



Aeratsia WWTP Rehabilitation

TENDER DOCUMENT

VOLUME 2: CONTRACT (APPENDIX 6)

JANUARY 31, 2014

VTI -International Activities

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Index	Date	Author	Reviewer
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APPENDIX 6

CONTRACT

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PART 1 – GENERAL CONDITIONS OF CONTRACT

REPUBLIC OF ARMENIA / YEREVAN MUNICIPALITY

**YEREVAN WATER AND WASTEWATER SYSTEM
IMPROVEMENT PROJECT
REHABILITATION OF AERATSIA WWTP**

PART 1 – GENERAL CONDITIONS OF CONTRACT

**CONDITIONS OF CONTRACT FOR CONSTRUCTION
FOR BUILDING AND ENGINEERING WORKS DESIGNED BY THE EMPLOYER (RED BOOK)
FIDIC, EDITION 1999**

REPUBLIC OF ARMENIA / YEREVAN MUNICIPALITY
YEREVAN WATER AND WASTEWATER SYSTEM IMPROVEMENT PROJECT
REHABILITATION OF AERATSIA WWTP
PART 1 – GENERAL CONDITIONS OF CONTRACT

The General Conditions of this Contract are the General Conditions of Contract for Construction, issued and published by FIDIC (Fédération Internationale des Ingénieurs Conseils) in 1999”

The Bidders can contact FIDIC for procuring these General Conditions at the following address:

FIDIC

Office
World Trade Center II
Geneva Airport
29 Route de Pré-Bois, Cointrin
CH-1215 Geneva 15, Switzerland
Postal address
Box 311, CH-1215 Geneva 15, Switzerland

PART 2 – SPECIAL CONDITIONS OF CONTRACT

REPUBLIC OF ARMENIA / YEREVAN MUNICIPALITY

**YEREVAN WATER AND WASTEWATER SYSTEM
IMPROVEMENT PROJECT
REHABILITATION OF AERATSIA WWTP**

PART 2 – PARTICULAR CONDITIONS OF CONTRACT

Clause 1 – General Provisions

Sub-Clause 1.1 – Definitions

Sub-Clause 1.1.1.9:

Replace this sub-clause by “*Particular Conditions means the completed pages entitled Particular Conditions*”.

Add: when “appendix to tender” appears in the general conditions it shall be replaced by “Particular Conditions”.

Sub-Clause 1.1.2.2 and Sub-Clause 1.3

Data for Employer’s name and address:

Yerevan Municipality
“Municipal Development Projects Implementation Unit” SI,
Mr. G Aleksanyan
Director,
Street Address: Vardanantsstr blind alley 8
City: Yerevan
Post Code: 0010
Country: Armenia
Telephone: (374 10) 54 70 74
Facsimile number: (374 10) 54 70 72
Electronic mail address: mdpiu@arminco.com

Sub-Clause 1.1.2.4 and Sub-Clause 1.3

Data for Engineer’s name and address:

Artelia Ville et Transport
Mr. Andreas Enzinger
Project Director,
Street Address: B.P. 218
City: Echirolles Cedex
ZIP Code: 38 432
Country: France

Sub-Clause 1.1.3.3

Data for Time for Completion of the Works:

18 months

Sub-Clause 1.1.3.7

Data for Defects Notification Period:

365 days

Sub-Clause 1.2 – Interpretation

Add the following:

e) Wherever these Conditions require the Contractor to indemnify the Employer from any matter, the Contractor shall also indemnify the Engineer, the Beneficiaries and the Contracting Entity from the same matter.”

Sub-Clause 1.3 – Communication

Data for Electronic transmissions systems:

Faxes incorporating signature of authorized persons

Sub-Clause 1.4 – Law and language

Replace the first paragraph of the Sub-Clause 1.4 by ” *For the implementation of the Contract it is agreed that the Armenian Law shall be understood and analysed in conjunction with the French – Armenian Protocol signed on May 27th, 2008.*”

Data for Ruling language:

English

Data for Language for communications:

English

Sub-Clause 1.5 – Priority of documents

Add the following sentence before the last paragraph:

“Addenda, Memoranda and/or Clarifications shall have the order of precedence of the document they are modifying”.

Sub-Clause 1.6 – Contract Agreement

Replace “*the form annexed to the Particular Conditions*” by “*the form included in the Tender Document*”.

Sub-Clause 1.10 – Employers use of Contractor’s documents

Add in the second paragraph, the words “, *and other design documents made by (or on behalf of) the Contractor*” after Documents and before, including making.

Sub-Clause 1.11 – Contractor’s use of Employers documents

Replace “*in the Specification, the Drawings*” by “*in the Contractor’s Documents*”.

Add after “Employer” the following sentence:

“including all maps, drawings, photo-graphs, mosaics, plans, reports, recommendations, estimates, documents and all other data compiled or received by the Contractor under the Contract. Such maps, drawings, etc, compiled or received by the Contractor shall be delivered only to the duly authorized representative of the Employer on completion of the Works”.

Sub-Clause 1.12 – Confidential details

Add the following at the end of the Sub-Clause:

“The Contractor shall treat the details of the Contract as private and confidential, save insofar as may be necessary for the purposes thereof, and shall not publish or disclose the same or any particulars thereof in any trade or technical paper or elsewhere without the previous consent in writing of the Employer. If any dispute arises as to the necessity of any publication or disclosure for the purpose of the Contract the same shall be referred to the Employer, whose decision shall be final.”

Sub-Clause 1.13 – Compliance with Laws

At the end of Sub-Clause 1.13, add the following:

- (b) Add to this paragraph: *The Contractor shall submit the Construction Documents to the Technical Expertise for approval in accordance with Armenian Law and obtain the Construction Permit in accordance with Armenian Law (after Technical Expertise approval). The approved Environmental Impact Assessment shall be provided by the Employer to the Contractor for the Construction Permit submittal.*
- (c) *According to the requirements of Article 9 of the Financial Protocol signed between the Governments of the Republic of Armenia and the Republic of France, no duties or taxes shall be paid by the Contractor on the amount spent under the RPE loan. As a consequence the following shall apply:*
 - *Any element of duty or tax applicable to the price of locally produced and/or supplied goods shall be paid by the Contractor at the time of purchase.*
 - *The Contractor shall be paid by the Employer for all locally produced and/or supplied goods used on the project without any taxes.*
- (d) *The Employer will provide such documentation as may be required by the customs and excise authorities to facilitate the Contractor to import without payment of duties and local taxes , all materials, supplies and equipment that will form a permanent part of the Works.*

The Employer will further provide such documentation as may be required from him by the customs and excise authorities to facilitate the Contractor to import and to export when removed from the Site, any Constructional Plant, materials, equipment and Temporary Works necessary for the fulfilment of the Contract.

- (e) *The Employer will provide documentation necessary to facilitate consents including permits-to-work and approvals required for the Works at the Site from the appropriate authorities. The Employer will assist the Contractor as may be required to obtain any temporary rights-of-way that the Contractor may require in order to facilitate the fulfilment of the Contract.*

At the end of Clause 1, add the following Sub-Clauses:

Sub-Clause 1.15 – Electronic formats

All notices and documents required to be submitted by the Contractor shall also be submitted electronically in formats that can be read by:

Microsoft Word 2003 (or later version) – for text

AutoCAD version 2005 (or later version) – for drawings

Microsoft Project 2003 (or later version) – for planning

Microsoft Excel 2003 (or later version) – for numerical information.

Sub-Clause 1.16 – Legal relationship

The Contractor and the sub-contractor(s), if any, shall have the status of an independent contractor vis-à-vis the Employer. The Contract Documents shall not be construed to create any contractual relationship of any kind between the Engineer and the Contractor, but the Engineer shall, in the exercise of his duties and powers under the Contract, be entitled to performance by the Contractor of its obligations, and to enforcement thereof. Nothing contained in the Contract Documents shall create any contractual relationship between the Employer or the Engineer and any sub-contractor(s) of the Contractor.

Sub-Clause 1.17 – Records and accounts

The Contractor shall maintain accurate and systematic records and accounts in respect of the work performed under this Contract.

The Contractor shall furnish, compile or make available at all times to the French Government any records or information, oral or written, which the French Government may reasonably request in respect of the Works or the Contractor's performance thereof.

The Contractor shall allow the French Government or its authorized agents to inspect and audit such records or information upon reasonable notice.

Clause 2 – The Employer

Sub-Clause 2.1 – Right of Access to the Site

At the end of Sub-Clause 2.1, add the following paragraph:

Should the Contractor require the temporary use of any additional land to that of the Site for the purposes of storage, working space or additional points of access, he shall be responsible for obtaining all necessary permits and agreements from the relevant authorities and land owners and shall bear all the related costs and expenses. The Contractor will be responsible for all matters arising from the use of such land and the Employer shall have no liability in respect of such use by the Contractor.

Data for Time for access to the Site:

The day of the Commencement Date

Sub-Clause 2.5 – Employer's Claims

Add the following after “shall” on the first line of the third paragraph:

, promptly,

Clause 3 – The Engineer

Sub-Clause 3.1 – Engineer’s Duties and Authority

Add the following wording at the end of the second paragraph:

,except as specifically provided for in the Contract with respect to variations of the form, quality and quantity of the Works, related payments and Extensions of Time.

At the end of Sub-Clause 3.1, add the following paragraph:

The Engineer shall obtain the approval of the Employer before taking the following actions:

- (a) Issuing a commencement notice pursuant to Sub-Clause 8.1*
- (b) Issuing any determination pursuant to Sub-Clause 8.4 – Extension of Time for Completion*
- (c) Issuing any instruction to suspend progress of the Works pursuant to Sub-Clause 8.8 – Suspension of Work*
- (d) Issuing any Taking-Over Certificate pursuant to Sub-Clauses 10.1 and 10.2*
- (e) Issuing any Performance Certificate pursuant to Sub-Clause 11.9*
- (f) Issuing any instruction or determination pursuant to Sub-Clauses 13.1, 13.2, 13.3, 13.4, 13.5, 13.6, 13.7 – Variations and Adjustments which is estimated by the Engineer to have the effect of increasing the Contract.*
- (g) Issuing any determination or making any agreement pursuant to Sub-Clause 15.3 – Valuation at Date of Termination*

At the end of Clause 3 – The Engineer, add the following Sub-Clauses:

Sub-clause 3.6 Transfer of Engineer’s Duties to the Employer

All of the duties and authorities vested in the Engineer pursuant to the Contract, shall pass to the Employer on the date of issue of the Taking Over certificate.

Sub-Clause 3.7 Management Meetings

The Engineer may require the other to attend management meetings in order to review the progress of the Works and the arrangements for future work. The Engineer shall record the business of management meetings and supply copies of the record to those attending the meeting and to the Employer. In the record, responsibility for any actions to be taken shall be ascribed and should be consistent with the obligations set out in the Contract.

Clause 4 – The Contractor

Sub-Clause 4.2 – Performance Security

In the second paragraph replace “28 days” by “30 days”

In the last paragraph replace “28 days” by “5 days”

Add at the end of the sub-clause:

The Contractor shall inform the Employer previously, in written form about bankruptcy or dissolution process during the validity of the Contract Performance Security.

Data for Amount of Performance Security:

10% of the Contract Amount, in the currencies and proportions in which the Contract Price is payable

Sub-Clause 4.3 – Contractor’s Representative

Add the following wording at the end of the sixth paragraph:

and the Engineer has given his consent

Sub-Clause 4.4 – Sub contractors

Add the following wording at the end of (b):

(b) the approval of proposed subcontractor will be based on the evaluation of its proved experience. The Engineer decision will be final.

Sub-Clause 4.15 – Access Route

Delete “as between the Parties” after “shall” on the first line of the sentence (a)

Sub-Clause 4.22 – Security of the Site

Add the following words to sentence (b) after “Employer’s” on the second line:

and the Engineer’s authorized personnel

Sub-Clause 4.23 – Contractor’s Operations on Site

Replace the third paragraph by the following paragraph:

Upon the issue of a Taking-Over Certificate, the Contractor shall clear away and remove from the Site, all Contractor’s Equipment, surplus materials, wreckage, rubbish and Temporary Works that are related to the Works for which the Taking-Over Certificate has been issued. Any such equipment or materials that the Contractor may require for use during the Defects Notification Period may be retained on the Site subject to the Engineer’s prior written consent.

Sub-Clause 6.5 – Working hours

Data for Normal working hours:

Monday to Friday, 7:00 to 16:30

Sub-Clause 6.7 – Health and Safety

First paragraph, add “*Employer’s Personnel and the Engineer*” after “*Contractor’s Personnel*”

Sub-Clause 6.8 – Contractor’s Superintendence

Insert at the end of Sub-Clause 6.8 the following wording:

A reasonable proportion of the Contractor’s superintending staff shall have a working knowledge of the Armenian language or the Contractor shall have a sufficient number of competent interpreters, at its own cost, available on Site during all working hours.

Clause 7 – Plant, Materials and Workmanship

Sub-Clause 7.3 – Inspection

On the first line after “Employer’s” add the following words:

and the Engineer’s.

On the first line of the second paragraph after “Employer’s” insert the following words:

and the Engineer’s

Clause 8 – Commencement, Delays and Suspension

Sub-Clause 8.1 – Commencement of Work

Add the following wording at the end of the sub-clause:

As soon as the Contractor shall receive the Commencement Date Notice, the Time for Completion will be “on”.

Sub-Clause 8.2 – Time for Completion

Add the following wording at the end of the sub-clause:

*The Time for Completion shall be 20 months, including a mobilization period of minimum 60 days.
Before the Start of Work on site, the Construction Permit shall have been obtained by the Contractor.
The complete Technical Expertise documentation shall be submitted at the latest one month after the Commencement Date. The delay for a complete Technical Expertise approval and Construction Permit delivery by the Armenian Authorities is one month.*

Sub-Clause 8.3 – Programme

After “Employer’s” on the fourth line of the second paragraph, add the following words:

and the Engineer’s

Sub-Clause 8.5 – Delays Caused by Authorities

After “Unforeseeable” on line (c) add the following wording:

or that foreseeable delay or disruption could not have been reasonably avoided.

Sub-Clause 8.7 –Delay damages

Data for Maximum amount of delay damages:

10% of the final Contract Price in the currencies and proportions in which the contract Price is payable

Sub-Clauses 8.7 –Delay damages& 14.15(b) Currencies of Payment

Data for Delay damages for the Works:

0,05% of the final Contract Price per day, in the currencies and proportions in which the Contract Price is payable

Sub-Clause 8.10 – Payment for Plant and Materials in Event of Suspension

This Sub-Clause is deleted from the Contract.

Clause 9 – Tests on Completion

Add the following wording at the end of the Clause:

The test will be carried out in accordance with the Provisions of the Employer’s General Requirements

Clause 10 – Employer’s Taking Over

Introduce the following as additional Sub-Clause 10.5:

Notwithstanding the mechanisms set out in Sub-Clauses 10.1, 10.2, 10.3, 10.4, the putting into operation of the whole or any part of the Works by the Contractor prior to the issue of the related Taking Over Certificate of the Works shall not constitute a de facto taking-over of either a part or the whole of the Works.

The Taking Over Certificate shall be issued with consideration of the Clauses of the Employer’s General Requirement.

Clause 11 – Defects Liability

Sub-Clause 11.1 – Completion of Outstanding Work and remedying Defects

Replace the last sentence with the following:

If a defect or damage occurs, the Contractor shall inform the Engineer or the Employer immediately, including in writing.

Sub-Clause 11.11 – Clearance of the Site

Replace "Performance Certificate" on the first line of the first paragraph, by "Taking Over Certificate":

Clause 13 – Variations and Adjustments

Sub-Clause 13.5(b) – Provisional Sums

Data for Percentage for adjustment of Provisional Sums, including day works, if any:
0%

Sub-Clause 13.8 – Adjustments for Changes in Cost

Delete the first paragraph and "If this Sub-clause applies" at the beginning of the second paragraph. Delete the end of third paragraph after the word "determine" on the third line and replace by the following:

from the following formulae applied in the contract value of the Works expressed in Euros:

The adjustment price formula is:

$$P = P_o (0.50 + 0.20 I/I_o + 0.10 T/T_o + 0.10 E/E_o + 0.20 M/M_o)$$

Where:

P = the amount on the estimated contract value in Euro of the permanent work executed for the Works as defined in the Bill of quantities, on the last day of the month, due to price fluctuations

P_o = the value of that part of the Works as defined in Sub-Clause 14.1(a) determined in accordance with the Contract.

I = the available construction cost within the country of the International Contractor head office last day of the month in which the permanent Works are executed and/or valued.

I_o = the available construction cost index within the country of the International Contractor on the Base Date as defined in Sub-Clause 1.1.3.1 of the General conditions of contract.

T = the available price index of the Consultancy industry within the country of the International Contractor head office last day of the month in which the permanent Works are executed and/or valued.

To = the available price index of the Consultancy industry within the country of the International Contractor on the Base Date as defined in Sub-Clause 1.1.3.1 of the General conditions of contract.

E = the available price index of Electrical industry within the country of the International Contractor head office last day of the month in which the permanent Works are executed and/or valued.

Eo = the available price index of Electrical industry within the country of the International Contractor on the Base Date as defined in Sub-Clause 1.1.3.1 of the General conditions of contract.

M = the available price index of Mechanical industry within the country of the International Contractor head office last day of the month in which the permanent Works are executed and/or valued.

Mo = the available price index of Mechanical industry within the country of the International Contractor on the Base Date as defined in Sub-Clause 1.1.3.1 of the General conditions of contract.

The values of indexes I, Io, T, To, E, Eo and M, Mo, for use in the above formulae shall be as officially issued by the relevant Department of Statistics and Research for the relevant dates.

In case of non availability of indexes or inconsistency with the above definition, the Engineer shall determine, within 28 days after the commencement Date, which indexes shall be used for the duration of the Contract.

Delete the forth, fifth and eight paragraph (last paragraph) of sub-clause 13.8.

Clause 14 – Price and Payment

Add Sub-Clause 14.1 (e) as follows:

According to requirements of Article 8 of the Financial Protocol signed between the Governments of the Republic of Armenia and the Republic of France the VAT is paid by the Employer.

Sub-Clause 14.2 – Advance Payment

Data for Total advance payment:

- 10 % of the Accepted Contract Amount in the currencies and proportions in which the Contract is payable
- One instalment payable 30 days after receipt by the Employer of Performance Security, Advance payment guarantee and due invoice

Sub-Clause 14.2(b) – Advance Payment

Replace “25% by “10%”

Sub-Clause 14.3 – Application of Interim Payment Certificates

Data for percentage of retention:
10%

Sub-Clause 14.4 – Schedule of Payments.

Replace Subclause by:

No schedules of Payments are included in this Contract. A Forecast cashflow schedule shall be provided by the Contractor during the Mobilization Period and updated every month.

Sub-Clause 14.5 – Plant and Materials intended for the Works.

Delete subclause 14.5(b).

Sub-Clause 14.5(c) applies.

Replace Sub-Clause 14.5(c) (i) by:

*Interim payments shall be as follows:
are all supplies and installation of equipment as listed under the BOQ (Bill of Quantity) of the Contract, except for civil works; and
are Completed Civil Works items as listed on the BOQ of the Contract, and paid as lump sums, as a percentage of completed items.*

Data for repayment amortisation of advance payment
As per items quoted in Euros

Sub-Clause 14.6 – Issue of Interim Payment Certificates

Data for Minimum amount of Interim Payment Certificates
5% of the Accepted Contract Amount

Sub-Clause 14.15 – Currencies of Payment

Data for Currency/currencies of payment
Euro

Clause 17 – Risk and Responsibility

Sub-Clause 17.1 – Indemnities

After “Employer’s” on the first line of the first paragraph, add the following words:

the Engineer’s

At the end of Clause 17 – Risk and Responsibility, add the following Sub-Clause

Sub-Clause 17.7 – Non Conformity with the technical specifications

When the implementation of Works shall not comply with the Technical specifications of this Contract and/or Order’s, the Contractor pays penalty – 0.5 % of the Order’s price.

Clause 18 – Insurance

Sub-Clause 18.1 – General Requirement for Insurances

Data for Periods for submission of insurance:

- (a) evidence of insurance.....28 days
- (b) relevant policies.....90 days

Sub-Clause 18.3 – Insurance against Injury to Persons and Damage to Property

Data for Minimum amount of third party insurance:

5.000.000 EUR or equivalent for any claim, number of claims unlimited.

Clause 20 – Claims, Disputes and Arbitration

The Sub-Clauses 20.1 to 20.8 are replaced by the following new Clause 20 –Settlement of Disputes :

Clause 20 – SETTLEMENT OF DISPUTES

SETTLEMENT OF DISPUTES

In the case of any claim, controversy or dispute arising out of, or in connection with this Contract or any breach thereof, the following procedure for resolution of such claim, controversy or dispute shall apply.

1 Notification

The aggrieved party shall immediately notify the other party in writing of the nature of the alleged claim, controversy or dispute, not later than seven (7) days from awareness of the existence thereof.

2 Consultation

On receipt of the notification provided above, the representatives of the Parties shall start consultations with a view to reaching an amicable resolution of the claim, controversy or dispute without causing interruption of the Works.

3 Conciliation

Where the representatives of the Parties are unable to reach such an amicable settlement, either party may request the submission of the matter to conciliation in accordance with the UNCITRAL Rules of Conciliation then obtaining.

4 Arbitration

Any claim, controversy or dispute which is not settled as provided under clauses 1 through 3 above shall be referred to arbitration in accordance with the UNCITRAL Arbitration Rules (UNCITRAL website: http://uncitral.org/uncitral/en/about_us.html, as revised in 2010) then obtaining. The Parties shall be bound by the arbitration award rendered in accordance with such arbitration as the final adjudication of any such controversy or claim.

PART 3 – GENERAL AND TECHNICAL SPECIFICATIONS

PART 03 – TECHNICAL SPECIFICATIONS

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01 000 GENERAL REQUIREMENTS

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01 000 GENERAL REQUIREMENTS

1. GENERAL

1.1. REFERENCE TO OTHER CHAPTERS

Throughout the Specifications and Bill of Quantities, references are occasionally made to other Chapters. All such references are intended solely for the convenience of those using the documents, and the absence of a reference in no manner excludes the application of every other Chapter in the Specifications which may, in the opinion of the Engineer, have any bearing upon the point in question, the intention being that the Contract Documents shall be read and applied as a whole.

1.2. NON-DISCLOSURE OF INFORMATION

The Contractor shall not without the consent in writing of the Employer disclose particulars of the Contract to any person or furnish or publish or permit to be furnished or published any information with regard to the Employer's business to any person save in so far as may be necessary for the due performance of the Contract and shall preserve strict confidence with regard to any information of a confidential or secret nature received from the Employer or the Engineer.

1.3. CLAIMS FOR DAMAGES TO PERSONS OR PROPERTIES

Any claim received by the Employer in respect of matters in which the Contractor is required under the Contract to indemnify the Employer will be passed to the Contractor who shall likewise inform the Employer of any such claim which is submitted directly to him by a claimant. The Contractor shall do everything necessary, including notifying the insurers of claim received, to ensure that all claims are settled properly and expeditiously and shall keep the Employer informed as to the progress made towards settlement. If the Contractor receives a claim which he considers to be in respect of matters for which he is to be indemnified by the Employer under the Contract, he will immediately pass such claim to the Employer. All information as aforesaid shall be given in writing and shall be copied to the Engineer.

2. SPECIFIC INFORMATION RELATED TO THE PROJECT

2.1. PROJECT LOCATION

The construction site for the new and rehabilitated Aeratsia Waste Water Treatment Plant is located at the existing wastewater treatment site in the Shengavit District of the Yerevan Municipality.

2.2. SITE CONDITIONS

2.2.1. GENERAL

A site investigation has been carried out for the WWTP, a copy of the soil investigation works (Boreholes logs + laboratory tests) has been attached in the Tender (part 5 of Appendix 6).

The Contractor shall analyse these investigations and shall draw his own conclusion from the Site Investigation Report. The Client recognizes no responsibility of any conclusion the Contractor may draw thereof.

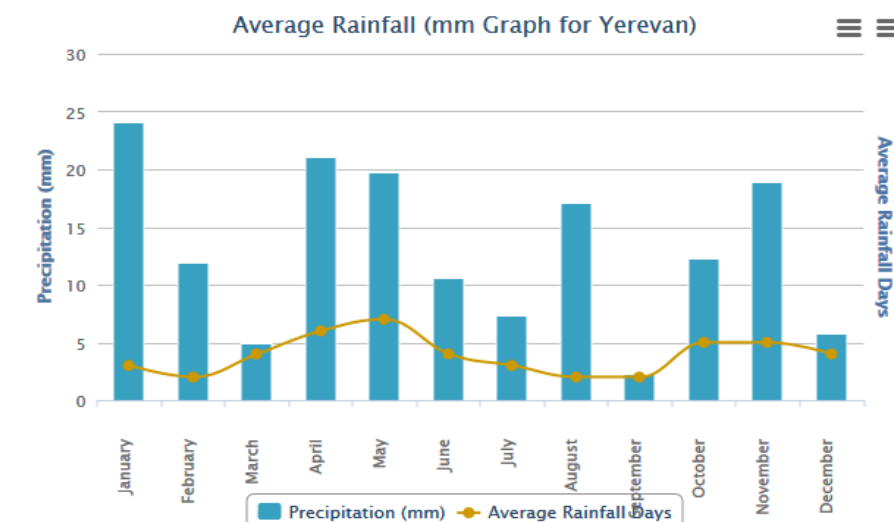
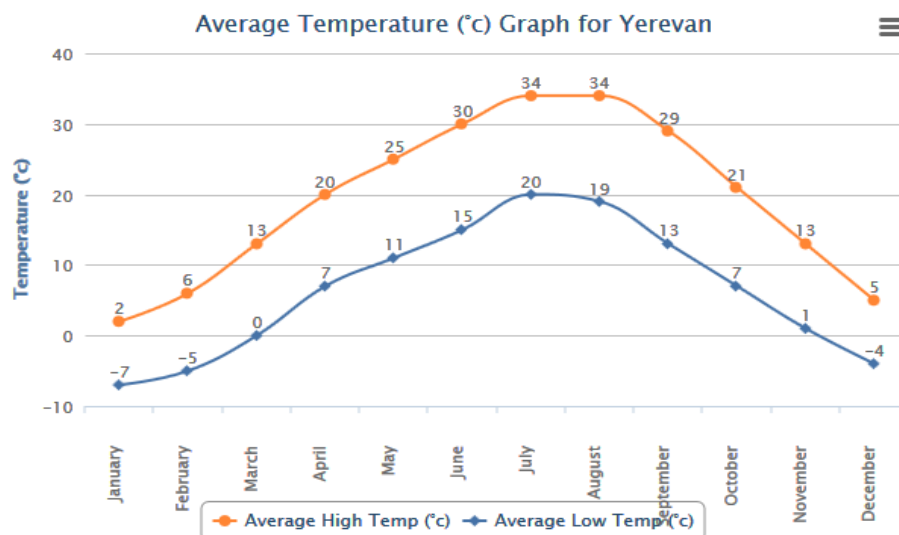
2.2.2. SEISMICITY

The evaluation of the ground acceleration to use for the structural calculations will be done in accordance with the National regulations.

2.2.3. CLIMATE

The climate is typically continental with hot summers and cold winters. The average monthly temperature varies between 34°C to -7°C. The temperature may be -20 °C for more than one week.

The average rainfall in Yerevan has a maximum in January with 24 mm. The number of rainy days per month varies from 2 to 7 days per month. Intense rain event occur regularly.



Source: World Weather Online

2.2.4. EXISTING FACILITIES WITHIN THE SITE OF WORKS

There are many buildings from the old Aeratsia plant at the site. The following buildings are in good conditions and will be reused for this project:

- Office building for the plant director and his staff
- Laboratory
- Main Entrance gate with Guard house
- Storage building to be reconverted as a sludge handling building, including a guard house and a secondary entrance
- Substations and power supply
- Artesian well with its pump
- Small Building for electrical room
- Two Inlet Pipes (gravity flow): one ND 1600 gravity pipe and one ND 1200 gravity pipe.
- Plant Bypass (inlet structure and pipe)
- One Outlet Pipes (gravity flow): ND 2000 gravity pipe from the plant Bypass to the Hazdran river, located on the side of the road, outside of the WWTP site.

In addition the site has many building or works that are to be demolished by the Owner prior to the beginning of the Construction Works under this Contract. The demolition performed by the Owner is shown on the drawings.

2.2.5. CONSTRUCTION PHASING

The Contractor shall consider the following elements for the construction Phasing to be submitted to the Engineer:

- Connection to the two existing Inlet Pipes: The ND 1600 gravity pipe and the ND 1200 gravity pipe are connected approximately 100 m upstream of the inlet Chamber by a ND600 connecting pipe. The ND 1200 pipe drops approximately 1m vertically in a chamber at the location where the connection to the ND 1600 pipe is located. Therefore backflowing of the ND 1200 pipe is feasible. If all flow is diverted from one pipe to the other during the construction of the connection Works to the existing pipes, the contractor shall provide a temporary pump if needed, as the ND600 may not pass the entire flow. Backflow to the sewer Networks upstream of the WWTP entrance gate shall not be acceptable.
- Connection to the existing outlet Pipe: The ND 2000 gravity pipe is continuously used as it transports the bypass and existing treated wastewater to the Hazdran River. The ND 2000 gravity pipe discharges to an existing effluent chamber located outside of the WWTP site, and approximately 300 m downstream of the “Offsite Outlet Chamber”. From this existing Chamber the ND2000 pipe goes to the Hazdran River.

2.3. SCOPE OF WORKS

2.3.1. DESCRIPTION

The services to be provided by the Contractor include, but are not limited to the following:

- A. Mobilization Period documents

- Foundation drawings and temporary works
- Additional soil investigations, as considered required by the Contractor
- Construction Phasing Plan for connecting to existing facilities, including a written description and drawings as needed.
- Shop drawings and working drawings with the corresponding calculation
- Submission to the Armenian Authorities of the appropriate above listed documents for the Expertise and Construction Permit obtention.

B. Implementation

Works to be carried out by the Contractor include the following in particular:

- a) Installation of the site and preparatory works, connection to telecoms, water and other networks.
- b) Implementation of works in accordance with the “The Design”, as specified in the General Conditions of Contract, including in particular:
 - Preliminary drillings and investigations, as deemed necessary by the Contractor,
 - Earthworks and final backfilling, drainage (including removal and storage of materials and earth),
 - Special foundations, if necessary
 - All shell construction (reinforced concrete, masonry, framework, roofing, sealing, cladding, etc.),
 - All finishing and fitting works for the plant,
 - All equipment installation,
 - Fences, roads and utilities networks,
 - demolition of existing structures to be removed, if any, including pipes and the reuse or removal and dumping of the corresponding materials in locations authorized by local legislation, and levelling of the land thus freed,
 - Connection of the new installations with existing structures (pipes).
 - All pipes, whatever the position, as described on the drawings
- c) Implementation of the “electricity and electromechanical and hydro mechanical equipment” section in conformity with the Design, including the supply, testing and transportation on site of all necessary materials and equipment and their implementation or erection and adjustment, namely:
 - Hydraulic, mechanical and electrical treatment equipment, including driving equipment and control, monitoring, measurement, protection and safety devices
 - Miscellaneous equipment required for the proper operation and maintenance of the installations, (lighting, ventilation, heating, telephone, etc.),
 - The remote surveillance system, if any

- All small equipment, pipes, and all adjustments required for a proper operation
- d) The installation of all necessary fire safety equipment in technical rooms of the facility, in accordance with Armenian regulations.
- e) The commissioning of the installation and performance of the tests.
- f) The provision of maintenance and operating manuals, as-built drawings of the structures and yard piping.
- g) Supply of spare parts.
- h) Services for the Employer, as defined below and/or in this tender documents.
- i) No interference with the existing operation of the plant during construction, except during the connections to the existing facilities and in accordance with the submitted Construction Phasing Plan.

C. Operation and Maintenance

No Operation and maintenance service shall be provided under this Contract.

2.3.2. PARTICULAR PROVISIONS

2.3.2.1. PRODUCTS AND COMPONENTS STORAGE

While establishing their bids' prices, the bidders should be aware of the specific situation of Armenia in regards to transport and availability of construction materials. Then, the Contractor shall organize the supply of the works in order to manage to have enough materials and equipment on site in case of transport issues.

2.3.2.2. MAINTAINING EXISTING PLANT OPERATION DURING CONSTRUCTION

The Existing plant (screening with manual cleaning and grit removal) shall continue to operate during the Construction works and until the flooding of the new treatment plant.

The Grit is removed by front loaders and trucks which will need to have access to the existing grit tanks during construction.

2.3.2.3. PROVISIONS FOR A FUTURE PHASE 2

The wastewater treatment plant may be expanded to accommodate larger flows. For this purpose several provisions shall be included, as. noted on the drawing

In addition, under a future Phase 2, the primary solids might be directed to an anaerobic digestion prior to dewatering. For this purpose provisions shall be included as shown on the drawings.

In the future a Coagulation and Flocculation (area 104) could be added between the grit tanks (area 103) and the lamellar sedimentation tanks (area 105). For this purpose provisions shall be included as shown on the drawings.

2.4. ADJOINING CONTRACTS

This contract is one of three contracts to be implemented separately under "the RPE Yerevan project". These contracts are

- 1- Contract 1: Aeratsia Waste Water Treatment Plant,
- 2- Contract 2 : Water Supply & Wastewater Network Works
- 3- Contract 3: SCADA Projects (for the Water Supply Network)

2.5. SERVICES TO PROVIDE

2.5.1. VEHICLES

No Vehicles shall be provided by the Contractor to the Employer or the Engineer.

2.6. COMMISSIONING

With reference to Section 17 of this Specification, the following duration shall be strictly applied:

Pre-commissioning period: minimum 14 days

Commissioning period: 2 months

These periods are considered as a minimum, included in the time of completion.

3. DAY WORK

3.1. GENERAL

The Contractor shall complete the Day work prices in the Bill of Quantity.

No increase or decrease in price will be made for labour and materials day work charges.

The day work prices are not subject to adjustment.

Day works shall be paid, if any, through the Provisional Sum amount.

Day works shall be used and implemented only if the Engineer requests to do so.

3.2. LABOUR CHARGES

The labour categories qualifying as reimbursable to the Contractor when employed on day work shall include the gangers and charge-hands working with their gangs but shall exclude supervision for foremen level and above.

The Contractor will be reimbursed for the actual gross remuneration at the current rate for each labourer, tradesman, artisan, etc., which shall be deemed to include the following, but not limited to:

- Basic wage

- Unemployment insurance
- Workmen's compensation
- Service bonus
- Foods and water
- Transportation if any

The rates provided by the Contractor shall cover all the following cost:

- Supervision
- Overheads
- Profit
- Time keeping
- Accommodation
- Insurances
- Holidays with pay
- Travelling
- Subsistence
- Other bonuses
- Allowance for paid sick leave
- Allowance for non-productive time
- Recruitment costs
- Pay packet costs
- Pension
- Allowance for paid public holidays
- Allowance for paid annual leave
- Any statutory charges due
- Any and all other relevant to the employment of such employees including all liabilities, obligations, risks and incidentals for all employees to execute work by day works.

In addition,

- Only gangers and charge-hand who are working with their gangs shall be paid for under day works. The composition of each working gang on day works shall be approved by the Engineer prior to the commencement of such day work. Any ganger or charge-hand who does not work with the gang shall be deemed to be in a supervisory category.
- Site Agents, Quantity Surveyors, Engineers, Foremen and the like shall be deemed to be covered in the rates and prices in the Bill of Quantities.

- Overtime hours on day work operations will be worked when expressly required by an instruction in writing from the Engineer. Overtime when required will be paid in the same proportions as actually paid to the employees.
- The day work hours that labour work will be calculated from the time of arrival of the labour at the site where the work is to be carried out to the time of departure from such site but excluding meal breaks and rest periods, etc., i.e. the net time expended for the work.

The combination of the gross remuneration as stated in the Bill of Quantities and the percentage allowance on labour for day work will be deemed to constitute the full inclusive charge to the Employer for each respective labourer, artisan, etc. Such combination shall include for all items of equipment and consumable which are normal to the particular labourer, tradesman or artisan in question including portable power tools, manual plant and tools, etc. which have not been listed in the Day work Equipment Schedule. It shall also include the use of water, lighting, power, the ventilation and sewerage facilities, the use and maintenance of staging, scaffolding, workshops, stores and the like.

3.3. CONTRACTOR'S EQUIPMENT CHARGES

The Bidder shall complete the Day work Equipment Schedule in the Bill of Quantities in order to provide prices for all items of equipment to be provided on Site which may be required to execute work under day work.

The schedule must indicate clearly the total hourly operating rate, such as at 28 days prior to the closing date of tender, for each item of equipment. Such rates shall constitute the net charge to the Employer for the equipment, in a state fit to perform its intended function, including operating labour required for the equipment.

The cost of operators shall be included under equipment charges.

Equipment rates for day work shall take account for the following:

- Small tools are not to be listed separately and the use of such tools will be deemed to be covered in the percentage allowance tendered for day work labour charges and shall not be the basis of claims for payment under day work charges.
- No addition shall be allowed on the quoted rate for the transport of the said equipment to and from the areas of work if the equipment is already on Site. If, however, the equipment is brought onto Site especially for the extra work ordered, then the transport shall be charged extra at cost, unless such equipment continues in operation for work of a normal nature under the Contract.
- The operating rates to be quoted are to include for items such as fuel, oils, power, consumable, ground-engaging tools, maintenance, repairs, etc. and other incidentals.
- Full payment of the bid rate will not be made for items not capable of operating properly or unable to perform any of their intended functions.

The day work operating for equipment will be calculated from the separate times of arrival of each item of equipment at the site where the work is to be carried out to each time of departure from such site but excluding meal breaks and rest periods, etc. as arranged by the Contractor for the respective equipment operators. The time for transport between Working Areas or from a Working Area to other Site areas as relevant will subject to prior agreement with the Engineer, be included for reimbursement at the applicable day work rates.

The minimum time paid for each item of equipment commencing work on each day work order will be one hour (operating or standby if applicable) and thereafter the times operating or on standby will be paid to the nearest 0.25 hour (15 minutes).

The combination of the net cost as stated in the Schedules and the percentage allowance on equipment for day work will be deemed to constitute the full inclusive charge to the Employer in respect of the incorporation of such materials in the Works except as allowed for in the Day work Labour and Equipment items in the Bill of Quantities.

3.4. MATERIALS CHARGES

Reimbursement for materials used in day work will be at the net current cost of such materials as delivered to the Site (including delivery to and handling at the usual points at which materials are received on the Site), which will be assumed to be the Contractor's Working Area closest to where the work is to be executed.

The net cost of materials shall mean the cost, after the deduction of any discounts on the materials, as substantiated by invoices or other such documentary evidence. The measurement of materials shall exclude all waste, i.e. the total to be paid shall be for the net quantity actually incorporated in the completed work. The materials charges shall include:

- All overheads and profit,
- All storage and handling of materials and for distribution to the individual area(a) where day work is in progress,
- All other charges relevant to the use of materials for day work.

The combination of the net cost as stated the Bill of Quantities and the percentage allowance on materials for day work will be deemed to constitute the full inclusive charge to the Employer in respect of the incorporation of such materials in the Works except as allowed for in the Day work Labour and Equipment items in the Bill of Quantities.

4. DOCUMENTS

4.1. TENDER DRAWINGS SUPPLIED TO THE CONTRACTOR

The only drawings provided by the Employer to the Contractor are the drawings included in the Tender Documents – Part 4, Appendix 6.

4.2. DOCUMENTS AND DRAWINGS TO BE CARRIED OUT BY THE CONTRACTOR

4.2.1. DESIGN DOCUMENTS:

No design documents are required.

4.2.2. SHOP DRAWINGS

A. General provisions for shop drawings

- a) Such drawings shall be deemed to be shop Drawings, part of the Contractor's Documents pursuant to Clause 4.1 of the General Conditions of Contract.
- b) The drawings issued by the Contractor for construction will include:
 - The foundation drawings, including if any temporary works such as excavation drawings, etc.

- Detailed drawings of installation of any steel works, wood works, including calculations notes if required.
- All additional electrical, automation, plumbing, HVAC, handling, etc. drawings to develop in greater detail, if necessary, and as required for the construction.
- The detailed drawings of concrete reinforcement and calculation works, as well as bar bending and cutting list, as installed.
- Reinforcing steel shop drawings, formwork drawings
- The additional drawings as required by the Engineer to develop in greater detail the construction required.
- Detail erection drawings, concrete placing (lift) drawings, shop drawings on mechanical and electrical drawings, wiring diagrams (electrical cabinet and structures) and cabling; other detail drawings shall be prepared by the Contractor on the basis of the Construction Drawings; they will be given for information to the Engineer before construction.
- All drawings shall be in the Contract's language, and all dimensions shall be in Metric system. Symbols shall be in accordance with approved Standards. All drawings submitted for approval shall conform to ISO paper sizes A1 to A3. Title block and numbering shall be approved by the Engineer.

These drawings will be submitted by the Contractor in accordance with the Documents' submittal program, to the approval of the Engineer.

The Permanent Works shall be executed in conformity with the Construction Drawings and other drawings approved by the Engineer.

- c) All the above listed drawings shall be referred to hereinafter as Shop Drawings.

B. Civil works

All particular arrangements on the civil structures (cranes, temporary loads, batching plant, additional or variant equipment...) shall comply with the following provisions.

- a) Design calculations

The design calculations may be presented in a computer format and shall include:

- A title page
- Design calculations conditions and criteria;
- The values of the maximum stresses under normal and exceptional operating conditions and during handling, transport and erection;
- The main dimensional characteristics:
- The properties of the materials used;
- Bibliographical references used for the calculations.
- The loads to which the supply is subjected and their origin;

- The forces transmitted to supplies and to the foundations;
- Stresses to which the equipment will be subjected under normal and exceptional operating conditions (including handling, transport and erection);
- The permitted safety factors;
- In general, any indications required for a proper understanding of the design of the supply;
- The output, power and characteristics of drive or control motors.
- All design calculations of the approved variant, if any.

The Engineer reserves the right to request the Contractor for any additional design calculations which he considers necessary. The above listed calculations shall be prepared during the mobilization period and submitted as part of the “Expertise” package for construction permit obtention.

The drawings prepared by the Contractor will be established for cases of maximum load likely to occur during operation of the Permanent Works, and exceptional load situations which may occur during construction in compliance with the method of works.

The Contractor shall be responsible for assuring the adequacy of all parts of the works with respect to loading which might occur during construction and shall supply calculation notes and drawings for any necessary false work, supports, strengthening as may be required by the Engineer.

b) Other drawings

In addition to the drawings listed above, the Contractor shall prepare and deliver to the Engineer prior to the start of construction the drawings for:

- the Temporary Works
- the performance of the Works as necessary for showing the construction methods
- Access roads;
- Contractor’s camp and facilities,
- The other drawings necessary for the performance of each part of the Works in accordance with the Contract.

The Contractor shall perform the necessary calculations in connection with the required drawings.

- c) The Contractor shall be responsible for the behaviour of the Permanent Works during the various phases of construction. He shall provide all equipment and accessories and all working arrangements necessary to limit stresses on the Works, so that stability of the structures is not threatened and so that stresses and deformation remain within acceptable limits.
- d) It is the responsibility of the Contractor to inform the Engineer in case of mistakes on the Tender Drawings.

C. Mechanical equipment included in the present contract

a) General

The Contractor is responsible for the execution of documents (drawings, diagrams, design calculations, erection, etc.) for the different supplies.

PART 3 – TECHNICAL SPECIFICATIONS

A list of all drawings, diagrams and design calculations to be submitted to the Engineer shall be drawn up at the start of the Works in agreement with the Engineer. However, the Engineer reserves the right to request further details at a later stage in order to facilitate understanding of equipment functions.

b) Overall and detail drawings of the equipment

The Contractor shall supply drawings for information of assemblies, parts of assemblies and large parts of the equipment to the Engineer for information.

These drawings, or where applicable their technical associated documents, shall include, in addition to production dimensions, flatness, straightness, horizontal and vertical tolerances, the values of assembly and operating clearance with the minimum and maximum acceptable deviations, the type and the properties of the materials used in the different parts, the weld categories and the types of non-destructive testing to be carried out on welds, the surface condition valued to be achieved for parts machined in accordance with ISO/R 468 standard or applicable Armenian standards, whichever is more stringent.

Drawings, or, where applicable, their technical associated documents shall also include the weights of assemblies, parts of assemblies and detailed parts as well as the surface areas to be painted for large structures.

D. Submission and approval

- a) The Contractor shall submit in three (3) hard copies to the Engineer, for review, information or approval, all documents and drawings which he prepares under this Clause. The Engineer will analyse all such designs and drawings, will appraise them as to whether they are reasonable and consistent with the Construction Drawings, will approve if requested and will order changes when deemed necessary.

The Contractor's documents and drawings shall be submitted in a sequence to facilitate the Engineer's study and scrutiny of the same, shall be completed in regard to all computations and data, and shall be traced on size 840 mm x 594 mm (A1-size) or 297 mm x 420 mm (A3-size) paper. The title of the drawings, the signature of the Contractor's representative, the date of preparation and the reference to Construction Drawings, if any, shall appear in the bottom right hand corner of the drawing. Within twenty-one (21) days after submission of the drawings, the Engineer will advise the Contractor of his conclusions regarding the drawings.

- b) When approval is requested, the Engineer's conclusions may be one of the following:

- "APPROVED"
- "DISAPPROVED" (with relevant reasons determining rejection duly indicated).

Within seven (7) days of the return of documents and drawings marked "APPROVED" the Contractor shall present to the Engineer one reproducible copy of the drawings traced in ink and two (2) prints of the same with an new index x+1 stated "approved by the Engineer by decision of date"

No drawing shall be considered valid unless signed by the Engineer. The approval by the Engineer of such drawings shall not relieve the Contractor of his obligations and responsibilities under the Contract.

Those marked "DISAPPROVED" shall be redone or/and modify and submitted once again to the Engineer. The above process will then be followed again.

The Contractor shall not be entitled to a time extension based upon the rejection of designs or detail drawings, because such designs or detail drawings fail to conform to sound engineering principles, or to the Specifications.

All Works should be executed with the relevant approved drawings. All materials ordered or Works performed prior to approval of the relevant designs, shall be at the Contractor's risk.

The Contractor shall bring to the attention of the Engineer any variation to the Contract in the document submitted for approval.

c) When no approval is requested within twenty-one (21) days after submission of the drawings, the Engineer will notify his comments or requests. All materials ordered, or work performed, prior this notification shall be at the Contractor's risk.

E. Ownership of drawings and data

All the drawings, details, bill of materials and any other information or documents furnished by the Contractor shall become the property of the Employer and shall be non-returnable. The Employer will have the right to use this property.

Such information shall be given in paper copy and in digital format.

F. Design criteria

Unless otherwise specified, the following figures will be used as design criteria.

Acceleration due to gravity: for any relevant calculation or evaluation will be: $g = 9.81 \text{ m/s}^2$.

Unit weight:

- Waste water: 11KN/m³
- Clarified water: 10KN/m³
- Sludge and floating waste: 11KN/m³

4.2.3. AS BUILT DRAWINGS

At the date of the Taking-Over Certificate, the Contractor should have submitted the full set of "As built" Drawings, (2 copies) in A3 format.

Drawings shall be filed and printed, within different books, each of them being organized as follows:

- Formworks,
- Reinforcements,
- Pipes,
- Electrical,
- Instrumentation,
- Mechanical,
- Roads and utilities.

The lack of submission of such drawings will automatically postpone the Taking-Over Certificate, and such delay will be the responsibility of the Contractor.

4.3. STANDARDS, CODES AND REGULATIONS

4.3.1. GENERAL

A. General Standard specifications and codes of the following listed authorities wherever cited herein are referred to by use of the abbreviations shown below. All materials and workmanship shall comply with requirements of applicable codes.

In case of discrepancies between these standards, the order of priority shall be as detailed here after:

		Abbreviation
1	Armenian codes	SNIP
2	European Committee for Standardization 36 rue de Strassart 1050 Brussels, Belgium	EN
3	British Standards Institution Linford Wood, Milton Keynes MK14 6LE - UK	BS
4	AWWA 6666 W. Quincy Ave., Denver, CO 80235 - USA	AWWA
5	Deutsches Institute fuer Normung e.v D-1000 BERLIN 30, Burggrafen Str. 6 Germany	DIN
6	Fédération Européenne de la Manutention 80 boulevard A. Reyers B-1030 BRUXELLES – Belgique	FEM
7	Commission Electrotechnique Internationale 1 rue de Varembe Case Postale 56	CEI
8	International Standard Organisation 1, rue de Varembe Case Postale 56 CH1211 GENEVE 20 - Suisse	ISO
9	American Society for Testing and Materials 1916 Race Street PHILADELPHIA, PA 19103 – USA	ASTM
10	American Association of State Highway and Transportation Officials 444 North Capitol Street, NW WASHINGTON, DC20001 – USA	AASHTO
11	American Concrete Institute	ASI

	Box 19150 - Belford Station DETROIT, MI 48219 - USA	
12	Bundesanstalt fuer Wasserbau D-7500 KARLSRUHE, Kussmaulstr. 17 Germany	BAW
13	Association Française de Normalisation Tour Europe - Cedex 7 92080 PARIS LA DEFENSE – France	AFNOR
14	American National Standards Institute, Inc. 10 East 40th Street NEW YORK, NY 10016 - USA	ANSI
15	American Petroleum Institute	API
16	American Welding Society 205 MW 7th Street MIAMI FLO 33125 - USA	AWS
17	United States Bureau of Reclamation Engineering and Research Center Code 922 Post Office Box 25007 Denver Federal Center DENVER, Colorado 80225 - USA	USBR
18	The Institution of Civil Engineers Publication Thomas Telford Ltd. 1 Heron Quay LONDON E148XF - UK	ICE
19	Eurocode 2, rue Bréderole B-1000 BRUXELLES – Belgique	

B. The following particular Standards will be used for items not covered under the Armenian code:

EN 12255, part 1 to 16: Wastewater treatment plants

EN 752, part 1 to 7: Drain and sewer systems outside buildings

EN 809: Pumps and pump unit for liquids- Common safety requirements

EN: 1085: Wastewater treatment- Vocabulary

C. Copies of Specifications, codes or standards of the above organizations may be obtained at the addresses shown.

4.3.2. STANDARDS TO BE ON SITE

The Contractor shall obtain and keep on Site at least one copy of each standard which is referred to in the Specifications. One copy shall be at the disposal of the Engineer's Representative.

4.3.3. SPECIFIC APPLICABLE STANDARDS

A. In particular, unless otherwise specified, the Standard to apply will be as follows:

- Civil works and process: Armenian Standards, SNIP
- Mechanical works: DIN
- Electrical works: IEC (in addition to EAC requirements)
- Handling equipment: FEM
- Road: AASHTO

B. Except if otherwise specified, where such standards are mentioned, the latest revision or edition on the Reference Date shall apply.

C. When the Contract Documents contain particular specification or more restrictive specification than required in Standards and Codes listed above, the Contract Documents will always prevail.

D. In case of lack of precise requirements in the Specifications and even if no reference to any standard listed in Sub-Clause hereof, these standards shall be used as a reference.

4.3.4. STANDARDS OTHER THAN THOSE SPECIFIED

Where requirements are specified by reference to a standard which has its origin in one country, it is not the intention to restrict the requirements solely to that standard and that country. The Contractor may propose to the Engineer an equivalent standard other than that specified, in which case he shall submit the proposed standard and all other information required by Section 6 (Approval of Materials and Equipment), and shall submit written proof that his proposed standard is equivalent in all significant respects to the standard specified. All submissions shall be made in English language.

5. SPECIFIC SERVICES TO BE PROVIDED BY THE CONTRACTOR

5.1. COORDINATION

The contractor shall co-ordinate his work with that of his sub-contractors and, if any of the other contractors at the site to whatever extent may be necessary to complete the project in accordance with the program of works, the drawings and specifications and the requirements of the engineer.

5.2. EMPLOYER'S USE OF CONTRACTOR'S TEMPORARY WORKS

The Contractor shall during the progress of the Works allow the Employer, the Engineer and other contractors employed by the Employer in connection with the Works the use of his roads, scaffolding, constructional plant, other temporary works or services such as described in the present Section. The Contractor shall at every place of working provide proper drainage, lighting and ventilation for other contractors' erection work and for the Engineer's inspection of the Works. Except for those items entered in the Bill of Quantities, such assistance shall be included in the rates.

5.3. ASSISTANCE TO THE ENGINEER'S STAFF AND TO OTHER CONTRACTORS

The Contractor shall provide labour for attendance on the Engineer for operations connected with supervision of the Works in particular for topographical survey. The attendance and assistance to the Engineer and his staff shall be included in the rates or lump sums.

5.4. DISPOSAL OF SURPLUS EXCAVATED MATERIALS

Surplus excavated material and debris arising from the Works shall be dumped on unused space at the WWTP site as agreed to by the Employer or on agreed disposal sites, within a distance of 20km, at the expenses of the Contractor. In order to avoid unauthorized disposal the Contractor shall arrange that each cartage contractor and lorry driver employed for the disposal of such materials is given written instructions as to the approved place where each load is to be tipped. The Contractor shall retain in his office copies of such instructions, together with a list of approved places to be used, for inspection at any time by the Engineer.

The Contractor shall indemnify the Employer against any claims arising from unauthorized disposal of such materials.

Surplus excavated materials may be re-used on the site for the landscaping development; in this case, the Contractor Proposal shall justify the characteristics and volume of materials; should the Contractor Proposal not include such arrangements, the re-use shall not be allowed.

5.5. VEHICLES

No Vehicles shall be provided to the Employer or to the Engineer.

5.6. SITE OFFICES

A. The Contractor shall supply fully furnished and equipped site offices for the sole used of the Employer and Engineer as follows:

- 4 x 15 m² offices
- 2 x 20 m² offices
- 1 x meeting room for 20 persons (at least 30 m²)

B. The Contractor shall supply the offices for the Engineer's and Employer's use along with the required connections for electricity, phone, water and sanitation. He shall be responsible for adequate regular maintenance and repairs of structures, furniture, equipment and appliances therein.

C. Each office shall be fitted with electric lighting and wall mounted socket outlets: water heater, hot plate, an air-conditioner, fan, one 0.8 m x 1.5 m table with drawers, one fixed 0.9 m x 1.8 m desk with shelves above to take fold drawings, one stool, four chairs, wash basin and stand, one cupboard fitted with shelves, hat and coat hooks, one bed 0.9 m x 2.00 m.

D. The offices compound shall be provided with simple toilet facilities, chemical type or similar, located in a covered and enclosed privy separated from the field office, provided with lock and key. The type of toilet facilities, method of waste disposal, location and type of construction therefore shall be submitted to the Engineer for approval.

E. The complete offices shall have to be supplied with all utilities and facilities not more than 28 days after the Engineer's notice to commence the Works and be maintained until the Performance Certificate.

5.7. TELEPHONE AND COMMUNICATIONS

5.7.1. TELEPHONE FOR ENGINEER'S REPRESENTATIVE

A. The Contractor shall, subject to the Engineer's approval, design, supply, install, operate and maintain during the execution of the Works a telephone exchange which shall revert to the Employer at the completion of the Works. The minimum number of telephones and their locations shall be as follows:

Location	No. of lines (Telephones)
Engineer's site office	2 permanent line

B. These external telephone lines shall be suitable for making calls in National area with extensions connected to the public telephone system. The telephones shall be connected to central PABX switchboard which is capable of handling up to ten extensions. One line in each office shall be connected to the international network.

C. These telephone lines shall be for the sole and exclusive use of the Employer or the Engineer's Representative and his staff.

D. The Contractor shall pay for the installation and rental of such equipment and for local calls made by the Employer or the Engineer's Representative and his staff.

Site radio or telephone system

In the event of the Contractor being unable to provide a telephone system he shall arrange, install and maintain a private radio or telephone system for use by the Engineer's Representative and his staff and to his requirements.

Where the Contractor has installed a site radio or telephone system for communication he shall allow permanently the Engineer's Representative and his staff free use of such equipment for their own equipment.

5.7.2. HIGH RATE INTERNET CONNECTION

A. The Contractor shall, subject to the Engineer's approval, design, supply, install, operate and maintain during the execution of the Works a high rate internet connection to the Engineer's site office, which shall revert to the Employer at the completion of the Works.

6. MATERIAL AND EQUIPMENT

6.1. MATERIALS

6.1.1. NATURAL MATERIALS

A. All materials, fixtures, fittings, and supplies furnished under the Contract shall be new and unused, of standard first-grade quality and of the best workmanship and design. No inferior or low grade materials, supplies or articles will be either approved or accepted, and all work of assembly and construction shall be done in a first-class and workmanlike manner.

B. In asking for prices on materials intended for delivery to the site and incorporation in the Works under any portion of these Specifications, the Contractor shall provide the manufacturer or supplier with complete information as may, in any case, be necessary to secure compliance with this Clause and, in every case, he shall quote this Clause in full to each such manufacturer or supplier.

6.1.2. QUARRIED MATERIALS

The Contractor shall be responsible for investigating and obtaining clayed materials, rip-rap stones, rock-fills, granulates, filters and transitions and aggregates for concrete and other purposes. The Contractor shall develop such investigations that he may require to meet the Contract requirements.

6.1.3. CEMENT

The Contractor shall, within 28 calendar days after the Commencement Date, submit i) all the chemical and physical characteristics of the cement in compliance with the specifications and ii) a forecast on a monthly basis detailing his local cement requirements for the duration of the Contract in a form approved by the Engineer. Throughout the Contract period, the Contractor shall review this forecast at quarterly or more frequent intervals as may seem to him necessary or as may be required by the Engineer. Prior to commencing the Works, the Contractor shall establish a stockpile of cement based on his forecast of cement requirements and sufficient for maintaining his operations during the first three months of construction.

6.1.4. ENGINEER'S RIGHT TO TEST

The Engineer could make tests on concrete, concrete aggregates, embankment materials, filter materials and other materials as he may from time to time elect, and the Contractor shall provide such samples or assistance in sampling materials at the Site as the Engineer may reasonably require. Testing by the Engineer shall in no way relieve the Contractor of his responsibility to test materials to ensure that they meet all the specified requirements and to control their quality.

6.2. MANUFACTURED EQUIPMENT

6.2.1. SUBMISSION OF SAMPLES AND DATA

A. The Contractor shall submit for the approval of the Engineer samples, drawings, catalogues, cuts, diagrams and other descriptive data for all mechanical, electrical, architectural and such other materials and equipment as may be designated by the Engineer and which the Contractor proposed to incorporate in the Works. For certain materials and equipment data may be required to be submitted in accordance with a detail form furnished by the Engineer.

B. Items submitted shall be properly labelled to indicate the Project Contract number, Contractor, source of supply, manufacturer Contract Item number, and other data required by the Specifications.

C. All items shall be submitted in sufficient time, but not later than 90 calendar days prior to purchase, to allow proper consideration and action thereon without delaying the construction schedule.

D. Items sent for approval shall be shipped prepaid by the Contractor and the Contractor shall give the Engineer advance notice in writing of all items shipped.

6.2.2. INSPECTION AT THE PLACE OF MANUFACTURE

A. To allow possible inspection of materials and equipment in the course of or on completion of preparation or manufacture, the Contractor shall give the Engineer written notice of the workshops and places where the materials and equipment are manufactured or stored and advise him of the state of progress, so that the inspection may take place at appropriate times and without delaying the dispatch of materials and equipment to the Site. In particular, the Contractor will inform the Engineer of the date of final erection tests or inspection test prior shipping.

B. If the Engineer decides to attend these tests (or any representatives duly nominated, and accompanied by the Employer), the cost of flights tickets and accommodation shall be paid by the Contractor (for 3 persons maximum).

6.2.3. MANUFACTURER'S CERTIFICATE OF COMPLIANCE

In the case of standard labelled stock products of standard manufacture which have a record of satisfactory performance in similar work over a period of not less than 2 years, the Engineer may accept a statement from the Manufacturer attested by a notary public certifying that the product conforms to the applicable Specifications.

6.2.4. MILL CERTIFICATES

In the case of materials for which such practice is usual, the Engineer may accept the manufacturer's certified mill and laboratory certificate.

6.2.5. SERVICE RECORD

If a demonstrable satisfactory service record is available for a material, certain specified tests may be waived by the Engineer.

6.2.6. TESTING LABORATORY CERTIFICATES

The Engineer may accept at his own decision a certificate from an independent commercial testing laboratory, satisfactory to him, certifying that the product has been tested within a period acceptable to the Engineer and that it conforms to the requirements of the Specifications.

6.2.7. ASSEMBLY MARKING

All parts, or units of shop assemblies, shall be marked, or tagged with piece marks. Marks shall be in accordance with approved erection drawings, shall be clearly legible and so placed as to be readily visible when the part is being erected in the field. Before dismantling for shipment, connecting parts assembled in the shop shall be match marked to facilitate erection in the field and marked so as to identify each part with the assembly to which it belongs. The location of the match marks shall be clearly indicated on erection drawings. All parts or assembly of parts shall also be so marked as to identify them with this Contract.

6.2.8. SHOP CLEANING AND PAINTING

After shop assembly and inspection all parts of the Plant and Erection Equipment shall be cleaned and painted in accordance with the Specifications.

6.2.9. NAMEPLATES

A. Each major and auxiliary items of equipment shall have a nameplate permanently affixed thereto, or as directed, showing in a legible and durable manner the serial number, name and

address of the manufacturer, rating data, electrical and mechanical characteristics, and other significant information, as applicable. Nameplate of distributing agents only will not be acceptable.

B. Nameplates shall also be provided where required for panel-mounted devices. Dials, gauges, and nameplates shall be marked with the nomenclature and units of measure in the metric system, and a schedule of such makings shall be submitted for review and approval by the Engineer.

C. All nameplates shall be in the English language.

D. Nameplates for Plant Identification and record purposes shall be manufactured from stainless steel with satin finish and engraved with black lettering of a size which is legible from the working level.

E. Warning plate shall be manufactured from stainless steel with satin finish and engraved with red lettering and sited in a position affords maximum personnel safety.

6.3. APPROVAL OF MATERIAL AND EQUIPMENT

6.3.1. GENERAL

A. All materials and equipment intended to be incorporated in the Permanent Works shall be subject to information given by the Contractor to the Engineer. The Engineer shall give approval for the materials incorporated in the civil works (including architectural materials), and the Contractor shall wait for this approval prior to ordering. For the mechanical and electrical equipment, the Engineer shall give only comments or refusals if necessary.

B. Unless otherwise authorized by the Engineer no material or equipment shall be shipped from its point of original manufacture or final shop assembly to the work site before it has been inspected in accordance with Clause 6.2.2.

C. Except otherwise stated by the Engineer, all materials and equipment intended to be incorporated in the Permanent Works shall be subject to the Engineer's approval.

6.4. CONTRACTOR'S TESTING LABORATORY

6.4.1. GENERAL

The Contractor's laboratory shall be equipped to perform the following main tests:

A. Soils

- Identification.
- Compaction tests.
- Relative density determination.
- Permeability (laboratory).
- Particle size determination.

B. Concrete

- Fresh concrete analysis.
- Concrete workability.

- Concrete strength (compression, tensile strength by Brazilian test).
- Ultrasonic pulse velocity.
- Permeability.
- Concrete and grout modulus determination
- Temperature
- C. Rock and aggregate
 - Dynamic crushing tests.
 - Particle size determination.
- D. Cement
 - Setting time.
 - Blaine fineness.
 - Heat of hydration.
 - Mechanical characteristics (Strength, Young Modulus, Poisson Ratio).
- E. Grout for injections
 - Design and control.
- F. Bituminous materials
 - Design and control.
- G. Laboratory computer equipment

The Contractor's Laboratory shall be equipped with one PC Computer from a well-known manufacturer accompanied by printing facilities.

