanically mixed with clean water to a consistency of thick oil paint. Approximate mixing ratio is 0.8 parts water to 2 parts powder (by volume).

Materials mixed shall be as can be used within 20 minutes. Mixture should be stirred frequently. If mixture starts to set, no water should be added, the mixture should be stirred to restore workability.

3-3-E-1-3 Application

The mix is applied by masonry brush or appropriate power spray equipment. When two coats are specified the second coat shall be applied while the first coat is still "green".

3-3-E-1-4 Post Treatment

The treated surfaces should be kept damp for a period of five days and must be protected against direct sun, wind and frost by covering with polythene sheeting, damp hessian or similar.

3-3-E-1-5 Safety

The use of rubber gloves and goggles during mixing and application is recommended.

3-3-E-2 GENERAL REQUIREMENTS

Waterproofing material shall be applied to interior concrete surfaces.

It is made of cement base, sand, and other chemical. It is composed of two contents:

- Powder: Mixed of cement and other mixes as specified by the Engineer
- Liquid: Resin base and other mixes as specified by the Engineer

The above product must be:

- Waterproofing
- Weather and chemical product resistant
- Suitable for potable water, not harmful nor poisoning nor unhealthy

Before placing waterproofing on concrete surfaces, mastic of hydraulic cement base shall be used in concrete holes and cracks which provides a complete blockage to water. This mastic is a mixture of powder placed in special can closed tightly and shall be mixed with water before usage as directed by the Engineer.

3-3-F ELASTOMERIC SURFACE JOINT (COMBIFLEX)

This joint shall be as shown on the Plans and as specified herein. The joint is formed of an elastomeric sheet painted on both sides with a viscous resin coating and protected by an aluminium or copper sheet riveted on one side only.

The elastomeric sheet shall conform to the following requirements:

- Thickness 10/10 mm
- Resistance to rupture : 12 kg/cm²
- Elongation at rupture : 300%
- Modulus at 100% elongation : 85 kg/cm²
- Elongation at the elastic limit : 15%

The dimensions of the sheet, the method used in welding and the manufacturer's name shall be indicated. The resin shall be of a quality approved by the Engineer.

3-3-G BITUMINOUS COATING FOR BURIED WALLS

This material shall be applied on the exterior side of the concrete elements buried surfaces.

Ground water should be checked previously by the Contractor for chemicals which may have a deleterious effect on the structure or internal finishes.

The Contractor must obtain the previous approval of the Engineer on the support as well on the type of material proposed.

The bituminous coating for damp-proofing should be cold applied emulsion in two coats (of at least 0.750 kg/m^2 each) and cross applied.

Bitumen primer should be of the same cold bitumen emulsion compound diluated to 50% with water and applied at a minimum rate of 0,400 kg/m^2. The damp-proof bituminous coat shall be applied around 24 hours after the primer application.

3-3-H VAPOR BARRIER

This layer shall meet the following requirements:

- Thickness not less than 2 mm
- Durability against vapor penetration not less than 120,000µ
- Sustains a temperature of minus 10 degrees C without form change.

3-3-I SELF-ADHESIVE POLYETHYLENE SHEET

Flexible, preformed waterproof membrane comprising strong, high density polyethylene film with self-adhesive rubber/bitumen compound, and having the following minimum properties:

- total thickness : min 1.5 mm
- weight : 1.6 kg/m2
- ensile strength : 42 N/mm2
- elongation : 210% long.; 160% trans.
- tear resistance : 340 N/mm long.; 310 N/mm trans.
- puncture resistance : 220 N 65 mm
- Man: Servicised Ltd.

  Ref: Bitu-thene 1000X HC

  or other equal and approved.

3-3-J STEEL ROOF COVER

Steel roof covers to be as follows:

- Coated with natural stone chips, with pressure formed 0.4mm Zinc Aluminum base.
- Tested to withstand:
  - 2000Kg/m2 for snow load.
  - 400 Kg/m2 for uplift wind force.
  - Fire tested (agreed) CSTB T30/1
- Simulated Cyclone Wind loading:
  - 8000 cycles 3.44 kPa (72 psf).
  - 2000cycles 4.13 kPa (86 psf).

- 200 cycles 5.50 kPa (115 psf).

3-3-J-1 STEEL ROOF COVER TO BE WATER PROOF

Tiles withstand: 100mph Wind speed

160Km/h Wind speed

With rainfall intensity of 203mm of rain/Hour without any leakage.

3-3-J-2 HAIL RESISTANCE

Roof covers should resist damage from hailstone up to 90mm.

3-3-J-3 TECHNICAL SPECIFICATIONS

Base steel	0.39mm
Zinc-aluminum coating	150g/m2
Total substrate thickness	0.43mm
Tile coverage	2.15 tiles/m2
Tile weight	7 Kg/m2

Steel roof cover composition:

1. Backing coat
2. Epoxy primer
3. Aluminum-Zinc coating
4. Steel base
5. Aluminum-Zinc coating
6. Epoxy primer
7. Seal coat
8. Acrylic base coat
9. Natural stone chips
10. Acrylic overglaze.

Part III-4 : FINISHES

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PART 3.4 - CIVIL & ARCHITECTURAL WORKS: FINISHES

3-4-A PLASTER WORKS

3-4-A-1 DESCRIPTION

This work shall consist of furnishing and installation of Portland cement plaster for the areas designated on the Plans or where specified. Work shall begin after the Contractor's request to start work has been approved.

3-4-A-2 MATERIALS

3-4-A-2-1 Portland Cement

Portland cement shall conform to LIBNOR.

3-4-A-2-2 Water

Water shall be clean, pure and free from all deleterious substances.

3-4-A-2-3 Aggregates

The aggregate shall be natural sand, clean, sharp, free from impurities and conforming to granularly hereafter described.

3-4-A-2-4 Hydrated lime

Lime shall be used only where mentioned and after being approved by the Engineer.

Quantities used in the mixtures must be approved by the Engineer.

3-4-A-2-5 Waterproofing additive

Waterproofing additive shall be a brand approved by the Engineer.

3-4-A-3 PLASTER MIXES

3-4-A-3-1 Designation

Plaster work shall be designated as follows :

a. Ordinary Interior Plastering : Plaster work applied to interior surfaces.

b. Ordinary Exterior Plastering : Plaster work applied to exterior surfaces.

c. Water Resistant Exterior Plastering : Plaster work containing waterproofing additive applied to exterior surfaces.

d. Tyrolean Plastering : Plaster work applied to exterior surfaces.

3-4-A-3-2 Batching and mixing

Mixing of the ingredients shall be done either manually or mechanically. In both cases, measurement of cementitious material should be based on full bag increments of cement whenever possible.

3-4-A-3-3 Manual mixing

The mixing process shall be done in a clean area away from natural soil and any other substances. First, the dry ingredients shall be mixed before any water is added. Then water is added only enough to produce a workable mix. The volume of the sand shall be measured in calibrated boxes such that each volume of plaster requires a whole number of 50 Kg cement bags. The mortar shall be used in the first half hour after its preparation and before it starts to set.

3-4-A-3-4 Mechanical mixing

Portland cement plaster shall be mixed in a paddle drum mixer for 3 to 10 min. Excessive mixing which could be detrimental to the quality of the plaster shall be avoided. Only sufficient water shall be added to produce a suitably plastic mortar.

3-4-A-4 PREPARATION OF SURFACES

Before proceeding with the plaster work, the substrates and the conditions under which the work is to be installed shall be examined and any unsatisfactory conditions detrimental to the proper and timely completion of the work shall be corrected. The following background conditions shall be satisfied before coatings are applied :

- Adequately true and level to achieve specified tolerance
- Adequately fixed
- Free from contamination and loose layers

- Adequately prepared to give a good bond
- Free of any coating of bituminous compound or any other detrimental waterproofing or damp-proofing agent.

3-4-A-5 SAMPLES

One square meter of each plastering sample shall be executed before starting the plaster work. The approved samples shall be kept until all the plastering work is finished. Plaster work shall be of a quality the same or better than the sample.

3-4-A-6 PROTECTION

All fixtures, frames, inserts and other contiguous work shall be protected from rusting, soiling or clogging due to plastering.

3-4-A-7 PLASTER COATS

Unless otherwise specified plaster work shall consist of three coats :

1- Scratch coat which is the first coat

2- Brown coat which is the second coat

3- Finish coat which is the final coat and can be replaced or covered with decorative plastering.

3-4-A-8 APPLICATION OF PLASTER

3-4-A-8-1 General

Immediately prior to the application of plaster, surfaces shall be thoroughly sprayed with water few hours before plastering and all free water shall be allowed to run off.

All arises, corners and internal angles shall be straight and level or plumb.

Plaster shall be made good up to frames and skirting and around fittings and pipes. Angles shall be rounded to a 5 mm radius.

Undercoats and finish coats shall be protected from the weather until they have set and shall not be allowed to “dry out” or “sweat out” to the detriment of the surface and shall be kept covered with damp sacking or other approved means for the period specified.

Thickness guide markers of porcelain tiles splinters or similar markers shall be placed at the rate of one marker per square meter of surface to be plastered.

Unless otherwise specified the surface of the plaster shall be rendered smooth and level by the use of a felt. Rough patches, ridges or any other flaws shall not be permitted.

Plastering shall be executed under almost horizontal light so that any flaw such as undulations, ridges, etc. can be detected and repaired.

A straight edge, a plumb, a spirit level, a square and an electric lamp shall always be kept at the site so it can be possible to check the plastering work.

Plaster work containing cracks, blisters, pits, checks or discoloration will not be accepted. Such plaster shall be removed and replaced with new plaster. Patching of defective work will be permitted only when approved. Such patching shall match existing similar work in texture and color as determined by the Engineer. Moistening must occur twice a day.

The Contractor shall provide easy and secure access to all surfaces to be plastered.

Plastering is forbidden when one of the following weather condition occur:

- Temperature below 5 degrees C.
- Dry air (Unless approved by the Engineer)
- Rainy day (Unless approved by the Engineer)
- Hot weather (Unless approved by the Engineer)

3-4-A-8-2 Application of coats

3-4-A-8-2-1 Scratch Coat Plastering

This coat shall be a plastic workable mix. It shall be laid on with sufficient material to form full key with the base material. It shall be cross raked and allowed to set for 48 hours before applying brown coat. It shall be continuously damp during the entire period between coats.

This coat is not to be used on interior or rough surfaces.

This coat is to be used on exterior and flat surfaces.

Properties of the ingredients in the plaster mix shall be as follows:

- 600 Kg Portland Cement for 1 cubic meter of sand, or 1 part Portland Cement for 3 part sand.
- Sand granulometry: 0.1 - 0.3 mm. Particles less than 0.1 mm shall be less than 10%.

Using of lime for exterior plastering coat is forbidden.

Scratch coat thickness shall be between 5 and 8 mm.

3-4-A-8-2-2 Brown Coat Plastering

The scratch coat shall be moistened with water before applying the brown coat. The water sheen on the surface of the scratch coat shall be allowed to disappear before applying the brown coat. If the prewetting operation interferes with the proper floating of the plaster surface, it may be reduced or eliminated depending upon the moisture condition of the scratch coat.The brown coat shall be hand-troweled with enough force to key this coat to the scratch coat. After obtaining the desired thickness, it shall be rodded to a plane surface. Sufficient

stiffening shall be allowed to occur prior to floating. The brown coat shall be damp proofed for a period of 5 to 15 days depending on weather conditions.

Proportions of the ingredients in the plaster mix shall be as follows:

- 600 Kg Portland Cement for 1 cubic meter of sand
- Sand granulometry: 0.1 - 0.5 mm.

Using of lime for exterior plastering coat is forbidden.

Brown coat thickness shall be between 5 and 8 mm.

3-4-A-8-2-3 Finish Coat

Finish coat shall not be applied until brown coat has cured for seven days. Before application of finish coat, wet brown coat to a true, even surface and trowel in a manner that will give a level, even surface of sandy texture, free from trowel marks, checks and other blemishes.

Care should be taken to apply finish coat continuously between natural breaks in the surface plane. On multiple-level staged walls, lower levels of plaster in the same panel shall be continued immediately to avoid joining stains, shouldering and texture variation. The finish coat shall be moistened for at least three days; thereafter it shall be protected against rapid drying until properly, thoroughly cured.

Proportions of the ingredients in the plaster mix shall be as follows:

- 600 Kg Portland Cement for 1 cubic meter of sand.
- Sand granulometry: 0.1 - 2 mm.

Using of lime for exterior plastering coat is forbidden.

Thickness of the finish coat is between 5 and 8 mm.

When Tyrolean coat is applied as a finish coat, plaster shall have the same characteristics of cement plaster, but with finishing layer of white cement sprayed with a machine in many passes to get a homogeneous rough surface.

The roughness of the finished layer is as per sample approved by the Engineer.

Approximate thickness is 10 mm.

Proportions of the ingredients for Tyrolean coat are:

- 1 part Portland Cement
- 4 part fine sand

3-4-A-8-3 Internal Plastering

Internal plastering shall be applied in two coats of minimum total thickness of 15 mm on vertical faces and 10 mm on ceilings (excluding the thickness of any initial dash coat).

On vertical faces the plaster shall be applied in widths not exceeding one meter between screed laths prepared and set up true and plumb.

The finished faces of plaster shall be true to shape and angle even in all directions, free of cracks and trowel marks to the complete satisfaction of the Engineer.

The plastering of each face between two corners shall be carried out in one operation and work must in no case be interrupted and continued the following day, all reveals for jambs, lintels shall be plastered in one operation with the respective wall faces.

At least one day shall elapse between the execution of consecutive coats of plaster.

Floated coat for tiled surface shall be applied as for internal plastering in general. It shall be plumb, true and level and shall bring the finished tiled face to required plane.

The surface of floated coats should be left with a steel float finish.

3-4-A-8-4 External Plastering

External plastering shall be applied in two coats to a minimum total thickness of 20 mm.

The finishing surfaces of plaster shall be true to shape and angle even in all directions, free of cracks and trowel marks to the complete satisfaction of the Engineer.

3-4-A-8-5 Tolerances and permissible deviations

- The finished plaster shall be straight, true, square with adjoining work, smooth where required, free from imperfections impairing appearance or performance. Angles shall be plumb and true.
- A 3 m. ruler placed on the surface in any direction shall not show a tolerance more than 3 mm.

3-4-B WALL TILES

3-4-B-1 DESCRIPTION

This work shall consist of furnishing, installing cutting, grinding and fitting of tiles and cladding as shown on the drawings or as approved by the Engineer.

3-4-B-2 GENERAL

Tiles and cladding plates shall be perfectly plane (no warping shall be tolerated) and shall have exactly the required specified dimensions.

All defects in the work shall be repaired by the Contractor as directed by the Engineer.

The Contractor shall not begin work before the approval of the Engineer and after finishing all necessary civil works.

The Contractor shall leave openings for sanitary, electrical works and others as specified on the drawings or as required by the Engineer.

The area shall be clean from dirt before placing any mortar for tiling.

Tile skirting shall be placed correctly so they will cover tile edges without leaving gaps. The thickness of the concrete bed beneath skirts shall be 1 cm. at least after skirts have been placed.

The Contractor shall make sure that all work shall be executed by a competent and experienced tile layer.

Laying may not proceed in temperatures exceeding 35 degrees C except with the approval of the Engineer. Laying may then only proceed under temporary shades.

All tiling shall be thoroughly soaked in clear water for at least 2 hours prior to laying.

Before laying commences, all tiling shall be checked for size to insure a correct fit into the area chosen for the day's laying schedule.

The concrete or floor screed sub-base shall be cleaned of dirt, dust and loose particles, and saturated with clean potable water several hours before placing the setting bed. About one hour before placing the setting bed, any surface water shall be removed.

About 15 minutes prior to placing setting bed a slush coat of cement grout 1.5 mm thick shall be applied to the sub-base. The slush coat shall be applied by trowel or brush in a limited area in order to avoid drying out.

The setting bed (cement and sand screed, 1:4 nominal mix) shall be level in plan or uniformly slopped for drainage as shown on floor plans. The screed shall be mixed and placed in limited amounts prior to the initial set of bed.

All tilings shall be locally manufactured.

3-4-B-2-1 Materials

Portland cement: Shall comply with the requirement of BS 12 ordinary and rapid hardening Portland blast furnace complying with BS 146 high alumna cement complying with BS 915. Cement used in preparation for Mortar for bedding Marble slabs shall be Portland White Cement to BS 12.

Sand for floated coat: shall comply with the requirements of BS 1199, of BS 1198: 1200 building sands from natural sources; Table 1.

For cement-sand bedding mix, sand or crushed rock should be clean, moderately sharp not too fine and free from clay, organic and soluble matter.

Lime: shall comply with the requirement of BS 890 " Building Lime " and should be properly hydrated.

Water: shall be fresh clean drinkable and complying with the requirement of BS 3148.

Reinforcement: Where required for flooring or screed it shall be expanded metal (10 mm. to 20 mm. mesh) complying with BS 405 expanded metal ; or wire netting (1 mm. to 25 mm. mesh) complying with BS 1485 galvanised wire netting.

Cement based adhesive: Shall comply with B.S.C.P. 212 Part 1. Appendix (B).

