

REPUBLIC OF LEBANON

MINISTRY OF ENERGY AND WATER

PROJECT No

CONTRACT No

CONSTRUCTION OF RESERVOIR, LIFT LINE, AND WATER DISTRIBUTION NETWORK IN JAJ - JBAIL CAZA

VOLUME 3 – i

TECHNICAL SPECIFICATIONS

(REVISION B)

- ✓ **Part 1 - General Requirements**
- ✓ **Part 2 - Civil Works**
- Part 3 – Mechanical Works**
- Part 4 – Not Used**
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PART 1

GENERAL REQUIREMENTS

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101 GENERAL REQUIREMENTS

101.1 GENERAL REQUIREMENTS AND PARTICULAR SPECIFICATION

These General Requirements shall form an integral part of the General Specifications. In addition to these General Requirements, the Contract contains a Particular Specification, to supplement and/or modify the General Specification as may be necessary in each particular case.

The provisions of the Particular Specification for any specific section or number of sections shall prevail over those of the General Specification. Whenever the term "Specification" without further qualification is used in the Contract Documents, it shall mean this General Specification together with the Particular Specification.

101.2 REQUIREMENTS OF SPECIFICATION

The Contractor shall fulfil all requirements and obligations of all clauses of the Specification applicable to the construction work involved in the Contract. Neither the following clauses of this Specification nor the Bill of Quantities shall limit the obligations of the Contractor under the accompanying Conditions of Contract. Where items are not included in the Bill of Quantities for any such requirements or obligations the cost of such requirements or obligations shall be deemed to be spread over all the items of the Bill of Quantities unless otherwise stated.

101.3 ISO 9000 CERTIFICATION

Imported manufactured products and equipment shall comply with their relevant international standards. The quality assurance of all imported goods shall be granted the ISO 9000 certification.

Locally manufactured products and equipment shall comply with US or Western European Standards. ISO 9000 certification for locally manufactured goods is not essential, however these good shall be subject to the approval of the Engineer.

101.4 DRAWINGS, RECORDS AND DOCUMENTS

101.4.1 Drawings

All works shall be performed in accordance with the drawings furnished with the Contract documents and any such additional drawings as may be issued by the Engineer from time to time during the progress of the work or any drawing furnished by the Contractor and approved by the Engineer. Additional drawings (if any) will be furnished to the Contractor in due time so as to enable him to perform the work shown thereon in its proper sequence and for any advance planning that may be necessary for the efficient performance of such work. The Engineer will decide in each instance whether additional drawings are required for advance planning of the works and determine the time required for same.

In all cases, detailed shop drawings for all components of the Works shall be prepared by the contractor, after the approval of all related equipment items. The design and the shop

drawings shall be submitted to the Engineer who shall within 21 days approve, reject or ask the Contractor to revise or modify such documents and resubmit them for approval. All these documents shall be approved by the Engineer prior to commencement of the work. The structural design will be in accordance to the recommendations based on soil investigations.

101.4.2 Records and “As-built” Drawings

After the work has been completed, the Contractor shall furnish “as-built” drawings prepared whilst surveying during construction, showing the Works as constructed together with all other information that may either be required or be useful for the operation and maintenance of the Works in the future, such as alignment and depth of cover of pipelines, type of soil, type, dimensions and location of structures, size of pipelines and cables encountered during excavation.

Unless specific items are included in the bill of Quantities, the cost of preparing the shop drawings, “as-built” Drawings and Records shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately. The As-built Drawings shall be submitted, if required by the Engineer, on computer diskettes.

101.4.3 Ownership of Drawings and Documents

The Drawings and documents are issued to the Contractor for the purpose of the execution of the Works under the Contract and shall remain the property of the Employer to whom they are to be returned by the Contractor after completion of the work, as a precondition for the issue of the Certificate of Completion.

101.5 BOREHOLE INFORMATION

The Contractor shall satisfy himself as to the nature of the strata underlying the sites of the works. He may carry out at his own expense borings, tests and investigations as he may consider necessary and utilize the information thus gained for the preparation of his tender.

Any subsoil information and test results provided by the Employer shall be given to the Contractor for his preliminary information only. Such information shall not relieve the Contractor in any way of his obligation to inspect the sites and of his sole responsibility for carrying out the works as specified and required by the Engineer and at the rates set out in the Bill of Quantities. No claims for additional payment and/or extensions of time shall be entertained in respect of data furnished to the Contractor by the Employer or the Engineer.

101.6 METEOROLOGICAL AND HYDROLOGICAL CONDITIONS

The Contractor’s attention is directed to the meteorological and hydrological conditions prevailing in the project area and its vicinity. In his planning of the work and in his unit rates, the Contractor shall take these factors into account. No increase in prices and/or

extension of time shall be granted due to rains, floods and/or other adverse climatological conditions in the project area and along the roads to it.

For information, the climatic conditions in Lebanon can be summarized as follows:

	Temperature (deg C ^o)						Relative humidity					
	Coastal zones		Mountanious zones		Bekaa Valley		Coastal zones		Mountanious zones		Bekaa Valley	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Summer	20	35	15	25	10	35	65	85	50	60	40	65
Winter	7	15	-5	10	-1	15	60	75	55	75	55	80

101.7 BILL OF QUANTITIES

101.7.1 Rates and Prices

The rates and prices inserted by the Contractor in the Bill of Quantities are to be the full and inclusive value of the work described. They are to cover all costs, expenses and general risks which may be involved, together with all liabilities and obligations set forth or implied in the Specification and other documents on which the Tender is based. They must include all plant, tools, materials, transport of men and materials, insurance and labour of every description. They must also take into account the conditions referred to in the general Conditions, and include time lost due to weather, payment of guaranteed minimum and holidays with pay. The cost of any travelling time subsistence and incentives such as overtime etc. must be included in the rates and prices. Where any special risks, liabilities and obligations, mentioned above or otherwise, cannot be dealt within the rates, then the price thereof is to be separately stated in items provided for the purpose or added by the Tenderer.