H. Laboratory Alternative

If the Contractor wishes to not install a laboratory on site, he could propose to the Engineer the use of some others laboratories; based on the technology and staff and references of these laboratories the Engineer is not committed to accept.

I. The sheets recording test results shall be of a type approved by the Engineer. The Records Book of tests and results shall be kept by the Contractor.

J. A copy of the Records Book shall be supplied once a month to the Engineer's Representative.

6.4.2. SPECIFIC EQUIPMENT

In addition the Contractor shall provide other Laboratory equipment or/and field testing equipment as specified in the different Sections for the purpose of controlling particular works or/and determining in-site parameters. This equipment shall be available as necessary during the execution of such activities and could be removed from the Site as and when approved by the Engineer.

6.4.3. METEOROLOGICAL EQUIPMENT

The Contractor shall supply and install at site or where instructed by the Engineer the following supplementary meteorological equipment:

- 2 recorder thermometers;
- 1 pluvio-meter (rain gauge)
- 1 hygrometer;
- 1 anemometer;
- 1 Simplified Piche meteorological shelter

6.5. ACCEPTANCE OF MATERIALS

The approval by the Engineer of any material or equipment shall in no way relieve the Contractor of any of his responsibilities for meeting all of the requirements of the Specifications and shall not prevent subsequent rejection if such material or equipment is later found to be defective or not conforming to the Specifications.

7. QUALITY ASSURANCE AND QUALITY CONTROL SYSTEM

Quality Assurance (QA) Quality Control (QC) System covering all aspects of the Contract and the Works must be implemented, documented and maintained by the Contractor during the period of the Contract. The system shall comply with a recognised international Quality Assurance Standard. The System shall as a minimum consist of the following items.

A. General

The Quality Assurance System for the Company shall show the overall QA Organisation and the lines of responsibility, monitoring and action. Furthermore, the overall principles and procedures for establishing Quality Assurance Plans, Control Plans, QA Organisation, etc. for specific projects and contracts, sub-contractors and suppliers shall be provided.

B. Quality Assurance System

As a minimum the Contractor shall, as part of his tender, submit the QA System for the Company, and QA organisation, providing all important and critical activities for controls, inspections and tests to fulfil the specifications.

It is a general requirement that works are only sub-contracted to companies with an effective QA System.

The other following documents shall be submitted within 1 month after the Commencement Letter.

C. Quality Assurance Plan (QAP)

The QAP shall as a minimum cover the following issues:

- The Contractor's staff and management organization for the project, management plan, and the quality assurance organization.

The person responsible for the Contractor's QAS shall be authorized and qualified to take decisions on quality assurance issues, and his reference and communication lines to the Company's overall quality assurance organization and its responsible management shall be clearly

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shown. Persons performing quality control and testing shall be independent of those executing or supervising the Works.

- Management of documents.
- Management of procurement.
- Management of sub-contractors and suppliers, and requirements of their QAS's.
- Control of materials and workmanship, defects and material reconciliation, procedures for corrective actions, etc.
- Handling of deviations, additions or variations to the Contract Documents.

The Contractor's system of management of current documentation for the execution of the Works shall include his sub-contractors and suppliers. It shall show:

- how it is ensured that only valid and approved documents are used for the execution of the Works and
- The method of recording variations and amendments to the documentation.

D. Control Plans (CP)

The Contractor shall present for the Engineer's approval his detailed CP for all quality assurance efforts or measures for the Works or sections thereof. Such CP shall be presented to the Engineer not later than one month before the commencement of the Works or an approved section of the Works.

The plan shall include the quality control of all aspects of on-site construction, laboratory tests and on-site tests. It will include a quality inspection plan which will cover all items intended for inspection at the Contractor, Sub-contractors and Supplier's works and premises, as specified in the Contract.

The CP shall for each control activity describe type, method, criteria for approval and documentation and who is responsible for performing the activity.

The plan shall contain but will not be limited to the following items:

- Organization chart for quality control.
 - Curriculum vitae of his staff exclusively appointed for all aspects of quality control during the Contract period.
 - List of the Contractor's staff engaged in quality control and material testing.
 - Name and address of site materials testing laboratory.
 - List of laboratory equipment and description of the laboratory testing capabilities.
 - Arrangements for any tests to be performed beyond the capability of the Contractor's laboratory.
 - Procedures for comprehensive records.
- a) The Contractor shall be responsible for establishing and maintaining procedures for quality control which will ensure that all aspects of the Works comply with the requirements of the Contract.

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- b) The Contractor shall be responsible for routine inspection, sampling and testing of all materials, workmanship, plant and measuring devices.
- c) The Contractor shall establish at Site an efficient, comprehensive records facility and library. Books, drawings, standards, publications and manuals shall be indexed and their distribution controlled.

If the Engineer does not approve the CP as submitted, then the CP shall be amended for further approval. Subsequent changes in terms of the quality assurance work will not cause changes in agreed deadlines or contract sums.

E. Non effective implementation of QAP and CP:

It is not the objective of the Employer and the Engineer to perform QAP and CP on behalf of the Contractor. Then if it appears that the documents provided by the Contractor are badly prepared, non-consistent with other documents not compliant with the Contract, the Employer could claim against the Contractor with reference to Clause 2.5 of the General Conditions.

A lack of QAP and CP compliance shall be based for example in the following cases:

- Document not modified and nevertheless re-submitted,
- Numbering, titling and general data non consistent with the requirements,
- Changes on previously approved document not clearly mentioned,
- Nature of the document not consistent with the requirements.

F. The Contractor's control and documentation

1) General

During the Contract period, the Contractor shall, to the satisfaction of the Engineer and State Quality Control body, document that the Works comply with the quality assurance requirements stipulated in the Contract or approved during the Contract period.

Consequently, based on the approved QAP and the CP's, the Contractor shall during the execution of the Works carry out and document the quality control and its compliance with the stipulated requirements.

The Contractor's quality control does not limit his responsibility for the Works according to the Contract.

If the Engineer, during the period of the Contract, can substantiate that the Contractor's control and/or documentation shall be extended, the Contractor shall follow the Engineer's written instructions to this effect at his own cost and within the agreed time for completion.

2) Method of documentation and filing during execution of the Works

All control activities specified in the Control Plan shall be documented.

The CP's and all other issues related to the QA System shall be kept and maintained by the Contractor in the QA filing system, which shall be kept at the project site throughout the period of the Project.

On the basis of the QAP and CP's the Contractor shall produce the necessary forms for registration, log books, and check lists, etc. before work is commenced.

All documentation shall be provided with identification, the date and signature of the person responsible for the documentation. The identification shall as a minimum comprise:

- name of project,
- activity number as defined in the CP,
- Time and place of the control activity.

The Engineer shall have full access to the filing system and he may without notice commission a quality audit.

The Contractor shall keep and maintain at his own costs the “Construction Book” (Log Book) according to Cypriot regulations and submit it regularly for the approval of the Engineer.

3) Documents at delivery

At the time of delivery of materials and goods, the Contractor shall submit the following documentation to the Engineer in one original and two certified copies, all certificates, documentation of tests etc. of materials and goods to be used in the Works.

All documents verifying that inspection control and tests performed are in accordance with the Specifications.

Identification lists with cross-references between documents and materials and goods.

8. SURVEYS

8.1. REFERENCE POINTS, LINES AND LEVELS

A. Level reference

The data for all levels shall be based on current national datum.

B. General setting out

At the beginning of the Works, the Contractor and the Engineer shall agree on the definition and general setting out of the structures to be built on the site, based on the general network established for the project.

Three points which shall be used as a reference basis in three dimensions (X, Y, and Z) will be made available at site by the Employer by the date of beginning of the work. These three points shall be handed over by the Employer to the Contractor, which will accept them as references. These three points shall be adequately anchored and protected by the Contractor.

Additional bench marks may be installed by the Contractor for triangulation reference.

The Contractor shall be responsible for the conservation of the related benchmarks during the entire duration of the construction and Defects Liability Period.

The Engineer shall draw up a report to confirm completion of these operations in the field.

C. Complementary setting out

During the execution of the Works, the Contractor shall complete the general setting out by as many stakes, seats and gauges as may be necessary.

D. Reference points

At the beginning of erection of equipment, complementary reference points shall be placed by the Contractor at his own expense.

E. Approval

The Engineer will draw up a report to confirm completion of these operations in the field.

8.2. TOPOGRAPHICAL SURVEY

A. The initial topographical survey shall be provided by the Employer as shown on the Drawings. The Contractor may either accept the results of this study or undertake a new topographical survey at his own expense. In this case, the new topography shall be approved by the Engineer before use.

B. In any case, the Contractor will undertake all survey during the implementation of the works as required.

8.3. TOPOGRAPHICAL EQUIPMENT

A. The Contractor shall provide for the use of the Employer and the Engineer permanently on Site for the following equipment:

- 1 level with tripod,
- 1 theodolite (reading 1 sec.) with tripod,
- staff gauges,
- chains or steel tapes,
- all other equipment necessary for the day-to-day surveying,
- 1 paint thickness controller,
- 1 concrete sclerometer.

B. All equipment supplied to the Engineer under this clause shall remain property of the Contractor on completion of the work.

C. All equipment for the use of the Employer and the Engineer on Site shall be maintained in good order by the Contractor.

D. All costs relevant to the present paragraph are deemed to have been spread over the unit prices indicated in the Bill of Quantities.

9. ACCESS TO THE WORK SITE

9.1. THE SITE

The Site shall be deemed to include all areas on which temporary and permanent Works are to be constructed, all other areas made available to the Contractor for the execution of the Works and all roads, tracks and footpaths whether private or public between the various parts of the Works.

9.2. USE OF LAND AND RIGHT OF WAY

A. The Contractor will, during the execution of the Works, have free and temporary use of working areas and accesses thereto, of the land shown on the drawing(s). The working areas will include space for the Contractor's offices, camps, stores, yards, constructional plant, temporary roads, parking areas and other temporary works. The Contractor's proposal for temporary works including overall layout plan in conformity with the Tender Documents shall be included in the Contractor proposal.

All use of land is subject to the Engineer's approval.

If the area of the sites is found to be inadequate, the Contractor shall make his own arrangements for all additional working areas in the vicinity of the Works or elsewhere for his site compound, offices, temporary accommodation and living facilities, for offices for the Engineer's Representative. In this case, neither the Employer nor the Engineer shall have any kind of responsibilities concerning these arrangements.

B. Apart from transport to and from these areas the Contractor shall confine his operations under the Contract to these areas. Before entering any working sites, the Contractor shall give 30 day notice to the Engineer in writing. Such notices shall be given for each occupation of the working sites.

C. Before entering any additional working sites (if any) the Contractor shall obtain and forward to the Engineer a copy of the written consent of the owner or occupier or Authority having charge of the land stating the purposes for which such land is to be used by the Contractor, and defining the extent and periods of his occupation for which such consent is granted. Notwithstanding the requirements of such consent, additional working sites shall be protected by fences or barriers or other works as required by the Engineer. Wherever practicable a passage shall be maintained for vehicles and pedestrians along public roads and to all adjacent properties.

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

E. Temporary fences and barriers

Temporary fences and barriers shall be provided by the Contractor for the Sites and Working Sites.

Where there is no existing fencing or boundary walls the Contractor shall provide, erect before commencing the Works and maintain in good condition to the satisfaction of the Engineer temporary fencing in positions around the Contractor's areas shown on the Drawings or where

directed by the Engineer. Except where otherwise specified fencing shall be close-boarded 2400 mm high for structures building sites or chain link for the remaining area; he shall provide lockable gates at each site entrance.

The Contractor shall remove all temporary fencing on completion of the Works, except for such fencing, or parts thereof as the Engineer may direct to be left in place in good condition for the Employer's use.

F. Temporary buildings etc., Classified as temporary works

Starting from the Commencement date, the Contractor shall have to bear the cost of management of all temporary buildings and/or works.

G. Notice boards

The Contractor shall manufacture notice boards and erect these where directed by the Engineer. The notice boards shall be 1 x 2 m of 20 mm thick plywood W.B.P. bonded to BS 1088 or similar approved with softwood surround to Class 2 of BS 1186 Part 1. The notice boards shall have the indication as instructed by the Engineer and be painted after fabrication on all surfaces.

The Contractor shall erect these boards on suitable supports in positions within the Site as directed by the Engineer.

H. Advertising and publicity

Advertising will not be allowed on any hoarding whether temporary or permanent, or on any other part of the Works, except such as the Employer may require for this own purposes.

The Contractor shall obtain the permission of the Employer before publishing any article describing the Works. The Engineer's permission shall be obtained before any member of the public is allowed to inspect the Works. All visitors will be required to sign a form of indemnity.

9.3. SPECIAL CONDITIONS AND HAZARDS

The Contractor shall observe the following conditions when drawing up his proposal for traffic access to the Sites and Working Sites and such proposals shall be submitted to the Engineer for his approval before implementation.

- a) Location of access gates to suit the agreed traffic plan;
- b) Restricted headroom due to flyovers and overhead cables;
- c) Restricted loading to existing services, manholes, etc.
- d) Restrictions on height of temporary structures and/or the location of temporary offices due to the proximity of commercial/residential property;
- e) Buildings in the locality particularly sensitive, due to their use or condition, to undue noise and vibration;
- f) Access to private and public properties and buildings;
- g) High voltage overhead cables;

9.4. TRAFFIC ARRANGEMENTS

- A. The Contractor shall seek information on and comply with all requirements and recommendations of the police regarding traffic safety measures.
- B. Plans for re-routing traffic along public streets during occupation of the Working Sites will be arranged by the Employer with the appropriate Government Authorities which include the Traffic Police. Such arrangements include, if any, the acquisition and costs on behalf of the Contractor of provisional Permits from the traffic authorities to occupy Working Sites. The Contractor shall not occupy any Working Sites without holding such Permits.
- C. The Contractor shall provide, erect and maintain during his occupation all barriers and traffic signs as required by the Authorities or instructed by the Engineer. All signs must comply with standard international practice or as otherwise required by the traffic authorities. All written notices on signs shall be in both national language and English.
- D. The Contractor shall arrange with the owners and occupiers of properties alternative temporary access and shall submit details of such agreed temporary access arrangements where necessary.
- E. The Contractor shall liaise and arrange directly with the Authorities, all required traffic arrangements for transportation of equipment and materials. In all cases, he will comply with the traffic regulation.

9.5. TRANSPORTATION OF MATERIALS AND EQUIPMENT

- A. The Contractor shall take all reasonable precautions to ensure that public streets and thoroughfares used by him either for the construction of the Works or for the transport of plant, labour and materials are not made dirty as a result of such construction or transport and in the event of their becoming thus dirtied in the opinion of the Engineer the Contractor shall take all necessary and immediate steps to clean them.
- B. Vehicles shall be thoroughly cleaned down before leaving the Sites and shall be so loaded that spillage therefore is prevented. Particular care shall be observed when disposing of slurry type material in a highly fluid condition which may additionally be contaminated with bentonite.
- C. Each individual site must be kept clean during the work and must be thoroughly cleaned upon completion.

10. IMPLEMENTATION OF THE WORKS

10.1. AMENITIES TO BE PRESERVED

The Contractor shall cause the least possible interference with existing amenities, whether natural or man-made. No trees shall be trimmed or felled except as authorised by the Engineer.

All lights provided by the Contractor shall be so placed or screened as not to interfere with the use of adjacent buildings, road users, traffic or signal lights or other equipment of the Employer or other authority.

The Contractor shall store and place all materials, plant and appliances in such a manner as to prevent them causing injury or damage to persons or property and at a safe distance from roads, tracks and footpaths.

10.2. PROTECTION AND DIVERSION OF EXISTING SERVICES

- A. The Contractor shall be responsible for notifying the service authorities and the Engineer of his intention to expose the services and where so required by the service authority shall not commence operations until the service authority is represented on Site.
- B. The Contractor shall excavate, protect until backfill and backfill in a manner so as not to damage the services.
- C. As soon as a service is encountered in the excavation whether previously located or discovered during the course of excavation for the Permanent Works the Contractor shall forthwith call the attention of the Engineer and the appropriate service authority thereto.
- D. The Contractor shall be responsible for maintaining all such services including natural and artificial watercourses encountered by him in the construction of the Works and shall make good any damage caused directly or indirectly by his activities.

10.3. PROTECTION OF ANTIQUITIES AND FOSSILS

- A. As soon as antiquities or fossils are encountered during the course of any excavation, the Contractor shall forthwith call the attention of the Engineer and the appropriate service authority thereto.
- B. Vulnerable parts of the discovered antiquities of fossils shall be protected by the Contractor as may be reasonable required by the Engineer.
- C. No requirement of the Specifications regarding the disposal of material arising from site clearance or excavation shall override any provision in the Conditions of Contract as to the discovery of ownership, of fossils, coins, articles of value or antiquity of anything of geological or archaeological interest found on the Site.

10.4. SAFETY IN SEWERS AND AT SEWAGE WORKS

- A. The recommendations contained in the booklet « Safety in Sewers and at Sewage Works » published by the Institution of Civil Engineers London shall be adhered to in respect of all work in operational sewers and waste water treatment plants.
- B. The Contractor shall make all necessary arrangements with the appropriate authority before entering in or working on existing sewers and associated works.
- C. The Contractor shall ensure that sufficient resources of supervisory staff are readily available to carry out such continuous working at established levels of safety.

10.5. PREVENTION OF NOISE AND DISTURBANCE

- A. The Contractor shall in general comply with the recommendations of National Law.
- B. The Contractor shall justify the details and arrangements of all plant before installation to ensure that suitable provisions are provided to reduce noise emission in built-up areas.
- C. The Contractor shall take noise intensity readings as required by the Engineer and shall submit the results to the Engineer. The Contractor shall comply with measures required by the Engineer to keep noise and disturbance to the reasonable minimum.
- D. The Contractor shall comply with the requirements stipulated in local Law.

10.6. FIRE PREVENTION

- A. The Contractor shall make arrangements to the satisfaction of the Engineer for the protection of the Works and any Temporary Works and any adjacent property from fire and shall give the Fire Authority all facilities periodically to inspect the fire prevention arrangements.
- B. Particular care must be exercised in connection with the operation of electric-arc welding equipment, oxy-acetylene cutting equipment and other processes involving the use of naked lights. Special arrangements will be necessary for the storage of highly flammable liquids on the Site.
- C. The Contractor shall remove all rubbish and surplus material of a flammable nature and take such other steps as the Engineer may require but this shall not relieve the Contractor of any of his obligations under the Contract.

10.7. WORK IN THE VICINITY OF OPERATIONAL MECHANICAL AND ELECTRICAL EQUIPMENT

- A. Any permanent fencing or other safeguards required to be erected around electrical equipment shall be completed as far as practicable before connection is made to the electricity supply. In so far as this is not practicable the Engineer may permit the use of temporary fencing or other safeguards.
- B. Where work has to be carried out in proximity to operational mechanical and electrical equipment other than the Contractor's own plant, the Contractor shall put into operation a « Permit to Work » system to the approval of the Engineer.
- C. The Contractor shall comply with the requirements stipulated in local Law.

10.8. SITE FACILITIES TO BE PROVIDED BY THE CONTRACTOR

10.8.1. ACCESS TO WORKING AREAS

The Contractor shall construct, operate, maintain and remove, if required, access routes to construction site areas from existing permanent access and/or site roads, such alternative proposals and additional proposals by the Contractor as may be approved from time to time by the Engineer. Such proposals shall allow all phases of Construction.

Any of these accesses will not be removed except when formally agreed by the Engineer. Removal of these accesses shall be indicated with full details in the General Programme of Works.

10.8.2. HAUL AND ACCESS ROADS

- A. The Contractor shall maintain the existing roads to different site works, as are necessary for the conduct of the work under the contract.
- B. These roads will also be used as access roads by the Employer, the Engineer and other contractors engaged on the construction and completion of the Works.
- C. As indicated here above the Contractor shall establish reasonable traffic regulations governing traffic on the roads maintained by him, and shall provide signs, pavement markings, traffic signals or other control devices and flagmen as may be required to maintain a safe and unimpeded flow of traffic.
- D. Construction and maintenance of such haul and access roads not explicitly paid under separate bills will not be measured for payment as a separate Contract Item.

10.8.3. ELECTRICITY AND POWER SUPPLIES

- A. The Contractor shall make his own arrangements for the supply of electricity for his Temporary Works and other site usage, including tests.
- B. The Contractor shall install operate maintain and subsequently remove equipment to provide sufficient supplies of electricity for the heating lighting and air conditioning of all offices stores laboratories and other temporary buildings used by the Contractor and by the Engineer in addition to any supplies he may require in connection with the construction of the Works.
- C. In addition to his main source of power supply the Contractor shall where necessary provide and maintain standby power supplies adequate to ensure the safety of the Works in the event of failure of the main supply irrespective of the timing or duration of such failure.
- D. All site electrical installations shall be carried out in accordance with the current Regulations for the Electrical Equipment of Buildings.
- E. The Contractor shall also install on his own expenses all the equipment for the permanent power supply of the plant in accordance with the Drawings and Specifications.
- F. The Contractor shall provide at the date of the completion, all approval and clearance for connection of the Permanent Works, issued by the National Power Supplier.

10.8.4. LIGHTING

- A. The Contractor shall provide sufficient lighting to ensure that, at all times:
- safe working conditions are provided for all personnel on the work sites;
 - the Works can be constructed in complete compliance with the Contract;
 - complete inspections of all work in progress can be made by the Engineer, and security of the Works area and public safety measures are adequate and effective.
- B. Unless otherwise directed the minimum intensity of illumination on ground or working surface to be provided for the various operators or work areas shall be as tabulated below:

Illuminance Operation or Area	Design Value (Lux)	Minimum Measured Value (Lux)
Earthworks and excavation	50	20
Concrete placing	100	50
Maintenance shops and mechanical and electrical works	300	200

- C. The Contractor shall supply a suitable instrument to the Engineer for measuring the intensity of illumination. The instrument shall comply with BS 667 or equivalent standard as approved by the Engineer.
- D. All moving plant used during night operations shall be equipped with sufficient lights and reflectors and fluorescent markings to ensure safe working conditions.

E. The submission to or approval by the Engineer of the Contractor's proposals for lighting shall not relieve the Contractor of any of his liabilities or obligations under the Contract.

10.8.5. HOUSING FACILITIES FOR THE CONTRACTOR AND HIS SUB-CONTRACTORS

A. The Contractor shall supply:

- Site offices for his staff.
- Site offices for each of his sub-contractors (one office of 20 m² for each sub-contractor).
- Stores, workshops, compounds.
- Temporary accommodations and living facilities.
- Parking areas.
- All necessary services in relation with these works including water supply, lighting, drainage, heating, air conditioning and refuse disposal.

B. The Contractor shall be responsible for the general cleaning and maintenance of the areas including sanitary installations.

C. Buildings shall be complete ready for use including furniture, household appliances (stove, fridge, fan, air-conditioner, heater, lighting tubes and bulbs). Buildings shall be of the same type as the ones provided for its own staff.

D. The Contractor shall provide medical facilities as required by the Medical Officer for Health.

E. Details and layout of site offices and appurtenant buildings and services shall be to the general approval of the Engineer. The Contractor shall obtain any necessary approval from any local authorities concerned.

10.8.6. WATER SUPPLY

A. The Contractor shall make all provisions for the supply of water required for the execution of the Works as well as adequate quantities of potable water for all personnel.

B. The Contractor shall arrange for the water supply for his staff residences, labour camps, site offices, Works, workshops in addition to the supply of the Operator's Camp. Construction of tube wells, storage tanks, overhead tank, distribution system, and their proper running and maintenance shall be his responsibility. Potable water should be supplied 24 hours a day.

C. Water samples shall be tested every 3 months and certificates submitted to the Engineer indicating that the water is fit for human consumption from an agency approved by the Engineer.

D. The Contractor shall supply water to sub-contractors or other contractors for all their requirements.

E. Construction and maintenance of such water supply facilities not explicitly paid under separate bills will not be measured for payment as a separate contract item, and it is assumed that those items are included in the Bill of Quantities.

10.8.7. STORAGE AREAS

The Contractor shall make his own arrangements for the installation, operation and removal of this temporary storage and works and during the Contract period. Location and layout of these storage and work yard shall be subject to the prior Engineer's approval.

10.8.8. SEWERAGE

The Contractor shall make all provisions, subject to the Engineer's approval to construct, operate and maintain throughout the Construction Period a sewerage system comprising collection, treatment and disposal for all the camps.

10.8.9. SOLID WASTES

The Contractor shall make all provisions, subject to the Engineer's approval, for collection and disposal of solid wastes from all camps and work places. Wastes shall be collected at least twice a week and disposed in an approved location.

10.8.10. STORAGE AND USE OF EXPLOSIVES

The Contractor will not use explosives, except if specifically approved by the Engineer in writing.

10.8.11. WATER CONTROL

A. Without prejudice to other stipulations in the Contract, all constraints related to the presence of or risks caused by water, all additional work which may prove necessary on this account, all damage caused by water, all pumping in all structures not mentioned in the Contract which the Contractor may find he has to build for water control purposes shall be at the expense of the Contractor.

B. Without prejudice or other stipulations in the Contract, the Contractor shall be responsible for all damage caused to the foundations of the structure or any part of the Works and occasioned by floods, surface water or runoff, or by failure of any part of the diversion or protection works carried out by the Contractor. Any repairs that are necessary will be carried out at his own expense.

C. Before any works are begun, the Contractor shall submit to the Engineer's approval the methods and arrangements he proposes to apply in order to protect the Works, unless these are imposed by the design incorporated in the Contract. Such Engineer's approval shall not relieve the Contractor of his obligations and responsibilities under these requirements.

10.8.12. DEWATERING OF FOUNDATIONS

A. The Contractor shall provide, install, maintain and operate all pumping and other equipment for dewatering for all parts of the Site where this is necessary, and for as long as required for implementation of the works.

B. The dewatering facilities shall be such as to avoid any loss of fine materials, and shall ensure stability of the excavation works and adjacent buildings and facilities.

C. Water removed from the excavations must not be allowed to cause nuisance or damage to traffic or any public or private property or service.

D. All costs relevant to the present section are deemed to have been spread over the unit prices indicated in the bill of quantities.

10.9. PROTECTION OF FINISHES

The Contractor shall take every care to prevent damage to the works and shall ensure that adequate protection is given to all works from the activities of following trades and any third party. Vulnerable parts of the works particularly liable to damage shall be protected as may be reasonably required by the Engineer and shall be deemed to be insured against damage in accordance with the conditions of contract.

11. RECORDS

11.1. PROGRESS REPORTS

- A. By the last working day of each calendar month, the Contractor shall submit two copies of a draft monthly progress report which shall contain at least the following information:
- Percentage progress of the Works compared with the approved programme, together with a description and percentage estimate of the work programmed for the following month.
 - List of Contractor's Equipment on Site together with its deployment during the month.
 - List of all personnel employed on Site.
 - Accident record, if any.
 - Summary of all work carried out during the month in question together with a description of any difficulties or problems occurring therein.
 - Description of the daily climatic conditions during the month.
 - Situation with respect to payments, together with the dates on which the Payment Certificates were submitted by the Contractor.
 - Description of any claim made by the Contractor during the month and the Engineer's decision.
 - Progress photographs.
 - State of progress of customs clearance and local transport operations.
 - Inventory of materials stored on Site.
 - Tests in progress or already carried out during the month and those planned for the next month.
- B. Within ten working days of receipt of the draft monthly reports the Engineer will return to the Contractor one copy marked for amendment together with any separate comments for correction or addition to the draft report.
- C. Within two working days of receipt of the Engineer's comments the Contractor shall submit ten copies of the final monthly progress report which will include all of the corrections, additions and amendments requested by the Engineer.
- D. Each monthly report shall be in a format approved by the Engineer.

11.2. PHOTOGRAPHS

- A. To record the general progress of the work as well as particular details and special phases of erection and commissioning the Contractor shall take photographs at regular intervals, not more than 2 months.
- B. Photographs of a given part of the Works shall as far as possible be taken from the same location and at the same angle.
- C. The negatives shall be colour negatives not less than 24 x 36 mm in size, alternatively, digital photographs will be provided on a CD.

- D. The Contractor shall take enough photographs of each stage of work or manufacture to enable the Engineer to make a representative selection of subsequent enlargement.
- E. The procedure shall be as follows:
 - Ten days before the end of each reporting period the Contractor shall furnish two proofs (postcard size) of each view.
 - The Engineer will select the views to be enlarged.
 - Eight enlarged prints (18 x 24 cm) of each selected view shall be supplied with the corresponding Monthly Report.
- F. The number of views to be enlarged shall be 20 per each reported period.

12. MEETINGS

A. The Contractor or his nominated Representative shall participate in progress meetings convened by the Engineer. Such meetings will generally be held at regular intervals through prior notice, but may also be convened without prior notice, in the event of any unusual occurrence, at the discretion of the Engineer.

The Contractor shall immediately notify the Engineer of any unusual occurrence which he considers would justify an exceptional meeting.

B. The agenda shall include approval of the minutes of the previous meetings, progress of the works with respect to the schedule and analysis of the difficulties encountered in the work.

C. The minutes of the meeting shall be prepared by the Engineer and shall be deemed, after approval by the other participants, to be written confirmation of the declarations, instructions and decisions taken during the meeting.

D. The Contractor or his nominated representative shall be able to take decision during the meeting; otherwise he shall be considered that the Contractor didn't attend the meeting.

13. HEALTH AND SAFETY

The Contractor shall submit a Health and Safety Plan. He shall comply with the requirements stipulated in the local Law.

The Contractor shall be responsible for the safety of all workmen and other persons entering the Works and shall, at his own expense (where not otherwise stated) and to the approval of the Engineer, take all measures necessary to ensure their safety. Reference in these respects is made to the Conditions of Contract, but in particular, such measures shall include, but are not limited to, the following:

- A. Provision of proper safety and emergency regulation; fire, gas (if any) and electric shock prevention, stretchers and first aid boxes, together with rescue facilities generally, for each place of working.
- B. Safe shoring of all excavations.
- C. Provision of efficient safety helmets for all personnel including the Employer and the Engineer and each of their staff and any authorized visitors to the Site.
- D. Safe control of water including provision of ample standby pumping plant.

E. Provision and maintenance of suitable lighting to provide adequate illumination of the Works with appropriate spares and standby equipment.

F. Provision of good and safe access to any part of the Works.

G. Provision of notices written in English and local languages to be erected at points likely to be used by the public, which shall warn the public of the existence of the Works. These notices shall be in addition to any statutory requirements demanded of the Contractor.

The Contractor shall submit for the approval of the Engineer detailed proposals under sub-clause A. above. Once the regulations have been approved, and before the work is started, the Contractor shall distribute copies in English and local languages of the national regulations to all his employees and to the Engineer.

The Contractor shall ensure that all his employees are fully conversant with the regulations, emergency and rescue procedures, etc., and the Contractor shall enforce the rule that any employee committing a serious breach of such regulations shall be instantly dismissed and shall not be re-employed.

H. Personal protective equipment shall be available and used by operatives when appropriate, including: safety helmet, eye protection, ear protection, hand protection, foot protection.

14. SPARE PARTS

14.1. SPARE PARTS

Mandatory Spare-Parts are described in the Specifications for each equipment. They are deemed to be included in the Bill of Quantities.

A. Spare part book

The Contractor shall give a spare part book. This spare parts book shall contain an assembly drawing of the plant which shall show all parts of the plant separately marked, designated and referenced.

The book shall also contain sketches of each part with the part number and the designation of the part. The material of the part shall also be indicated. These sketches and lists of parts shall be cross-indexed with the assembly drawings.

The spare parts book shall present information in a simple manner so that non-technical personnel may be able to indent these spare parts. The lists of spare parts required shall be made with reference to the spare parts book.

B. Duplicate

All spare parts shall be duplicates of the original parts furnished and interchangeable therewith.

C. Packing and packing list

The spare parts shall be suitably identified, treated and packed for a long storage in containers plainly marked "SPARE PARTS ONLY". A packing list, indicating the contents of each such container, shall be securely fastened in a moisture-proof envelope to the outside of the container. The packing list shall also provide the following information:

- Contractor and Contract number

- Identification, including Contractor's drawing number, reference of each spare part in the container.

D. Storage room

All spare parts shall be stored in a safe place under the responsibility of the Contractor up to the Taking-Over Certificate; at this date, he will transfer the Spare Parts in a place indicated by the Engineer.

15. TRAINING OF EMPLOYER'S STAFF

15.1. TRAINING

A. General

On-Site Training of the Employer's staff to manage, operate and maintain the project shall be included in the tender.

The objective of the training is to provide selected staff members of the Employer with the necessary knowledge of technology, operation and maintenance of all equipment, installations and work included in the project, which will ensure a sound and stable operation and maintenance of the project components carried out under the contract.

The Contractor shall provide on-site training of the Employer's staff in managing, operating and maintaining the Works on the basis of a structured programme submitted at least two (2) months before the start of the training period for the approval of the Employer's Representative.

The Contractor will be required to provide practical instructions to the Employer's staff during the Operation and Maintenance Period to ensure that by the end of this period, the staff of the Employer will be capable of managing, operating and maintaining the Works to the highest internationally accepted standards without additional supervision.

Training shall be based on all the procedures detailed in the Operation, Maintenance and Safety Manuals including, but not limited to managing, operating, controlling and performance monitoring of the treatment process, data filing and processing, reporting, assembly, dismantling and maintenance of equipment and Plant as well as fault finding, without affecting the normal Operation and Maintenance. Particular emphasis shall be laid on safety precautions during Commissioning.

The training shall in general consist of familiarization with the operational aspects of the systems as a whole, followed by familiarization with specific items of equipment.

The training shall be based on the actual plant and the implementation of operation and maintenance schedules outlined in operation and maintenance manuals provided by the Contractor.

The training shall also be directed towards the specific requirements of the trainee, as the instruction and familiarization of the various personnel involved will vary with respect to their operational capacity, as the personnel will require different aspects to be emphasized.

All training shall be successfully completed and demonstrated before termination of the Commissioning Period can take place. If in respect of progress of works and the daily operation of the plant and systems, it is required that any systems or equipment has to be put into use by the Employer before the Certificate of Substantial Completion, it is the Contractor's responsibility that all necessary instructions and training have been given to the Employer's personnel, for full understanding of the technology and operation, prior to commencement of the Employer's utilization of such systems or equipment.

The Contractor shall employ a specific engineer for the training procedure. This representative shall have an adequate knowledge of the English language and the national language. The Contractor shall make available to him all procedural documents produced in accordance with the Employer's Requirements.

The representative and the trainees shall be allowed the unhindered access at any time to any part of the Works.

The liability for the entire Works during training remains with the Contractor, independently of who may be responsible for any fault or damage.

The Employer will cover all costs in connection with wages the Employer's personnel assigned for training and instruction.

All other total costs to cover the Contractor's expenses in connection with training shall be included in the tender.

15.2. TRAINING PROGRAMME

The training program shall include, but need not be limited to the following:

- Organizational structure of the personnel required for management, Operation and Maintenance of each component of the Works.
- Manpower requirements, by skills and trades, necessary for the management, Operation and Maintenance of each component of the Works.
- Detailed description of each element of the training programme, which will show how the necessary skills shall be imparted to the personnel, assigned by the Employer.
- Identification of the minimum educational levels or standards of technical skill which must have been obtained for each position by the assigned personnel, which levels and standards should be readily available in Palestine.
- Theoretical and on-site technical training.
- CVs of the proposed Instructors, including qualification and education.

15.3. EXECUTION OF TRAINING

To ensure that adequate training is given, the training personnel from the Contractor shall carry out each and every Operation and Maintenance activity identified in the Operation, Maintenance and Safety Manuals and shall train the Employer's personnel to carry out these activities even if they are not required during the actual operation of the Works.

The Contractor shall pay particular attention to safety training for all assigned personnel. Safety training shall not be limited to personal safety, but shall include detailed actions to be taken by all staff in emergency situations and the use of all safety equipment. The Contractor shall be responsible for establishing procedural links with the appropriate emergency services.

The Contractor shall provide all necessary facilities for training including didactic equipment, simulators video, slide and overhead projection equipment. The necessary specialist buildings or rooms for training shall be provided as part of the Permanent Works. All training equipment shall become the property of the Employer at the end of the Training Period.

Training shall be carried out in the English language. However, the Contractor shall provide a sufficient number of local language / English interpreters to overcome any difficulties arising due to the assigned personnel not being completely fluent in the required languages.

15.4. CONTRACTOR'S PERSONNEL

The duties of each of the training personnel shall be to manage, operate and maintain that element or those elements of the Works appropriate to his position, and to train the Employer's assigned staff members for that particular position. The emphasis shall be on "hands-on" training.

In addition to his normal training personnel, the Contractor shall also provide specialist trainers who shall be responsible for formal classroom, laboratory or workshop training.

As a non-exhaustive overview, the training will cover in particular the following aspects:

- Basic theoretical principles of plant and practical use for this plant.
- Description and working limits of each equipment/component.
- Operation of each piece of equipment, including safety rules.
- Understanding and use of the supervision system of the plant.

16. OPERATION AND MAINTENANCE MANUAL

16.1. GENERAL

A. The Contractor shall provide Operation and Maintenance Manuals of the facilities.

B. The manual shall be on paper size A4 (210 x 297 mm) paper 80-90 grams with offset or equivalent printing strongly bound in a durable stiff cover bearing the title in approved legend. Drawings shall be folded or reduced to 297 mm height. All volumes shall bear on the spine an approved shortened version of the title.

C. Each manual shall contain all relevant information on the operation, maintenance, servicing and dismantling of the relevant equipment.

D. General Comments concerning Printings of Manuals

- Technical documents of commercial type, containing the necessary information, may be used partly or in full.
- Drawings, diagrams, sketches or photographs shall be included whenever necessary for easier understanding or clarity.
- Precautions and warnings relating to the safety of persons and of the equipment shall be clearly stated.
- The sections of the Manual shall be arranged in the following order:

- a) Title page
- b) Table of Contents
- c) Section I - Operation
- d) Section II - Maintenance

- e) Section III - Dismantling
- f) Corresponding publications
- g) Perspective drawings, scale drawings, diagrams, etc.

16.2. PROCEDURE

The Contractor shall submit 3 draft copies of each manual to the Engineer 3 months before the Pre-commissioning Tests.

Once the Engineer has given written approval of the draft, the Contractor shall hand over an additional 6 copies of the manuals to the Engineer at the date of the Commissioning Tests.

Final version shall be strictly identical to approved drafts.

16.3. CONTENT

A. Section I - Operation

This section shall include:

- A general description.
- Operating instructions:

These shall specify the precautions which must be taken and critical points to be observed and shall recommend a method for monitoring and recording observations and maintaining operational records.

- Fault-finding table:

A single document for the intention of operating staff shall indicate the full list of all faults that may occur in all the equipment and which are detected by protection systems activating alarms.

For each fault, the document shall indicate the probable causes and the remedial measures to be taken to ensure return to normal operation.

- Characteristic data:

The main specific characteristics of each item of Plant shall be listed including but not limited to rated capacity, power, voltage, amperage, pressure, temperature, number of revolutions per minute, discharge, operating range, efficiency.

- Curves:

Characteristic curves of each item of Plant shall be provided whenever specified or whenever it is normal practice to do so.

B. Section II - Maintenance

This section shall contain the following:

- Maintenance instructions:

These shall include instructions for routine preventive maintenance and lubrication requirements and a list of recommended spare parts. Schedules shall be given for Plant shut-down indicating the frequency in the operating cycle at which they should occur, and the tests to be made during shut-down. The instructions shall also include a brief description and identification of special tools required.

- Calibration and tolerances:

Information shall be given in tabular form of the calibration of instruments and alarms. Information on operating temperatures, pressures, discharges, and other such data, shall also be given in tabular form. Settings for protection relays, contact gaps, clearances, contact pressures shall be given.

This information shall be set out under two headings: "Recommended" and "Actual". Actual characteristics shall be ascertained during the Commissioning Tests on Site after the Plant has been erected.

C. Section III - Dismantling

This section shall describe the sequence and procedure to be followed, operation by operation. Points where exceptional care is needed and precautions to be taken shall be specifically noted.

17. COMMISSIONING

The sequence of the Works completion will be as follows: Fill-in authorization, Pre-commissioning, Certificate of Substantial Completion, Commissioning, and Taking-over Certificate in accordance with the Conditions of Contract.

17.1. FILL-IN AUTHORIZATION AFTER DRY-TESTS COMPLETION

As soon as "dry tests" on equipment and water tightness tests on concrete structures or pipes are successfully performed at the satisfaction of the Engineer, the Contractor is deemed to issue a notice, for informing that the Works have been completed.

It is reminded that dry tests are carried out under the Contractor responsibility only.

Within 7 days after receipt of this Notice, the Engineer will authorize to fill-in all the plant with water and to "switch on" all the equipment under the Contractor responsibility.

17.2. PRE-COMMISSIONING

The pre-commissioning starts with the Engineer's approval to fill in the plant with clean water ("flooding"). During the Pre-commissioning period, the Contractor is fully responsible of the Plant; he will be able to perform and conduct any tests or adjustments he wishes.

The Contractor will take in charge energy, chemical (if any), staff costs and other incidental costs during the Pre-commissioning period.

When applicable, the Contractor shall issue a notice, for informing the Engineer that, based on its judgment, the Pre-commissioning period will be completed at the date he has to fix; then the Engineer will issue, if agreeable at its satisfaction, the Certificate of Substantial Completion, within 7 days after receipt of the notice.

17.2.1. COMMISSIONING PERIOD

As soon as the Engineer shall issue the Certificate of Substantial Completion, the Commissioning period shall be "on".

The commissioning period will be considered as a normal operation period; as such all the equipment and all parts of the plant shall be in operation.

The Employer or its selected Operator will take in charge energy, chemical (if any), newly hired operation's staff costs and other incidental costs during the Commissioning period.

During the commissioning period, the Contractor is liable to successfully perform the followings tasks:

- Additional Adjustments to be made, if any, before the Commissioning tests.
- Training of Employer's staff
- Performance tests on the sludge dewatering equipment

During the Commissioning period, the Contractor remains responsible of the day-to-day operation of the plant. The Contractor shall be responsible to provide all means as described here above.

At the end of the Commissioning Period, the Engineer will issue, the Taking-Over Certificate, if agreeable, in particular if:

- The Contractor demonstrated that the plant was fully operable and workable under nominal running during at least half of the Commissioning Period.
- The performance tests on sludge dewatering equipment have been successfully performed and accepted by the Engineer.

In any other circumstances, the provisions of the Particular Conditions shall apply.

17.3. TAKING-OVER CERTIFICATE

It will be issued by the Engineer as per the provisions of the Contract.

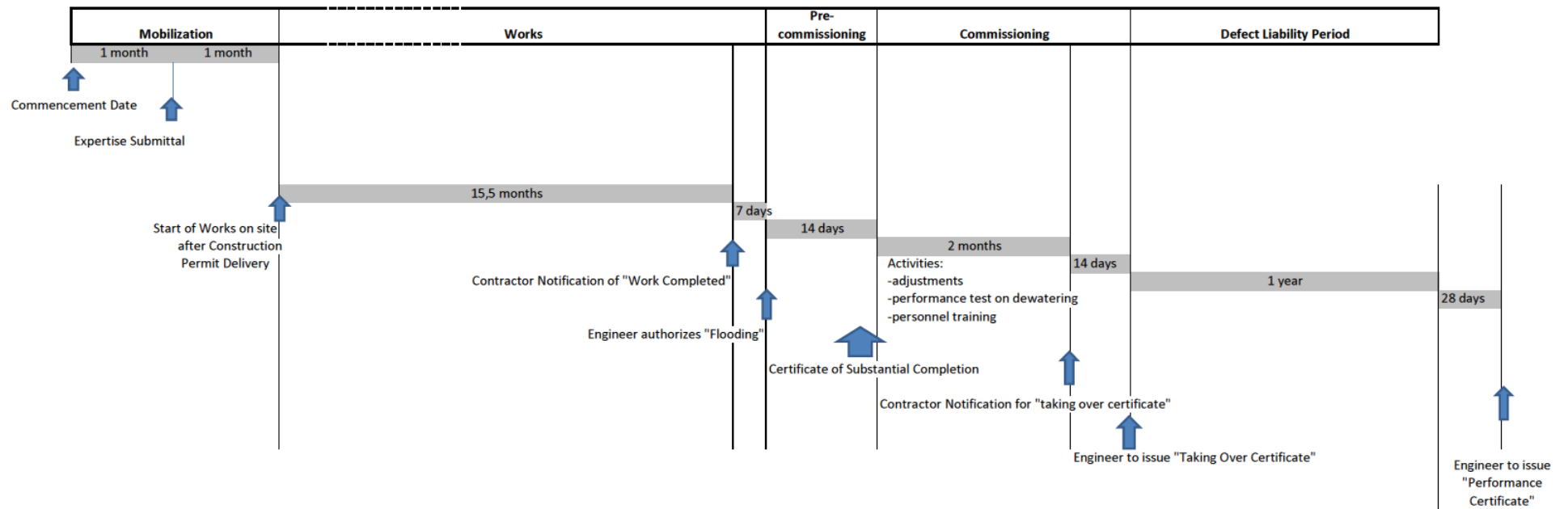
The lack of spare-parts, stored as required, and the lack of as built drawings and Operation manual shall post-pone the issuance of the Taking-over Certificate.

17.4. PERFORMANCE CERTIFICATE

It will be issued by the Engineer as per the provisions of the Particular Conditions.

17.5. DEFECT LIABILITY PERIOD

The Defect Liability Period as define in the Contract shall be 12 months.



Note: This diagram is given only for information; the Contractual Clauses of the Contract General Conditions and Particular Conditions still remain in force. Indicated durations are considered minimum. If these durations need to be extended no additional time shall be given to the Contractor and penalties shall apply if the Time for Completion is overrun.

SECTION 01001

DESIGN CRITERIA FOR STRUCTURAL ENGINEERING

1. STANDARDS

The following Standards shall be used for the structural design:

- HHSN – Seismic Code of the Republic of Armenia
- SNiP – Construction rules and regulations

And more precisely:

- HHSN II-6.02-2006 Earthquake-resistive construction. Design codes
- SNiP 2.01.07-85 Loads and actions
- SNiP 2.02.01-83 Basements of buildings and structures,
- SNiP 2.02.02-85 Basements of hydraulic structures
- SNiP 2.03.01-84 Concrete and Reinforced Concrete Structures
- SNiP 2.03.06-85 Aluminum structures
- SNiP 2.03.11-85 Protection of construction structures against corrosion
- SNiP 2.04.03-85 Sewerage. External networks and structures
- SNiP 2-23-81 Steel structures
- SNiP 2-23-81 Stone and Reinforced Stone structures
- SNiP 2-25-80 Timber structures
- HHSN I-2.01-99 Engineering investigations for construction,
- HHSN II-8.04.01-97 Fire safety of buildings and structures,

2. GENERAL

The following criteria shall be considered in the design:

- 1) Class of consequences of structure: First
- 2) Service life of the structures: 150 years
- 3) Class of water tightness of liquid retaining structures: W6
- 4) Class of exposure:

- a) Moderately aggressive, according to SNiP 2.03.11-85 Protection of construction structures against corrosion
- b) For concrete surfaces exposed to weather and not included in the above category: F100
- 5) Thermal effects:
 - a) The thermal difference between internal and external faces of the reservoir wall is taken to 30°C for thermal moment's calculation
- 6) Crack opening criteria:
 - a) For the concrete elements retaining liquid, crack opening depends on the class of watertightness. For a Class of watertightness W6, crack opening is limited to 0.15 mm.
 - b) In all cases, the maximum stress in steel at Serviceability Limit State shall be limited to 200 MPa for all water retaining structures.
- 7) All dispositions shall be taken into account concerning the stability and the watertightness of pipes embedded into concrete elements.
- 8) Levels indicated on drawings are considered after settlement.
 - a) Maximal absolute settlement: 10 mm
 - b) Maximal relative settlement: 1 mm / meter

3. MATERIALS

A. Concrete

The concrete of the structures shall have a minimum grade of B25 class heavy concrete.

- Minimum concrete compressive strength at 28 days..... = 25 MPa

B. Rebars

- Type A1c, A500c, Br class
- Yield Strength..... = 500 MPa
- Concrete cover to reinforcement in water retaining structures:≥ 50 mm

C. Structural Steel

- Minimum Yield Strength: 355 MPa at a nominal thickness ≤16mm

4. ACTIONS

A. The design of all structures shall take into account all loads as per the requirements of the applicable Standards, for both temporary and permanent works.

Those loads are the following:

- Wind loads,
- Earth pressure loads,
- Hydrostatic pressure loads,
- Snow loads,
- Seismic loads,

- Live loads: in particular, the following live loads shall be taken into consideration in the structural design calculations:
 - Raft, industrial slab and slab receiving public : 5 kN/m²
 - Inaccessible terrace (except for maintenance) : 1,5 kN/m²
 - Accessible terrace : 2,5 kN/m²
 - Heavy load roads : 30 tonnes truck or 5 kN/m²
 - Live loads around structures: 10 kN/m²
 - Grating platforms (for operator access): 2.5 kN/m²
 - Grating platforms (for equipment maintenance): according to equipment loads
 - Equipment support: according to equipment loads

B. Fire

Electrical rooms shall be designed according to HHSN II-8.04.01-97 Fire Safety of Buildings and Structures

C. Freezing

Upper level of pipes (crown) and structures foundations shall be at least -0,70 m under ground level.

5. CALCULATION

All structural calculations shall take into account the geotechnical characteristics of the site, the dimensioning combination of actions as per the applicable Standards and shall ensure that all structures will be stable against uplift pressures (including for buried pipes), and also that all excavations will remain stable regarding buoyancy.

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SECTION 01010

CORROSION PROTECTION

1. GENERAL

1.1. WORK INCLUDED

This section of specifications covers the corrosion protection of all equipment and steel structure element to be supplied, unless different requirements are specified in the subsequent sections.

1.2. RELATED WORK

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. CODES AND STANDARDS

Supplies and works shall comply with the following standards or equivalent:

- Standards of the US Steel Structure Painting Council (SSPC) for corrosion and metal protection.
- European scale of rusting degree for anti-rust paint. Published by the European Committee of the association of paint printing inks and art colours (42 avenue Marceau, PARIS 8e).
- BS 729: Hot dip galvanized coatings on iron and steel articles.
- BS 5493: Code of practice for protective coating of iron and steel structures against corrosion.
- BS 7079: Preparation of steel substrates before application of paints and related products.
- BS EN 22063 Metallic and other inorganic coatings –Thermal spraying-zinc aluminium and their alloys.
- Din 55928 or Swedish standard S.I.S. 05590 or equivalent on the cleanness degree of metallic surfaces.

1.4. REFERENCES

The Contractor shall furnish references of the paint manufacturers and of the paint application subcontractors.

1.5. SYSTEM DESCRIPTION AND CHARACTERISTICS

1.5.1. GENERAL

Paint characteristics shall be determined taking into account the function, location of each equipment and/or steel structure element and type of protection required.

With the exception of surfaces to be embedded in concrete, all equipment and steel structure element shall be given marine protection for overseas shipment. Corrosion protection systems shall be selected considering the shipment, site storage and final use conditions.

Equipment and steel structure element shall be protected from the corrosive action of water when they are intended to be submerged or partially submerged, and from the corrosive action of the atmosphere.

The protection shall be designed for all possible types of corrosion, namely: chemical, electrochemical and biological.

When using painting for corrosion protection, each coat of paint shall be of a different colour.

All safety components and accessories which, in contact with water, might be subject to serious corrosion or scaling, liable to cause operating faults, shall be protected from corrosion and, wherever possible, from scaling by the use of materials whose mechanical and physical qualities must meet the conditions of use imposed on the components.

1.5.2. EQUIPMENT AND STEEL STRUCTURE ELEMENT SUBMERGED, PARTIALLY SUBMERGED OR SUBMITTED TO HUMID ENVIRONMENT

Equipment located in parts of the structure where humidity or condensation is high shall be protected with the same system as that used for the submerged or partly submerged parts.

On the parts inaccessible after erection, the entire protective system shall be applied before shipment to the site.

The paints system shall be an epoxy-tar based system. The system selected shall be such that it can accept a final coat at site. The minimum guaranteed thickness of the protective coating shall be 450 micrometers.

1.5.3. EQUIPMENT AND STEEL STRUCTURE ELEMENT EXPOSED TO THE OPEN AIR

The protection system shall be applied without the final coat.

The minimum thickness of the total intermediate coat shall be specified and guaranteed by the Contractor.

1.5.4. PARTS EMBEDDED IN CONCRETE (CAST-IN-PLACE)

All parts (supporting systems, frames, etc.) embedded in concrete shall be made of stainless steel 304L.

1.5.5. BOLTS AND NUTS

All bolts and nuts shall be protected by hot dip process galvanization, unless otherwise specified by the equipment manufacturer for preventing electro-chemical corrosion.

1.5.6. MACHINED SURFACES

A protective varnish shall be applied to the dried and cleaned surfaces either with the aid of a brush or with a spray gun. This varnish must be capable of being easily removed by the application of petrol or trichlorethylene. The Contractor supplying trichlorethylene shall warn personnel of the health hazard resulting from the use of this ingredient.

1.5.7. INTERNAL SURFACES OF METALLIC TANKS

Unless otherwise specified, the internal surfaces of metallic tanks designed to contain oil shall be blast cleaned and immediately protected with two coats of oil-proof enamel paint.

1.5.8. INSIDES OF BOX GIRDERS

The insides of box girders not accessible for painting after erection shall be subjected to a watertightness test using compressed air, unless specified to the contrary for each particular case at the written request of the Contractor. The compressed air pressure will be 1.5 bar for the test.

On completion of this test, a desiccating powder shall be blown into the box girders in order to dry the air. The aperture shall then be carefully sealed by means of a welded plate.

1.5.9. ACCESS WAYS, PLATFORMS, HANDRAILS, LADDERS, COVERS, LAMPPOSTS, STEEL STAIRS, FOOTBRIDGES, GRATING

All these items shall be protected by hot dip process galvanization, unless otherwise specified ;

1.5.10. SURFACES INACCESSIBLE AFTER ASSEMBLY AND ERECTION

Surfaces inaccessible after assembly and/or erection of the equipment and/or steel structure shall be prepared and protected before such erection and assembly are carried out.

1.5.11. COLOURS

The colours of painting proposed shall be submitted to the Engineer for approval.

The colours of pipework for services shall be according to Employer's standards.

1.6. DOCUMENTS TO BE SUBMITTED

For each type of protection system, the Contractor shall submit the following documents to the Engineer for information and comment:

1.6.1. TECHNICAL INFORMATION SHEETS

Technical information sheets concerning the paint used, giving the following:

1. Origin, definition, destination, composition;
2. Properties, including: recommended thickness of dry coat, graphs showing drying times, maximum and minimum coating times and pot life as a function of temperature, highest and lowest duty temperatures, flash point;
3. Conditions of application, including air temperature and humidity and temperature of the substrate;
4. Compatibility and method of protection;
5. Efficiency;
6. Packing and storage;
7. Reference to Standards.

1.6.2. GALVANIZATION PROCESS

1. The galvaniser's references in the field covered by the present Specification.
2. Test certificate for factory galvanised products or attestation of conformity with Specifications.
3. Identification of the factory producing the galvanised products.
4. Identification marks for galvanised parts checked at the factory.

1.6.3. PAINTING PROCEDURE

1. Preparation of surfaces (substrate, underlying layers, damaged area),
2. Products applied and thickness of each coat,
3. The Contractor shall confirm the number of coats (applications) as specified by the Paint Manufacturer if not the minimum given in this specification.
4. Place of application;
5. Description of the paint application facilities;
6. Temperature and humidity limits.

1.6.4. APPLICATION REPORT

1. Daily report of the maximum and minimum ambient temperature and list of parts to be painted;

2. Daily report of the maximum and minimum humidity level in the paint application room;
3. Other pertinent information;
4. A table indicating the various items to be protected (on X-axis for example) and the various types of protection (on Y-axis for example): quality, thickness, colour per coat and areas to be painted.

1.6.5. SCALE OF RUSTING

Stereotype No. 7 of the European scale of rusting for anti-rust paint.

1.7. STORAGE

The storage conditions of painting products shall comply with the recommendations indicated on the supplier's technical data sheets. Non-respect of these conditions may give rise to rejection of the product. In particular, the Contractor is deemed to be fully acquainted with the climatic conditions prevailing on site and shall be required to take such conditions into account.

The stores used for the storage of paints and associated thinners shall be closed and covered, thereby enabling the temperature and degree of humidity to be maintained at a level consistent with the specifications indicated on the product instructions for use.

1.8. ENVIRONMENTAL LIMITATIONS

Sand blasting and painting work shall be carried out only when the ambient air temperature and degree of humidity are within the requirements of the product instructions for use.

Generally, all such work shall be suspended as soon as the degree of humidity exceeds 75% and the ambient temperature exceeds 40°C or drops below 5°C. The substrate temperature shall always be at least 3°C higher than the dew point.

The Contractor shall bear the cost of equipping each work station with sufficiently accurate measuring instruments. Temperature and humidity shall be recorded during paint application.

1.9. PROGRAMME

The contractor shall clearly indicate in his manufacturing programme and in his erection programme, the global periods scheduled for the application of corrosion protection coatings.

1.10. SITE CONDITIONS

1. Blast cleaning and painting work shall be carried out only when the ambient air temperature and degree of humidity are within the requirements of the instructions for use of the products.

2. Generally, all such work shall be suspended as soon as the degree of humidity exceeds 75% and the ambient temperature exceeds 40°C or drops below 5°C. The substrate temperature shall always be at least 3°C higher than the dew point.
3. The Contractor shall bear the cost of equipping each work station with sufficiently accurate measuring instruments. Temperature and humidity shall be recorded during point application.

1.11. GUARANTEE

1. All the protection systems adopted shall have a design life of 8 years, to be certified by the Office d'Homologation des Garanties de Peinture Industrielle (French Office for Certification of Industrial Painting Guarantees), or equivalent International Organization of Certification.
2. A letter of guarantee shall be submitted by the Contractor from the specialist subcontractor that the products proposed for use when applied with the specifications of this Part and the manufacturer's instructions will withstand the environmental service conditions to be encountered for a period of 8 years.
3. The performance of the protective paintwork during the Maintenance Period will be inspected by the Engineer in presence of both the Contractor and the Employer. No rust point or blister shall be accepted at the end of the maintenance period. Any necessary repair work shall be determined on the basis of the results of these inspections.

2. PRODUCTS

2.1. GENERAL

1. Each coat of paint shall be of a different colour.
2. Equipment exposed to ultra-violet radiation shall be given special protection. Areas to be protected in this manner shall be determined in relation to the normal operating conditions of each item of equipment.

2.2. COLOURS

The colours proposed shall be submitted to the Engineer for approval. For guidance purposes, the Contractor could make the choices indicated hereafter:

1. Aluminium: for equipment exposed to sunlight, the thermal effects of which could be detrimental to protection performance.
2. Moving parts in the immediate vicinity of personnel access ways shall feature black stripes 6 cm wide and inclined at 30° to the vertical.
3. The colours of pipework for services shall be according to RAL standards.

2.3. SCHEDULES OF PAINTING

2.3.1. FERROUS METAL SUBJECT TO CONTINUOUS OR INTERMITTENT IMMERSION IN WATER

1. Abrasive blast cleaning SA 2.5.
2. Two or three coal tar epoxy coats.

The minimum dry film thickness of the system shall not less than 450 µm.

Or:

1. Abrasive blast cleaning SA 2.5.
2. One coat of zinc rich primer minimum thickness 50 µm.
3. Two or three coats of vinyl coal tar.

The minimum dry film thickness of the system shall not less than 450 µm.

2.3.2. FERROUS METAL SUBJECT TO SPLASH, UNFAVOURABLE ATMOSPHERIC EXPOSURE OR HUMID ENVIRONMENT

Same as for ferrous metal subject to continuous or intermittent immersion in water.

2.3.3. PAINTING SCHEDULES FOR TYPICAL OUTDOOR LOCATIONS

1. Abrasive blast cleaning SA 2.5
2. One coat epoxy polyamide metallic zinc rich primer.
3. One coat epoxy polyamide.
4. One chlorinated rubber tie coat.
5. One coat high build chlorinated rubber.

The minimum dry film thickness of the system shall not less than 220 µm.

Or:

1. Abrasive blast cleaning SA 2.5
2. One coat zinc rich epoxy paint.
3. One intermediate coat epoxy paint.
4. One top coat acrylic polyurethane paint.

The minimum dry film thickness of the system shall not less than 180 µm.

2.3.4. PAINTING SCHEDULES FOR TYPICAL INDOOR LOCATIONS

1. Abrasive blast cleaning SA 2.5.
2. One coat weldable holding primer for protection during manufacture and erection.
3. One coat of epoxy zinc rich primer.
4. One intermediate coat of epoxy paint.
5. One coat of epoxy paint.

The minimum dry film thickness of the system shall not less than 150 μm .

Or:

1. Abrasive blast cleaning SA 2.5.
2. One coat of epoxy zinc rich primer.
3. One intermediate coat of modified epoxy paint.
4. One coat of modified epoxy paint.

The minimum dry film thickness of the system shall not less than 150 μm .

2.4. GALVANIZATION

Galvanization shall be applied by the hot-dip process and shall consist of a continuous coating to minimum thickness as follows:

	Average of Specimens tested μm (g/m ²)	Any Individual Specimen μm (g/m ²)
Rolled steel exposed to the atmosphere only		
t < 6 mm	87 (609)	79 (553)
t > 6 mm	100 (700)	87 (609)
Rolled steel directly placed in the ground or in water	210 (1470)	165 (1155)
Cast iron and malleable iron	87 (609)	79 (553)
Bolts, nuts and washers	55 (385)	44 (308)

The zinc coating shall meet the requirements according to ASTM A123, A153, A239 and A385 or equivalent.

A. Zinc for galvanization

Zinc ingots used for galvanization shall comply with British or European Standards.

B. Minimum zinc content in the galvanization bath

98.5% pure zinc with a lowest permissible limit of 98.3%.

3. EXECUTION

3.1. PREPARATION

3.1.1. GENERAL

The Contractor shall take all reasonable precautions to ensure that the protective coatings are not damaged during handling in the factory, during transport or during erection. In particular, he shall ensure that no damage is caused through the use of inappropriate packing systems.

In the event of damage, the Contractor shall make good the existing protective coating, using the same products and under the same conditions of application.

For all the equipment and steel structure element included in the supply, a single make of paint approved by the Engineer and identical products for identical operating conditions shall be chosen.

Regardless of where the corrosion protection coating is applied, the cost of all the necessary installations shall be borne by the Contractor.

3.1.2. SURFACE PREPARATION

3.1.2.1. BARE METAL SUBSTRATES AND DAMAGED AREAS

1. Before any treatment, the surfaces will be cleaned using an appropriate method.
2. Blast cleaning (using non-siliceous sand, corundum, treated slag or shot). The surface quality grade will be DS 2.5, minimum. The surface roughness value to be obtained after cleaning shall be defined by the paint supplier. Wet sand-blasting is prohibited.
3. Careful removal of dust.

3.1.2.2. PRE-PAINTED SUBSTRATES AND SURFACE PREPARATION BETWEEN EACH COAT

1. Before carrying out any treatment, the surfaces will be cleaned using an appropriate method.
2. The surface preparation will be defined in relation to the primer applied in the workshop and to the requirements for the correct adhesion of the other coats, which will be defined by the paint supplier (surface roughness, possible removal of zinc salts, etc.).
3. Careful removal of dust.

3.2. PAINT COATINGS

The choice of place(s) for the application of the final coats shall be made in relation to the following:

1. Type of product,
2. Programme and procedure of manufacture and erection,
3. Climatic conditions,
4. Mode of application of the paint,
5. Equipment, materials and personnel available,

Other factors may be taken into account.