Mastic adhesive: Shall comply with B.S.C.P. 212 Part 1. Appendix (A).

Metal anchorages: Should be made of suitable non-ferrous metal e.g. Copper, Phosphor-Bronze, Gun metal or other approved metal. They shall be of such shape, dimension and strength and properly fixed to the wall and to the marble sand stone that they are adequate to carry the loads and stresses to be imposed on them.

Brass and Bronze cramps, ties and connections for wall cladding and other elements shown on drawings shall conform to the applicable requirements of BS 2870, rolled copper and copper alloys.

Floor dividing strips: Shall be non corrosive metal as shown on drawing and shall be used at the junction between different floor finishing.

The profile shall be uniform in size and capable of being cut, drilled and where necessary around the profile shall be adjustable to level tolerances in the slab.

3-4-B-2-2 Product Delivery, Storage And Handling

The Contractor shall transport, handle and store all materials with proper equipment, and in a manner to prevent soiling, staining and damage. Any damaged, broken , or permanently stained products will be replaced at the Contractor's expense.

3-4-B-2-3 Workmanship

3-4-B-2-3-1 Surface Preparation

Before laying any kind of tiles on floor screed or plastered walls, the surfaces shall be thoroughly cleaned of all dust and sand. Extra Mortar shall be knocked off with a hammer and removed. The surfaces shall be profusely sprayed with water and allowed to drain.

3-4-B-2-3-2 Laying Screed

Screed battens carefully levelled and trued should be fixed at the correct height for the required thickness of screed. In hot or drying weather care should be taken to ensure that portland cement mixes do not stiffen or dry out to an extent that prevents full compaction. After compaction, the surface must not be allowed to dry out quickly and protection by plastic sheeting or other suitable means may be necessary.

A base make-up slab may be laid, bonded to the structural slab with a PVA type bonding agent, and the floor tiles bedded on the make-up slab using a pre-mixed rubber-latex : cement mortar.

These mortars are specialist mortars with the manufacturer's instructions .

3-4-B-2-3-3 Mortar

Mortar for setting and backing up shall be cement and sand.(1:4) mix by volume of white, non staining portland cement mixed to a stiff consistency. Do not use mortar if more than 2 hours has elapsed since initial mixing.

Mortar bed shall be placed in specified locations with accurate thickness and measures as shown on the drawings or as required by the Engineer.

Mortar bed shall be poured and leveled with a leveling rod. The leveling rod shall be flat and clean. The percent water in the mix shall be adequate not to leave a foam on the surface of the layer after spreading it.

The Contractor shall verify with the Engineer whether the strength additives he wishes to mix with the concrete is applicable for use and shall also provide the name of the manufacture.

White cement grout for joints shall be from the best quality and approved by the Engineer.

Sand to be used for the mix shall conform to the requirements of sand specification.

3-4-B-2-3-4 Floated Coat

Floated coats of Portland cement and sand (1:4) mix with a total thickness to be 1.5 cm applied on the whole surface to be tiled.

The materials should be mixed together thoroughly before adding water. Only sufficient water should be added to make the mix workable, and should be used within two hours of the addition of the water.

It is very important that the floated be plumb, true and level, any unevenness should be such that a variation of no more than 0,15 cm. In any distance of 3,00 meter is required to bring the finished tiled face to the required plane.

It is necessary to apply the floated coat in two separate operations render and float. The surface of floated coats should be left with a steel float finish.

3-4-B-2-3-5 Precautions

The Contractor shall make sure that tiles are immersed in clean water for 6 hours and surplus water drained off, before bedding. Tiles shall be fixed to the floating coats with an approved adhesive, in accordance with B.S.C.P 212 a true vertical joints and pointed in neat white or colored cements, any surplus which adheres to the face of the tile shall be wiped off with a damp cloth before it sets hard.

Where tiling abuts against wood or metal frames or other tiling at angles and around pipes etc... It shall be carefully cut and fitted to form a close neat joint.

Whenever specified, the sand beds shall be of the thickness necessary to make up the finished floor level. They shall be salt free.

3-4-B-2-3-6 Grouting

All paving shall be grouted up on completion, care being taken to fill all joints completely. The grout shall consist of neat cement of a color to match tilling. Any surplus grout shall be cleaned off the face of the tiling and surrounding surfaces immediately and all tiling shall be carefully cleaned.

3-4-B-2-3-7 Allowance For Movement

The Contractor shall give due allowance for movement of the marble slabs. Therefore the Contractor is to take all necessary precautions in respect of these movements by providing compression and expansion joints in his design and detailed working drawings taking into consideration the type of structural backing, climatic conditions and exposure to sun, as well as the type of marble being used.

These joints should be filled with Polysulphide mastic compound.

3-4-B-2-3-8 Tolerances

The height and length dimensions of individual slabs shall be worked to within plus or minus 1 mm from those specified. Thickness shall be within 3mm from the specified, except where the thickness of the slab, forms a "seen" end. In such cases the thickness must be accurate to close limits.

All blocks, concrete or other backing must be formed so as to allow 13 mm clearance (void) between it and the back of any marble slab cladding.

3-4-B-2-3-9 Protection

After setting, all work liable to staining and damage shall be protected with an adequate type of covering approved by the Engineer. Any paper or wood used in connection with such protection shall be free of coloring matter and shall be of an approved non-staining type. This protection shall be kept in position and in repair, and shall be removed only at the direction of the Engineer.

3-4-B-3 CERAMIC TILES FOR FLOORS AND SKIRTINGS

Ceramic tiles shall be of the best quality. They shall present qualities and properties of the highest standard, and in particular flatness, orthogonality, resistance to wear, porosity, etc.

They shall be resistant to acids, bases, grease and hydrocarbons. The back of the tile and skirting shall carry the type and name of manufacture.

The Contractor shall submit samples for the Engineer's approval.

Tiles shall conform to the following requirements:

- Water absorption 0.3 % max.
- Erosion: Less than 7 mm.
- Breaking Resistance: At least 150 Kg/cm²
- Sound: No hollow sounding
- Tolerance (composed of a pack of 10 pieces)
  1. Width: ± 2 mm.
  2. Thickness: ± 1 mm.
- Weight: Approximately 2.3
- Porosity: 0.2 max.
- Size: As shown on the drawings or as required by the Engineer with a thickness ranges from 9 to 10 mm.
- Exterior appearance: No defects shall be apparent

Tiles shall be laid on sand bed 7 cm. thick or more, or as shown on the plans or as required by the Engineer. The sand bed shall be saturated and compacted well.

Sand used for floors shall be of the best quality and clean of all dirt.

Tiles shall be laid on a 2.5 cm. thick mortar bed proportioned at 600 kg. of Portland Cement CPA 210/325 per cubic meter of sand. The thickness of the mortar bed shall be 2 cm. at least after tiling.

The Contractor shall place all necessary installations before tiling.

The alignment of tiles shall be attained by means of perfectly straight tight strings.

The joints of the skirting shall be aligned with those of the tiles. During tile laying, tiles shall be taped on softly to assure that they are dipped enough in the mortar.

Levelling rod and level shall be placed on top of the tiles to make sure that the alignment and levelling are correct and even in every direction.

In the case of a step in tiling, and unless otherwise shown on the plans or directed by the Engineer, the two tiles forming the angle, shall be chamfered so that the joint is along a straight line.

After the laying, circulation shall not be allowed on ceramic tiles for 4 days.

24 hours after laying the tiles, the joints shall be covered with white cement grout.

The Contractor shall take all necessary measures to ensure protection of the executed works until their receival. He shall be responsible for repairing any damage.

The Contractor shall, at the end of works, clean the tiles and skirtings with spirits of salt.

Tile works shall include all necessary tools to cut the tiles either on site or in the factory if needed. This work shall also include transporting the tiles to the factory, cutting it, and transport it back to the rooms.

Tile works shall also include all tile skirting works including mixing, transferring the sand, cement, water and all necessary tools for a perfect tile skirting job as shown on drawing or as required by the Engineer.

All defects in the work shall be repaired by the Contractor as directed by the Engineer on his own expense.

The Contractor shall provide water drains in bathrooms and balconies.

The Contractor shall provide and install factory mounted dry pressed flat tile complying with the following requirements or as directed by the Engineer.

Unglazed vitrified ceramic tile.

Nominal dimensions	:	20x20 cm
Nominal thickness	:	10 mm or as specified and required
Breaking strength	:	1500N – 3000N
Stress group	:	U4 – EN 102Plain with square edges
Resistance to deep abrasion	:	< 300 mm^3 - EN 186-1
Wearing surface	:	Smooth
Face	:	Plain with square edge
Water absorption	:	E < 3% - Group B1
Density by Volume	:	2.4 g/cm^3
Quality	:	First choice
Color of the tile	:	Selected by the Engineer
Type of installation	:	Layed with enriched cement sand mortar (1:3) over floor creed(measured separately)
Joints	:	1- 1.5mm (to the approval of the Engineer)
Grout	:	Colored grout and joint filler as per Manufacturer's recommendation and to the approval of the Engineer. Waterproofing additives shall be added to the grout for the

damp areas.

Installation and grouting as per BSCP 202 Tile flooring and BS 6431 Ceramic wall and floor tiles.

All Corners vertical and horizontal in damp areas, shall receive adequate silicone filler to the approval of the Engineer.

3-4-B-4 MARBLE TILES

3-4-B-4-1 Light ivory color marble tiling for floor and skirtings

The Contractor shall provide and install factory polished flat tile complying with the following requirements:

Descrpition	**:**	**Light Ivory Color Marble Tiles.**
Nominal thickness	:	40x40x2cm thick
Country of origin	:	Lebanon
Absorption by weight	:	0.16% - C97
Density	:	2688Kg/m^3 - C97
Compressive strength	:	1209 kg/cm^2 - C170
Abrasion resistance	:	4.72mm
Thermal expansion coefficient	:	0.0072 mm/m°C
Ultimate tensile strength	:	174 kgs/cm^2
Face	:	Plain
Type of installation (measured separately)	:	Laid with enriched cement sand mortar (1:3) over floor screed
Joints	:	1 - 1.5 mm (to the approval of the Engineer)
Grout	:	Colored grout and joint filler as per Manufacturer's recommendation and to the approval of the Engineer. Waterproofing additives shall be added to the grout for the damp areas.
Grinding and polishing	:	Grinding and polishing shall be done after laying and grouting the marble tiles of a minimum of 21 days. The crystallisation of the finished surface shall be refused.

A setting tile layout drawing shall be submitted to the Engineer for approval before starting any tiling works.

The edges of the marble tile shall be sound without any chipping or fractures subject to the refusal of the tiling works.

3-4-B-5 LIGHT IVORY COLOR MARBLE TREADS AND RISERS

The Contractor shall provide and install factory manufactured precast flat treads and risers with the following requirements:

Source of fabrication: One source for each type in conformity with BS 4131 or equivalent.

Description: Light Ivory Color marble treads and risers shall each be in one piece. In general they shall be identical in specification to perlato tiles as specified previously, but the thickness of the tread shall be 3 cm while the riser is 2 cm with sizes as specified on the drawings and approved by the Engineer. Reinforcement shall be provided if required by the Engineer according to the length of tread or riser.

The treads shall incorporate a cast iron nosing, minimum 30 x30 x 3 mm with tangs cast in. The nosing shall incorporate a non-slip textured top surface, all to the approval of the Engineer. The treads shall incorporate handling/anti crad reinforcement. Treads and risers shall be solidly bedded on cement and sand, all in accordance with the approval of the Engineer.

The height of the risers shall be in conformity with the detail drawings and checked on site prior to any ordering of material.

The Contractor is bound to produce to the Engineer approval, detailed drawings for the as-built staircase with the treads and risers to be ordered.

3-4-B-6 GLAZED CERAMIC WALL TILES (CHINESE PORCELAIN TILES)

Wall tiles shall be of the best quality with sizes as shown on the drawings.

Before installation, samples shall be provided to the Engineer for approval.

Walls shall be cladded with chinese porcelain tiles as shown on the drawing with the consideration of tile and tile bed thickness.

The bed beneath the tiles shall be white grout and shall meet the requirement of the manufacture that provides the tiles. These tiles shall conform to the following requirements:

- Porosity: less than 10%
- Breaking resistance: Under pressure of (7±0.5) Kg/cm² , it shall not show any breaking signs. Under pressure of (10±0.5) Kg/cm².
- Width tolerance: ±0.3 mm.
- Thickness tolerance: ±0.4 mm.
- Maximum offset in the surface: Less than ±0.7 mm.

Tiles shall be saturated with water before being laid and shall be laid with narrow joints without sticking to each other. Wall joints shall be aligned with floor joints. 24 hours after laying the tiles, the joints shall be covered with white cement grout.

The Contractor shall, at the end of the works, clean the tiles with spirits of salt.

If a ruler of 2 m. long is used, no unevenness shall be allowed of more than 2 mm.

If a plumb is used, no unevenness shall be allowed for more than 5 mm. of the total height.

3-4-C PAINTING

3-4-C-1 DESCRIPTION

This work shall consist of painting work as shown on the plans.

3-4-C-2 GENERAL REQUIREMENTS

Unless specified otherwise, the Contractor shall:

Have painting work conform to D.T.U. Standard No. 59.1 or BS 6150.

Provide samples showing the brand, quality, ingredients and shall be approved by the Engineer.

Supply all paints, primers, varnishes, distemper, oil, etc. ready mix in original sealed containers bearing the brand maker's name identifying the contents and giving directions for its proper use.

Have painting materials to be of the best quality products of recognised manufacturer's and shall be subject to the approval of the Engineer. The quality of the finishing colors shall be capable of giving three years minimum satisfactory performance under conditions of high temperatures and humidity, and capable of withstanding temperatures of up to 40 degrees C for long periods without color change. Paints shall also be resistant to oils, acids and alkalis.

Execute all paint works for flat concrete, plaster, wood, or steel as shown on drawings or as required by the Engineer.

Clean surfaces to be painted before applying paint or surface treatments. Remove oil and grease prior to mechanical cleaning. Program cleaning and application so that contaminants from cleaning process will not fall on wet, newly-painted surfaces. Paint shall only be applied on a properly brushed surface, so as to eliminate all loose sand or mortar particles.

Not be undertaken the application of paints in a temperature over 30 degrees C or below 5 degrees C, in a humid atmosphere over 80% and when weather is dry, in a dusty or foggy, or rainy weather, or on frozen or overheated surfaces.

Take every precaution to keep down dust before and during painting and decorating operations. No paint shall be applied to surfaces structurally or superficially damp and all surfaces shall be free from condensation, effloresce, crease, oil, dirt and like before the application of each coat.

Have primed or undercoated wood or metal not to be left in an exposed or unsuitable situation for an undue period before completing the painting. No exterior or exposed painting shall be carried out during adverse weather conditions.

Have metal hardware and door furnishings not required to be painted to be fitted first and then removed before any painting processes are commenced. When all painting is completed the fittings shall be cleaned and refixed.

Keep clean all brushes, pails, kettles and the like used in carrying out the work and free from foreign matter. They shall be cleaned before being used for different types or classes of materials.

Use the undercoats, primers and the like manufactured or recommended by the manufacturer of the finishing paint and not withstanding anything herein specified and shall prepare the

surfaces, mix and apply the materials in accordance with the manufacturer's specification and as required on the drawings.

Not allow tile mixing of materials of different brands. No dilution of materials will be allowed except as detailed by the manufacturer. All paints for the site shall be ready mixed for use and brought on site in their original containers as supplied by the manufacturer.

Submit complete color charts for the paints to the Engineer for approval and the preparation of the color schedules. The number of coats and film thickness required is the same regardless of the application method. Do not apply succeeding, coats until the previous coat has cured as recommended by the manufacturer. Sand between applications where sanding is required to produce an even smooth surface in accordance with the manufacturer's directions.

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 ensure that surfaces, including edges, corners, crevices, welds, and exposed fasteners, receive a dry film thickness equivalent to that of flat surfaces.

Extend coatings in exposed surfaces to maintain the system integrity and to provide desired protection.

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 grills, with a flat, non-specular black paint.

Paint back sides of access panels and removable or hinged covers to match exposed surfaces.

Finish interior of wall and base cabinets and similar field-finished casework to match exterior.

Finish exterior doors on tops, and side edges same as exterior faces.

Sand lightly between each succeeding enamel or varnish coat.

Omit primer on metal surfaces that have been shop-primed and touch unpainted.

Remove before painting commences, all hardware, furniture and accessories for doors and windows, together with any exposed electrical installation in walls. Upon completion of all paint work, all such hardware, furniture and accessories etc. shall be re-installed and left in a good working order.

Have all woodwork to be painted to be reasonably dry and humidity must be less than 12% and its surface shall be cleaned and made smooth by sanding it with sand paper obliquely across the grain. The surfaces shall then be dusted off with a dusting brush and wood glue completely removed.

Have concrete surfaces to be painted to be washed down first and then allowed to dry. Any efflorescence present shall be thoroughly removed, and the areas so affected shall be given a coat of porous alkali-resistant primer. After any traces of grease have been removed, the surfaces shall be painted with two coats of emulsion paint of the copolymer acrylic type. Any cracks in walls shall be cleaned, filled and puttied up then left to dry before application of paint.