Any item left unpriced shall be held to have had its cost included in the unit rates for other items of work.

101.7.2 Provisional Items and Quantities

Care shall be taken to distinguish between "Provisional items" which represent work they may not be required, and "Provisional Quantities" which represent work that will be required but the quantity of which cannot be closely estimated in preparing the Bill of Quantities and details of which will be given on site.

101.7.3 Methods of Measurement and Payment

The methods of measurement and payment for each trade are normally specified in the General Specification, provided that where a different method of measurement is indicated in the Bill of Quantities or specified in the Particular Specification, the Bill of Quantities and the Particular Specification, in that order, take precedence over the General Specification.

Where no method of measurement is specified in any of the foregoing documents, the work will be measured in accordance with the latest edition of the Standard Method of Measurement of Civil Engineering Quantities, published by the Institution of Civil Engineers of London, U.K.

101.8 UNITS

In this Specification, on the Drawings and in the Bill of Quantities the S.I. (Systeme International d'Unites) metric system of dimensioning has been employed.

Where dimensions are given in metric units for materials which are only available in Imperial dimensions, the Contractor may, subject to his obtaining prior approval of the Engineer, substitute suitable sizes of materials as are available in the Imperial system. Such approval shall not unreasonably be withheld, provided that there is no difficulty in making interface connections with any other parts of the Works.

101.9 STANDARDS

For convenience and in order to establish the necessary standards of quality, reference has been made in the Contract Documents, to specifications issued by International Standards. Such specifications shall be defined and referred to hereinafter as "Standard Specifications" and shall be the latest editions of such Standard Specifications issued prior to the issue of Tender Documents together with such additions and amendments to such editions as may have been issued prior to the same date. Subject to the approval of the Engineer, any other internationally accepted Standard which specifies an equal quality of work may be used.

In reference to Standard Specifications, the following abbreviations have been employed:

B.S.	British Standard
A.S.T.M.	American Society for Testing Materials
D.I.N.	Deutsche Industrie Normen
I.S.O.	International Organization for Standardisation
A.A.S.H.T.O.	American Association of State Highway and Transport Officials
A.W.W.A.	American Water Works Association
N.F.	Normes Française
AFNOR	Association Française de Normalisation

101.10 SURVEY AND SETTING OUT

101.10.1 Engineer's Benchmarks and Survey Markers

Prior to the commencement of the work, the Contractor will receive from the Engineer a number of benchmarks and survey markers on the Site. Before starting any work, the Contractor shall check the alignment and levels of the benchmarks and markers in the presence of the Engineer's Representative and shall correct any error or mis-alignment which may be discovered during such checking with the consent of the Engineer's Representative. Thereafter, the Contractor shall establish from these corrected benchmarks and markers all levels and lines necessary for the performance of the work.

The Contractor shall be responsible for the preservation of the benchmarks and markers during the entire period of construction, and shall at his own cost repair or replace any of them that may be damaged, destroyed, or removed by any cause whatsoever.

101.10.2 Setting Out

The Contractor shall appoint and employ the necessary qualified and experienced staff to set out the work accurately and shall establish and locate all lines and levels and be responsible for the correct location of all works.

Whether or not directed by the Engineer's Representative, the Contractor shall take such levels and dimensions as may be required prior to disturbance of the ground for the purpose of measurement and these shall be agreed between the Contractor and the Engineer's Representative in writing before any of the surface is disturbed or covered up.

The Contractor shall establish parallel survey lines or other points of reference at a safe distance, permitting the re-establishment of lines and points, wherever the original lines and points must inevitably be destroyed or removed during the progress of work.

101.10.3 Surveying for Measurement of Earthwork

All intermediate and final surveying necessary for the establishment of quantities of excavation and earthfill will be done by the Contractor, who shall establish elevation points and prepare cross-sections sufficient to permit an accurate calculation of the quantities of earthwork. The Contractor shall notify the Engineer's Representative at least three days in advance of his intention to perform such measurements. The cross-sections prepared by the Contractor and approved by the Engineer's Representative shall be basis for the measurement and payment of earthworks.

101.10.4 Payment

Unless specific items are included in the Bill of Quantities, the cost of all surveying, modifications to drawings, setting out, and measuring to be done by the Contractor and all other expenses incurred by him in complying with the requirements of this section shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.11 PROGRAMME OF WORKS AND PROGRESS REPORTS

The time allocated for the performance and completion of all works under this Contract shall be as stated in the Appendix to Form of Tender (Volume 2 of Contract Documents).

The Contractor shall submit to the Engineer, before commencing work on site, a fully detailed programme showing the order or procedure and method by which he proposes to carry out the construction and completion of the Works, and particularly of the organisation and staff proposed to direct and administer the performance of the Contract.

The information to be supplied to the Engineer shall also include drawings showing the general arrangement of his temporary offices, camps, storage sheds, building and access roads, and details of Construction Plant and Temporary Works proposed.

The Contractor when preparing his programme shall take due account of the time required for the delivery of materials.