3.3. GALVANIZATION

3.3.1. SURFACE PREPARATION

1. Cleaning: Parts to be treated shall be brushed thoroughly to remove any substances adhering to the surface (such as foundry sand, paint marks, etc.).
2. Degreasing: Irrespective of the technique used (degreasing with alkalis or solvents), this operation shall be carried out with all necessary care and shall not under any circumstances be replaced by pickling operations.
3. Pickling: Parts shall be pickled to remove completely any surface scale and rust. Either of the following processes may be used:
 - Chemical pickling: hydrochloric or sulphuric acid baths for steel.
 - Mechanical pickling: shot blasting.

In this case, the maximum depth of rough surface shall be compatible with the thickness of zinc corresponding to the specified weight of deposit per unit area of surface.

3.3.1. GALVANIZATION PROCESSING

The galvanization process shall be submitted to the Engineer for approval. It may consist of any of the following process:

1. Wet galvanization.
2. Dry galvanization.
3. No-flux galvanization.

3.3.1.1. CHARACTERISTICS OF COATING

1. Appearance: The layer of zinc shall be smooth, uniform and homogeneous, with no interruption of continuity and free from stains or zinc seams and ash. If there should be any

surface crystallization, this must be regular, but the dimensions and shape of the crystals shall not be taken into account at all in assessing the quality of the coating.

2. Weight of zinc per unit area of surface: The weight of zinc deposited shall be on average 7 g per dm² and at least 5 g per dm², with a minimum thickness of 70 µm. In the case of tubes, hollow parts and assembled parts, these values apply to both faces.

3.3.1.2. TYPE OF PARTS

1. The properties, shapes and characteristics of the material shall not be affected by the galvanization process.
2. Bolts with nominal diameters of between 14 mm and 20 mm inclusive shall be tapped so that nuts can be screwed without forcing on to the bolts, while maintaining a sufficient thickness of zinc.
3. Parts consisting of welded components may be galvanized without difficulty provided that the components:
 - a) are of the same quality of steel,
 - b) have been fabricated by identical processes (forging, rolling, casting, etc.),
 - c) have the same degree of surface oxidation.

Any trace of flux or working residue shall be completely eliminated. After cleaning, welds shall have a continuous, regular surface free from any porosity and perfectly watertight.

4. All components of any assembly to be bolted or riveted shall be delivered to the galvanizer unassembled for separate treatment.

Holes for bolts, rivets or pins shall be carefully bored before galvanization to a diameter that takes into account the thickness of the deposit, as no retouching work shall be carried out after treatment.

3.3.1.3. FIELD QUALITY CONTROL

By visual inspection.

3.4. APPLICATION IN WORKSHOP

3.4.1. GENERAL

1. The Contractor shall not proceed with painting of any of the equipment subject to workshop inspections and tests without the prior written approval of the Engineer.
2. All steel work shall be fully fabricated before galvanization, no machine or shop work, boring, punching etc. will be allowed after galvanization is processed. Minor damage to the treated surface resulting from transportation and erection shall be repaired at site in an approved manner, e.g. by painting with an approved zinc-rich paint, containing at least 92 weight per cent zinc powder.
3. After galvanization all members shall be dipped in a dichromate solution bath to avoid formation of white rust during storage and transportation.

3.4.2. APPLICATION REPORT

The Contractor shall submit the application report defined as follows:

- Daily report of the maximum and minimum ambient temperature and list of parts to be protected against corrosion,
- Daily report of the maximum and minimum humidity level in the corrosion protection application room,
- Other pertinent information.

3.4.3. QUALITY CONTROL IN WORKSHOPS

Inspection before shipment:

1. The Engineer reserves the right to inspect the corrosion protection application facilities in the Contractor's and/or his subcontractor's workshops and to ensure that they comply with the prescribed standards and application procedure.
2. The number of protection coats and the total thickness of the coating will be checked and the Engineer reserves the right to have the thickness of individual coats checked in his presence. On a protected surface, a test area and a number of test points shall be defined by the Engineer. The minimum measured thickness shall not be below 90% of the guaranteed thickness and the average of all measurements shall not be below the guarantee. The Contractor shall supply the measuring apparatus, which shall be of the electronic detection type (Brandl Positector or similar), giving readings accurate to within 1 micrometer. One measurement shall be taken every 0.5 m² or every 0.5 linear metres.
3. Adhesion tests shall be performed on submerged and partially submerged equipment or steel structure element, in accordance with British or European standards. The instruments required, in accordance with the same standards, shall be supplied by the Contractor.

3.5. APPLICATION ON SITE

3.5.1. GENERAL

The protective coating on surfaces damaged during handling, transportation and erection shall be repaired using the same surface preparation and products, depending on the protection system approved.

3.5.2. INSPECTION BEFORE APPLICATION

Inspection of the corrosion protection shall be carried out jointly by the Engineer and the Contractor after:

1. Full erection of the equipment and/or the steel structure;
2. Dust removal, washing with fresh water (except where otherwise instructed by the Engineer) and drying if deemed necessary by the Engineer.

Surfaces to touch up will then be defined by mutual agreement.

3.5.3. INSTALLATIONS FOR THE APPLICATION OF PROTECTIVE COATINGS ON SITE

The Contractor shall install all necessary equipment for:

1. Rinsing of structural surfaces that have been in contact with a salty atmosphere during transport, with the exception of surfaces to be sand blasted at site.
2. Drying of surfaces to be sand blasted;
3. Checking of air temperature and degree of humidity at the place of work execution, together with the necessary shelters and special arrangements required for carrying out these measurements;
4. Distributing compressed air for sand blasting and paint work;
5. Removal of sand blasting dust and thinner evaporation gases;
6. The protection of ancillary equipment and structures against the projection of products, their vapours, sand and dust.

3.5.4. APPLICATION OF PROTECTIVE COATING ON SITE

3.5.4.1. SUBMERGED OR PARTIALLY SUBMERGED EQUIPMENT

Reapplication of the protective coating on surfaces damaged during handling and transport, using the same products, depending on the protection system selected.

3.5.4.2. EQUIPMENT IN THE OPEN AIR

1. Reapplication of the primer protection on surfaces damaged during handling or transport, using the same products, and depending on the protection system used in the workshop;
2. Application of top coat;
3. The minimum thickness of the top coat shall be defined and guaranteed by the Contractor.

3.5.4.3. SURFACE OF PARTS EMBEDDED IN CONCRETE

All traces of grease and scaling shall be removed prior to concreting.

3.5.5. QUALITY CONTROL ON SITE

1. Checking of application conditions, compliance with paintwork standards and procedures.
2. Checking of surface preparation.
3. Checking of the number of coats and of the total coating thickness using testing apparatus to be provided by the Contractor.
4. Where deemed to be necessary the Engineer as the right to require additional adhesion tests as per French Standard NFT 30-038 or equivalent British or European Standard. Testing apparatus to be provided by the Contractor.

5. Acceptance of the protection system shall be combined with the overall acceptance procedures for the equipment or steel structure covered.

SECTION 01020

BASIC MECHANICAL REQUIREMENTS

1. GENERAL

1.1. WORK INCLUDED

This section of the specifications covers the general requirements applicable to all mechanical equipment to be supplied, unless different requirements are specified in the subsequent sections.

In case of conflict between the requirements of this general specification and those of the specific equipment specifications, the latter shall have precedence.

1.2. QUALITY ASSURANCE

1.2.1. GENERAL

The equipment shall be manufactured in accordance with established practice. All the components shall be finished as required by their importance, position and destination. The manufacture shall be sound, without any faults likely to impair their ability to fulfil their purpose:

1. All equipment shall be designed in compliance with up-to-date practice;
2. Equipment design shall take into account control and maintenance operations as well as operating incidents;
3. The general aesthetic appearance shall be studied and shall blend in with the overall architecture of the structures.

1.2.2. MATERIALS

1.2.2.1. GENERAL

Materials shall be new and of first class quality.

Rolled and cast steel shall be of good quality and free from blow or shrinkage holes, porosity, cracks or other defects.

Cast iron is not acceptable for any tap, valve bodies or components subject to internal pressure.

The Contractor shall indicate in the calculation notes the quality of the materials with reference to International (ISO) or American (ASTM,...) or European (DIN or BS or NF,...) or Japanese (JIS) or equivalent standards, and their mechanical and chemical properties. Such information shall be given for all materials used in the construction of the main items of equipment before procurement commences.

Materials shall comply with the list below or be similar according to other acceptable standards:

1.2.2.2. MAIN TYPES OF MATERIALS

European standards or equivalent as below:

- Structural steel:.....EN 10025
.....EN 10137
- Non alloy high strength steel: EN 10083
- Low alloy high strength steel: EN 10083
- Corrosion resisting steel: EN 10088
- Iron casting: EN 1561
- Alloy steel casting:..... A 32054
- Steel bolts and nuts: EN ISO 3506
.....EN 20898.
- Corrosion resisting steel bolts and nuts: EN ISO 3506
.....EN 20898
.....EN 10088.
- Steel pipes and fittings: EN ISO 559
..... EN ISO 2604
..... EN ISO 4200
..... EN ISO 5252.
- Bronze: E 44158
..... EN ISO 5755

Alternative materials shall be submitted to the Engineer's approval.

1.2.2.3. TESTING OF MATERIALS

All materials shall be tested in compliance with the relevant European or ASTM or similar acceptable standards. In particular:

- CCH 70-2 for the castings.
- CS GFF 3-72 or equivalent for the forgings.
- ASTM for steel plates pipes and laminated products.

1.2.2.4. CAST STEELS AND CASTINGS

Before any part is cast, drawings of the major items showing the proposed locations of the samples which are to be sent for mechanical and chemical tests, shall be submitted for the Engineer's approval.

Blow holes and all other such defects which become apparent after cleaning or machining must be ground to sound metal before any rectification is undertaken.

Castings shall not be twisted nor show any other form of distortion, nor increase in their dimensions (above that already taken into account) which could cause interference with other parts. The metal structure of the castings shall be homogeneous and free of all non-metallic impurities.

If, at any point of a critical section, the casting exhibits any unacceptably high concentration of impurities or alloying elements, the part will be rejected.

Major castings shall be submitted to ultrasonic inspection or radiographic examination where the results of ultrasonic testing is doubtful or not practical. These tests shall be complemented by magnetic particle inspection or dye penetration test.

The Manufacturer shall establish a quality sheet for each major casting.

Castings exhibiting defects of severity levels 4 or 5 in category A through E in accordance with ASTM-E 186 will be rejected.

Casting defects shall only be corrected by welders of the highest quality using the best welding techniques. All castings requiring rectification during any stage of the manufacturing process after they have been initially annealed, shall, unless otherwise indicated, be re-annealed.

Casting defects which require correction by welding shall be reported to the Engineer and shown on a drawing or by means of photographs. Approval shall be obtained from the Engineer before the corrective work is carried out.

1.2.3. WELDINGS

1.2.3.1. QUALIFICATION

For pressure tanks and hydraulic cylinders, the qualification of welding procedures and welders shall be in accordance with the requirements of ASME, Boiler and Pressure Vessel Code, Section IX.

For other components the qualification of welding procedures and welders shall conform either to ASME, Section VIII, Division 1, Section IX or the Standard Qualification Procedure of the American Welding Society at the Contractor's option.

Other welding standards and procedures translated in English will be accepted only to the extent that they conform to the above accepted codes and specifications. Exceptions to these standards and procedures will be made only where approved in writing by the Engineer.

1.2.3.2. WELDING

Welding shall be performed by the electric-arc method. Electroslag welding will also be permitted.

All welds shall be made continuous. Welds on gate or other submerged equipment shall be watertight. Butt welds shall be full penetration welds welded from both sides.

Contractor will provide sufficient temporary bracing to control distortion during welding.

1.2.3.3. WELDED STRUCTURES - STRESS RELIEVING

Components, mainly those made up of large cross-section members, welded to the middle of the section or having large weld beads, shall be given stress-relieving heat treatment. This treatment shall apply in particular to:

- a. Components which will have to be precision machined;
- b. Structures exposed to buckling forces;
- c. High carbon steel components;
- d. Equipment submitted to internal or external pressure.

This list is given for guidance purposes and shall not relieve the Contractor of his responsibility.

1.2.3.4. WELD FINISH

Welds shall display good appearance and shall be suitable for painting. Structural welds shall be ground.

Final machining of welded parts shall be performed after welding and if applicable after stress relieving.

1.2.3.5. WELD TESTING

Non-destructive tests shall be in accordance with EN 10246.

For each item of equipment the Contractor shall propose for the Engineer's approval the type and extent of non-destructive weld testing.

- A. The Contractor will proceed with examination of at least 20% of the weld lengths completed by each welder.**

Butt welds will be given radiographic test. The Contractor shall propose the best suited type of test for welds other than butt welds.

- B. Welds on pressure tanks and servomotors shall be fully tested.**

- C. In addition to the requirements A, all main welds shall be fully tested by ultrasonic and magnetic particle or dye penetrant tests complemented by radiographic examination where interpretation by other methods is unclear.**

- D. Minor welds shall be spot tested.**

Examination of welds and acceptance or rejection will comply EN 10246.

1.2.3.6. WELD REPAIRS

Defective welds shall be repaired by removing the weld material from the defective zone until sound metal is reached. The weld shall then be remade. Repaired areas shall be subjected to a new radiographic examination.

If a radiograph reveals an unacceptable zone, an extra radiograph will be taken on each side of the said zone.

If the new radiographs do not indicate any defect that would require rejection of the weld, only the zone covered by the first radiograph will be repaired. If further unacceptable defects are indicated, a complete radiographic examination shall be carried out.

Any given weld area cannot be repaired more than twice.

1.2.3.7. ELECTRODES

Electrodes must be stored under the conditions specified by the supplier and used within a maximum time of six months as from their date of manufacture. If this duration is to be exceeded, the Engineer will have the right to require the execution of new electrode quality tests.

For electrodes particularly sensitive to humidity (especially basic electrodes), if they have not been stored in a dry condition in perfectly watertight wrappings, they shall be baked before use, according to the supplier's instructions.

1.2.4. GENERAL PROVISIONS FOR EQUIPMENT DESIGN

1.2.4.1. WEAR

The Contractor shall be considered to be fully aware of the properties of the water used and the atmospheric conditions and, accordingly, under normal operating conditions, the equipment supplied shall not be subject to any abnormal wear.

All parts of equipment subject to water-induced wear shall be provided with interchangeable parts that can be easily refilled by welding or replaced. These interchangeable parts shall be made from a material selected in relation to the intended use and the probable wear of the part. The Contractor shall indicate the composition and properties of the materials used on the basis of analyses carried out by the suppliers. He shall specify the type of electrode suitable for refilling by welding if this process is used. The design of bearings shall be such that no friction-induced corrosion shall occur. The absence of any such wear will be checked at the end of the period of guarantee during equipment inspections.

The design of bearings shall be such that no friction-induced corrosion shall occur. The absence of any such wear will be checked at the end of the period of guarantee during equipment inspections.

All electrical equipment parts liable to normal or accidental wear shall be designed to resist the action of atmospheric agents and climatic conditions.

1.2.4.2. NOISE

The project is designed to limit noise as much as possible.

- In technical equipment rooms:

The sound power radiated by all the equipment during maximum operation must not exceed the following values (per octave band):

Frequency in Hz	25	250	500	1000	2000	4000	8000
Log in dBA	82	82	78	75	72	69	65

Overall value: 80 dBA.

- Generally speaking, the levels must not be in excess of 80 dBA at 3 m of each equipment.

PART 3 – TECHNICAL SPECIFICATIONS

1.2.4.3. VIBRATIONS

During normal operation, the vibration r.m.s velocity, measured on the unit bearing supports, shall not exceed 4.5 mm/s. The vibration r.m.s speed is defined in standard VDI 2056.

The various manoeuvres of the gate and valve equipment shall be carried out under all possible loads without any harmful vibration or excessive noise occurring.

The knife edge of each gate shall be streamlined and designed to prevent vibrations regardless of their degree of opening.

1.2.4.4. ACCESS AND PROTECTION EQUIPMENT

Provision shall be made for access to and protection of the equipment so as to ensure safety during operation, maintenance and inspection. All rotating parts such as wheels, shafts, transmission belts and all live electrical equipment shall be suitably protected by metal housings. Such provision is to be made at the locations and in the positions approved by the Engineer.

The Contractor shall supply all catwalks, platforms, ladders, railings, trap-doors, manholes, and access hatches tied up to the equipment and necessary for proper operation, maintenance and personal safety.

The Contractor shall submit to the Engineer for approval his proposals for the passage of gutters and for the locations of trap-doors, platforms, access doors and ladders, together with all dimensions of spaces to be allowed for the passage of equipment.

1.2.4.5. ARRANGEMENT OF OPERATING EQUIPMENT

No manual controls for lifting or pulling manoeuvres shall require a force of more than 200 Newton, and no manual controls involving the operation of a wheel crank shall require a force of more than 100 Newton.

Wheel cranks shall be located approximately 1 m above floors or platforms. The controls and measuring instruments shall be readily accessible, without any need for special equipment, and clearly marked with identification numbers.

1.2.4.6. HANDLING AND DISMANTLING

All equipment shall be installed by using the normal operational ways. No acceptance will be done by the Engineer for installations using exceptional means.

Equipment shall be designed for easy dismantling and maintenance operations. Dismantling and maintenance of electrical equipment shall be possible without stopping or disturbing other equipment in its vicinity.

All equipment or parts of equipment designed to be dismantled and handled shall be provided with:

- a. Lifting rings, lugs, hoisting collars;
- b. Slings, chassis and special handling apparatus such as: grappling beams, monorails, trolleys, jacks, pulley and ratchet systems, etc.;

- c. Special jack screws appropriately located and in sufficient numbers for the dismantling of the relevant parts.

For heavy components, the Contractor shall provide special facilities for lifting each component. The Contractor shall also provide the necessary lifting gear for this equipment such as manually or electrically operated monorail hoists, hydraulic jacks, etc.

The above equipment shall be included in the Contractor's supply and shall be retained by the Employer.

1.2.4.7. INTERCHANGEABILITY

All machined parts included in winches, pumps, gears, etc. and all moving parts in general, shall be interchangeable and capable of being easily erected on a similar type of apparatus, except for standardised equipment.

For all the contract equipment, all electrical or hydraulic apparatus, equipment, instruments and accessories (for air, water or oil circuits) of the same rating and designed to perform the same functions or operate under comparable conditions within a given operating range, shall be identical and interchangeable.

If certain modifications are made to the equipment during manufacture or erection, these modifications must be submitted for the Engineer's prior approval and shall be made to all the equipment of the same type.

At his own expense, the Contractor shall keep for a minimum period of ten years all the manufacturing drawings and all design data likely to be of use in making repairs or possible replacement of components of the equipment.

1.2.4.8. TEMPERATURE RISE

The maximum temperature of metal parts of bearings and thrust bearings and that of lubricating oil shall be:

- Metal parts: 80°C.
- Lubricating oil: 60°C.

These temperatures when reached shall trigger an alarm in the control room.

The temperatures hereunder shall trigger emergency shut down of the unit:

- Metal parts: 85°C.
- Lubricating oil: 65°C.

The temperature rise of metal parts of bearings, thrust bearings, reduction gears and other mechanical systems shall not exceed 40°C above the ambient temperature or, in the case of outdoor equipment, 40°C above the outdoor temperature in the shade.

The rise in temperature of lubricating oil, measured around the metal parts quoted above shall not be more than 30°C above the ambient temperature or, in the case of outdoor equipment, 30°C above the outdoor temperature in the shade.

PART 3 – TECHNICAL SPECIFICATIONS

1.2.4.9. LUBRICATION

Lubrication devices and systems are included in the supply. Lubricating bearing materials shall be submitted to the Engineer's approval.

Self-lubricating systems will be provided wherever possible and are mandatory for submerged or temporarily submerged equipment unless the loads applied prevent their use.

Self-lubricating systems for submerged or partially submerged parts shall be provided with protective seals.

The systems proposed shall be of proved and referenced design. References shall be supplied by the Contractor.

1.2.4.10. OPERATING SPEEDS AND LOADS

The operating speeds defined in the technical specifications shall be guaranteed under normal operating conditions and under all loads within a 5% tolerance band.

The maximum operating loads specified by the Contractor shall be considered as guaranteed.

1.2.4.11. NAMEPLATES

All equipment shall have a permanent engraved metal nameplate secured by screws clearly showing all pertinent information regarding the equipment, in the English language, including at least the following:

- a. Manufacturer's name and address,
- b. Name, type, serial number and other equipment identification data,
- c. Rating and other design data,
- d. Date of manufacture.

1.2.5. DESIGN OF MISCELLANEOUS DETAIL EQUIPMENT

1.2.5.1. AUXILIARY PIPEWORK AND PRESSURE TANKS

Pipework shall be supplied with the corresponding flanges, nuts and bolts, threaded unions, isolating valves (cast iron excluded), supports and anchoring.

Pipework design shall comply with the following values:

- a. Slope greater than 1% for the drainage lines.
- b. Water and oil flow velocities not to exceed 4 m/s.

Pipework embedded in concrete shall be systematically tested under pressure before concreting. All pipe end seals or blank flanges necessary for these tests shall be provided by the Contractor. No pipework made of malleable materials, such as lead, copper, etc. shall be embedded in concrete.

Pipe internal and external protection shall be by hot galvanizing. Subsequently, after each welding operation, the galvanization is to be repaired by wire brushing and application of a compatible enriched zinc paint.

Galvanization is not required for oil piping. The external surface of the oil pipes shall be protected by painting as per Section 01010 - Corrosion protection.

All flanges and couplings shall be suitably placed to facilitate dismantling of corresponding equipment and appliances, with a sufficient number of isolation valves to avoid loss of fluid when partial dismantling work is carried out.

All pipes shall be installed in order to be easily dismantled for maintenance.

Flanges and couplings shall be suitably placed to facilitate dismantling. These flanges and couplings shall be indicated on drawings, with the dimensions.

Tests:

- c. Pressure tanks and pipework shall be tested at a pressure at least 50% greater than the maximum operating pressure.
- d. Free-surface tanks and basins shall be tested for watertightness before painting. They shall be filled with water for 24 hours. The watertightness of the welds shall be tested with compressed air and a soapy solution, or by any other method approved by the Engineer.

1.2.5.2. TIGHTNESS OF WATER AND OIL CIRCUITS

All bearings, oil, water and air pipes, pumps and other associated apparatus shall be perfectly tight. No water, air, oil or grease leak shall take place. Any condensation and possible leakage shall be collected and drained off. The design shall be such that no oil splashes or vapour will reach electrical equipment.

1.2.5.3. COUPLINGS

Couplings between electric drive motors and the various types of driven equipment shall be of the semi-elastic type and shall have a service factor of 1.5.

1.2.5.4. BOLTS, NUTS, SCREWS

All bolts, nuts and screws in contact with water or in a damp atmosphere shall be made of corrosion-resisting materials. A pre plating treatment of 10-12 microns shall be applied to High Resistance Bolts subject to continuous or intermittent immersion in water. Particular care shall be taken to avoid contact corrosion. Threads under vibration shall be especially treated with special resins.

All shims to be used shall be protected from corrosion by cadmium plating, sherardisation or by any other process approved by the Engineer.

1.2.5.5. ANCHORING

For all anchoring, use of "fish-tail" systems is strictly prohibited.

1.2.5.6. SEALS FOR GATES AND VALVES

The Contractor shall pay particular attention to seal joints, especially in corners, so that a continuous line of contact is maintained. The seal corner joints shall be cast in one piece and vulcanised or glued to the lateral and frontal seals.

The seal backing plate holding bolts shall be of stainless steel. The bolt holes in the gate skin plate, the seals themselves and the backing plate shall be drilled in the workshop. If the gates are to be shipped dismantled, the seals shall be removed and packed separately.

All gate and valve seals shall be free of any defect. The seals must be made of synthetic rubber, non-reactive to contact with grease or hydrocarbons. The seals shall be designed to make field adjustment and maintenance easy.

The seals of the gates shall comply with the requirements given hereunder without any special devices having to be used. Local leaks and average leaks per linear metre of seal shall not exceed the following values:

- a. Local leaks: 0.25 litres per second;
- b. Average leaks: 0.10 litres per second per metre.

Valves seals shall be completely watertight.

1.2.5.7. HOLES FOR CONCRETING AND GROUTING

Holes of at least 200 mm in diameter shall be provided in the horizontal part or bottom of linings between stiffeners and welded seams, in order to concrete a surface area of approximately one square-metre. Hole-covers shall also be provided.

All holes in the hydraulic conduits for concreting and grouting purposes shall be fitted with screwed plugs and then seal welded in place, rendering the part watertight, and shall be carefully ground flush.

1.2.6. EMBEDDED PARTS AND LININGS

1.2.6.1. GENERAL

All embedded parts and linings shall be designed to withstand both the hydrostatic pressure at the point of installation as well as the grouting pressure.

The stiffeners of the vertical embedded parts shall be designed so as not to hinder the concreting carried out on site.

Sufficient quantities of tie bars and adjusting rods shall be provided. The latter shall be attached to the steel plates embedded in the primary concrete. The steel plates will be designed solely for adjusting the position of the corresponding embedded parts and shall under no circumstances be subjected to high loads nor shall they replace the anchorings embedded in the primary or secondary concrete. If, according to the design of the embedded parts, the Contractor supplies and installs steel sections to be embedded in the secondary concrete for adjustment of the embedded parts, then such sections shall not be less than 40 mm from the concrete surface facing.

All surfaces having contact with the seals as well as the sliding surfaces shall be made of corrosion resisting materials.

All corrosion resisting parts, whether intended for the sill, the side walls, etc. installed in the sluiceway shall be perfectly flush with the sluice profile. Any unevenness or level differences will be rejected.

For normal stiffening of vertical or horizontal embedded parts (except in the case of self-resisting embedded parts), the end of the stiffeners shall not, insofar as possible, cut the concrete in the form of "L" or "T" sections.

1.2.6.2. FIXED PARTS FOR GATES

In order to facilitate the introduction of gates into their slots, the top of the embedded parts making up the gate slot shall have a lead-in section which diverges 30° from the vertical. The frontal embedded parts shall comprise an upper section to ensure good contact with the transverse seals when the gate arrives in the closed position.

1.2.6.3. LININGS

The welds joining the steel plates together and joining the steel plates to the corrosion resisting steel sliding surfaces located in the sluices shall be very carefully ground flush and refilled if necessary, so that there are no cracks, protrusions nor misalignments.

All welds shall be continuous, solid and watertight. They shall all be subjected to crack detection tests:

- a. Crack detection tests along 100% of the joints between liners;
- b. Crack detection tests for 20% of all other welds.

No indentations or protrusions over 1.5 mm in depth or height, or with a slope greater than 3° shall be permitted on any part of the sluices surface.

1.2.6.4. LOADING CONDITIONS

1.2.6.4.1. *Water loads*

Water loads shall be considered as follows:

- 10 kN/m³ for clean water
- 11 kN/m³ for sewage water

1.2.6.4.2. *Allowance shall be made for the following loads:*

- a. Weights, buoyancy, hydrodynamic loads and loads generated by gates, valves and penstocks movements (such as friction forces);
- b. Loads generated by the guiding systems;
- c. Loads generated by the obstruction of trash racks.

1.2.6.4.3. *Earthquakes:*

The Contractor shall design structures according to local seismic rules and data, submitted to the approval of the Engineer.

1.2.6.4.4. *Hydraulic transient*

The pressure surges generated by the closure of valves and gates shall be taken into account. The maximum amplitude of the pressure surge to be taken into account is specified in the corresponding section.

1.2.6.4.5. Load combination

Each of the following conditions shall be considered for normal loading of gates.

a. Gate or valve closed:

The effect of the following loads shall be combined:

- Hydrostatic load corresponding to the water level acting on the gate or valve, no water on the opposite side;
- Dead weight of the gate and hoist connecting rods bearing on the gate, reaction forces acting on the supports;

b. Gate or valve being closed or opened at any point of travel:

The effects of the following loads shall be taken into account:

- Weight of the gate (included weight of any other gate-mounted equipment, ballast,...);
- Weight of hoist connecting rods bearing on the gate;
- Hydrostatic load corresponding to the piezometric level acting on both sides of the gate or valve;
- Hydrodynamic loads corresponding to flow conditions;
- Rated hoist pull, rated thrust (if any) or required control load acting on the gate;
- All load components caused by seal friction, guide loading, friction of pistons and pins of cylinders after a long inactive period and other effects;
- Additional friction and/or blocking forces in the guiding devices and against the seals.

1.2.6.5. ALLOWABLE STRESSES

Gate: unless otherwise specifically indicated for a type of structure or equipment, allowance shall be made for the following values: - DIN standard 19704. Chapter 7 or equivalent.

1.2.6.6. BUCKLING OF CYLINDRICAL PARTS, CONDUITS, PENSTOCKS

The factor of safety against buckling for cylindrical parts shall be as specified in the CECT design code.

1.2.6.7. LOADS ON SUPPORTS, ANCHORS AND CONCRETE

The Contractor shall furnish the values of the loads applied by the equipment on the supports and anchors.

The allowable compression stress applied on the concrete shall meet DIN 19704/4114 standards or equivalent.

1.2.6.8. PERMISSIBLE TOLERANCES ON GATES AND FITTINGS

(Any tolerances specified in the subsequent sections have priority over these tolerances).

Tolerances shall be as follows:

1. For all stainless sealing strips: sills, lateral risers and frontal cross pieces: In the longitudinal and transverse directions:
 - a) local flatness: 0.5 mm over 100 mm
 - b) general flatness: 1 mm
 - c) general straightness: 1 mm
2. On the standard lining panels:

Along the height and width of the sluice:

 - a) local flatness: 1.5 mm over 500 mm
 - b) general flatness: 2 mm
 - c) general straightness: 2 mm

Along the length of the lining panels:

 - a) general straightness: 2 mm

The general flatness condition shall apply to the lining panels after on-site welding, i.e. along the whole length of a given side wall.

Between the lateral stainless steel sealing strips:

1. Parallelism (between sealing strips): 2 mm.
2. Perpendicularity (of each sealing strip to the sill): 1 mm.

All tolerances shall allow a good operation of the equipment. All tolerances not in agreement with above specified values shall be submitted to the Engineer's approval.

oOo

SECTION 01030

BASIC ELECTRICAL REQUIREMENTS

1. GENERAL

1.1. WORK INCLUDED

This contract includes the supply and the installation of all the electric equipment as well as all the electric works allowing to assure the smooth running of the Water-treatment plant Aeratsia.

Electrical works include arranging both main and a spare power supply for the wastewater treatment plant.

1.1.1. REQUIRED POWER FOR WWTP

Electrical power is needed in Aeratsia WWTP for operating equipment and for lighting. The required power is inventoried based on four geographic zones on the site plan.

- Decanted Water Area (110) & Transformer Building (400).
- Screening Areas (101 & 102), Well Water (110) & Electrical Room (402).
- Grit and Grease Removal Tank (103), Primary Settling Tank (105) & Odor Control (300).
- Sludge Building (200) & Outlet Chamber (107).

The power estimates are detailed for each component within each area and are summarized in the following three tables.

Tabl. 1 - Power Requirements for Decanted Water Area (110) & Transformer Building (400) areas

Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
110 - Well Water	Surpression Pump	N	5			6.25
	Surpression Pump	N	5			6.25
400 – Transformer Building	Air Conditionning Unit	N	1			1
	Air Conditionning Unit	N	1			1
Miscellaneous	Outdoor Lighting	N	1			1
	Building Lighting	N	1			1
	Building Electrical Outlets	N	3			3
Total Normally Used			17			19.5
Total Stand by Used						
Total Futur Equipment						

Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
Total Installed			17			19.5

Note: (N: Normal Use, SB: Stand-by, FE: Future Equipment)

The electrical power required for the Decanted Water Area (110) & Transformer Building (400) areas is estimated at 20 kVA.

Tabl. 2 - Power Requirements for Screening Areas (101 & 102), Well Water (110) & Electrical Room (402) areas

Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
101 – Coarse Screening	Coarse Screen	N	0.55			0.69
	Coarse Screen	N	0.55			0.69
	Coarse Screen	FE			0.55	0.69
	Belt Conveyor	N	2.2			2.75
	Heat Tracing	N	0.3			0.3
102 – Fine Screening	Fine Screen	N	0.55			0.69
	Fine Screen	N	0.55			0.69
	Fine Screen	N	0.55			0.69
	Fine Screen	FE			0.55	0.69
	Screw Conveyor / Compactor	N	1.5			1.88
	Air Compressor	N	2.2			2.75
	Submersible Pump Drainage	N	0.75			0.94
110 - Well Water	Existing Artesian Well Pump	N	45			56.25
402 – Electrical Room	Air Conditionning Unit	N	1			1
Miscellaneous	Outdoor Lighting	N	2			2
	Building Lighting	N	1			1
	Building Electrical Outlets	N	3			3
Total Normally Used			61.70			
Total Stand by Used						
Total Installed			61.70		1.10	76.70

Note: (N: Normal Use, SB: Stand-by, FE: Future Equipment)

The electrical power required for the Screening Areas (101 & 102), Well Water (110) & Electrical Room (402) areas is estimated at 77 kVA.

Tabl. 3 - Power Requirements in the Grit and Grease Removal Tank (103), Primary Settling Tank (105) & Odor Control (300) areas

Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
103 - Grit & Grease Removal Tank	Grit Pump	N	2.4			3
	Grit Pump	N	2.4			3
	Submerged Air Turbine (x8)	N	27.2			34
	Submerged Air Turbine (x8)	N	27.2			34

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Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
	Submerged Air Turbine (x8)	N	27.2			34
	Submerged Air Turbine (x8)	N	27.2			34
	Air Lift Compressor	N	3			3.75
	Air Lift Compressor	N	3			3.75
	Travelling Bridge	N	0.5			0.63
	Travelling Bridge	N	0.5			0.63
	Surface Scraper	N	0.18			0.23
	Surface Scraper	N	0.18			0.23
	Surface Scraper	N	0.18			0.23
	Surface Scraper	N	0.18			0.23
	Grit Classifier	N	0.75			0.94
	Grit Classifier	N	0.75			0.94
	Grit Classifier	SB		0.75		
	Drain Sump Pump	N	11.8			14.75
	Drain Sump Pump	SB		11.8		
	Grit Tank Heat Tracing	N	0.3			0.3
	Grit Tank Heat Tracing	N	0.3			0.3
	Grease Tough Heat Tracing	N	0.3			0.3
	Grease Tough Heat Tracing	N	0.3			0.3
	Grease Tough Heat Tracing	N	0.3			0.3
	Grease Tough Heat Tracing	N	0.3			0.3
	Pump Room Electro-heating	N	3			3.75
	Pump Room Exhaust Ventilation	N	2.2			2.75
105 - Pr Settling Tanks	Pickets Fence	N	3			3.75
	Pickets Fence	N	3			3.75
	Pickets Fence	N	3			3.75
	Pickets Fence	N	3			3.75
	Air Compressor	N	1.5			1.88
	Immersed Mixer	N	4			5
	Immersed Mixer	N	4			5
	Progressing Cavity Pump	N	7.5			9.38
	Progressing Cavity Pump	N	7.5			9.38
	Progressing Cavity Pump	N	7.5			9.38
	Progressing Cavity Pump	FE			7.5	9.38
	Submersible Pump for Gallery Sump	N	1			1.25
	Heat Tracing Sedimentation	N	0.3			0.3
	Heat Tracing Sedimentation	N	0.3			0.3
	Heat Tracing Sedimentation	N	0.3			0.3
	Heat Tracing Sedimentation	N	0.3			0.3
	Pump Gallery Electroheating	N	6			7.5
	Pump Gallery Electroheating	N	6			7.5
	Pump Gallery Exhaust Ventilation	N	8			10
105 – Decanted Water	Decanted Water Pump	N	7.5			9.4
	Decanted Water Pump	N	1.5			1.88
300 – Odor Control	2 Speed Fan Unit	N	4			5
	Heater	N	12			15

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Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
	Heat Tracing Biofilter	N	0.5			0.5
Miscellaneous	Outdoor Lighting	N	3			3
	Building Lighting	N	2			2
	Building Electrical Outlets	N	6			6
Total Normally Used			244.32			
Total Stand by Used				12.55		
Total Installed			244.32	12.55	7.5	312.24

Note: (N: Normal Use, SB: Stand-by; FE: Future Equipment)

Electrical power required for the Grit and Grease Removal Tank (103), Primary Settling Tank (105) & Odor Control (300) areas is estimated at 312 kVA.

Tabl. 4 - Power Requirements in the Sludge Building (200) & Outlet Chamber (107) areas

Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
200 – Sludge Building	Air Condionning Unit	N	1			1
	Exhaust Ventilation	N	10			12.5
	Exhaust Ventilation	N	10			12.5
	Solids Handling Room Electroheating	N	6			7.5
	Solids Handling Room Electroheating	N	6			7.5
	Solids Handling Room Electroheating	N	6			7.5
	Solids Handling Room Electroheating	N	6			7.5
	Solids Handling Room Electroheating	N	6			7.5
201 - Sludge Conditioning	Polymer Preparation Package	N	6.88			8.6
	Surpression Pump	N	2.2			2.75
	Motorized Valve	N	0.15			0.15
	Motorized Valve	N	0.15			0.15
	Motorized Valve	N	0.15			0.15
	Motorized Valve	FE			0.15	0.15
202 - Sludge Dewatering	Dewatering Unit	N	18.75			23.45
	Dewatering Unit	N	18.75			23.45
	Dewatering Unit	N	18.75			23.45
	Dewatering Unit	FE			18.75	23.45
203 - Sludge Liming	Dust Filter	N	0.2			0.25
	Dust Filter	N	0.2			0.25
	Dust Filter	N	0.2			0.25
	Arch Breaker	N	0.55			0.69
	Arch Breaker	N	0.55			0.69
	Arch Breaker	N	0.55			0.69
	Screw Dosing	N	1.1			1.38

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Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
	Screw Dosing	N	1.1			1.38
	Screw Dosing	N	1.1			1.38
	Screw Dosing	FE			1.1	1.38
	Conveyor	N	1.1			1.38
	Conveyor	N	2.2			2.76
	Conveyor	N	1.1			1.38
	Conveyor	FE			1.1	1.38
	Screw Injector	N	0.75			0.94
	Screw Injector	N	0.75			0.94
	Screw Injector	N	0.75			0.94
	Screw Injector	FE			0.75	0.94
	Sludge-lime Mixer	N	2.2			2.76
	Sludge-lime Mixer	N	2.2			2.76
	Sludge-lime Mixer	N	2.2			2.76
	Sludge-lime Mixer	FE			2.2	2.76
	Screw Conveyor	N	15			18.75
	Screw Conveyor	N	15			18.75
	Belt Conveyor	N		2.2		2.76
	Liming Room Electroheating	N	6			7.5
	Liming Room Electroheating	N	6			7.5
204 – Sludge Storage	Heat Tracing	N	0.3			0.3
205 – Sludge Building for Water Pit	Immersed Pump	N	10			12.5
	Immersed Pump	SB		10		
206 – Odor Control Sludge Building	2 Speed Fan Unit	N	11			13.75
Miscellaneous	Outdoor Lighting	N	2			2
	Building Lighting	N	3			3
	Building Electrical Outlets	N	6			6
107 – Outlet Chamber	Submersible Pump	N	0.5			0.63
Total Normally Used			219.28			
Total Stand by Used				10.0		
Total Futur Equipment					24.05	
Total Installed			214.88	12.2	24.05	291.45

Note: (N: Normal Use, SB: Stand-by; FE: Future Equipment)

Electrical power required for the Sludge Building (200) & Outlet Chamber (107) areas is estimated at 292 kVA.

Electrical power required for all areas is estimated at 701 kVA.

The power supply at existing substation is not sufficient to power the new installation. Therefore it is necessary to build of a new substation.

The new substation will be used to power all the new equipments. The existing substation spare capacity of 140 kVA could be used for the future Phase 2 Digestion.

The location of the new substation is projected near the odor treatment area, in the vicinity of the former grit tanks.

1.1.2. MEDIUM VOLTAGE LINE

The existing medium voltage will be extended, buried and deviated to power the new substation. A new buried medium voltage cable will be laid between the new substation and the existing substation . (See Electrical Cables Layout drawing)

All networks will be provided by the contractor (Trenches, cables, connections etc...). The Contractor will ensure the continuity of operation of the existing facilities during this work. A temporary generator will be required for the transition.

1.1.3. MAIN POWER SUBSTATIONS AND SWITHGEARS

1.1.3.1. NEW SUBSTATION

The contractor will have in is scope of works the supply of the equipment of MV and LV for the realization of a substation near the odor treatment area. (See Electrical Cables Layout drawing)

He will owe all the necessary works for the supply, the installation, the cabling and the connections of the following equipment:

- MV arrival cell.
- MV departure cell.
- MV metering Cell.
- MV general circuit breaker cell.
- Two cells protection transformer
- Two transformers 6kV/410V de 800 kVA.
- The low voltage general cupboard.
- Reactive power compensation capacitor.

1.1.3.2. NEW LV GENERAL CUPBOARD

The contractor will have in is scope of works the supply of the equipment for the realization of the Low-Voltage General Cupboard.

The Low-Voltage General Cupboard shall be installed in the electrical room in the transformer building (area 400) and power supply the Decanted Water Area (110) and Transformer Building (400).

The contractor will owe all the necessary works for the supply, the installation, the cabling and the connections of the departures listed in the table below:

Tabl. 5 - Low-Voltage General Cupboard supply of departure

Area	Departure	Number of Departures	Power (kW)	Calibre of the protection circuit-breaker (Ampere)
402	Screening divisional cupboard	1	63	4x100
103	Grit and Grease divisional cupboard	1	253	4x400
200	Sludge Building Divisional cupboard	1	249	4x400
110	Surpression Pump	2	5	3x16

Area	Departure	Number of Departures	Power (kW)	Calibre of the protection circuit-breaker (Ampere)
400	Air Conditionning Units	2	1	2x10
400	Outdoor Lighting	1	1	2x20
110	Building Lighting	1	0.5	2x10
110	Building Electrical Outlets	1	3	2x16
400	Building Lighting	1	0.5	2x10
400	Building Electrical Outlets	1	3	2x16
400	230Vac to Control Circuits	1	3	2x16

1.1.3.3. SCREENING DIVISIONAL CUPBOARD

The contractor will have in is scope of works the supply of the equipments for the realization of the Screening Divisional Cupboard.

The Screening Divisional Cupboard shall be installed in the electrical room (area 402) and power supply the Screening Areas (101 & 102), Well Water (110) and Electrical Room (402)

The contractor will owe all the necessary works for the supply, the installation, the cabling and the connections of the departures listed in the table below.

Tabl. 6 - Screening Divisional Cupboard

Building	Type	Number of Departures	Power (kW)	Calibre of the protection circuit-breaker (Ampere)
101 – Coarse Screening	Coarse Screen	2	0.55	3x10
	Belt Conveyor	1	2.2	3x10
	Motorized Sluice Gate	2	0.1	2x10
	Solenoid Valve	1	0.1	2x10
	Heat Treacing	1	0.3	2x10
102 – Fine Screening	Fine Screen	3	0.55	3x10
	Screw Conveyor / Compactor	1	1.5	3x10
	Motorized Sluice Gate	5	0.1	2x10
	Air Compressor	1	2.2	3x10
	Submersible Pump	1	0.75	3x10
110 – Well Water	Existing Artesian Well Pump	1	45	3x80
402 – Electrical Room	Air Conditionning Unit	1	1	2x10
	Uninterruptible Power Supply	1	1.5	2x10
	Building Lighting	1	1	2x10
	Building Electrical Outlets	1	3	2x16
	230Vac to Control Circuits	1	3	2x16
	Outdoor Lighting	1	2	2x20

1.1.3.4. GRIT AND GREASE DIVISIONAL CUPBOARD

The contractor will have in is scope of works the supply of the equipments for the realization of the Grit and Grease Divisional Cupboard.

The Grit and Grease Divisional Cupboard shall be installed in the Grit Pump room (area 103) and power supply the Grit and Grease Removal Tank (103), Primary Settling Tank (105) and Odor Control (300).

The contractor will owe all the necessary works for the supply, the installation, the cabling and the connections of the departures listed in the table below.

Tabl. 7 - Grit and Grease Divisional Cupboard

Building	Type	Number of Departures	Power (kW)	Calibre of the protection circuit-breaker (Ampere)
103 – Grit & Grease Removal Tank	Grit Pump	2	2.4	3x10
	Submerged Air Turbine	32	3.4	3x10
	Air Lift Compressor	2	3	3x10
	Travelling Bridge	2	0.5	3x10
	Surface Scraper	4	0.18	3x10
	Grit Classifier	3	0.75	3x10
	Submersible Pump	2	11.8	3x20
	Heat Tracing	2	0.3	2x10
	Grease Trough Heat Tracing	4	0.3	2x10
	Pump Room Electro-Heating	1	3	4x10
	Pump Room Exhaust Ventilation	1	2.2	2x10
	Uninterruptible Power Supply	1	1.5	2x10
	Building Lighting	2	1	2x10
	Building Electrical Outlets	2	3	2x16
	230Vac to Control Circuits	1	3	2x16
	Outdoor Lighting	1	3	2x20
105 - Primary Settling Tanks	Pickets Fence	4	3	3x10
	Air Compressor	1	1.5	3x10
	Immersed Mixer	2	4	3x10
	Progressing Cavity Pump	3	7.5	3x16
	Submersible Pump	1	1	3x10
	Sedimentation Heat Tracing	4	0.3	2x10
	Pump Gallery Electro-Heating	2	6	4x16
	Pump Gallery Exhaust Ventilation	1	8	4x16
	Motorized Sluice Gate	2	0.1	2x10
105 - Decanted Water Service	Sludge Dewatering Pump	1	7.5	3x16
	Odor Treatment Pump	1	1.5	3x10
300 – Odor Control	2 Speed Fan	1	4	4x10
	Heater	1	12	4x20
	Heat Tracing	1	0.5	2x10

1.1.3.5. SLUDGE BUILDING DIVISIONAL CUPBOARD

The contractor will have in is scope of works the supply of the equipments for the realization of the Sludge Building Divisional Cupboard.

The Sludge Building Divisional Cupboard shall be installed in the electrical room in the Sludge Building (area 200) and power supply the Sludge Building (200) and Outlet Chamber (107).

The contractor will owe all the necessary works for the supply, the installation, the cabling and the connections of the departures listed in the table below.

Tabl. 8 - Sludge Building Divisional Cupboard

Building	Type	Number of Departures	Power (kW)	Calibre of the protection circuit-breaker (Ampere)
200 – Sludge Building	Air Conditionning Unit	1	1	2x10

Building	Type	Number of Departures	Power (kW)	Calibre of the protection circuit-breaker (Ampere)
	Exhaust Ventilation	2	10	4x20
	Solids Handling room Electroheating	5	6	4x16
	Uninterruptible Power Supply	1	1.5	2x10
	230Vac to Control Circuits	1	3	2x16
	Building Lighting	2	1.5	2x10
	Building Electrical Outlets	2	3	2x16
	Outdoor Lighting	1	2	2x20
201 - Sludge Conditioning	Polymer Preparation Package	1	7	4x16
	Surpression Pump	1	2.2	3x10
	Motorized Valve	3	0.15	2x10
202 - Sludge Dewatering	Dewatering Unit	3	18.75	4x32
203 - Sludge Liming	Dust Filter	3	0.2	3x10
	Arch Breaker	3	0.55	3x10
	Screw Dosing	3	0.75	3x10
	Conveyor	2	1.1	3x10
	Conveyor	1	2.2	3x10
	Screw Injector	3	0.75	3x10
	Sludge-lime Mixer	3	2.2	3x10
	Screw Conveyor	2	15	3x32
	Belt Conveyor	1	2.2	3x10
	Liming Room Electro-Heating	2	6	4x16
204 – Sludge Storage	Heat Tracing	1	0.3	2x10
205 – Sludge Building Foul Water Pit	Submerged Pump	2	10	3x16
206 – Odor Control	2 Speed Fan	1	11	4x16
107 – Outlet Chamber	Submersible Pump	1	0.5	3x10

1.1.4. ELECTRICAL WORKS

The contractor will have in is scope of works the supply of the others equipments for the realization of the lighting system, of the low power installations, of the building service, of the lighthning protection system, of the heating system, of the ventilation system, of the air conditionning system, of the telephone system and of the other electrical needs.

The contractor will owe all the necessary works for the supply, the installation, the cabling and the connections of the equipments of this systems.

The contractor will owe all the necessary works for the cabling and the connections of all the equipments of the process; of the monitoring (instrumentation) and of the control systems.

2. ELECTRICAL PLANT

2.1. APPLICABILITY

The following clauses specify the general requirements for the electrical equipment. General specification clauses shall apply except where specifically redefined elsewhere in the Specification.

2.2. POWER TRANSFORMERS GENERAL

1. Power transformers shall comply with IEC 76 unless otherwise specified. They shall be suitable for General use on a three-phase system.
2. The materials used and the method of construction shall be of the first class quality and shall be such as to ensure optimum performance and uniform temperature throughout the transformer.
3. In the design of the transformer, special attention shall be paid to reduce noise level to a minimum.
4. Each transformer shall be provided with a main frame earthing terminal which shall be separate from the neutral terminal of a star connected winding.

Where the neutral of a star connected winding is to be separately connected to earth, an insulated neutral connection shall be brought out via a separate neutral chamber having provision for housing one or more current transformers for earth fault protection. A removable cover shall permit access to the current transformers and their secondary wiring.

5. Main cable terminations shall be provided to suit the type of cable used.

Cable boxes shall be fitted with cable glands and all fittings necessary to terminate the cable and cores.

The boxes shall provide sufficient space for segregating the cores and maintaining the minimum insulation clearance and creepage distances applicable.

Cable boxes to accommodate low voltage (up to 1 000 volts) PVC or XLPE insulated cables shall be air insulated, designed to exclude direct ingress of moisture and dirt.

For voltages above 1 000 volts, cable boxes to accommodate XLPE insulated cables shall be air insulated, totally enclosed and sealed to exclude moisture and dust.

6. Auxiliary wiring from current transformers, Buchholz relays, winding temperature indicators, pressure switches, etc., shall be marshalled to a separate termination chamber with separate access cover. The terminal boards or blocks shall be as specified for switchboard components. Removable, undrilled cable gland plates shall be provided.

2.3. OIL FILLED TRANSFORMERS

1. Oil filled transformers shall be suitable for outdoor service and arranged for natural air cooling (Type ONAN) and shall comply with the specification for power transformers.
2. Constructional steelwork shall be shot blasted or chemically pickled internally and externally and shall be thoroughly descaled and degreased before being given the first coat of a comprehensive painting process which shall, for the interior, be of paint or varnish able to resist the action of oil. The exterior shall be primed with one coat of zinc-enriched paint followed by two undercoats of contrasting colour followed by one top coat of durable, oil resisting and weather resisting paint.
3. Main connections shall be brought out through oil-tight bushings into their respective connecting chambers and shall be provided with disconnecting links to facilitate cable testing and complete removal of the connecting chamber from the transformer without the necessity of breaking the cable termination.
4. Each transformer shall be delivered filled with oil.

5. Temperature sensing devices shall operate a dial type indicator with a red line showing maximum permissible operating temperature. The indicator shall incorporate adjustable alarm and trip contacts to operate on excess temperatures.

Silica-gel breathers shall be fitted with indicators and shall be conveniently located for regular inspection and ease of silica-gel renewal.

Buchholz relays shall have their gas sampling cocks conveniently placed for operation from ground level.

2.4. TAP-CHANGERS

Off-circuit tap-changers shall comply with IEC 76-4, unless otherwise specified.

Tapping on HV side (%) shall be: ± 2.5 , ± 5 .

Tap-changers shall be delivered filled with oil.

2.5. ENCLOSURES FOR ELECTRICAL POWER APPARATUS

1. Enclosures shall be fabricated from sheet Electrical Power steel of adequate thickness, suitably braced to form a rigid structure. The thickness of medium voltage boards and low voltage boards shall be 2 mm as a minimum. Exterior corners and edges shall be rounded to give a smooth overall appearance. Designs involving the use of externally visible assembly bolts and screws or rivets will not be acceptable.

Enclosures mounted indoors and outdoors shall provide a degree of protection not less than IP54 to IEC 529 unless otherwise specified. The design of the enclosures shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Cable entries shall be closed and made vermin proof.

Unless otherwise specified, enclosures shall be suitable for floor mounting.

Where wall mounting enclosures are provided, the fixing details shall preferably comprise externally welded brackets but internal fixing arrangements will be acceptable provided that they prevent ingress of moisture. With either arrangement, the rear of the enclosure shall be not less than 10 mm from the wall.

Lifting eyebolts shall be removed after installation and replaced by bolts.

2. Enclosures shall be pleasing in appearance, extensible, and symmetrically arranged as far as possible with projections kept to a minimum.

Where two or more enclosures are fitted together, they shall form a flush fronted continuous suite of uniform height. Instruments, relays, and control devices shall not be mounted at a height greater than 2 000 mm nor less than 300 mm from floor level.

All individual components of equipment associated with a single item of plant shall be contained in a single enclosure. Where a number of plant items are in close proximity, the use of individual enclosures shall be avoided and composite enclosures shall be provided. Enclosures for multi-circuit switchboards shall be subdivided into single circuit compartments. Compartments shall be segregated by rigidly braced steel sheets and screens arranged so that, in the event of internal fault conditions, the fault damage is entirely confined to the faulted compartment.

3. The arrangement of the equipment within each enclosure shall be such that all normal maintenance can be carried out from the front through a hinged door. Composite enclosures shall be provided with a hinged access door for each compartment.

Enclosures containing switchgear and motor control gear shall be fitted with hinged front access doors to each compartment and, where rear access is available, bolted removable covers or hinged access doors at the rear.

Enclosures not requiring front access doors shall be fitted with hinged access doors at the rear.

Access doors shall have a flush appearance, and shall be fitted with locks or lockable handles. Front access doors shall be of rigid construction and free from distortion when equipment is mounted and supported on the door. Rear access doors shall have lift-off hinges arranged so that one shank engages before the other to permit ease of fitting. No instruments, relays or other equipment shall be mounted on rear access doors or removable covers.

4. Panels and cubicles shall be provided with earthing arrangements.

On single cubicles, an earth stud shall be provided.

Multi-panel switchboards or composite enclosures comprising a suite of individual sections or cubicles shall incorporate a continuous earth busbar.

The earth busbar shall extend to all panel/cubicle sections. All panels and individual sections/cubicles shall be earthed by direct connections to the earthing busbar, which shall also include extensions and terminations for the earthing of the metal cladding and armouring of all incoming and outgoing power cables.

On equipment having only front access, the main earth busbar shall be internally mounted but readily accessible.

The earth busbar shall incorporate an external terminal assembly for the connection of a copper tape or cable from the station earthing system.

A positive earthing conductor and termination shall be provided on all enclosure doors on which electrical equipment is mounted.

The short-time rating of the earth busbar and connections shall be not less than that of the associated switchgear equipment, or the maximum through-fault current of the power source, and under fault conditions, the temperature rise of the busbar and connections shall not cause damage to the connections or any equipment to which they may be connected.

For main distribution and plant control switchboards the cross-sectional area of the earth busbar and connections shall be not less than 25 x 3 mm.

No earth terminal bolts or studs shall be less than 8 mm diameter.

5. Panels and cubicles shall be provided with anti-condensation heaters.

2.6. BUSBAR AND PRIMARY CONNECTIONS

Busbars and primary connections shall be of electrolytic copper and shall be rated for continuous operation. The mechanical and dielectric strengths of busbar and connection insulators and supports shall be able to withstand the worst conditions of electrical surge which can occur on the installation, for any system fault condition internal and external to the switchboard.

Busbars and primary connections shall be housed in air-insulated enclosures which shall be arranged such that no direct access to or contact with live conductors is possible via slots or apertures.

All bars and contacts shall be coated with tin or any suitable paint resistant to hydrogen sulphide. Suitable baffles shall be provided to prevent the accidental entry of tools, etc., whilst maintenance work is being carried out in the vicinity of the chambers which shall be fitted with suitable warning labels.

The busbar shall be divided for both high voltage and medium voltage to provide maximum security and easy maintenance.

The busbars and primary connections shall have a short-time rating of not less than that of the associated switchgear.

All busbars, primary connections and power circuit conductors and wiring shall be colour coded.

Phase sequence indicator shall be provided at the main feeders.

2.7. CABLE TERMINATIONS AND CABLE BOXES

1. On multi-circuit switchboards and control panels, the power and control cables shall be glanded and terminated directly to the panel/circuit or compartment concerned.

The cable boxes or gland plates for individual circuits shall be designed and located to permit the termination of the circuit cable without impeding access to the cable terminations of other circuits or sections of the switchboard.

The use of common cable termination compartments on multi-circuit and low voltage switchboards will be approved only when the equipment location or mounting arrangement impedes direct access to individual circuits.

Common cable termination compartments shall be complete with cable core terminations, with permanent wiring or cable riser connections to the individual circuits. Cable gland plates shall be arranged or split to permit the independent termination of individual circuit cables.

Cable gland plates and/or supports for cable sealing boxes shall be provided and positioned to provide a minimum gland height of 250 mm from the surrounding floor level.

2. Cable boxes to accommodate PVC or XLPE insulated cables for voltages up to 1 000 volts shall be air insulated and designed to exclude direct ingress of moisture and dust.

For voltages above 1 000 volts, cable boxes to accommodate XLPE insulated cables shall be air insulated, totally enclosed and sealed to exclude moisture and dust.

Cable termination methods shall be as specified.

Cable boxes shall be fitted with cable glands and all fittings necessary to terminate the cable cores.

The boxes shall provide sufficient space for segregating cores and maintaining the minimum insulation clearances and creepage distances applicable.

2.8. CIRCUIT BREAKERS – GENERAL

1. Circuit breakers for indoor installation on systems having a nominal voltage up to 15 kV shall be of the air, vacuum, or sulphur hexafluoride (SF₆) filled type and, unless otherwise specified, shall be of the withdrawable pattern incorporated in metal-clad switchgear.

Circuit breakers for installation on systems having a nominal voltage up to 36 kV shall be of the minimum vacuum or SF₆ pattern.

Circuit breakers shall be capable of interrupting all faults up to their maximum rating without damage to equipment or danger to personnel.

Test evidence of the normal current rating, and certification by an independent switchgear testing authority of the symmetrical breaking capacity of circuit breakers shall be submitted when required.

Isolating facilities shall be provided for all circuit breakers. Means shall also be provided for testing the normal operation of the circuit breaker when in the fully isolated position.

2. Circuit breaker operating mechanisms shall be of the following types:

- Independent manual spring.
- Hand-charged spring with manual release.
- Motor-charged spring with electrical release.
- Direct current (dc) solenoid.

All operating mechanisms shall be trip-free and shall have mechanical “ON” and “OFF” indicators and a manual trip device fitted with locking facilities. Hand charged and motor charged spring mechanisms shall have “SPRINGS CHARGED” and “SPRINGS DISCHARGED” indicators.

Operating mechanisms of the hand-charged and motor-charged spring types shall be arranged so that release of the spring energy to close the circuit breaker can only be achieved by deliberate action. It shall not be possible for vibration or mechanical shocks to release the charged springs. Motor-charged spring mechanisms shall be arranged so that the charging is initiated automatically following a discharge and the necessary limit stops and switches for the automatic control of the charge once initiated, shall form an integral part of the mechanism. It shall be possible to hand-charge a motor-charged spring mechanism.

The closing solenoids of d.c. solenoid operated mechanisms shall be suitable for operation at a minimum of 80% of the nominal supply voltage, and shall not mal-operate or cause excessive vibration when energised at a voltage equal to that of the closing battery with the charger set at the maximum rate, or equal to that from a full wave rectified source designed for multiple simultaneous operation. Unless otherwise specified or agreed, this higher voltage shall be taken as 120% of the nominal supply voltage.

To facilitate maintenance and adjustment of contacts, it shall be possible to “slow-close” the circuit breaker, but this operation shall only be possible in the fully isolated position. Any necessary operating handle or lever shall be supplied.

3. Circuit breakers shall be provided with interlocks to ensure that:

- The breaker shall be open before operation of the circuit isolation device is possible.
- The breaker cannot be closed until the circuit isolation device has been fully operated.
- The breaker cannot be closed in the service position without completing the auxiliary circuits.
- The breaker cannot be “slow-closed” except in the fully isolated position.
- With hand charged or motor charged spring mechanisms, the springs cannot be discharged until they have been fully charged and until the means for charging has been removed or disconnected.

Where key interlocking (Castell or similar) is employed, tripping of a closed circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism.

4. A set of safety shutters shall be provided on indoor metal-clad switchgear to cover each three-phase group of stationary isolating contacts. The shutters shall be opened automatically by a positive drive from the circuit breaker moving portion and when closed shall prevent access to the stationary isolating contacts. When the circuit breaker is withdrawn, each set shall be capable of being individually operated and of being padlocked in the closed position.

To facilitate high voltage and current injection testing via the isolating contacts, a device shall be provided for fixing (not locking) the shutters in the ‘open’ position and for releasing them into the ‘closed’ position. The device shall be arranged to be cancelled by the circuit breaker moving portion to ensure the restoration of the automatic features of the shutters.

Busbar shutters shall be coloured red and labelled “BUSBARS” in large white letters. Shutters in bus-section units shall be coloured red and shall be labelled with a large white arrow pointing in the direction of the section of busbars to which the isolating contacts are connected.

5. Indoor circuit breaker moving portions shall be fitted with positive guides so as to ensure correct alignment of the isolating contacts.
6. Indoor high voltage circuit breakers shall be provided with circuit and/or busbar earthing facilities. Circuit and busbar earthing shall be carried out through the circuit breaker and so arranged that the earthing operation is completed on closing the breaker by its normal local means of operation.

Selection of either circuit or busbar earthing shall only be possible after the circuit breaker has been fully isolated, and by means of a fully interlocked and labelled “SERVICE/EARTH” position selector which shall be designed to permit padlocking in any position.

Facilities shall be provided on all incoming feeder circuit breakers for earthing, the circuit side. On at least one circuit breaker panel in any section of busbar facilities shall be provided for busbar earthing. Where the switchboard incorporates a busbar sectionalising panel, this panel shall have the busbar earthing facility and it shall be possible to earth either section from this panel.

When the circuit breaker is connected to an earthing location, tripping shall only be effected by the manual device on the operating mechanism and automatic tripping shall be inhibited. The manual tripping device shall be capable of being locked to prevent unauthorised operation.

The mechanical interlocks on the breaker shall remain operative when the circuit breaker is in either earthing position.

7. Indoor fixed pattern high voltage circuit breakers shall be provided with three-phase test sockets on the circuit side for high voltage and current injection testing. Test sockets shall be provided with a hinged, lockable access cover which shall be mechanically interlocked to prevent it being opened until the circuit breaker has been opened and isolated.

2.9. HIGH VOLTAGE CIRCUIT BREAKERS

1. High voltage circuit breakers shall mean circuit breakers working at above 1 000 volts. They shall comply with the requirements given below.
2. Vacuum circuit breakers shall incorporate means of measuring contact wear in-situ without the necessity to dismantle the breaker or mechanism assembly.
3. SF6 circuit breakers shall be fitted with pressure switch contacts for remote initiation of a gas failure alarm. Easily accessible means shall be provided for refilling the breaker with dry SF6 gas at the correct operating pressure after carrying out maintenance.
4. Enclosures for high voltage switches-fuses shall be metal-clad conforming to IEC 298.

2.10. LOW VOLTAGE CIRCUIT BREAKERS

Low voltage circuit breakers (up to 1 000 volts) shall be of the air break horizontal withdrawable pattern.

Earthing facilities through the circuit breaker are not required.

2.11. LOW VOLTAGE CIRCUIT BREAKERS

Miniature circuit breakers (MCB's) and moulded case circuit breakers (MCCB's) shall comply with IEC 898 and IEC 947-2 and shall be fitted with thermal over-load and instantaneous magnetic short-circuit protection; this protection to be adjustable in frame sizes above 63 amps. Where earth leakage protection is specified, it shall be of the current operated type.