Follow the manufacturer’s instructions on the use of paint and shall be delivered to the site unopened with the original cover.

Submit for approval all types of paint he intends to use with manufacturer's certificate showing the following physical properties:

- Viscocity
- Adherance
- Durability
- Abrasion
- Permeability
- Resistance to washing
- Stability of color

All tests shall meet the requirements of U.N.P. and the Contractor is the sole responsible for these materials and their use for the particular job.

Have mastic base water for gaps filling components for concrete or plaster to be compose of the following materials:

- Sealer 8.5%
- Water 25%
- Powder 40%
- Zinc 20%
- Oil 6.5%

3-4-C-3 PARTICULAR SPECIFICATIONS

3-4-C-3-1 Emulsion Paint

The Contractor shall provide, store and apply emulsion paint to substrates with the following requirements complementary to the general specifications including all needed materials, accessories, tools and scaffolding.

Emulsion based flat finish, to be used in water thinnable paint systems applied on interior and exterior walls and ceilings

Recommended thinner	Sweet water
Volume of thinner	*0-5%*
Description	Superior quality thixotropic paint based on a copolymer emulsion. Alkaline resistant
Mass Density	Approx. 1.4g/cm^3
Solid Contents	31-33% by volume, depending on colors
Overcoating intervals	min. 2 hours
Flash point	> 65degreesC - Din 53213

Type of application	Spray, brush or roller
Total thickness of paint	7-8 dry mils
Number of coats	To the satisfaction of the Engineer and the following minimum application
Plastered walls and ceilings	Cleaning - Sealer - Putty - Sanding- Undercoat - Putty - Sanding - Paint – Checking –Paint
Masonry Concrete Cleaning	Masonry filler – Sanding – Undercoat - Putty - Sanding - Paint – Checking –Paint
External walls and ceilings	Cleaning - Sealer - Putty - Sanding-Undercoat Paint Putty Sanding - Paint – Paint

3-4-C-3-2 Acrylic Paint

The Contractor shall provide, store and apply emulsion paint to substrates with the following requirements complementary to the general specifications including all needed materials, accessories, tools and scaffolding.

Emulsion based semi-glass finish to be wed in water thinnable paint systems applied on interior and exterior walls and ceilings.

Recommended thinner	Sweet water
Volume of thinner	*0-5%*
Description	High quality semi-gloss water borne thixotropic paint based on a pure acrylic emulsion. Alkaline resistant.
Mass Density	Approx. 1.2g/cm^3
Solid Contents	Approx. 34-36% by volume depending on colors
Overcoating intervals	min. 2 hours
Flash point	> 65 degrees C - Din 53213
Type of application	Spray, brush or roller
Total thickness of paint	7 - 8.5 dry mils
Number of coats	To the satisfaction of the Engineer and the following minimum application
Plastered walls and ceilings	Cleaning - Sealer – Putty - Sanding- Primer - Putty - Sanding - Paint – Checking -Paint
Masonry Concrete	Cleaning - Masonry filler – Sanding – Primer - Putty - Sanding – Paint
External walls and ceilings	Cleaning - Sealer - Putty - Sanding-Primer Paint – Putty – Sanding – Paint

3-4-C-3-3 Oil Paint

The Contractor shall provide, store and apply oil paint to substrates with the following requirements complementary to the general specifications including all needed materials, accessories, tools and scaffolding.

Finishing coat in an alkyd system applied on interior and exterior walls and ceilings.

Recommended thinner	Thinner flash point = 39 degrees C
Volume of thinner	*0-5%*
Description	High glass coating on alkyd resins
Mass Density	Approx. 1.0g/cm^3
Solid Contents	40-50% by volume, depending on color
Overcoating intervals	min. 16 hours
Flash point	> 39° C - Din 53213
Type of application	Spray, brush or roller
Total thickness of paint	8 dry mils
Number of coats	To the satisfaction of the Engineer and the following minimum application.
Plastered walls and ceilings	Cleaning - Sealer – Putty - Sanding- Undercoat - Putty - Sanding - Paint – Checking -Paint
Masonrv Concrete	Cleaning - Masonry filler – Sanding –Undercoat - Putty - Sanding - Paint –
External walls and ceilings	Cleaning - Sealer - Putty - Sanding-Undercoat Paint Putty Sanding –Paint

3-4-C-3-4 Epoxy Paint

The Contractor shall provide, store and apply epoxy paint to substrates with the following requirements complementary to the general specifications including all needed materials, accessories, tools and scaffolding.

General purpose, epoxy based, corrosion resisting, adhesion primer for steel, galvanized steel, aluminum and synthetic.

Recommended thinner	Thinner flash point = 26°C
Volume of thinner	*0-5%*
Description	Epoxy solvent-free heavy abrasion and chemical resistant coating – Epoxy paint applied after Epoxy primer coating to the recommendation of the manufacturer.
Mass Density	Approx. 1.4g/cm^3
Solid Contents	57% by volume
Overcoating intervals	Approx. 7 days
Flash point	Base and hardener
Type of application	Spray, brush or roller
Total thickness of paint	Min. 140 microns cured film
Number of coats	To the satisfaction of the Engineer and the following minimum application
Plastered walls and ceilings	Cleaning - Sealer - Putty - Sanding-Undercoat - Putty - Sanding - Paint - Checking - Paint
Masonrv Concrete	Cleaning - Masonry filler - Sanding- Undercoat - Putty - Sanding - Paint
External walls and ceilings	Cleaning - Sealer - Putty - Sanding-Undercoat Paint - Putty - Sanding - Paint

3-4-C-3-5 Anti-Acid Paint

The Contractor shall provide, store and apply Anti-acid paint to the substrates with the following requirements complementary to the general specifications, with all needed materials, accessories, tools and scaffolding.

Epoxy enamel coating applied on interior and exterior walls and floors.

Recommended thinner	Depends on the epoxy paint Manufacturer's recommendation.
Description	Epoxy resin chemical coating highly resistant to extreme chemical attack, preferable bis-phenol type.

Solid Contents	Approx. 40% by volume
Pigment concentration	Approx. 20% by volume
Overcoating intervals	min. 8 hours
Flash point	26°C
Type of application	Spray, brush or roller
Number of coats	To the satisfaction of the Engineer and the following minimum application Cleaning – Primer – Paint

3-4-C-4 PAINT ON CONCRETE OR PLASTER

The Contractor shall prepare concrete or plaster surfaces to be painted as follows:

- Concrete or plaster surfaces shall be allowed to dry completely.
- Any signs of salt present shall be brushed away with steel brush then wait for a week. If salt reappears, it shall be brushed again and treated with phosphoric acid and zinc chloride.
- Check all cracks and holes in the concrete and putty them in a special mastic.
- Sand paper concrete and plaster surfaces.
- Clean concrete and plaster surfaces from all dust, sand, oil, etc.
- Surfaces shall receive one or more applications of putty filler until smooth surface is obtained to the Engineer's approval.
- Emulsion paint shall be applied by brush or roller and shall consist of a priming coat and two coats of paint internally and a priming coat and three coats of paint externally.
- Oil paint shall be applied by roller or brush and shall consist of a priming coat, two under coats and one finishing coat of paint.

The finishing coat of paint shall be applied after the completion of the electrical installation, sanitary work and false ceiling.

No oil paint shall be applied when the humidity exceeds 70% RH

3-4-C-4-1 Interior Oil Or Water Base Paint On Concrete Or Plaster With Mastic

After preparing concrete or plaster surfaces, painting shall be executed as follows:

- First coat - Prime coat (paste)
  - Apply first mastic layer. When dries, sand it with sand paper and clean it from dust.
- Second coat - 50% less fluid than the first coat.

- Apply second mastic layer. When dries, sand it with sand paper and clean it from dust.

– Third coat - Color coat as required.

- Check mastic and sand it with sand paper it, then apply mastic at needed locations.

Finally, apply two paint coats in conformity with the color approved by the Engineer either by brush or roller.

If the required paint is water base, mastic and prime coat shall be water base too. If the required paint is oil base, mastic and prime coat shall be oil base too.

3-4-C-4-2 Oil Or Water Base Paint On Concrete Or Plaster Without Mastic

After preparing concrete or plaster surfaces to be painted either inside or outside, painting shall be executed as follows:

– Applying a base coat with the required color.

– Repairing small holes with mastic then rubbing it with rough cloth until the textures matches the wall on it.

– Finally, applying two paint coats in conformity with the color approved by the Engineer either by brush or roller.

If the required paint is water base, mastic and prime coat shall be water base too. If the required paint is oil base, mastic and prime coat shall be oil base too.

3-4-C-4-3 Exterior Paint Protection On Concrete

Concrete surfaces shall be prepared to paint by a base coat, then paint brush with the required paint with one coat to reach a transparent cover, or two coats to reach a complete colored paint as required by the Engineer.

3-4-C-4-4 Coarse Texture Or Scratch Paint On Concrete Or Plaster

Interior or exterior concrete surfaces shall be prepared to paint by a base coat the same color as the final coat, then applying the paint either by the roller or spray as required by the Engineer.

3-4-C-5 WOODWORK

Woodwork shall be prepared for paint as follows:

– Wood shall be dry and humidity must be less than 12%

– Knots shall be sealed with knotting putty.

– Wood shall be rubbed and dusted off.

- Place special base layer on joints and leave until dry.
- Clean wood from all dirt.

3-4-C-5-1 Woodwork With Mastic

Woodwork to be painted shall be cleaned of impurities. Teak surfaces shall be cleaned with white spirit to remove free oil.

Knots shall be treated with two coats of knotting.

Items of rough woodwork, which are to be built into walls shall first be treated by twice coating with creosote or other preservative suitable for the position in which the timber is to be built.

The moisture content of wood at the time of painting should not exceed 18.%

Priming paint shall be applied by brush. Priming paint shall be applied on site after the Engineer's Representative has approved the joinery and before it is fixed.

When the priming, paint is dry, all cracks, holes, open joints and the like shall be filled with stopping and rubbed down with fine glass paper.

After preparing woodwork, it shall be painted as follows:

- First coat - Prime coat (paste) and saturate wood well.
  - Apply first oil base mastic layer. When dries, sand it with sand paper and clean it from dust.
- Second coat - 50% less fluid than the first coat.
  - Apply second oil base mastic layer. When dries, sand it with sand paper and clean it from dust.
- Third coat - Color coat as required.
  - Check mastic and sand it with sand paper, then apply mastic at needed locations.

Finally, applying two paint coats in conformity with the color approved by the Engineer either by brush or roller.

3-4-C-5-2 Wood Paint With Varnish Or Clear Lacquer

3-4-C-5-2-1 Varnishing

Woodwork to be varnished shall be cleaned and prepared as described in item above.

Where wood is required to have a clear finish the sanding shall follow the line of the grain.

Knots shall be treated with two coats of knotting.

Where shown on the drawings or require by the Engineer the wood shall be stained with an approved stain.

Before applying the second or third finishing coats of alkyd varnishes, then preceding coats shall be thoroughly dry and hard and shall be rubbed down with fine abrasive paper to get a smooth matt surface unless otherwise recommended by the manufacturer of the varnish.

Two or three coats of clear varnish shall be applied as recommended by the manufacturer of the varnish or as directed by the Engineer.

3-4-C-5-2-2 Lacquer To Wood

Woodwork to be lacquered shall be cleaned of impurities and rubbed down with fine -lass paper to a smooth finish, knots shall be treated with two coats of knotting and the whole surface filled with stained putty filler.

Where shown on drawings or required by the Engineer the wood shall be stained with an approved water and spirit stain.

Woodwork surfaces shall be rubbed down after filling and between coats of lacquer to obtain a surface of high quality to the Engineer's satisfaction.

Two or more coats of lacquer shall be applied by spray gun to obtain an approved standard thickness of finish.

3-4-C-6 METAL WORK

Metal shall be prepared for paint as follows:

- All metalwork shall be cleaned free from all rust, scales, grease, oils and any other surface stains and painted with one coat of priming paint applied by brush .
- Cracks and holes shall be filled with steel mastic and sand cleaned, then dusted.
- Two prime coats matches the specified color if possible.
- Two coats of finish paints as required by the Engineer.

Steelworks delivered to the Site primed shall be cleaned of impurities and damage to the priming paint made good with priming.

Metalwork which is concealed shall be. prepared and primed as above and shall be painted with two undercoats and one finishing coat of paint applied by brush.

In cases where protection coat against chemical effects such as chlorine is used (Chlorine bottle’s door room), special prime and base paint shall be used to resist such effects as approved by the Engineer.

3-4-C-7 SAFETY & CLEANLINESS

Unless specified otherwise, the Contractor shall:

keep all painted works until the end of the project. In case of damages or deterioration, the Contractor shall repair them on his own expense as required by the Engineer.

During progress of work, remove from site discarded materials, rubbish, cans and rags at end of each work day.

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 otherwise damage finished surfaces.

Protect work of other trades whether to be painted or not, against damage by painting and finishing work. Correct damage by cleaning, repairing or replacing, and repainting, as directed by the Engineer.

Provide "Wet Paint" signs in Arabic/English and laborers' native languages as required to

protect newly-painted finishes. Remove temporary protective wrappings provided by others for protection of their work, after completion of painting operations.

At completion of work by other trades, touch-up and restore all damaged or defaced painted surfaces

Finally, at the end of the project, the Contractor shall deliver all paint work in a perfect way.

3-4-D NATURAL STONE CLADDING

3-4-D-1 NATURAL BUMP STONE

Stone shall be from the best quarries and approved by the Engineer.

It shall meet the following requirements:

- No hollow sounding.
- Free of defects.
- Weighs at least 2.5
- Breaking strength greater than 600 Kg/cm²

Natural bump stone shall not be affected by ice or any porosity signs. The size of stones shall follow the requirements of the drawings.

The Contractor shall submit a sample for the Engineer's approval and shall stay at site during the whole period of cladding.

3-4-D-2 BUSH HAMMER NATURAL STONE

Stone shall be from the best quarries and approved by the Engineer.

Stone shall not be affected by ice and shall be free of any scratches, cracks or defects to give an even appearance. Under the hammer, stone shall give a clear sound.

It shall meet the following requirements:

- Resistance to breaking: 600Kg/cm² at least.
- Weighs: 2.5 at least.

The Contractor shall submit a sample for the Engineer's approval and shall stay at site during the whole period of cladding.

3-4-D-3 MORTAR

Mortar for laying the stone and pointing shall be composed of 600 kg CPA 250/315 cement for 1 cubic meter of sand. The thickness is 3 cm of the mortar after stone has been laid. The quantity of water to be used in the preparation of mortar shall be only that required to produce a mixture sufficiently workable for the purpose intended. Mortar shall be used as soon as possible after mixing and shall show no visible signs of setting prior to use. Retempering of mortar will not be permitted.

The materials of mortars shall be measured out in their correct proportions and shall first be thoroughly mixed together in a dry state by turning them over upon a clean wooden stage until they are of a homogeneous appearance in consistency and color. Clean water shall then be added while the mixture is being turned over until it.

Part III-5 : METAL WORKS

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PART 3.5 - CIVIL & ARCHITECTURAL WORKS: METAL WORKS

3-5-A STEEL DOORS/WINDOWS

See part III-4- Doors and windows.

3-5-B HARDWARE

Hardware sets, hinges, bolts, doors closers, door stops, signs and other items of hardware, unless otherwise specified, shall be satin, anodised aluminum finished. Door hinges shall comply with BS 7352 whereas locks and latches shall comply with BS 8572. Door lock, latch lever and knob furniture are to be products of one approved manufacture.

For all hardware to be used, samples shall be submitted to the Engineer for approval.

3-5-C GRILLS, SCREENS, ETC.

All grills, screens, protective meshes, louvers and guards shall be obtained from an approved manufacturers and shall be entirely suitable for their purpose.

All ferrous metal shall be galvanized, sherardized or coated with bonded zinc. All non-ferous metal shall be finished with an appropriate process to minimize corrosion.

3-5-D COVERS AND FRAMES

Covers recessed for floor finishes shall be provided with galvanized rolled steel angles of height equal to the thickness of floor finishing and fixed to the surface of the structural floor slab along all edges of the trenches so that the top edge is level with the finished floor level. The angles shall be laid so as to form seatings for covers and all additional galvanized rolled steel tee. Sections shall also be provided to support the duct covers.

The covers shall be galvanized to suit the ducts and the seatings described above. A lightweight galvanized steel mesh shall be fixed to the upper surface of the trays to provide a key for floor finishes. The seatings and the trays shall be laid that the finished floor is perfectly level and all trays fully supported at all edges without the use of loose packings. At least one tray in every series of trays covering a length of duct shall be provided with cast-in lifting eyes and a pair of suitable lifting keys. The above shall be handed to the Engineer on completion.

3-5-E FENCES AND GATES

Fences generally shall be in accordance with the relevant parts of BS 1722 Part 1 1986.

Chain link fencing shall be Type PLC.213 Grade A with high plastic covered chain link mesh. The mesh and line wires shall be galvanized prior to being plastic covered.

The straining posts, intermediate posts shall be manufactured and erected complete as specified in BS 1722. The fencing shall be true to line and vertical, following the profile of the ground, previously graded so as to prevent access beneath the bottom wire.

Gates shall be hung on reinforced concrete column, and shall be truly vertical.