The Engineer will check the proposed programme and will return same to the Contractor within 14 days of its receipt with his approval or comments and requirements for changes (if

any). The Contractor shall make all requested corrections and changes not later than 7 days after having received the Engineer's comments. The programme as finally agreed to and approved by the Engineer will serve as the only basis for the carrying out of the Works.

After the commencement of each and any part of the Contract, the Contractor shall forward to the Engineer in triplicate, for each calendar month, a progress report and a chart showing the approved programme, the work completed to date and the progress made during the month. Such monthly progress reports and charts shall be submitted by the Contractor to the Engineer or his Representative not later than the 6th day of the month following that to which the report and chart refer.

101.12 WORK SITES

101.12.1 Right of Way and Sites of Works

The Employer will provide all the necessary rights of way, lands and sites on which the Works are to be carried out and will designate the access roads to the sites which the Contractor will be permitted to use.

In no case shall the Contractor occupy lands, right-of-ways or way-leaves without the previous written permission of the Engineer.

101.12.2 Contractor's Work Area

The location of the Contractor's work area, i.e. the area or areas where the Contractor may set up his offices, stores, workshops, yards for mechanical plant, etc., and transport depots, shall be agreed beforehand with the Engineer and shall be such as to avoid obstruction and nuisance to the public. The Contractor shall provide, within his work area, a Site Office for the use of his agent where written instructions from the Engineer may be delivered.

The Contractor shall make his own arrangements for and pay all costs incurred in the use of such areas of land as he may require for work areas for the purpose of the Contract.

101.12.3 Access and Construction Roads

The Contractor shall at his own expense construct and maintain within the right of way any temporary access roads and construction roads on the work sites that he deems necessary for the proper performance of the works, but the routes of such temporary roads and the method of their construction shall be subject to the Engineer's approval.

The Contractor will be permitted the use of existing roads on the Site provided that such use is co-ordinated with other users.

The Contractor will be permitted to use public roads as access roads to the Works only after having obtained permission in writing from the relevant Authorities and from the Engineer. The Contractor shall strictly adhere to all requirements and conditions prescribed by the relevant Authorities and set out in Clauses 29 and 30 of the Conditions of Contract.

The cost of preparation and maintenance of all access and construction roads and all costs incurred in complying with the requirements of this subsection shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.12.4 Existing Services

The Contractor shall make himself acquainted with the position of all existing works and services inter alia roads, sewers, stormwater drains, cables for electricity and the telephone lines, telephone and lighting poles, and water mains, before any excavation is commenced.

The Contractor will be held responsible for damage caused in the course of the execution of the Works to such existing works and services and shall indemnify the Employer, the Engineer and their agents against any claims arising from such damage (including consequential damages). Any damage caused must be made good at the Contractor's own expense.

Where the works required the crossing of existing roads, railways, fuel pipelines and services, the Contractor shall obtain the prior permission of and shall make all necessary arrangements with the relevant authorities and/or owners of said utilities and shall obtain their consent to the time and manner of execution of all work connected with such crossings.

When crossing a road in public use the Contractor shall either leave half the width of the road free for traffic or shall construct a bypass, as may be required by the road authority. The length, width and shape of any such bypass and the mode of its construction shall be as directed by the Engineer, but shall at all times permit for the passage of traffic using the main road. The Contractor shall put up warning and traffic signs, and shall employ flagmen to direct the traffic and shall mark the road crossings and put up lights from sunset to sunrise.

The Engineer's Representative may order the Contractor to repair bypasses, strengthen any temporary structures, put up additional signs or lights and generally improve the arrangements as he may deem necessary, and the Contractor shall forthwith comply with such orders. Regardless of whether or not the Engineer's Representative orders any such repairs or improvements, the Contractor shall remain solely responsible for the proper performance of all work in connection with the erection, maintenance and subsequent removal of all temporary structures required under this Clause, to the complete satisfaction of the Engineer.

Where the Works cross existing pipes, sewers, drains, channels, telephone or power lines and cables, the Contractor shall be responsible for the preservation of all such utilities in a good and serviceable condition during the execution of the Works and shall see to it that any damage done to any of the services be immediately repaired. Insofar as necessary, the Contractor shall construct temporary bypasses for such pipes, channels and cables and restore them to their original position after the work at the junction or crossing has been completed.

The Contractor shall construct all bypasses and do all repairs to roads, pipes, channels and cables in accordance with the requirements of the proper authorities and/or the owners thereof or shall bear the expenses of all such work done by them.

Existing access to lands, property and all other facilities shall be maintained by the Contractor during the continuance of the Works to the Engineer's satisfaction.

Where work is being carried out in the vicinity of overhead power lines the Contractor shall take special measures to ensure that all persons working in such areas are aware of the relatively large distance that high voltage electricity can "short" to earth when cranes or other large masses of steel are in the vicinity of power lines and that adequate safety precautions are being taken. The Contractor shall ensure that none of his employees commits any act which will cause damage from, or to, overhead power lines.

Unless specific items are included in the Bill of Quantities, the cost of all works required under this section shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.13 WATER AND POWER FOR USE IN THE WORKS

The Contractor shall be solely responsible for the location, procurement and maintenance of water supplies adequate in quality and quantity to meet his obligations under the Contract.

The Contractor shall be responsible for the supply of all electric power to meet his obligations under the Contract and for the distribution thereof.

All costs associated with the supply of water and power shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.14 BUILDING REGULATIONS

All buildings erected by the Contractor upon the Site and Work Area shall comply with all Laws and local By-laws insofar as they are applicable.