Current limiting fuses shall be fitted where necessary to provide the specified interrupting capacity. The ratings of MCB's and MCCB's shall be correctly coordinated with fuse ratings to achieve the necessary degree of discrimination. MCB's shall be rated in accordance with IEC 899.

MCCB's shall be operated by a toggle type handle and shall have a quick-make quick-break over-centre switching mechanism that is mechanically trip free from the handle so that the contacts cannot be held closed against abnormal currents. Tripping due to overload or short circuit shall be clearly indicated by the handle automatically assuming a position midway between the manual on and off positions. All latch surfaces shall be grounded and polished. All poles shall operate simultaneously.

MCCB's shall be completely enclosed in a moulded case. Non-interchangeable trip breakers shall have their covers sealed; interchangeable trip breakers shall have the trip unit sealed to prevent tampering. Ampere ratings shall be clearly visible. Contacts shall be of non-welding material. Arc extinction shall be accomplished by means of arc chutes, consisting of metal grids mounted on an insulating support.

The protective actions shall be so coordinated that overcurrents will be cleared by the thermal action; short circuits of relatively low magnitude will be cleared by the magnetic action; high fault currents above a pre-determined point will be cleared by the current limiting fuses. The current limiting fuses shall not be affected when the thermal and/or magnetic trip functions clear the circuit. Regardless of which tripping device serves to clear the circuit, all poles of the breaker shall simultaneously open automatically.

The breaker shall not be resettable until current limiting fuses which have functioned have been replaced by an identical or similar fuse and the cover refastened. The current limiting fuse shall have a visual means to determine which has operated and requires replacement when the cover is removed.

MCCB's used for motor protection shall provide instantaneous short circuit protection by means of a front adjustable magnetic element on each pole of the breaker. The adjustment button(s) shall have main setting points and mid-setting points following a linear scale so that each point has a significant value within calibration tolerances. Current limiting fuse may be incorporated into the circuit breaker where required, to cater for high interrupting currents.

All MCCB's shall be ambient temperature compensated. Compensation shall be accomplished to allow the breaker to carry rated current between 25°C and 50°C with tripping characteristics that are approximately the same throughout this temperature range.

2.12. CORROSION PROTECTION

High voltage switches shall mean switches operating above 1 000 volts. They shall conform to IEC 265-1 as general purpose switches category II with normal service conditions adjusted as specified. Switches shall have rated voltages, normal current, breaking capacity and making capacity suitable for the system and load circuit being switched, or as specified.

Closing and opening mechanisms shall be of stored energy pattern both manually charged and released or as an independent manual operation.

The assembly shall incorporate an earthing switch connected to the feeder cable side of the main switch. This shall comply generally with IEC 129 with a minimum continuous current rating of 200 amps and making capacity and short time current rating to suit the system, or as specified. The operating mechanism shall be independent manual for both closing and opening. Mechanical interlocks shall be provided to:

- Prevent closing of the earth switch unless the main switch is open.

- Prevent closing of the main switch unless the earth switch is open.

High voltage combinations of switches and fuses shall conform to IEC 420. The switches shall conform to IEC 265-1 except that the rated breaking current shall be seven times the rating of the largest size fuse in the combinations. The switch closing mechanism shall be independent manual and shall provide stored energy for opening mechanically by fuse-striker or by manual release.

High voltage fuses shall be cartridge type, current limiting with striker pins, conforming to IEC 282-1. Current ratings shall be as required for the circuit protection or as specified. Fuses shall be accommodated within an air insulated chamber, the access door or cover of which shall be interlocked so that it can only be opened if the main switch is open and the feeder connections are earthed. It shall not be possible to open the earth switch or close the main switch if the fuse access door/cover is open.

Earthing switches for high voltage switch-fuses shall earth the feeder cable side of the fuse and shall otherwise be as required for high voltage switch units.

2.13. AIR BREAK ISOLATORS AND FUSE SWITCHES

Air break isolators and fuse switches mounted indoors or incorporated in indoor metal-clad switchgear shall comply with IEC 947-3 and shall be of the “on-load” type.

Operating mechanisms shall be fitted with mechanical “ON/OFF” indicators. Operating handles shall be of semi-flush or telescopic pattern to reduce front projection to a minimum.

Fuses in fuse-switches shall be of the HRC cartridge type.

Isolators and fuse switches shall be provided with means of locking in the “OFF” position.

Access to outgoing terminals of isolators and fuse switches shall not expose live incoming supply terminals or contacts.

2.14. CONTACTOR TYPE MOTOR STARTERS

1. Contactor starters shall incorporate air break, SF6 or vacuum contactors. Contactors shall be selected to suit the particular duty and application but shall have a minimum standard of mechanical endurance of 3 million operations and electrical endurance of 150 000 on-load operations. The utilisation category and duty class shall be as specified.

Vacuum contactors shall be provided with means of measuring contact wear, and any necessary gauges or other measuring devices shall be provided.

Starters shall incorporate HRC fuses unless otherwise specified. These fuses may be incorporated in the starter isolator as a composite fuse switch assembly. Overcurrent and earth leakage protection shall be incorporated together with all necessary auxiliary relays, contactors, timers, auxiliary fuses, wiring and terminals. Control and indicating facilities shall be provided on each starter.

2. Low voltage starters up to 1 000 volts shall comply with IEC 9474-1 and shall incorporate contactors complying with IEC 947-4-1.

Low voltage starters shall incorporate a triple pole fully interlocked load breaking isolating switch capable of breaking the stalled motor current. Moulded case circuit breakers may be fitted, where specified.

Where low voltage starters incorporate moulded case circuit breakers, fault switching coordination between the circuit breakers and the contactors shall comply with IEC 947-4-1.

Isolators shall be provided with an external operating handle, mechanical “ON/OFF” indication and facilities for locking in the “OFF” position. Operating handles shall be of the telescopic or semi-flush pattern to reduce front projection to a minimum.

Starters shall be of the fixed or withdrawable pattern as specified. If withdrawable, facilities shall be provided for testing the starter control circuits and operation when withdrawn without the necessity for complete removal of the starter chassis.

Where control circuit supplies and interlock circuits are broken via plugs on withdrawal of the starter, at least one jumper lead and plug assembly of each size and type shall be provided to facilitate testing in the withdrawn (isolated) position.

Three-phase motor starters shall be complete with a triple pole hand reset thermal overload device with single phasing protection unless otherwise specified.

3. High voltage contactor starters above 1 000 volts shall incorporate contactor complying with IEC 470.

High voltage starters shall be of the fixed or withdrawable pattern as specified and shall incorporate facilities for earthing outgoing cables. Fixed pattern starters shall incorporate a fully interlocked triple pole off-load pattern isolator having three positions ‘CLOSED’/‘OPEN’/‘EARTHED’. Interlocks shall be provided to ensure off-load operation.

On withdrawable pattern starters, cable earthing shall be effected by means of a fully interlocked integral earthing switch arranged so that cables can only be earthed when the starter is withdrawn (isolated). Re-entry of the starter shall be prevented whilst the cables are earthed.

Means shall be provided to permit control circuit testing with the main isolator open.

2.15. SWITCHBOARD

1. All individual components of control equipment associated with any item of plant shall be contained in a single control cubicle or panel.

Instruments, relays, switches, lamps, pushbuttons and the like shall be arranged on the cubicle in a neat, functional and logical manner. Similar items shall be of the same type, style, pattern or appearance throughout.

Instruments, controls and relays mounted on different panel sections but having similar functions shall be located in a physically similar position.

2. All instruments, gauges and meters which perform similar duties shall be of uniform type and manufacture. They shall be flush pattern, dust and moisture proof suitable for the environment in which they are installed. Where hinged covers are necessary, they shall be provided with locks. Indicating instruments shall be of the dial or digital type fitted with zero adjuster externally accessible from the front, have no parallax error and normal maximum reading at approximately 60% full scale. Dials shall be white with black scales and lettering not subject to fading. Scales shall be of such material that no peeling or discolouration will take place with age under humid conditions.

Motor ammeters shall be capable of withstanding the starting current and shall have a compressed overload scale.

3. Unless otherwise specified, all control circuit supplies for contactor starters shall be obtained from a 110 volts 50 Hz integral control transformer contained in the starter cubicle. In the case of multi-motor and composite boards, one or more master control circuit transformers shall be provided for each section of busbars in the switchboard to feed a group of outgoing starters via bus wires in the board. Each control transformer

shall be busbar connected and shall be provided with isolation facilities, and primary and secondary MCB's.

Transformers shall be of the double wound pattern and shall be provided with earth screens between primary and secondary windings. One end of the secondary winding shall be earthed.

4. Indicating lamps on panels shall be rated to withstand not less than 10% continuous over-voltage. Alternatively lamps shall be transformer operated or of a low voltage with series dropping resistors. On DC operated lamp circuits, suitably rated resistors shall be connected across each lamp operating contact.

Lamps shall be well ventilated and the design shall permit removal of lamp glasses and bulbs from the front of the unit.

5. Electrically operated circuit breakers shall be fitted with control switches of the pistol grip type, with spring return to the "neutral" position, and with an interlock to prevent repetitive closing without moving first to the "trip" position. They shall be capable of being padlocked in the "neutral" or "trip" position.

Switches for control selection, motor control and other purposes shall have spade, tee or other approved shape handles.

6. Pushbuttons shall be coloured as follows:

- START - green.
- STOP - red.

"START" pushbuttons shall be effective only in selected circuits, primarily hand control circuits.

"STOP" pushbuttons for motors controlled by circuit breakers shall be arranged to trip the circuit breaker and shall have an additional contact to interrupt the breaker closing circuit.

7. Where practicable, all fine wire operating coils and wire wound resistors shall be vacuum impregnated with an approved insulating varnish.
8. Terminal boards or blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw. Pinch screw type terminal blocks will not be acceptable. The minimum size of terminal shall be suitable for a 4 mm conductor. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled, and the voltage grouping and terminal board layout shall correspond with the wiring diagrams. Where approved, barrier-pattern screw or stud-type terminal boards are used, covers of transparent insulating material, which does not sustain combustion, shall be provided.

Terminals which may be live when the main equipment is isolated from the mains supply shall be suitably labelled to reduce the risk of accidental contact. All terminals shall bear a permanent identification number or letter.

Terminal boards shall be located adjacent to the point of cable entry and adequate space shall be allowed for terminating the cable tails on site.

An extra 25% spare terminal shall be provided for terminating spare cable cores.

9. Fuses or MCB's and links shall be provided to enable any circuit to be isolated as necessary for maintenance and test purposes without isolating the whole panel. All fuses shall be of the HBC cartridge type. Fuse carriers and solid link carriers and bases shall be made of plastic moulded insulating material of an approved make. Ceramic materials will not be accepted. Accessible live connections shall be efficiently shrouded and it shall be possible to change fuses with the circuit live without danger of contact with live metal. The fuses shall be rated to give maximum protection to the apparatus in circuit and the rating shall be inscribed on the fuse label.

Earthing and neutral links in main supply circuits shall be of the solid copper bolted pattern.

Fuses or MCB's and links functionally associated with the same circuit shall be mounted side by side.

Descriptive circuit/function labels shall be mounted adjacent to all fuses or MCB's, the layout of which shall correspond to the wiring diagram.

10. Auxiliary switches shall be supplied as required for indication, protection, metering, control, interlocking and supervisory purposes. They shall be readily accessible and enclosed in a transparent dustproof cover. Adequate secondary disconnects shall be included where appropriate to enable the auxiliary switch to be wired to the fixed portion of the equipment.

Two normally open and two normally closed spare auxiliary contacts shall be provided and shall be wired to suitably identify spare terminals.

11. Where volt-free contacts are specified on any equipment, e.g. a circuit breaker or contactor starter, they shall comprise contacts operated directly by the equipment but electrically separate such that no potential derived from the equipment appears at the contacts. Volt-free contacts shall be used to complete external control, alarm or indication circuits, the supplies for these circuits being obtained from an external source.

Unless otherwise stated, these supplies will be from low voltage ac or dc sources and auxiliary isolating poles, e.g. on starter isolators, need not be provided.

12. Switchboard and panel wiring shall be carried out in 1 000 volts grade PVC insulated cable. Flexible wiring shall be 600 volts grade.

Wiring shall be carried out in a neat and systematic manner and securely fixed by insulated cleats or other approved methods and arranged so that access to any apparatus or connection point is not impeded. Wiring installed in trunking shall have a space factor not greater than 50%.

Where wiring passes between compartments, the access hole shall be fitted with a suitable grommet.

Sleeve type identification ferrules shall be fitted on all wires at both ends. The numbers and letters used shall correspond with the appropriate wiring diagram and shall read from terminals outwards.

The wires shall not be joined or broken into between terminal points.

Terminations for screw or stud terminals shall be of the claw washer pattern or equal, or of the crimped-on-ring type, the latter being preferred. Terminations of stranded conductors to clamp type terminals shall be of the crimped-on solid rod type.

Wiring for future equipment shall be provided as far as possible and all wires shall be terminated.

Not more than one core of either internal or external wiring shall terminate on any outgoing terminal. Where duplication of terminal blocks is necessary, suitable solid bonding links shall be incorporated in the design of block selected.

13. Switchboard cubicles shall incorporate anti-condensation heaters. The heater circuits shall be energised from a single-phase supply obtained from an independent power source.

Individual floor mounting cubicles shall each be fitted with an anti-condensation heater together with a suitably positioned adjustable thermostat, rotary "ON/OFF" heater switch and MCCB protection.

Multi-tier type cubicles shall have a cubicle heater and thermostat for each vertical panel section except that multi-tier motor starters may have individual heaters controlled by a normally closed contact on the contactor auxiliary switch in place of the controlling thermostat.

14. Switchboard for outdoor installation shall be provided with suitable sunshade for protection against direct sunlight.

2.16. SWITCHBOARD SAFETY ARRANGEMENTS

Switchboards, control panels and all items of electrical control equipment shall be designed and constructed to provide a maximum standard of safety for all Operation and Maintenance procedures.

Multi-circuit switchboards shall be fully sectionalised and provided with dividing sheets and screens to give safe access to individual switchboard circuits, and to permit all normal Operation and Maintenance procedures to be carried out without interference to, or risk of accidental contact with live conductors or components of independent circuits within adjacent switchboard sections.

Access to circuit compartments or cubicles through hinged doors shall be inhibited by a positive interlocking arrangement, until the isolator or switching device feeding unscreened or exposed conductors or equipment terminals within the cubicle is switched to the “off” position.

Isolators, clearly labelled, shall be provided in such positions and connected so that maintenance can be carried out with maximum safety. This particularly applies to control circuits fed from a remote position. Where it is necessary to maintain certain components in a cubicle in a live condition when the isolator is in the “off” position such apparatus shall be screened and labelled to eliminate the possibility of accidents. Additionally, a system of removable insulated links or isolating type terminal blocks shall be provided to enable particular components to be isolated for maintenance purposes whilst retaining other essential circuits energised.

Terminals, connections, relays and other components which may be live when front access doors are open shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle when any door is opened.

Where several outgoing circuits occupy a common termination chamber, all copper work, cable lugs, terminations and terminal boards shall be fully screened or insulated to enable work on any one circuit to be carried out with other circuits live.

2.17. PROTECTION TRANSFORMERS

Protection and instrument transformers shall comply with the following:

1. Current transformers shall be of the bar primary pattern where practicable. Current transformers shall have a short-time current rating of not less than that of the switch panel in which they are incorporated. For bar primary current transformers, this rating shall be for a period of 3 seconds and for wound primary designs, the rating shall preferably be for a period of 3 seconds but may be reduced to not less than 0.5 second subject to the approval of the Engineer.

Current transformers for high voltage equipment shall be resin encapsulated, except that for bar primary designs with ring type cores mounted on resin insulated bushings, alternative secondary winding insulation will be accepted, provided that an earthed screen is introduced between the toroidal winding and the bushing and that the toroid is adequately clamped either to the bushing or to the main structure.

Where multi-ratio current transformers are supplied, a label shall be provided, clearly indicating the connections required for the alternative ratios. These connections shall also be shown on panel wiring diagrams.

Secondary winding currents shall be 1A or 5A.

Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels shall be fitted on the exterior or the mounting chambers suitably located to enable reading without the removal of any cover.

Current transformers for balanced earth fault protection shall be designed for a stability of not less than six times the rated primary current.

Current transformers for unit protection schemes shall be designed for a stability of not less than the maximum through fault current of the units.

Where attracted armature relays are employed, the spill current with maximum stability conditions shall not exceed one quarter of the operating current of the relay.

Magnetisation characteristics, calculated performance and protection setting shall be provided by the Contractor.

Current transformers for use in conjunction with a portable precision kWh meter shall be of class 0.2 accuracy. Other metering current transformers shall be of class 0.5 accuracy.

2. Voltage transformers (up to 1 000 volts) shall be supplied where test metering connections are required to terminate at test terminal blocks. They shall have a winding ratio to give a three-phase voltage between lines of 110 volts. They shall have a rated burden, at the stated accuracy, in accordance with the requirements of all connected instruments, meters and relays and of any instruments or meters to which they may be connected via test blocks.

The primary circuit shall be protected by HRC fuses having a short-circuit rating not less than that of the switchgear. The connections between the fuses and the switchgear primary conductors shall be of sufficient cross-section and be supported to withstand the short-circuit rating of the switchgear.

The secondary circuit shall be protected by HRC fuses mounted as closely as possible to the secondary terminals. The fuses shall have safe access for renewal without the necessity for complete isolation of the switchgear.

3. Voltage transformers on high voltage (1 000 volts and above) systems shall have a rated burden, at the stated accuracy, in accordance with the requirements of all instruments and meters to which they may be connected via test blocks. The windings shall be resin encapsulated. Voltage transformers for metal-clad switchgear shall be housed in naturally air-cooled, totally-enclosed sheet-steel enclosures which shall be of the isolatable pattern capable of being padlocked in the plugged-in position.

Safety shutters shall be provided to cover automatically the fixed isolating contacts when the transformer is isolated, the means shall be provided to padlock the shutters in the closed position. The shutters shall be coloured yellow, when the isolating contacts are connected to the feeder side of the circuit, and red, inscribed "BUSBARS" in large white letters, when connected to the busbars side of the circuit.

Connections to the primary isolating contacts shall have a short-time rating equal to that of the switchgear and shall be capable of carrying 200 amps continuously.

The primary winding shall be connected through cartridge type fuses incorporating current limiting resistances. These fuses shall be removable only when the transformer is isolated. Secondary circuit fuses shall also be provided and shall be readily accessible for renewal.

2.18. PROTECTION RELAYS

Protection relays shall fully comply with the requirements of BS 142 or equivalent IEC.

Relays shall be contained in dustproof cases, shall be mounted on the front of the switchgear or relay panel. Auxiliary relays may be mounted within the panel but shall be accessible for

inspection and wiring. Plug-in pattern relays shall have a positive means for retaining them in the service position.

Relay contacts shall be capable of making and breaking the maximum current which can occur in the circuit they control. Contacts for remote alarms and indications shall be volt-free, hand reset type.

Operation indicators shall be fitted to tripping relays and such other protection relays or relay elements as will enable the type of fault condition to be identified. Indicators shall be capable of being reset without the relay case being opened.

2.19. EMERGENCY STOP PUSH BUTTONS

Emergency stop pushbuttons shall be provided and positioned in the immediate vicinity of the associated motor drive in all cases where:

1. there is no direct line of sight between the motor and the controlling starter; or
2. where the distance between the motor and the controlling starter exceeds 5 metres.

Emergency stop pushbuttons shall be connected in control circuits so that they are effective under all operating conditions and shall have red mushroom headed pushes of the stay-put pattern. A deliberate re-set action shall be required before the drive can be put back into service and resetting of the pushbutton shall not restart the drive.

Where a “start/stop” pushbutton controlling station is specified, local to the motor drive the emergency stop pushbutton shall be integral with the local controlling station.

2.20. DIRECT CURRENT SUPPLY SYSTEMS

Batteries shall be of the nickel-cadmium type having cells contained in heat resistant, transparent, high impact plastic containers. Cell containers shall be clearly marked to show the maximum and minimum levels of electrolyte, and shall be provided with vented filler plugs. Cells shall be numbered consecutively. Cell terminals shall be of robust construction and shall be permanently marked to show their polarity.

Battery trays shall be factory treated with an electrolyte corrosion resistant finish, e.g. plastic coating.

Battery chargers shall be of the solid state constant voltage type incorporating a self-protecting current limiting feature for protection against low battery volts and short circuits. Reverse battery protection shall also be provided.

Chargers shall be suitable for continuous operation in an ambient temperature of 50°C. Their output voltage regulation shall be not less than $\pm 2\%$ irrespective of ac mains input variations of $\pm 10\%$ for load variations from 0% to 100%.

Chargers shall be fitted with an “ON/OFF” switch, dc ammeter, and indicating lamps for “automatic charger” and “charger output failed”. In addition, volt-free changeover contacts shall be provided on relays to give remote indication of “charger supply failed” and “charger output failed”.

Battery and charger equipment shall be housed in well ventilated sheet steel enclosures having front access doors. The enclosure shall be designed to provide total segregation of the battery and charger equipment.

Direct current distribution boards shall be as specified for distribution boards except that suitably rated load breaking double pole switches with HBC fuses for the incoming and outgoing circuits shall be incorporated.

Distribution boards shall be fitted with relays for battery earth fault and battery voltage low, with local lamp or flag indication and volt-free contacts for remote indication. A dc ammeter and voltmeter shall also be fitted to the incoming equipment.

2.21. MOTORS

1. All electric motors shall comply with the requirements of IEC 34.

Constant speed alternating current motors shall be of the induction type suitable for operation on a three-phase supply and shall be capable of operating continuously, at rated torque, at any voltage between $\pm 10\%$ of the nominal value, and nominal frequency ± 2 Hz.

Direct current motors, which are to operate from batteries, shall be capable of operating under service conditions at any voltage between $\pm 10\%$ of the nominal value.

Motors operating from rectifier equipment shall meet the voltage and frequency conditions required for ac motors.

All motors shall, unless otherwise specified, be capable of running continuously at an output not less than 10% in excess of maximum power absorbed by the driven plant under any operating conditions.

2. Enclosures shall afford a degree of mechanical protection not less than IP54. Submersible motors shall meet the requirements of IP58. Motors for outdoor installation shall comply with protection class IPW 55.

Totally enclosed motors shall be provided with suitable means of breathing and drainage to prevent accumulation of condensation.

Motors for installation outdoors shall be provided with suitable covers for protection against direct sunlight.

3. Windings shall be impregnated to render them non-hygroscopic and oil resistant, and shall be braced to prevent any movement of the coils during all conditions of service.

Motors operating in an ambient temperature not exceeding 50°C shall be insulated to IEC 85, with the limits of temperature rise applicable to Class B insulation.

All motors shall, unless otherwise specified, be designed for direct-on-line starting, and 6 starts per hour, S4 switching duty to BS 4999 Part 101 or equivalent IEC at maximum site ambient temperature.

4. Bearings shall be plain or roller type as appropriate, vertical shafts having approved thrust and guide bearings.

Where necessary to prevent damage by any shaft currents which may be produced, the bearings and their lubricating and cooling systems shall be insulated from the bedplate or frame.

Bearings shall be sealed or self-lubricated and provided with readily accessible filler. Dial type bearing thermometers with adjustable alarm and cut-out contacts shall be provided for large motors.

5. Embedded temperature detectors for stator temperature measurement shall be provided on HV motors. All detectors shall have the same characteristics and instruments shall be provided with adjustable alarm and tripping contacts.

6. Anti-condensation heaters shall be provided on all motors above 40 kW. The heaters shall be suitable for use on a single phase ac supply and wired to a separate terminal box.
7. On slip-ring and commutator motors the brush gear shall be designed to operate without injurious sparking and with the minimum need for adjustment or replacement of brushes. Removable covers shall provide access to brush gear, slip-rings or commutator.
8. Terminal boxes shall be positioned to accept cables which rise vertically from below, or angled to accept cables without stress being introduced to the cable. Phase segregation shall be provided on power cable terminal boxes fitted to all high voltage motors.

All terminal boxes shall be provided with disconnecting links and be designed so that the cable box may be removed without the necessity of breaking the cable termination. Alternatively, pre-moulded cable connectors, with stress relief provisions for HV cables, may be employed provided that their use complies with the recommendations of the specialist manufacturer of such connectors.

2.22. STATIC INVERTERS

Inverters shall be solid state type and shall provide a single phase or 3-phase output as specified.

Inverters shall have the following characteristics:

- Maintain an output frequency constant within $\pm 1\%$ of nominal.
- An adjustable ac output voltage of $\pm 5\%$ at nominal dc input voltage.
- A maximum deviation of ac output voltage of $\pm 2\%$ over the entire ranges of load, dc voltage and power factor, whilst supplying a symmetrical load.
- Be capable of supplying unbalanced ac loads to an extent and at a voltage deviation referred to the line to line voltage which shall be stated by Contractor for 3-phase inverters.
- Be capable of continuous operation under the ambient temperature specified.
- A limited overload capacity.
- An in-built current limiting circuit to provide short circuit protection.
- An ac output filter to limit the total harmonic voltage distortion across linear loads to 5%, over the entire ranges of load, voltage and power factor.
- A dc input filter to ensure that the r.m.s. value of ac voltage does not exceed 5% of the dc voltage.
- A totally enclosed floor mounting sheet steel enclosure with front access doors.

2.23. FIXINGS AND FIXTURES

All nuts and bolts shall be threaded in accordance with ISO standards and fitted with 3 mm thick washers beneath bolt and nut.

All bolts, nuts, washers, except high tensile, for all ferrous parts shall be steel galvanised to ISO 1459-1460-1461 or equivalent, primed and painted hereof after assembly and tightening.

All bolts, nuts, washers and anchor plates, for fastening galvanised components or aluminium alloy components shall be of stainless steel Grade 316S16 to BS 970 or equivalent and shall remain unpainted. PTFE washers shall be fitted beneath stainless steel washers for bolt head and nut.

Holding down and anchor bolts, nuts, washers shall be galvanised steel to ISO 1459-1460-1461 or equivalent, and shall be painted after assembly and tightening.

Woodscrews shall be brass with round head or countersunk heads and single slotted for a standard screw driver.

Drilled anchor fixings for use on concrete structures shall be of a type approved by the Engineer's Representative.

All holes in concrete and civil works for anchor fixings or plugs for wood screws shall be made with a rotary drill.

Single shot cartridge tool fixings may be used only at the discretion of the Engineer.

3. CABLING AND EARTHING

3.1. APPLICABILITY

The following clauses specify the general requirements for the supply and installation of cabling and earthing systems. The general specification clauses shall apply where appropriate except where redefined elsewhere in the Specification.

3.2. POLARITY

Power cables shall be connected between main switchboards, distribution boards, plant and accessories so that the correct sequence of phase colours is preserved throughout the system.

Cable cores shall be identified with the phase colours corresponding to those used in the electrical plant. The use of different phases on a number of single phase circuits in one room shall be avoided wherever possible. If unavoidable, then the live cores shall be identified with their appropriate phase colour. When more than one single phase circuit live conductor of different phase polarity is terminated in a common multi-gang switch or other apparatus, that equipment shall be sub-divided by metal or insulating material screens to segregate the different phase circuits. Danger labels shall be provided and fixed adjacent to the terminal equipment to warn of the presence of different phases.

3.3. CABLES

Cables shall be delivered on robust cable drums with cable ends treated to form an effective seal. When a cable is cut from a drum, the cable end and the end left on the drum shall immediately be sealed in an approved manner to prevent the ingress of moisture.

Conductors shall be of high conductivity copper.

The Contractor shall ensure that each cable is of sufficient rating for its duty under both normal and possible fault conditions. In assessing the rating and cross section required for each cable, the following factors shall be taken into account:

1. fault level and duration;
2. ambient air and soil temperatures;
3. soil thermal resistivity;

4. voltage drop under steady state and transient conditions;
5. loading under steady state and transient conditions;
6. overcurrent settings of circuit breakers;
7. disposition of cables.

Cable referred to as PVCSWAPVC shall be PVC insulated and bedded single wire armoured cable with an overall PVC sheath. Non-magnetic armour of hard drawn aluminium shall be used on single core types.

Cables referred to as PVCPVC shall be PVC insulated and sheathed.

Power cables referred to as XLPESWAPVC shall be cross linked polyethylene insulated, single wire armoured cable with PVC overall sheath. Non-magnetic armour of hard drawn aluminium shall be used on single core types.

Cables referred to as MICV shall be copper sheathed cables, with powdered mineral insulation and copper conductors with a PVC outer sheath to IEC 702-1. MICV cables shall be 1000 V rating.

All buried cables shall incorporate a metal tape termite barrier with PVC outer sheathing.

3.4. CABLE TERMINATION AND JOINTING

3.4.1. CABLE TERMINATIONS

All PVCSWAPVC, PVCPVC and XLPESWAPVC cables shall be terminated with mechanical glands which shall be of a type to seal the cable against ingress of dirt and moisture and provide adequate mechanical support. Glands shall conform to BS 6121 or equivalent and shall have PVC shrouds and an earth tag at one cable end only.

Termination glands for armoured cables shall provide a positive armour clamp both for cable support and for a high level of earth continuity.

Encapsulated termination techniques, either heat shrink and/or pre-moulded, with stress relief provision for HV terminations, shall be employed for these cables.

All cable conductors shall be terminated in a suitable copper lug crimped or sweated.

Particular care shall be taken in the drying out and sealing of the ends of MICV cables and in the making of connections to boxes and fittings. The manufacturers' terminations shall be used throughout. MICV cable glands shall conform to IEC 702-2. Cable end seals shall be of the brass pot type.

The Contractor shall ensure that any special tools required for the installed MICV cable are made available to his operatives and that they understand and are competent in their use.

The ends of all cable shall be at all times temporarily sealed to prevent the ingress of moisture. When MICV cables are used in conjunction with equipment liable to vibrations, suitable terminal boxes shall be provided in the vicinity of such motors or equipment and the final interconnections shall be made by means of flexible cable or multi-strand wiring in flexible conduit.

Cable glands shall be protected by corrosion-resistant PVC hoods.

The cable termination and sealing equipment shall be obtained from the cable manufacturer, or other approved supplier, and shall be purpose-made for the type, size and grade of cable concerned. The application of these materials shall be strictly in accordance with the manufacturer's instructions.

3.4.2. UNDERGROUND CABLE JOINTS

The underground cable joints in power and auxiliary cable installations shall not be used unless specified.

Underground cable joints in power and auxiliary cable installations shall only be used (subject to the approval of the Engineer) in circumstances where cable route lengths exceed the maximum possible cable drum lengths.

All underground joints shall be by encapsulated jointing techniques.

Wherever it is necessary to remove the PVC sheath of a cable for jointing or termination, only the minimum length necessary shall be removed and the exposed armour or copper screen shall be protected by PVC tape or sleeves.

3.5. CABLE INSTALLATION WITHIN BUILDINGS

Cables which are to be run on walls, ceilings or other building structures shall unless otherwise agreed by the Engineer, be secured on cable trays and ladders or enclosed in conduit or trunking.

Every cable shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

Suitable screens shall be provided to protect the cables run on the external surface of structures or above ground level, from the effect of the sun radiation. All screens used to protect the cables shall be of an approved design, securely fixed to the structure or ground and be fully ventilated.

All vertical cable runs shall be protected to a height not less than 450 mm above floor level by inverted cable tray, cable channel, conduit or other approved method.

Where the building structures incorporate covered floor trench systems, cables shall be installed on horizontal trays racked against the side(s) of the trench. Other support systems may be used for heavy power cables subject to the approval of the Engineer. The minimum vertical distance between horizontal trays shall be 300 mm. Adequate space shall be provided at the side of the trays to facilitate easy installation. Cables installed close to the bottom of the trench shall be arranged and spaced to allow adequate air circulation. No cables shall be laid direct onto the trench floor.

Where the structure incorporates general service ducts or trenches containing pipework, chemical lines and other services, all cabling shall be segregated from the other services and shall be run on the trench walls.

The Contractor shall supply all covers and associated steelwork for the structure and building cable trench systems. Trench covers shall be chequer plate pattern.

Throughout the installation due regard shall be paid to the spacing of cables to maintain current rating, to prevent interference between power and signal cables, and to avoid unnecessary crossovers.

The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips, etc., shall be by means of non-corrodible screws inserted into approved wall fixings.

Cable fixing on horizontal trays and ladders shall be arranged to secure the cables and maintain the specified cable grouping and segregation. The spacing of clips and saddles shall be not greater than 600 mm.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self locking plastic buckle clips and strapping shall not be used.

Where a number of cables are terminated in any particular item of equipment, special care shall be taken to ensure that the cables finally approach the equipment - from a common direction and are individually terminated in an orderly and symmetrical fashion.

3.6. CABLE TRAY AND LADDERS

3.6.1. HOT DIP GALVANISED TRAYS

Perforated tray and cable support systems for dry structures shall be heavy duty hot dipped galvanised steel.

Wherever tray and ladder sections are cut and shaped on site, cut edges shall be dressed and painted with a coat of cold galvanising compound within two hours of cutting and dressing followed by a further coat in accordance with the coating manufacturer's instructions.

3.6.2. GLASS REINFORCED POLYESTER (GRP) TRAYS

Cable tray systems in chemically corrosive locations and areas affected by the effluent shall be of pultruded glass reinforced ultra violet and corrosion resistant stabilized polyester pattern.

GRP cable tray systems shall be of the ladder type design having "Z" shaped side rails. Rungs shall be of the same material as the side rails and securely bonded in place. Rungs shall be mechanically locked into place by means of an intermediate side rail flange to prevent roll-over when cables are pulled into the tray.

Where appropriate GRP cable tray sections shall not be less than 6 m long and each, straight section shall be furnished with pre-punched holes for splice plate attachment. Trays shall be complete with all necessary fasteners, hold-down clips, splice plates, support systems, covers, etc.

Splice plates and cable fasteners used with GRP tray systems shall be fibreglass encapsulated stainless steel and shall be installed using torque limiting tools to prevent damage to the encapsulating coating.

3.6.3. CABLE TRAY INSTALLATIONS

Cable tray and ladder systems shall be installed using factory made supports, joints and junction/bend pieces.

Brackets shall be provided at a maximum of 1 200 mm centres and be prefabricated hot dipped galvanised steel.

Fixing of galvanised trays shall be by means of non-corrodible screws inserted into approved wall fixings.

Where GRP tray systems are installed, all fixings and supports shall be stainless steel.

Bends and tees shall be prefabricated and have an inside radius of not less than 300 mm and where large cables are to be accommodated the radius shall be sufficient to fully support correct minimum cable radius.

Cables shall be fixed to trays by means of purpose made fixing clamps. Cable fasteners used with GRP trays shall be fibreglass encapsulated stainless steel.

Single core cables of the same circuit shall be laid and mounted in purpose made trefoil cleats.

Vertical tray systems shall be provided with protective covers to a height not less than 1 000 mm above floor level.

Particular care should be taken on vertical rise trays providing adequate cable fixings to ensure distribution of load and security.

3.7. CABLES INSTALLED IN THE GROUND

3.7.1. GENERAL

Power, control and signal/monitoring cabling external to, and interconnecting the main plant buildings, shall be installed in underground duct systems under permanently made-up areas, and shall be directly buried in trenches in all other areas.

The Contractor shall prepare drawings showing his precise requirements for cable ducts and trench work. The drawings shall detail the number of ducts required, the width and depth of trenches and the number and location of drawpits. These drawings shall be prepared in consultation with the Engineer and shall be approved before issue.

Cable routes shall be agreed with the Engineer.

The excavation and backfilling of trench works and the supply and installation of all cable ducts shall be the responsibility of the Contractor.

The Contractor shall supply and lay the sand bedding, supply and lay the cables, supply and lay sand blinding and supply and lay protective tiles and warning tape; he shall also supply and lay cable route marker posts after the backfilling and top soiling has been carried out.

3.7.2. CABLES DIRECT IN THE GROUND

When cables are buried, the bottom of the excavated trenches shall be free of sharp objects and shall be covered with sand or fine sifted soil to a depth of 50 mm. The depth of excavated trenches for low voltage and high voltage cables shall be as specified.

Cables shall be unrolled from the drums so as to avoid loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath.

Cables shall not be straightened completely after laying into the trenches to avoid excessive tensile stresses during backfilling or from subsequent settlement. After laying, cables shall be covered to a minimum depth of 100 mm with sand or sifted soil. Cables shall be overlaid with protective interlocking tiles.

A warning tape shall be installed along the entire cable route. The tape shall be yellow coloured polyethylene nominally 150 mm wide and 100 microns thick with the words CAUTION ELECTRIC CABLES BELOW in both English and Armenian at regular intervals. The tape shall be installed approximately 400 mm above the associated cable(s).

Concrete marker posts shall be provided at 40 metres intervals and at points of change of direction along the cable run, each fitted with a suitably inscribed metal plate showing the voltage of the cable marked. Similar plates shall be provided and fitted to the outer walls of buildings at the points of entry. Marker posts shall also identify the position of any cable - joints.

3.7.3. CABLES IN DUCTS

When installing cables in ducts the following procedures shall be used:

- Cables shall be pulled in a straight line.
- Rollers shall be positioned at the edges of drawpits both at the drawing-in and drawing-out points.
- Plastic pipes and cable sheaths shall be lubricated with boiled-down soap of low alkali content or other approved lubricant.
- A continuous check on the tensile forces shall be carried out by means of a strain gauge or a dynamometer attached to the rope holding the winch, with the latter resting on rollers.
- A shearing pin or other tension limiting device shall be provided at the winch, which shall interrupt the pulling if the maximum permissible stress is exceeded.
- The pulling rope shall be guided by rollers.

Cable ducts shall be made of UPVC or glazed earthenware material having a minimum diameter of 150 mm. Duct systems under roadways and areas liable to subsidence shall be encased in concrete.

3.7.4. SEALING OF CABLE ENTRY HOLES

Where cables pass through walls below ground level, the point of entry shall be sealed against the ingress of moisture. Individual cable entry points shall be sealed by using Denso tape and "Denso-mastic" compound or similar approved materials. Multiple cable entries shall be sealed by multi-cable transit units (MCT) comprising steel frames and insert blocks. MCT'S shall be flange mounted on the inside surface of substructure walls or cable ducts.

3.8. JOINT BOXES

The use of through and tee joints are prohibited on main and auxiliary control cable installations unless otherwise approved by the Engineer.

Junction boxes in auxiliary control cable circuits for the purpose of marshalling a number of cables feeding to a common item of equipment shall only be used with the written approval of the Engineer.

Any such junction box shall be of the wall mounting pattern with double terminals with cores ferruled and identified in accordance with the system schematic and cable diagrams.

3.9. CABLE IDENTIFICATION

Every cable shall be permanently identified at each end by its cable number as shown on the cable schedule. Cable markers shall comprise an approved system of engraved plastic or

stamped metal marker plates, secured to the cables by self locking plastic buckle clips or similar fixings.

Cable marker plates shall also be installed at exit and entry points of buried ducts, exits from buildings and in such other positions as are necessary to identify and trace the route of any cable.

All power cables shall be connected at main switchboards and other items of plant so that the correct phase sequence and phase colour coding are preserved throughout the system. Cables shall be identified with phase colours for three and four wire systems and red and black for single phase. On rotating plant, where to achieve the required direction of rotation it is not possible to connect the phase cores to the appropriately identified terminals, special core ferrules shall be fitted to identify each core with the terminal to which it is finally connected.

Control and instrument cables shall have individual cores identified by means of suitable permanent ferrules bearing the same numbers or letters at both ends and corresponding with terminals on equipment. Core identification shall occur at every point of termination using an approved system of ferrule markers.

Numbering shall read from the terminal outwards on all cores. At those points of interconnection between wiring where a change of number cannot be avoided, double ferrules shall be provided on each wire. The change of numbering shall be shown on the wiring diagrams of the equipment at which the change is made.

3.10. EARTHING

1. A complete earthing system shall be provided for each equipment installation comprising a copper tape/conductor earth network and earth electrodes, which shall comply with the requirements of the BS 7430 or equivalent.
2. The earth networks shall comprise a main tape/conductor earth, conductor run around the structure with separate subsidiary branched copper tape/conductor connections taken from the main conductor to each item of electrical equipment, metal frameworks and castings, and to the neutral points of generators and power transformer secondary windings as appropriate to the method of system earthing.

All metal pipework shall be bonded to the main earth network at the point of entry to a building.

The earth network conductor shall comprise annealed high conductivity hard drawn copper strip which shall be supported on building or substation structures or cable trench walls by means of clamps suitably spaced. It shall be neatly run parallel to adjacent walls, ceilings and beams.

The earthing of each item of electrical equipment shall be effected by bonding the earth tape/conductor to the special earth terminal provided thereon. Particular care shall be taken on cable termination boxes to ensure that the cable sheath and armour is adequately bonded to the frame of the item of plant to which the cable is connected. If the earth continuity through the cable termination gland is inadequate, a special copper connection shall be made, between the apparatus frame and the cable earth sheath and armour.

Joints and connections in the earthing network shall be riveted, tinned and soldered, or brazed to the approval of the Engineer.

Earthing on low voltage distribution and sub-distribution circuits of connected load capacity not exceeding 20 kW shall be affected by means of the metal sheath and/or armouring of cables which shall be securely bonded at each end to the metalwork or the apparatus concerned.

Particular care shall be taken to ensure continuity across items of apparatus situated within a cable run and, should the design of such an item of apparatus not give adequate and lasting continuity through its structural body, additional earthing clips and conductors shall be provided to bond the cable sheaths or armouring together. Similarly, additional earthing clips shall be provided to bond

the cable sheaths/armour to any piece of apparatus fitted with a special earth terminal should the earth connection of termination gland prove inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.

Where rigid or flexible conduit is used, an internal earth conductor shall be run which shall be securely bonded to the terminating or intermediate apparatus by means of a special earth terminal.

3. Unless otherwise specified two earth electrodes shall be provided for each installation.

Subject to determination by tests on Site, which shall be carried out by the Contractor, each electrode shall comprise either a system of interconnected driven rods, or alternatively buried copper plates.

The two electrodes shall be physically arranged and spaced to be electrically independent and leads from each shall be brought to an earthing bar located inside building or to common concrete disconnection chamber set in the ground. Two bolted copper links shall be provided in the disconnection chamber to enable each electrode to be disconnected from the system for test purposes.

Each electrode shall be capable of providing an effective earth of resistance not greater than the values specified, with the other electrode disconnected.

Earthing rods shall be steel cored with a metallic bonded copper outer surface of thickness not less than 0.38 mm and a total diameter not less than 16 mm. Rods shall be provided with special hardened tips and caps to avoid distortion when being driven into the ground. The rod extension length shall be of the screwed type arranged so that the diameter of the rods is not greater at the point of extension.

Each rod shall be provided with an approved non-ferrous clamp for the connection of the copper strips and these connections shall each be housed in individual inspection chambers set flush with the ground level.

Interconnections between electrode rods or plates and between the electrode test chamber and the main plant earthing conductor system shall be by stranded copper cable.

After the earth installation has been completed, the Contractor shall demonstrate to the Engineer that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

Marker posts and plates shall be provided to mark the positions of the electrodes and buried connections. The markers shall be similar to those provided for cable routes.

3.11. CABLING AND EARTHING RECORD DRAWINGS

Record drawings for the cabling and earthing installation shall include cable route drawings, block diagrams and cable schedules. Cable schedules shall detail the cable type, voltage rating, core size, installed length and terminal equipment. Core identification numbers shall be given for control cables.

Block diagrams shall illustrate the complete power and control cabling systems, each cable being identified as in the cable schedules.

Within buildings, cable route record drawings shall show to scale the location of all items of electrical plant and the route and method of installation of all cables, e.g., on tray, in trench, on hangers, in ducts and in conduits.

External cable route drawings shall show:

- The route of the buried cable.
- The depth of laying including any deviations to avoid local obstructions encountered during installation.

- Positions of marker posts.
- Positions of joints, test terminal points, drawpits, etc., located from marker posts or other agreed key points.
- Distances of cable runs from pipe runs or other buried services.
- Positions of earth electrodes, earth rod inspection chambers and interconnecting earth tapes/conductor.

3.12. NEUTRAL EARTHING RESISTORS

3.12.1. RESISTORS

The resistor elements shall be of the air insulated, air coded grid pattern, formed from continuous, rustless and non-magnetic alloy steel.

The resistor elements shall be mounted on mica or porcelain insulated steel rods. The resistor elements shall be assembled in tiers on interlocking insulators and supported on a welded steel framework. Interconnections between resistor elements shall be made using copper strip.

The whole resistor unit shall be designed to ensure ample strength to withstand the mechanical and thermal stresses imposed during the passing of the rated current.

The resistor voltage and current shall be as specified. The resistance value shall be that at the design ambient temperature, and the unit shall, unless otherwise specified, be capable of carrying the specified current for a minimum time of 30 seconds with a maximum temperature rise as stated in the Schedules.

3.12.2. ENCLOSURES

The resistor unit shall be provided with a sheet steel enclosure with side covers.

The enclosure shall be suitable for indoor or outdoor location as specified.

3.12.3. CONNECTIONS

The resistor unit shall be provided with either cable termination facilities or porcelain top bushing as specified. A stud, insulated from the resistor unit metalwork shall be provided for the main earth connection. A separate stud shall be provided for the earthing of the metalwork.

3.12.4. FINISH

Unless otherwise specified, all metalwork shall be hot dipped galvanised.

3.13. LIGHTNING PROTECTION SYSTEM

Lightning protection system shall be provided for the buildings in accordance with IEC 1024-1.

Lightning pole shall be connected to an earth rod separate from the earth networks of the installations.

4. BUILDING SERVICES

4.1. ELECTRICAL SERVICES

4.1.1. APPLICABILITY

The following clauses specify the general requirements for the supply and installation of electrical services for buildings and area throughout the works. The general specification clauses shall apply where appropriate except where redefined elsewhere in the specification.

4.1.2. DISTRIBUTION BOARDS

Distribution boards shall be of zinc coated mild steel sheet construction of adequate thickness, suitably braced to form a rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance. Doors shall be fitted with gaskets and shall be easily removable to simplify installation. Each distribution board shall be arranged for top and bottom cable entry and shall be provided with removable termination plates and space to enable cables and conduits to be neatly grouped and terminated. Distribution board shall be wall or floor mounted and shall, when specified, incorporate on-load isolators which shall be front of panel operated with “ON/OFF” indicators and capable of being padlocked in the “off” position. Distribution board shall incorporate combinations of single pole and neutral and triple pole miniature circuit breakers (MCB’s) as specified.

Each bank of MCB’s shall be clearly identified with its appropriate phase colour/code, and the mounting framework for the banks of MCB’s shall be easily removable to simplify installation. Adequate phase barriers and shields shall be fitted to ensure that, after installation and wiring, all bare terminals and wires are covered to prevent accidental contact with live conductors when resetting MCB’s.

MCB’s shall be rated to afford “close” overcurrent protection to circuits as defined in the IEC Recommendations.

Distribution boards shall incorporate neutral bars or terminal assemblies providing an independent terminal for each MCB circuit.

The termination of circuit cables at distribution board shall be neat and slack left to enable complete internal assembly to be partly removed for inspection without disconnection. Neutral conductors shall be connected to the bar in the same order as the phase conductor to the busbars.

Each distribution board shall be complete with a permanent circuit identification chart, mounted within the front door. This chart shall be permanently and legibly filled in as circuits are completed.

4.1.3. CONDUITS

Conduits shall be hot dipped galvanised steel. Conduits shall be neatly run on the surface or sunk as specified and shall be installed so as to permit complete rewiring without the need to remove false ceilings or wall cladding materials or carry out builders work.

Only continuous lengths of buried conduit shall be installed between boxes. No joint boxes shall be installed in the floor screeds. Conduits crossing expansion joints shall be fitted with couplings of approved manufacture with an earthing clip at each side of the coupling, connected by the correct size of tinned copper stranded wire.

Inspection couplers may be used in long runs to facilitate drawing in cables.

The ends of the conduit laid or set in formwork prior to concreting shall be temporarily sealed off with a coupler and a solid brass plug.

Particular care shall be taken to ensure that no water is allowed to enter the conduit and all conduits shall be arranged with adequate ventilation and drainage. Inaccessible junction boxes will not be allowed.

The sizes of conduit used shall be determined by the number of cables to be drawn in, but conduit smaller than 20 mm diameter shall not be used.

Fixings to surfaces of walls shall be by means of spacer bar saddles securely fixed by screws. Where conduits are concealed or laid in construction floors, they shall be held in position with substantial fixings of a make and pattern to be approved by the Engineer.

Surface run conduits shall be supported at intervals in accordance with the following schedule:

Size	Interval
20 mm	1.2 m
25 mm	2.0 m
32 mm	2.5 m

Where bends and sets occur in the conduit run, the conduit shall be securely fastened at a distance of 225 mm either side of the diversion.

The conduits shall be screwed into spout outlets of conduit boxes or, where fixed to boxes drilled with properly sized clearance holes, they shall be secured by means of sockets and hexagon smooth brass bushes. Threads shall be cut clean and all burrs shall be removed with a reamer.

Any exposed metal such as ends of conduit or exposed threads cut on site shall be treated by a cold galvanising compound or lead based anti-corrosive paint.

Any bends and sets shall be formed in the conduit itself. Factory made bends shall not be installed without the written permission of the Engineer.

Standard junction or adaptor boxes shall be provided at all junctions and at sharp changes of direction.

Junction and adaptor boxes shall be made from galvanised steel and shall be provided with gasketed flat covers secured with brass screws.

Weatherproof boxes and accessories shall be used outdoors.

Conduit ways shall be installed for telephone services run as for other conduit with a single cable pulled in and left for draw-in purposes.

For telephone points, conduits shall be terminated at flush standard boxes each with a stainless steel telephone outlet plate.

4.1.4. FLEXIBLE CONDUITS

Where the conduit system terminates at any equipment requiring a non-rigid connection, a flexible conduit shall be installed of the PVC or PVC sheathed metallic type fully watertight with purpose made connection adaptors.

Each flexible connection shall include not less than 400 mm length of flexible conduit and a separate earth conductor shall be run within the conduit connected to the earth terminals in the equipment and the fixed conduit run. The flexible conduit shall not be used as an earth continuity conductor.

4.1.5. TRUNKING

Trunking shall be manufactured from heavy gauge continuous hot dipped galvanized steel. Each length shall be supplied with the necessary connection sleeves and shall have sides suitable for flush fitting.

The Contractor shall ensure that the size of trunking is adequate for the number of cables passing through it, but the minimum size shall be 50 mm x 50 mm. Bends, tees and intersections shall be of the gusset type and manufactured by the maker of the trunking and to similar standards. Trunking shall be fixed to ceilings by means of a secure and permanent fastening. Where standard lengths of steel trunking are cut, the Contractor shall, prior to assembly, treat the cut edge with a cold galvanising compound or lead powder based anti-corrosive paint.

4.1.6. WIRING

Cables for drawing into conduit shall be single copper core PVC insulated, non-sheathed, 1 000 volts grade and shall be supplied by an approved manufacturer. Insulation shall be coloured to indicate phase and neutral.

The conductor sizes shall not be less than 1.5 mm² for lighting circuits, and 2.5 mm² for socket outlet circuits.

No conduit serving a single phase socket outlet, lighting point or switch shall contain more than one phase.

Wiring shall be carried out on the looping-in system and no joints other than at loop-in points will be allowed.

4.1.7. SOCKET OUTLETS

All socket outlets shall incorporate an earth continuity pin or, subject to the approval of the Engineer, a scraping earth contact. Socket outlets of differing voltages shall have differences in plug dimensions and/or incorporate the appropriate keyway interlock for supply discrimination.

Switch socket outlets shall incorporate dolly type switch levers, either fully recessed or having a raised surround to prevent damage or inadvertent operation.

Socket outlets shall be of the shuttered pattern or, subject to the approval of the Engineer, shall be fitted with spring operated flap covers.

Each socket outlet shall be complete with a steel mounting box incorporating an earthing terminal and a metal cover plate.

Special care shall be taken to ensure that all fittings are securely fixed truly vertical, and that in the case of a flush mounted socket outlet, the mounting box is fitted flush with the wall finish so that the overlapping cover plates seat onto the rims of the boxes.

4.1.8. LIGHTING SWITCHES

Interior lighting switches shall be supplied complete with metal box, cover plate and fixing screws.

At multi-switch positions, the switches shall be contained in multi-gang boxes.

Exterior lighting switches shall be metal-clad, galvanised and watertight, with rotary switch action.

All switches shall be securely fixed truly vertical and flush mounted switches shall be flush with the wall finish so that the overlapping cover plates seat onto the rims of the boxes.

4.1.9. BULK SWITCHING CONTACTORS

Bulk switching contactors (e.g. for large lighting or heating loads controlled from a single switch) shall comply with IEC 947-4-1. The contactors shall be continuously rated for the duty specified and shall have a minimum utilization category AC1 and shall have an intermittent duty Class 1 with the characteristic mechanical endurance of that class.

Contactors shall be single pole or triple pole as required, each type with a neutral terminal.

Where contactors are not integral with main switchboards, enclosures shall be constructed similar to those for distribution boards and shall have a minimum protection characteristic IP52 to IEC 529.

4.1.10. LIGHTING

Luminaires shall be complete with all supports, suspensions, flexible cables, pendants and plugs. They shall be connected to the main circuit wiring with heat resisting flexible cables of a minimum core size of 24/0.20 mm insulated with silicon rubber.

The earthing of all luminaires shall be by a separate core in the connecting flex of cable securely bonding the earth terminal of the fitting to that of the interconnecting cables. Pendant chains or conduit support tubes shall not be used as a means of earthing.

Where weatherproof luminaires are installed, all cable entry and securing holes shall be adequately sealed to prevent ingress of moisture.

Fluorescent luminaires shall have two suspension or fixing points.

The length of fluorescent tubes shall be not greater than 1 200 mm.

When luminaires are installed in areas incorporating suspended ceilings, they shall not be attached to or transmit load to the suspended ceilings unless the ceiling and lighting is of integrated design with the appropriate supports.

Where high bay discharge luminaires are suspended from the structural ceiling, the connection between the fitting and fixed wiring shall be by plug and socket to facilitate removal of the complete fitting.

Lamp holders for flexible pendants shall be of the all insulated skirted pattern with cord grips.

The point box suspensions and other parts of the luminaires shall be erected at times to suit the building programme for finishes. The glassware, diffusers, shades, lamps and tubes shall not be fitted until all building work is complete.

Fittings shall be left clean inside and outside and be ready for use; fluorescent fittings shall be suitable for switch start operation.

Fluorescent tubes shall be of energy efficient type and of an approved manufacture and standard white.

Incandescent lamps shall be of an approved manufacture with metal coiled filaments, gas filled and pearl in all sizes. Bayonet type fixtures shall not be used for lamps rated above 100 watts.

Exterior luminaires for site and area lighting shall be of the outdoor, weatherproof, anti-vandal, high pressure sodium vapour or metal halide type.

Security lighting shall be designed so as to be inaccessible to intruders.

The level of required illumination is at minima for:

- Outside ways 20 luxes.
- Inside ways and stairs 100 luxes.
- Rooms inside buildings 300 luxes.
- Offices inside buildings 500 luxes.

4.1.11. EMERGENCY LIGHTING

Emergency light fittings shall be designed to provide a level of illumination under mains failure in compliance with BS 5266 Part 1 or equivalent.

Emergency lighting fittings shall be self contained, incorporating fluorescent lamp(s), battery charger and mains failure relay.

The fittings shall be fully automatic in operation, providing instant illumination in the event of mains failure for a duration of 3 hours. The battery shall be automatically recharged when the mains supply is restored.

Alternatively self-contained emergency power modules may be incorporated into the normal lighting luminaires, such fittings being distinctively labelled for identification.

4.2. HEATING, VENTILATION AND AIR CONDITIONING PLANT

4.2.1. APPLICABILITY

The following clauses specify the general requirements for the supply and installation of heating, ventilating and air conditioning plant to be provided throughout the Works. The general specification clauses shall apply unless redefined elsewhere in the Specification.

4.2.2. PACKAGED AIR CONDITIONING UNITS

Packaged air conditioning units shall be one piece air to air electric cooling units, each comprising an air cooled condensing section containing compressor/condenser coil and cooling fan and an air handling section containing return air/fresh air dampers, filters, direct expansion cooling coil, electric heater battery and centrifugal fan. The units shall be complete with all internal interconnecting pipework and control equipment and shall be supplied as a single packaged unit suitable for direct site installation.

Each packaged unit shall be housed in a totally enclosed fabricated steel floor-mounting cubicle, complete with removable panels or doors to facilitate access to all component parts for

maintenance purposes. The units shall be designed for outdoor mounting and all component steel parts shall be hot dip galvanised. The units shall be installed on raised anti-vibration mountings.

The air handling section shall incorporate air filtration, air mixing and fan components. Air mixing dampers for return air and fresh air control shall be galvanised steel construction individually adjustable with damper rods, rotating in nylon bearings.

Air filtration shall be by cleanable filter cartridges located on slides for ease of access. Air filtration shall have an efficiency of not less than 90% based on EN 779.

The condenser coil shall be constructed of seamless copper tubes, arranged in staggered rows, mechanically expanded into aluminium fins.

The condenser fans shall be propeller type providing vertical air discharge. Fan blades shall be statically and dynamically balanced, protected above by anodized fan blade guards. Each fan shall be driven directly by an individual motor.

Compressors shall be of the serviceable hermetic type. The compressor and fan motors shall be suitable for continuous 380 Volts, three-phase, 50 Hz operation.

The units shall be complete with all motor and refrigeration control equipment, factory wired and suitable for direct connection to the power supply. All control equipment shall be contained in an integral but fully segregated cubicle compartment with lockable hinged access doors. The units shall be suitable for pushbutton starting locally, or from a remote control station.

4.2.3. INDIVIDUAL ROOM AIR CONDITIONING UNITS

Each individual room air conditioning unit shall be of the through the wall pattern comprising two sections for indoor and outdoor equipment divided by an insulated steel bulkhead. The indoor section shall contain the evaporator electric heater battery, centrifugal fan, electrical terminal block and all electrical capacitors. The outdoor section shall house the compressor, condenser and propeller fan. The entire unit shall be mounted on a slide-out chassis within a weatherproof cabinet with removable front panel.

The compressor shall be hermetically sealed and resiliently mounted.

The evaporator shall be a single pass copper coil with light gauge aluminium fins and with an automatic thermostat to prevent excessive frosting.

The condenser shall be a copper coil with aluminium fins.

Filtration shall be provided by a washable filter accessible from the front.

The unit shall be suitable for continuous operation in an ambient temperature of 45°C.

4.2.4. PACKAGED AIR COOLED WATER CHILLERS

Packaged air cooled water chillers shall be completely factory assembled, including all interconnecting refrigerant piping and internal wiring of controls, and shall be mounted on a steel base which shall accommodate the air cooled condenser, compressor and cooler. The units shall be delivered complete with full operating charge of the refrigerant (R22).

Frames and panels shall be fabricated from heavy gauge galvanised steel, complete with removable panels to facilitate access to all component parts for maintenance purposes. The compressors shall be of the hermetic reciprocating type with all rotating parts statically and

dynamically balanced. The compressor shall have a forced feed lubrication system using a reversible positive displacement type oil pump.

The compressor shall also include a suction strainer, oil strainer, crankcase oil sight glass, crankcase oil heater and back seating seal-cap suction and discharge stop valves. The compressor shall be mounted on spring isolators.

The evaporator shall be direct expansion shell and tube type with refrigerant in the tubes and liquid to be chilled in the shell. The water connections shall be fully accessible without going through the condenser sheet metal panel section.

The condenser coil shall be constructed of seamless copper tubes, arranged in staggered rows with aluminium fins. The condenser shall include as an integral part of the design a sub-cooling circuit. The condenser coils shall be of a “V” bank arrangement and shall be fully protected by sheet metal panels.

The condenser fans shall be propeller or axial flow type, providing vertical air discharge. Fan blades shall be statically and dynamically balanced, protected above by anodized fan blade guards. Each fan shall be driven directly by an individual motor. Each packaged chiller shall be complete with a built-in control centre. The control panel shall be split into two compartments, one housing the power circuits and one the auxiliaries. The control panel shall be complete with weather proof doors. The control panel shall include but not be limited to the following items:

- High and low level refrigerant pressure cut-outs.
- Low water temperature thermostat.
- Control thermostat.
- Motor starters.
- Overload relays.
- Time delay relays for starting compressors in sequence.
- Fuses.
- “On-off” switches for each compressor and reset pushbuttons.
- Auxiliary terminals for interlocking.
- Anti-short cycling device.

The units shall be suitable for operating continuously on a three-phase 50 Hz supply at an ambient temperature of 45°C.

4.2.5. AIR HANDLING UNITS

1. Air handling units shall comprise a number of sections combined into ventilation or air conditioning units.

Ventilation units shall be any combination of a fan section, panel filter, bag filter, mixing section or intake damper and sand trap louvers.

Air conditioning units shall be any combination of a fan section, cooling coil, electric heater, filter and mixing section.

2. Each section shall consist of a rigid assembly, formed from enclosure panels, constructed from double skinned galvanised steel sheet with 25 mm mineral wool internal insulation, resting on supporting beams.

The different unit sections shall be assembled on robust clamping strips provided with seals to prevent air leakage. Inspection panels shall be provided with quick-acting opening locks.

3. The air filter section shall consist of disposable type filter bag cartridges located on slide rails for ease of replacement. Each filter bag cartridge and slide rail shall be provided with seals.

The filter type shall be in accordance with ASHRAE 52 and filter efficiency shall be to BS 2831 or equivalent.

Each filter section shall be provided with two spare complete sets of filter cartridges.

Pre-filters shall be of the disposable panel type, with filter media of fibreglass. Filters of this type shall have an efficiency of not less than 90% based on the test specified in BS 2831 or equivalent with test duct No. 2.

A manometer shall be fitted to each filter section, arranged for measuring the pressure drop across the filter.

4. The mixing section shall contain two sets of dampers for mixing the outside and recirculated air.

The dampers shall be of galvanised steel sheet double skinned construction and shall be interlinked externally to the casing. The dampers shall be individually adjustable with the damper rods rotating in nylon bearings.

5. Direct expansion cooling coils shall be provided where specified. They shall be of the extended surface, non-ferrous, fin type.

The casing shall be constructed of heavy gauge galvanised steel. Coils shall have suction tapplings located to permit universal mounting of the coil for right or left hand airflow and shall have equal pressure drop through all circuits. All long coils shall have stays to hold the fin-tube assembly in place. Primary tubes shall be seamless copper tube brazed into a heavy gauge header tube with intruded holes to allow for expansion or contraction of small radius return bends. Secondary surfaces shall consist of copper fins mechanically bonded on to the copper tubes. The coil fins and tube shall be electro-tinned after assembly. Brass liquid distributors of the pressure type shall be provided. Loading of each circuit shall maintain the refrigerant pressure drop within adequate limits to prevent loss of coil capacity.

Coils shall be factory air tested to 2100 kN/m² under water. Coils shall be dehydrated and sealed after manufacture.

6. Chilled water cooling coils shall be constructed as described for direct expansion cooling coils. The primary tubes shall be seamless copper with secondary surfaces of copper fins, mechanically bonded to the tubes and electro-tinned after assembly. Tubes shall be brazed into copper headers and filled with screwed male copper connections. Vents and drains shall be provided at the highest and lowest points.
7. All cooling coils shall have a maximum air velocity across the coil not exceeding 2.5 m/s to prevent moisture carry over. A condensate tray shall be provided at the base of the cooling coils complete with a drain connection. The condensate drip tray shall be coated with corrosion resistant paint.
8. Electric heater batteries shall be arranged to balance the electrical load over three phases. The heating elements shall be removable for cleaning and inspection. The connections from each heating element shall be taken to an accessible terminal box arranged for conduit entry. Each element shall be separately fused.