Ornamental fabricated metalwork fences and gates shall be constructed of mild steel bar, strip or tube in accordance with the Drawings. All welded joints and drillings for bolts shall be made before painting, and all bolts, nuts and washers shall be galvanized or plated with two coats of bituminous paint.

3-5-F STRUCTURAL STEELWORK

Material for structural steelwork and workmanship shall comply with french standards. 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, mild steel electrodes and high yield steel as well as all structural steel fabrication shall comply with French Standards.

All structural steelwork shall be fabricated using welded joints where possible for shop joints and bolted for field assembly.

3-5-G STAIRCASES

Staircases shall be suitable for superimposed load of 5kN/m² calculated on the plan area of the stair.

Open mesh type flooring shall be used for the treads and on the landings.

Stairs and landings shall be guarded on each side with a continuous handrail which shall be between 840 mm and 1000 mm in height on stairs measured from the tread nosings, and 1000 mm high on landings.

The riser / go dimensions shall fit the formula:

Twice the riser plus ONE TREAD = not less than 570 mm nor more than 635 mm. Consecutive treads shall overlap by not less than 16mm or as shown on the drawings.

3-5-H LADDERS

Ladders shall comply with BS 4211 and shall be of galvanized steel.

Stringers shall be extended 1000 mm above the upper platform and suitably opened out for access, or where ladders are below manhole covers, separate hand holds shall be fixed to the upper platform.

After fabrication, ladders under manhole covers shall dipped with hot galvanized.

3-5-I HANDRAILING

Handrailing shall be designed for horizontal loadings.

Standards and rails shall be manufatured from black mild steel or from extruded aluminum alloy approved by the Engineer. The nominal bore of steel tubing shall not be less than 32 mm.

Adequate provisions shall be made for thermal movement.

Steel handrailing shall be hot dip galvanized after fabrication.

3-5-J RAILWAY

This work shall consist of furnishing and installing railways as and where shown on the drawings or as directed by the Engineer. The anchorage system shall be approved by the Engineer. The Contractor shall submit to the Engineer's approval all the elements and dimensions of the railway. The materials of construction of the railway shall be structural steel.

Structural steel used for railings shall conform with the requirements of the AFNOR.

All elements shall be protected by zinc coating (galvanizing, refer to paragraph below).

The anchorage system shall be such that damaged metal posts and rails can be readily replaced without the need for cutting or coping edge unit into which the anchorage is located.

During erection the railway units shall be securely held in their correct positions until all connections and fixings are complete and the post fixings have gained adequate strength to develop the full holing down moment. The assessment of the adequacy of the post fixing shall be subject to the Engineer's approval. The finished railways shall be true to line and level throughout their length.

3-5-K STEEL ACCESS COVERS

Steel access covers shall be to the duty required and sized to suit the opening shown on the Drawings. They shall be complete with frame and shall be weatherproof (prevent the ingress of water) when closed and shall in all respects be strong and durable.

The covers shall be hinged and lockable and provided with stays to prevent the covers opening more than 105°. The Contractor shall provide with each cover a heavy duty non-corrodible padlock and four keys.

The covers and frames shall be galvanized or painted.

3-5-L GALVANIZING

Where galvanizing 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 .

All items to be protected shall be prepared as specified in the above standards.

Articles altered as the minor alternations at site or requiring minor repair at site shall be wire brushed to remove all rust and coated with 3 coats of approved zinc rich cold galvanized compound.

The minimum weight of coating and other requirements shall be as shown in the following table. If there is a conflict between the ASTM and minimum weight columns, the minimum weight column shall apply. The weight shown is ounces per square foot of surface area. The weight of coating shall be determined in accordance with ASTM A 90, modified to determine the coating of each surface separately. All surfaces, when tested separately, shall meet the minimum requirements.

Material	ASTM	Minimum Weight of Coating (oz./sq.ft.)
Steel products including structural shapes, tie rods, handrails, manhole steps, and miscellaneous items.	A 123 A 153 B 633 B 695	2.00 2.00 2.00 2.00
Hardware including cast, rolled, pressed and forged articles.	A 153 B 633 B 695	2.00 2.00 2.00
Bolts, screws, nuts and washers	A 153 B 633 B 695	1.25 1.25 1.25
CSP culverts and underdrains	A 444	1.00
Chain link fence fabric, tie wire only	A 392	1.20
Steel pipe (includes fence posts, braces and rails)	F 1083	1.80
All other chain link fence articles	A 123	1.80
Iron or steel wire fencing	A 116	0.80
Steel or iron sheets	A 525	1.20
Barbed wire	A 121	0.80
Electrolier standards, 7 gage steel and over	A 386	2.00
Electrolier standards, under 7 gage steel	A 386	1.50

The zinc coating shall adhere tenaciously to the surface of the base material. The finished product shall be free from blisters and excess zinc, and the coating shall be even, smooth and uniform throughout. Machine work, die work, cutting, punching, bending, welding, drilling, thread cutting, straightening, and other fabricating shall be done as far as is practicable before the galvanizing. All members, nuts, bolts, washers, etc. shall be galvanized before a structural unit is assembled. All uncoated spots or damaged coatings shall be cause for rejection.

Products that are warped or distorted to the extent of impairment for the use intended shall be rejected.

Zinc coating which has been field or shop cut, burned by welding, abraded, or otherwise damaged to such extent as to expose the base metal, shall be repaired and recoated by one of the following methods :

3-5-L-1 HOT-DIP PROCESS

The damaged areas shall be thoroughly stripped and cleaned and a coating of zinc shall be applied by the hot-dip process.

3-5-L-2 METALIZING PROCESS

This process can not be used unless the Contractor has the approval from the Project Manager.

The damaged area shall be thoroughly cleaned by blasting with sharp sand or steel grit. The blasted area shall lap the undamaged zinc coating at least ½ inch.

Zinc wire containing not less than 99.98 percent zinc shall be used in the metalizing operation. A zinc coating shall be applied to the damaged area with a metalizing gun

to a thickness of not less than 0.005 inch on the damaged area, and shall taper to zero thickness at the edge of the blasted undamaged section.

3-5-M WELDING

3-5-M-1 QUALIFICATION

In addition to the welding of structural steel, all welding shown on the plans or ordered by the Engineer shall conform to the Standard Specifications for Welded Highway and Railway Bridges of the American Welding Society.

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, Part II, or such other qualification test acceptable to the Engineer. If required by the Engineer, the Contractor shall submit identifying stenciled test coupons made by any operator whose workmanship is subject to question. The Contractor shall require any welder to retake the test when, in the opinion of the Engineer, the work of the welder creates a reasonable doubt as to the proficiency of the welder. Tests, when required, shall be conducted at no additional expense to the Employer. Recertification 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 twelve (12) month period.

3-5-M-2 INSPECTION OF WELDS

Radiographic inspection of welds will be required, as specified in the current edition of the Standard Specifications for Welded Highway and Railway Bridges of the American Welding Society. Additional welds to be inspected radiographically will be specified on the plans.

When specified on the plans, other methods of nondestructive inspection of welds will be required.

The Contractor shall secure the services of an approved organization qualified in the inspection of welds and will bear the cost of this inspection service.

Inspection of all welds shall be done only by persons skilled in such inspection and who are acceptable to the Engineer. The Engineer shall review and interpret radiographs and other non-destructive or destructive testing and has the sole authority to accept or reject the inspection or Works.

All film and/or other records of weld inspection shall become the property of the Employer.

In the inspection of welds, the presence of any of the following defects in excess of the specified limits will result in rejection of the weld as being detective:

(1) Cracks. Cracks, regardless of length or location, will not be allowed.

(2) Overlaps. Overlaps, lack of penetration or incomplete fusion will not be allowed.

(3) Inclusions, Including slag, Porosity and Other Deleterious Materials. Inclusions less than one and one-half (1.5) millimeters in the greatest dimension will be allowed if well-dispersed, such that the sum of the greatest dimensions of the inclusions in any twenty-five (25) millimeters of welded joint does not exceed nine and one-half (9.5) millimeters and there is no inclusion within twenty-five (25) millimeters of edge of a joint or a point of restraint.

(4) Inclusions, Including Slag, Porosity and Other Deleterious Material. Inclusions one and one-half (1.5) millimeters or larger in greatest dimension will be allowed provided that such defects do not exceed the following limits:

(a) Six and one-half (6.0) millimeters, for T up to nineteen (19) millimeters, one-third(1/3) T, for T from nineteen (19) millimeters to fifty-seven (57) millimeters, nineteen (19) millimeters, for T over fifty-seven (57) millimeters, where T is the thickness of the thinner plate being welded.

(b) Any group of inclusions in line that have an aggregate length greater than T in a length of twelve (12) T will not be allowed.

Defects shall be removed by mechanical means or by oxygen grooving, after which the joints shall be welded again.

Part IV : Mechanical Works

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PART 4 - MECHANICAL WORKS

4-A INTRODUCTION

This Specification sets out the general standards of the Facilities to be supplied by the Contractor and mention of any specific Plant and Equipment does not necessarily imply that such is included in the Facilities.

All component parts of the Facilities shall, unless specified otherwise, comply with the provisions of this Specification.

The names of the manufacturers of the Plant and Equipment proposed for incorporation in the Facilities together with performance, capacities, certified test reports and other significant information shall be provided, when requested, for consideration by the Engineer. The Engineer shall have power to reject any Plant and Equipment which in his opinion is unsatisfactory or not in accordance with this Specification and such Plant and Equipment shall be replaced by the Contractor at no extra cost to the Buyer.

4-B STANDARDS

All ductile iron pipes, pieces, joints, connections, parts and accessories shall comply with the following Standards, Norms and Specifications:

Pipes:	NF A 48-801, NF A 48-806, NF A 48-841, ISO 2531, EN 545-2002, EN598.
Connections and joints:	NF A 48-863, NF A 48-842, NF A 48-830, NF A 48-860, NF A 48-870, BS EN 545-1998, ISO 2531.
Joint's fittings:	NF T 47-305, ISO 4633
External Protection (Zinc coating):	NF A 48-852, ISO 8179
External Protection (Bituminous coating):	EN 545-2002, EN 598
Internal Protection (Cement mortar):	NF A 48-901, NF A 48-806, ISO 4179, EN 545, EN 598.
Excellency of Productions and Installations:	ISO 9001
Testing:	ISO 2531
Special Protection (Polyethylene):	ISO 8180

4-C GENERAL PLANT DESIGN MATERIALS AND WORKMANSHIP

4-C-1 PLANT DESIGN

Plant shall be new, of sound workmanship and robust design, and of a grade and quality suitable for the climatic and working conditions at the Site.

Due attention shall be given to expansion due to temperature changes, the stability of paint finish for high temperatures, the rating of engines, electrical machinery, thermal overload devices, cooling systems, and the choice of lubricants for the possible prolonged high operating temperatures. Suitable precautions, such as lagging or trace heating, shall be taken where necessary for protection against damage by frost.

Plant shall be designed to provide protection against damage by the entry of vermin and dust, and to minimize fire risk and consequent fire damage. It shall also be protected against damage due to dampness and condensation by sealing or temperature compensation.

All manually controlled Plant located outside a building shall be provided with facilities for making it tamperproof. This is in addition to any requirements for securing Plant under operational conditions.

All component parts of Plant shall be manufactured to strict limits of accuracy and shall be interchangeable with the component parts of similar Plant.

Plant shall be designed for continuous operation for prolonged periods with a minimum of maintenance and shall have a high resistance to change in these properties due to passage of time, exposure to light or any other cause which may affect the performance or life of the Works. Tenderers should be called upon to demonstrate this for any equipment under consideration either by service records of similar equipment, or by the records of extensive type tests.

Materials shall be selected taking into consideration their location and duty. In the case of Plant conveying water, particular attention shall be given to the risk of electrolytic reaction between differing materials of construction and to the effects of corrosion and, where there are impurities in the water, erosion.

Where wear is likely to occur during normal operation, the Plant shall be designed to enable a potentially affected area of a component part to be replaced without replacing the whole component. No part subject to wear shall have a life from new to replacement or repair of less than one year of continual operation. Where major dismantling to replace a part cannot be avoided, the life of such parts shall not be less than 5 years.

4-C-2 SUBSTANCES AND PRODUCTS

Substances and products used in the Works which may be applied to or introduced into water which is to be supplied for drinking, washing or cooking shall not contain any matter which could impart taste, odor, color or toxicity to the water or otherwise be objectionable on health grounds.

4-C-3 METALS

Unless stated otherwise cast iron shall be gray iron to ISO 185 Grade 220.

Mild steel shall be to ISO 1052.

Stainless steel shall have a corrosion resistance, in the relevant environment, not less than required for steel in accordance with ISO 683 - 13. The minimum grades of stainless steel used shall be:

a- Submerged conditions; Austenitic grade 316S12

b- Exposed to the ambient atmosphere; Martensitic grade 416S21

Stainless steels used for welding shall be a grade not subject to inter-granular corrosion.

Prevention of seizure, by fretting where two corrosion resistant metals are in contact, shall be by selection of suitable relative hardness and surface finish and/or lubrication.

Where bronze is specified, or used, it shall be zinc free.

Dissimilar metals in contact shall be selected so that the electrolytic potential difference does not exceed 0.6 volt unless the surface area of the lower potential metal is negligible. Alternatively an approved insulation material shall be used.

When the Engineer requires the submission of material samples for assessment they shall be submitted by and at the expense of the Contractor not less than thirty calendar days prior to the time that the material is required for incorporation into any Plant and Equipment. Samples shall be subject to written approval by the Engineer and shall not be used without such approval.

4-C-4 WELDING

Metal arc welding shall comply with ISO 3834.

In all cases where welds are liable to be highly stressed the Contractor shall supply to the Engineer before fabrication commences detailed drawings of all welds and weld preparations proposed. No such welding shall be carried out before the Engineer has signified his approval of the details proposed. No alteration shall be made to any previously approved detail of weld preparation without prior approval of the Engineer.

All other welding shall be carried out by welders qualified in accordance with the requirements of the appropriate section of ISO 9606.

Radiographic examination which may be required of highly stressed welds shall comply with the provisions of ISO 1106 or ISO 2504, except as otherwise specified or ordered by the Engineer.

Mechanical and other non-radiographic tests, if required, shall be carried out in the presence of the Engineer.

All welded constructions shall be heat treated to relieve residual stresses prior to finish machining.

4-C-5 CASTINGS

The structure of the castings shall be homogeneous and free from non-metallic inclusions and other defects. All surfaces of castings which are not machined shall be fettled to remove all foundry irregularities.

Minor defects not exceeding 10 mm in depth or 10% of total metal thickness whichever is less or which will not ultimately affect the strength and serviceability of the casting may be repaired by welding. If the removal of metal for repair should reduce the stress-resisting cross-section of the casting by more than 25%, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25%, then that casting shall be rejected.

Castings repaired by welding for major defects shall be stress-relieved after such welding, or as otherwise instructed in writing by the Engineer.

Non-destructive tests may be required for any casting containing defects whose effect cannot otherwise be established, or to determine that repair welds have been properly made.

Unless otherwise specified castings shall be produced to the following standards:

Flake graphite cast iron	BS 1452 Grade 220
Carbon steel	BS 3100 Steel alloy
Stainless steel	BS 3100 Steel 316C16
Copper & copper alloy	BS 1400 Group A grade LG2 Group B grade CT1, AB2 Group C grade G1

4-C-6 FORGINGS

All major stress-bearing forgings shall be made to a standard specification which shall be submitted to the Engineer for approval before work is commenced. They shall be subject to internal examination and non-destructive tests for the detection of flaws, and shall be heat-treated for the relief of residual stresses. The name of the maker and particulars of the heat treatment proposed for each such forging shall be submitted to the Engineer. The Engineer may inspect such forgings at the place of manufacture with a representative of the Contractor.

4-C-7 BALANCING

All complete rotating assemblies shall be dynamically balanced. Balance quality shall not be less than G6.3 in accordance with ISO 1940/1

4-C-8 NON-METALLIC MATERIALS

Fabrics, cork, paper and similar materials which are not subsequently to be protected by impregnation, shall be treated with a fungicide. Sleeving and fabrics treated with linseed oil varnish will not be permitted.

The use of organic materials shall be avoided as far as possible but where these have to be used they shall be treated to make them fire resistant and non-flame propagating.

The use of wood shall be avoided as far as possible. If used, woodwork shall be thoroughly seasoned teak or similar hardwood which is resistant to fungal decay and other blemishes. All woodwork shall be treated to protect it against damage by fire, moisture, fungus, vermin, insect, bacteria or chemical attack, unless it is naturally resistant to all these. All joints in woodwork shall be dovetailed or tongued and pinned. Metal fittings on wood shall be of non-ferrous material. Adhesives shall be impervious to moisture and fungus growth. Synthetic resin cement only shall be used for joining wood. Casein cement shall not be used.

4-C-9 BOLTS, SCREWS, STUDS, WASHERS AND NUTS

Bolts, screws, studs and nuts shall comply with ISO 225, ISO 272, ISO 885, ISO 888, ISO 898, ISO 8992 and ISO 4759/1. Washers complying with ISO 887 and ISO 4759/3 shall be used under all nuts and hexagon bolts and screws.