101.15 WORKS IN THE DRY

All parts of the Works are to be carried out in the dry, and shall be kept free at all times from surface or groundwater from whatever source it may come to the satisfaction of the Engineer. Keeping the Works dry shall include all pumping and diversion of water that may be necessary in carrying out the Works, also provision and filling-in of sump holes, installation and operation of drains, pumps, well points etc., in a manner and with equipment and materials satisfactory to the Engineer.

The Contractor shall, at his own expense, make such provision for the discharge of any water from the Works as shall be satisfactory to the Engineer and to any person having rights over the lands or watercourses over or down which such water is discharged. He shall hold the Employer indemnified against any claim that may be made through non-compliance with this section. In the event of any interference with existing land or road drains due to the construction of the Works or to the dumping of spoil, etc., within or without the limit of the Works, the Contractor shall take immediately steps to restore the drainage to the satisfaction of the Engineer and the Owners, occupiers, or Authority concerned.

Unless specific items are included in the Bill of Quantities, the cost of keeping the Works dry as specified in this section, shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.16 WATCHING, FENCING AND LIGHTING

The Contractor shall employ competent watchmen and guard the Works by day and night.

From the time that any portion of the Works shall be commenced, until the end of the works, the Contractor shall be responsible for protecting the public and his workmen from anything

dangerous to persons or property and for the safe and easy passage of pedestrian, animal and vehicular traffic.

Any excavation, material dumps, soil dumps or other obstructions likely to cause injury to any person or thing shall be suitably fenced off and at night protected by red warning lights. The Contractor shall, at his own expense, and immediately upon completion of any part of the Works, fill up all holes and trenches, and level all mounds and heaps of earth which have been excavated or made in connection with the Works. The Contractor shall be responsible for the payment of all costs, charges, damages and expenses incurred or sustained on account or in consequence of any accident which may happen by reason of holes and trenches being dug and left or placed in improper locations.

Fencing shall consist of at least three 15 mm diameter hemp ropes or 4 mm diameter wires, or more, if required, stretched tightly between poles, standards, etc., securely planted in solid ground, well clear of the excavation and enclosing the spoil from the excavation. The poles, standards, etc., shall not be more than 15 m apart. If circumstances require it, they shall be placed closer and the ropes or wires shall be stretched tight, approximately 0.40 m, 0.80 m and 1.20m, respectively, above the ground.

Banks of spoil of suitable height and form may be accepted by the Engineer in lieu of fencing.

Fences and spoil banks shall be clearly marked at the ends, all corners and along the length at intervals of not more than 15 m, by means of white lime-washed boards, discs, stones or oil drums during the day and by red lamps kept burning at night. Markers shall be freshly lime-washed at regular intervals to ensure that they are white and clean.

The Contractor shall detail a man to trim and fill the lamps during the day and they shall be lit at least one half hour before sunset and not extinguished until at least one half hour after sunrise.

If a road is closed, or partly closed, to traffic, temporary traffic signs and barricades shall be erected by the Contractor, to the satisfaction of the Engineer and the Police, to give proper warning to traffic and to the public. Road signs shall be not less than 1.20 m x 0.80 m in size, surmounted by a red circle. Lettering shall be black, on a yellow ground and shall incorporate reflective material. The signs shall be adequately illuminated at night. The Contractor shall be solely responsible for the proper control of all traffic.

The cost of watching, fencing and lighting and all other costs incurred in complying with the requirements of this section shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.17 PRESERVATION OF TREES

No trees shall be cut down without prior permission of the Engineer who will limit the removal of trees to the minimum necessary to accommodate the Permanent Works.

If trees are cut down or damaged by the Contractor or his employees and without approval, then the Contractor shall replace such trees at his own expense with trees of not less than two years of age obtained from a reputable nursery and of species to be approved by the Engineer. The Contractor shall plant, water and ensure that the replacement trees are properly established all at his own expense.

All costs incurred in complying with the requirements of this section shall be deemed to be included by the Contractor in his unit rates for the various items on the Bill of Quantities and shall not be paid for separately.

101.18 WORKS EXECUTED BY THE EMPLOYER OR BY OTHER CONTRACTORS

The Employer reserves the right to execute on the Site works not included under this Contract and to employ for this purpose either his own employees or another Contractor whose contract may be either a sub-contract under this Contract, or an entirely separate Contract. The Contractor shall ensure that neither his own operations nor trespass by his employees shall interfere with the operations of the Employer or his Contractor employed on such Works and the same obligations shall be imposed on the Employer or other Contractor in respect of work being executed under this Contract.

101.19 MATERIALS

101.19.1 General

All materials shall be of the best quality throughout. Materials delivered to the Works shall be equal in all respects to the samples approved by the Engineer. The methods of stocking, mixing, transporting, fixing, placing and applying all materials shall be in compliance with the specifications and to the approval of the Engineer, who shall be kept advised of any change of plan. Materials failing to comply with the Specifications shall be immediately removed from the Works, at the Contractor's expense.

All goods and materials used in the execution of the Contract shall comply in all respects with ISO 9000 Standards or other equivalent standards approved by the Engineer.

101.19.2 Approval of Materials

Before entering into any sub-contract for the supply of any material or goods, the Contractor shall obtain the Engineer's approval in writing of the manufacturers and/or suppliers from whom he proposes to obtain such materials or goods. If requested, the Contractor shall submit to the Engineer samples of such materials and shall have them tested in approved laboratories. Such tests shall be carried out at least seven days prior to the inclusion of such materials in the Works. The cost of all samples and tests shall be borne by the Contractor.