4.2.6. FANS

1. Fans shall be provided as specified. Each fan shall be capable of providing the required duty when tested in accordance with BS 848 or equivalent.

To standardise fan performance, standard air shall be taken as having a weight per unit volume of 1.2 kg/m³, corresponding to atmospheric air at a temperature of 20°C, a barometric pressure of 1013 mbar and a relative humidity of 50%.

All rotating assemblies shall be balanced both statically and dynamically after assembly in the manufacturer's works.

2. Axial fans shall be of aerofoil cross-section and of the single stage type or the multi-stage contra-rotating type, with each impeller driven by a separate motor, and mounted in a cylindrical casing. The blades of each impeller shall be fabricated from die cast aluminium, with pitch angles adjustable without removal from the fan casing. Balancing shall not be affected by altering the pitch angle.

Casings shall be rigidly constructed from heavy-gauge hot-dipped galvanised steel sheet, with the overall length containing the impeller and the motor. The casing shall be provided with flanged connections and with two inspection doors incorporated diametrically opposite to each other.

The impellers of the fans in the Chlorine House duct system shall be non-adjustable bifurcated rigid PVC pattern with non-overloading characteristics. The motor casing and fan support metalwork shall be constructed of hot dipped galvanised steel and protected with an approved chlorine resistant rubber based paint.

Motor bearing arrangement and bearing ratings shall permit continuous fan operation in the vertical or horizontal position. Ball or roller bearings shall be used.

3. Centrifugal fans shall be double-inlet or single-inlet. The fans shall be V-belt driven with backward or forward curved impellers. The fans shall consist of galvanised steel casing, fan impeller shaft and bearings, motor, steel frame, anti-vibration mountings, belt drive, pulleys and guards. The steel frame shall have adjustable rails. The fans shall be provided with an inspection cover.
4. Propeller fans shall be suitable for ring mounting or diaphragm mounting. The impellers shall be of steel or aluminium and fastened to the hub or formed with the hub in one piece. Ball or sleeve bearings may be used. The motor and impeller shall be a complete integrated unit. Anti-vibration mountings shall be fitted. Unless otherwise specified, the arrangement shall be with the motor upstream of the impeller. All fans impellers shall be finished with corrosion resistant coatings.
5. Air intakes and exposed fan moving parts shall be protected by rigid galvanised wire guards. Access shall be provided for measurement of shaft speeds and belt tension.
6. Roof extract units, where provided, shall be fitted with propeller or mixed flow type fans.

The housing shall be constructed from corrosion resistant spun aluminium with a glass fibre base and weathering skirt for kerb mounting.

7. Where duplicate extract fan units are specified for toilet areas, each fan shall provide the full air flow required. The fans shall be connected in parallel and arranged for automatic changeover upon failure of the duty fan. Either fan shall be capable of being selected as the duty fan. In the event of failure of the operating fan, an airflow switch shall detect the failure and immediately activate the standby fan. A damper shall be provided to prevent back feed of air through the idle fan. A warning light shall be provided to indicate fan failure.
8. Ceiling mounted ventilation fans shall comprise capacitor start and run type motor, supporting down rod and three bladed fans. Blades shall be of steel. Each unit shall be complete with a surface mounted six speed and off speed regulator.

4.2.7. AIR DISTRIBUTION

1. Grilles, diffusers and louvers shall be provided throughout and shall be sized to meet the requirements of the system and in accordance with approved design. Diffusers, grilles and louvers shall be constructed of spun anodised aluminium.

Supply and return air grilles and diffusers shall incorporate key operated, opposed blade, manual, volume control dampers.

2. Ceiling mounted and duct mounted supply air diffusers shall incorporate removable and adjustable cores to provide a full range of air control. Return air diffusers shall match the supply air diffusers within the same space.

Ceiling mounted diffusers shall be installed flush with the ceiling surface on duct extension collars arranged so that no load is imposed on the ceiling structure.

3. Supply air grilles shall incorporate double deflection, individually adjusted, air foil blades with front blades arranged parallel to the grilles longest side.

Return air grilles shall be of the fixed horizontal blade pattern.

Transfer grilles shall be of the single deflection fixed horizontal blade pattern.

4. External intake louvers shall be of the sand trap pattern. Each louver shall comprise fixed pattern, extruded aluminium, vertical mounted blades designed to form an effective sand trap. The intake louver frame structures shall incorporate an effective vermin screen, external sand drainage holes, removable bottom cover plates for cleaning, and shall be designed for mounting into the building structure.

5. The size of the louvers shall be such that the face velocity does not exceed 0.5 metres per second and at this velocity shall be capable of removing 85% of a typical desert sand and dust mixture from the incoming air.

6. The pressure loss across the louvers at 0.5 metres per second face velocity shall not exceed 25N/m².

7. External exhaust louvers shall comprise fixed pattern, extruded aluminium, horizontal mounted blade incorporating an effective vermin screen, and shall be designed for mounting into the building structure. The louvers shall be fitted with automatic non-return dampers incorporating edge seals to provide a fully air tight seal when closed.

4.2.8. DUCTWORK

1. The ductwork and all component fittings for installation in Chlorine House shall be constructed of unplasticized polyvinyl chloride (uPVC) extruded sheets and circular sections to BS 3757 and BS 3506 or equivalent.

The ductwork and all component fittings in all other areas shall be constructed from hot-dipped galvanised steel to EN 10142.

2. PVC duct systems shall be designed and constructed in accordance with the Heating and Ventilating Contractors Association (HVCA) Specification DW151 or equivalent.

Ductwork joints shall be flanged with neoprene gaskets secured with cadmium plated mild steel bolts.

3. Galvanised steel duct systems shall be designed and constructed in accordance with the HVCA Specification DW141 and DW144 or equivalent for low velocity duct systems.

Ductwork shall be constructed with lap or standing seams. Normal cross section joints shall be spigot and socket slip joints with a minimum 50 mm overlap. Bolted flange joints shall be provided for all fan and duct fitting insert sections. Lap joints and seams shall be sealed and riveted. Flanged joints shall incorporate neoprene gaskets and shall be secured with cadmium plated steel bolts.

4. Air flow control, non-return and fire barrier dampers shall be provided as required.

Air flow control dampers shall be of the opposed blade pattern and provided with external operating handle with position indicator and means of padlocking in any set position.

Dampers in uPVC ductwork shall be constructed of uPVC coated galvanized steel. Operating shafts shall be stainless steel.

Fire dampers shall be of the single blade, hinged, self-closing pattern. Dampers shall be held open with fusible links set to release the damper at not greater than 72°C.

Duct access openings shall be provided wherever necessary for plant routine maintenance, lubrication and adjustment. Hinged plates and removable covers shall be gasketed and secured with bolts.

Duct test holes shall be provided for system balancing and commissioning.

5. Support brackets and fittings for all ductwork shall be of hot-dip galvanised steel.

Fans, dampers and other duct inserts shall, wherever possible, be supported independently from the ducts to which they connect.

Duct sleeves shall be provided where ducts pass through floors and walls. Duct sleeves shall be sealed after installation by an approved method.

No duct support fixings shall be made to the building structural cladding.

4.2.9. THERMAL INSULATION

1. Thermal insulation shall be provided for all air conditioning ductwork systems. Each duct or pipe shall be individually insulated and shall have a complete vapour seal. Supports shall not be in direct contact with the pipe or duct.
2. Ductwork within plant rooms shall be insulated with aluminium foil-faced rigid fibreglass slabs 50 mm thick. The slabs shall be securely held in position with adhesive and 50 mm x 50 mm aluminium angles fitted as additional protection on all corners. Ductwork over 900 mm size shall be further held in position by means of stick clips and washers. The whole shall then be encased in a layer of heavy quality canvas, and sealed with a vapour sealer.
3. Internal ductwork outside plant rooms shall be insulated with aluminium foil-faced rigid fibreglass slabs 50 mm thick, applied with an adhesive and vapour sealed.
4. External ductwork shall be insulated as described for plant room ductwork, then further protected with a layer of 2-ply aluminium foil-faced roofing felt which shall be well lapped at joints and secured with 32 mm mesh x 19 gauge galvanized wire netting, and the whole vapour sealed.

4.2.10. NOISE CONTROL

Acoustic attenuators shall be provided as required to achieve the noise levels specified. Attenuators shall be uncased units for plenum chambers and builders' ducts, or cased units elsewhere. Cased units shall be of the straight-through splitter bend, lined bend or straight-through cylindrical type.

Rectangular splitter type attenuators shall be constructed from galvanised mild steel sheet of the following thickness:

- Longest side up to 680 mm - 1mm.
- 680 mm and over - 1.6mm.

Galvanised steel angle flanges shall be attached to the casing.

Internal splitters shall be constructed from profiled galvanised steel sheet which contains absorption acoustic material. The absorption material shall be incombustible and shall incorporate a 40% free area (electro-galvanised) expanded metal facing to prevent erosion of fibrous particles.

Cylindrical attenuators shall be of similar construction to the cased splitter type and, where higher insertion losses are needed, axially-mounted acoustic pods shall be fitted.

Attenuators shall be lined with a transparent polyester film not less than 0.025 mm thick to prevent absorption of dirt and contaminants.

Mechanical equipment shall be mounted upon anti-vibration mountings so that the transmission of dynamic forces to the building structure shall be attenuated by not less than 90% for all possible equipment operating speeds. The mounting types shall be either rubber in shear or steel spring.

Mechanical equipment shall be provided with flexible connection. The flexible connectors shall provide maximum structural isolation between the mechanical equipment and the distribution pipework or ductwork. Flexible connectors shall be as near to the mechanical equipment as possible.

4.3. TELEPHONE SYSTEM PLANT

4.3.1. GENERAL

The Contractor shall furnish all materials, labors and services required for the installation of a complete private telephone system for the job site(s) as specified herein.

Approvals on all items included in this section must be obtained from the local telephone network Administrator and the Engineer, before supply of any item.

The Contractor to arrange with local telephone network Administrator to ensure the completion of the telephone services for each of the job sites. This shall include but not limited to liaison with the local telephone network Administrator to carry out inspection for the whole telephone installations.

4.3.2. SYSTEM DESCRIPTION

The system shall comprise an Electronic, Private Automatic Branch Exchange (EPABX) with a Main Distribution Frame (MDF) equipped with power supply equipment and UPS of 4 hours full autonomy.

The telephone system installations shall be complete with all wiring, conduits, telephone junction boxes (TJB), outlets and telephone sets.

4.3.3. REGULATIONS AND STANDARDS

All equipment and installations thereof are to be in new standard material in accordance with the relevant national and local codes and regulations.

4.3.4. MANUFACTURER

All major items of equipment are to be the product of one manufacturer, where practical, to ensure a unified quality and comparable styling and appearance.

4.3.5. SYSTEM PERFORMANCE AND FACILITIES

4.3.5.1. SYSTEM FUNCTION

System is to provide a means of intercommunication within the different parts in each of the waterworks sites as well as distribution of the incoming and outgoing telephone calls.

4.3.5.2. SYSTEM FUNCTION

The system features shall include the following:

1. Extension-to-Extension Calls

Extension-to-extension calls are to be directly made by dialing the other extension number without operator assistance.

2. Direct Outward Dialing (DOD)

Non-restricted and semi-restricted extensions are to be able to gain access to lines without operator assistance by dialing an access code and then dial the exchange number.

3. Direct Inward Dialing (DID)

External callers can reach extensions by dialing the exchange and the extension numbers without the operator assistance.

4. Camp-On-Busy

If an extension called is busy, the caller can dial a digit and hang up and be called back when the busy extension becomes idle.

5. Call Forward

Any extension is to be able to have all calls to his extension automatically forwarded to any other extension.

6. Call Hold

Any extension can hold a call on his extension while calling a third party. Extension is to be able to confer privately with the third party, recalls the first party thus, establishing a three-party conversation or transfer the first party to the third party.

7. Call Pick-Up

Any extension in an assigned extension group is to be able to pick-up and answer an incoming call to any other extension within the group.

8. Executive Override

Selected extensions are to be able to cut into a busy extension following a warning tone to the talking parties.

4.3.5.3. EQUIPMENT AND MATERIALS

1. Type

EPABX is to be fully electronic, time-division, switching-based, stored program controlled and designed to support all types or key telephone sets.

2. Characteristics

EPABX shall have the following characteristics:

Operator's Console:..... 1

Operating Temperature: 0 - 50 °C

Relative Humidity:..... 60 - 100%

3. Housing

All exchange components are to be grouped in a modular, totally enclosed, sheet metal cabinet with lockable front access door. Cabinet is to be dust and insect proof. Ventilation is to be provided as required for the specified ambient conditions.

4. Power Supply Equipment

Mains-operated power supply comprising rectifier, charger and batteries are to supply continuous DC power at the specified voltage to the EPABX. Batteries are to provide a minimum of four hours of continuous operation without loss of system functions or reduction in the system capacity after power supply failure.

4.3.6. OPERATOR'S CONSOLE

The console shall be desktop, compact type equipped with the necessary controls and displays to provide all services specified herein and verify full control of the system operation.

1. Terminals

All internal and external lines are to be connected by means of high quality and reliable quick-clip connectors. No soldering or wire wrapping will be allowed.

Cables are to be arranged and guided in cable positioning slots.

2. Numbering

Terminals are to be identified by numbered tags corresponding to the respective lines or extensions. The Contractor shall submit proposed numbering scheme for prior approval by the Engineer.

3. Protection

All trunks are to be fully protected by a set of plug-in, gas discharge tube over-voltage protectors, fuse ring for thermal protection against prolonged mains contact and rated fuses for over-current protection. Frame earthing is to be provided and interconnected to the earthing system.

4.3.7. TELEPHONE CABLES

Cables are to be two-pair or multi-pair, polyethylene insulated, tinned solid copper conductors, twisted into pairs, color coded, with wrapping of aluminum polyester tape and PVC sheath of

gray color. Minimum diameter of the conductor shall be 0.65 mm for multi-pair cables and 0.6 mm for two-pair cables.

4.3.8. OPTICAL FIBER CABLES

Optical fibers, cables shall be multi-mode, graded index optical fibers with nominal 62.5/125 µm core/cladding diameter.

Fibers shall comply with ANSI/EIA/TIA 592-A AAAA (Ref. B1.18) and also with ANSI/EIA/TIA 568A Paragraph 12.5.1 on mechanical terminations.

Outdoor optical fibers shall be used to connect MCC buildings to the main distribution frame.

Outdoor optical fibers shall comply with the same specifications, however cables shall also be steel jacketed, jelly filled, rodent proof specifically made for outdoor applications, with 12 strands.

Optical fibers shall meet the graded-index multi-mode performance specified in following table.

Graded-Index 62.5/125 µm Multi-mode Cable Characteristics

	850 nm	1300 nm
Attenuation – dB/km	3.75	1.5
Bandwidth – MHz. km	160	500

Attenuation shall be measured in accordance with EIA fiber optic test procedure ANSI/EIA/TIA 455-46, 61, or 53 (Ref. B1.39). Information transmission capacity shall be measured in accordance with the ANSI/EIA/TIA 455-51, or 30 (Ref. B1.39)

Mechanical and environment specifications for indoor fiber optical cables shall be in accordance with ANSI/ICEA S-83-569 (Ref. B1.40). Outdoor fiber optic cables shall be in accordance with Bellcore TR-TSY-000020 (Ref. B1.36).

4.3.9. PATCH PANELS

Patch panels shall be type RJ45, 16 port, 1U type in rows of three with extension possible of up to six patch panels.

Patch panels shall be housed inside racking system (19" preferred) cabinets with hinged doors on either sides and lockable front doors.

Ventilation slots shall be provided in both sides.

Rack size shall suit patch panels.

4.3.10. PATCH CORDS / LINE CORDS

Patch cords, shall be 2 meters long with adapters at both ends suitable for connection to RJ45 16 port IU patch panels.

Patch cords shall be Category 5 and be flexible enough to bend without loosing any performance.

Patch cords shall be the flexible stranded type.

Line cords shall have the same specifications as patch cords, however these shall be the solid type, used at wall outlets to connect computers or terminals to distribution cabling systems.

Cables shall comply with the performance data specified in the following Table.

Specifications for Category 5 solid/stranded line cords or patch cords		
Frequency (MHz)	Attenuation (Max. dB/305 m)	Next (Min Loss dB/305 m)
1.00	6.80	62.0
4.00	14.0	53.0
10.0	22.4	47.0
16.0	28.3	44.0
20.0	31.7	42.0
25.0	35.9	41.0
31.25	40.9	40.0
62.5	59.3	35.0
100.0	76.1	32.0

4.3.11. OUTLETS

These shall be twin outlet type RJ45 to EN 60950 IBS 7008 having white molded plastic plates with black shutters for computer outlets and white shutters for telephone outlets.

Outlets shall conform to the following specifications:

1. Attenuation (dB): <-0.12.
2. Return loss (dB): <-21.54.
3. Bulk resistance (milli-ohm): 21.85.
4. Voltage rating: >1050 V DC for 1 minute.

4.3.12. TELEPHONE OUTLETS

Outlets are to be cord-grip outlet cover and setscrew terminal block inside box, fixed mounted. Cover plates are to be as other power socket outlets and switches and complying with the building furnishing.

4.3.13. TELEPHONE SETS

4.3.13.1. TYPE

Telephone sets shall be desk or wall mounted type as shown on the drawings, provided with the necessary keypad. Telephone set construction is to be shock-resistant molded plastic of attractive design and color. Design and color are to be subject to the Engineer's approval. Telephone set is to be dust and insect tight with bell and adjustable volume control.

Telephone sets shall be with digital programmable facilities to comprise in addition to the standard keypad, a set of programmable function keys, alphanumeric LCD display, push buttons and associated LED's as well as a memory with a minimum of ten (10) telephone numbers. Selection of number of programmable telephone sets is to be subject to the Engineer's instructions.

4.3.13.2. CONNECTORS AND CORDS

Telephone sets are to have lock-in plug-ended cords for connecting handset to the telephone set base and for connecting base to the wall outlet. Cord is to be of not less than three (3) m long.

4.3.14. FIELD AND INSTALLATION WORKS

4.3.14.1. INSTALLATION

All equipment shall be installed in accordance with the manufacturer's recommendations and in coordination with other trades on site. The Contractor to consider local regulations during installations.

4.3.14.2. CABLES

Cables are to be run inside heavy gauge PVC conduits with a diameter of 25mm, concealed in walls or under floors.

Outdoor telephone cables shall be installed inside Upvc conduits with a diameter of 90mm, with the required hand holes and inspection chambers.

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SECTION 02100

SITE PREPARATION

1. GENERAL

1.1. WORK INCLUDED

1.3.1. SCOPE OF WORK

This section covers all operations in connection with clearing, grubbing and stripping of various parts of the Works sites and other locations related to the Works.

1.3.1. LIMITS OF WORK

It is the intent of these Specifications that the site preparation in connection with demolition, excavation and backfill shall be within the limit lines and grades shown on the Drawings and defined herein, but the right is reserved by the Employer to modify such limits and grades as may be deemed necessary and/or directed by the Engineer during the progress of the work.

1.2. RELATED WORK

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. SUBMITTALS

The overall sequence and programme of site preparation works shall be as set forth in the Contractor's Programme of Work to be submitted within fourteen (14) calendar days after the award of the Contract in accordance with the stipulations of the Conditions of Contract

Not less than seven (7) days prior to commencement of clearing, stripping and grubbing of any section or area of the Works the Contractor shall submit to the Engineer a method statement detailing the arrangements the Contractor intends to adopt to carry out the work, so as to enable the Engineer to assess the consequences of the clearing and stripping works, as regards to the final site conditions and requirements of the relevant Authorities.

No clearing, stripping or grubbing shall be carried out without prior approval by the Engineer.

1.4. SEQUENCING – SCHEDULING

The clearing component of site preparation works shall be performed at the earliest practicable time in order to facilitate further survey works.

2. PRODUCTS

Not applicable

3. EXECUTION

3.1. CLEARING

Clearing shall comprise the removal from the specified area of the works and disposal to the satisfaction of the Engineer of all surficial trees, vegetation, structures, fences, rubbish, and other objectionable matter.

3.2. STRIPPING AND GRUBBING

Stripping and grubbing shall consist of removing natural ground surface layers of natural soil comprising top soil, vegetal matters, and humus as well as excavation and removal of all solid roots, stumps, embedded logs structural foundations and other embedded materials foreign to the natural surface soil layers...

Stripping and grubbing shall be required for all earth foundations of permanent works where the foundation is not specified to be prepared by excavation.

Topsoil removed shall be disposed in a stockpile on site as directed by the Engineer.

All waste shall be removed prior to any work in the area and shall be placed on the existing waste area on site which is specified to be subsequently capped and closed as part of the works under the Contract.

No separate stripping or grubbing will be required in areas to be excavated when the excavated materials will not be used in the Permanent Works.

The minimum depth of stripping shall be 25 cm or where this requirement is inapplicable as directed by the Engineer.

The Contractor shall not dispose of any surplus topsoil from stripping operations or excavated soil from excavations without the written permission of the Engineer.

3.3. DEMOLITION

Demolition works is included in clearing; they concern all structures, pipes, roads to be demolished in the works area as shown on the Drawings or directed by the Engineer.

3.4. PROTECTION OF OTHER AREAS

The Contractor shall ensure that trees and other vegetation outside the areas of the permanent works and the areas required for temporary works including access are protected and preserved from damage.

Any additional clearing required by the Contractor for construction of temporary works, Contractor's facilities, or for any other purpose shall be at the Contractor's expense and shall not be carried out without the prior approval of the Engineer.

The Engineer reserves the right to direct the reinstatement of any damage to vegetation and the surface of the ground beyond the areas of the Works resulting from the Contractor's construction activities (including temporary works) at the expense of the Contractor.

3.5. DISPOSAL OF MATERIALS

All inert materials from demolition works shall be disposed of within the site limits, as directed or approved by the Engineer, or shall be reused as recycled materials for construction works, upon Engineer's approval, if they comply with the Contract documents and the local regulation.

Stumps, roots, logs and other objectionable matter removed in the site preparation operation and other than inert materials arising from demolition works shall be removed from the limits of the work and disposed of in disposal areas as directed or approved by the Engineer.

Burning of in-situ vegetation, and/or waste vegetation, rubbish, timber from demolition works, etc. as part of clearing operations will **not** be permitted except when and where specifically approved by the Engineer at the request of the Contractor; and at such locations as approved by the Engineer. If and when such approval is granted the Contractor shall take all special precautions necessary to prevent fire from spreading to beyond the limits of the designated areas and shall have available at all times suitable fire-fighting equipment and supplies for use in preventing and suppressing fires.

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SECTION 02210

OPEN AIR EXCAVATIONS

1. GENERAL

1.1. WORK INCLUDED

This section covers all operations in connection with such excavation methods and to such dimension and depths that allows for proper execution of the Works.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DESCRIPTION

Excavation as specified under this section shall include manual and mechanical excavation techniques including when necessary use of heavy excavation equipment, ripping, percussion and/or hydraulic breaking, temporary supporting of excavations where required; scaling down and preparation of excavated surfaces for foundations; and, loading, transporting, placing and spreading of all excavated materials in approved stockpile and/or disposal areas.

1.4. DEFINITION

1. According to the dimensions, lines, levels and grade as shown on the drawings or directed by the Engineer:
 - the « elevation » line or neat-line shown on the drawings shall be the line within which no material shall be permitted to remain.
 - all excavations out of « elevation » line shall be classified as over-excavation or overbreak.
 - "geological overbreaks" shall be those due solely to the geology of excavated material. This will not apply to overbreaks due to other reasons such as the method of excavation employed by the Contractor. Classification of over-excavation/overbreak as geological overbreak shall be as decided by the Engineer.

Unless otherwise approved by the Engineer, the Contractor will not be entitled to payment for over-excavation or overbreak outside the excavation line, with the exception of geological overbreaks.

2. Classifications of excavation types

a) Rock excavations

Rock will be defined as sound and solid masses, 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 minimum 250 kW (335 HP) flywheel operating in low gear.

In the case where the above criterion is not convincing, rock excavation will be defined as sound material with a longitudinal seismic velocity greater than 2000 m/s.

All boulders or detached pieces of solid rock, more than 2.7 tons weight or 1 cubic metre volume will be classified as rock excavation.

b) Common excavations

Common excavation includes all materials other than rock excavation and may also be termed soil excavation. All boulders or detached pieces of solid rock less than 1 cubic metre in volume or 2.7 tons weight will be classed as common excavation.

In the event of a dispute as to classification of a material, the decision of the Engineer shall be final.

1.5. CODES AND STANDARDS

BS 410 Test sieves. Technical requirements and testing.

BS 1377 Methods of test for soils for civil engineering purposes

BS 5930 Code of practice for Site investigations

BS 6031 Code of practice for earthworks

ISO EN 965, 964-1, 12956, 10319 : Test of geotextile

USBR: Earth Manual of "Bureau of reclamation" US Department of the Interior.

LCPC: Laboratoire Central des Ponts et Chaussées.

1.6. SUBMITTALS

1. Mass haul diagram.

Prior to the commencement of any excavation works, the Contractor shall prepare and provide to the Engineer for review and approval a Mass haul diagram.

This diagram shall be submitted to the Engineer as part of the Traffic Management Strategy Plan to be submitted within 14 days after the award of the Contract and shall be updated, as and where necessary, at least 7 days prior to commencement of excavation works for any part of the Permanent Works.

In the planning and preparation of excavation works, the Contractor shall take into due account all available data on site investigations and geotechnical surveys that have been carried out previously (if any), an/or independent investigations carried out by the Contractor.

2. Method of work

Not later than 14 days prior to programmed commencement of the work, the Contractor shall provide the Engineer with the methods, sequences and equipment proposed for carrying out the excavation works including the planning of exploitation for quarries and borrow areas. This shall include all provisions for support and safety of the excavation where appropriate.

Within 7 days of receipt of any excavation plan, the Engineer will give in writing to the Contractor, approval or rejection of that plan in whole or in part. If approval is withheld the Contractor shall submit a new plan. No rock excavation shall be started in areas for which the excavation plan has not been approved by the Engineer.

The Contractor shall submit to the Engineer, at least two weeks before commencement of any excavation works, all calculations notes, documents and drawings that he will have produced relating to slope stability. Works shall not begin before the Engineer's agreement concerning the technical solution chosen by the Contractor to ensure slopes stability and safety. If supports and protections are found to be necessary, technical justifications shall be submitted.

No excavation work shall start before the Engineer has notified his complete and unreserved agreement to the relevant Contractor's excavation plan and the Contractor shall not be entitled to claim any compensation in this respect.

3. Topographical survey before any works

At least 14 days before start of any excavation work, a topographical survey - as described in § 3.1 Inspection - shall be submitted to the Engineer.

4. Topographical survey on completion of the excavation work

On completion of each type of excavation and not later than 3 days after a topographical survey, as described in Clause 3.1 hereinafter, shall be submitted to the Engineer.

5. Excavation records

The Contractor shall provide the Engineer each day with one copy of the record for the previous day's work of all excavations works. When applicable the following data shall be recorded for each working face together with such other data as the Engineer may request:

- volume excavated in soil,
- volume excavated in rock,
- location methods used for rock excavation,
- number and classification of men and plant engaged,
- unusual occurrences, such as unstable or soft ground, inflows of water, slope instability, rockfalls or the like.

1.7. TOLERANCES

Excavations shall be made to the dimensions, lines, levels, grades, as shown on the Drawings or directed by the Engineer and shall be finished to tolerances as specified hereinafter.

Any excavation beyond the lines, levels and grades shown on the Drawings or directed by the Engineer which is performed by the Contractor for any purpose (such as for working space) shall be kept within the limits approved by the Engineer. If such excavation should in the opinion of the Engineer, require to be backfilled, such backfilling shall be done to the satisfaction of the Engineer with material approved by the Engineer.

Beneath load bearing structures, foundations and other reinforced concrete work, the filling of any over-excavation or overbreak shall be of the same quality concrete as that required for the associated concrete structure unless the Engineer permits leaner concrete.

For the excavations to be covered by concrete, the tolerances shall be as follows:

- for the levels: +0 / -100 mm
- for the horizontal dimensions: +100 mm / -0

For other excavations the following tolerances shall be required unless otherwise shown on the Drawings or directed by the Engineer:

- for the levels: +0 / -100 mm
- for the horizontal dimensions: +100 mm / -0

2. PRODUCTS

Not applicable.

3. EXECUTION

3.1. INSPECTION

Topographical survey before works

Before the commencement of any excavations or earthworks the sites shall be surveyed by the Contractor in conjunction with the Engineer's Representative to establish existing ground levels. These agreed ground levels shall form the basis for the calculation of quantities of any subsequent excavation and/or filling when required.

Topographical survey on completion of excavation works

On completion of each type (common excavation, rock excavation), and section, of excavation work the areas shall be surveyed by the Contractor in conjunction with the Engineer's Representative to establish the different volumes excavated.

3.2. GENERAL

The Contractor shall arrange excavation activities with due regard for the safety of the Works and the personnel on site.

Excavated surfaces which will remain permanently exposed shall be finished off in a neat and workmanlike manner and shall be graded to provide adequate drainage.

All necessary precautions shall be taken to preserve the material below and beyond the prescribed lines for excavation in the soundest possible conditions.

Excavations for the Contractor's installations shall be submitted to the approval of the Engineer.

3.3. INVESTIGATIONS

No specific site investigations are required for this contract. However, the Contractor can carry out investigations at his own expenses if he judges it necessary or if required for obtainment of permits (example: excavation permit).

The foregoing notwithstanding the Contractor shall be deemed to have obtained and evaluated all available data and information on site conditions pertaining to the execution of the works under the Contract. If the Contractor deems that such available information is insufficient for the programming and execution of the Works under the Contract, he shall carry such additional investigations and/or testing as he deems necessary at his own expense and risk. The costs of any such additional investigations and testing shall be deemed to be included in the unit rates and prices, or lump sums, in the priced Price Schedule

Investigations carried out by the Contractor at his own expense and risk, and potentially affecting the time for commencement or completion of the works shall be subject to approval by the Engineer.

3.4. SUPPORT AND PROTECTION

All temporary slopes shall be made safe and protected if necessary. Protection measures shall include temporary supports including shoring, sheeting and bracing where necessary; the diversion of water and the provision and maintenance of such protection.

During the works, the Contractor must ensure that the dumping of excavated material and the circulation of machines do not cause landslips.

3.5. COMMON EXCAVATION

Common material shall be excavated to existing rock level or to the lines, levels and grades shown on the Drawings or as required by the Engineer. Excavation for any structure or other permanent works shall include excavation necessary to ensure the stability of slopes associated with such structure or works.

Where the excavation is provided to accommodate structures, such excavation shall allow for the proper placing and bracing of required formwork.

If at any point in excavation the natural foundation material is disturbed or loosened during the excavation process or otherwise, it shall be compacted in place or where directed by the Engineer it shall be removed and replaced with approved suitable material, placed and compacted as directed by the Engineer for the preparation of the structure or embankment foundation as required, and at the expense of the Contractor.

3.6. ROCK EXCAVATION

Rock excavation shall be performed with heavy percussion tools complete with rock bits, or by hydraulic wedges, blasting or other specific methods for rock excavation.

Except as may be specifically approved by the Employer or the Engineer in writing, the Contractor shall not use explosives in the execution of any of the works under the Contract.

When required by the Engineer, concrete structure foundation shall be finished using hand tools for the last 25 cm.

3.7. EXCAVATION IN BORROW AREAS

1. At least two weeks before any borrow area is opened the Contractor shall submit to the Engineer a plan of operations for the working of the area and he shall not exploit the area until the Engineer has given his approval.
2. All material obtained from borrow areas for use in the permanent works shall be tested by the Contractor and approved by the Engineer.
3. At any time during the exploitation of a borrow area, the Engineer may withdraw approval for the continued utilization of that borrow area.

3.8. EXCAVATION IN QUARRIES

1. At least two weeks before a quarry is opened, the Contractor shall submit to the Engineer a plan of operations for the working of the area and he shall not exploit it until the Engineer has given his approval.
2. All materials from quarries for use in the permanent works shall be tested by the Contractor as described in these specifications and approved by the Engineer.

3.9. TRENCH EXCAVATIONS

Trenches must be sufficiently wide at all points to lay pipes or ducts and carry out backfilling operations around them. Unless otherwise shown on the Drawings or directed or approved by the Engineer, the bottom width of the trench in metres shall not be less than:

- $1.2 D + 0.70$ for one pipe, and

- $n (D+0.50) + 0.70$ for n pipes of the same type for same network in one trench

in which D = outer diameter of the pipe in metres.

[Note Laying of pipes for different types of network (e.g. stormwater, water supply, etc.) in the same trench will not be permitted.]

- $3 \times n \times D$ for one or more ducts

in which n = number of ducts and D = widest outer diameter of the ducts in metres.

The bottom of the trenches shall be excavated to and levelled at least 0.10 m below the level planned for the outer invert of the pipes. If there are any rocks projecting above this level, they shall be completely excavated and the corresponding cavities filled in if necessary.

Trenches for welded steel pipes shall include recesses for joints. These recesses shall be at least 1 m wide on either side of the trench edge.

The normal depth of the trenches shall be such that the thickness of fill above the outer soffit of the pipe shall not be less than 0.80 m.

The Contractor shall take all necessary measures to avoid cave-ins and ensure safety for staff, if necessary by sloping, shoring, planking or reinforcing the sides of the excavation using all means suited to the nature of the soil and as approved by the Engineer.

All trench excavation for installation of pipework (or other work) of depths greater than 1.5 metres must be continuously supervised by a suitably qualified officer.

Excavated material shall not be deposited less than 3 m from the edge of any trench.

The Contractor shall excavate trenches in such a way that, where required, the pipes installed by the Contractor can be connected to existing pipes previously installed by the Owner.

3.10. DISPOSAL OF EXCAVATED MATERIALS

All excavated materials shall remain the property of the Employer and shall not be used in the works or disposed of without the prior approval of the Engineer.

Excavated material shall be stockpiled or disposed of in disposal areas within the Site as indicated on the Drawings or directed by the Engineer regardless of distance.

Disposal areas shall be well drained and left in tidy, safe and stable conditions.

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

All surplus or unsuitable excavated materials shall be disposed to spoil banks at locations shown on the Drawings or approved by the Engineer subject to the following conditions:

- ☐ all necessary measures shall be taken not to obstruct natural drainage courses with the spoil banks;
- ☐ suitable slopes shall be given to the surface to ensure drainage;
- ☐ maximum heights shall be as determined by the Engineer.

3.11. PREPARATION OF EXCAVATED SURFACES

1. Common excavations for foundations

The surface shall be cleaned of all loose material.

The foundation shall be compacted if necessary to a depth of 0.20 m to a minimum dry density of 95% of the Maximum Dry Density according to the standard proctor test (NF P 94 093).

For foundation on gravel materials, the in situ foundation material to depth 0.20 m shall be compacted in such a manner as to achieve a uniform density throughout of 80% of the relative density.

The surface shall be free from standing or running water.

Where the ground surface under any compacted embankment or structure is not suitable, as determined by the Engineer, after the required excavation or removal of top soil, the Contractor shall further remove the unsuitable material to such depth and in such area as may be directed.

The foundation just after compaction shall receive a layer of blinding concrete.

2. Rock excavations for foundations

After completion of the excavations and other required works, the following operations shall be carried out where relevant.

A first cleaning shall be carried out to allow a geological examination of the foundation surface and to define possible treatment if required.

Any degraded or weathered material located beyond the theoretical excavation lines shall be removed. This includes materials in cracks, seams, faults and cavities, which shall be removed by using hand tools or compressed air water jet to a depth where sound materials is encountered or until the depth cleaned out is at least four times the width of the surface opening.

Rock surfaces shall be thoroughly cleaned by the use of high pressure water air jet. Brushing shall be employed if appropriate and required by the Engineer.

After having been cleaned out, cracks, seams, faults cavities, trenches or pits in rock surfaces shall be filled with concrete, or cement slurry as required or agreed by the Engineer.

After acceptance by the Engineer, a final cleaning of rock surfaces in foundations to structures shall be made not more than 24 hours before concreting and the rock shall be kept wet and protected from the sun up to the time of placement of blinding concrete or structural concrete as the case may be.

3.12. POSSIBLE DMOLITION OF BURIED STRUCTURES.

If masonry or concrete structures are encountered during excavation works, the Contractor shall first inform the Engineer then proceed with the demolition, removal, transport and disposal of the materials as approved by the Engineer. Unless otherwise approved or directed by the Engineer, such material shall be treated as rock for purposes of payment and the required works shall not give the Contractor right to any additional payments.

3.13. RESTORATION OF BORROW AREAS AND QUARRIES

At the end of works, all borrow areas and quarries shall be left in safe conditions as approved by the Engineer.

The surface of borrow areas shall be left in a reasonably smooth and even condition as approved by the Engineer.

Borrow areas shall be drained by the means of open ditches where necessary to prevent the accumulation of standing water.

3.14. SPECIAL REQUIREMENTS

1. Bottom of excavation

Any local pockets of materials that are more compressible than the bottom of the excavation in general shall be removed and replaced by similar material compacted to similar compressibility to that of the sound earth at the same depth.

In particular, before blinding concrete is placed, the bottom of excavations must be carefully inspected in order to check the quality of the foundation.

2. Excavations at the foot of slopes

Care must be taken when excavating at the foot of slopes so as to avoid causing any instability or movement of the slope.

3. Acceptance of excavations for structures

A band of at least 0.80m in width outside the specified limits shall be provided for formworks in excavations for structures.

In the case of foundations to structures the Contractor shall supply the Engineer with:

- working drawings for the excavations and associated earthworks in conformity with the approved design Drawings including tolerances in compliance with Clause 1.7 of this Section,
- bearing capacity checked by plate bearing tests (1 test for 250m² of excavation), EV1 and EV2 being the deformation moduli according to the procedure of LCPC-CT2: $EV2/EV1 < 2$ with $EV2 > 50$ MPa, Westergaard's modulus: $K > 50$ MPa/m.

3.15. KEEPING EXCAVATIONS DRY DURING WORKS

1. General

Except for any special dispensations which might be granted by the Engineer, the Contractor shall protect the excavations from water, at his own expense, so that the works can be performed in dry conditions.

The method used to drain water from the excavation shall be the responsibility of the Contractor and shall be submitted for the Engineer's approval, including, where requested by the Engineer, the recommendations of a geotechnical specialist where the stability of the ground may be involved.

2. Runoff outside the site

The crest of the excavations shall be surrounded by surface interception drains to collect runoff outside the excavation and evacuate it at a suitable distance from the excavations.

3. Water from the walls and bottom of excavations

Any seepage from the walls and bottom of excavations shall be blocked off or intercepted and diverted at the source. The measures used for this purpose shall not cause soil erosion or subsidence.

During the works, the Contractor must ensure that the dumping of excavated material and the circulation of machines do not cause landslips.

4. Water collection and pump sumps

If, because of the site layout, water in the excavations cannot be evacuated by gravity, the water shall be collected in a sump from which it can be pumped. The Contractor shall take all the necessary precautions to prevent wash out of fines.

5. Dewatering or water table drawdown

The Contractor shall take all necessary precautions so as to avoid effects of water table drawdown on existing structures and excavations (stability, wash out of fines, etc.).

Before any operation involving water table drawdown, the Contractor shall submit to the Engineer calculations and notes related to the dewatering measures as established by a

geotechnical specialist, as well as the precautionary measures taken for the existing structures.

oOo

SECTION 02220

EMBANKMENTS, FILLS AND BACKFILLS

1. GENERAL

1.1. WORK INCLUDED

This section covers all operations in connection with:

1. Backfill around all structures.
2. All embankments
3. Road embankments.
4. Backfill of trenches.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DESCRIPTION

1. Fills and backfills works as specified under this Section shall include filling or backfilling with materials approved by the Engineer and built up in horizontal layers, the thickness of which shall be determined according to trials carried out by the Contractor before the beginning of any filling work.

1.4. REFERENCES

1. BS 1377:1990 Methods of test for soils for civil engineering purposes
2. ASTM: American Society for Testing and Materials.
3. USBR: Earth Manual of "Bureau of Reclamation"
US Department of the Interior.

1.5. SUBMITTALS

1. A mass haul diagram shall be submitted to the Engineer in the form and following the description given in Section 02210 "Open air excavations".

This mass haul diagram shall be drafted and submitted together with the general mass haul diagram of Section 02210.

2. At least one month before starting the filling operations, the Contractor shall submit a complete programme showing the proposed filling program including quantities and origin of materials.
3. At least one month before starting the filling operations, the Contractor shall submit to the Engineer a detailed method statement covering the filling operations and material placement.
4. On a weekly basis, the Contractor shall submit to the Engineer summary sheets giving the results of all controls performed during the week on a format to be agreed with the Engineer.
5. The Contractor shall provide the Engineer each day with one copy of the record for the previous day's work for all fill work including:
 - a) quantities of materials placed with their type,
 - b) location of the material placed,
 - c) number and classification of men and plants engaged,
 - d) weather during the day,
 - e) inflows of water or any other unusual occurrence.

1.6. TOLERANCES

1. All fill and backfill shall be constructed to the lines and dimensions shown on the Drawings or as required by the Engineer.
2. For compacted fill and backfill, the following tolerances shall be required unless otherwise shown on the Drawings or ordered by the Engineer:
 - level (vertical) = ... +0, -5 cm,
 - dimension (horizontal) = ... +15, -0 cm (on the dimension of fill).

1.7. CONTROLS

1. All the controls required in the present Specification shall be performed in the Contractor's laboratory or in a laboratory he will have chosen with the agreement of the Engineer.

2. PRODUCT

2.1. GENERAL

1. Fill and backfill materials shall be derived as much as possible, from required excavations for permanent works to be constructed under the Contract, or from designated on-site borrow areas and quarries, subject to their compliance with the relevant Specifications and approval of the Engineer. Where quantities are insufficient or available materials do not

comply with the Specifications materials shall be obtained by the Contractor from external sources approved by the Engineer.

2. All fill and backfill materials shall be “well graded” in terms of particle size distribution in accordance with the relevant EN, BS, ASTM, USC classification systems.
3. All materials as specified hereinafter shall be subject to the prior approval of the Engineer

2.2. SELECTED COMPACTED FILL

The material shall comply with the following requirements:

- D max = 100 mm.
- Organic matter content < 0.1%.
- Fraction passing 0.074 mm standard sieve (square openings) between 5 and 15%.
- Plasticity index IP ≤ 15.

2.3. GRAVEL 20-40 MM

The material shall comply with the following requirements:

- D maxi = 40 mm.
- D min = 20 mm.
- Organic matter content < 0.1%.

2.4. GRAVEL 50-100 MM

The material shall comply with the following requirements:

- D maxi = 100 mm.
- D min = 50 mm.
- Organic matter content < 0.1%.

2.5. SELECTED COMPACTED ROCKFILL

The material shall comply with the following requirements:

- D max = 200 mm.
- Organic matter content < 0.1%.
- Fraction passing 0.074 mm standard sieve (square openings) between 0 and 5%.

2.6. RANDOM COMPACTED FILL

The material shall comply with the following requirements:

- D max = 800 mm.
- Organic matter content < 0.1%.
- Fraction passing 0.074 mm standard sieve (square openings) between 0 and 5%.
- Maximum particle size of the top layer of embankment shall be 250mm.

2.7. SMALL FILL

The material shall comply with the following requirements:

- D max = 20 mm.
- Gypsum content < 2%.
- CBR test (at 95% of modified Proctor test): > 80.
- Sand equivalent: $40 < SE < 60$.

2.8. SAND LAYER

The material shall comply with the following requirements:

- D max = 4 mm.
- Fraction passing 0.074 mm standard sieve (square openings): $\leq 5\%$.
- Plasticity index: < 6.

3. EXECUTION

3.1. INSPECTION

Before the commencement of any fill works the site shall be surveyed by the Contractor in conjunction with the Engineer's Representative to establish a record of existing ground levels and/or excavated ground levels and these agreed ground levels shall, when required, form the basis for the calculation of quantities of any subsequent filling.

No fill shall be placed in any section of the Works until the foundation has been inspected and approved by the Engineer.

Placing of any fill layer shall not be done until the preceding layer has been inspected and accepted by the Engineer.

3.2. GENERAL

All fill and backfill operations shall be performed in the dry.

Prior to the commencement of placing backfill materials adjacent to structures, the backfill areas shall be cleared of all remaining concrete forms, other temporary works and unsuitable materials, and shall be subject to the approval of the Engineer.

The backfill materials shall be placed in such manner as to ensure that they can be satisfactorily compacted without damage to the structure.

The sequence of filling behind or around a structure and the maximum difference in height at any time between fill levels shall be approved by the Engineer.

Filling around structure is permitted only if the structure is completely achieved, or if the unachieved part is not necessary to handle earth pressure. In all cases, approbation of the Engineer is required before filling around any structure.

Filling around liquid retaining structure shall begin only after validation of watertightness tests.

Sheeting and timbering supporting the excavations shall be removed, step by step, to prevent any settlement.

Where instructed by the Engineer, timbering and sheeting shall be left in place.

Unless otherwise directed by the Engineer, backfill material shall not be placed and compaction shall not be permitted adjacent to concrete for 14 days after the placing of concrete, and compaction of backfill material placed above buried concrete shall not be permitted to be carried out with vibrating rollers within 100 cm vertically of the surface of the concrete.

Where instructed, selected granular fill material approved by the Engineer shall be placed around the structure.

A special care shall be given to compaction along concrete structures and at all locations where easy access is not possible. At these locations all the required criteria for each type of fill shall be fulfilled.

3.3. SELECTED COMPACTED FILL

1. Placing and compaction

Selected compacted fill shall be placed in layers not exceeding 250 mm and at least 1.5 time D_{maximum} .

Each layer shall be compacted by means of a vibrating smooth drum roller or vibrating plate so as to achieve a dry density:

$$DC = \frac{\gamma_d}{\gamma_{d_{\text{max}}}} \geq 95\%$$

with:

γ_d = field dry density;

$\gamma_{d_{\text{max}}}$ = Standard Proctor maximum dry density in accordance with ASTM D698.

2. Placement moisture content of the material shall be so that:

$$-2 < w - w_{\text{opt}} < +2$$

with:

w: placement moisture content measured on the compacted layer;

w_{opt} : optimum moisture content of the Standard Proctor compaction test in accordance with ASTM D698.

3. Test Pad

Prior to the commencement of Contract Earthworks on site, the Contractor shall propose a methodology for the Compaction of soils in accordance with the requirements of this Specification, for approval by the Engineer.

The Contractor shall demonstrate their methodology consistently achieves the requirements of the Specification by constructing a number of test pads (minimum 20m dimension) and recording the layer thickness, any required drying or moisture conditioning, applicable construction plant (eg 10t vibrating sheeps foot roller) and required number of passes.

The Contractor shall undertake in situ field density tests (and permeability tests as appropriate) in accordance with the testing requirements of this Specification, sufficient to satisfy the Engineer that the required material parameters are achieved.

4. Control

Two controls shall be made on the first layer placed in order to determine the suitability of the equipment used and the number of passes.

If changes occur in the nature or the origin of the fill material used during the works or at the request of the Engineer, new tests shall be performed.

A minimum of one control every 250m³ of material placed shall be performed.

Final acceptance of materials shall only be made after they have been placed, spread and compacted.

3.4. BACKFILLING OF TRENCHES

1. General

Every section of the pipeline shall be covered as soon as possible after being lowered into the trench, but no section of the line shall be covered without pipe surveying and express approval of the Engineer.

Each section shall be backfilled after the pipe has been placed in its final position in the trench and after all welded joints and bends have been coated and all defects in the pipe coating repaired.

Backfilling shall be done carefully to prevent displacement of the pipes or injury to the pipes and their coating. The backfill material shall completely fill the entire space between the pipe and the trench sides, without leaving any voids.

Care shall be taken that the backfill material does not contain any electrodes, scrap iron, fragments of timber or shrubs, roots, broken skids, tyres, ashes, refuse, oil or soil soaked with oil. Stones removed during trench excavation may be used in the second stage of backfilling as specified herein.

On hillsides or sloping ground, furrows or terraces shall be provided across the pipeline trench to direct the flow of rainwater into the natural drain courses and away from the pipeline trench.

2. Sand layer placement

In all cases and for all types of pipe, a “Sand layer” as described hereinbefore of at least 10cm in thickness shall be laid under the pipe.

3. Small fill placement

The backfill around and up to 40cm above the pipes shall be in accordance with “Small fill” materials as described hereinbefore, placed, compacted and controlled as described in paragraph 3.3.

4. Selected compacted fill placement

Above the “small fill” layer and except otherwise shown on drawings or directed by the Engineer, trenches shall be backfilled using “Selected compacted fill” materials as described hereinbefore, placed, compacted and controlled as described in paragraph 3.3.

SECTION 02232

ROADS

1. GENERAL

1.1. WORK INCLUDED

Roads and related works inside the project boundaries.

The Contractor shall be responsible of the design, the construction, the maintenance and reinstatement of the various access roads to the Site Works.

The Contractor shall in consequence take all necessary arrangements to build the access roads in accordance with local Standards and Regulations.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. STANDARDS AND REGULATIONS

AASHTO	Standard Specifications for Highway Bridges
BS 434 Part 1	Bitumen road emulsions
BS 594	Hot rolled asphalt for roads and other paved areas
BS 598	Sampling and examination of bituminous mixtures for roads and other paved areas
BS 812	Testing aggregates
BS 1377	Methods of test for soils for civil engineering purposes.
BS 4987	Coated macadam for roads and other paved areas
NF P 18561	Aggregates – Measurement of the flakiness index
ASTM Standards as referenced throughout this Section	

1.4. SUBMITTALS

All documents concerning the quality of materials and all the results of routine tests prescribed in the present Section shall be submitted to the Engineer, at the frequency and on the form agreed at the start of the Works.

1.5. TOLERANCES

The surface at each stage during the construction of the roads shall comply with the requirements set out below.

« Specified level » shall be the level shown on the Drawings, or deduced by reference to the finished road level and minimum layer thicknesses.

« Smoothness » shall be measured as the maximum gap beneath a 3.0 m long straight-edge used longitudinally or beneath a template, to suit the specified camber shape of the road, used transversely.

Surface	Tolerance from specified level (mm)	Smoothness (mm)
Sub-grade (formation)	+0 to -25	-
Sub-base course	+0 to -25	-
Base course	+5 to -10	10
Wearing course	+5 to -5	5

In addition, the wearing course shall have no backfall from any drainage point.

Immediately before the construction of any layer, the surface on which it is to be laid shall be tested for accuracy of formation and smoothness, and if any areas are found to be outside the specified tolerances such areas shall be scarified, reshaped, recompact, broken out and replaced, or otherwise treated until the specified smoothness and accuracy are obtained.

Notwithstanding the above requirements, no layer of road construction shall have a thickness less than the thickness shown on Drawings.

2. PRODUCTS

2.1. GENERAL

Fill and backfill shall come, as much as possible, from excavations of nearby structures.

All the hereafter materials shall have the prior agreement of the Engineer.

2.2. GENERAL FILL

The material shall comply with the following requirements:

- Maximum diameter: 200 mm
- Fraction passing 0.074 mm sieve (square opening) $\leq 15\%$
- Plasticity index ≤ 15
- Organic matter content $< 0.1\%$

2.3. SUB-BASE COURSE

It shall be approved material reasonably “well graded” in terms of particle size distribution, complying with the following requirements:

- Maximum diameter: 50 mm.
- Plasticity Index: ≤ 15 .
- Californian Bearing Ratio $\geq 25\%$ at 95% of Proctor optimum density.
- Los Angeles Abrasion Test of mineral aggregates $\geq 2.36\text{mm}$ (BS sieve):..... ≤ 30 .
- Organic matter content $\leq 0.1\%$.

2.4. BASE COURSE

Base course material may be either naturally occurring sound hard gravels or crushed rock obtained from quarries.

The material shall comply with the following grading requirements:

Material size (in millimetres) (square openings)	Per cent finer by weight
20	100
10	50 - 80
5	30 - 60
2	20 - 40
0.2	5 - 20
0.075	2 - 15

In addition, the material shall meet the following test requirements:

- Dry density: $\geq 17.5 \text{ kN/m}^3$.
- Plasticity Index: $6 \leq IP \leq 15$.
- California Bearing Ratio: $\geq 80\%$ at 95% of Proctor optimum density.
- Los Angeles Abrasion Test: ≤ 30 .
- Organic matter content:..... $< 0.1\%$.

Where graded crushed stones are used, the following requirements shall be added:

- Flakiness index (BS EN 933-3:2012) ≤ 30 .

2.5. AGGREGATES FOR READY MIX ASPHALT-CONCRETE WEARING COURSE

The aggregate shall be of crushed gravel conforming to the following gradation:

Sieve size	Per cent passing
25.0 mm	100
20.0 mm	85 - 100
5.0 mm	45 - 65
2.5 mm	30 - 50
315 microns	12 - 23
80 microns	4 - 8

The portion of the total aggregate passing the 400 micron sieve shall have a plasticity index of not more than 6.

2.6. MINERAL FILLER

Mineral filler when separately supplied from an external source shall consist of finely ground mineral matter such as rock dust, hydrated lime, cement or other material which can satisfy the Engineer will produce asphalt mixes of at least equal quality. It shall be free from organic substances and clay, shall be thoroughly dry and free from agglomerations, shall be non-plastic and shall meet the following grading requirements:

<u>BS Sieve (mm)</u>	<u>% Mass Passing</u>
0.600	100
0.300	95-100
0.150	90-100
0.075	70-100

Hydrated lime shall conform to the definitions given in ASTM C51. Sampling, packaging and marking of hydrated lime shall be in accordance with ASTM C50. Storage and use of the hydrated lime shall at all times be such as to protect the material from the weather.

When cement is used as mineral filler, it shall meet the requirements of BS 12.

2.7. BITUMEN

The bitumen specified for use in the asphalt mixes shall be 60-70 penetration grade in accordance with BS 3690 and shall only be obtained from approved sources.

The bitumen shall be prepared by the refining of petroleum. It shall be uniform in character and shall not foam when heated to 175°C. Blending of bitumen materials from different refineries will be permitted only with the written approval of the Engineer.

2.8. TACK COAT

Emulsified asphalt for use in asphalt works shall comply with BS 434: Part 1 class K1-40.

Alternatively emulsified asphalt for use in asphalt works may be CSS-lh or CRS-2 cationic emulsified asphalt in accordance with AASHTO M 208 or SS-lh anionic emulsified asphalt in accordance with AASHTO M 140 unless otherwise designated.

Emulsified asphalt shall be of the slow-setting cationic or anionic type of the CSS-lh or SS-lh grades respectively and shall conform to the designated requirements.

2.9. CONTROLS

The frequency of the tests shall be as required by the Engineer according to the results of previous tests and material variations.

3. EXECUTION

3.1. INSPECTION

No excavation and fill operations shall start without prior agreement of the Engineer.

3.2. GENERAL

All excavation and fill operations shall be performed in accordance with Sections 02210 and 02220 of the Technical Specifications.

3.3. SUB-GRADE PREPARATION

Prior to receiving the base course or sub-base course, the sub-grade shall be graded to the lines and levels shown in the Contractor's approved drawings and the surface shaped to the same profile as the finished surface of the road.

Once the required level is obtained, the sub-grade material shall be compacted to a depth of 300 mm minimum, up to a minimum of 95% of the Maximum Dry Density in accordance with ASTM D698.

Compaction shall be achieved by means of a smooth drum vibrating roller with the following minimum characteristics:

- Minimum static weight 8t
- Drum diameter not less than 1500 mm
- Minimum static weight per metre of drum 3.5t

The number of passes shall be adapted to the material.

- All soft areas shall be cut out and filled with approved material brought to the correct level after compaction.
- The Contractor shall perform all relevant tests in order to prove that compaction depth can be reached as required.

3.4. SUB-BASE COURSE

The sub-base course shall be of a total thickness not less than 300mm in every point.

The sub-base course material shall be spread longitudinally in uniform layers not exceeding 150 mm loose thickness.

Each layer shall be compacted to the following standards:

- a. Dry density:

$$DC = \frac{\gamma_d}{\gamma_{d_{\max}}} \geq 95\%$$

with:

γ_d = field dry density

γ_{dmax} = Standard Proctor maximum dry density in accordance with ASTM D698.

b. Placement moisture content:

$$-2 \leq w - w_{opt} \leq 2$$

with:

w : placement moisture content measured on the compacted layer;

w_{opt} : optimum moisture content of the Standard Proctor compaction test in accordance with ASTM D698.

CBR $\geq$ 25% shall be achieved for the sub-base course to be approved.

3.5. BASE COURSE

The sub-base course shall be of a total thickness not less than 200mm in every point.

The Contractor may propose to add cement to the base course material, in order to:

- reduce moisture content of the material;
- improve the characteristics of the base course and thus diminish the quantities used and/or diminish the maintenance.

The base course material shall be spread longitudinally in uniform layers not exceeding 200 mm loose thickness.

Each layer shall be compacted to the following standards:

a. Dry density:

with:

γ_d = field dry density

γ_{dmax} = Standard Proctor maximum dry density in accordance with ASTM D698

b. Placement moisture content:

$$-2 \leq w - w_{opt} \leq 2$$

with:

w : placement moisture content measured on the compacted layer;

w_{opt} : optimum moisture content of the Standard Proctor compaction test in accordance with ASTM D698.

CBR $\geq$ 80% shall be achieved for the base course to be approved.

3.6. TACK COAT

a. General

This work shall consist of furnishing and applying diluted emulsified asphalt to the previously prepared road base surface, to provide bond for the superimposed wearing course to the full designated width.

Tack coat shall not be applied during rain, fog, dust storms or other unsuitable weather, unless otherwise directed by the Engineer.

Tack coat shall not be applied when the air temperature at the surface on which it is laid is below 10 °C, nor when the wind speed at any temperature exceeds 40 km/h at 2m height unless specifically approved by the engineer.

b. Equipment Required

The equipment used by the Contractor shall include a pressure type asphalt distributor as well as a power broom and a power blower. In addition, the Contractor shall supply and use efficient and approved equipment for diluting the emulsified asphalt with water.

c. Surface Preparation

The full width of the surface to be treated shall be cleaned with a power broom or power blower to remove dust, dirt or other objectionable materials. All faulty or unsuitable patches, excess cracks or joint filler and all surplus bituminous material shall be corrected in accordance with the instructions of the Engineer. The surface shall be dry when treated.

d. Application

Immediately after cleaning the surface, the tack coat shall be applied by means of the distributor in accordance with the respective specification, or as directed by the engineer.

Hand spraying of restricted, inaccessible areas is permitted, subject to the approval of the Engineer.

The diluted emulsion shall be applied at a rate between 0.15 to 0.38 kg/m² as specified by the Engineer. The Contractor shall ensure that excessive application of tack coat is avoided.

The application temperature for the diluted emulsified asphalt shall be between 10 °C and 60 °C as directed by the Engineer.

The surface of structures, kerbstones and other fixed objects adjacent to areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

e. Maintenance and Traffic

After application, the surface shall be allowed to dry until it is in a proper condition of tackiness to receive the superimposed wearing course. Tack coat shall be applied only so far in advance of the superimposed course placement as is necessary to obtain this proper condition of tackiness.

Until the superimposed course is placed, the Contractor shall protect the tack coat from damage.

If the tack coat is unavoidably damaged by rain or dust, it shall be allowed to dry, shall be cleaned again by a power broom or power blower and, if required by the Engineer, a

subsequent light application of tack applied to the surface. Where, in the opinion of the Engineer, a tack coat is not necessary between layers of freshly placed courses, he may give instructions in writing to omit the tack coat. Any cleaning required in these areas shall be carried out before the application of the next course.

3.7. ASPHALT-CONCRETE ROADS

Where shown on Drawings or as directed by the Engineer, the roads and platforms shall be built according to the drawings and the following specifications:

1. A 60 mm wearing course shall be made of a ready mix asphalt-concrete spread with a grader or finisher and then compacted; the wearing course shall have the following characteristics:
 - a) Aggregates as specified in section 2.
 - b) Content of asphalt of penetration grade 60/70 (in accordance with ASTM D946) shall be between 4 and 6 percent.
 - c) Marshall Stability test (ASTM D1559) shall not be less than 10 kilonewtons and the flow value less than 4 mm.
 - d) Degree of compaction not less than 97 percent of the Standard Specimen Specific Gravity (ASTM D1074).

3.7.1. HAULING EQUIPMENT

Vehicles used for the transport of aggregates or bituminous mix shall have tight, clean and smooth insulated metal beds and shall be free from dust, screenings, petroleum oil and volatile or other mineral spirits which may affect the material being hauled. The vehicle metal bed shall, if required, be sprayed with a minimum amount of soapy water or lime solution to prevent the bituminous mix from adhering to the bed. After spraying, the truck shall be raised and thoroughly drained and no excess solution shall be permitted. Use of diesel or other solvents to spray in the truck bed is prohibited.

Provision shall be made for covering truck loads with canvas or other suitable material of such size that the bituminous mix is fully covered.

Any truck causing excessive segregation of material by its spring suspension or other contributing factors, or that shows oil leaks in detrimental amounts, or that causes undue delays, shall, upon the instruction of the Engineer, be removed from the work until such faults are corrected.

End dump trucks shall be equipped with chains on the tail gates for control when dumping the mix into the paving machine. Hauling trucks shall not be routed over wet or muddy access ways such that tyres accumulate dirt that is deposited on the laying surface.

The Contractor shall provide an adequate number of trucks of such size, speed and condition to ensure orderly and continuous progress of the work all to the approval of the Engineer.

3.7.2. OTHER EQUIPMENT

a. Spreading and Finishing Equipment

The asphaltic mixture shall be fed to the paver by end tipping of the truck or by means of a windrow elevator. The equipment for spreading and finishing the asphaltic mixtures shall be of an approved mechanical, self-powered electronic controlled floating screed type, capable of spreading and finishing the mixture true to line, grade and required crown.

The pavers shall be self propelled and equipped with hoppers and distributing screws of the reversing type to place the mixture uniformly in front of adjustable electronic controlled screeds. The pavers shall be so designed to allow a minimum paving width of 2 m, although paving in widths of less than 3 m will require the approval of the Engineer.

Pavers shall be equipped with such provisions and attachments to suit paving widths specified for road widening as well as to suit paving on sloped sections. They shall be equipped with fast and efficient steering devices and shall have reverse as well as forward travelling speeds. The operational speed of the pavers shall be adjustable from 3 to 6 m/min in accordance with the instructions of the Engineer.

The pavers shall employ mechanical devices as equalising runners, straight edge runners, eveners or other compensating devices to maintain trueness of grade and to confine the edges of the pavement to true lines without the use of stationary side forms. The equipment shall include blending or joint levelling devices for smoothing and adjusting longitudinal joints between lanes. The assembly shall be designed and operated in such a manner that it will place the material at the required compacted thickness.

Electronic screeds shall include automatic feed controls to maintain a constant level of material along the full length of the screed, automatic grade control and automatic slope control. The grade controller shall be activated by a travelling, articulated averaging beam not less than 9 m in length. The automatic slope control shall be equipped with a proportioning manual override to enable smooth transition of changing slope rate. Automatic screed controls shall be approved by the Engineer before use.

Screeds shall be provided with devices for heating the screeds to the temperature required for the laying of the mixture without pulling or marring. Pavers shall also be provided with the standard attachable screed extensions. All screeds shall be of the vibrating type that permit material to be tamped into position.

The term "screed" includes any cutting, crowning or other physical action that is effective in producing a finished surface of the evenness and texture specified, without tearing, shoving, or gouging.

If, during construction, it is found that the spreading and finishing equipment in operation leaves in the pavement surface tracks or indented areas or other objectionable irregularities that are not satisfactorily corrected by scheduled operations, the use of such equipment shall be discontinued and other satisfactory spreading and finishing equipment shall be provided by the Contractor.

b. Rolling Equipment

Rolling equipment shall consist of vibratory steel-wheeled rollers, dead weight steel-wheeled rollers and pneumatic-tyred rollers as required for proper compaction and finishing of the asphalt surface. Unless otherwise permitted, rollers shall be equipped with reversible or dual controls to allow operation both forward and backward with the operator always facing in the direction of movement.