Bolts, screws, nuts and washers exposed to the weather or in damp atmospheres inside buildings shall be zinc coated and painted or stainless steel.

Zinc coated items shall be hot dip galvanized, in accordance with ISO 1459, ISO 1460 and ISO 1461, and centrifuged. The threads of nuts shall be cut oversize.

Stainless steel items shall be manufactured from Grade 316S31.

Bolting for pipes and fittings shall comply with ISO 7005. Spheroidal graphite iron bolts for use with ductile iron pipes and fittings shall be manufactured from iron complying with ISO 1083.

Bolt lengths shall be sufficient to ensure that nuts are full threaded when tightened in their final position.

4-C-9-1 Fixing Bolts

Fixing bolts, nuts and washers for concrete, brick or masonry shall be of stainless steel. The bolts may be rag or indented bolts, expansion bolts, or resin bonded bolts. The Contractor shall submit details of the type he proposes to use, including manufacturer's specification literature, for the Engineer's approval.

When the bolts etc., are used for fixing aluminum items they shall be insulated from the aluminum by a non-metallic sleeve and under-washer.

The building-in material for use with rag or indented bolts shall be a proprietary epoxy non-shrink grout or a proprietary non-shrink mortar or caulking compound. Bolts shall not be brought into service until they are effectively anchored and the building in material has achieved adequate strength.

4-C-10 SAFEGUARDING PLANT

All designs and equipment shall be safe. The installation layout and plant design shall not allow any item of plant to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of hot pipes, valve hand wheels, air vents and rotating machinery.

4-C-11 RATING PLATES, NAME PLATES AND LABELS

Each main and auxiliary item of Plant and equipment shall have permanently attached to it in a conspicuous position a nameplate and rating plate. Upon these shall be engraved the manufacturer's name, direction of rotation, type and serial number of plant, details of the loading and duty at which the item of Plant has been designed to operate, and such diagrams as are deemed necessary. All indicating and operating devices shall have securely attached to them or marked upon them designations as to their function and proper manner of use. Provision shall be made to incorporate descriptive numbering codes.

All valves shall have an identification plate bearing the valve number and a short description of valve function.

Nameplates, rating plates and labels shall be of a non-flame propagating material, either non-hygroscopic or transparent plastic, with engraved lettering of a contrasting color. Fixing shall be by means of screws. No drive rivets or adhesives shall be used.

4-C-12 LUBRICATION

4-C-12-1 General

Provision shall be made for suitable lubrication to ensure smooth operation, heat removal and freedom from undue wear. Plant selected shall require minimum lubrication attendance and down time for lubricant change.

All grease nipples, oil cups and dip sticks shall be readily accessible, being piped to a point as near as practicable to the lubrication point.

4-C-12-2 Oil Lubrication

Gear boxes and oil baths shall be provided with adequately sized filling and draining plugs and suitable means of oil level indication.

Roller chain drives shall have oil bath reservoir lubrication.

Drain points shall be located or piped to a position such that an adequately sized container can be placed beneath them. Where a large quantity of oil is involved or drainage to a container difficult, a drain valve and plug shall be provided at the point of discharge.

Bearings equipped with forced fed oil lubrication shall be automatically charged prior to machinery starting up and pressure monitored during operation with automatic shutdown of machinery and alarm on low oil pressure.

All points where oil leakage may occur shall be suitably trapped to prevent oil contamination of water. Oil filling and drain points shall be arranged so as to avoid the risk of contamination of water by accidental spillage.

Access, without the use of portable ladders, to lubrication systems shall be such as to permit maintenance, draining and re-filling, without contamination of the charged lubricant.

The design of breathers shall take into account the humidity and atmospheric contamination at the vent point and measures be incorporated to prevent contamination of the lubricant.

4-C-12-3 Grease Lubrication

Grease application shall be by steel lubrication nipples.

Anti friction bearings requiring infrequent charging shall be fitted with hydraulic type nipples.

Plain bearings requiring frequent charging shall be fitted with button head pattern nipples.

A separate nipple shall be provided to serve each lubrication point. Where a number of nipples supply remote lubricating points they shall be grouped together on a conveniently placed battery plate.

4-C-13 GASKETS AND JOINT RINGS

Joint rings suitable for hot or cold water or specified hydrocarbon fluids or for drainage applications shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80 C, or greater to suit the application.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Graphite grease or similar shall be applied to the threads of bolts before joints are made.

4-C-14 ELECTROPLATING, GALVANIZING AND SHERARDIZING

Hot dip galvanizing shall be carried out with a deposition rate of at least 460 g/square meter. After galvanizing all parts shall be passivated to minimize discoloration.

Electroplating or galvanizing will be acceptable as an alternative to painting for small ferrous components.

All fixing bolts, washers, nuts and other fixings required for erection shall be spun galvanized, or sherardized unless otherwise specified. Stainless steel shall be used in wetted areas.

4-C-15 NOISE

No item of Plant intended for installation in a building shall produce a sound pressure level exceeding 85 dB (A) and preferably 56 dB(A) when measured at a distance of 1 m from the reference surface of that item in a horizontal direction and under environmental conditions appropriate to the test requirements of I.S.O. 3746 "Acoustic Determination of Sound Power Levels of Noise Services - Survey Methods".

Plant such as compressors, diesel engines, blowers etc. where reduction of noise emission to below 85 dB at 1 m is impractical will be installed in a separate room constructed in or containing sound absorbing material.

4-C-16 VIBRATION

All items of rotating machinery shall be dynamically balanced so that the level of vibration is within the limits set by BS4675, Pt 1, for a class IV machine to grade B.

This limit on vibration shall extend to the communicating pipework and mounting arrangements and include adjacent machinery either in operation or not.

4-C-17 ACCESS STEELWORK

Gaps between items of Plant and the surrounding structure shall be covered, and access ladders, platforms and handrails must be attached to items of Plant to facilitate operation, inspection or maintenance.

Adequate access shall be provided to all hand wheels, sight glasses, gauges, lubrication points and any other items to which access is necessary for routine maintenance.

Handrails shall consist of double ball forged steel standards with tubular rails. Chequer plating shall be of 'Durbar' or other non-slip pattern, not less than 4.5 mm thick (exclusive of pattern).

Diamond type pattern chequer plate shall not be used. Open type or solid type chequer plate flooring shall be used as appropriate for the location, taking into account ease of cleaning, precautions against slipping and areas below walkways.

All components for access steelwork shall be hot dip galvanized after manufacture.

4-C-18 HANDRAILING

Handrailing shall be double rail 1,100 mm high and 900 mm high on stairs measured vertically from the nose of the tread.

In case of no special requirements of the Engineer or on drawings, standard handrailing shall be 38 mm diameter solid forged steel with 60 mm diameter solid forged steel balls at handrail locating points. Standards shall have a minimum base width of 65 mm and be set at maximum 1 800 mm centers.

Handrails shall be 33.7 mm OD x 3.2 mm thick tubular steel Joints shall be arranged to coincide with the spacing of standards where possible, otherwise they shall have butt joints with a tubular steel ferrule, plug welded or fixed with a 5 mm diameter countersunk head pin.

Removable sections of handrail shall have half-lap joints secured with a countersunk head pin.

Chains across openings shall be 10 mm x 3 links per 100 mm galvanized mild steel. The hooks and retaining eyes shall be securely fixed to the balls of the standards.

All components for handrailing shall be hot dip galvanized after manufacture.

4-C-19 PAINTING AND PROTECTION

4-C-19-1 General

Protective coatings shall comply with BS 5493 "Code of practice for the protective coating of iron and steel against corrosion" except as otherwise specified in this section. For coatings designed to BS 5493 exterior conditions shall be assumed to be "polluted inland" conditions and the interiors of buildings shall be assumed to be "frequently damp or wet" except for control rooms. The thickness of coatings stated in this section of the specification is the minimum allowable thickness as defined in Clause 19 of BS 5493. Where the paints that are available do not provide dry film thickness as specified additional coatings shall be applied. Protective coatings for surfaces of tanks and other plant in contact with chemicals or otherwise in conditions not foreseen in this section of the specification or in BS 5493 shall be suitable for those conditions and shall be the subject of design submissions supported by evidence proving satisfactory experience of the proposals elsewhere.

Where dissimilar metals are in contact, insulation shall be provided to prevent electrochemical corrosion.

The protective coating system shall have a minimum 10 year life to first maintenance. A five year minimum performance warranty shall be given in respect of the paint as applied.

All coatings applied to any part of the plant in contact with water to be used for drinking, washing or cooking shall be non-toxic, non-carcinogenic, shall not impart taste, odor, color or turbidity to the water or foster microbial growth and they shall be approved by an international recognized authority for use on potable water.

To avoid the possibility of the presence of carcinogenic polyaromatic hydrocarbons all bituminous paints and coatings must be manufactured from petroleum or asphaltic bitumen and not from coal tar bitumen.

Lead based paints shall not be used.

All machined, polished or bright surfaces, both external and internal, shall be afforded suitable and adequate protection against corrosion, damage and deterioration.

No manufacturer's name plate identification, vented filler plugs in gearboxes or grease nipples shall be painted over.

Steel subject to hydrogen embrittlement through galvanizing shall not be used.

All iron and steelwork to be painted shall be blast cleaned to achieve a surface profile with a minimum amplitude of 0.025mm and a maximum of 0.100mm.

Following blast cleaning, steel surfaces shall be pure zinc metal sprayed where specified.

Aluminum structures and fittings shall not necessarily be painted.

All steel fabricated pipework and other plant, where specified, shall have a lining and coating, not less than 250 microns thick, of 100% solids, thermosetting fusion bonded, dry power epoxy coating.

GRP covers and guards shall be pigmented to give the finished color without painting.

4-C-19-2 Coating Systems

Tables A and B identify the coating systems to be used and minimum coating thickness.

TABLE A: REQUIRED COATING SYSTEMS AND MINIMUM COATING THICKNESSES FOR PLANT AND EQUIPMENT

	APPLIED PRIOR TO DELIVERY AND ERECTION					APPLIED FOLLOWING INSTALLATION
	SUBSTRATE	**PRETREATMENT**	**FIRST COAT**	**SECOND COAT**	**THIRD COAT**	**FINISHING COAT**
ABOVE WATER LEVEL Machinery & Steelwork not in contact with Sewage, sludge or Water to be used for drinking, washing or cooking	Steel (galvanized)	Etch Prime or T Wash	Zinc Phosphate/CR Alkyd Primer Undercoat (0.050mm)	High Build Chlorinated rubber Paint (0.075mm)		High Build chlorinated rubber paint (0.075mm)
	Steel Zinc Sprayed (0.070mm)	Etch Prime				
	Steel, Cast iron, Ductile iron	Blast clean BS 4232 2nd quality	Zinc Phosphate/CR Alkyd Blast Primer (0.050mm)	Zinc Phosphate Alkyd Primer (0.050mm)	High Build Chlorinated Rubber (0.075mm)	
BELOW WATER LEVEL Machinery and Steelwork in Contact with Water to be used for drinking, washing or cooking	Steel (Galvanized)	Etch Prime or T Wash	Epoxy Primer High Build (0.125mm)	Epoxy High Build (0.50mm)	Epoxy High Build (0.075mm)	
	Steel, Cast iron, Ductile iron Zinc Sprayed (0.70mm)	Etch Prime				
Pipework	Steel	As specified				
Switchboard Shells, Frames and Backplates	Steel	As specified				

TABLE B: REQUIRED HEAT RESISTANT COATING SYSTEMS FOR STEELWORK

WORKING TEMPERATURE	AL: SURFACE TREATMENT	FIRST COAT	SECOND COAT	THIRD COAT
50°C to 175°C	Blast clean BS 4232 2nd quality	Polyvinyl Butyral (0.025mm) Zinc Chromate Primer (0.023m-0.015mm)	Aluminum heat resistant @ 200°C (0.025mm)	Aluminum heat resistant @ 200°C (0.025mm)
175°C to 500°C	Blast clean BS 4232 2nd quality	Aluminum pigmented silicone heat resistant (0.025mm)	Aluminum pigmented silicone heat resistant (0.025mm)	
	NB A minimum temperature of 350°C within a short time after application is required.			

4-C-20 MACHINERY, LIFTING AND DISMANTLING

Machinery bedplate design, packing and fixing shall be such as to minimize distortion and vibration. Aligned machinery shall be mounted on either bed or sole plates, permitting removal and reinstatement without a requirement to re-grout. Bedplates shall incorporate fine adjustment of the vertical and horizontal alignment between driver and driven members.

All machinery shall be fitted with lifting facilities. Large structures shall be provided with jacking points.

Tapped holes or other provision must be made in all main castings, for the insertion of jacking screws or the fixing of drawing gear to facilitate dismantling on items of machinery subject to frequent dismantling. Bolts or studs shall be employed in preference to set screws.

4-C-21 SEALS

4-C-21-1 General

Seals compatible with the Plant and best suited for the worst conditions likely to be met when the Plant is in operation shall be selected.

All seal materials shall be compatible with and/or resistant to the fluid or gas being handled. For potable water, seal materials shall be specifically approved.

4-C-21-2 Soft Packed Glands

Shafts shall be provided with renewable gland sleeves. Glands subject to abrasive liquors or negative pressures shall embody suitably positioned lantern rings and a clean water continuous flushing system, operative whenever the Plant is in motion.

Gland adjustment nuts shall be readily accessible for routine maintenance.

Gland drain pipework, shall be installed, incorporating rodding facilities and adequate inclines, of 25mm minimum diameter on water reclamation plant and 12.5mm on water supply plant, discharging to the nearest sump or drainage channel.

4-C-21-3 Mechanical Seals

Mechanical seals which are subject to abrasive liquor or gas, negative pressures or corrosive elements, shall be provided with a clean water continuous gland flushing system, operative when the item of plant is in motion or the corrosive element present. A back-to-back sealing arrangement with a flushing/cooling system shall be accepted as satisfying the requirements of this clause.

4-C-22 BEARINGS

4-C-22-1 Below Water Bearings

The Contractor shall select the most appropriate type of bearing for the Plant being supplied.

Equipment with vertical shafts shall have thrust and guide bearings. All bearings shall be designed to exclude the ingress of dust and water.

Sealed for life units are acceptable subject to a minimum design life of 50,000 hours operation at maximum loading.

Plant which may be subject to vibration whilst stationary shall be provided with bearings designed to withstand damage from such a cause.

Below water bearings shall be of the journal type, of ferrobestos, gunmetal or equivalent and journals of stainless steel.

4-C-22-2 Above Water Bearings

Single journal plain bearings shall be phosphor bronze or synthetic lubrication impregnated bushes with carbon or stainless steel journals respectively. Synthetic bearings shall only be used where bearing condition can be inspected readily.

Plain type bearings shall be self-lubricating by either grease, forced oil or impregnation.

Ball and roller type bearings shall be adequately lubricated by oil or grease and sealed to prevent leakage of lubricant along the shaft. Attention shall be given to ensure the dismantling of bearings is simple and free from risk of damage.

Bearings fitted to gear boxes shall a minimum design life of 100,000 hours at maximum loading.

4-C-23 GEARBOXES

Where driven plant requires a drive system incorporating a speed reducing or increasing gearbox, the drive system shall be supplied by the driven plant manufacturer.

The gear form shall be in accordance with the relevant ISO or AGMA standard. The gear load carrying capacity for strength and wear shall be determined in accordance with the relevant ISO or AGMA standard but the following parameters shall be taken as a minimum.

i- 24 hours per day operation

ii- Service factor of 1.4 based on the rated output of the respective prime mover.

iii- Rated life of 100,000 hours

The surface hardness of gears shall be determined in accordance with the relevant ISO or AGMA standard and for case hardened gears the depth of case shall be not less than 0.4 mm after profile grinding to counteract distortion.

The gears shall be enclosed in a cast or fabricated case. Fabricated steel cases shall be stress relieved prior to final machining. The case shall be split or provided with covers to facilitate inspection of the gears without dismantling the shafts.

Shaft bearings shall be selected with a rated life of 100,000 hours at the maximum speed and power rating of the gears. Any end thrust from the gears shall be accommodated by the shaft bearings.

Input and output shafts shall be adequately sealed to retain lubricant and prevent ingress of contaminants under all operating conditions.

Drain and filling plugs shall be provided. Where necessary extension tubes shall also be provided to facilitate filling and draining. Breathers shall be provided with filters to prevent ingress of dust and moisture etc.

Oil lubricated gearboxes shall be fitted with a sight glass indicating both the hot and cold oil levels.

Dependence on splash lubrication alone is not acceptable but it may be used in conjunction with a forced feed method to reach all bearings and gears.

Each gearbox shall be equipped with an embossed nameplate including at least the following information:

i- Manufacturer’s name

ii- Gearbox type reference

iii- Serial or Order Number

iv- Power rating of gears

v- Speed ratio

vi- Lubrication specification (type and viscosity)

4-C-24 FLEXIBLE COUPLINGS

Flexible couplings where supplied, shall be generously rated to cover the full range of duty.

Couplings liable to impregnation by oil shall be of the all metal flexible type.

General service couplings shall be of the flexible multi-pin and bush type, having not less than six bushes and each bush shall have an inner sleeve to allow rotation on the pin (bushes shall not be in direct contact with the pin). All pins shall have shoulders to allow positive location and securing to the bosses.