Should the Engineer, at any time, be dissatisfied with such material or goods or with the methods of production or operation carried out at the manufacturer's or supplier's works or place of business, he shall be empowered to cancel his previously given approval of such supplier and to specify any other supplier whom he may choose for the supply of such material or goods. The Contractor shall then obtain such said material or goods from such other supplier and shall bear any additional costs thereof.

Materials which, in the opinion of the Engineer, do not comply with the Specification, shall be classified as rejected materials and shall be cut out and removed from the Works and replaced as directed by the Engineer, at the Contractor's own expense.

101.19.3 Alternative Materials

Where brand names or products of a specific manufacturer are specified in the Contract, the Contractor may, subject to the Engineer's approval (which shall not be unreasonably withheld) supply alternative materials, having similar characteristics and showing performance and quality at least equal to those specified.

Whenever the Contractor wishes to propose an alternative material he shall submit detailed information concerning the type of material and/or product, the Vendor's name, drawings if required, test certificate, etc. If the alternative material is not approved by the Engineer, the Contractor shall supply the material originally specified in the Contract.

If the price of the approved alternative material is in excess of the material specified in the Contract, the Contractor shall not be entitled to extra payment over the rates in the Bill of Quantities.

101.19.4 Supply by Contractor

Pursuant to Clause 36 of the Conditions of Contract, all materials required in the Works, except as otherwise provided for in the Contract, shall be supplied by the Contractor and the cost thereof shall be included by the Contractor in his rates in the Bill of Quantities.

The Contractor's Tender shall be construed as an undertaking that all the materials and equipment to be provided by the Contractor are in his possession, or readily available and will be delivered to the Site in accordance with the Time Schedule.

101.20 MAINTENANCE OF WORKS

During the period of maintenance the Contractor shall maintain the Works and make all repairs, as defined in clauses 49 and 50 of the Conditions of Contract.

After the commencement of the Period of Maintenance, the Contractor shall do nothing which might endanger the safety of the Public and he shall carry out all instructions of the Engineer or other duly authorised person or authority in this regard. Throughout the Period of Maintenance the Contractor shall notify the Engineer what work or operations it is intended to be carried out on the Site and he shall carry out any instruction which the Engineer may give as to times and manner of working so that any inconvenience to the Public is kept to a minimum.

The Engineer will give the Contractor due notice of his intention to carry out any inspections during the Period of Maintenance and the Contractor shall upon receipt of such notice arrange for a responsible representative to be present at the times and dates named by the Engineer. This representative shall render all necessary assistance and take note of all matters and things to which his attention is directed by the Engineer.

101.21 WORKS LOG BOOK

The Engineer's Representative will keep a Works Log Book on the Site.

To assist the Engineer's Representative in keeping the Log Book, the Contractor shall supply daily to him full details in writing on the following:

1. The number of workmen of the various trades and grades employed in carrying out the Works.
2. Quantities of the various materials brought to or removed from the Site.
3. Quantities of the materials incorporated by the Contractor in the Works.
4. Constructional Plants and Contractor's equipment brought to and removed from the Site.
5. The use of Constructional Plant in the Performance of the Works.
6. Other details as requested by the Engineer's Representative.

The Engineer's Representative may, if he so desires, use the above data to conduct the Log Book. However, such data shall not bind the Employer or the Engineer in any manner whatsoever.

The Log Book will be signed by the Engineer's Representative, and a signed copy of the daily entries will be handed to the Contractor or his authorized representative, who within 48 hours from the receipt of said copy, may object to any of the entries therein by written notice to the Engineer's Representative. Such objections by the Contractor shall be recorded in the Log Book. If the Contractor or his authorized representative has not made any such objection within 48 hours as aforesaid, he shall be deemed to have confirmed the correctness of the data entered in the Log Book.

The Contractor may enter in the Log Book his remarks regarding the performance of the Works. However, such remarks shall not bind the Employer or the Engineer.

Entries in the Log Book, except those to which the Contractor has objected in writing as described above, shall serve as evidence between the parties as to facts included therein; however, they shall not in themselves form the basis for a demand for any payment under the Contract.

101.22 RESIDENT ENGINEER'S OFFICE

101.22.1 Construction

The Contractor shall, within 4 weeks of the issuance the order to commence of works, hand over to the Engineer a fully completed, furnished and equipped Engineer's office. The Contractor shall provide suitable temporary office space for the Engineer until the office is completed.

All facilities provided for the Engineer and/or Employer's staff shall be provided upon issuance the order to commence of works and shall remain available until the end of the defects liability period or until such earlier time as the Engineer may instruct.

The Contractor shall provide prefabricated portable or demountable offices or other as may be approved by the Engineer for the sole use of the Engineer and his staff, comprising:

- 2 offices size of each approximately 4 m x 4 m
- 1 meeting room for 10 people
- 1 secretary's room of approximate size 4 m x 4 m
- 1 pantry
- 2 toilets
- 1 store
- 1 multiple purpose room
- Entrance area with space for desk
- Car sheds for 5 cars.

Offices are to be of proprietary manufacture, with hard-wearing, easy-clean surfaces and robust and secure fittings. Submit full details to the Engineer for approval before delivery to the Site and erection.