Steel-wheeled rollers shall be two-axle tandem rollers or three-axle tandem rollers. These rollers shall be self-propelled and equipped with power units of not less than four cylinders and under working conditions shall develop contact pressures under the compression wheels of 45 to 65 kg/cm of width. Each two-axle roller shall have a minimum weight of 10,000 kg each and three-axle roller shall have a minimum weight of 13,000 kg. Vibrating steel-wheeled rollers shall have dual drums with a minimum weight of 7000 kg. Vibrating frequency shall be between 2000 and 3000 cycles per minute with individual controls for each tandem drum. Rollers shall be in good working condition and shall be equipped with a reversing clutch. Rollers shall be equipped with adjustable scrapers to keep the wheel surface clean and with efficient means of keeping them wet to prevent mixes from sticking. These surfaces shall have no flat areas or projections which will mark the surface of the asphalt courses. The three-axle rollers shall be equipped with a centre axle which may be operated either fixed or floating. The three-axle tandem roller shall be so constructed that when locked in a position for all treads to be in one plane, the roller wheels are held with such rigidity that, if either front or centre wheel is unsupported the other two wheels will not vary from the plane by more than 6 mm. All steel-wheeled rollers shall be in good condition and the Contractor shall furnish to the Engineer the manufacturer's technical data for each roller and no roller shall be used except after approval of the Engineer.

Pneumatic-tyred rollers shall be self-propelled. The rollers shall be equipped with pneumatic tyres of equal size and diameter which are capable of exerting varying average contact pressure. Pneumatic-tyred rollers shall be in good condition and with enough ballast space to provide uniform wheel loading as may be required. The Contractor shall furnish to the Engineer charts or tabulations showing the contact areas and contact pressures for the full range of tyre inflation pressures and for the full range of tyre loading for each type and size compactor tyre furnished and used in pneumatic-tyred rollers. The total operating weight and tyre pressure may be varied by the order of the Engineer to obtain contact pressures which will result in the required asphalt course density.

c. Liquid Bitumen Distributor

The liquid bitumen distributor truck shall be of the pressure type with insulated tanks. The use of gravity distributors will not be permitted. The distributor shall have pneumatic tyres of such width and number that the load produced on the road surface shall not exceed 100 kg/cm tyre width.

Spray bars shall have a minimum length of 2.4 m and shall be of the full circulating type. Spray bar extensions shall also be of the full circulating type. The spray bar shall be adjustable to maintain a constant height above the surface to be treated.

The spray bar nozzles shall be slotted and shall be of such design so as to provide a uniform unbroken spread of bituminous material on the surface. The valves shall be operated by levers so that one or all valves may be quickly opened or closed in one operation. The distributor shall be equipped with a hose and nozzle attachment to be used for spotting areas inaccessible to the distributor. The distributor and booster tanks shall be so maintained at all times as to prevent dripping of bituminous material from any part of the equipment.

The distributor shall be equipped with devices and charts to provide for accurate and rapid determination and control of the amount of bituminous material being applied and with a tachometer of the auxiliary wheel type reading speed in m/min. The spreading equipment shall be provided with a separate power unit for the pump or a variable displacement pump driven by a hydrostatic transmission so that a uniform application of bituminous material, in controlled amounts, may be made ranging from 0.15 to 5.0 kg/m². The distributor shall have satisfactory heating equipment and thermometers in order to provide the full range of application temperatures for the bituminous material being used.

Before commencing the work and as required by the Engineer, the liquid bitumen distributor shall be checked and calibrated such that the rate of transverse spread or longitudinal spread shall not vary more than 10 % from the required rate of application.

3.7.3. PRODUCTION OF ASPHALTIC CONCRETE WEARING COURSES

a. Weather Limitations

Production and spreading of asphaltic Concrete mix shall not be permitted when the ambient temperature is less than 8 °C, nor during rain, fog, dust-storms or other unsuitable weather.

b. Equipment Required

The equipment required for construction of the asphaltic concrete courses shall include but not be limited to the equipment mentioned in Clauses hereinbefore, together with such miscellaneous equipment and tools as required for the satisfactory preparation and performance of the work.

All equipment shall be checked, calibrated and approved by the Engineer before use. The equipment shall be satisfactorily maintained and shall be used in an approved manner.

Adequate equipment and labour shall be used so that there is continual production and distribution of the asphalt course being constructed.

c. Survey and Preparation

The area to be paved shall be true to line and grade and shall have a properly prepared surface before the start of paving operations.

When an asphaltic concrete pavement course is to be placed on top of an existing pavement, the existing pavement surface shall be prepared as designated by the Engineer.

Priming or tacking of surfaces to be paved shall be carried out as designated.

The surface of kerbs, vertical faces of existing pavements and all structures in actual contact with asphalt mixes shall be painted with a thin and complete coating of tack coat as instructed by the Engineer to provide a closely bonded, watertight joint.

All openings or structures in the road for water, drainage and other specified utilities shall be constructed and their positions and levels determined before the start of paving operations.

d. Heating of Bitumen

The 60/70 penetration grade bitumen shall be heated to a temperature of between 150 to 165 degrees centigrade.

Bitumen of other penetration grade shall be heated to yield viscosity's in the range of 150 to 300 centistokes (175 to 150 seconds Saybolt-Furol) when delivered to the mixer, as determined from the Temperature Viscosity Chart of the product used.

Bitumen shall not be used if foaming occurs or shall it be heated above 177 °C at any time.

e. Heating of Mineral Aggregate

When using 60/70 penetration bitumen the materials shall be thoroughly dried and heated so that their temperature is 165 to 180 degrees centigrade.

When using bitumen of other penetration grade the materials shall be thoroughly dried and heated so that their temperature is within ± 8 °C of the temperature needed to satisfy the viscosity requirements of the asphalt cement.

In no case shall the materials be introduced into the pugmill with a temperature, including the 8 °C tolerance permitted, of more than that at which the bitumen has a viscosity of 75 seconds Saybolt-Furol.

The moisture content of the heated and dried materials shall not exceed 1%.

The quantity of materials fed through the drier shall in all cases be held to an amount which can be thoroughly dried and heated within the limits specified.

The heated materials shall be screened into sizes such that they may be combined into a gradation meeting the requirements of the Job Mix Formula and the hot aggregate storage bins shall be such as to minimise segregation and loss of temperature of aggregate.

Hot bins shall be drawn and cleaned of material at the end of each day's operation.

f. Proportioning and Mixing

The heated ingredients together with the mineral filler and bitumen shall be combined in such a manner so as to produce a mixture which complies with the requirements of the Job Mix Formula.

Mineral filler, in a cool dry state, shall be proportioned into the mixer either with the aggregate or after the introduction of the bitumen to avoid loss of fines that may occur in dry mixing as a result of turbulence in the mixer.

In batch type plants a dry mixing period of not less than four seconds shall precede the addition of the bitumen to the mix. Excess wet mixing shall be avoided. Wet mixing shall continue as long as it is necessary to obtain a thoroughly blended mix but shall not exceed 75 seconds nor be less than 30 seconds.

The Contractor shall propose the length of time for both dry and wet mixing for the approval of the Engineer. Approval of the lengths of time for mixing shall not relieve the Contractor of his responsibilities and obligations under the Contract.

Once approved, mixing times shall not be altered unless so ordered or further approved by the Engineer.

3.7.4. DELIVERY, SPREADING AND FINISHING

a. Delivery of Mixes

Sufficient plant capacity, haul vehicles and storage shall be provided so that adequate supplies of mixture are delivered to site to ensure that continuous paving can be achieved.

The dispatching of the hauling vehicles to the job site shall be so scheduled that all material delivered may be placed in daylight, unless the Engineer has approved the use of artificial light. Delivery of material shall be at a uniform rate and in an amount well within the capacity of the paving and compacting equipment.

All precautions shall be taken to protect the mix from the weather during transit and while waiting to discharge.

Hauling vehicles shall not be permitted to carry out tight turns on the laying surface.

The mixture at delivery to the paver shall be within 14 °C of the Job Mix Formula temperature and above an absolute minimum temperature of 135 °C. Material which has fallen below the minimum temperature of 135 °C before discharge shall be rejected and immediately removed from site. Delivery temperature shall not exceed the maximum temperature specified for mixing at the plant

Should a significant proportion of the mixture delivered to the paver fail to meet this requirement, or should cold lumps be found in the mixture, the Engineer shall order that paving operations be suspended until measures are taken, to the approval of the Engineer, to ensure compliance.

b. Spreading and Finishing

Prior to the commencement of delivery of the mix the Contractor shall erect and maintain an approved reference guide wire for controlling the levels of the laid mix. The reference guide wire shall be supported at intervals of not less than 10m.

The mix shall be laid upon an approved surface and only when weather conditions are suitable and as designated. Upon arrival at the point of use, the asphalt mix shall be spread and struck off to the grade, elevation and cross-section shape intended, either over the entire width or over such partial width as may be required. If the material does not conform to the requirements, it shall not be used and shall be discarded.

The laid material shall be compacted as soon as rolling can be effected without causing undue displacement and while the temperature does not fall below 120 °C. Materials still uncompacted and below this temperature shall be rejected.

The Contractor shall supply accurate calibrated thermometers suitable for measuring the inner and surface temperature of the material. The material temperature shall be checked immediately before rolling and at least every 30 minutes thereafter during forward progress. A record of these temperatures shall be passed to the Engineer at the end of each days work.

While paving is in progress, the output of the batching plant shall be exclusively reserved for the operations and no mixture shall be supplied to other sites or projects.

If during laying, the paver is repeatedly delayed because of lack of mixture or if the paver stands at one location for more than thirty minutes (for any reason), a transverse joint shall be constructed. Paving shall not recommence until the Engineer is satisfied that paving will proceed uninterrupted and until at least four loaded vehicles have arrived at the paving site.

The asphalt course shall be constructed to proposed levels and shall be homogeneous, providing after compaction an even surface free from undulations, rises or depressions and within the tolerances stipulated.

In no case shall construction of a new asphaltic concrete course begin until the previously laid course has been tested and approved.

When the same asphalt course is to be laid in more than one layer the second layer shall be placed as soon as practicable after the first layer has been finished, rolled and cooled, and the Engineer may at his discretion request cleaning of the first layer and the application of a tack coat thereon if he so deems necessary.

Transverse joints in succeeding layers shall be offset at least 2 m. Longitudinal joints shall be offset at least 300 mm.

The use of motor grader or hand spreading of the asphalt mix shall not be permitted except in places where it is impractical to use pavers and shall be only with the specific permission of the Engineer. The asphalt mix shall comply with all conditions regarding trueness of level, thickness, and homogeneity of the mix.

Automatic electronic screed controls shall be required on all pavers and shall be used with a 9 m long articulated averaging beam or grade wire control as approved by the Engineer.

c. Compaction of Mixes

At least three rollers shall be required at all times, one self-propelled pneumatic-tyred and two self-propelled steel-wheeled. As many additional rollers shall be used by the Contractor as necessary to provide specified asphalt course density and surface characteristics in an orderly, efficient and continuous manner.

Before beginning construction of the permanent works, unless otherwise agreed with the Engineer, the Contractor shall carry out compaction trials for each type and thickness of asphaltic course to establish an approved compaction procedure which shall then be used as a minimum requirement for the compaction of the permanent works unless otherwise directed or agreed by the Engineer.

The compaction trials shall involve all procedures specified for the permanent works including testing as specified for the asphaltic course under consideration and any equipment, processes or procedures proposed by the Contractor which are not designated. Construction of the permanent works shall not commence until a compaction procedure has been approved in writing by the Engineer. Such approval shall in no way relieve the Contractor of his responsibilities and obligations stipulated in the Contract.

Immediately after the asphalt mix has been spread and struck off, the surface shall be checked and any irregularities adjusted and then compacted thoroughly and uniformly by rolling.

To prevent adhesion of the mix to steel-wheeled rollers, the wheels shall be kept properly moistened but excess water shall not be permitted.

After the longitudinal joints and edges have been compacted, rolling shall start longitudinally at the sides of the road and shall gradually progress towards the centre. On superelevated sections, rolling shall begin on the low side and progress to the high side, overlapping on successive trips by at least one-half the width of tandem rollers and uniformly lapping each proceeding track. The rollers shall move at a slow but uniform speed with the drive wheels nearest the paver. The speed shall not exceed 4-5 km/h for steel-wheeled rollers or 8 km/h for Pneumatic-tyred rollers. The operating speed shall be approved by the Engineer.

The line of rolling shall not be changed suddenly or the direction of rolling reversed suddenly. If rolling causes displacement of the material, the affected areas shall be loosened at once with hand tools and restored to the original grade of the loose material before being rerolled. Heavy equipment or rollers shall not be permitted to stand on the finished surface before it has been compacted and has thoroughly cooled.

When paving in a single width, the first lane placed shall be rolled in the following order:

- (a) transverse joints
- (b) longitudinal joints
- (c) outside edge
- (d) initial or breakdown rolling, beginning on the low side and progressing towards the high side second rolling
- (e) finish rolling.

When paving in echelon, 50 mm to 100 mm of the edge which the second paver is following shall be left unrolled. Edges shall not be exposed more than 15 minutes without being rolled. Particular attention shall be given to the construction of the transverse and longitudinal joints in all courses.

d. Transverse Joints

Transverse joints shall be carefully constructed and thoroughly compacted to provide a smooth riding surface. Joints shall be checked with a straightedge to assure smoothness and true alignment. Joints shall be formed with a bulkhead, such as a board, to provide a straight line and vertical face.

If the joint has been distorted by traffic or by other means, it shall be trimmed to line and the face shall be painted with thin coating of emulsified asphalt before the fresh material is placed against it. To obtain thorough compaction of these joints the material placed against the joint shall be tightly pushed against the vertical face with a steel-wheeled roller.

The roller shall be placed on the previously compacted material transversely so that not more than 150 mm of the rear rolling wheel rides on the edge of the joint. The roller shall be operated to pinch and press the mix into place at the transverse joint. The roller shall continue to roll along this line, shifting its position gradually across the joint, in 150 to 200 mm increments, until the joint has been rolled with the entire width of the roller wheel. Rolling shall be continued until a thoroughly compacted, neat joint is obtained.

e. Longitudinal Joints

Longitudinal joints shall be rolled directly behind the paving operations. The first lane placed shall be true to line and grade and have a vertical face. The material being placed in the abutting lane shall then be tightly pushed against the face of the previously placed lane. Rolling shall be done with a steel-wheeled roller.

The roller shall be shifted over onto the previously placed lane so that not more than 150 mm of the roller wheel rides on the edges of the newly laid lane. The rollers shall then be operated to pinch and press the fine material gradually across the joint. Rolling shall be continued until a thoroughly compacted, neat joint is obtained.

When the abutting lane is not placed in the same day, or the joint is distorted during the day's work by traffic or by other means, the edge of the lane shall be carefully trimmed to line, cleaned and painted with a thin coating of emulsified asphalt before the adjacent lane is placed.

The longitudinal joints in the surface course shall be along the same line as the traffic lane markers.

f. Paving Edges

The edges of the asphalt course shall be rolled concurrently with or immediately after rolling the longitudinal joint.

Care shall be exercised in consolidating the course along the entire length of the edges. Before it is compacted, the material along the unsupported edges shall be slightly elevated with hand tools. This will permit the full weight of the roller wheel to bear on the material to the extreme edges of the mat.

g. Breakdown Rolling

Breakdown rolling shall immediately follow the rolling of the longitudinal joints and edges. Rollers shall be operated as close to the paver as possible to obtain adequate density without

causing undue displacement. In no case shall the mix temperature be allowed to drop below 120 °C before breakdown rolling.

If the breakdown roller is steel wheeled, it shall be operated with the drive wheel nearest the finishing machine. Pneumatic-tyred rollers may be used as breakdown rollers.

h. Intermediate Rolling

Pneumatic-tyred rollers or Steel wheeled rollers shall be used for the intermediate rolling.

The intermediate rolling shall follow the breakdown rolling as closely as possible and while the paving mix is still hot. Rollers shall be used continuously after the initial rolling until all of the mix placed has been thoroughly compacted. Turning of rollers on the hot paving mix which causes undue displacement shall not be permitted.

i. Finish Rolling

The finish rolling shall be performed with three-axle tandem rollers unless otherwise permitted by the Engineer. Finish rolling shall be accomplished while the material is still warm enough for the removal of roller marks.

All rolling operations shall be conducted in close sequence.

In places inaccessible for the operation of standard rollers as specified, compaction shall be performed by manual or mechanical tampers of such design as to give the desired density.

After final rolling, the smoothness, levels, crossfalls, density and thickness shall be checked and any irregularity of the surface exceeding the specified limits and any areas defective in texture, density or composition shall be corrected as directed by the Engineer, including removal and replacement as directed by the Engineer.

j. Protection of Laid Courses

Sections of the newly finished work shall be protected from traffic of any kind until the mix has been properly compacted and cooled. In no case shall traffic be permitted less than 24 h after completion of the asphalt course unless a shorter period is authorised by the Engineer.

3.7.5. SAMPLING, TESTING AND ACCEPTANCE

a. General

Each completed asphalt concrete course shall be tested and approved in accordance with the following requirements before placing any subsequent asphalt concrete course.

In addition to the following requirements one set of three laboratory compacted specimens and one uncompacted coated sample for each mix type and mixer plant for each day's production shall be delivered to the Central Materials Laboratory no later than 12 h after compaction of the specimens. Details of compaction date, time and temperature of mix shall be provided with the specimens together with mix type and project details.

b. Sampling

The Contractor shall cut samples from each completed asphalt course during the progress of the work and before final acceptance as directed by the Engineer. The Engineer shall determine the location of the samples.

When testing for compaction at joints the edge of the core shall not be more than 50 mm or less than 25 mm from the joint.

Compacted samples shall be taken by coring in accordance with BS 598, for testing by an approved laboratory. The core diameter shall be 150 mm. Where the Contractor fails to provide cores as required by the Engineer, the Engineer may arrange for the taking of cores on behalf of the Contractor at his cost. Samples shall be taken of the asphalt mix for the full depth of the course from the location directed by the Engineer at a rate of not less than one sample per 100 m run of road or 1000 m² of paving whichever is less. A sample shall comprise a pair of adjacent cores and the average density of these shall be the density of the sample.

Whenever deficiencies are noted in loose mix samples or core samples, the Engineer may direct the taking of additional cores at the Contractor's expense in order to define the area of pavement involved.

Hot asphalt mix of the same type shall be placed and compacted in holes left by sampling. The mixture shall be compacted to the % compaction required for the layer using a vibrating hammer such as a Kango hammer.

c. Compaction

The degree of compaction determined in accordance with BS 598: Part 104 is the ratio of the bulk density of the pavement sample to the bulk density of the laboratory Marshall specimens prepared in accordance with the Job Mix Formula.

The field density, as determined from each core sample, shall be a minimum of 98% of the job standard density of the mix for the wearing and intermediate courses and a minimum of 97% for the base course.

The field density, as determined from each core sample, shall not exceed 101.8% of the job standard density of the mix.

d. Mix Composition

Loose samples of mixed material shall be taken at the rate of one for each 1,000 m² laid or at least twice per day from the paving machine for testing of the mix gradation and bitumen content.

If it appears from the analysis of samples of loose mix or cores that the asphalt content or aggregate gradation are beyond the permissible tolerances specified for the Job Mix Formula (established for each respective asphalt course mix) and that, such variation affects the characteristics of the asphalt mix conformity to the designated requirements is concerned, this shall be considered a major defect in the work. The portion of the asphalt course represented by these samples shall be rejected.

e. Thickness and Level

Cores shall be taken to determine the thickness of asphaltic paving courses. As determined from each core, the thickness of a paving course shall not be less than that specified by more than 5 mm in the case of a single – layer construction. Furthermore, the thickness of the wearing course shall not be less than that specified by more than 5 mm and the total thickness of all asphaltic paving courses combined shall not be less than that specified by more than 10 mm.

In addition, the variations in the falls to cross sections of the road shall not vary from the required value by more than 0.3%. Any asphalt paving course containing deviations or

variations exceeding these tolerances shall be corrected or removed and replaced by the Contractor, in accordance with the instructions and to the satisfaction of the Engineer.

Where any individual course is marginally out of tolerance on the low side, the Engineer may allow adjustment in the succeeding course to correct the overall thickness of the pavement.

The tolerances herein specified shall not invalidate the tolerances set forth for the evenness of surface of the asphalt paving course.

f. Evenness of Surface

The Engineer shall test the evenness of surface for each course of the various asphalt paving courses to determine compliance.

The Contractor shall put at the disposal of the Engineer a 3 m long straightedge and a crown template of sturdy and approved design and enough labour to assist in the checking operations.

Any layer containing deviations or variations exceeding the tolerances specified here shall be corrected or removed and replaced in accordance with the instructions of the Engineer and to his satisfaction.

3.8. RELATED WORKS

1.3.1. KERB KEYING

Edges shall be of type T4 according to EN 1340 and NFP 98 340/CN, with mass concrete and standard grey facing. They shall be made of prefabricated concrete sections 1.00 m and exceptionally 0.33 m long.

Precast concrete kerbs shall be laid true to lines, grades and levels and any kerb found to be more than 5 mm out of lines, grades or levels at either end shall be removed and relaid.

Kerbs shall be laid on a concrete foundation with concrete Class B according to Section 03300, 20 cm thick, and shall be backed with concrete shaped up to the required cross-section, all as detailed on the Drawings.

Specially cast radiused kerbs shall be used on curves of 12 m radius or less.

Kerbs shall be jointed with cement mortar except at expansion joints which shall be made with performed joint filler 13 mm thick. Expansion joints shall be carried through the concrete backing and foundation.

Kerbs shall be made with concrete class B according to Section 03300.

1.3.1. ROAD MARKINGS

Where directed by the Engineer, the Contractor shall paint markings on the completed road surfaces.

Before paint is applied, the road surface shall be thoroughly cleaned and dried to remove all dust and other deleterious matter.

Except where otherwise specified all lines shall be 100 mm wide. All lines shall be premarked with dots at approximately 3 m centres on straight lines and 1 m centres on curves. Lines on curves shall not be formed by a series of straight sections around the curve. The alignment shall

not deviate more than 20 mm in 25 m. The width of the lines shall not be varied more than plus or minus 6 mm from the specified width.

The paint shall be applied with due regard to the Manufacturer's instructions. Lines and other road marking shall be applied uniformly and shall have sharply defined edges without runs or spatters.

3.9. CONTROLS

The following controls shall be made on materials either placed or in situ, after compaction:

Test	Sub-grade	Sub-base	Base
Californian Bearing Ratio (in situ)	1 per 300 m ²	1 per 100 m ³	1 per 100 m ³
Density (in situ)	-	1 per 200 m ³	1 per 200 m ³

Nuclear method may be used for testing density of soil in place.

The frequency and nature of the tests may be amended as required by the Engineer depending on the results of previous tests, material variations or climatic conditions.

3.10. MAINTENANCE WORKS

The Contractor shall properly maintain all roads, both permanent and temporary to the Engineer's satisfaction.

Such maintenance shall include all measures necessary to maintain the roads in an operational and safe condition for the vehicle and weather condition for which the particular road is designed, and shall include, but not be limited to, repairs to foundation and road surface, clearing of drains, repairing or supplementing signs, and clearing and stabilizing batter and fill slips.

Upon completion of the Contract and before the issue of Taking Over Certificate, all roads constructed, upgraded and/or used by the Contractor shall be left in good condition to the satisfaction of the Engineer.

The asphalt works for the required permanent roads shall be done at the end of works, when the circulation of heavy trucks is not likely to occur. If the Sub-base or Base courses are damaged during construction works, the Contractor shall repair such according to the specifications and to the satisfaction of the Engineer before asphalt sealing works. For temporary roads, the Contractor can propose a design different from the specifications, provided he demolishes it at the end of works to build the permanent roads according to the specifications. In all cases, the price items for roads in the Price Schedule include all temporary, maintenance and permanent road works.

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SECTION 02240

GEOTEXTILE

1. GENERAL

1.1. SCOPE

This specification is applicable to placing geotextile at locations indicated on Drawings.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. REFERENCED DOCUMENTS

ASTM Standards :

D 123	Standard Terminology Relating to Textiles
D 276	Test Methods for Identification of Fibers in Textiles
D 3786	Test Method for Hydraulic Burst Strength of Knitted Goods and Nonwoven Fabrics, Diaphragm Bursting Strength Tester Method
D 4354	Practice for Sampling of Geosynthetics for Testing
D 4355	Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon Arc Type Apparatus)
D 4439	Terminology for Geosynthetics
D 4491	Test Methods for Water Permeability of Geotextiles by Permittivity
D 4632	Test Method for Grab Breaking Load and Elongation of Geotextiles
D 4751	Test Method for Determining Apparent Opening Size of a Geotextile
D 4759	Practice for Determining the Specification Conformance of Geosynthetics
D 4833	Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
D 4873	Guide for Identification, Storage, and Handling of Geotextiles
D 5141	Test Method to Determine Filtering Efficiency and Flow Rate for Silt Fence Applications Using Site Specific Soil

1.4. SCHEDULE

In addition to the general schedule, the Contractor shall hand the Engineer a precise schedule for laying the various geotextiles with the corresponding layout drawing.

2. PRODUCTS

2.1. PHYSICAL AND CHEMICAL REQUIREMENTS

- A. Fibers used in the manufacture of geotextiles and the threads used in joining geotextiles by sewing, shall consist of long chain synthetic polymers, composed of at least 95% by weight polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.
- B. Geotextile Requirements. The geotextile shall meet the requirements of following List. Woven geotextiles shall not be allowed. All numeric values in the following table, except AOS, represent minimum average roll values (MARV) in the weakest principal direction (i.e., average test results of any roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the minimum values). Values for AOS represent maximum average roll values.

The geotextile should comply with the following characteristics:

- - Non-Woven geotextile
- - Mass per unit area : at least 600 g/m²
- - Thickness (standard NF EN 964-1): ≥ 4 mm
- - AOS (Apparent Opening Size) as per ASTM D 4751 : 0.42 mm ($\pm 10\%$)
- - POA (Percent Open Area) : at least 10%
- - Permeability > 0.09 m/s
- - Grab tensile strength : 1500 N
- - Trapezoidal tear strength : 750 N
- - Puncture strength : 750 N
- - Gradient Ratio test (ASTM D5101). Ratio should be < 2.5 .

2.2. CERTIFICATION

- A. The Contractor shall provide to the Engineer a certificate stating the name of the manufacturer, product name, style number, chemical composition of the filaments or yarns and other pertinent information to fully describe the geotextile.
- B. The Manufacturer is responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the specification. Documentation describing the quality control program shall be made available upon request.

- C. The Manufacturer's certificate shall state that the furnished geotextile meets MARV requirements of the specification as evaluated under the Manufacturer's quality control program. The certificate shall be attested to be a person having legal authority to bind the Manufacturer.
- D. Either mislabeling or misrepresentation of materials shall be reason to reject those geotextile products.

2.3. SAMPLING, TESTING AND ACCEPTANCE

- A. Geotextiles shall be subject to sampling and testing to verify conformance with this specification. Sampling for testing shall be in accordance with ASTM D 4354. Acceptance shall be based on testing of either conformance samples obtained using Procedure A of ASTM D 4354, or based on manufacturer's certifications and testing of quality assurance samples obtained using Procedure B of ASTM D 4354. A lot size for conformance or quality assurance sampling shall be considered to be the shipment quantity of the given product or a truckload of the given product, whichever is smaller.
- B. Testing shall be performed in accordance with the methods referenced in this specification for the indicated application. The number of specimens to test per sample is specified by each test method. Geotextile product acceptance shall be based on ASTM D 4759. Product acceptance is determined by comparing the average test results of all specimens within a given sample to the specification MARV. Refer to ASTM D 4759 for more details regarding geotextile acceptance procedures.

2.4. SHIPMENT AND STORAGE

- A. Geotextile labeling, shipment, and storage shall follow ASTM D 4873. Product labels shall clearly show the manufacturer or supplier name, style number, and roll number. Each shipping document shall include a notation certifying that the material is in accordance with the manufacturer's certificate.
- B. Each geotextile roll shall be wrapped with a material that protect the geotextile from any damage due to shipment, water, sunlight, and contaminants. The protective wrapping shall be maintained during periods of shipment and storage.
- C. During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 71EC (160EF), and any other environmental condition that may damage the physical property values of the geotextile.

3. EXECUTION

3.1. GENERAL

Atmospheric exposure of geotextiles to the elements following lay down shall be a maximum of 7 days to minimize damage potential.

3.2. SEAMING

- A. If a sewn seam is to be used for the seaming of the geotextile, the thread used shall consist of high strength polypropylene, or polyester. Nylon thread shall not be used. For erosion control applications, the thread shall also be resistant to ultraviolet radiation. The thread shall be of contrasting color to that of the geotextile itself.
- B. For seams which are sewn in the field, the Contractor shall provide at least a 2 m length of sewn seam for sampling by the Engineer before the geotextile is installed. For seams which are sewn in the factory, the Engineer shall obtain samples of the factory seams at random from any roll of geotextile which is to be used on the project.
1. For seams that are field sewn, the seams sewn for sampling shall be sewn using the same equipment and procedures as will be used for the production of seams. If seams are to be sewn in both the machine and cross machine directions, samples of seams from both directions shall be provided.
 2. The seam assembly description shall be submitted by the Contractor along with the sample of the seam. The description shall include the seam type, stitch type, sewing thread, and stitch density.

3.3. PREPARATION OF FORMATION LEVEL

Before installing the geotextile, the following points shall be checked:

- The area shall be cleaned and compacted so that it is free of any vegetation, irregularity, depression or sudden change in elevation.
- The surface shall be cleared of all roots, rocks more than 50 mm in diameter and other debris.
- No surface shall have suffered excessive erosion due to water or wind.
- The water content shall not be excessive at any point on the surface.
- The surface shall not display any shrinkage cracks beyond the project specifications.

At each stage, the Geotextile Installer shall confirm in writing that the state of the formation level on which the geotextile are placed is acceptable. The acceptance certificate shall be sent to the Engineer before any geotextile is deployed on the surface in question.

The acceptance certificate report concerning the foundation levels shall include at least the following information:

- - Date and time,
- - Description of the accepted area(s),
- - Sketch indicating the accepted area(s),
- - Partial or complete acceptance,
- - Comments,
- - Name and signature of the Geotextile Installer's representative.

In case the surface to be laid is a trench, the excavation shall be done in accordance with details of the Drawings. Excavation shall be done in such a way so as to prevent large voids from

occurring in the sides and bottom of the trench. The graded surface shall be smooth and free of debris.

3.4. GEOTEXTILE PLACEMENT

- A.** The geotextile shall be placed loosely with no wrinkles or folds, and with not void spaces between the geotextile and the ground surface. Successive sheets of geotextiles shall be overlapped to a minimum of 300 mm, with the upstream sheet overlapping the downstream sheet.
 - 1. When required in trenches equal to or greater than 300 mm in width, after placing the drainage aggregate the geotextile shall be folded over the top of the backfill material in a manner to produce a minimum overlap of 300 mm. In trenches less than 300 mm but greater than 100 mm wide, the overlap shall be equal to the width of the trench. Where required in trench less than 100 mm the geotextile overlap shall be sewn or otherwise bonded. All seams shall be subject to the approval of the Engineer.
 - 2. Should the geotextile be damaged during installation, or drainage aggregate placement, a geotextile patch shall be placed over the damaged area extending beyond the damaged area a distance of 300 mm, or the specified seam overlap, whichever is greater.
- B.** At the time of installation, the geotextile shall be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacturer, transportation or storage.
- C.** Unless for placement in trench, geotextile shall not be placed during strong wind events (wind velocity ≥ 4 m/s).
- D.** The geotextile shall be free of tensile stresses folds, and wrinkles.
- E.** The geotextile shall be ballasted after positioning. The Contractor shall choose the most appropriate ballasting method for site conditions and the expected winds. The Contractor may use bags of soil or tires. The Contractor shall be responsible for the supply, placement and removal of the ballasting used.
- F.** The deployed geotextile should not be exposed over the maximum allowable exposure time specified by the Manufacturer. If the allowable exposure time has been exceeded, a joint inspection shall determine if the geotextile has been damaged. If needed, additional CQA tests will be requested in order to verify that the physical properties of the geotextile have not been diminished due to inappropriate exposure.

3.5. DRAINAGE AGGREGATE AS BACKFILL FOR TRENCH APPLICATION

When applicable (as shown on Drawings), placement of drainage aggregate should proceed immediately following placement of the geotextile. The geotextile should be covered with a minimum of 300 mm of loosely placed aggregate prior to compaction. If a perforated collector pipe is to be installed in the trench, a bedding layer of drainage aggregate should be placed below the pipe, with the remainder of the aggregate placed to the minimum required construction depth.

3.6. SITE VERIFICATION

- A.** The installation of the geotextile shall be inspected by the Contractor's representative in presence of the Engineer: visual inspection of the placement and aspect, measurement of the overlap, ballasting.

- B.** If the installation does not comply with the specifications and rules of the art, the Contractor shall be responsible to make necessary arrangements at no cost for the Employer.

SECTION 02346

BOLTING

1. GENERAL

1.1 WORK INCLUDED

The section covers the requirements for:

1. the supply bolts and dowels,
2. the installation of bolts and dowels,
3. the testing of bolts and dowels,
4. the supply and placement of wire mesh fabric for temporary protection.

The specifications for the bolts cover resin grouted and cement grouted bolts.

The works will be carried out with the Engineer' approval for particular case only.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DEFINITIONS AND DESCRIPTIONS

1. A bolt is a high yield deformed bar of specified diameter and length which is end anchored with resin grout, fully column bounded with either resin or cement grout, equipped with a faceplate, hemispherical washer and nut and tensioned to a specific load. The use of resin or cement grout for the column grout shall be at the contractor's discretion.
2. Alternative materials with equivalent service characteristics may be proposed to the agreement of the Engineer.
3. A **dowel** is a high yield deformed bar of specified diameter and length for which the protruding portion may be either straight or bent, which is fully grouted with either resin or cement grout. Dowels will not be fitted with accessories nor will they be tensioned. The use of resin or cement grout shall be at the Contractor's discretion.

Bolts and dowels shall be installed in portions of the work where anchorage of concrete or steel structures are required or where the stability of soil faces exposed by the excavations will not be maintained naturally.

It is intended that in general treated soils reinforcement will be provided mainly by dowels.

1.4 CODES AND STANDARDS

1.3.1. GENERAL

The work including in this Section shall comply with the requirements of the following standards and codes, except where this Specification differs from these standards and codes, in which case the requirements of the Specification shall take precedence.

International Society of Rock Mechanics (ISRM).

ISRM Suggested method for Rock Anchorage Testing (ref. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 22, n2, p 714-83, 1985).

1.4.2 AMERICAN CONCRETE INSTITUTE

ACI 318-77 Building code requirements for pre stressed concrete.

1.3.1. AMERICAN SOCIETY FOR TESTING MATERIALS (ASTM)

ASTM A 185 Steel welded Wire Fabric, for Concrete Reinforcement

ASTM C150 Portland Cement

ASTM D4435 Standard method for rockbolt anchor pull test

ASTM F432 Standard specification for roof and rock bolts and accessories

1.4. QUALITY ASSURANCE

1.3.1. TESTS AND CONTROLS

1. The Contractor shall make trial tests of bolts and dowels before any installation proceeds.
2. The trial programme shall include sufficient pull-out tests to failure, or to such lesser load as the Engineer may approve, and dowels anchored in suitable rock to determine the adequacy of the anchorage used and the correct torque or tension where appropriate to apply to the bolts. The trial assemblies shall show that the bolt, the anchorage system and the tensioning system proposed by the Contractor will be suitable for the work.
3. the effectiveness of the installation procedure shall be checked by testing to yield load a minimum of 1 bolt in 100 installed.

1.5.2 TOLERANCES

4. Position ± 150 mm
5. Alignment $\pm 5^\circ$

1.5. SUBMITTALS AND APPROVALS

1. Not later than 45 das prior to commencement of excavation, the Contractor shall submit to the agreement of the Engineer.

The different types and characteristics of dowels, bolts and accessories he intends to use.

For exposed bolts and accessories, the protective coating compound the Contractor intends to have applied at the factory with possibility of recoating at site if required.

Grouting equipment and method.

2. Schedule for grouting bolts and dowels

Prior to grouting the Contractor shall submit a schedule for grouting for the Engineer's approval.

All granted bolts shall be grouted in place immediately prior to backfilling or concreting or in the case of permanently exposed faces, upon completion of the work in any area, unless otherwise required by the Engineer.

2. MATERIALS

2.1. TENSIONED BOLTS

1. Bolts shall be manufactured from hot rolled deformed bars with a minimum tensile strength of not less than 415 Mpa complying with ASTM F432, in various lengths and diameters as specified.
2. The bar length specified shall be the required length of bar to be bonded to the soil and due extra allowance in the cutting length shall be made for any length including the threaded portion protruding from the rock as required for installation. One end shall be threaded for at least 150 mm with coarse cut thread which shall not reduce the overall specified bar diameter by more than 3 mm. The other end shall be chamfered to facilitate installation.
3. Bolts shall be provided with face plate, hard steel flat and hemispherical washers and nuts.
4. The face plate shall be domed load indicating type and fitted with hemispherical washer to permit seating of the plate at inclinations up to 30° from normal to the bolt, with the following minimum dimension characteristics:
 - for 20 mm dia rockbolt, diameter 120 mm and 8 mm thick plate,
 - for 25 mm ida rockbolt, diameter 150 mm and 8 mm thick plate.
5. Couplings for connecting adjacent sections of a bolt shank and bolt extensions shall have a center stop so that each section is connected by an equal length of thread. Such threads shall be capable of transferring the yield load of the bolt from one section to the other

without, in any way, overstressing the coupling or the threads of the bolt shank or extension. Couplings for hollow core bolts shall be such as not to interfere in any way with the flow of grout through the core of the bolt.

6. Cement grouted bolts shall be supplied with suitable tubes for injecting grout and permitting release of air from the hole. Bearing plates for bolts to be grouted shall be supplied with holes to accommodate the grouting and venting tubes. Alternatively, groutable bolts having a hollow core may be used, in which case the bearing plates shall have one hole for the grouting or air venting tube.
7. For all bolts which be permanently exposed, all portions of the bolts, the bearing plates and accessories which will be permanently exposed shall be coated after installation with an approved protective coating compound. The engineer may nevertheless require grouting to be used for protection of the shank.

2.2 DOWELS

Dowels shall be manufactured from hot rolled deformed bars with a minimum tensile strength of not less than 415 Mpa, in various lengths and diameters as specified.

Dowels shall be either straight bars or shall have the protruding end bent to facilitate the specified connection between the rock and surrounding concrete or shotcrete when so detailed on the drawings.

Dowels for installation with resin or cement cartridge shall be threaded at one end sufficiently for attachment of the installation equipment. The other end shall be chamfered to facilitate installation.

2.2. WIRE MESH

1. Wire mesh shall be of a standard approved by the Engineer.
2. Welded wire mesh shall comply with ASTM A 185.

2.3. GROUT

1. Resin grout shall be a commercially produced epoxy product in capsule form with both fast and slow setting times as applicable especially formulated for use with rockbolts or dowels, and transported, stored and utilised in accordance with the manufacturer's recommendations.
2. Cement grout shall be a commercially prepared product in capsule form especially produced for use with rockbolts or dowels. The product shall not contain any material which could corrode the bolts or dowels.

2.5 RESERVE SUPPLY

3. To be able to perform the excavation work without delay, the Contractor shall always have a reserve inventory of bolts and dowels of various types and length, wire mesh and other accessories. Such inventory shall be adequate to meet the requirement for the following month as well as provision for unforeseen conditions. The inventory status shall be reported to the Engineer on a monthly basis.

4. As the work progresses the Contractor shall supply additional bolts to site as instructed by the Engineer.

2.4. TORQUE WRENCH

The Contractor shall have a standard torque wrench for calibrating impact and torque wrenches used in the work. This controlled torque impact wrench shall have a control device that can be set to cut off over the required range of torques. This wrench shall not be used for any other purpose. All impact and torque wrenches shall be calibrated at least once every month.

2.5. PULLOUT TEST EQUIPMENT

The Contractor shall provide two sets of approved pullout test equipment for use in making tests, to comprise of a suitable hydraulic jack, having a center bore in the ram for installation of the jack concentrically over the longitudinal axis at the bolt, hydraulic pump, and all other required accessories.

3. EXECUTION

3.1. GENERAL

1. Bolting shall be carried out in the pattern and sequences as indicated on the drawings or as directed or as proposed by the Contractor and agreed by the Engineer.
2. Before grouting, the Contractor shall check the tension of all tensioned bolts and retorque where necessary.
3. Where opencut excavation is carried out in successive lifts or benches, support of each newly exposed soil face shall be completed prior to blasting of the next bench unless otherwise authorized by the Engineer.
4. Bolts required to support the underground excavation shall be set and tensioned at agreed locations, as soon as practicable after each round is excavated and before the face is further advanced. Any bolt, which is damaged by blasting or other operations to the extent that it can no longer be effectively retensioned, shall be replaced as required by the Engineer.

3.2 DRILLING

5. Standard percussion drilling equipment may be used for drilling bolts or dowels.
6. Holes for bolts shall be drilled to the depths and at locations and orientation shown on the drawings, directed or as agreed by the Engineer.
7. Unless otherwise proven acceptable by site trials, the bolts shall be installed in holes of diameter from 10 mm to 15 mm greater than the maximum diameter of the bolt, and will be such that, for the anchorage used, the load capacity of the bolt at the yield point of the steel can be developed. In cases where it is necessary to couple lengths of grouted bolts to achieve the total length of bolt required, the diameter of the hole around and above the coupling shall be sufficient to allow the free passage of grout.

8. The holes shall not be more than 100 mm longer than the grouted length of the bolt unless otherwise proven acceptable by site trial.
9. Immediately prior to installation of any bolt, the hole shall be flushed with water and cleaned of all drill cuttings and debris to the satisfaction of the Engineer.

3.3 INSTALLATION AND TENSIONING OF BOLTS

3.3.1 INSTALLATION AND TENSIONING OF BOLTS

10. Installation

The method of installation and tensioning of bolts shall be to the approval to the Engineer, Manufacturer's instructions for the use of proprietary components shall be followed wherever appropriate.

Bolts shall be inserted in the hole and the anchorage firmly seated and tightened. No damage shall be caused to the thread of the protecting end of the bolt.

Prior to installing the bolts, the soil surface shall be prepared to provide uniform bearing at right angles to the longitudinal axis of the bolts.

For resin grouted rockbolts a sufficient number of cartridges shall be used to ensure the annulus around the bolt is completely filled over the full length of the hole.

End cartridges for the anchorage zone shall be of fast setting resin whilst the column shall be filled with slow setting resin or cement cartridges. Tensioning shall be carefully controlled to ensure that it takes place after setting of the end cartridges but prior to commencement of setting of the column grout.

11. Tensioning

The hexagonal nut of the tensining end of the bolt shall be free running on the thread of the bolt and shall be tightened to a torque required to cause a load in the bolt equal to 50 kN for the 20 mm dia rockbolt and 100 kN for the 25 mm dia rockbolt. The requisite torque for the bolts shall be determined by in place testing of the bolts in accordance with the bolt Manufacturer's directions. Bolts which are damaged or overstressed by over torquing shall be replaced by the Contractor.

All necessary preparation of a bolt for grouting shall be made during the initial installation of the bolts. After the bolt has been tensioned, the tension shall not be relaxed for grouting or any other purpose.

If it is found that any bolt will not take the required torque without anchorage slip, another bolt shall be installed in a new hole drilled in the immediate vicinity of the unsatisfactory bolt.

If, at any time, the Engineer or Contractor finds that any bolts have become loose or have lost their tension, the Contractor shall retension all such bolts by reapplying the specified torque.

3.3.2 INSTALLATION OF DOWELS

The method of installation of dowels shall be to the approval of the Engineer. Manufacturer's instructions for the use of proprietary components shall be followed wherever appropriate.

Holes of diameter from 10 mm to 15 mm greater than the maximum diameter of the dowel shall be drilled and cleaned to the approval of the Engineer. The gauged amount of cement grout or cartridges of resin or cement grout shall then be inserted and the bar driven firmly into the hole (by spinning in the case of resin cartridges). If cement grout is used, the grout shall be inserted using a tremie pipe pushed down to the bottom of the hole and withdrawn slowly as the grout is placed. After installation the bar shall be vibrated for a short period to ensure the complete distribution of the grout around the full length of the bar. Additional grout shall be added to make up any shortfall.

3.4 TESTING OF ROCK BOLTS AND DOWELS

3.4.1 GENERAL

Prior to the installation of bolts in the Works the Contractor shall carry out a series of tests as agreed with the Engineer to prove the capacity of the system and the Contractor's capability to correctly install and tension the bolts.

12. for the purpose of these tests, anchorage slip shall be deemed significant if an outward movement of the bolt anchorage occurs and continues without increase in the hydraulic jack loading, or with a decrease in the hydraulic jack loading.
13. If a bolt fails to meet the pullout test requirement, another bolt shall be installed in a new hole drilled as close as practicable to the unsatisfactory bolt.

14. The tests shall demonstrate:

The number of resin cartridges required to provide the end anchorage with an applied load equal to the bars characteristic yield strength and taking into account the overlength variation of holes.

The number of resin or cement cartridges to fill the annulus around the rockbolt over the length of the hole between the anchorage and collar of the hole.

The strength of the resin grout to fully anchor the bars up to the characteristic strength of the bolts.

The composition of the cement grout.

The capacity of the equipment to install the longest fully grouted bolts.

The equipment for tensioning the bolts to the specified loads.

The capability of each crew to correctly install and tension the bolts.

The Contractor shall undertake the tests with the equipment to be used on the Works and shall install the test bolts in a suitable rock face in a steeply upward direction.

The Contractor shall provide a suitably calibrated direct tensioning jack and/or load cell of capacities in excess of the characteristic strength of the rockbolts. Loads and deformations shall be recorded during the tests.

3.4.2 TENSIONED BOLTS

15. A final torque test of bolts shall be made in the presence of the Engineer during the final inspection of the work, and immediately prior to any grouting of bolts. The number of bolts

to be tested will be determined by the Engineer, with consideration given to the total number of bolts installed and the results of such tests.

16. The Contractor shall make a pullout test of each bolt that does not retain the applied torque, as determined by the Engineer. All pullout tests shall be made in the presence of the Engineer. A pullout test result which indicates that the anchorage will take a tension equal to 90 percent of the yield strength of the bolt shank as determined by trial tests, without significant anchorage slip; will be acceptable.
17. All bolts which are installed and tensioned within 15 metres of subsequent blasting work shall be tested after each blast within such longer period as may be approved by the Engineer.

3.4.3 DOWELS

As locations designated by the Engineer, the Contractor shall conduct pullout tests in the presence of the Engineer. A pullout test which indicates that the dowel will take a tension equal to 90 per cent of its yield strength without significant slip will be acceptable.

3.5 CEMENT GROUTING OF BOLTS

18. The grouting shall be performed in accordance with a method approved by the Engineer.
19. The Contractor shall supply all plant and materials required to grout the bolts in place after installation.
20. Where a tube system is proposed by the Contractor, such system shall be subject to the Engineer's approval, and the Contractor shall demonstrate to satisfaction of the Engineer that the proposed system will provide complete filling of the annular space around the bolt.
21. The water/cement ratio by weight shall be between 0.30 to 0.44. Special agreed admixture shall be added to the grout to prevent shrinkage. This non shrink admixture shall be added strictly as recommended by the Manufacturer. Calcium chloride will not be permitted. Grout shall be forced into the drill hole at the appropriate point to completely fill the space all around the rock bolts. All air shall be vented from the drill hole adequately. If during the grouting of any bolt, grout is found to flow from points in the rock surfaces adjacent to the bolts, such leak shall be plugged or caulked. Grout which has not been injected into a hole within 1 hour of mixing shall not be used.
22. The Contractor shall ensure that grouted bolts are neither loosened nor disturbed in any way until at least 7 days after completion of grouting.

3.6 WIRE MESH

23. Where wire mesh will be placed for temporary protection for safety of person and equipment, it shall be securely fastened to the bearing plates or bolts.
24. Overlaps in the wire mesh shall not be less than 300 mm and shall be secured with wire clips.
25. Additional wire mesh anchors shall be used to secure wire mesh to the soil surface between bolts and to secure the edges of wire mesh and provide anchorage at overlaps

and where sagging may occur. There wire mesh anchors patterns shall be approved by the Engineer.

SECTION 02432

DEWATERING AND CARE OF WATER

1 GENERAL

1.1 WORK INCLUDED

This section covers the requirements for dewatering and maintaining the surface and underground work areas in a dewatered state.

Unless otherwise instructed by the Engineer during construction, the Contractor shall investigate, design, construct, maintain and operate temporary drainage facilities as are necessary for controlling all water entering the work areas which includes seepage of ground water, surface runoff. Water removed from the work areas shall be disposed of in such a manner as will not harm the environment, the stability of existing and constructed slopes, the works and the public health.

Dewatering shall mean works required to pump ground water out of surface or underground excavations.

1.2 RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3 CODES AND STANDARDS

Not used.

1.4 QUALITY ASSURANCE

Not used.

1.5 SUBMITTALS AND APPROVALS

The Contractor's schemes for dewatering the surface and underground works shall be submitted for approval not less than 14 days prior to commencement of related excavation.

2 MATERIALS

2.1 GENERAL

All materials required by the Contractor to ensure effective drainage of the Works shall be approved by Engineer.

2.2 COFFERDAM FILL

Fill materials for cofferdams shall be obtained from required excavations, quarries, borrow pits or stockpiles as required. Fill materials shall be free of objectionable quantities of roots, organic and other foreign objects, as determined by the Engineer, and shall comply with the requirements of Section 02223 - Fills, Backfills and Embankment Construction.

2.3 CONCRETE

Materials for concrete shall comply with the requirements of Section 03301.

2.4 GROUT

Materials for grout shall comply with the requirements of Section 02398.

3 EXECUTION

3.1 DEALING WITH SURFACE WATER

Excavations and platforms shall at all times be maintained in a well-drained condition and free of ponded water from whatever source including precipitation run-off, groundwater percolation, water back-up, or water for construction operations.

After having served their purpose, all temporary protective works shall be removed or leveled so as not to interfere in any way with the operation of the project works, and to give a tidy appearance at the satisfaction of the Engineer.

The Contractor shall be responsible for, and shall repair at his own expense, damage to any part of the work caused by floods, water back-up, or failure of protective works.

Excavated borrow pits shall be developed with regular profiles and graded to drain, via ditches to the nearest water course. Measures shall be taken when necessary to prevent watercourses from backing up into the borrow areas.

The Contractor shall do whatever is necessary to prevent water from entering excavations or from flowing over excavated slopes in overburden or rock.

Unless otherwise directed by the Engineer, gravity drainage will be preferred to dewatering by pumping wherever feasible.

3.2 DEWATERING OF UNDERGROUND WORKS

The underground works shall be maintained in a dewatering state. Ponding of water shall be avoided.

Water from underground works shall be treated in a silt and oil trap before release to any watercourse.

3.3 DEWATERING OF SURFACE WORKS FOUNDATIONS

The Contractor shall provide and maintain all temporary stoplogs, cofferdams, dykes and other protective works and shall provide, operate and maintain any channels, flumes, drains, sumps, pumps and other drainage facilities and equipment required to dewater the areas required for the Work and maintain them free from water and ponding for such periods as are necessary for satisfactory completion of the Work.

The Contractor's methods shall be such that they do not interfere with the progress or safety of the Work.

Where existing minor streams are to be diverted, the Contractor's arrangements shall be subject to the approval of the Engineer.

Subject to the approval of the Engineer, the Contractor will be permitted to leave in place sumps and pipes which form part of the dewatering system, provided they are backfilled and give a tidy appearance, to the satisfaction of the Engineer.

3.3 CARE OF WATER

Excavation and platforms shall at all times be maintained in a well-drained condition and free of ponded water from whatever source including precipitation run-off, groundwater percolation, water back-up, or water for construction operations.

Water removed from any excavations shall be treated if necessary and disposed of in such a manner as will not endanger public health, the environment, the stability of existing slopes, or the Works.

Drains, ditches, sumps and other facilities shall be lined as required or directed to prevent erosion of the underlying soil or rock.

The Contractor shall be responsible for, and shall repair at his own expenses, damage to any part of the work caused by floods, run-off, water back-up, or failure of protective works.

3.5 SPOIL AREAS

The Contractor shall do whatever is necessary to prevent water from flowing over spoil areas and adequate measures shall be taken to prevent erosion of the material by surface runoff and watercourses.

Pipes and conduits through spoil dumps shall be solid and continuous and will require specifically formed inlets and outlets in impermeable and non erodible headwalls. Pipes or conduits shall have a minimum dimension of 1000 mm regardless of discharge requirement. Pipe or conduit shall be suitably constructed to prevent erosion.

If necessary, and upon request by the Engineer, a surface drainage system will be installed on the completed spoil dump.

3.6 SHAFT

The shafts will be excavated with care of water.

A pumping installation with high capacity ($> 200 \text{ m}^3/\text{h}$) shall be installed in the shafts and regularly relocated in accordance with the progress of the works.

Any permanent pond will be authorized by the Engineer at the bottom of the excavation.

The Contractor will always have on site a supply equipment to replace if necessary the equipment in duty.

A permanent water level measuring device shall be installed in the shafts; the records will be submitted to the Engineer every day.

SECTION 03100 FORMWORKS

1. GENERAL

1.1. WORK INCLUDED

This section covers the supply, installation and execution of formwork for concrete structures.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DESCRIPTION

Formwork shall be designed supplied and installed in order to produce concrete parts meeting specified shape, dimensional and position requirements, without defects or irregularities and within the prescribed tolerance limits.

1.4. DEFINITIONS

A. Abrupt irregularities

Any local irregularity resulting from incorrect alignment or relative displacement of the formwork, unsatisfactory condition of formwork or any other cause.

Abrupt irregularities will be measured directly or using a rule or a template of 20 cm long.

B. Gradual irregularities

Refer to any other difference between the theoretical and actual lines of the concrete faces. They shall be measured with a straight rule for plane surfaces and with an appropriate template for curved surfaces of 1.50 m long.

C. Honey combs, grout losses and surface plucking shall not be considered as irregularities but as defects.

1.5. STANDARDS AND REGULATIONS

The following Standards shall be used, in this order of priority:

1. British Standards

2. European Standards.

1.6. STANDARDS OF FINISH

A. Class 1

This is a very high quality finish where formwork shall ensure a particularly accurate line of finish: surfaces in contact with hydraulic flow and surfaces exposed to view:

1. The surfaces delineated by panel joints shall be regular.
2. Unless otherwise indicated, panel joints shall be vertical or horizontal, perpendicular or in alignment with the water flow.
3. Construction joints shall match architectural design details where necessary and shall be submitted for the Engineer's approval.
4. Formwork linking systems shall not be permitted unless otherwise approved by the Engineer.
5. All abrupt irregularities shall be ground to obtain chamfers of 1-over-50.

For surfaces that will be subjected to flowing water at a rate of more than 10 m/s, no smoothing will be tolerated and any irregularity outside specified limits which cannot be repaired by bush hammering or grinding shall be repaired with epoxy resins or any other product approved by the Engineer. Such resins or products shall be applied by approved specialists.

B. Class 2

Formwork for structure surfaces and joints and, in general, all structures not requiring a special finish, i.e. surfaces not exposed to the view:

1. The surfaces delineated by joints between formwork panels shall be regular.
2. Unless otherwise indicated, joints shall be vertical or horizontal or parallel to the overall lines of the structure.
3. Construction joints positions shall be submitted for the Engineer's approval.
4. If accepted, formwork linking systems shall be placed uniformly with aligned joints as to achieve a symmetrical pattern in the finish concrete surface.

C. Class 3

1. Surfaces designed for construction joints between different construction stages with, where applicable, steel bars passing through them.
2. Surfaces designed to be coated at a later stage.

D. Class 4

Surfaces contained by formwork but which will be permanently concealed in the completed work.

E. Surface state tolerances in millimetres

Formwork class	Abrupt irregularities	Gradual irregularities
Class 1	2	6
Class 2	4	8
Class 3	8	15
Class 4	nil	40

N.B.: The clauses of this article are also applicable to concrete surfaces not effectively shuttered.

1.7. DESIGN

- A. Formwork and falsework shall support without appreciable deformation the weight of the fresh concrete, reinforcement and embedded parts as well as the forces induced by falling concrete, with vibration, impacts of handling equipment, personnel, temperature variations and climatic agents.**
- B. Joints between panels shall be grout-tight and shall provide satisfactory continuity of concrete surfaces.**

1.8. CURVED FORMWORK

- A. Curved surfaces of radius less than or equal to 2 m shall conform strictly to the theoretical curve.**
- B. Curved surfaces shall be given by curved formworks, even for 2D curved ones:**
 - a. Either by plywood built on site,
 - b. Either by industrial curvable iron formworks.

1.9. SUBMITTALS

- A. Working drawings of formwork with props, stays, spacers and fastening systems shall be submitted to the Engineer for information.**
- B. The specifications and manufacturer's instructions for the following items and products shall be submitted for the Engineer's approval:**
 - 1. Sheathings or liners.
 - 2. Spacers and falsework.
 - 3. Special supports embedded in the concrete if agreed on principle.
 - 4. Dressing material for stripping.
 - 5. Slip forms where applicable.

1.10. LAYOUT TOLERANCES

- A. Layout deviations of concrete facings shall be compatible with the functions of the structure considered and with related structural functions, especially with regard to mechanical supplies.**

For electromechanical works, tolerances shall be indicated on the drawings.

- B. Unless otherwise indicated, the positive and negative tolerances are as follows:**

1. On any linear dimension L (in m), measured between opposing facings, edges or intersecting edges:

$$T \text{ (cm)} = \frac{1}{4} \sqrt[3]{L}$$

with a minimum of 0.5 cm and a maximum of:

- a) 1 cm for class 1 formwork
 - b) 3 cm for other classes of formwork
2. On vertical dimensions:

$$T(\text{cm}) = 0.0005 \times H$$

where:

H = height of the item in cm

Upper limits: 0.05 x E or 3 cm

E = thickness of the item in cm

3. On alignments or gradients:

$$T(\text{cm}) = 0.0005 \times L$$

where:

L = length in cm

For the curved parts, the tolerances are fixed by analogy

4. On the layout with respect to the reference marks indicated to the Contractor: planimetry and altimetry:

$$T \text{ (cm)} = \frac{1}{2} \sqrt[3]{D}$$

where:

D = distance in metre between the control point and the reference mark with an upper tolerance limit of 3 cm and a lower limit of 0.5 cm.

2. PRODUCTS

2.1. FORMWORK MATERIALS

- A. Generally speaking, forms shall be made of wood or metal. Unless specified to the contrary, they shall be made of plywood for wood or exposed surfaces where the visual impact is particularly important.

All panels other than metal panels shall be new when they are first used on site.

- B. Panels may be reused on site on condition that they are carefully cleaned, reconditioned or surfaced from time to time and if they will be capable of producing concrete surfaces conforming to the specifications. After repeated use, the Engineer may require the Contractor to scrub the form or to provide new ones.
- C. Spacers and fasteners shall be designed in such a manner that, after stripping, no metal part will be closer to the surface of the facing than the minimum concrete cover agreed for the reinforcement.
- D. For water retaining concrete structure, a plate of 50 mm minimum diameter shall be welded in the middle of spacers and fasteners to avoid leakages.

2.2. DRESSING MATERIALS FOR STRIPPING

- A. Surfaces exposed to concrete must be coated with form oil or other approved dressing material.
- B. Dressing material shall facilitate wetting of the form surface, reduce bubble formation, leave no notable trace on concrete surfaces and protect the form surface from any damage such as corrosion.
- C. They shall be compatible with the treatment that may be applied to the concrete surfaces (painting, coating, etc.).

2.3. EXCAVATED SURFACES USED AS FORMS

- A. At the Contractor's request, and after the Engineer has given his approval, the lateral forms of buried parts of concrete structures may be omitted with the concrete being placed directly the excavated surfaces.
- B. In cases where the omission of formwork is accepted, the dimensions of the concrete parts shall be increased by 3 cm on each face in contact with the excavated surfaces.
- C. At the Engineer's instruction, a layer of blinding concrete shall be spread or projected over the excavated surface before placing the concrete.

3. EXECUTION

3.1. INSPECTION

Reference levels and alignments, levels and positions of previous concrete lifts and the position of previously placed reinforcement bars shall be checked before installing the formwork.

3.2. PREPARATION

- A. After cleaning, the forms shall be coated with a dressing material in accordance with the manufacturer's instructions.**
- B. The forms shall be protected from dust and dirt, after the above treatment.**

3.3. INSTALLATION

- A. The forms shall be installed and securely braced in such a manner that the concrete surfaces produced come within the tolerance limits defined in Part I herein.**
- B. If necessary, forms shall be installed with a counter-deflection.**
- C. Unless otherwise indicated, exposed corners shall be provided with 25 x 25 mm chamfers by mean of moulding strip placed in the formwork.**
- D. Construction joints levels shall be provided with battens defining the limits between two concrete lifts, where directed by the Engineer.**
- E. Formwork for successive vertical lifts must make good contact with the concrete in the preceding lift, such that there will be no excrescences, bulges, tears or other outward signs of a faulty junction such as grout leakage.**
- F. Blockouts, inserts and embedded items should be properly identified, positioned and secured.**

3.4. STRIPPING OF FORMS

- A. Formwork shall not be removed without the approval of the Engineer. Notwithstanding this approval, the forms shall not be moved or removed until the concrete has acquired sufficient strength to support its weight and the construction or design loads that it may be required to bear.**
- B. Stripping shall take place without impact or vibration to the concrete and care shall be taken not to damage the concrete surfaces.**
- C. Stripping operations may be decided in relation to the results of compression tests on specimens kept under conditions similar to those of the structure considered. These test specimens shall be taken in addition to the test pieces specified in section on concrete.**
- D. Concrete compressive strength tests may be replaced by sclerometer measurements.**

- E. Generally speaking, the forms and supports of suspended structures shall not be removed until the ratio of the compressive strength of test specimens kept under similar conditions to those of the structure considered to the specified strength is greater than the ratio of the deadweight plus construction loads to the design load, with a minimum value of 0.50.**
- F. In general, formwork shall be left in place for the following period after the concrete is cast:**
1. minimum of 36 hours: vertical surfaces of piers and columns,
 2. minimum of 36 hours: vertical surfaces of footings, walls and dams,
 3. minimum of 20 days: suspended beams and slabs,
 4. minimum of 12 hours: tunnel linings,
 5. minimum of 7 days: arch roof of underground chambers.

The times above specified shall have elapsed from the end of concreting. According to the results of the laboratory tests and site trials, the aforesaid minimum times may be reconsidered by the Engineer. In all cases, the Contractor shall demonstrate that removal of formwork will not in any way adversely affect the concrete of permanent work.