Bosses shall be a tight fit on the shafts and secured with hand fitted keys.

Couplings shall be supplied in matching balanced sets and shall be machined, balanced and marked before leaving manufacturer's works.

4-C-25 STRAINERS

Strainers shall be flange mounted type. Foot strainers shall be installed at least 0.5m (or as directed by the Engineer) above the bottom of the water reservoirs. The strainer basket shall be of the perforated cylinder type made from galvanized steel or stainless steel. It shall be easily accessible via a removable flange.

Also inline strainers shall be installed upstream the flow and water meters.

4-C-26 SAFETY SIGNS

Safety signs are required for all hazardous plant areas. The signs shall be of durable quality and shall comprise a substrate of 22 gauge aluminum, pre-drilled for fixing and with radiussed corners free of burrs or sharp edges. Symbols and lettering shall be screen printed.

4-C-27 SAFETY GUARDS

All sections of the plant which constitute a safety hazard shall be covered by substantial guards or barriers.

All moving parts of plant shall be adequately guarded to ISO/TR 12100.

All parts that in normal working are hotter than 60°C or colder than -5°C shall either be adequately fenced or shall be lagged.

All live electrical conductors, including conductors forming part of electrical apparatus, shall be either insulated or so fenced or placed as to prevent danger.

Guards shall be fabricated in mild steel wire mesh or expanded steel sheet, or should a fully enclosed type be necessary, in mild steel sheet.

Guards shall be designed to provide ready access to bearings, greasing points, thermometer pockets and other check points to allow routine observations to be made by the operating staff without danger or the need to dismantle any part of the guard. Hinged doors let into the guards with padlocking facilities shall be provided where necessary to facilitate access to the check points.

Guards shall be bolted in position in such a way that they cannot be unintentionally dismantled or removed.

All mild steel used in the construction of guards, including bolts, nuts, washers and brackets shall be hot dip galvanized unless otherwise specified.

Drawings of safety guards shall be submitted to the Engineer for approval before manufacture.

4-C-28 PLANT IDENTIFICATION

All pipework equipment, panels and valves shall be identified. Pipework shall be painted or color banded and labeled. Adhesive labels shall be used to identify tanks. Equipment shall be identified using engraved plates of a non-corrodible metal fixed on to the item using four screws. Engraved tags of a non-corrodible metal shall be used for valve identification. Tags shall of a uniform shape and shall be fastened by a jack chain.

4-D VALVES AND ACCESSORIES

4-D-1 VALVES

4-D-1-1 General

The valve, components and all its related parts and accessories shall comply to one of the International Standards Institutes requirements (i.e. ISO, BSS, DIN, etc…).

Manufacturer(s) must have the Label of Quality ISO 9001 to be qualified as supplier. The contractor shall not submit any materials for approval if not compatible with the required specifications and from an approved manufacture.

4-D-1-2 Ductile Iron Gate valves

The Ductile Iron Gate valves should have the following characteristics:

- Working Pressures up to 25 kg/cm2 (PN 6/10/16 and 25).
- Working Temperature: From –10 °C up to 70 °C, resilient type Soft sealing for PN10 /16 /25, metal seated for PN25 and DN>300
- Body and bonnet in spherical graphite ductile iron EN-GJS-400-15 (GGG-40), with blue Ral 5015 epoxy powder coating electrostatically applied (EN1563) with min 250 microns
- Wedge in spherical graphite ductile iron EN-GJS-400-15 (GGG-40), fully coated by EPDM, or NBR (DVGW). EN1563
- Wedge lock nut in copper alloy with high resistance to corrosion, EN 12165
- Stem in stainless steel AISI-420 (X20C13), EN 10080
- Body-bonnet gasket in EPDM or NBR (DVGW), EN681-1
- Body-bonnet bolting in steel quality 8.8, with anticorrosive coating DIN 912

- Gate valves are supplied with handwheel in stamped steel, or square cap in EN-GJS-400-15 (GGG-40) for 30x30 T-key. They can also be operated with gear-box, electric, pneumatic actuator, extensions,… EN 10088 / EN1563.
- Gate Valves should be tested according to EN 12166-1, DIN 3230, and according to EN 1074 (2.500 cycles endurance resistance) or BS 5163 part2. Seat: 1.1 x PN, Body: 1.5 x PN
- Third Party approval: product conformity certificate from Bureau VERITAS or similar in addition to a proof of suitability for drinking water
- Dimensions : as per EN558 or BS 5163 part1
- Flanges and drilling EN1092-2

The Metal Seated Gate valve for DN>300 and PN 25 should be according to BS5163 & BS5150 and having the additional following characteristics:

- Wedge in Ductile Iron, BS EN 1563 / EN-GJS 400/15.
- Wedge Face Aluminum bronze, EN1982 CC331G.
- Hydraulic test to BS 5150 / EN 1171, Seat: 1.1 x PN, Body: 1.5 x PN

For all valves types for DN>350mm., bypasses are required.

4-D-1-3 Butterfly Valves

Butterfly valves, manual or motorized, fitted with maintenance free worm gear including mechanical position indicator and hand wheel, other Combined gear type may be used for specified application if particular min number of turns is specified. Where required, valves shall be electrically actuated with a manual override.

The Ductile Iron Butterfly Valves should have the following characteristics:

- On /Off duties manufactured according to EN593, eccentric (double offset) design, tight in both flow directions according to EN 1074-2
- Possible to replace profile sealing ring without disassembling the disk
- Installation: Underground, or in chamber
- Permissible working temperature: 70 C
- Hydrostatic test 1.5 PN for body 1.1PN for seat, according to EN 1074 1 and 2, and ISO 5208:
- Working pressure classes PN10/ PN16 /PN25 /PN40
- Body in ductile iron EN-JS 1030 Former GGG40
- Disc in ductile iron EN-JS 1050 or EN-JS 1030, EN1563
- Sealing seat in 316L stainless steel
- Valve sealing in EPDM
- Shaft Bearing in zinc free bronze
- Valve shaft Stainless steel EN10088 Gr 1.4057.

- Wetted bolts in S.S A4, outside bolts S.S A2
- Face to face dimension EN558-1 , Basic series 14
- Flanges drilling to EN 1092-2
- Third Party approval: product conformity certificate from Bureau VERITAS or similar in addition to a proof of suitability for drinking water
- Epoxy coating blue electrostatically applied EN 14901 min 250 microns
- Drinking water compliance approved with third party certificate
- Handwheel in Steel

4-D-1-4 Ball Float Valves

Ball float valves which are to be installed within reservoirs shall be of the delayed action type to eliminate inflow at small valve openings. They shall comply with B.S. 1212 and shall be fitted with a stilling chamber, auxiliary float valve and inlet bellmouth with regulating valve. The main valve shall be fitted with long actuating lever to provide a long float travel for slow valve closure.

Valves shall be of the right angle pattern type with flanged inlet and have a resilient synthetic rubber disc which forms a drop tight seal against a removable seat insert. Valves shall be free of vibration under the specified working conditions. Flanged tapers shall be provides on the inlets as necessary to suit the size of valves proposed.

Valves shall be capable of withstanding the maximum static pressure and of passing the maximum flow rate. Orifice plates shall be provided as necessary to absorb excess working pressure at the initial flow rates indicated.

The pressure rating of the valve shall be cast into the body of the valve.

4-D-1-5 Check Valves

Check valves shall be of the swing, nozzle, dual disc, titled as directed by the Engineer. When used, Swing type shall be fitted with lever and counterweight to improve the response and anti-slam feature. When the check valve is installed next to surge vessel it should be titled disc or nozzle or dual disc type. They shall be installed on horizontal or upward vertical pipes. All check valves shall be of a type that will operate without shock. Valve bodies shall be of ductile iron unless otherwise specified by the Engineer and shall be fitted with renewable type seating (resilient or similar). Covers shall be provided to allow ample access for cleaning and service and shall be supplied complete with tapped bosses.

In the case of swing gate type valves the hinge pin shall be of stainless steel, mounted in zinc free bronze bushes and extended and fitted with external levers and counter balance weights, all protected by a screen guard.

Other types of valves will be considered. In every case the non return valve shall be selected with full consideration of the system characteristics, and shall avoid valve slam, and have low maintenance requirements.

Where specified, limit switches shall be provided to operate from the external lever. The screen guard being slotted to allow the guard to be removed without disturbing the switch cabling.

4-D-1-6 Cast Steel Valves

The cast steel valves shall be used where ductile iron valves are not permissible to operate at pressure > 25 bars, and shall comply to NF E 29-328, NF E29-331. The specifications of other valve parts shall be at least the same of the ones of ductile iron valves.

4-D-2 VALVE ACCESSORIES

1. Hand wheel : in steel DIN 17100 or cast iron epoxy coated DIN 1691
2. Stem cap in cast iron DIN 1691 or ductile iron EN1563
3. Extension spindle : Mild steel ST3/ZN6
4. Operation keys: Combination prizing bar and lifting key tube, with 1.5 m vertical bar and 0.5 m horizontal bar.

4-D-3 AIR-RELEASE VALVES

Air-release valves, body and components shall comply to SG 400-15 ductile iron, and are to be installed as specified on the drawings, where needed and as directed by the Engineer.

Air-release valves are introduced into the water main in order to eliminate air collections at high spots and changes in slopes.

a) Single air-release valves are meant to discharge the trapped air automatically under normal operating conditions, (when pipes are under pressure).

b) In addition to the role mentioned in paragraph a), double air-release valves (triple function air valves) permit bulk air vent under pressure, blowing off air when filling the pipes with water, and air ingress during emptying. They are also used at steep slopes to protect against sharp pressure drop in case of accidental breakage.

Air-release valves shall be supplied with an isolating valve which permits the complete removal of the air-release valve from the main without affecting the flow of water.

Air-release valve are mounted on a vertical branch connection with at the top of the main.

Air-release valves shall operate automatically and shall be constructed in a manner that the operating mechanism will not jam in either position (open or close).

Air-release valves shall be of single orifice valves (SOV) for distribution networks, and of double orifice valves (DOV) for transmission lines, pumping lines, and inside reservoirs valve chambers.

4-D-4 PRESSURE REDUCING VALVES

The pressure reducing valves shall be of the spring loaded type and of an approved design with a single external hydraulic relay system to ensure a constant downstream pressure for a variable upstream pressure.

The main valve body, cover and internal valve shall be of meehanite cast iron. The liner shall be bronze to BS 2870. The indicator rod shall be of stainless steel to BS 970 with all other components being of appropriate non corroding materials.

The relay system body shall be in bronze as shall all control valves. All connection piping and internal fittings shall be in non corroding materials.

Each valve shall be subjected to a body pressure test in the manufacturers works and witnessed by the manufacturer accordingly.

The relay system shall be capable of being checked or replaced without breaking the supply.

4-D-5 DOWNSTREAM LEVEL CONTROL VALVE AND PRESSURE HEAD BREAKER

This valve is installed in order to fulfill both functions of:

- Adjusting the upstream pipeline flow rate with the downstream side consumed flow rate.
- Local energy dissipation.

The downstream level control and head breaker valve should be installed at the end of a pressure pipeline before discharging into a water basin. It should control the water level within the water basin, where it is installed, regardless of the flow variations. This valve should be of Self – Centering Disc Obturator type from Alstom or Hydrostec or equivalent.

The upstream pipeline is connected to a vertical orifice (nozzle) at its end, above which is placed a flat disc linked with an operating rod. When exposed to the jet of water, the disc centers itself even in the absence of any lateral guiding. Using a rocker arm, the disc is operated by a cylindrical float having a vertical axis; the float moves in a chamber communicated with the downstream reservoir.

The type of obturator to be used is the hooded disc obturator type – OBCA, where the orifice and disc are located above the water level to be controlled. The orifice is a sharp – lipped nozzle and the disc is flat. A completely watertight seal should be insured by a reinforced rubber lining on the underside of the disc. This valve should include the following accessories:

- Roker arm
- Bearing
- Swivel ring
- Self – centering disc
- Deflector hood
- Convergent nozzle
- Adjustable stop
- Float

Through the rock arm, the float controls the self – centering disc, which regulates the aperture trough the water flows. When the water level in the reservoir rises, the float is lifted thus tending to close the abturator. The float chamber communicates with the reservoir trough on orifice, which is equipped with a control valve, thus providing and adjustable damping effect.

4-D-6 FLAP VALVES

Flap valves shall be normally closed, by weight of the door only, and shall open under minimum flow conditions. They shall be capable of withstanding 1.5 times the specified maximum seating head.

Where flap valves are required for flange mounting, they shall be supplied with rubber gasket and the full number of holes to BS.4504 NP 16.

All flap valves shall be operated and painted in accordance with metal painting and protection requirements.

4-D-7 STRAINERS

Strainers shall be flange mounted type. Foot strainers shall be installed at least 0.5 m above the bottom of the water reservoirs.

The strainer basket shall be of the perforated cylinder type made from galvanized steel or stainless steel. It shall be easily accessible via a removable flange.

4-D-8 MANHOLES FOR POTABLE WATER

The construction of manholes and valve chambers shall be located as specified on the drawings and as directed by the Engineer during constructions:

- Excavation and backfilling generally shall comply with appropriate requirements of PART III-1- EARTHWORK.
- Concrete works generally shall comply with the appropriate requirements of PART III-2- CONCRETE AND MASONRY.
- Ductile iron cover shall comply to ISO 1083, EN 124, or equivalent.
- Cement to be ordinary Portland cement or PA-S cement.
- Coating: Protective bituminous coating for external surfaces of concrete manholes, valve chambers, or other equal approved.

Manholes are to be precast or cast in situ as shown on the drawings and shall be completely water-tight. Particular attention shall be given to the joints between the pipes and the walls to ensure proper tightness against any leaks into the manholes.

Where valves are directed to be fixed in a chamber, etc. the necessary frames shall be placed in position using approved expanding shell bolts or an approved proprietary resin anchor system.

For precast units the Contractor shall obtain the Engineer’s approval to all details of the precast units and method statement before commencing casting units.

All manhole covers located in roads shall be brought to the final finishing level of the pavements. The covers and frames shall have accurate seating faces to prevent rocking and the ingress of sand or water, and shall be fitted tight to resist overflow conditions or any leakage from under the frame base.

4-D-9 FLANGED ANCHORING PIPE WITH PUDDLE FLANGE

Flanged anchoring pipes with puddle flange shall be used in the concrete walls of manholes, valve chambers and water tanks as specified in the drawings or as instructed by the Engineer. The puddles flange will provide additional fixation to the pipe in the wall in addition to reduce or eliminate the water leakage.

The flanged anchoring pipe with puddle flange is made of ductile iron and shall comply to the appropriate requirements.

The installation requirements and fixation in concrete shall follow the manufacturing recommendations.

4-D-10 DISMANTLING JOINTS

Self restrained dismantling joints, made from ductile iron, are used to ensure extensible connections between sections of pipe work, to be mounted next to valves to enable easy dismantling from pipe work or to permit jointing pipe work when butterfly valves is removed for maintenance.

The dismantling piece is to be flanged type composed of two parts, one sliding into the other, and a free flange to compress a trapezoidal section seal to ensure water tightness.

4-D-11 FLEXIBLE JOINTS

Flexible joints shall be flanged type, the body shall be made of rubber and the flanges of mild or stainless steel. The working pressure of the flexible joints shall be 1.2 x the maximum pressure of the pump. Flexible joints shall be fit for suction and delivery, eliminate sound & vibration and shall be able to resist the effect of heat, water and weathering.

4-D-12 FLOW STRAIGHTENER / STABILIZER

The required type of the flow straighteners / stabilizers shall be selected to stop the turbulence in the water pipes.

4-D-13 DUCTILE/CAST IRON GRATING

The cover and frame shall be manufactured to ISO 1083, EN 124, or equivalent. Use rectangular grate and frames as specified on the plans and according to the following classification: Class D400; heavy duty; for minimum test load 40 tons.

The contractor shall submit certifications of Test Load according to British Standard Institute or equivalent and Quality Assurance according to the European Standard EN 124 section 10 or equivalent. The grate shall bear the following information:

- The name of the manufacture, initials and identification mark,
- Initial and number relevant standards, example EN 124,
- Production excellency stamped by one of the known agencies Example: The French standard Institute (AFNOR) or the British Standard Institute (BSI),
- Initial of material used, example: GS for Ductile Iron,

- Load capacity. Example: D400 for minimum test load 40 tons.

4-D-14 DUCTILE IRON FRAME AND COVER

The cover and frame shall be made of ductile iron manufactured to ISO 1083, EN 124, or equivalent. For Manholes, Use only round covers and frames, minimum 600 mms for cover and 850 mms for frame, as specified on the plans and their use according to the following classifications:

Class E 600: Super heavy duty; used for industrial plants, ports, airports, etc…Minimum test load 60 tons.

Class D400: Heavy duty; for streets, roads. Minimum test load 40 tons.

Class C250: Medium duty; for sidewalks, gullies, parking areas accessible for lorries. Minimum test load 25 tons.

Class B125: Light duty; for sidewalks, parking areas only accessible to passenger cars.

The contractor shall submit certifications of Test Load according to British Standard Institute or equivalent and Quality Assurance according to the European Standard EN 124 section 10 or equivalent.