101.22.2 Furnishings

Each office shall contain:

- 2 desks with lockable drawers and swivel chairs
- 2 lockable steel filing cabinets
- 2 office chairs
- 1 drawing hanger for 10 sets
- 2 shelves
- 2 pin boards
- 2 waste paper baskets.
- 1 reference table

CONFERENCE ROOM FURNITURE AND EQUIPMENT

- 1 conference table for 10 people
- 10 chairs
- 2 pin boards
- 2 shelves
- 2 waste baskets
- 1 reference table.

KITCHEN FURNITURE AND EQUIPMENT

- 1 refrigerator 14 cu. ft. capacity
 - 1 water filter and 20 liters water cooler/hot/cold
 - 2 electric boiling rings
 - 1 stainless steel sink and drainer
 - 1 heat resistant worktop
 - 1 set of storage cupboards
 - 1 set of crockery and cutlery for each member of the staff
 - 1 large waste basket with cover.
- and all necessary consumables for the making of beverages for the duration of the contract

LAVATORY FURNITURE AND EQUIPMENT

- 1 w.c. suite
 - 1 toilet roll holder
 - 1 wash hand basin
 - 1 mirror
 - 1 paper towel holder
 - 1 soap dispenser
 - 1 waste basket with cover.
- and all necessary consumables.

and, in addition, the following shall be provided:

- 1 secretary's desk and swivel chair
- 2 large lockable sheet filing cabinets
- 2 reference tables
- 6 office chairs
- 6 calculators
- 1 photocopying machine similar to FT500 I with duplex, sorter and document feeder + consumables + all photocopying papers pin boards, shelves and waste paper baskets.
- 2 computers (each as defined in computer section) + all consumables with all stationary and offices supplies.
- 1 digital camera (Min. capacity 4GB, Canon or equivalent) with necessary accessories for downloading photos to PC.

SERVICES: The Contractor shall provide and maintain the following minimum services:

- heating and air-conditioning
- electric lighting and power
- water supply
- drainage system
- fire fighting appliances
- cleaning facilities and general attendance including all personal.
- All bills and charges related to the services shall be paid by the Contractor.

TELEPHONES: The Contractor shall provide a three separate telephone connection (one cellular) and one regular phone line and one dedicated Facsimile service for the representative's offices, with PABX, extensions and telephone set for each office, secretary and conference room and shall pay all charges.

REPRESENTATIVE'S VEHICLES: The Contractor shall provide and maintain the following new brand vehicles for the sole use of the Engineer and his staff and shall supply all fuel and lubricants, insurance repair and maintain the vehicles to keep them in good roadworthy condition at all times, comprehensively insure each vehicle for any driver at all times and

replace with identical vehicle any vehicle removed for maintenance or repair or for any other reason

1 № "Four Wheel Drive" air-conditioned vehicle 3500cc., or equivalent.

At the end of the Defects Liability Period the above car shall remain the property of the Contractor.

VEHICLE DRIVERS: Each vehicle shall have a competent driver and be available for the employer's representative during normal working hours. The vehicles are to remain in the possession of the Engineer and his staff after normal working hours.

COMPUTER The Contractor shall provide on-site for the use of the Engineer:

- Intel I 7, 3.2 GHz minimum, 8.0 Giga byte of Ram, 500 Giga byte hard disk capacity, video local bus, video graphic adaptor 256 MB VGA.
- 56 x CD drive (Read/Write)
- 16 x DVD drive (Read/Write).
- 101 key English-Arabic Keyboard.
- SVGA Flat, non-interlaced, low power, low radiation 19" rotating color monitor.
- One parallel port
- Two serial ports
- USB ports
- One Mouse port
- Key lock
- Optical Mouse
- The necessary supplies throughout the Contract.
- License for latest version of "Windows 7 and Microsoft Office 2007", "AutoCAD", and "Primavera".
- Colour Laser Jet printer with A4 and A3 papers (total No. 2).
- Parallel / USB cable for printer.
- UPS for all above equipment with minimum 2 hours backup batteries
- Computer table & chair to accommodate computer, monitor, keyboard and printer
- Antistatic dust covers for all above equipment
- The necessary supplies throughout the Contract.
- Internet and E-mail service.

At the end of the project all the above equipment shall remain the property of the Contractor.

101.22.3 Miscellaneous Facilities and Services

The Resident Engineer's office shall be cleaned daily and provided with clean towels (every other day), soap, glasses and at all times with a fresh and adequate supply of drinking water. The cost of these services shall be paid for by the Contractor.

The Contractor shall be responsible for the security of all plans, papers, books, instruments from theft or fire during the continuance of the Contract and his insurance policies shall cover the office of the Resident Engineer.

The Contractor shall provide a complete set of all ASTM, AASHTO, BS EN and other Standards, Materials Manuals and Codes of Practice referred to in this Contract, or relevant thereto, shall be provided to the Engineer by the end of the mobilization period.

The Contractor shall provide all ladders, access lighting facilities and assistance etc. required by the Engineer to inspect any part of the Works.

The Contractor shall provide for the use of the Engineer when required by the Engineer, one total station surveying equipment, all of approved type and make, complete with accessories and all instruments, tapes, staffs, poles, pegs, stagings, moulds, templates, profiles, and all other requisites for checking and setting out and measurement of the Work. The Contractor shall also provide, when required by the Engineer, the services of two experienced chainmen.

101.22.4 Maintenance and Removal

The Contractor shall fully maintain the Resident Engineer's office throughout the Contract Period and effect all repairs, painting etc. required during that period.

At the end of the Contract, the office with all its furnishings and facilities will revert to the Contractor who, upon receiving the Engineer's instructions to do so, shall dismantle the office and remove it, leaving the Site neat and tidy to the Engineer's satisfaction.