3.5. REPAIR OF SURFACE DEFECTS

- A. If the concrete surfaces after stripping have certain local defects (such as honey combs or surface defects) or irregularities, the Contractor shall advise the Engineer before undertaking any repairs so that the said defects and irregularities can be inspected and notified in a jointly-signed report.**
- B. If in the Engineer's opinion that the defects will not have any significant impact on the quality of the structure, the Contractor shall propose the necessary repair work prior to any repairs.**
- C. In case of serious defects, the Engineer may order the whole lift concerned to be removed and replaced.**
- D. Repairs of local defects and holes left by form fasteners and spacers shall be carried out using cement mortar containing an adhesive and an additive mixture to prevent shrinkage.**
- E. Holes left by form fasteners and spacers may, for certain concrete facings not in contact with water, be left as they are, with the Engineer's approval.**
- F. Spalling, burrs and irregularities not compatible with specified type of finish shall be repaired by smoothing as specified for defects, or ground.**
- G. Within 24 Hours after form removal all fins and loose materials shall be removed and surface defects including the holes shall be remedied unless otherwise required by the Engineer.**

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SECTION 03200

REINFORCEMENT

1. GENERAL

1.1. WORK INCLUDED

This section covers the supply and installation of steel bars or steel fabrics used for reinforcement in concrete works, either for permanent or for temporary structures.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. QUALITY ASSURANCE

1.3.1. CODES AND STANDARDS

The following Standards shall be used, in this order of priority:

1. British Standards.
2. European Standards.

1.3.1. TESTS AND INSPECTION

- A. If the Contractor does not have the Supplier's Certificate or mill certificates, or if the reinforcement appears to be in a deteriorated condition in the Engineer's opinion, the Contractor shall bear the cost of arranging for tests to be carried out in an approved laboratory.
- B. The tests will cover the following characteristics:
 1. Diameter (determined by weighing)
 2. Tensile strength
 3. Bending tests
- C. Six samples per diameter shall be taken for determining each of the above-mentioned characteristics.
- D. If two tests of a given characteristic give unsatisfactory results, the reinforcement bars concerned shall be considered defective.
- E. If one test of a given characteristic gives an unsatisfactory result, a new sampling of six samples from the same batch shall be taken for a new series of tests on the characteristic in question. If

the results of the new tests are all satisfactory, the reinforcement bars will be accepted. If this is not the case, the bars shall be considered defective.

1.4. SUBMITTALS

A. Supply of steel bars

Manufacturer's test certificates or mill certificates including details of physical and chemical properties.

B. Welding of reinforcement bars will not be allowed

Nevertheless in particular cases, the Engineer could agree with bars welding; in such cases the following documents will be submitted to the approval of the Engineer.

1. A welding programme.
2. Certificates of steel reinforcement weldability.

C. Spacers shall be submitted to the approval of the Engineer.

1.5. TOLERANCES

A. Tolerance on the distance (d) between reinforcement bars in walls, slabs or beams:

1. 0.5 cm for d less than 15 cm
2. 1.0 cm for d between 15 and 80 cm
3. 2.0 cm for d greater than 80 cm

B. Tolerance on length of bars: + 4 cm except when these bars are in a discontinuity zone (support surface, etc.) where the tolerance will be + 1.5 cm.

C. Tolerance on concrete covering thickness:

1. Minus 15% with a maximum of 10 mm
2. Plus 30%

2. PRODUCTS

2.1. STEEL GRADES

The following types of steel shall be used for reinforcement:

1. Plain round mild steel or High yield steel bars conforming to BS 4449.
2. Cold worked steel bars conforming to BS 4461.
3. Fabric reinforcements made of cold drawn high tensile bars conforming to BS 4483.

Reinforcement shall be High yield steel bars conforming to BS 4449 as well as BS EN 1992-1 and BS EN 1992-3, with a minimum yield strength (noted f_{yk} in BS EN 1992-1) of 460 MPa and a minimum characteristic strain (ϵ_{uk}) of 5%, which corresponds to a class B of ductility in BS EN 1992-1.

2.2. REINFORCEMENT SPACERS

- A. Spacers may be made of metal, concrete, cement mortar or plastic.
- B. Metal spacers or metal chairs shall not come into contact with the formwork.
- C. Concrete or cement mortar spacers shall be of sufficient size to remain stable and shall be of equivalent quality to that of the concrete.
- D. Unless their actual shape makes them perfectly stable, all spacers shall be provided with systems for attaching them to the reinforcement.

2.3. DELIVERY OF STEEL REINFORCEMENT

- A. When the steel bars for concrete reinforcement are delivered on site, they must be straight, without bends or windings, without stains or other damage. Bars accidentally bent will be rejected; however, after removal of the bent parts, the remaining straight sections could be accepted if the available length is sufficient.
- B. When the steel reinforcement is delivered already shaped and assembled, it will be transported to the place of use with great care to ensure that no parts will not be permanently deformed.

2.4. STORAGE OF STEEL REINFORCEMENT

- A. The steel reinforcement bars shall be stored in such a manner that different diameters cannot be mixed.
- B. Storage yards shall be clean and designed in such a manner that none of the steel reinforcement is in contact with the ground or subject to damp conditions.

2.5. WELDING OF BARS

- A. The Engineer may authorise end-to-end welding of steel bars and spot welds on bars as a replacement for binding, depending on the steel bar weldability certificates.

- B.** The Engineer will prescribe tensile and bending tests on welded parts in order to check the quality of welds and prove that the procedure will produce adequate strength and other necessary properties in the splice.
- C.** Where agreed, welding of bars shall be carried out in strict accordance with the steel Manufacturer's instructions.

2.6. BENDING OF REINFORCEMENTS

1. Steel reinforcement for reinforced concrete shall be fixed in accordance with the detailed Drawings to be prepared by the Contractor and approved by the Engineer. The Contractor shall provide bending schedules and shall be responsible for checking them and ensuring their accuracy before ordering and bending the reinforcement.
2. The bars shall be bent cold in a manner that will not injure the metal and in accordance with BS 4466. No bar exempt links and stirrups shall be bent to a smaller radius than twice its diameter. All bars which are lapped to secure continuity shall, unless otherwise stated to the contrary, overlap not less than the values given in BS 8110. Reinforcement projecting from partly finished work shall not be bent unless permitted by the Engineer and shall be protected from damage.

3. EXECUTION

3.1. PREPARATION

Firm rust on steel reinforcement will be permitted but rust which is loose or flaky shall be wiped off firmly with burlap or wire-brushed.

3.2. PLACING OF REINFORCEMENT

1. Before being fixed in position all reinforcing bars shall be cleaned of all mill scale, rust, dried grout, paint, oil, grease, earth or any other substance which may impair the bond between the reinforcement and the concrete.
2. The reinforcement shall be placed and securely fixed in the exact position required and the Engineer's approval obtained before concreting is commenced. On walls the horizontal and vertical bars shall be securely bound together with 16 s.w.g annealed soft iron wire at intervals not exceeding 400 mm and at all intersection.
3. The ends of links and bindings shall be bent around the bars for at least 225 degrees so as to fit tightly.
4. Fabric reinforcement when laid adjacent to other sections of reinforcement or when lapped shall have a minimum lap of 300 mm for the main wires and 150 mm for transverse wires.
5. Anchorage length and overlap length shall not be inferior to 60 times bar diameter, unless stated otherwise.
6. Reinforcement in angles shall be placed taking into account the unwanted thrust effect from curved rebars in tension.

3.3. COVERING OF REINFORCEMENT BARS

Unless otherwise indicated, the minimum thickness of concrete covering the steel reinforcement shall be as follows:

1. For concrete cast directly against earth: 7,5 cm

2. Concrete in contact with water and atmospheric or aggressive agents: 5 cm (protection such as coating or painting shall be neglected, unless if approved by the Engineer)
3. Concrete in dry rooms: 3 cm
4. The covering over all reinforcement is to be at least equal to:
 - a) its diameter (Φ) if it is a single bar,
 - b) $\Phi \times n^{0.5}$ if it is a group of n bars, with a maximum of 55 mm
5. The concrete cover of the horizontal bars of a vertical layer of reinforcement shall exceed 4/3 of the maximum nominal aggregate diameter.

3.4. MINIMUM REINFORCEMENT FOR RESERVOIRS

In addition to BS EN 1992-1 and BS EN 1992-3, the following criteria apply for reservoirs:

For reservoir walls, the steel section of reinforcement (in m²) shall not be inferior to 0,125 % of wall width (in m) on each face and both vertically and horizontally.

For reservoir raft, the steel section of reinforcement (in m²) shall not be inferior to 0,25 % of raft thickness (in m) in each direction. This section shall be spread on the top and bottom layer of reinforcement.

3.5. PROTECTION

As the concrete sets, after it has lost its plasticity, the steel reinforcement shall not be subjected to shocks or any external force (bending or use of bars for moving personnel) for a period of 48 hours.

SECTION 03250

CONCRETE STRUCTURE JOINTS AND NEOPRENE BEARING PAD

1. GENERAL

1.1. WORKS INCLUDED

This section covers the supply, installation or execution of different types of joints in all concrete structures and neoprene bearing pads.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DEFINITION AND DESCRIPTION

A. Contraction joint

1. It is a contact between 2 elements generally without continuity of reinforcement, or half continuity of reinforcement.
2. Such joints will enable concrete cracks to be localized and construction phases to be localized.
3. They shall have no filler material (concrete cast against concrete).

B. Expansion joint

1. An expansion joint is formed by creating complete discontinuity with clear gap between 2 elements.
2. The purpose of expansion joints is to prevent structural disruptions as a result of temperature variations or differential movements, including earthquake effects in seismic regions.
3. The joints shall be filled with preformed joint filler.

C. Construction joint

1. The continuity of both concrete, by special preparation, and reinforcement shall be assured.
2. These joints localize construction phases.

D. Sealing strip (or waterstop)

1. Watertight sealing is achieved by a natural rubber or PVC strip held in the two parts of structures in contact.
2. Strips are fitted to contraction and expansion joints.

E. Joint sealing compound

Joints may be sealed with an elastomer joint-sealing compound.

F. Neoprene bearing pads:

These elements shall provide vertical support and allow small horizontal displacements. They can be used for example between roof slabs and supporting water retaining walls under temperature shrinkage or during earthquake.

G. Preformed gap filler:

For the remaining part of gap in expansion joint and around neoprene bearing pad.

1.4. QUALITY ASSURANCE

All the products used in joint work shall be of proven quality and shall be obtained from reputable manufacturers and approved by the Engineer.

1.5. STANDARDS AND CODES

The following Standards shall be used, in this order of priority:

1. ASTM D1751
2. British Standards.
3. European Standards.

1.6. SUBMITTALS

A. Technical data sheets giving the physical, chemical and mechanical characteristics of:

1. Sealing strips and special connection parts
2. Preformed joint fillers
3. Joint sealing compound
4. Neoprene bearing pads

B. A sample of all the products to be used in joint construction.

- C. Results of quality control tests carried out in the factory on sealing strips and joint sealing compound.
- D. Manufacturer's instructions for the storage and use of products.

1.7. TOLERANCES

A. Sealing strips

- 1. With respect to the formwork before pouring of concrete: 5 mm in all directions.
- 2. With respect to the final faces of the structure after pouring of concrete: 20 mm in all directions.

B. Joint sealing

After making the joint, the surface of the facing shall be continuous and smooth and shall not have any local irregularity greater than 5 mm.

C. Bridge joints

- 1. The level difference between the top carriage way surface of the bridge joint and the finished surface of the bridge deck shall be less than 5 mm.
- 2. The level difference between the 2 sectional irons forming the built-in part of the joint shall be less than 2 mm.

D. Neoprene bearings

1 mm in flatness and horizontality for lower surface (head of water retaining wall) and upper surface (roof slab).

2. PRODUCTS

2.1. SEALING STRIPS AND CONNECTION PARTS

A. Material

Sealing strips shall be of rubber sections for type 1 and polyvinyl chloride (PVC) for type 2 waterstop.

Type 1 will be used for expansion joints or contraction joints in structures bearing a water pressure more than 5 mwc.

Type 2 will be used for contraction joints.

B. Rubber Material Characteristics

	At 25°C	After aging (48h at 70°C under 2 MPa of Oxygen)
Tensile strength greater than	20 MPa	15 MPa

Elongation on rupture greater than Percentage of cinders less than Shore hardness	450% 4% 60 to 70	350% 4%

C. PVC material characteristics

	At 25°C	After aging (48h at 70°C under 2 MPa of Oxygen)
Tensile strength greater than Elongation on rupture greater than Maximum water absorption after 48 h immersion at 50°C Shore hardness	12 MPa 250 % 3 % 50 to 60	15 MPa 350 %

D. Range of dimensions (in mm)

Type	Width	Centre bulb	Outer flanges
1	300-350	45-55	23-27
2	200-230	No	18-22

E. Protection

During storage, sealing strips shall be protected from UV light.

2.2. PREFORMED JOINT FILLER

The preformed expansion joint fillers shall consist of a compressible, rot-proof and elastic material of the Flexcell or equivalent type conforming to ASTM D1751.

2.3. JOINT SEALING COMPOUND

A. The joint sealing compound will be an elastic, adhesive, waterproof elastomer capable of stopping the intrusion of foreign materials in the joint.

B. The product shall not have any chemical action on the materials with which it will come into contact (concrete, preformed joint filler).

C. Characteristics

1. Density:..... 1700 kg/m³ minimum
2. Shore hardness: 25-30
3. Consistency after polymerization: Rubbery
4. Proportion of solvent: Nil
5. Shrinkage: Nil
6. Vertical creep:..... Nil

- 7. Minimum deformation: 25 %
- 8. Minimum deformation in compression and traction without bond breaking, creep or cracking in the temperature range of 0-70°C.

2.4. BRIDGE JOINTS

- A. Bridge joints shall be formed by steel and neoprene rubber.
- B. Bridge joints shall be of the medium-heavy type capable of accommodating movements of 20-30 mm.

2.5. NEOPRENE BEARING PADS

Same quality as for bridge joints but without reinforcement of steel plates. Sticking with approved glue on its sub-surface.

3. EXECUTION

3.1. INSPECTION

All the products making up the joints (sealing strips, special parts, preformed joint filler, joint sealing compound, bridge joints) will be inspected and checked by the Engineer before installation.

3.2. SEALING STRIPS AND SPECIAL PARTS

- A.** Sealing strips as well as special intersection or connection parts, shall be fastened to the formwork or the reinforcement so as to keep them in the correct position as defined on the drawings during concreting operation.
- B.** Under no circumstances shall sealing strips fastening devices compromise watertightness (nailing for example).
- C.** Sealing strips as well as special intersection or connection parts shall be interconnected in order to guarantee total continuous sealing. The method of connection shall be of an approved type such as hot-vulcanized connection using an electric vulcanizer, or cold connection using a preformed rubber sleeve, and special solvent, as specified by the manufacturer of the strips.
- D.** The Contractor shall take particular care when concreting around the sealing strips. The consistency, particle size distribution, placing and internal vibration of the concrete shall be such that encasing is obtained. Large aggregates shall in all cases be removed from the strip encasing zone.
- E.** Restarting parts of sealing strips or special parts shall be protected from the risk of mechanical accidents and, if necessary, from the effects of solar radiation if the exposure time were to exceed one month.
- F.** All sealing strips or special parts incorrectly installed or connected, punctured or damaged, will be rejected and replaced.

3.3. PREFORMED JOINT FILLER

- A.** The preformed joint fillers shall be installed in the positions defined on the drawings against the first concreted face of the joint.
- B.** The method of fixing the preformed joint filler (copper or bronze nailing or bonding with an adhesive compatible with the filler material) shall ensure proper stability of the joint filler before and during concreting.
- C.** Joints between preformed joint filler panels shall be made watertight in order to prevent the penetration of underlying cement grout.

3.4. JOINT SEALING

- A.** The edges of joints shall not show any signs of spalling or beading. Any repairs that may be required on the joint lips shall be carried out using epoxy resins approved by the Engineer.
- B.** Before filling with the joint sealing compound, the joint faces shall be cleaned of any loose laitance by sand-blasting or grinding or brushing. The faces shall be clean and dry when the mastic compound is applied.
- C.** The joint sealing compound shall be applied in strict accordance with the manufacturer's recommendations.

3.5. BRIDGE JOINT

- A.** Anchor bars of bridge joint shall be welded to the reinforcement bars.
- B.** The two parts of the bridge joint shall form an integral part during concreting of the second part of the joint and shall be separated as soon as concrete setting is done.

3.6. NEOPRENE BEARINGS

- A.** The reinforced neoprene pads shall be settled on perfectly flat and horizontal surfaces.
- B.** The performances (ashlar) of the bearing surfaces shall be slightly larger than the neoprene pad. The ashlar shall be refilled on pointed surface with a mortar dosed at 500 kg of cement per cubic metre of sand. The neoprene bearings shall be placed on green mortar. For case in-situ structures the Contractor shall design a formwork system allowing for an easy stripping around the bearing.

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SECTION 03300

CONCRETE

1. GENERAL

1.1. WORK INCLUDED

This section covers the execution of concrete works for all structures.

1.2. RELATED SECTIONS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. STANDARDS AND REGULATIONS

A. Local Standards

HHSN – Seismic Code of the Republic of Armenia

SNiP – Construction rules and regulations

B. British Standard

BS EN 1992-1 Eurocode 2 - design of concrete structures - part 1-1: general rules and rules for buildings

BS EN 1992-3 Eurocode 2 - Design of concrete structures - Part 3: Liquid retaining and containment structures

BS EN 1998-1 Design of structures for earthquake resistance – General rules, seismic actions and rules for buildings

BS EN 1998-4 Design of structures for earthquake resistance – Silo, tanks and pipelines

BS EN 1998-5 Design of structures for earthquake resistance – Foundations, retaining walls and geotechnical aspects

BS EN 206-1 Concrete - part 1: specification, performance, production and conformity

BS EN 197-1 Cement - Part 1: composition, specifications and conformity criteria for common cements

BS I2 Specification for ordinary and rapid hardening Portland cement

BS I46: Part 2 Specification for Portland blast furnace cement (Metric units)

BS 340	Specification for precast concrete kerbs, channels, edgings and quadrants
BS 368	Precast concrete flags
BS 812	Grading of aggregates
BS 1200	Building sands from natural sources
BS 1881	Testing Concrete
BS 3148	Methods of tests for water for making concrete
BS 4027	Specification for sulfate-resisting Portland cement
BS 4246	Low heat Portland blast furnace cement
BS 5328	Methods for specify concrete
BS 5896	Specification for high tensile steel wire strand for the prestressing of concrete
BS 6073	Specification for precast concrete masonry units
BS EN 933-3	Tests for geomtrical properties of aggregates
BSI 6089	Guide to assessment of concrete strength in existing structures

C. American Concrete Institute (ACI)

ACI 121R	Quality Assurance Systems for Concrete Construction
ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 305	Hot Weather Concreting

D. American Society for Testing and Materials (ASTM)

ASTM A 416	Specification for Uncoated Seven-Wire Stress-Relieved Steel Strand for Prestressed Concrete
ASTM A 421	Specification for Uncoated Stress-Relieved Wire for Prestressed Concrete
ASTM A 615	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM C 31	Test Method of Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Specification for Concrete Aggregates
ASTM C 39	Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 40	Test Method for Organic Impurities in Fine Aggregates for Concrete
ASTM C 42	Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 70	Test Method for Surface Moisture in Fine Aggregate
ASTM C 88	Test Method for Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate

ASTM C 94	Specification for Ready-Mixed Concrete
ASTM C 114	Methods for Chemical Analysis of Hydraulic Cement
ASTM C 177	Test Method for Material Finer than 0.075 mm Sieve in Mineral Aggregates by Washing
ASTM C 125	Definition of Terms Relating to Concrete and Concrete Aggregates
ASTM C 127	Test Method for Specific Gravity and Absorption of Coarse Aggregate
ASTM C 128	Test Method for Specific Gravity and Absorption of Fine Aggregate
ASTM C 131	Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 142	Test Method for Clay Lumps and Friable Particles in Aggregate
ASTM C 143	Test Method for Slump of Portland Cement Concrete
ASTM C 150	Specification for Air-Entraining Admixtures for Concrete
ASTM C 151	Test Method for Autoclave Expansion of Portland Cement
ASTM C 172	Method of Sampling Freshly Mixed Concrete
ASTM C 191	Test Method for Time of Setting of Hydraulic Cement by Vicat Needle
ASTM C 192	Method of Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 204	Test Method for Fineness of Portland Cement by Air Permeability Apparatus
ASTM C 231	Test Method for Air Content of Freshly Mixed Concrete by the pressure Method
ASTM C 309	Specification for Liquid Membrane - Forcing Compounds for Lining Concrete
ASTM C 348	Test Method for Flexural Strength of Hydraulic Cement Mortars
ASTM C 349	Test Method for Compressive Strength of Hydraulic Cement Mortars (Using Portions of Prisms Broken in Flexure)
ASTM C 360	Test Method for Ball Penetration in Fresh Portland Cement Concrete
ASTM C 403	Test Method for time of setting of concrete mixtures by Penetrations Resistance
ASTM C 451	Test Method for Early Stiffening of Portland Cement (Paste Method)
ASTM C 469	Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
ASTM C 494	Specification for Chemical admixture for concrete
ASTM C 496	Test for Splitting Tensile Strength of Cylindrical Concrete Specimens
ASTM C 535	Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 566	Test Method for Total Moisture Content of Aggregate by Drying
ASTM C 595	Specification for Blended Hydraulic Cements
ASTM C 596	Test Method for Drying Shrinkage of Mortar Containing Portland Cement

- ASTM C 618 Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
- ASTM D 75 Practices for Sampling Aggregates
- ASTM D 2419 Test Method for Sand Equivalent Value of Soils and Fine Aggregate
- ASTM D 2487 Classification of Soils for Engineering Purpose.

E. Association Française de Normalisation (AFNOR)

- NF P 15-436 Binders - Measuring of hydration heat of cement by means of semi-adiabatic calorimetry (Langavant method)
- NF P 18-561 Aggregates - Measurement of the Flattening coefficient
- NF P 15-317 Hydraulic binders – sea-water resisting cements
- NF P 15-319 Hydraulic binders – sulphate resisting cements

F. Deutsches Institut Fur Normung

- DIN 1048 Testing Method for concrete; fresh concrete.

1.4. SUBMITTALS

- A. The Contractor shall advise the Engineer not later than 2 months after the commencement date, by means of a detailed memorandum, of the arrangements he proposes to adopt regarding the production of sand and aggregates and the manufacture of concrete, as well as for casting of the concrete.**
- B. Documents on concrete manufacturing**
- C. The Contractor shall submit to the Engineer's approval detailed drawings of the phases of concreting, specifying the locations of the various construction joints, any particular arrangements which may be required, and the order of implementation of the different phases.**
- D. Test results**
- The results of the tests shall generally indicate:
1. Identification number of sample.
 2. Origin of sample.
 3. Part of structures represented by the sample.
 4. Drawing date of the sample.
 5. Description of test with reference to a given standard.
 6. Test result.
 7. Date of test.
- E. Cement**
1. Test report for approval of cement before use.
 2. Chemical and physical analyses for each make.

3. Copy of the cement storage record-book submitted at the end of each week.

F. Aggregates

Test report for approval of aggregate before any use.

G. Water

Detailed memorandum for approval.

H. Additives

Test results.

I. Concrete

1. Results of tests on mix design studies.
2. Results of concrete suitability tests.
3. Results of control tests.
4. Complete records shall be kept by the Contractor of all concreting. The records shall include the time of mixing and casting, weather conditions, quantity, mixture proportions, amount of additives, slump and water content of each cast, as well as the results of any tests made on the concrete.

1.5. DESCRIPTION

- A. The major part of the concrete may be considered as medium reinforced concrete except in volume with some embedded items. In consideration of the behaviour of massive concrete blocks (setting temperature, shrinkage) and for reasons of construction (concreting or/and equipment erection schedules, etc.) concrete shall be placed in a number of planned pours or lifts (a lift being defined as a volume of concrete poured without any interruption).
- B. Except as otherwise specified or shown on the drawings or directed by the Engineer the extent of any horizontal length of a lift shall not exceed 15 m. The height shall in general not exceed 2.5 m, in some exceptional cases (with at least one small horizontal dimension) higher.
- C. In the building parts such as service rooms, staircases, etc.. reinforced concrete works with a medium to high percentage of reinforcement shall be involved. In principle, the above mentioned provision concerning the massive concreting sections remains valid.
- D. Finally, concreting sections will be provided such as second phase concrete for pockets or around embedded items. In these cases, relatively small quantities of concrete will be placed under confined conditions.
- E. All concreting of contiguous lifts are separated by construction or expansion joints. In general, the reinforcement will be continued over the construction joints.
- F. Pouring of lifts of limited dimensions does not exclude other means to avoid cracking such as the use of low heat of hydration cement, low cement ratio and refrigeration of concrete constituents.
- G. All concrete shall be “hydraulic type concrete”, watertight by its own media.

2. PRODUCTS

2.1. CEMENT QUALITY

- A. Unless otherwise specified, the cement shall be Portland Cement type CEM I or CEM III according to EN 197-1, and resisting to sulphate according to NFP 15-319**

The cement shall meet the following specifications:

Characteristics	Value	Test Method
Minimum compressive strength at 28 days	30 MPa	ASTM C 349
Initial setting time (Vicat needle) more than	90 mm	ASTM C 191
Initial setting time less than	180 mm	
Le Chatelier stability - cold and hot expansion less than	3 mm	NFP 15-432
Shrinkage at 28 days of mortar less than	0.08 %	ASTM C 596
+ chemical characteristics S03 less than	5 %	ASTM C 114
Hydration heat at 5 days (Langavant bottle) less than	260 J/g	NFP 15-436
+ equivalent sodium oxide ($Na_2O+0.658 K_2O$) less than	0.6 %	ASTM C 114
Potential alkali reactivity of cement - aggregate Combination - expansion at:		
6 months less than	0.075 %	ASTM C 227
12 months less than	0.1 %	ASTM C 227

+ for cement only.

- B. The mixing of cements or cement and mineral admixtures, such as milled slag, fly ash, pozzolan or fillers shall be authorised provided the effect of such blends made before mixing in the batching plant or during mixing be tested in accordance with the Engineer's instructions and the result submitted to the Engineer.**

2.2. APPROVAL OF CEMENT BEFORE ANY USE

- A. Each make of cement shall be constituted by cement from a homogeneous source (same factory, same fabrication process and same basic material).**
- B. The delivery of any make of cement to the primary silos at site shall not take place until written approval has been given by the Engineer, after examination of the test report. This test report shall be the result of tests carried out in the cement works or in a laboratory approved by the Engineer.**
- C. The tests shall include:**
- Flexural and compressive strength at 2,7, 28 and 90 days.
 - Initial and final setting time on pure paste.
 - Cold and hot expansion.
 - Shrinkage of cement mortar.
 - Chemical analysis.

6. Hydration heat (measured at 12 hours 1, 2, 3, 5 and 7 days) by the insulated. Langavant bottle method. (NF P 15-436) which is a semi-adiabatic measurement.
 7. Potential alkali reactivity of cement - aggregate combination (test duration: at least 2 years: the 6 months test will be extended for at least six additional months).
 8. Blaine's specific surface (ASTM C 204).
- D. Each characteristic shall be taken as equal to the average of three measurements made under each test (except for the compressive strength which shall be the average of 6 measurements).**

2.3. VERIFICATION OF CEMENT DELIVERED

- A. Control sampling shall be effected on each supply before the cement is delivered to the primary silos at site and when required by the Engineer.**
- B. Every 1000 t or not less than once a month, the following control tests shall be carried out:**
1. Hot and cold expansion
 2. Flexural and compression strength at 2 and 28 days
 3. Initial and final setting time on pure paste
 4. Blaine's specific surface
- C. Every 5000 t or not less than once a month, the following control tests shall be carried out:**
1. Heat of hydration (measured at 12 hours, 1, 2, 3, 5 and 7 days).
 2. Chemical analysis.
- D. Every 1000 t, and not less than once a month, a sample shall be taken at the silo of the batching plant and shall be kept in the laboratory for a minimum duration of 6 months (conservation samples). These samples (5 kg) are designed to allow the performance of tests a posteriori, in case of dispute or for information.**
- E. No cement shall be used before the flexural and compression strength at 2 days, the initial and final setting times, and the Blaine specific surface are known.**

2.4. CEMENT DELIVERY

- A. The cement shall be delivered in bulk or in bags, with the exception of cement for grouting, repair or finishing works or any other particular works, which will be delivered exclusively in bags.**
- B. Transport from the factory to the site shall be effected in watertight containers specially designed for this purpose.**
- C. The installations for transport from the container to the silo and from the silo to the mixer shall be watertight.**

- D. Once the supply in bags has been approved, the cement shall be delivered in bags of standard dimensions. The identification of the cement, the name of the manufacturer and the weight of the bags shall be clearly marked on each bag. Cement from damaged bags shall be neither used nor replaced in the bag without the prior approval of the Engineer.

2.5. CEMENT STORAGE

- A. The cement supplied in bulk shall be stored in watertight silos designed to ensure that there is no loss in storage. The silos shall be emptied and cleaned every 6 months and whenever there is a change in the type or origin of the cement.
- B. The cement supplied in bags shall be stored in a dry place, fully enclosed and covered, isolating them from the soil and from atmospheric agents. The store shall be of sufficient dimensions to allow easy access for identification, removal of samples, counting and moving the bags. The bags shall not be stored in piles exceeding 2.5 m in height.
- C. The cement shall be used in chronological order of its arrival. The temperature of the cement at the time of its use shall not exceed 70°C.
- D. The total storage capacity of the primary silos at site shall be sufficient to guarantee normal progress of works on site for a duration of 20 calendar days.
- E. The use of any cement that has remained in storage on site for more than 4 months shall be subject to a complete series of physical tests to ensure that the specifications are complied with.
- F. Any cement which has been exposed to the elements or which has set, even partially, or which has been rejected in compliance with the specifications shall not be used for the permanent Works and shall be removed from the silos or stores.

2.6. CEMENT STORAGE RECORD-BOOK

The Contractor shall keep for every silo a cement storage record-book in which the following will be noted:

1. The quantity of cement in store at the end of the week.
2. The quantities, origin and location of storage of the various batches delivered during the week.
3. The quantities used daily and the structures in which the cement is used.

2.7. OVERALL QUALITY OF AGGREGATES

- A. The aggregates shall be crushed material originating from rock that is neither sensitive to the environment nor likely to have any harmful effect with regard to the other concrete ingredients. Fine aggregates for concrete may consist of natural sand. Provenance of aggregates after washing, screening and possibly crushing is subject to prior Engineer's approval with evidence of their suitability as regards to the requirements of the present specification.
- B. The aggregates shall meet the requirements of ASTM C 33.

- C. The density of the aggregates shall be greater than 2.55 t/m³.

2.8. GRADING OF FINE AGGREGATES

- A. The fine aggregate shall be made up of two separate categories, which shall be:

1. Fine sand 0 - 0.630 mm
2. Coarse sand 0.630 mm - 5.0 mm

- B. The grain size characteristics of the fine aggregate after mixing the two categories shall be within the following range:

Sieve Designation	Per cent passing by weight
4.8 mm (N°4)	95 to 100
2.4 mm (N°8)	85 to 95
1.2 mm (N°16)	60 to 85
0.595 mm (N°30)	30 to 65
0.297 mm (N°50)	15 to 40
0.149 mm (N°100)	5 to 20
0.074 mm (N°200)	0 to 5

- C.

1. The fineness modulus shall be within the range of 2.2 to 3.1.
2. Continuity, that is the percentage in mass retained between two successive sievings, shall not be greater than 40%.

2.9. GRADING OF COARSE AGGREGATES

- A. The coarse aggregates shall be divided into 3 categories:

1. 5/12.5
2. 12.5/25
3. 25/50

- B. Coarse aggregates will be divided into classes defined by d/D, and shall meet the following conditions:

US Standard Sieve Designation	Per cent passing by weight		
	5 /12.5 mm	12.5 /25 mm	25 /50 mm
76.2 mm (3 inches)	-	-	100
50.8 mm (2 inches)	-	-	90-100
38.1 mm (1 1/2 inch)	-	100	35-65
25.4 mm (1 inch)	-	90-100	3-10
19.1 mm (3/4 inch)	100	35-65	0-3
12.7 mm (1/2 inch)	90-100	3-10	-
9.5 mm (3/8 inch)	35-65	0-3	-
4.8 mm (No. 4)	3-10	-	-
2.4 mm (No. 8)	0-3	-	-

2.10. NOT USED.

2.11. PROPERTIES OF AGGREGATES

A. General

Characteristic	Value	Test Method	Field of application
Water absorption, Ab	< 5	ASTM C 127 ASTM C 128	Coarse aggregate Fine aggregate
Los Angeles, LA	< 40	ASTM C 131 ASTM C 535	Aggregates > 2.5 mm Coarse aggregates
Flattening coefficient	< 30	NF P 18-561	Aggregates > 4 mm
Sand equivalent ESV	> 75	ASTM C 2419	Fine aggregate mixtures of sands

B. Sand equivalent

Fine aggregates having an equivalent sand value (ESV) which is less than the specified value may be accepted if the blue value (BV) measured according to standard NFP 18-595 is less than 1 g per 100 g of fines passing through the 80 micron sieve.

2.12. TRANSPORT AND STORAGE OF AGGREGATES

- A. The transport and storage methods shall be such as to guarantee a stable and uniform water content and to avoid any segregation.**
- B. The different classes of aggregates shall be stored separately in silos or on a concrete platform or by any other means guaranteeing an equivalent level of cleanliness. The storage area must be designed to ensure effective drainage of the aggregates. The aggregates shall be stored sheltered from rain and protected from solar radiation.**
- C. The capacity of the storage specified in para. B for each class of aggregates shall be sufficient to ensure progress of work on the site for a duration of 8 days.**

2.13. VERIFICATION OF AGGREGATES

A. Normal frequency N

- 1. Every week or every 500 m³ of concrete if the volume of concrete manufactured is less than 500 m³ per week.
- 2. For every new delivery of a material of different origin or obtained by a different process.

B. Frequency xN

- 1. Every x tests carried out at the normal frequency.
- 2. For every new delivery.

C. Tests to be performed on the aggregates:

Characteristics	Method ASTM	Field of application	Frequency
Grain size analysis	C 136	All aggregates	N
Water content	C 566	Fine aggregates	N
Water content	C 566	Coarse aggregates	N
Fineness modulus diagram	C 136	All aggregates	10 N
Water absorption	C 127	Coarse aggregates	5 N
Water absorption	C 128	Fine aggregates	5 N
Los Angeles	C 131-C535	Aggregates > 2.5 mm	15 N

Organic matter	C 40	Fine aggregates	10 N
Sand equivalent	D 2419	Fine aggregates	N
Soundness	C 88	All aggregates	15 N
Flattening Coefficient	NF P 18-561	Aggregates > 4 mm	5 N

D. The tests shall be performed on samples taken in accordance with the Engineer's instructions.

E. Diagram of fineness modulus

At the specified frequency, a series of 10 sieve analyses will be made at intervals of about 1 hour. The following will be noted on a diagram: the 10 results, the average of the 10 results, the straight lines situated at 0.10 and 0.20 unit above and below the mean value. The results of the fineness modulus determined by the normal sieve analyses shall also be shown on this diagram.

F. Blue value

Measurement of the blue value shall be made where the equivalent sand value (ESV) is less than the specified value.

2.14. WATER

A. The mixing and curing water shall be free of any impurities which might significantly affect the duration of setting, the strength or durability of the concrete or which might affect the appearance of the concrete by discolouration, coloration or efflorescence.

B. The mixing and curing water shall meet the following specifications:

Impurity	Maximum content (part per million - ppm)
Suspended matter	2000
Carbonates and bicarbonates	1000
Sulphate (SO ₃)	1000
Dissolved salts	2000

C. Where the dissolved salt concentration exceeds the specified value, or where the water quality is doubtful in the Engineer's opinion, comparative tests of compressive strength and setting time will be performed on two cement pastes with the same cement, one with the water in question and the other the reference paste, with distilled water in the same proportions. The water will be acceptable if the test results comply with the following values:

Test	Limit	Standard
Compressive strength at 7 days minimum result compared to reference paste	90 %	ASTM C 349
Start of setting: maximum difference from time of reference paste	1 h	ASTM C 191

D. Control tests shall be carried out:

- For approval of the water.
- For any change in the source of supply.
- In any event, once every three months.

2.15. ADDITIVES

- A. Additives shall comply with ASTM C 494.
- B. The use of additives containing calcium chloride is forbidden.
- C. All additives shall be in liquid form.
- D. Provision shall obligatorily be made for the automatic addition of any additive.
- E. The concrete shall be made with addition of a water-reducing plasticizer, with the exception of blinding concrete.
- F. The Contractor shall submit, for approval of any proposed additive, a memorandum demonstrating, on the basis of test results, the compatibility of the additive with the other concrete ingredients, its influence on the proportion of water for equal consistency, its effect on consistency for equal proportions of water, the times of beginning and end of setting of the neat cement paste, and the mechanical strengths of the concrete obtained. These tests are performed for the optimum proportion proposed and for half and double of this optimum proportion.
- G. Where specified, the following additives shall be used:
 - 1. Air entrainer.
 - 2. Shrinkage reducer for certain sealing grout or mortars; this additive shall be free of iron.
 - 3. Setting accelerator for shotcrete.

2.16. CLASSES OF CONCRETE

- A. The concrete classes are defined by their characteristic strength f_{ck} in MPa, followed by the specified coarser aggregate dimensions in mm.
- B. The characteristic strength f_{ck} is the compressive strength at 28 days on 150 mm dia cylinder for all concrete classes A, B, C, D, below which less than 5% of the tested samples should be found.
- C. Classification table:

Class	Class according to BS EN 206-1	Definition	f_{ck} (MPa)	Coarser aggregate dimension (mm)	Cement content kg/m ³		Max water/ Cement ratio max W/C
					min	max	
A	C35/45	Reinforced concrete Precast concrete	35	25	350		0.45
B	C20/25	Unreinforced and lightly reinforced concrete	20	40	250	320	0.55
C		Shotcrete	25	-	350	400	-
D		Blinding concrete	15	25	180	250	-
E		Porous concrete	10	40	200	250	-

2.17. CONCRETE COMPOSITION

For each class of concrete, a memorandum shall be submitted to the Engineer demonstrating that for the design consistency, the proposed composition and the installations on site will produce concrete satisfying the specifications.

If the proposed concrete has not been made previously from materials of the same type and origin and with equivalent site installations, a concrete design study shall be made for testing, with the exception of blinding concrete.

2.18. CONCRETE DESIGN STUDY (CONCRETE CLASSES A, B, C)

A. Purpose

1. Check that the nominal composition of the concrete proposed by the Contractor enables the specification to be met.
2. Check that the concrete specifications are still respected if the quality of the ingredients reaches the specified limits or the probable limits of the ingredients used.
3. Check that the concrete specifications are still respected if the proportions of the ingredients reach the specified limits or the probable limits resulting from the site installation (the design limits may also be chosen so as to study several nominal compositions simultaneously).

B. The design test will involve the following operations:

1. Three batches meeting the nominal formula.
2. Eight batches varying from the nominal formula as follows:
 - a) Two batches by modifying the proportions of aggregates (for example variation of the ratio of the mass of coarse aggregates to that of finer aggregates by 10% in either direction).
 - b) Two batches by altering the quantity of mixing water (10 l/m³ more and less).
 - c) Two batches by altering the quantity of cement (25 kg/m³ more and less).
 - d) If an additive or additives are used, two batches by altering the quantity or quantities of additives (half and double the optimum quantities).

C. Measurements made for concrete classes A, B and C:

1. Each batch shall be the subject of the following measurements:
2. consistency;
3. density and air content within the fresh concrete;
4. density of concrete at 28 days;
5. compressive strength at 7 days on three samples;
6. compressive strength at 28 days on three samples and static modulus of elasticity and Poisson's ratio (in addition to ASTM C 469 strains shall be measured for stresses of 3, 5, 7, 9, 11 MPa).
7. The components shall be subject to the control measurements specified elsewhere.
8. Also to be noted are the following factors:

- Temperature of the components and of the concrete during the tests.
- Aspect of the fresh concrete during performance of the consistency test and of the preparation of the specimens.
- Aspect of breakage during the mechanical tests.

D. Not used.

E. Interpretation of the design test:

1. The design test shall be considered valid and the composition of the concrete accepted if all the following conditions are met:
 - e) All consistency results are within the specified ranges.
 - f) The arithmetic mean (f_{cE}) of the 9 measurements (3 tests on each of 3 batches) of compressive strength in MPa measured at 28 days is greater than:
$$f_c + (C_E - C_{min})$$
and greater than $1.1 f_c$,
formula in which C_E is the compressive strength at 28 days of the cement used for the design test and C_{min} is the minimum guaranteed value of the cement's compressive strength at 28 days.
 - g) The arithmetic mean of the 3 compressive strength tests on each of the complementary batches is within the range of $f_{cE} \pm 0.15 f_{cE}$.
2. If the above conditions are not totally satisfied but the concrete is close to the required values or well in excess of these values, the Engineer will, if the Contractor submits a proposal to this effect, fix the nominal composition of the concrete without any further design test.

F. Not used.

2.19. CONCRETE SUITABILITY TESTS (CONCRETE CLASSES A AND B)

A. The suitability test, to be performed on the site at least 40 days before making any concrete for the permanent Works, shall be aimed at verifying the following:

1. that the concrete made by applying the nominal composition, using the materials and constructional plant delivered to the site, satisfies the specifications,
2. that the concrete composition, considering the installations it is envisaged to use, will enable the structures to be built in a satisfactory manner,
3. that the characteristics of the plant are in conformity with those submitted to the Engineer's approval.

B. The suitability test, performed under conditions representative of the site (transport, installations and plant used, temperature, etc) implies the making of three batches to the nominal composition and will involve:

1. Casting of a reference concrete sample in representative formwork, where required by the Engineer.
2. Casting of a volume of 1 m³ of concrete.
3. Performance of the same sampling and tests as for the design test.
4. Verification of the characteristics of the site installations or the materials supplied.

C. The test shall be interpreted on the same basis as the design test.

2.20. NOT USED

2.21. CONCRETE CONSISTENCY (CONCRETE CLASSES A AND B)

- A. The consistency of the concrete shall be such that it can be placed using the site facilities and compacted so as to enclose completely the reinforcement bars and embedded parts and completely fill the formwork, with neither voids nor segregation.**
- B. Consistency shall be checked by measuring the slumps test (ASTM C 143).**
- C. For concrete with aggregate larger than 40 mm, the test shall be performed on the fraction of concrete passing 40 mm sieve (the larger aggregate being removed in accordance with ASTM C 172).**
- D. The consistency classes are as follows:**

Consistency Class	Nominal slump (in cm)	Nominal Tolerance
Very stiff	1	0 - 2
Stiff	3	2 - 4
Semi-plastic	5	3 - 7
Plastic	8	6 - 10
Fluid	15	12 - 20

- E. The consistency classes shall be applied in the following manner:**
 - 1. 3 cm for mass concrete without embedded parts.
 - 2. 5 cm for slabs and lightly reinforced parts of the structures, for the main structures and the upper sections of walls and columns.
 - 3. 8 cm for narrow walls (< 40cm), columns, beams and heavily reinforced parts of the structures, and for lining concrete in underground excavations.
 - 4. Fluid conditions (slump of 15 cm or higher) shall be exceptionally applied when required by Engineer (around steel lining penstock for instance).
- F. The Engineer reserves the right to specify different consistencies where required by the nature of the works.**
- G. The concrete consistency shall be measured at the time it is used at the Engineer's discretion. If the measurement made falls outside the specified limits, two control measurements shall be made immediately, and the result shall be taken as the average of the three measurements, rounded off to the nearest centimetre.**
- H. In case of sampling for testing the strength of the concrete, 3 measurements shall always be made.**

2.22. PARTICULAR SPECIFICATIONS FOR SHOTCRETE

The composition of shotcrete shall be defined according to the recommendations of the AFTES (Association Française des Travaux en Souterrain i.e. French Association for Underground Works) relating to the technology and application of shotcrete.

The Contractor shall propose to the Engineer the composition of the shotcrete in terms of sieving of the aggregates alone and of the aggregate-cement mix. The particle size curves shall fall within the reference ranges recommended by AFTES. The Contractor shall also communicate to the Engineer the results of the tests carried out in laboratory in accordance with the same recommendations, depending on which concrete projection technique is adopted.

A. Suitability test

Forty days before commencing any shotcrete works, the Contractor shall perform suitability tests in the Engineer's presence, which shall cover, depending on the observed characteristics of the concrete ingredients:

1. Operation of the cement-mixers, of the control devices and the sprayed installations, under normal site operating conditions.
2. The quality of the shotcrete:
 - simple compressive strength at 8 h, 24 h, 7 days and 28 days,
 - adherence of the shotcrete to the terrain (minimum adherence on the most critical fissures or joints: 50% of the maximum adherence obtained on sound surfaces),
 - continuity of the shotcrete (no voids between the terrain and the shotcrete nor within the shotcrete itself),
 - apparent density of the shotcrete,
 - effective composition of the concrete,
 - consistency measurement (without additives).

These tests shall be carried out on not less than three tests panels for each mix for testing. Sets of test panels shall comprise one shot downwards on to a horizontal surface, one shot on to a vertical surface and one shot on to a overhead horizontal surface.

2.23. SPECIAL SPECIFICATIONS FOR POROUS CONCRETE

- A. Porous concrete is one containing no sand, used for drainage purposes under structures.**

The Engineer shall be responsible for defining whether or not it is to be used.

B. Composition

No sand shall be used.

2.24. PARTICULAR SPECIFICATION FOR BLINDING CONCRETE

- A. The blinding concrete is designed to be placed in the structure foundations on common soil; the layer of blinding concrete must be impermeable.**

- B. The concrete shall be obtained from a mix of sand, aggregates in the 5-12.5 and 12.5-25 size categories and cement at 275 kg minimum per m³ of concrete. The exact composition shall be proposed by the Contractor.

2.25. PARTICULAR SPECIFICATIONS FOR FLUIDIFIED CONCRETE

- A. Fluidified concrete will be used only when required by the Engineer.
- B. The concrete composition shall be the composition of a pumpable concrete and the amount of material finer than 0.250 mm (fine sand and cement) shall be at least 450 kg per cubic metre of concrete.

This concrete shall have a consistency measured by the slump test of 6 cm with the tolerance specified above, before addition of the fluidizer.

- C. The fluidizer shall be added to the concrete mixture already transported to the concreting site in a liquid form by means of an automatic control system. The fluidizer addition shall be followed by an additional mixing of the concrete-fluidizer mixture in a special concrete mixer (minimum mixing time: 3 mn) or in the truck mixer itself (minimum mixing time: 5 mn).
- D. The amount of fluidizer added shall be such that the slump of the mixture after the additional mixing is 15 cm. However this amount shall not be less than 0.5 % of the cement in weight.
- E. The setting retarder effect of the fluidizer may be compensated by use of an approved combined setting accelerator if required.
- F. **Suitability test**

Forty days before commencing any concrete works, the Contractor shall perform suitability tests in the Engineer's presence, which shall cover, depending on the observed characteristics of the concrete ingredients:

1. Operation of the cement mixers, of the control devices for fluidizer addition, of the additional mixing and of the final transport of fluidified concrete to the site (pipes, channels...).
2. The quality of the fluidified concrete:
 - a) Consistency measurement (before and after the fluidizer addition).
 - b) Simple compressive strength at 1, 3, 7 and 28 days.

The strength shall be at least 90 % of the corresponding strength of the same concrete without addition of the fluidizer.
 - c) Measurement of air content of fresh concrete after the additional mixing.
 - d) The compatibility of the fluidizer with any other additive possibly used, as requested above for any additive proposed.
 - e) Suitability of the concrete mix as regards to segregation.
 - f) Suitability of the concrete mix as regards to pumpability.
 - g) Effect of the variations in the quantity of fluidizer added, as described above for the submittal of any additive to the approval of the Engineer.

2.26. CONCRETE MIXING

- A. The aggregates, water, cement and additives shall be mixed in an automatic concrete-mixer with batching by weight, equipped with:
1. a wattmeter (slumpmeter or any other approved concrete workability meter),
 2. a printed register for recording the date and time of batching, the weight of cement and aggregates and the water-cement ratio.
 3. A continuous moisture measuring device for sand.
- B. The output of the plant shall be adapted to the programme of work and shall be at least 100 m³/hour.
- C. After the concrete has been mixed, no subsequent addition of water in the course of concreting will be tolerated.
- D. The mixing operation shall be under the control of a suitably experienced supervisor.
- E. The sequence of filling a mixer with the concrete ingredients shall be studied during the suitability tests and subject to the approval of the Engineer and unless otherwise authorized, the same sequence of filling shall be followed throughout the work.
- F. The quantity of mixed materials per batch shall not exceed the manufacturer's rated capacity of the mixer, and shall be further reduced for fluid concrete.
- G. An automatic timing device shall be used to set the duration of mixing.
- H. Mixing time shall be adjusted according to mix compositions and the mixers used and shall be at least 45 s after all components have been added. In the case of concrete containing admixtures, a minimum mixing time of 60 s shall be observed.
- I. At intervals decided by the Engineer, but which normally be once per day for coarse aggregates and at some other interval depending on the operation of the continuous moisture measuring device for sand, the Contractor shall carry out tests by an approved method to determine the free moisture content of the aggregates. Based on these tests, adjustments shall be made to the quantity of water added to the mix to maintain the specified water cement ratio.
- J. On commencing work with a clean mixer, the first batch shall contain only half of the normal quantity of the coarsest aggregate category and 10 % extra cement so as to compensate for the fine material and cement which is left sticking to the drum. This batch shall be mixed for at least one minute longer than normal.
- K. The mixer shall be completely emptied before being charged with the materials for the succeeding batch.
- L. Weight tolerances:
1. Cement and water:± 2%
 2. Aggregates:
 - Sand..... ± 3%
 - Coarse aggregate ± 5%
 - Total of the aggregate..... ± 3%
 3. Admixture: ± 5%
- M. Checking of weighing scales

The precision of the weighing scales of the batching plant shall be checked at the beginning of each month.

If the precision falls outside the specified tolerances, the batching plant shall not be used again until the scales have been adjusted or repaired as necessary.

N. Mixer performance

Mixer performance shall be determined in accordance with ASTM C 94 to determine the uniformity of the mixture.

3. EXECUTION

3.2. INSPECTION

- A. No concreting shall start until issue by the Engineer of a 'concrete permit'.**
- B. The Contractor shall request this permit at least 24 hours before the presumed start of concreting and after checking that the parts designed to be embedded in the concrete (reinforcement bars, waterstop joints, tie-rods, etc) and the formwork are correctly placed and fixed and that all surfaces designed to be in contact with the concrete have been prepared. The checking before concreting will also include for the dam, water circulation through the watertight coiled pipes, as well as the resistance of these pipes to pressure in excess of the maximum service pressure.**

3.3. PREPARATION

- A. Before casting any concrete layer, the surface of the previously cast concrete shall have been subjected to treatment consisting of the following operations:**
 - 1. Grout shall be removed from the surface, so as to reveal the mosaic of the concrete, without dislodging the coarser aggregates, nor the reinforcement bars or other embedded parts. Where possible, treatment shall be effected after the concrete has set but before hardening, using either a water jet under pressure or a mixture of air and water under pressure, alternatively by brushing the surface with a wire brush. Where this treatment is precluded by the hardening of the concrete, the surface shall be treated either by high-pressure water jet or by sand blasting, or by scabbling the surface. In case of scabbling, the fissured or loosened pieces shall be removed
 - 2. Cleaning with water and air under pressure.
 - 3. Moistening for a minimum duration of 24 hours before concreting.
 - 4. Elimination of excess water and final cleaning.
- B. Before placing concrete on the rock or common soil, the foundation surfaces shall be prepared as indicated under Section 02210.**

3.4. CONCRETE PLACING

- A. Concrete shall be transported from the mixer to its final position in such a manner that the concrete as placed shall not have lost excessive moisture or grout, nor become segregated.
- B. The concrete shall be placed and compacted in a such a manner as to avoid any movement of formwork, reinforcement bars, embedded parts or parts to be embedded.
- C. If required by the Engineer, the first layer of fresh concrete placed on hardened concrete shall consist of a mix which is the same as that of the new lift but without the larger nominal category of coarse aggregates. This layer shall be between 4 and 10 cm thick as directed and shall be covered before it has started setting.
- D. On rocky surfaces, immediately before concreting, a 5 cm thick layer of concrete class A shall be placed over the entire surface and in any fracture joints, so as to ensure an effective rock-concrete bond. The necessary arrangements shall be adopted to cover this mortar with concrete before it has started setting.
- E. The necessary arrangements shall be taken to ensure that all waterstop and other embedded items are effectively well covered by concrete and that they are not subject to any movement compared to their theoretical position.
- F. Qualified personnel shall be included in the concreting team to apply the appropriate remedial action in case of any incident such as movement of forms, steel bars, joints, drains, ducts, grouting valves, grouting groove protection, etc.
- G. The Contractor shall provide a means of direct communication between the concrete batching plant and the location of concreting (telephone or radio-telephone).
- H. In case of simultaneous placing of different classes of concrete, the Contractor shall provide a system of identification which will follow each concrete until it is placed.
- I. The concrete shall be poured as close as possible to its final position. The concrete shall be moved within the formwork by shovel and not simply by flow induced by vibration which is forbidden. Any accumulation of gravel shall be dispersed within the mass of the concrete. Any water shall be removed as and when it appears.
- J. Within each lift, concreting shall be effected in successive layers not exceeding 50 cm in thickness, unless otherwise stipulated by the Engineer.
- K. For massive concrete structures, the lifts shall not exceed 2.50 m in height. The time interval between completion of one lift and starting the next shall be at least 72 hours. The height of these lifts and the time elapsed between successive lifts may be modified depending on temperature changes recorded in the concrete already cast, as compared to the specified temperatures.
- L. Before it is covered by a new layer, each layer shall be fully compacted but shall not have begun to set.
- M. All concrete shall be compacted by internal high frequency vibrators except the fluidified concrete. The number, size, frequency and power rating of the vibrators shall at all times be adequate to obtain appropriate and rapid compaction of the entire volume of concrete to be placed. A third of the required number shall be kept available for use no more than 15 min from the location of compaction.

- N. The vibrators shall be introduced vertically at regular intervals within the concrete to be compacted. If the layer being placed covers a freshly compacted layer, the vibrators shall be introduced to a depth of about 10 cm in the preceding layer. The vibrators shall be withdrawn slowly, so as not to allow the formation of any void.
- O. Vibration shall continue until the rise of air bubbles has practically stopped, and shall be stopped as soon as laitance or excess water appears.
- P. The vibrators shall not be inserted into the concrete hazardly or irregularly, nor used to move the concrete from one point to another within the formwork. The vibrators shall not enter into contact with the reinforcement bars nor with the formwork.
- Q. Where use of external vibrators is agreed, they shall be securely clamped to the shutters to ensure maximum efficiency.
- R. Where the presence of air bubbles is prejudicial to the structure, the thickness of the layers shall be reduced, and additional compaction shall be effected along the formwork, after the regular compaction of the overall concreted area.
- S. If in the course of placing concrete, it may become necessary by reason of an unavoidable breakdown of plant or for other reasons accepted by the Engineer, to interrupt concreting and if the concrete has taken its initial set, the surface of the concrete shall be treated as a construction joint.

3.5. CONCRETING IN HOT WEATHER

- A. When the daily maximum temperature exceeds 35°C, concreting shall take place at night-time, unless special arrangements are adopted for mixing, transport and placing of the concrete.
- B. These particular arrangements could include:
 - 1. Spraying of gravel and pebbles.
 - 2. Cooling of water.
 - 3. Spraying of formwork.
 - 4. Protection of the concrete during transport and placing against solar radiation.
 - 5. Use of ice in mixing water.
 - 6. Painting water tanks with reflecting paint.
- C. In all cases, the temperature of the concrete when it is placed shall be less than:
 - 1. 28°C for massive structures, i.e. structures with a thickness more than 0.60 m.
 - 2. 32°C for other structures of which the thickness is less than 0.60 m.

3.6. CONCRETING IN COLD WEATHER

- 1. In cold weather concreting may take place only if the following precautions and provisions are rigorously observed.
- 2. Suitable means shall be provided to warm the aggregate and/or mixing water, or otherwise to ensure that the temperature of the concrete leaving the mixer shall not be lower than

100C. Aggregates, cement and mixing water bearing or containing ice shall not be used and no ice shall be present in any mixer, hopper, skip, vibration or other apparatus in contact with the concrete. Mixing water shall not be heated above 60oC. Salt or chemicals including proprietary accelerators or hardeners shall not be mixed with the concrete for the purpose of preventing freezing or accelerating hardening unless permitted by the Engineer.

3. Concrete when deposited shall have a temperature of not less than 5oC. Suitable precautions shall be taken to ensure that the temperature of the concrete after placing does not fall below this temperature until it has thoroughly hardened.
4. In putting forward his proposals for concreting in cold weather, the Contractor shall have regard to the recommendation contained in “Winter Concreting” as published by the Cement and Concrete Association, 52 Grosvenor Gardens, London SW1, UK.
5. If the Engineer is not fully satisfied with the Contractor’s arrangements, no concreting shall take place when the shade temperature is below 20C or if there is any prospect of frost within 24 hours (i.e. if the shade temperature is below 30C and falling).
6. The Contractor shall provide and keep available for the Engineer’s use a thermometer suitable for measuring the temperature of aggregate and a maximum and minimum thermometer which shall be hung in a position approved by the Engineer.

3.7. CONCRETING IN WET WEATHER

During wet weather, all necessary tarpaulins, baffles, diversion channels, etc., shall be laid to protect areas prepared for concreting and/or newly placed concrete from heavy rain and run-off. Surfaces on or against which concrete is to be placed shall be protected from becoming excessively wet prior to concreting.

3.8. CURING OF CONCRETE

- A. Exposed concrete surfaces shall be kept damp by one of the following methods:**
 1. Covering horizontal surfaces with a layer of sand, hessian or other absorbent material maintained in a damp condition.
 2. Continuous watering, maintaining a flow of water over the concrete.
 3. After watering, covering of the surface with an impermeable membrane.
 4. Application of a curing compound.
- B. The use of a curing compound will not be permitted for surfaces which will receive a further concrete lift without any further preparation and for surfaces whose aspect may be affected by the curing compound.**
- C. Curing shall commence as soon as possible after placing of the concrete for unshuttered parts and immediately after removal of formwork in other cases.**
- D. Curing shall be continued for a period of 14 days unless otherwise agreed by the Engineer.**
- E. Underground concrete shall not require curing when the relative humidity of the air is higher than 75%.**

3.9. SECOND STAGE CONCRETE FOR SEALING EMBEDDED PARTS OF EQUIPMENT

- A. Placing of second stage concrete shall not proceed until embedded parts have been completely assembled, aligned and secured.**
- B. Constant caution shall be exercised in placing concrete to avoid distortion and displacement of parts being embedded.**
- C. The workability shall be sufficient to achieve satisfactory pouring in the interstices of the first stage concrete.**
- D. A controlled expansive admixture from an approved manufacturer shall be added. The admixture shall be mixed in accordance with the manufacturer's instructions. Prior tests shall be conducted before final approval can be given by the Engineer to adjust the amount of admixture to obtain. Cast iron powder admixture shall not be used in contact with high-tensile steel nor in direct contact with water.**
- E. For small holes (section less than 1 dm²), mortar shall be used. The mix shall be 450 kg of cement per cubic metre of sand with the addition of an approved controlled expansive admixture.**
- F. Interface between the first and the second stage of concreting shall have a watertightness equivalent to construction, contraction and expansion joints.**
- G. Interface between the equipment and the second stage of concreting shall have a watertightness equivalent to construction, contraction and expansion joints.**
- H. Formwork shall be perfectly connected with the first stage concrete; irregularities shall be made good by means of grinding.**

3.10. PRECAST CONCRETE

- A. The working drawings may provide for certain parts of structures to be made from precast elements but, for ease of execution, the Contractor may ask to precast other parts of structures not initially indicated as such.**
- B. The Contractor shall submit clear details of the casting and placing procedures that he intends using as well as his planned arrangements for the precasting yard. Precasting work can start as soon as the Engineer has given his approval of the foregoing details and arrangements.**
- C. Precasting shall be organised in such a manner that:**
 - 1. Precast parts are always kept away from sunlight.**
 - 2. Precast parts are not handled for a period of 8 days after casting, unless concrete strength tests indicate the possibility of handling the parts within a shorter time.**
 - 3. All parts from the same mould are stored together.**
 - 4. No stored part shall be subjected to any load other than its deadweight.**
 - 5. Precast parts are installed in their final positions no earlier than 21 days after casting, unless concrete strength tests indicate the possibility of reducing this time.**

- D. The casting date and part references (or mould number) shall be written on each part in the fresh concrete.
- E. Faces in contact with covering concrete after placing shall, if necessary, be treated as concrete construction joints; this clause shall be especially applicable in cases where intermediate slabs are used, the restarting surface of which must be treated accordingly.

3.11. CONCRETE SHUTTERING UNDERGROUND

- A. Such concrete shall be placed mechanically unless otherwise approved by the Engineer.
- B. Inflowing water shall be collected and piped to a dewatering system before executing any lining concrete.
- C. Arch keying shall be carried out as accurately as possible and, in any case, shall meet the minimum lining thickness requirements. Unless otherwise specified on drawings or approved by the Engineer, the minimum thickness requirements is the thickness of the concrete between the 'A' line and the exposed surface of the concrete. Keying shall be checked by exploratory drillings made at the Engineer's request.
- D. With the exception of fluidified concrete (refer to the particular specification), the concrete shall be compacted using external vibrators and completed using internal vibrators inserted inside the formwork through windows. The number and size of these windows shall be sufficient to vibrate the concrete under optimum conditions.
- E. Closure of these windows shall be made watertight.
- F. Unless explicitly authorised by the Engineer, no timber supports shall be incorporated in the final lining.

3.12. BLINDING CONCRETE

- A. Blinding concrete shall be used when the structural concrete is in contact with a non-rock foundation.
- B. The final mean thickness shall be 10 cm and never less than 5 cm.
- C. Blinding concrete shall cover the entire area to be concreted.
- D. The Contractor shall arrange for the recovery and elimination of all infiltrating water so that there is no risk of the concrete being washed out.

3.13. SHOTCRETE

- A. Shotcrete shall be used for permanent work structures only as directed by the Engineer.
- B. In so far as is possible and after scaling and cleaning, walls shall be wetted before placing shotcrete. The same precautions shall be taken in the case of shotcrete placed in several layers.
- C. There shall be no significant inclusion of rebound in the finish work, no hollow areas, good adherence to the rock and reasonably smooth surface finish.
- D. The final thickness of shotcrete shall never be less than 5 cm.

- E. The Contractor shall provide for all inflowing water to be collected and diverted through drilled drains or surface pipes in order to prevent the shotcrete from being washed out and uplift pressures from forming on the treated surfaces.
- F. Mesh reinforcement must be fixed to the rock or to a preliminary layer of shotcrete at several points. The concrete covering on the reinforcement shall be of 20 mm minimum thickness.
- G. After placing the shotcrete, any movement of the steel reinforcement shall be prohibited.
- H. The profile after shotcreting shall be considered in the same manner as an excavation profile and shall not therefore have any part projecting inside the line as defined by the Engineer.

3.14. WEAR-RESISTANT CONCRETE

- A. The Contractor shall propose special micro-concrete of the Lafarge "Alag" type or similar with high adherence, abrasion-resistance and shock-resistance characteristics at places where this is necessary as defined on the drawings.
- B. A complete file containing the characteristics of the products and details of the procedure to be used shall be submitted to the Engineer for approval.
- C. In all cases, the following minimum procedure shall be followed:
 - 1. Floor reinforcements shall be placed at a minimum of 10 cm from the finished surface with a tolerance of +2 cm and -0 cm.
 - 2. Pouring of primary concrete shall take into account the thickness of the wear-resistant concrete, i.e. 8-10 cm from the finished level (rebars must be embedded by at least 2 cm).
 - 3. The top surface must be cleaned with air and water under pressure before it has completely set, or by high-pressure cleaning after it has set.
 - 4. The support must be completely saturated (24-48 hours).
 - 5. Wear-resistant concrete is poured and thoroughly vibrated in chequerboard 2 m x 2 m slabs during stage 1 (class 1 surface quality).
 - 6. The concrete is kept moist after it has begun to set (by spraying or by using a curing agent).
 - 7. The stage 2 slabs are cast after a minimum period of 24 hours.