The cover shall bear the following information:

- The name of the manufacture, initials and identification mark,
- Initial and number relevant standards, example EN 124,
- Production excellency stamped by one of the known agencies Example: The French standard Institute (AFNOR) or the British Standard Institute (BSI),
- Initial of material used, example: DI for Ductile Iron,
- Nominal diameter and class designations,
- Load capacity. Example: D400 for minimum test load 40 tons.

4-D-15 GALVANIZED STEEL STEPS OR LADDERS

Every inspection chamber and manhole which height exceeds 1 meter shall be fitted with metallic steps to allow easy access to the manhole from the opening in the frame.

Manholes and pressure breaker basin shall be furnished with 1 inch galvanized steel steps: to BS 729.

The steel steps can be installed during the construction of the concerned structures or after construction in case or precast units as specified in the drawings or as directed by the Engineer.

When drilling into the concrete walls for installing the steel steps, the hole shall be cleaned thoroughly and the space between the rod and the concrete shall be filled properly with non shrink cement mortar as specified by the manufacture and provide good finishing to the surface.

4-D-16 FERRULES

Gunmetal or Bronze Swivel Ferrules / vertical tapping valve / push-fit outlet for HDPE. The ferrule shall be designed for use underground and to handle potable water at temperatures of up to 40°C.

The ferrule shall work at pressures up to 16 bars without leakage.

The ferrule stem, banjo, inner plug and top cap shall be manufactured of gunmetal/bronze to BS1400 LG2, inlet shall be a male taper thread to BS 21 (ISO 7/1)

Its design shall permit service pipe installations via conventional drilling and tapping machines, under pressure or dry, with or without service saddles.

Ferrules shall be designed with a Push-fit outlet for PE pipe with grip ring , All ferrules shall be designed as a main stem with a 360° swivel outlet at 90° with control of water flow via a threaded inner plug.

4-D-17 STOP VALVES

- **Gunmetal stopcock valves /House connections/Push-fit for HDPE**

Easily operated, underground Stopcock BS valve type

BS5433 gunmetal stop -valves, highly resistant to corrosion

All metallic parts in gunmetal/Bronze, Gaskets in EPDM

Supplied with crutch heads or square heads for operation by underground stopcock key 5/8 size , common design of British water authorities

Supplied with plastic guard pipe and plastic chamber base with retaining clips for valve, chamber base designed to fit 160 mm guard tube.

- **Ductile iron Stop valves / house connections / Push–fit for HDPE**

Gate type with female thread connection acc. to ISO 228 on both sides

Resilient seated (EPDM) in accordance with EN 1074

Face-to-face length acc. to EN 558-1

Body: Ductile cast iron EN-GJS-400-15 or EN-GJS-500-7

Wedge: Brass CuZn40 Pb2 and ductile for DN 11/2” and 2”

Stem: Stainless steel X20 Cr13 EN 10088, Fix washer in bronze

Gaskets in EPDM, EN681-1

Supplied with bare square head or with extension spindle set for buried house connections, in this case the Extension spindle is made in ST3 / ZN6 min 20*20 with guard plastic pipe appropriate to valve body

- **Ductile iron Stop valves / house connections / threaded outlets**

Gate type with female thread connection acc. to ISO 228 on both sides

Resilient seated (EPDM) in accordance with EN 1074

Face-to-face length EN 558-1

Body: Ductile cast iron EN-GJS-400-15 or EN-GJS-500-7

Wedge: Brass CuZn40 Pb2 and ductile for DN 11/2" and 2"

Stem: Stainless steel X20 Cr13 EN 10088, Fix washer in bronze

Gaskets in EPDM, EN681-1

Supplied with bare square head or with complete extension spindle set for deeply buried house connections, in this case the Extension spindle is made in ST3 / ZN6 min 20*20 with guard plastic pipe appropriate to valve body.

4-D-18 SURFACE BOX FOR HOUSE CONNECTIONS

Manufactured in compliance with EN124, Load class: C250

Made in ductile iron with protective coating

Base inlet clear opening dimension 160mm to receive plastic guard pipe of same diameter

Min Top Clear opening 100 mm

Base Diameter 250 mm , Min H :120 mm

Marking: Water Authority

4-D-19 SADDLES FOR HOUSE CONNECTIONS

- **Saddles on Ductile Iron Pipes**

Saddle body in ductile iron EN-GJS-400-15 or EN-GJS-500-7 / EN1563, Epoxy or Rilsan coated min 250 microns EN 1563. PN16

Fitted with straps in stainless steel covered with rubber Strip of min. 2 mm

Stainless Steel Strap, bolts washers and nuts A2 70 DIN 933/ DIN 125

Single strap design allowed only for pipes of DN 50mm- 250mm, 2 straps design for larger diameters

- **Saddles on HDPE Pipes**

Electrofusion Saddles specially designed for Plastic pipes to be welded to the distribution line and to the outlet pipe, PN16.

4-D-20 WATER METERS FOR SERVICE CONNECTIONS

Water meters shall be of the volumetric type, turbine single jet liquid filled type magnetically driven or with mechanical-transmission. The meters body shall be bronze, and meters shall withstand a service pressure of 16 bars.

The accuracy at normal flow rates shall be better than ±2%. Meters shall be calibrated in cubic meters, and shall be compatible with the pipework in which they are being incorporated. The minimum reading must be 0.1 liter with head loss lower than 0.1 bar at

nominal flow (Qn). The maximum working temperature is 30°C for cold water and 90°C for hot water.

Water meters shall also be equipped with:

- Tamper proof counter,
- Five (or more) reading rolls totally immersed in a hermetically sealed casing and filled with a lubricating fluid
- The maximum reading shall be 100.000 m3 (or more),
- Index wiper,

The meter must be Class C (BS 5728/1, ISO 4064., EEC 75/33, OIML N049) for horizontal position and class B in any other position, and must have an external adjusting screw tamper proof.

4-D-21 FIRE HYDRANTS

Fire hydrants shall conform fully with BS 750 Type 2. with 'captive' internal valve.

Fire hydrants shall be Pillar type with triple delivery (2 x 65mm + 1 x 100mm) and visible outlets made of cast iron or ductile iron. The inlet flanges to fire hydrant shall be DN 100mm.

Fire hydrants shall 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.

The fire hydrants shall be capable of passing a minimum flow of 17 L/sec at a constant running pressure of 1.7 bar.

4-E TESTING

4-E-1 TESTING OF GATE VALVES

Gate valves shall be tested in accordance with BS 5150 or BS 5163 as relevant. In either case, valve seat tests shall be made under open-end conditions, the test pressure being applied to each face of the valve in turn.

4-E-2 TESTING OF BUTTERFLY VALVES

Butterfly valves shall be tested in accordance with BS 5155. The seat test shall be for tight shut-off and low leakage. Valves shall be tested under maximum unbalanced water test pressure in either direction.

4-E-3 TESTING OF AIR VALVES

Air valves shall be water tested for drop-tightness at all pressures from 0.2 bar in steps of 2 bar up to the specified pressure. The valve body shall be water tested at 1.5 times the specified pressure, at which pressure no damage or permanent deformation of the valve body, ball or seat shall occur.

Two valves of each type and size incorporating large orifices shall be tested for exhaust of air at a differential pressure up to 1 bar in steps of 0.1 bar and for inflow of air at a differential pressure up to 0.5 bar in steps of 0.1 bar. During the tests the airflow rates shall be measured by orifice plates in accordance with BS 1042. Pressures (positive or vacuum) shall be measured by Bourdon tube gauges or by means of mercury-in-glass manometers. The temperature of the flowing air shall be measured in accordance with BS 1041: Part 1 and Part 2. The barometric pressure shall also be measured.

If the manufacturer provides results of independently witnessed airflow tests similar to those specified and these are accepted by the Engineer, then the specified airflow tests shall be deemed to be completed.

4-E-4 TESTING OF CHECK VALVES

Check valves shall be tested in accordance with the requirements of BS 5153.

4-E-5 TESTING OF PRESSURE AND FLOW CONTROL VALVES

Pressure and flow control valves shall be tested hydrostatically as follows:

- Body strength : closed-end test, valve open, test pressure 1.5 times working pressure.
- Valve element strength : open-end test, valve closed, test pressure applied to inlet end of 1.5 times working pressure.
- Leak tightness : open-end test, valve closed, test pressure of the working pressure applied to inlet end, no visible leakage permitted.

4-E-6 TESTING OF BALL FLOAT VALVES

Ball float valves shall be tested hydrostatically in the closed position and a pressure of 1.5 times the working pressure applied to the inlet end.

Valves shall be tested for drop-tightness at the working pressure.

4-E-7 TESTING OF PLUG VALVES

Plug valves shall be subject to hydrostatic shell and seat tests in accordance with BS 5158.

4-E-8 TESTING OF PENSTOCKS

Penstocks shall be operated from fully closed to fully open positions to verify correct operation. For penstocks fitted with power-operated mechanism, the test shall be carried out to demonstrate correct manual and power operation.

A leakage test shall be carried out to prove the penstock is drop tight under seating and unseating conditions.

4-E-9 TESTING OF ELECTRIC ACTUATORS

Electric actuators shall be tested in accordance with the Reference Standards. Compliance with the specified functional and performance criteria shall be demonstrated.

4-E-10 TESTING OF PIPEWORK

Pipework shall be tested in accordance with the appropriate Reference Standards.

4-E-11 TESTING OF CASTINGS

Castings shall be tested hydrostatically to 1.5 times the maximum working pressure for a minimum period of 1 hour.

4-E-12 TESTING OF AUTOMATIC IN-LINE STRAINERS

Automatic in-line strainers shall be tested in accordance with the Reference Standards and with manufacturer's own requirements.

4-E-13 TESTS AT SITE

The Contractor shall submit to the Engineer detailed proposals for testing. The proposals shall give values of test parameters and make reference to standards and manufacturers' literature. The proposed format of test sheets shall be submitted at the same time. A separate sheet shall be used for each test. The testing shall not commence until the proposals and test sheets have been approved in writing by the Engineer.

The following inspections and tests shall be carried out as appropriate.

- Inspection to check the assembly of the Plant and conformity with the Specification.
- Rotational checking of all electric motors.
- Hydrostatic testing of all gravity flow pipework systems and penstocks at the maximum head or differential head that can occur in service. Leakage from penstocks shall be measured and recorded but shall not exceed the maximum value stated in the Contract or otherwise required for safe operation.
- Hydrostatic testing of all pressurized pipework systems at 1.5 x maximum working pressure for a period of at least one hour.
- Performance testing of each pump to prove correct operation, absence of fluid leaks, correct bearing temperatures and absence of undue vibration and noise.
- Functional testing of auxiliary items including automatic in-line strainers and valve actuators.
- Functional testing of valves to demonstrate correct operation.

Overhead cranes shall be tested with a load of 1.25 x Safe Working Load and results recorded in accordance with the Reference Standards.

Part V : Geotechnical Investigation

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PART 5 – GEOTECHNICAL INVESTIGATION

5.A. SCOPE

The purpose of the work specified herein is to determine the type, nature and characteristics of subsurface materials and the extent and conditions of the various materials of foundation soils and conclusion of soils bearing capacity and to identify any potential geotechnical problem (sliding, instability, settlement,…). This is to be accomplished by means of core drilling, field testing sampling and analysis, laboratory testing. The Contractor will provide access roads as he deems necessary for the execution of work. The Contractor will also provide a report summarizing and interpreting field and laboratory results.

5.B. QUANTITIES AND LOCATIONS OF HOLES

The locations of the drill holes to be executed by the Contractor are distributed on all the project sites (pumping stations, reservoirs, pipelines, access roads, treatment plant, springs,…) and wherever requested by the Engineer. The approximate number and location of drill holes and test pits shall be proposed by the Contractor and approved by the Engineer. The Engineer reserves the right to increase or decrease the quantity of work for the Contract items to such an extent that the total contract amount would be increased or decreased by 50 percent with no change in Contract unit prices. In case of test pits required by the Engineer, these will be paid as unclassified excavations.

5.C. MOBILISATION AND DEMOBILISATION

a. Mobilization: mobilization shall consist of the delivery to the site of all plant, equipment, materials, and supplies to be furnished by the Contractor; the complete assembly in satisfactory working order of all such plant and equipment on the job; and the satisfactory storage at the site of all such materials and supplies.

b. Demobilization: demobilization shall consist of the removal from the site of all plant and equipment after completion of the work and shall include restoration of the area as requested and approved by the Engineer.

5.D. INSPECTION

No work shall be performed in the absence of the Engineer unless authorized by him. The Contractor shall not remove casing or equipment from any completed boring or test pit except with the express permission of the Engineer and not until the Engineer has had the opportunity to obtain all relevant data prior to removal.

5.E. RECORDS

The Contractor shall keep accurate driller's logs and records of all work accomplished under this Contract and shall deliver complete, legible copies of these logs and records to the Engineer on completion of the work in each hole or pit, or at other times as he may be directed. All such

records shall be preserved in good condition and order by the Contractor until they are delivered and accepted. The Engineer shall have the right to examine such records at any time prior to their delivery to him. Separate logs shall be made for each hole and test pit. The following information shall be included on the logs or in the records for each hole:

1. Full information on the location, type of boring, diameter, ground elevation, inclination.
2. Location, elevation, depth, type, and number of each sample taken.
3. Driving energy and blow count data for each 15 centimeter penetration of drive sampler and 30 centimeter penetration of casing where the casing is driven.
4. Average rpm and hydraulic advance pressure of drill rig on undisturbed samples, cores, and casing, where the casing is advanced by drilling.
5. Length in centimeters of sampling or coring drive or run.
6. Length and percent of recovery for all samples and cores.
7. Driller's classification or description by depths of the materials sampled, cored, or penetrated, including a description of thickness of zones, moisture conditions, and of conditions of compactness or stiffness of soils materials encountered. This classification or description shall be made immediately following the taking of the samples or cores.
8. Size and lengths of casing used in each bore hole and where added.
9. Elevation of rock if encountered.
10. Elevation of depth of water in holes, daily, at the start of work and after completion of the bore hole until true water table conditions have been established as approved by the Engineer.
11. Elevations and depths of seepage tests and artesian measurements.
12. Elevations and depths at which drill water is lost and regained, and amounts and color of return water.
13. Elevation and depth of bottom of hole.
14. Dates and time by depths when test-pitting, drilling, sampling, seepage testing, and artesian measuring operations were performed.
15. Time required for drilling each run.
16. Time required for seepage tests and artesian measurements.
17. Pressure employed in seepage tests and artesian measurements.
18. Any changes in the drilling action which would be supplemental information to the sampling or coring.
19. Any information or data that the driller may deem pertinent or that may be requested by the Engineer.

The presence of the Engineer or the keeping of separate drilling records by the Engineer shall not relieve the Contractor of the responsibility for the work specified in this paragraph.

5.F. CONTAINERS

a. General The Contractor shall furnish litter size wide mouth jars, 10kg capacity moisture proof bags, undisturbed sample and core boxes, and accessories meeting the specified requirements, or approved as equal by the Engineer. The Contractor shall furnish as many containers as may be required. All such containers will become the property of the Engineer and the cost thereof shall be included in the Contract price for the applicable item for which payment is provided.

b. Core Boxes. Longitudinally partitioned core boxes constructed of lumber or other approved materials, shall be used for all rock cores, selected cores of soil, and selected cores of weathered zones taken from within the rock. Where the Contractor elects to advance a hole by coring in overburden, such core as may be designated by the Engineer shall also be placed in core boxes. The soil and weathered zones shall be preserved in undisturbed boxes or core boxes as directed by the Engineer. As many core boxes as may be required shall be used in submitting each core or group of cores. Core boxes shall be completely equipped with all necessary partitions, covers, hinges, screws for holding down the cover, identification plates, tags and other accessories.

5.G. LABELS

Each bag and core box shall have printed or typewritten labels shall be identified with water-proof and wear-proof labels or markings indicating the following:

Project
Hole No. _____ Location_____

Hole No. _____ of _____ Jars

Jar No. _____ of _____Bags

Top Elev. of Hole _____

Depth of Sample _____ to _____

Description of Material_____

5.H. BORINGS

a. General. The Contractor shall make vertical borings of minimum 101 mm in bedrock and 200 mm in overburden. Coring will be continuous from the top of rock to the bottom of hole.

b. Equipment and Supplies. The Contractor shall furnish and use sufficient numbers of drill rigs and associated equipment to successfully complete the project within the designated time scheduler. The drill rigs shall be capable of drilling vertical holes to a depth of 30 meters. Some rigs shall be provided with whirling capability but all rigs shall be provided with hydraulic feed mechanic lams and catheads, and capable of taking drive samples and

double tube core barrel rock cores to the depths required. The Contractor shall supply such equipment or accessories necessary for proper positioning of vertical borings.

All borings may be drilled with minimum 101 mm. Drilling mud will not be allowed because of permeability testing requirements.