101.22.5 Payment

Unless specific items are provided in the Bill of Quantities, the cost of the use by the Engineer and his staff of the office, its furnishings and all facilities and the cost of their maintenance etc., all as specified in this Section, shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.23 DAYWORKS

When Dayworks are authorized by the Engineer all equipment, labour and materials shall be paid for at the rates listed in the Schedule of Dayworks in the Bill of Quantities.

All major materials for Dayworks authorized by the Engineer but not included in the Schedule of Dayworks shall be paid for on a Prime Cost basis. The Contractor shall be paid on the basis of paid invoices showing cost of materials less any discount, paid receipts for transportation and handling charges and paid receipts for insurance on materials and delivery of materials. Before authorizing the use of materials in Dayworks the Engineer may require the Contractor to supply estimates of the costs of the materials.

The Contractor shall be compensated for his expenses, overhead, labour and profit involved in procuring and delivering the materials by an amount equal to a percentage of the actual cost of the Prime Cost Sum.

101.24 WATER SAMPLES AND ANALYSES

101.24.1 Procedure

Water samples shall be out from the well. For the physico-chemical analyses, it is advisable to take a minimum of 2 liters of water. Whereas for the dosage of heavy metals and trace elements, it is necessary to take a minimum of 5 liters of water. Water will be sampled according to the indications of the laboratory and/or of the Engineer, in one or several small polyethylene flasks, with an eventual adjunction of certain substances.

The Contractor will install a regulating valve on the upper part of the pipe. The regulating valve will be fixed at a minimum height of 0.50 m above the ground. The flask in which water is sampled will be rinsed 3 times with pumped water before being filled. Each flask will be hermetically sealed and carefully labeled.

Water samples for bacteriological analyses will be taken in sterilized flasks of 250 to 500 ml. The regulating valve should be imperatively previously sterilized. Sampling flasks should not be exposed to direct sunlight and kept at a temperature of + 4 °C, before being transported to the laboratory within a maximum delay of 24 hours.

Physico-chemical and bacteriological analyses should be carried out by a laboratory approved by the Engineer.

101.24.2 Water analyses

Water analyses will be carried out and defined according to the French regulation method (decree N° 89.3 of January 3, 1989).

The required analyses are defined in accordance with:

- The origin of water: Ground or surface
- The treatment performed (if any)
- The sampling point.

At each well head, a sample of raw water will be taken to undergo a complete analysis. According to the sampling point:

- First analysis before starting works: Type P2P - C3 + B3
- Second analysis upon completion of works: Type P1 - C2 + B2.

101.24.3 Essential elements, measurements and criteria for each type of analysis (Tables 1, 2 and 3).

Table 1: Bacteriological analysis

BACTERIOLOGICAL ANALYSES		
Limited (B1)	Summary (B2)	Completed (B3)
Thermotolerant coliforms. Fecal streptococci	Thermotolerant coliforms. Fecal streptococci. Count of aerobic bacteria revivable at 22 °C et 37 °C.	Thermotolerant coliforms. Fecal streptococci. Coliforms. Count of anaerobic bacteria revivable at 22 °C et 37 °C. Spores of sulfite-reducing anaerobic bacteria.

Table 2: Standard analyses defined in accordance with the sampling point.

Site	Source		Production				Distribution	
	(R.P.)	(R.S.)	(P1)	(P2)		(P3)	(D1)	(D2)
	At point of withdrawal, treatment performed (R)		After treatment and prior to discharge, or at the point of withdrawal if no treatment is performed (P)				In network (D)	
Origin of the water	Ground water	Surface water	Ground water and surface water	Ground water (P2P)	Surface water (P2S)	Ground water and surface water	Ground water and surface water	Ground water and surface water
Standard Analyses	B1 - - - C3 - -	B1 - - - C3 C4a C4c	- - B3 - C2 - -	- - - - C3 - -	- - - - C3 C4a -	- - - - - C4a C4c	- B2 - C1 - - -	- - - C2 - - C4b

Table 3: Types of physico-chemical analyses

PHYSICO-CHEMICAL ANALYSES						
	Limited physico-chemical analyses (C1)	Summary physico-chemical analyses (C2)	Complete physico-chemical analyses (C3)	Specific physico-chemical analyses (C4)		
				C4a	C4b	C4c
Organoleptic parameters	- Appearance (qualitative): odour, taste, colour - Turbidity	- Appearance (qualitative): odour, taste, colour - Turbidity	- Appearance (quantitative): odour, taste, colour - Turbidity			
Physico-chemical parameters Natural structure of the water	- pH - Conductivity	- Temperature - pH - Conductivity - Nitrates - 3 of the following parameters: nitrates, ammonium, chlorides, sulfates, permanganate value,, methyl orange alkalinity or total hardness.	- Temperature - pH - Conductivity - Chlorides - Sulphates - Silica - Calcium - Magnesium - Sodium - Potassium - Aluminium - DS - Dissolved oxygen - Free carbon dioxide (marble test) or calculation of carbonate balance - Carbonates - Hydrogen-carbonates.			
Parameters concerning undesirable substances	- Residual chlorine or any other parameter relating to the disinfection treatment	- Residual chlorine or any other parameter relating to the disinfection treatment	- Nitrates - Nitrites - Ammonium - Permanganate value, hot, in acid medium - Hydrogen sulphide - Iron - Copper - Zinc - Manganese - Phosphorus - Fluorine - Residual chlorine or any other parameter relating to the disinfection treatment.	- Kjeldahl nitrogen. - Dissolved hydrocarbons - Surface agents - Phenol index	- Iron - Copper - Zinc.	
Parameters concerning toxic substances					- Cadmium - Lead - PAH	- Arsenic - Cyanides - Chromium - Mercury - Selenium.
Other parameters						- Pesticides - Volatile halogenated organic compounds.