3.15. CONCRETE FOR DIAPHRAGM WALL COATING

Not used

3.16. DEPOSITION OF CONCRETE ON FOUNDATIONS

- A. The Contractor should keep free of running water and pools the surface of rock upon or against which concrete is to be deposited. Fissures or seams in the rock shall be cleaned out to a depth satisfactory to the Engineer and if necessary stemmed with cement mortar of an approved mix. The rock surface will be inspected by the Engineer before concreting starts.
- B. For deposition of concrete on earth foundations the surface of foundation shall be levelled out before concreting, a layer of blinding concrete shall be disposed on all the surface in contact with the concrete structure and the concreting may start after approval by the Engineer.

- C. The blinding concrete layer shall not be less than 5 cm thick. Blinding concrete specified on the drawings shall be measured and paid at the rate tendered.
- D. For hydraulic structures the concrete foundations shall be placed over and/or aside an adequate filter sufficiently drained, as shown in the drawings or as specified by the Engineer.

3.17. CONCRETING CONSTRUCTION JOINTS

- A. The location of concrete construction joints, other than joints shown of the Drawings or specified, shall be approved by the Engineer; concrete shall be placed continuously between joints.
- B. Duration between the two stages of concrete for a construction joint shall be approved by the Engineer.
- C. All construction joints shall terminate against firm shuttering. All necessary steps shall be taken by means of timber edgings, etc. to ensure an exact finish to edges of joints which are exposed to view.
- D. Before placing concrete against concrete which has already set at a construction joint, the surface of the previous concrete shall be prepared by the following methods. If the preparation is carried out before the previously placed concrete has hardened, the surface shall be cleaned with water and air at 5 kg/cm² pressure to expose the coarse aggregate. If the concrete has hardened the surface shall be scabbled at least 2 cm deep and cleaned in such manner that no loose particles of aggregate or damaged concrete remain on the surface. In all cases the surface shall be thoroughly cleaned with an air and water jet at 5 kg/cm² pressure to remove all laitance, scum and foreign matter. The surface shall be wetted before placing new concrete against it.
- E. Construction joints shall be so located and the amount of concrete placed at any one time shall be so limited in size and shape as to minimise shrinkage and temperature effects.

3.18. CONCRETING MOVEMENT JOINTS

- A. Joints between concrete surface are not intended to bond together (contraction joints) shall have the first formed surface painted with two coats of bituminous paint, the second applied after the first has thoroughly dried or according to the instructions of the Engineer.
- B. Waterstops shall be fixed with at least 5 cm clearance from any reinforcement bar, accurately positioned as shown on the Drawings and tightly fixed in the shutters before concreting starts. Connections shall be made to ensure watertightness and all precautions taken for careful concreting around the waterstop.
- C. No nail shall be driven through any part of a waterstop for fixing. Any waterstop punctured or torn to any extent shall be replaced before concreting.
- D. Shuttering of the first concreted surface of the joint shall be placed carefully perpendicular to the surface of the structure. Waterstops shall be placed carefully on a straight line and perpendicular to the surface of the joints, and/or according to the shape shown on the Drawings or instructions of the Engineer.

- E. Particular care shall be taken with the protection of the outer part of waterstops half embedded in the structure and awaiting completion.
- F. In the event of excavation in the vicinity of the waterstop or when more than one month elapses before completion of the structure, a protection device such as a wooden box shall be provided by the Contractor. Rubber waterstops shall be stored in as cool a place as practicable and in no case shall they be exposed to the direct rays of the sun.
- G. All joint implements such as waterstops, joint fillers, sealing compounds, etc. shall be handled and settled in accordance with the instructions given by the Manufacturer. All related notices and instructions shall be furnished to the Engineer prior to any approval being given.
- H. Compressive filler (flexcell) when placed against concrete faces shall be fastened with adhesive before concreting of the next element.
- I. When required, the joints shall be sealed with concrete mortar containing 400 kg of cement per cubic metre of mortar containing admixture if requested by the Engineer. The edges of the grooves shall be previously carefully watered and cleaned with a brush to remove any foreign bodies. Then the grooves shall be filled with mortar, compacted and surfaced and dressed by handwork. Immediately after completion, the joint shall be protected against the sun and regularly sprinkled with water as requested by the Engineer.

3.19. FINISHING OF NON-SHUTTERED CONCRETE SURFACES

- A. The Contractor shall be responsible for finishing non-shuttered concrete surfaces as soon as concrete placing has been completed and before hardening.
- B. Surfaces shall be finished using a simple screed, a vibrating screed, a float, etc. or by any other means enabling the required quality to be obtained. Screed guiding devices and supports shall be submitted for the Engineer's prior approval.
- C. Surfaces shall be provided with a slope to allow water to drain off, as provided for on the drawings or as instructed by the Engineer.

3.20. FLUIDIFIED CONCRETE

- A. The fluidified concrete shall not be poured from more than 1 metre in height and where required channels or pipes for the concrete transport shall be used.
- B. The fluidified concrete shall be poured within the time for which the fluidizer has a real effect. No addition of fluidizer or water or any other additive in order to prolong this effect will be tolerated after the initial addition of the fluidizer.
- C. Shuttering and forms shall be designed to withstand the full load exerted by the liquid concrete. In addition they shall be fully watertight in order to prevent any loss of the mix.
- D. Where required by the Engineer, the fluidified concrete will be slightly compacted by use of low frequency vibrators.

3.21. INSPECTION TEST AND ACCEPTANCE OF CONCRETES CLASSES (A, B AND C)

- A. Definitions

1. Lot: a lot of concrete is a structure or part thereof or set of structures or parts of similar structures cast in a single lift using concrete of the same class.
2. Sampling: a given sampling is effected on a single batch and one batch can give rise to only one sampling.
3. Result: a result is the average of the measurements made on all the samples taken for a given sampling (generally three).

B. Sampling frequency

1. The number of samplings made shall be as follows:
 - h) Mass concrete (Class B)
 1. one for a lot of less than 500 m³
 2. two for a lot of more than 500 m³
 - i) Other concrete (Class A)
 1. one for a lot of less than 50 m³
 2. two for a lot of 50 to 250 m³
 3. three for a lot of more than 250 m³
2. The sampling frequency shall be greater at the beginning of the works in order to make sure of quality levels as quickly as possible, and during periods when, in the Engineer's opinion, quality is considered doubtful.

C. Tests to be carried out

1. The following tests shall be carried out for each sampling:
 - j) Three samples 160 mm dia cylinder for determination of compressive strength after 28 days (ASTM C 39).
 - k) One measurement of air content (ASTM C 231).
 - l) One consistency measurement (ASTM C 143).
 - m) One temperature measurement.

Additional tests may be required by the Engineer, especially when the concrete consistency varies to a significant extent.

2. On average every three samplings and in accordance with instructions given by the Engineer:
 - n) Three samples for determination of the compressive strength after 7 days.
 - o) Three samples for determination of the tensile strength after 28 days (ASTM C 496).
3. On average every 30 samplings and in accordance with instructions given by the Engineer, 12 samples for determination of modulus of elasticity, compressive and tensile strength after 90 and 365 days (six after 90 days and six after 365 days).
4. All samples shall be taken at the time and on the site of concrete placing.

D. Concrete acceptance criteria

1. A lot shall be deemed to conform to specifications when the following conditions are satisfied:

- p) Consistency: the test result(s) come within the specified tolerances.
- q) Compressive strength after 28 days:
 - 1. Each result is higher than 0.85 f_c
 - 2. In the event of three or more samplings from a lot, the average of the results is greater than f_c .
- 2. A concrete of a given class shall be deemed to conform to the specification when the average of any 3 consecutive results (not necessarily from the same lot) is higher than f_c .

E. Use of 7-day and 28-day test results

For each class of concrete, the results of all the tests shall be used to establish a "least-square" line of best fit to define the relationship between test results and the age of the concrete. The relationships shall be continuously updated during the period of the Contract, and shall be used for the initial assessment of 90-day strength from 7-day and 28-day strengths, or the initial assessment of 28-day strength from 7-day strength.

F. Ready-mix lorries

The concrete in each ready-mix lorry shall be checked for uniformity within the context of the concrete suitability tests and then every quarter according to ASTM C 94. If concrete uniformity is not satisfactory, one of the following measures will be taken until the specifications are met:

- 1. Increase in mixing time.
- 2. Reduction in quantity of concrete transported.
- 3. Modification of ready-mix lorry.

3.22. TESTING FOR WATERTIGHTNESS OF REINFORCED CONCRETE RESERVOIRS

On completion of the works, the reservoirs shall be tested for watertightness when filled with water, before backfilling around the reservoirs and before applying coating or facing on external face of walls.

Each reservoir shall be filled slowly with a rate of 1.50 m (rise of water level in 24 hours, up to top water level). Before testing a period of 10 days will be necessary for the initial soakage and every day water will be added to raise the water level to its initial level. It will have to make clear that the level drop decreases each day.

Water for tests shall be provided by the Contractor. The Contractor shall provide all necessary equipment to transfer the water used for tests from one reservoir to another to be tested.

When the soakage period has been completed, the test shall be started by refilling the reservoir to top water level and accurately recording the level each day over a period of seven days. The evaporation shall be checked by fixed in the reservoir a steel tank filled with water. Any drop in level in the steel tank will then be considered as evaporation loss. The structure will be deemed to be watertight if the total loss of water does not exceed 0.5 l per day and per square meter of wet concrete face.

The reservoir shall not be finally accepted as satisfactory until all leakages exceeding this value have been eliminated by treatment with appropriate products and with pressure grouting

techniques. In this eventually, the treatment shall be approved by the Engineer and the Contractor shall repair at his own expense any leak involved.

From the time a reservoir is accepted, the Contractor shall keep the interior in wet conditions until commissioning of reservoir. This can be assessed by keeping a minimum water level inside each accepted reservoir, or any other mean approved by the Engineer.

Just before commissioning, each reservoir shall be emptied and disinfected according to a methodology proposed by the Contractor and approved by the Engineer.

3.23. ACTION IN THE EVENT OF NON CONFORMANCE (FOR CONCRETE CLASSES A, B AND C)

- A. If the consistency of the concrete is outside the nominal tolerance by inside the maximum tolerance, the composition of the fresh concrete shall be checked immediately, in particular the water content of the aggregates and quantity of water in the concrete. The Contractor shall make all necessary adjustments to recover the right consistency.**
- B. If the consistency of the concrete is outside the maximum tolerance, the concrete shall be rejected.**
- C. If the 28-day test results assessed from 7-day test results is abnormally low the Contractor shall stop concreting, establish the reasons for the strength decrease and take the necessary remedial action.**
- D. If the 28-day test confirm the assessment from 7-day test that the characteristics of concrete do not conform to the Specifications the volume of concrete represented by the samples shall at the discretion of the Engineer be subject to one or more of the following provisions:**
 - 1. Cores from the suspected portions of the structure shall be drilled and tested in accordance with BS 6089 to determine whether the equivalent cylinder strength of the in situ concrete satisfies the specified strength requirements.
 - 2. If the results of test on the cores taken in terms of (1) indicate that the concrete does not satisfy the specified requirements, the Engineer will decide whether or not full scale load tests or an ultrasonic pulse velocity investigation may be carried out.
 - 3. If in the opinion of the Engineer, the load tests are impracticable, or if a tested portion of the structure fails to pass the tests the Contractor shall, on the instructions and directions of the Engineer, and if possible, strengthen by approved means each section that failed or which contains concrete that failed, as relevant and also any other section, irrespective of strength requirements, the functional purpose of which is affected.
 - 4. The works shall be demolished and reconstructed at the Contractor's expense, if the reinforcement or strengthening of the structure is not possible.
- E. If it is found during concreting that the coefficient of variation of 28-day test results for a particular class of concrete is less or more than 14 percent, the Contractor and the Engineer shall meet to decide on the necessary reduction or increase respectively in cement content required to maintain the nominal strength of the concrete with the specified rate of failure. The reduction or increase in cement content shall be to the Contractor's account if this is attributable to him.**

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SECTION 03350

CONCRETE REPAIR

1. GENERAL

1.1. WORKS INCLUDED

This Section covers all operations in connection with concrete repair works to existing concrete structures.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DEFINITIONS AND DESCRIPTION

For the purpose of repairs to existing concrete the following types of defects shall be distinguished:

- Cracks 1 up to 3 mm wide
- Leaking Cracks 1 up to 3 mm wide
- Cracks 3 up to 20 mm wide
- Defective Concrete as loose, broken or honeycombed concrete
- Deteriorated Joints
- Voids under Concrete Slabs

1.4. SUBMITTALS

The Contractor shall furnish the Engineer with three (3) signed copies of the inventory of proposed works for approval to the Engineer. No works shall start until the Contractor has received the written approval from the Engineer.

2. PRODUCTS

2.1. GENERAL

For all mortars, grouts, resins and other products described in this section, the Contractor shall propose the products he intends to use in the Works and shall submit to the Engineer for

approval full information on these products. All products shall have no adverse effects on potable water.

Products named elsewhere in this section are an indication of the standard type and workmanship of goods which are satisfactory to the Engineer. The Contractor may use named products or equivalent other products after the approval of the Engineer in accordance with the Specifications, Conditions of Contract and with the manufacturers specifications.

2.2. WATER, STEEL AND AGGREGATE

Water for use in mortars and concrete shall be clean, fresh, water free from all deleterious matter, silt, organic matter, alkali, slate and other impurities. It shall preferably be from a potable water source (from the public water supply network) or from other approved sources.

Reinforcement steel shall in all aspects comply with the requirements described in *Section 03200 – “Reinforcement”*.

Sand or other aggregate for mixing with grout shall comply with the requirements for fine aggregate described in *Section 03300 – “Concrete”*.

3. EXECUTION

3.1. DEWATERING AND CLEANING

All repair work to existing concrete shall be carried out in the dry. The Contractor shall therefore dewater the concerned structures and clean the surfaces from all sediment, algae, bushes, stones, trash and all other foreign matter to the satisfaction of the Engineer.

3.2. IDENTIFICATION OF REPAIRS

After cleaning the concrete from any foreign matter the Contractor shall survey the exposed surfaces and make an inventory of the work to be done distinguishing the types of defects as described in this Section and submit the inventory of proposed work to the Engineer for approval. In a joint survey of the Engineer and the Contractor the inventory will be discussed and the Engineer may instruct the Contractor to make modifications in the inventory of proposed work after which modifications the Engineer shall approve the inventory for execution. The Contractor shall furnish the Engineer with three (3) signed copies of the inventory of proposed work for approval to the Engineer and after approval the Engineer shall sign these copies and return one (1) signed copy to the Contractor. The Contractor will execute the work accordingly and in accordance with these Specifications.

3.3. REPAIR OF CRACKS 1 UP TO 3 MM WIDE

The Contractor shall repair cracks in structural concrete by injection with an appropriate injection resin.

When the cracks are dry an epoxy resin of low viscosity shall be used. In other cases injection shall be done with a low viscosity polyurethane resin.

The Contractor shall first blow, clean, oil free compressed air through the crack before any resin is injected in order to remove as much as possible any dust or grit that may obstruct the flow.

When the crack is cleaned, a superficial seal will be applied at the surface of the member by using a fast setting material such as any appropriate polyester resin, in which injection nipples are fixed at intervals. The most satisfactory spacing of the injection nipples shall be found by experience, but is usually less than the estimated depth of the crack. The most suitable pressure for injection the resin shall also be found by experience. The spacing and pressure are to be to the satisfaction of the Engineer.

Injection shall be done by an approved and established epoxy resin injection system. Epoxy injection resin of low viscosity shall be subject to the approval of the Engineer. No injection shall be done without the approval of the Engineer.

3.4. REPAIR OF LEAKING CRACKS 1 UP TO 3 MM WIDE

3.3.1. REPAIR BY INJECTION

The Contractor shall inject leaking joints with waterstops in structures with a suitable polyurethane injection resin.

The polyurethane injection resin shall be of low viscosity and reacting with water as to fill all cavities in and adjacent to the joint. Injection shall continue until all leaks are stopped.

To relieve the water pressure if necessary, drain pipes shall be fixed into the remaining concrete so that the water can discharge freely. After the injection material has hardened, the drain pipes shall be cut off or removed and the remaining holes will be plugged one by one with a very quick-setting material that can be held in place by hand until it has set.

The Contractor shall submit for approval to the Engineer the method of injection, material and equipment he proposes to use. The Engineer may at his discretion instruct the Contractor to modify his proposal in accordance with the instructions of the Engineer. No injection will be done without the approval of the Engineer.

3.3.1. REPAIR BY LINING

Concrete slabs featuring many leaks due to cracks and other small porosities of the concrete shall be waterproofed by application of a internal lining. Slabs subjected to variable direction of water pressure shall not be repaired with this method but only via the method as described in Clause "Repair by Injection".

The lining shall be applied only on the inside of water retaining structures so that the lining is compressed between water and concrete.

The lining shall be an epoxy resin and or cement based sealant. The material shall have a durability of 25 years or more and provide a watertight and easy to clean surface. The material shall be capable of bridging and filling 3 mm wide cracks under the existing water pressures.

Particular care shall be taken to ensure all concrete surfaces are completely free from algae, oil, dust, grease, corrosion and any other deleterious matter before application of the lining.

3.5. REPAIR OF CRACKS 3 UP TO 20 MM WIDE

The Contractor shall clean the crack from all dirt and other foreign matter and roughen the surfaces mechanically. After cleaning the crack with oil free compressed air the surfaces will be primed with an approved and established primer.

All exposed reinforcement shall be thoroughly cleaned from any loose rust or other foreign matter. Exposed reinforcement shall be primed with an approved and established primer, to prevent further corrosion.

If the reinforcement has broken or deteriorated too far the crack must be repaired as described in Clause "Repair of Defective Concrete". Then the crack shall be filled with a suitable, approved and established watertight non shrink grout and cured directly after application with a curing agent.

3.6. REPAIR OF DEFECTIVE CONCRETE

When concrete has broken out, has become loose, shows honeycombing or any other similar defects, it shall be removed and the affected member reconstructed to its original section.

The Contractor shall remove all loose or deteriorated concrete until only sound material is encountered. Concrete shall in any case be removed to 25 mm behind any exposed reinforcement.

All exposed reinforcement shall be thoroughly cleaned from any loose rust or other foreign matter. Exposed reinforcement shall be primed with an approved and established primer, to prevent further corrosion.

If the reinforcement has broken or deteriorated too far, new reinforcement shall be placed. To accommodate this reinforcement, holes shall be drilled in which the new bars are fixed with an epoxy resin. As an alternative the surrounding sound concrete can be broken out until sufficient lap length has been acquired to accommodate the new bars. If neither option is suitable, an external steel or concrete bracing shall be constructed. The final solution to be applied shall be approved by the Engineer.

Particular care shall be taken to ensure all exposed concrete surfaces are completely free from laitance, oil, dust, grease, corrosion and any other deleterious matter. Laitance shall be mechanically removed by high pressure water blasting, grit blasting or a combination of both.

The edges of the repair area shall be sawn or cut to a depth of 10 mm to avoid feather edging.

All concrete surfaces shall be in a saturated surface dry condition prior to priming.

Priming shall be done with an approved and established primer after which the broken out area will be repaired with a suitable watertight non-shrink grout approved by the Engineer. Immediately after finishing the repair the mortar shall be cured with a curing agent.

3.7. REPAIR OF DETERIORATED JOINTS

At contraction, construction or movement joints where the filler and or sealant has deteriorated, replacement is required. Hereto the Contractor shall replace both the joint filler and or the sealant. He shall cut out and remove the existing joint filler and or sealant and clean the joint from vegetation, sediment and other foreign matter. The edges of the concrete shall be square. If edges have broken up to 10 mm deep the new joint filler shall be placed deeper. Broken edges from 10 to 30 mm shall be cut square to give a square but wider joint. At edges broken deeper than 30 mm the concrete shall be broken back till 25 mm behind the nearest reinforcement and repaired in accordance with the clause "Repair of defective concrete".

After clearing and squaring up the recess in the concrete the joints shall be filled with flexible filler and or sealant. This shall comply with the requirements as described in sub-clauses "Movement Joint Filler" and "Joint sealer".

Only in movement joints the following alternative construction may be used; a vacuum tube of butyl rubber shall be placed in the joint and the voids left over shall be filled with butyl putty. The vacuum tube and butyl putty shall be of an established type and approved by the Engineer.

3.8. REPAIR OF VOIDS UNDER CONCRETE

During reparation of cracks or joints in otherwise sound slabs, hollow spaces may be found behind the slabs. In such cases and where indicated by the Engineer the Contractor shall fill the hollow spaces with a suitable cement based grout.

Depending on the type of joint, grouting shall be done either before or after completing other repair works on the joints or cracks.

If the voids are not accessible through at least 10 mm wide joint rebates then holes shall then be drilled through the concrete slab, with a maximum distance between successive holes of 700 mm centre to centre. Through the holes the hollow spaces shall be grouted.

The grout will be subject to the approval of the Engineer and shall be of a suitable viscosity.

The area to be grouted and working method will be proposed by the Contractor to the approval of the Engineer; or as instructed by the Engineer. No grouting or drilling shall be done without the approval of the Engineer.

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SECTION 04000

MASONRY WORKS

1. GENERAL

1.1. WORK INCLUDED

This section covers masonry works as required for:

- Internal positions.
- Other small structures according to Drawings and description of the works.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. QUALITY ASSURANCE

Finished rendered work shall be true, plumb, or levelled and straight to a maximum tolerance of 3 mm in a 1 m.

Finished surface shall be free of waves or distortions, square with adjoining work, flush with casings, and free of any defect detrimental to appearance or performance.

All masonry works will be rendered (see 2.5) on both internal and external walls.

1.4. CODES AND STANDARDS

A. British standards

BS EN 1745 Masonry and masonry products - Methods for determining design thermal values

BS EN 772 Methods of test for masonry units

BS EN 845-2 Specification for ancillary components for masonry - Part 2: lintels

BS EN 1015 Methods of test for mortar for masonry.

BS EN 13139 Aggregates for mortar

BS EN 998-2 Specification for mortar for masonry - Part 2: masonry mortar

B. French standards

NF P 13-301 Hollow terra cotta bricks.

NF P 13-304 Facing clay bricks.

XP P 13-305 Clay masonry units. Common solid or perforated clay bricks and perforated clay blocks. Requirements and test methods.

2. PRODUCT

2.1. CONCRETE BLOCKS

The blocks shall be 20 cm thick for outside walls and 10 cm for partitions.

No overall dimension (width, height or length) shall differ by more than 3 mm from the specified dimensions.

The minimum compressive strength shall be:

- a. for individual unit: 15 MPa,
- b. for the average of 3 units taken as a sample: 17 MPa.

The maximum water absorption shall be 250 kg/m³, when soaked for one hour in water.

All units shall be sound and free of cracks or other defects, and shall have uniform colour, texture and appearance.

2.2. CONCRETE LINTELS

Lintels for doors, windows and other openings left in the concrete block walls and partitions shall be reinforced concrete designed according to the span of the opening, but never less than 10 x 15 cm. Each lintel shall be reinforced with a minimum of four 10 mm dia. bars.

2.3. MORTAR FOR PLACING BLOCKS

General requirement for sand used in concrete (Section 03300) applies except that the sand for mortar shall contain no particle greater than 2 mm.

The mix shall be 400 kg cement per m³ of sand.

The mortar is to be mixed dry in a mechanically operated drum type mixer and water shall be added after the constituents have been thoroughly mixed.

Mortar which has begun to set or which has been mixed for more than 30 minutes shall not be used or remixed.

The mixer shall be operated at the speed recommended by the manufacturer and the total quantity of materials mixed in each batch shall not exceed the rated capacity of the mixer.

The entire content of the drum shall be discharged before a new cycle of batching is started and at all times the inside of the drum shall be kept free from a build-up of materials. The mixer drum shall be thoroughly cleaned prior to change of mix or on cessation of mixing.

2.4. METAL WALL TIES

Cavity walls and wall facing shall be provided with galvanised steel ties with a minimum section of 10 mm².

Not less than 4 ties shall be fixed per square metre.

2.5. MIXES FOR RENDERING (CEMENT OR CEMENT-LIME PLASTERING)

The mixes for rendering shall be:

Treatment	Mix proportions (parts by volume)		
	Cement	Lime	Sand
Exterior	1	1	5
Interior	1	1	6
Rough cast finish	1	2	9
Smooth finish	1	4	8

The method of measuring materials for the render shall be such that the specified proportions of the materials can be controlled and accurately maintained during the progress of the work.

The quantity of water shall be such as to obtain a satisfactory workability for the specific use of each render.

Render which is set or become dry or unworkable shall not be used nor retempered with water.

Any render that is not used within 30 minutes after the first water has been added shall be rejected and removed from the Site.

The equipment and tools used for transporting and for placing batched render shall ensure that contamination and loss of ingredients do not take place.

2.6. BRICK WORK

2.3.1. BRICKS

Bricks will be used for partitions only.

Bricks shall be of the best available quality.

Bricks shall be sound, hard, uniform in colour, regular in size and shape with straight parallel surfaces and sharp edges and free of cracks, stones and lumps, especially of lime.

Bricks intended for fair-faced walls with tooled joints shall be particularly suitable with regard to durability and weather-resistance and of uniform colour.

Bricks shall be well burnt. Their compression strength shall be at least 5.5 N/mm² on an average of any twelve (12) bricks, but at least 3.5 N/mm² for any individual brick.

The Contractor shall submit brick samples along with test certificates to the Engineer for approval.

2.3.1. DAMP-PROOF COURSE

Damp-proof course shall be provided for all block-work at approximately 200 mm above ground level using.

- bituminous roofing felt not less than 3 mm thick or
- polyethylene sheeting not less than 0.5 mm thick
- or any other approved material,

laid on an even bed of cement-sand mortar (1:1) and lapped 150 mm at all joints. The damp-proof membrane shall cover the full width of the blocks.

2.3.1. MORTAR

Mortar to be placed between the bricks shall be cement-lime-sand mortar in the ratio of 1:1:6.

Below the damp-proof course, the blocks shall be laid in cement-sand mortar in the ratio of 1:4.

2.7. INTERNAL PLASTER

Internal plaster shall be applied to walls and partitions in offices, toilets and entrance hall.

Internal plaster to walls and ceilings shall be applied to the bonding coat. The undercoat shall be 1 part gypsum browning plaster to 3 parts sand by volume, applied firmly in one continuous operation between angles and joints to a thickness of not less than 10 mm, cross scratched to provide a key for the next coat.

The finishing coat shall be gypsum finishing plaster applied to a thickness of 5 mm and trowelled or floated to produce a tight, matt, smooth surface with no hollows, abrupt changes of level or trowel mark. This coat shall be applied to the undercoat as soon as it has set and has developed reasonable suction. Internal plastering shall generally be carried out in accordance with BS5492.

Alternatively internal plaster to walls shall be applied to the bonding coat in two coats. The undercoat shall be a mix of 150 kg cement, 0.30 m³ lime and 1 m³ sand applied to a thickness of 15 mm. The finishing coat shall be to the same mix, but the sand shall be very fine, applied to a thickness of 5 mm.

Surface shall be cleaned and wetted before plaster is applied.

Concrete work shall be rough plastered with 3 for 1 sand cement mortar which shall be kept wet for two days before base coat of plaster is applied.

2.8. EXTERNAL SMOOTH RENDER

Smooth render shall be applied to plinths, columns, overflows and gargoyles, copings, and elsewhere as required.

The undercoat shall consist of one part sulphate resisting cement to two parts lime to six parts sand by volume. It shall be applied firmly in a thickness of 15 mm cross scratched to provide a key for the next coat.

The finishing coat shall be composed of one part white Portland cement, one part lime, one part limestone powder and four parts white gypsum by volume with oxide colouring agent added to suit applied in a thickness of 8 mm. The coat shall be trowelled to create a flat, smooth, hard surface.

Coats shall be applied in a continuous operation wherever possible. Joints where unavoidable shall be formed with a neat V-joint through the full thickness of the finishing coat.

2.9. EXTERNAL TEXTURED TYROLEAN RENDER

Textured render shall be applied to mid-wall panels and roof fascias and elsewhere as required.

The undercoat shall be one part sulphate resisting Portland cement to two parts lime to four parts sand by volume applied in a thickness of 15 mm.

The textured coat shall consist of one part white Portland cement to five parts lime to three parts of sand by volume with oxide colouring agent added to suit and shall be spattered onto the wall by a hand operated machine to give an even but rough texture to the surface. All adjoining surfaces that are not to receive the finish shall be adequately masked. The thickness of coating shall be sufficient to cover the undercoat. External rendering shall be carried out in accordance with BS 5262.

3. EXECUTION

3.1. PREPARATION

All surfaces designated to receive concrete blocks shall be clean and level to the lines and grades shown in the Drawings or as directed.

Laying of blocks shall not proceed until the Engineer has inspected and approved the prepared surfaces.

3.2. BLOCKWORK (CONCRETE BLOCKS REFERRED ALL AS BLOCKS)

Blockwork shall be built without recesses or projections unless otherwise shown on the Drawings.

Blocks shall be soaked in water before use. The tops of walls left off shall be wetted before work is recommended.

Blocks shall be well buttered with mortar before being laid and all joints shall be thoroughly flushed up, raked or pointed as the work proceeds. Except or otherwise specified vertical and horizontal joints are not to exceed 1 cm in thickness.

Blockwork shall be carried out in a uniform manner such that no portion shall be more than 1 m above another. Blockwork shall be kept true and square and the whole properly bonded together. Particular attention shall be paid to ensure strict verticality of blockwork.

Half block walls and inner and outer skins of double-skin walls and casings shall be built in stretcher bond.

All blockwork shall be cleaned down on completion to remove mortar dropping, runs or stains and again before rendering to remove any efflorescence.

Expansion joints shall be provided in external blockwork at approximately 12 m centres. The joint shall be formed with "Flexcell" or other approved expansion strip and sealed with "Seaastic" or other approved joint sealer. Care shall be taken to ensure that the wall is properly bonded or tied at each side of the expansion joint to prevent any loss of stability.

When required, galvanised steel ties, meshes or cramps shall be carefully embedded in the mortar.

3.3. BONDING OF BLOCKS TO CONCRETE WORKS

Where blockwork abuts concrete columns, walls or beams, there shall be adequate bonding between the two materials by means of wire ties or approved wire mesh which shall be recessed 40 mm from the face of the brickwork or blockwork at such intervals as approved by the Engineer.

3.4. CONNECTION WITH DOORS AND WINDOWS

The spaces around the door frames and built-in items shall be solidly fixed with mortar.

Spaces around the door and window hold fasts shall be filled with concrete Class A.

3.5. BRICKS OR BLOCKS TO BE RENDERED

Blocks which are to receive rendering or plastering shall have a surface which will ensure good adhesion of the applied finish.

3.6. RENDERING

Projecting burs of grout shall be removed and the surface shall be wire brushed and cleaned with scrubbers. If the surface is smooth it shall be prepared by roughening with a pointed tool to form pocks, not less than 3 mm deep, spaced not more than 5 cm apart.

Outside rendering shall be of uniform thickness applied in one coat of 15 mm minimum.

Inside plastering shall be 20 mm thick made of two layers: 15 mm under coat and 5 mm finished coat.

Surface shall be cleaned and wetted before plaster is applied.

Concrete work shall be rough plastered with 3 for 1 sand cement mortar which shall be kept wet for two days before base coat of plaster is applied.

3.7. LAYING OF BRICKS

The Engineer will take samples of bricks at random from deliveries to the site for comparison with the approved specimen. Supplies which are not in conformity with the requirements shall be removed from the site.

All brick work shall be set out and built to the thickness and heights required, be built strictly vertical and all quoins etc. shall properly be bonded together, laid perfectly plumb, true to line, level and in accurately spaced courses.

Before laying the bricks they shall be soaked in water for at least one (1) hour.

Mortar shall be mixed dry and water added until the correct consistency is obtained. All mortar shall be used within forty-five (45) minutes after the addition of water.

Walls shall be bricked up in a uniform manner so that no portion is raised more than 0.75m at any time.

Mortar joints shall be full and approximately 10 mm thick. They shall be raked out at least 10 mm deep as the work proceeds.

At concrete columns, surfaces shall be chipped and steel binders shall provide rigid connection between column and blockwork, wherever no expansion joints are provided.

3.8. FINISHING

Following completion of rendering all surfaces shall be thoroughly cleaned.

Any unsatisfactory work shall be removed and the rendering shall be re-applied.

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SECTION 05100

STRUCTURAL STEEL CONSTRUCTION AND STEELWORKS

1. GENERAL

1.1. WORK INCLUDED

The Work included under this Section consists of shop design, supply and installations of miscellaneous metalwork (steel, stainless steel, aluminium,...) when required, including but not limited to the following items (if any):

1. Structural steel construction
2. Railings.
3. Ladders.
4. Steel stairs and rungs.
5. Hatches.
6. Hand rails.
7. Footbridges.
8. Chain-link fences.
9. Cast iron frames, covers and gratings.
10. Steel frames for precast concrete covers, miscellaneous metal covers and gratings.
11. Placing of anchor or embedded items.
12. Various steel supplies.

The work shall include all fittings, cutting, drilling and blocking required to install the Work, and to make all the required connections with adjoining work. All anchors, sockets, pipe sleeves and expansion bolts required for fixing the metalwork to the construction shall be furnished by the Contractor, except anchors for erection of equipment supplied under other contracts which will be supplied by other Contractors.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. QUALITY ASSURANCE

- a. General

Manufacturing of metalwork shall be executed by qualified personnel.

b. Qualification of Welders

Welders shall be certified welders in accordance with AWS 01.1.

Uncertified welders shall pass at site qualification tests in accordance with procedures recommended by AWS 01.1.

c. All the aluminium installation should be manufactured by a single manufacturer with a uniform finish and based on a prototype approved by the Engineer.

1.4. STANDARDS AND CODES

1. American Society for Testing and Materials

- a) ASTM A 36 Specification for Structural Steel
- b) ASTM A 48 Specification for Gray Iron Castings
- c) ASTM A 53 Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
- d) ASTM A 307 Specification for Carbon Steel Bolt and Studs, 60 000 psi Tensile
- e) ASTM A 575 Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
- f) ASTM A 788 Specification for Steel Forging, General, Requirement.
- g) ASTM B 221 Specification for aluminium Alloy Extended bars, Rods, Wires Shapes and Tubes

2. American Welding Society

AWS D1.1 Structural Welding Code

3. British Standards

4. European Standards

1.5. SUBMITTALS

The Contractor shall submit the following documents:

- Copies of certified manufacturer's tests.
- Shop drawings and erection drawings shall be submitted to the Engineer's approval at least one month before beginning the manufacture of the various items.

1.6. SHOP DRAWINGS

Shop drawings of all metalwork shall show detail of assembly, method of assembly, detail of anchorage or connection with the main structures.

1.7. TOLERANCES

A. Manufacture Tolerances

1. Dimensions without direct influence on the assembly of the element: 0.2%.
2. Main dimensions: 0.1%.
3. Local (area 200 x 200 mm): 0.5/400 cm².
4. Flatness: 1 mm.
5. Main parallelism, main squaring: 1 mm/m.
6. Straightness, alignment: 2 mm.

B. Erection Tolerance

7. Dimension without influence on the operation of the element: 0.2%.
8. Main dimensions: 0.1%.
9. Local (area 200 x 200 mm): 0.5/400 cm².
10. Flatness: 1 mm.
11. Straightness, alignment: 2 mm.
12. Verticality: 2 mm.
13. Horizontality: 2 mm.

C. All tolerances shall allow proper operation of the equipment.

2. PRODUCTS

2.1. MATERIALS

Except where otherwise specified, material shall be in accordance with EN 1993, EN 10025, EN 10210 and 10219.

2.2. FABRICATION

Each part shall be clearly marked in such a manner that part can be easily identified on shop erection drawings.

All metalwork shall be carefully and accurately assembled by welding or by screws, bolts and rivets, concealed as far as possible.

The joints shall be filled, milled or machined as may be necessary to secure close and perfect connections. All frames shall be provided with suitable bracing connections. All frames shall be provided with suitable bracing to maintain alignment during transport.

Members shall not be overstressed during the construction and hammering will not be permitted.

Any metalwork damaged during transport or erection shall be removed by the Contractor and replaced by new materials to the satisfaction of the Engineer at no extra cost to the Employer.

Built-up work shall be assembled completely at the shop, accurately finished and the section match-marked for field erection.

Concerning ladders, the fabrication shall include back protection whenever the ladder height is more than 2 m.

3. EXECUTION

3.1. INSPECTION

The Engineer will inspect all metalwork before erection on Site, such inspection covering:

1. assembly quality,
2. geometric characteristics,
3. corrosion protection,
4. embedded supports,
5. quality of surface finish.

3.2. ERECTION

No metalwork shall be incorporated into the Permanent Works until it has been inspected and approved.

All embedded metalwork shall accurately set in place before the concrete is poured or, subject to the approval of the Engineer, recesses may be left in the concrete and the metalwork placed, anchored and blocked in place after the concrete of the structures has set.

Where, in the Engineer's opinion, it is impracticable during construction to place anchors or fasteners required for the installation of ladders, or other miscellaneous metalwork, holes shall be drilled in the structures and expansion bolts installed.

Grout, where required, shall consist of epoxy cement or of aggregate, sand, cement and water in the proportions proposed by the Contractor and approved by the Engineer. Forms for grouting shall be installed where necessary. Grout shall fill all space of recesses, with no voids. After grout has hardened, any visible wedges shall be removed, and exposed joints neatly finished to a smooth dense surface.

3.3. WELDING

Members to be joined by welding shall be cut accurately to size, with edges sheared, flame-cut, or machined to suit the required type of welding and to allow thorough penetration. The surfaces of plates to be welded shall be free from rust, grease, and other foreign matter along the edges prepared for welding. The cut surfaces shall be free of all injurious defects.

Weddings shall be made in accordance with the Code for Arc and Gas Welding in Building Construction, as formulated by AWS. All welding shall be continuous along the entire line of contact, except where tack welding is permitted. All exposed welds shall be ground smooth.

No welding of galvanised steel shall be permitted.

Inspection of welds in all steel may begin immediately after the welds are completed. In addition to inspection as required by AWS D1.1, all welds shall be visually examined. Procedure, technique and standards of acceptance shall be in accordance with AWS D1.1.

The Engineer reserves the right to direct radiographs of the welds. Location and findings of all radiographic inspections, together with descriptions of any repairs made, shall be recorded on proper testing sheets.

3.4. CORROSION PROTECTION

Corrosion protection, galvanization and/or painting shall be carried out in accordance with Section 01010 - Corrosion protection.

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SECTION 07000

WATERPROOFING, INSULATION AND ROOFING

1. GENERAL

1.1. WORK INCLUDED

The works covered by this Section relate to the following items:

- Roofing;
- Framework;
- Covering;
- Weather-proofing;
- Heat insulation;
- Sound insulation
- Odour-proofing.

of all the closed and covered enclosures in order to guarantee closure and cover, and to prevent nuisance caused by noise and smells.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DESCRIPTION

The works in the present Section will cover all necessary works for the completion of the building, including framing, insulation, claddings, cladding accessories like bottom flap, acroterion cover, corner pieces, opening surround, cover strips, plugging,...

All the holes in the cladding will be such as to avoid any deformation (oblong holes), in any direction due to the deformation of the framing.

All the supply for the present Section shall be manufactured by a single manufacturer to insure a uniform finish.

When required, special washers shall be introduced to avoid direct contact between framing and aluminium cladding.

It also includes supply and installation of:

- Stormwater gutters and downspouts;
- Zenith lighting;

- Smoke outlets and associated remote control devices;
- Connections for roof outlets for smoke pipes or ventilation ducts;
- Connection and interface works between the different structures;
- All the accessories needed for perfect finishing work;
- Protective barriers to prevent falling of personnel and objects during the works period in accordance with regulations in force on the date of signature of the contract.

1.4. CODES AND STANDARDS

Works are to be carried out in accordance with standard professional practice, and in compliance with all current rules and standards.

- For example, French Standards AFNOR may be used together with DTU Specifications (Series 43 - Waterproofing, 43.1, 43.2, 43.3 and 43.5 - Ribbed steel sheet roofing.)
- Specific trade regulations where relevant (claddings, double-sided roofing, etc.).
- Fire prevention regulations (APSAIRD rules).
- Industrial safety regulations.

The Contractor shall propose a product and the corresponding standards guaranteed by the supplier and/or the manufacturer.

1.5. SUBMITTALS

- Calculation notes for framework, roofing, insulation, etc.
- Working design drawings with associated justification and detailed technical specifications;
- Report of terrace water priming test;
- Technical solutions, processes and schedule for work on structures to be rehabilitated.
- Colour shall be approved by the Employer and for this purpose, samples shall be submitted to the Engineer together with documentation required.

2. PRODUCTS

2.1. GENERAL

The materials used must comply with standards and regulations in force at the time of signature of the contract and must take into account the aggressive ambient atmosphere.

2.2. TRANSLUCENT PANELS

If PRV colourless translucent ribbed panels are used for external cladding, they shall comply with Standard NF P 38301 and shall be installed as indicated on the Drawings.

The supply shall include any additional connecting and supporting accessories.

2.3. HEAT INSULATION

2.3.1. VAPOUR BARRIER

Self-adhesive strips or added screens shall be laid as per DTU.

2.3.1. INSULATING SHEETS OR PANELS

Non-loadbearing insulating panels shall be installed and will contribute to heat resistance. It shall be laid as recommended per DTU.

Work shall comprise all laying and connection constraints, in particular for ventilation between roof sheets and insulation.

If panels are used, they shall be cut and raised level with ridge ventilation openings, to ensure free ventilation of buildings.

2.4. CLADDINGS

- A. Cladding shall be constructed of prelacquered steel sheets with minima thickness of 0.50 mm.**
- B. All accessories shall be prelacquered aluminium, as for outside cladding, with the same colour, or another colour as approved by the Engineer.**

All types of additional profiles and joint needed (like compriband expandable joints or gun laid joints), particularly at connecting points with other structures (for instance masonry, window and door frames) shall ensure absolute air and watertightness and perfect finish.
- C. Bottom flap shall be provided to form a dripboard at connection with walls and openings, closing up the bottom of the roof panels.**
- D. Acroterion cover shall be provided and crowns the top, at the connection with gutters, flashings or counterwallings.**
- E. Corner pieces shall be provided and especially shaped for re-entrant and projecting angles.**

3. EXECUTION

3.1. GENERAL

All waterproofing, insulation and roofing works shall be carried out in conformity with relevant European Standards.

3.2. COVERING AND WATERPROOFING

The terraced roofs shall be waterproofed by means of watertight layers and treated as specified hereinafter.

A. HEAT INSULATION

Before rendering the roof waterproof, a thermal insulation shall be laid consisting of 5 cm polystyrene foam, laid on a vapour barrier of 2/10 mm thick PVC sheet. Slabs of polystyrene foam shall be carefully placed without any gap. Broken slabs will not be allowed.

B. WATERPROOFING

The waterproofing shall be laid on a 100 g/m² glass fibre material for separating from heat insulation.

The waterproofing shall be constituted of two 110/35 thermoplastic bituminous elastomer flexible watertight coatings placed on a 250 g/m² unwoven polyester base. The first coating shall be unrolled dry and the second shall be propane gas heat-welded to the first.

The Contractor may propose non-conventional covering or sealing processes providing the same guarantees as standard solutions or elastomeric double layer lining.

All the necessary precautions shall be taken to limit noise (urban-type soundproofed equipment), dust and accident risks.

C. RAISING

On the inside faces of the parapet walls and all around the projections of the flatroofs (stacks of smoke pipes, ventilation, air coolers, etc.), the first coating shall be bonded by a cold impregnation sealant and a hot sealant application layer. The second flexible watertight coating shall be self-protected by aluminium sheeting and shall cover the inside face and the top of the parapet.

Expansion joints on the roof shall be covered with a continuous aluminium sheet, as shown on drawings. Special care shall be taken at crossing of two expansion joints.

D. COVERING

All roofs shall receive over the waterproofing:

- a layer of 10/30 gravel 8 cm thick, or
- precast tiles 30 x 30, 3 cm thick made with mortar with 350 kg of cement per cubic metre of sand; tiles will be placed with thin joint filled with bitumen and over a layer of sand 3 cm thick.

E. RAIN-WATER DOWN PIPES

Drainage or rain-water will be either through outside down pipes, or down pipes embedded in a concrete column or prefabricated water spout.

Down pipes shall be made of PVC, and 125 mm in diameter. A strainer shall be provided to prevent solid substances going through. At right angles with the emptying of rain-water a lead plate 40 cm x 40 cm welded to a pipe 30 cm long connecting the down pipe shall be provided. This plate shall be situated between two coats of bitumen felt, or butyl film.

When the rain-water down pipes are outside the building a lead plate shall be provided in order to pipe the waters down to a zinc box situated outside and fixed on the front of the buildings. From this box the rain-water down pipe shall be laid and fixed on the wall by removable pipe collars of galvanised steel.

Rain-water down pipes shall be connected to the general rain-water drainage system by means of a pit closed with a cast iron cover.

The Contractor shall submit the detailed layout of the drainage system to the approval of the Engineer.

All constructional measures shall be taken to weather-proof the facades of the structures.

SECTION 08100

DOORS AND WINDOWS - GLAZING

1. GENERAL

1.1. WORK INCLUDED

This section covers the manufacturing and fixing external air-tight doors and windows with single or double glazing as required for the various buildings.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. CODES AND STANDARDS

ASTM A-788 Specification for Steel Forging, General, Requirements.

ASTM B-221 Specification for Aluminium Alloy Extruded Bars, Rods, Wires Shapes and Tubes.

ASTM C-158 Method for Testing Flexural Testing of Glass.

1.4. QUALITY ASSURANCE

All the aluminium installation should be manufactured by a single manufacturer with a uniform finish.

2. PRODUCT

2.1. ALUMINIUM

Sections should be extruded from 6063-T5 aluminium alloy conforming to ASTM B-221.

2.2. FASTENING DEVICES

All the fastening devices shall be of aluminium, stainless steel or other corrosion resistant material with sufficient strength, and if visible should blend with the frame finishes.

2.3. HARDWARE - GENERAL

All the hardware fixed shall be of best quality available in the market. The finish of hardware must closely match the finish of doors and windows.

2.4. SCREEN AND MOSQUITO NET

All windows and ventilation openings shall be provided with insect corrosion resistant external screen and/or mosquito net.

2.5. HANDLE

Handle shall be brass or aluminium alloy, 100 mm long fixed with screws of the same material.

2.6. LOCK

At least all external doors shall be capable to be locked.

Locked doors shall be delivered with 3 keys.

Lock shall be automatic dead locking mortise lock with 2 bevelled latches and handles.

2.7. STOPPER

When required, doors shall be fitted with foot-operated friction door stoppers.

2.8. HYDRAULIC DOOR CLOSER

When required, doors shall be fitted with single-action type, face fixing hydraulic door closer.

2.9. HINGE

Hinge shall be brass built hinge of size 100 x 50 mm or extra heavy steel-butt-hinge of size 130 x 80 mm depending of the size of the door.

When shown on the Drawings or directed, doors shall be fitted with double-action oxidised brass, sprint-butt-hinge of size 100 x 50 mm.

2.10. GLASS

All the glass shall comply with the appropriate section of ASTM C-158.

Sheet glass shall be colourless free from bubbles, distortion and flaws of other significant nature. The glass shall be properly cut to fit the rebates so as to have a uniform space to accommodate rubber insertion all round the panel between edge of the glass and the rebate.

Plain glass is the type to be used for windows, doors, etc. unless otherwise directed. Its minimum thickness shall be 5 mm. The breaking strength under flexural load shall be not less than 30 MPa. It shall withstand 24 hours exposure to hydrochloric acid vapour and subsequent return to open air without impairment of either its transparency clearness or lustre.

Where phonic insulation is required, glasses shall have an acoustic absorption factor of 32 dB over the range 100 to 3200 Hz.

Unless otherwise agreed, glass blades for louvres shall be 150 mm wide with 25 mm overlaps and shall have polished edges.

Where the total length of a louvre exceeds 1100 mm, mullions shall be incorporated in the frame so that no louvre blade is larger than 1100 mm.

The blades shall be set into interlocking metal clips fixed to the frames. The clips and the frames shall be of aluminium.

Head and cell sections of the louvre frames shall match and be fitted with dual softness PVC or neoprene insert weatherstrips.

2.11. GLAZING BEADS

Metal glazing beads shall be supplied with the metal frame and shall be tightened with sunken screws.

All aluminium doors and windows shall have locking glazing beads and extruded vinyl gaskets.

2.12. DOORS AND WINDOWS

All windows and outside doors shall be designed to support a pressure of 1.5 kPa.

Buckling of openings: three angles of an opening being maintained fixed, a force of 100 N applied upright on the fourth free angle shall not introduce a displacement of this free angle greater than 5 mm.

The openings support a vertical force of 1 kN at the top edge of the door or windows opposed to the hinges without any permanent deformation.

Standard sized doors shall operate under a force of less than 5 daN and opening windows under a force of less than 3 daN.

Lock system shall be quick and efficient with the handle at 4 cm free distance from any fixed element.

Metallic joinery shall be built from standard sections allowing a dust proof joinery with double elastomer joints.

Number of hinges shall be 2, 3 and 4 for openings height of 1.00, 1.80 and 2.50 m respectively. Hinges shall be fitted with bronze ring and the male part shall be adjustable.

2.13. ENTRANCE ROLLING DOORS

Aluminium sheeting on steel framed door electrically controlled, suspended and rolling on an upper rail supported by the steel structure.

Insulation equivalent to insulation of aluminium insulated sheet walling (refer to section).

Ventilation openings with screen 600 x 600 mm.

Opening for glazing 600 x 800 mm (glass equivalent to the glass used for internal windows - refer to Section 2.10.D above).

Finishing equivalent to the sheet walling.

Shop drawings to be proposed to the Engineer's approval together with shop drawings for the whole buildings structural steelworks and sheet walling.

2.14. GLASS BLOCKS

Glass block walls shall be constructed from hollow glass blocks 240 x 240 x 80 mm or equivalent dimensions set in mortar in a perimeter framing to connecting walls and ceilings of aluminium channel sections.

The wall shall be set against the floor on 2 layers of bituminous felt. Channel sections shall be fixed to walls and ceilings with the concave face against the glass blocks and lined with 10 mm thick foamed polystyrene and 1 layer of bituminous felt before mortar is placed.

The glass blocks shall be set with flush joints to true horizontal and vertical lines in a 250 mm module. All channel sections shall be completely filled with mortar, and the joints between channels and mortar filled with an approved elastic joint filler.

Glass block walls shall be reinforced with 8 mm hot dip galvanized plain reinforcement bars around the perimeter and in every horizontal and vertical joint.

3. EXECUTION

3.1. FRAME

Where practicable, frames shall be placed prior to construction of enclosing walls and ceilings.

Frames shall be securely braced into position until permanent anchors are set.

3.2. GLAZING

Glazing channels, stops and rabbits shall be cleaned before receiving the glazing materials.

Glass shall be set in a manner which produces the best possible degree of uniformity in appliance.

Glass shall be protected from breakage after installation by installing streamers or ribbons attached to the framing and held free from glass.

3.3. PAINTING OF METAL WORK

All metal works shall be shop painted.

3.4. CLEANING

Glass shall be cleaned with methylated spirit on completion.

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SECTION 08200 PAINTING

1. GENERAL

1.1. WORK INCLUDED

1. Surfaces indicated to be painted in the description of the works.

1.2. RELATED SECTIONS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. STANDARDS

Society for Protective Coatings (SSPC) Specifications, or equivalent

1.4. QUALITY ASSURANCE

Adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods needed for proper performance of the work of this Section shall be used.

1.5. SUBMITTALS

The Contractor shall submit 4 months before the scheduled date of painting 3 colour schedules of painting together with a description of colour codes, composition and manufacturer's recommendations concerning preparation of the surface and method of application of the paint of each type of paint and each type of exposure condition, as directed by the Engineer.

1.6. SAMPLE AREAS

Sample areas of not less than 1.50 m x 1.50 m shall be prepared and painted, one for each colour and/or type of surface finish as required or as directed by the Engineer.

If approved by the Engineer the sample areas will serve as minimum reference standards for painting.

1.7. DESCRIPTION OF WORK

The rooms will include the following interior works:

- Acid-resistant paint on floors with 10 cm run-up on interior walls in all electrical equipment, deodorisation and reagent storage rooms.
- Two coats of glyptal paint on all interior walls in technical equipment rooms, except pump pits, UV and tank building rooms.
- Two coats of glyptal paint on ceilings in electrical equipment rooms.

1.8. DELIVERY, STORAGE AND HANDLING

Paint materials shall be delivered in sealed original labelled containers, bearing manufacturer's name, type of paint, brand name, colour designation and instructions for mixing and/or thinning down.

All paints and associated materials shall be stored in dry covered storage which is adequately ventilated and protected from temperature extremes. Any paint which is, in the opinion of the Engineer, not in good original conditions according to manufacturer's specifications, shall be replaced by the Contractor at his own expense.

Precautionary measures shall be taken to prevent fire hazards and spontaneous combustions.

1.9. ENVIRONMENTAL REQUIREMENTS

Blast cleaning and painting work shall be carried out only when the ambient air and degree of humidity are within the requirements of the instructions for use of the product.

Paints shall be applied only to surface that are thoroughly dry and under such conditions of humidity and temperature as will cause evaporation rather than condensation. The surface temperature shall always be at least 3°C higher than the dew point.

Generally all work shall be suspended as soon as the degree of humidity exceeds 75% and the ambient temperature exceeds 40°C or drops below 5°C.

Adequate continuous ventilation shall be maintained before, during and after application of paint up the time of the paint if thoroughly dry.

Paint when applied shall be at approximately the same temperature as the surface on which it is applied.

2. PRODUCT

2.1. GENERAL

The type and quality of paint to be incorporated in the Works will be nominated by the Engineer, and only those products approved by the Engineer shall be accepted.

All materials shall be proven, first grade products and shall meet or exceed the average standards of reputable local manufacturers.

3. EXECUTION

3.1. INSPECTION

The Contractor shall thoroughly examine surface scheduled to be painted prior to commencement of work.

Defects and deficiencies in surface which may adversely affect work shall be corrected.

3.2. PROTECTION

The Contractor shall adequately protect other surface from paint and damage and shall repair damage to other surface as a result of inadequate or unsuitable protection. This shall include furnishing sufficient shields and protective equipment to prevent spray or dropping from fouling surfaces not being painted and particularly surfaces within storage and preparation areas.

Cotton waste, cloths and materials which may constitute a fire hazard shall be placed in closed metal containers and removed daily from Site.

Fittings and fastenings shall be carefully removed prior to painting operations. These items are to be carefully stored, cleaned and replaced on completion of work in each area.

3.3. PREPARATION

3.3.1. GENERAL

1. Surfaces to be painted shall be clean before applying paint or surface treatments. All oil, grease, dirt, rust, loose materials and other foreign substances shall be removed.
2. No coating work shall begin before the prepared surfaces, or the manner of preparation, have been approved by the Engineer.
3. Cleaning and painting shall be so programmed that dust or spray from the cleaning process will not fall on wet, newly painted surfaces.
4. Where required, imperfections and holes in surfaces shall be filled or obliterated in an approved manner.
5. Hardware, electrical fixtures and similar accessories shall be removed during preparation and painting operations and shall be replaced upon completion of painting operations.

3.3.1. CONCRETE AND MASONRY SURFACE

1. New concrete surface receiving paint shall be cured for a minimum of 28 days before being painted.

2. The Contractor shall remove contamination and shall acid etch and rinse new concrete floors with clear water, ensuring acid alkali balance is achieved.
3. The Contractor shall remove dirt, loose mortar, scale, powder, and other foreign matter from concrete and concrete block surfaces which are to be painted or to receive a clear seal.
4. Oil and grease shall be removed with a solution of tri-sodium phosphate, which shall then be thoroughly washed and drained from the surface.
5. Hairline cracks, small holes and imperfections on plaster surfaces shall be filled with patching plaster and the surface shall be smoothed to match adjacent surfaces.

3.3.1. WOOD SURFACE

1. Wood surface shall be planned or sanded to remove all tool marks.
2. All holes, cracks and depressions shall be cleaned out and overfilled with non-shrinking wood filler which, when completely set, shall be sanded back to match the adjacent surfaces.

3.3.1. PLASTER

1. Plaster shall be at least 2 months old and shall be thoroughly dry, clean, and free from grit, loose plaster, and surface irregularities before paint is applied.
2. Cracks and holes shall be repaired with patching plaster.
3. All plaster surfaces shall be tested for the presence of alkali which, if present, shall be removed with a solution of zinc sulphate mixed in the proportion of 1 kg to 2 litres of water. After drying, the precipitate shall be removed by brushing.

3.3.1. APPLICATIONS

No paint or other products may be applied until the surface has been prepared to the satisfaction of the Engineer and until the surface is completely dry.

Each coat of paint is to be slightly darker than the preceding coat unless otherwise approved by the Engineer.

Each intermediate coat is to be lightly sanded back before the application of the subsequent coat.

The paint shall always be thoroughly mixed according to the manufacturer's instructions prior to application and only approved thinners may be used.

The time between coats shall not be less than that recommended by the manufacturer.

Any painting considered to be unsatisfactory by the Engineer shall be sanded back and repainted at the Contractor's expense.

3.4. CLEANING

During painting the work area shall be kept clean and free of dust or other harmful substances.

On completion of painting the whole area shall be thoroughly cleaned or any splashes, spills or runs.

3.5. DRY FILM THICKNESS

The protective paint systems shall be applied in continuous films to give, at the minimum, the total dry thickness indicated in the coating schedule, as measured by approved methods.

One steel material wet thickness gauges shall be used continuously by the applicator during application to ensure that the dry thickness requirements will be met.

3.6. COATING SCHEDULE

The following coating schedule shall be adopted:

a. Wooden frames, doors

- Surface preparation: as specified.
- Prime coat: plasticised nitrocellulose sealer (2:) (such as NC Wood Sealer).
- Finish coat: plasticised nitrocellulose topcoat (3:) (such as NC Glossy Wood Finish).

b. Concrete and plaster

- Surface preparation: as specified.
- 1.Vinyl Emulsion Paint
- Prime coat: alkali resisting masonry sealer (1:12) (such as Dulux Primeon).
- Finish coat: vinyl acetate emulsion paint (3:60) (such as Paintex Vinyl Emulsion).
- 2.Plastic Emulsion Paint
- Finish coat: (3:60)
- 3.Hard Gloss Enamel Paint
- Long oil alkyd resin paint (3:60) (such as Dulux Synthetic Enamel).
- 4.Oil Repellent Paint and Concrete exposed to chemical action or heavy duty
- In cracks and holes: epoxy sand mortar
- Prime and finish coat: epoxy paint (4:120) (such as Epoxy Concrete Finish).
- 5.White colour Paint.
- No painting shall be applied to aluminium, stainless steel, copper bronze, chromium, nickel, brass or galvanized surfaces, unless directed by the Engineer.

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SECTION 08300

SUSPENDED CEILINGS

1. GENERAL

1.1. WORK INCLUDED

This section deals with technical requirements for the design, manufacture, delivery, off-loading and erection of the miscellaneous suspended ceilings.

Works include but are not limited to the followings:

- supply and installation of metal framework and attachments for mounting to the load-bearing structure,
- supply and installation of tiles, strips, ceiling panels or other components of the ceiling itself including hooking, mounting and connection systems (anchors, clips, slides, slide rails, etc.),
- finishing (laquered metal profiles for edge covering, etc.) and all related works,
- protection of metal structures in the conditions defined in the present document,

1.2. RELATED WORK

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DESCRIPTION

Suspended ceilings shall be installed in halls, offices, sanitarities and in all pedagogical and living facilities. They won't be allowed neither in process areas nor in all exploitation and technical rooms in contact with water or condensation.

The false ceilings proposed may be of concealed framework, aluminium ceiling panels, coated gypsum board or laminated wood.

The selected materials must be suitable for the type of premises in which they are to be installed (humidity, excess pressure, etc.).

1.4. QUALITY ASSURANCE

1.3.1. CODES AND STANDARDS

Application of ceiling units shall be done in strict accordance with the manufacturer's specifications unless otherwise approved.

1.3.1. DESIGN CRITERIA

The false ceiling primary framework (where applicable) must be able to support the weight of lighting fixtures.

The secondary framework must be able to support the other technical equipment whether flush-mounted or suspended (fire detection system, sound installation, etc.).

All necessary measures must be taken to prevent problems due to condensation.

In damp premises, the false ceiling framework must be connected to the building earthing system.

1.3.1. SHOP TESTS AND INSPECTION

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
 - A. The seals and the embedded parts shall be presented separately and unpainted for checking.
 - B. The surface appearance of embedded parts shall be examined and their dimensions checked.
 - C. All dimensions shall be checked.
 - D. Welds: Refer to Section 01020.

1.5. SUBMITTALS

The Contractor shall carry out studies, calculations, diagrams, construction and detail drawings of structures. These drawings shall show clearly the sizes, methods of fixing, jointing and anchorages to be used in the process.

1.6. DIMENSION TOLERANCES

1. Ceiling panels and metal strips: 1/500 of the span between supports, with upper limit at 5 mm.
2. Fibreboard panels: 1/300 of the span in the case of visible framework.
3. Unevenness tolerances: 3/10 mm for chamfered components.
4. Gap between visible framework and panels: 1 mm maximum.
5. General flatness of suspended ceilings made of panels, of fibreboard and aluminium: deflection or camber less than 3 mm under 1.20 m rule for ceilings smaller than 4 m² and under 2.00 m rule for ceilings larger than 4 m².

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. MANUFACTURING

The Contractor shall choose framework and materials in relation to regulatory requirements, in particular those concerning fire and panic risks, and contractual requirements in terms of resistance, absence of uplift, suitability in relation to humidity conditions of premises and soundproofing,

Timber framework shall be treated with insecticide using products with the CTB.F label that do not stain the ceilings,

2.2. SPARE PARTS AND SPECIAL TOOLS

The contractor shall specify and supply the special tools required for equipment maintenance.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. GENERAL

Space to receive ceiling units shall be satisfactorily closed and protected against the weather two months before beginning and during work.

Temperature shall be maintained at 10°C or above while system is being installed.

Space to receive ceiling units shall be dry and with no more dampening materials to be installed.

All cuts and recesses for incorporating components supplied by the different trades (electricity, heating, ventilation, etc.) are under Contractor's responsibility. This work must be carried out on the basis of instructions supplied by the different companies during the preparation of slab layout drawings, to be submitted, prior to any production, for the approval of the Owner or his representative,

The Contractor shall create grooves, notches and holes in the walls and load-bearing framework for securing, anchoring or putting in place of suspended ceiling components. He shall also fill in any such grooves, notches and holes that remain visible after installation work,

The Contractor is responsible for installation and removal of any scaffolding needed for performance of the works, irrespective of the height of the structures,

Tarpaulins and protection of structures of other trades, that might be damaged during the performance of the works described in the present chapter, shall be set.

Perfect coordination shall be assured:

- for the fitting of ducts, piping and wiring and installation of apparatus (light fittings, outlets, fire detectors, sound installation etc.),
- for connection of the structures (stability, etc.),
- for painting and covering works.

3.3. CEILING SUSPENSION SYSTEM

The false ceilings will be either suspended to the underside of the floors, of poured reinforced concrete on standard formwork or COFRASTRA type metal formwork (or similar), or on prestressed permanent shuttering concrete slab, under the framework comprised of beams and prestressed purlins.

In these last three cases, drilling and power-activated fastening is prohibited.

False ceiling framework must be installed using clamps around the purlins.

The provision of any special parts for securing the components is included in the supply.

3.4. FIELD QUALITY CONTROL

1. Erection tolerances:
Refer to Section 01020 and paragraph 1.6.
2. Examination of paintwork.

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