The Contractor shall provide sufficient heavy-duty casing of such a type to be driven or drilled through the overburden to sound rock. The Contractor shall furnish drill rods, piping, pumps, water, tools, power and all other supplies required to execute the borings to the required depths by the procedure described. Prior to mobilization, the Contractor shall submit to the Engineer for approval a list of equipment he will use.

c. Additional Equipment. If it appears during the course of the work that the Contractor will not complete the contract work within the specified contract period, he shall be required to obtain additional equipment, as deemed adequate by the Engineer, to insure completion of the work as specified. When the Contractor is ordered by the Engineer to use additional equipment or rigs to complete the work on schedule, he shall employ the most expeditious measures and act with the utmost promptness to comply with the Engineer's instructions.

d. Advancing and/or Cleaning the Drill Hole. Samples taken above the water table shall be taken from a dry hole. Advancing and/or cleaning the dry hole to the sampling depth shall be accomplished using a clean out auger or approved equivalent so as to keep the hole dry and not disturb the virgin material at the depth to be sampled. Below the water table any method of cleaning the hole to the sampling depth that does not disturb the virgin material shall be used. If jetting is used, upward or baffled jets shall be required. Below the water table, a head of water greater or equal to the water table, shall be kept in the boring at all times, including the duration of the withdrawal of tools. Where seepage tests or double tube core barrel has introduced water into the hole above the water table, methods other than those required in a dry hole may be used at the convenience of the Contractor where approved by the Engineer. When core drilling through a boulder or ledge rock has been accomplished the cored portion of the hole shall be reamed out as required to advance the casing. If blasting is done, the Contractor shall obtain all necessary permits and shall comply with all laws, rules, regulations and ordinances governing blasting operations. Recirculated or clean water shall be used in overburden below the water table, in holes where seepage tests are designated or requested, and in rock coring. The holes shall be flushed out with clean water prior to testing in accordance with the appropriate Technical provision.

The Contractor shall be responsible for keeping the hole open at all times during the drilling and until all tests or other work in connection with the hole has been completed and the Contractor has been authorized by the Engineer to backfill the hole. In the event of collapse of the hole prior to receipt of authorization to backfill, the hole shall be reopened, in a manner specified by the Engineer, at the Contractor's expense.

e. Artesian Flow. Artesian flow may be encountered when drilling. Each time such flow is encountered, the advancement of the bore hole shall be immediately interrupted and the artesian rise in water or pressure in the casing measured.

f. Advancing the Casing. The casing shall be advanced by hammer, rotary drill, or any method approved by the Engineer, in such a manner to keep the hole open, and insure a tight seal in sound rock. The casing shall be advanced at a sufficient distance behind the sampling operation so as not to disturb the material to be sampled.

5.I. SAMPLING AND CORING IN BORINGS

a. General. Samples and cores shall be taken at designated elevations, with the designated sampler or core barrel as directed by the Engineer. The hole shall be properly advanced and cleaned in accordance with Subparagraph 7-H-d, Advancing and/or Cleaning Drill Hole, prior to sampling. Sampling shall be done by such means as to prevent the inclusion of wash in the sampler. The depths of starting and stopping drives or runs shall be accurately established to the nearest 10 cm.

b. Coring in Overburden. Where specifically requested by the Engineer, double tube core barrels with or without liners will be used to core overburden, generally in dense materials, boulders, and highly weathered rock. The speed of rotation, rate of hydraulic advance, and length of run shall be adjusted so as to provide minimum soil disturbance and maximum recovery. The speed of rotation shall not exceed 200 RPM unless otherwise approved by the Engineer and the maximum length of run shall be such as to provide a 150 cm long sample within the liner, when approved by the Engineer.

c. Rock Core Drilling. The casing through overburden or weathered rock shall be sealed tightly in sound rock prior to commencement of rock coring. The coring of rock with double tube core barrels 101 mm shall be in accordance with Subparagraph b, except that the maximum length of run may be increased to 3 meters when approved by the Engineer. The Contractor shall exercise particular care in recording water losses, rod jerks, and other unusual coring experiences that, supplementing the core record, will indicate the nature and the extent of any fracturing.

5.J. CASING

a. General. The advancing of casing shall be as mentioned in Subparagraph 7-H-f.

b. Removal of Casing. Except as otherwise authorized by the Engineer, all casing shall be removed on completion of the work, and it shall remain the property of the Contractor. Casing shall not be removed until authorized by the Engineer.

5.K. TEST PITS

a. General. A test pit shall be any excavation in soil, cinders, hardpan, decomposed rock or other unconsolidated or partially consolidated overburden which has an open cross-sectional area large enough to permit safe, efficient engineering inspection in situ density testing and undisturbed bag sampling. Bag samples totaling 450 kg or more may be required. The Contractor shall comply with all safety regulations governing this work.

b. Equipment and Supplies. The Contractor shall furnish all equipment and supplies necessary to perform the work.

c. Excavation. The test pits shall be excavated to the required depths.

d. Sampling. All sampling shall be performed by the Contractor as requested by the Engineer and labeled and preserved as specified in 7-G and 7-M, respectively.

e. Barricades. Immediately upon completion of excavation operations for each pit the Contractor shall construct an enclosure guard around each pit, set back about 1 meter from the edge of the pit. The enclosure shall be constructed of materials selected by the

Contractor. The enclosure shall be constructed in such a manner that no person or animal can fall into the test pit. Barricades will not be measured for payment, and all costs in connection therewith shall be considered a subsidiary obligation of the Contractor. In addition, it is the Contractor's responsibility to ensure that the barricades are placed; the liability associated with the failure to do so shall lie with the Contractor.

f. Refilling of Test Pits and Test Trends. The test pits shall be refilled when directed by the Engineer. The refilling of test pits will not be measured for payment and all costs in connection therewith shall be considered a subsidiary obligation of the Contractor.

5.L. ABANDONED BORINGS AND FALSE STARTS

No measurement or payment will be made for borings abandoned or lost before reaching the required depths. Except with the specific permission of the Engineer, the Contractor shall not abandon or complete any boring, or remove any casing or drilling equipment, without first affording the Engineer the opportunity of obtaining the position and depth of the boring prior to abandonment or completion, and any other information which the Engineer may require. The Contractor shall furnish the Engineer with complete records and samples for the depth penetrated in the manner hereinafter prescribed for completed borings.

5.M. PRESERVING SAMPLES AND CORES

a. General. The Contractor shall provide all material, equipment and labor necessary for preserving soil samples and rock cores. Wax for sealing sample containers shall be Socony Vacuum Oil Company Product 2300, or approved equal. The preserving and storage of samples and cores shall be a subsidiary obligation of the Contractor in connection with obtaining the samples or cores and no extra payment shall be made for preservation or storage of samples and cores.

b. Test pit Samples. Bulk samples selected by the Engineer from test pits shall be preserved in waterproof bags and shall be clearly marked with two (2) waterproof labels, one wired to the bag and one placed inside the bag. Jar samples taken as directed by the Engineer shall be scaled by double dipping the cap and threads into wax immediately after capping. Undisturbed samples requested by the Engineer shall be moisture proofed and handled accordingly and as requested by the Engineer.

c. Undisturbed Samples in Liners. After inspection by the Engineer, the ends of the sample tubes shall be cleaned out to a depth of 2 inches and a seal provided of micro crystalline wax, such as Socony Product 2300 or equal. A metal disc, having a diameter slightly less than the inner diameter of the tube shall be inserted into the wax at a distance of 2.5 cm from the end of the soil sample. The wax plug shall be flush with the ends of the tube and a metal cap shall be placed over the ends, taped and sealed with two coats of wax. Liners which are only partially full should be filled with wax before capping. Special care shall be made to mark the top and bottom of liner. Material taken from the shoe and the top shall be placed in separate litter jars and marked accordingly and sealed in accordance with the requirements of Subparagraph b.

d. Undisturbed Double Tube Core Samples Without Liners. After inspection by the Engineer, the undisturbed core sample shall be wrapped in polyethylene, coated with wax

twice, and wrapped in cardboard, or other stiff material approved by the Engineer. Special care should be taken not to break or disturb the sample during the handling.

e. Soil and Rock Cores. All rock cores and all soil cores such as undisturbed samples shall be arranged neatly in the partitioned boxes constructed and marked in the same sequence in which they occurred before removal from the hole. Facing the open box with the hinged cover above the open box below, cores shall be arranged neatly in descending sequence beginning at the left end of the partition nearest the hinges and continuing in the other partitions from left to right. The highest core shall be placed in box 1 and the lowest portions of the core shall be placed in the other boxes in consecutive order. The runs shall be sectionalized by wood Spacers showing depth, length of run, fractures and their estimated width, and recovery. Core loss blocks shall be used to indicate areas in which no core is recovered. Core sections as designated by the Engineer, shall be wrapped in polyethylene sheets, coated with wax twice, and wrapped in cardboard or other stiff material approved by the Engineer.

5.N. STORAGE AND DELIVERY OF SAMPLES AND ROCK CORES

a. General. The Contractor shall be solely responsible for preserving all samples in good condition. He shall keep samples from undue exposure to the weather. The Contractor shall keep all descriptive labels and designations on sample jars and boxes clean and legible until final acceptance by the Engineer. The Contractor shall comply with all requests of the Engineer concerning the care and protection of samples.

b. Storage. Upon completion of drilling and sampling operations in each hole, or as necessary to protect samples, all boxes containing samples and cores shall be delivered to a structure provided by the Contractor near the work site. Undisturbed samples shall be transported with the tubes in a vertical position, top down, to prevent consolidation and segregation of pore water. Boxes containing disturbed samples and core boxes shall be so arranged in the storage area that the samples and cores can be conveniently and readily examined by the Engineer. Undisturbed samples shall also be stored in an orderly method. Upon request of the Engineer, the Contractor shall furnish a laborer to assist the Engineer in inspecting the samples and cores. The Contractor shall provide all transportation and labor required for storage of the samples and cores at the desired location.

c. Shipment of Selected Samples. Upon request by the Engineer, soil samples and cores shall be boxed by the Contractor as described below and shipped to the Laboratory approved by the Engineer. Samples not directed to be shipped to the above address shall remain at the core storage area at the site. Every precaution shall be taken to avoid damage to samples and cores, especially to undisturbed samples, as a result of careless handling and undue delay in shipping. Undisturbed samples shall be shipped in partitioned wooden boxes made from lumber 6cm, or heavier lumber. The sample tube shall be placed vertically top down, in the box and well-packed in excelsior or other equal material to protect the sample against vibration. The undisturbed sample and core boxes shall be marked "Do Not Jar or Vibrate" and "Handle, Haul and Ship in a Vertical Position". Containers containing glass jars shall be marked as such.

5.O. SEEPAGE TESTS

a. General. Seepage tests shall be performed in bore holes and at depths designated by the Engineer. Prior to performing the seepage tests, the bore hole shall be cleaned out and flushed with clean water to the bottom of the hole by means of a shielded jet or deflected jet as approved by the Engineer, so that all material is removed from inside the bore hole and a clean surface of undisturbed material exists at the bottom of the hole. The rate of seepage shall be determined by one of two methods described below. After performing the above tests the bore hole may be advanced without advancing casing, cleaned as described above and the rate of seepage again determined. Ground water table shall be determined for each seepage test. The data to be recorded for each test which are common to each of the two test methods are as follows:

   1. Inside diameter of casing.
   2. Height of top of casing above ground surface.
   3. Length of casing during test.
   4. Diameter of bore hole below casing.
   5. Depth to bottom of boring from top of casing.
   6. Depth to standing water level from top of casing.
   7. Description of exposed material tested.

b. Falling Water Level Method. The casing shall be filled with water and the rate of drop in the water level in the casing determined by observing the depth of the water surface below the top of the casing at 1, 2 and 5 minutes after the start of the test, and at 5 minute intervals thereafter. The record of measurements shall include the depth of the water surface below the top of casing before and after filling of the casing, the time, and tile amount of the drop measured from the start of testing for each observation. Observations shall be continued until the rate of drop in water level becomes negligible or until stopped by the Engineer. If the drop in water level, as described above, is too rapid to permit accurate observations to be made, then the method described below shall be used.

c. Constant Water Level. Water shall be added in accurately measured quantities by pouring from calibrated containers or by pumping through a water meter at a rate of flow sufficient to maintain a constant water level at or near the top of the casing for a period of not less than 20 minutes, until stopped by the Engineer. The record of measurements shall include the depth of the water surface below the top of casing before filling and during the test period, the length of time during which the water in the casing was maintained at constant level, and the amount of water necessary to be added to maintain the constant water level in the casing at 1, 2, and 5 minutes, and at 5 minute intervals thereafter, as directed by the Engineer.

5.P. PRESSURE TESTING IN ROCK

a. General. Pressure testing of weathered and sound rock shall be performed as directed. The apparatus used shall consist of a single pneumatic or mechanical expanding packer to seal off a section of the bore hole for testing. The packer and drill rods shall be calibrated to

determine friction losses in the system. The length of the packer when expanded shall be about five (5) times the diameter of the hole. It is the Contractor's responsibility that the packers used are compatible with the size casing used in each borehole. Water lines shall be arranged so that water may be pumped below the packer. The system shall include a pressure gage, water meter, a manually adjusted automatic pressure relief valve, and a pressure pump. After each three (3) meter depth of hole is drilled, the packer shall be seated so that the entire three (3) meter length of hole can be pressure tested. Water under pressure shall be pumped into the test section and the readings recorded. Upon completion of the test, the packer shall be removed, the hole drilled deeper, and the packer reinserted after an additional three (3) meters of hole have been drilled. The packer shall be seated each time at an elevation that will allow the full three (3) meter length of newly drilled hole to be tested.

b. Water Pressures, Duration of Tests, Data to be Recorded The pressure testing shall be performed in five (5) steps for each complete pressure test with the maximum pressure (P_3) based upon the vertical depth to the mid-point of the test section. The value of P_3 will be determined by the Engineer but will be in the range of 0.35 to 10 Kg/cm². In no case will the pressure at the test section exceed 0.23 Kg/cm^2 per meter of depth. The following table shows "specified ratios" of pressure and times specified for each step of pressure test.

Step No.	Pressure (P)	Time(minutes)
1	$P_1 = 1/3\ P_3$	5
2	$P_2 = 2/3\ P_3$	5
3	P_3 (determined by test depth)	10
4	P4 = 2/3 P3	5
5	P5 = 1/3 P3	5

Additional data to be recorded in each test are as follows:

1. Elevation of bottom of hole at time of each test.
2. Elevation of packer.
3. Elevation of ground water table at the time of the test.
4. Elevation of piezometric level in artesian strata.
5. Length of test section.
6. Radius of hole.
7. Length of packer.
8. Height of pressure gauge above ground surface.

5.Q. ARTESIAN MEASUREMENTS

a. General. Where artesian flow is encountered the Contractor shall measure its pressure as directed by the Engineer.

b. Equipment. The Contractor shall supply all necessary equipment for performing these measurements, including two Bourbon Gages, a watertight casing cap with "Y" connection and bleeder valve, and expansion plugs to seal off a portion of the hole for testing. The expansion plugs shall be expandable rubber packer having a length about 5 times the

diameter of the hole. The Bourbon Gages shall be calibrated in meters of water relative to atmospheric pressure. One gage shall have a range of 0 to 6 meters and the other a range of 0 to 30 meters.

c. Procedure. Where the artesian pressure is of such magnitude that the water in the borehole does not rise above the top of the casing, the pressure shall be measured and recorded as the number of meters and tenths of a meter between the natural ground water level and the level of the water in the casing. Where the artesian pressure is of such a magnitude that the water rises above the highest elevation to which the casing can be practicably extended, the pressure shall be measured by means of a Bourbon Gage fitted to a watertight casing cap by means of a "Y" connection equipped with a bleeder valve.

After each measurement of artesian pressure, the bottom of the borehole shall be advanced at least 0.3 meters but not more than 1.5 meters below the elevation at which the artesian pressure is encountered. If the artisan condition persists after advancing and cleaning out the borehole, additional measurements shall be made.

Records shall be kept of the gage readings and the vertical distances in meters and tenths of meters between the center of the gage, the natural ground surface and the natural ground water level.

5.R. SURVEYING AND HOLE MARKERS

Upon completion, each test boring, test pit, and well shall be surveyed to determine its exact location and elevation. A piece of plastic pipe filled with neat cement shall be installed by the Contractor to mark the hole. A suitable rust proof metal tag shall be attached to each marker showing the whole number, depth, and surface elevation. No separate payment will be made for whole markers, and all costs in connection therewith shall be considered a subsidiary obligation of the Contractor.

5.S. LABORATORY TESTING OF SOIL SAMPLES AND ROCK CORES

a. General. Laboratory testing will be completed on disturbed and undisturbed samples of soil and on lengths of rock core selected by the Engineer and shipped to a laboratory proposed by the Contractor and approved by the Engineer, as described in subparagraph 7-N, Storage and Delivery of Samples and Rock Cores.

b. Testing Laboratory. The laboratory testing shall be performed by an approved laboratory.

c. Type and Approximate Number of Tests. The complete laboratory testing program cannot be determined until the field exploration has been completed and the number and condition of all the samples known.

d. Submittal of a final report. A written detailed report containing the results of the laboratory testing program shall be submitted following the completion of the work in 5 copies to the Engineer for review , then the Contractor will issue the finalized report (5 copies also). The report should identify also the soil strata of the site. The report shall contain the summary of the results and the procedures used. The report shall contain the results of the field testing and the summary of the results as well as the results of the laboratory tests and all conclusions.