101.24.4 Interpretation of analyses (Potability)

The results will be compared to the values set by:

- EEC directives/No/ 80/779/EEC-Official Journal of the European Communities, August 30, 1980. This directive groups together 62 admissible value parameters (guide level and maximum admissible concentration).
- WHO recommendations (Geneva 1986). Grouping parameters into five categories.
- French regulations (Decree No. 89.3-Official Journal of January 3, 1989). This decree groups analyses types and tables of admissible physico-chemical and bacteriological parameters relating to the definition of water potability.

These analyses will be given to the administration for the interpretation of data and the follow up.

101.24.5 Interpretation of analyses (corrosion)

During its transportation or use, water may cause various changes to the materials with which it is in contact. The most frequent deterioration is metal corrosion.

- Effects of aeration conditions (O_2H):
 - Corrosion in a non aerated place: corrosion caused by hydrogen
 - Corrosion in an aerated place: corrosion caused by oxygen.

The iron-water equilibrium potential in the absence of oxygen, and the oxygen and hydrogen electrodes equilibrium potentials will be controlled according to the pH value of the water.

- Effects of the mineralization influence (T.D.S.-T.A.C.)
 - The global mineralization of water increases its conductivity and decreases its resistance to corrosion. In particular, the concentration of chloride shall be verified (RYZNAR index).
- Effect of temperature variation

In conclusion, the approved laboratory should confirm, according to total mineralization and pH, the action of water and temperature on the different metals.

PART 2
CIVIL WORKS

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201 EARTHWORKS

201.1 GENERAL

201.1.1 Scope

Earthworks under this Specification include excavation and backfill for pipelines, excavation for ponds and open canals, excavation and backfill for structures, excavation from borrow areas, construction of embankments, compacted fill and surfaces and other earthworks and works related thereto, as required in the Works.

201.1.2 Classification of Excavation

Unless specific items for Rock Excavation are included in the Bill of Quantities, earthwork will not be classified in accordance with the hardness of the excavated material and all excavation will be deemed to consist of Common Excavation, as defined hereafter, regardless of the actual hardness of the excavated material.

Where excavation is classified according to hardness of excavated materials, the following definitions shall apply:

- Rock excavation shall include hard and solid rock that cannot be broken up by mechanical excavating equipment, including a heavy tractor equipped with a roter, but which necessitates the use of pneumatic tools or blasting for its loosening and removal. Rock excavation shall also include detached boulders exceeding one half of a cubic metre in volume.
- Common excavation shall include all material other than rock as defined above and also detached boulders less than one half of a cubic metre in volume.

No material, except the aforesaid, will be defined as rock and classified as such for the purpose of payment, whether actually loosened by blasting, pneumatic tools or otherwise.

The decision as to the classification of any excavation into “rock” or “common” shall be at the sole discretion of the Engineer’s Representative, subject only to Clause 2 of the General Conditions of Contract.

Where specific items for Rock Excavation are included in the Bill of Quantities, the Contractor shall not be entitled to be paid for excavation in rock unless, at the time the excavation is open and visible, the Contractor shall give notice in writing to the Engineer’s Representative that he claims to be paid for excavation in rock. After giving such notice the Contractor shall not fill in the excavation or otherwise prevent it from being inspected by the Engineer’s Representative for the purpose of classification and determination of payable in respect of same.

201.1.3 Natural Ground Levels

The natural ground levels, as marked on the Drawings, shall form the basis of measurement for payment for excavation, fill and all other works where the site levels have bearing and no

field surveys will be made. Natural ground levels at intermediate points shall be checked on the field by the Contractor.

The Contractor shall check the natural ground levels before the commencement of earthworks, and such checking shall be made by the Contractor at his own expense, in the presence of the Engineer. The results, approvals in writing by the Engineer, shall thereafter prevail.

The cost of checking natural ground levels shall be borne by the Contractor alone, whether checking is carried out at the Engineer's request or at the Contractor's own request. No allowance will be made for normal bulking or shrinking of the soil and the Contractor shall make allowance for this in his rates.

201.1.4 Dewatering, Supporting and Fencing of Excavations

The Contractor shall, during the whole period of construction, keep the work area and all excavations dry and protected from the influx of water from any source whatsoever (rain and seepage water, water from surface and subsurface streams, groundwater, etc.) and shall provide and operate all pipes, pumps, well points and other apparatus and materials and all labour required for this purpose. The Contractor shall, throughout the period of construction, prevent structures and/or pipelines from flotation either by keeping the work area dry or by temporarily filling the structure and/or pipeline with water, all as approved by the Engineer.

The provisions that the Contractor shall make for the discharge of any water from the Site of the Works shall be satisfactory to the Engineer and to any persons or authorities having rights over the lands through which such water is discharged. The Contractor shall keep the Employer indemnified against any claim or damage that may be caused by non-compliance with the requirements.

The sides of excavations shall be supported whenever necessary or directed by the Engineer's Representative by means of timber, steel or other type of struts, walling, boards, sheeting or any other approved system. No support work shall be removed without the approval of the Engineer.

Every precaution shall be taken by the Contractor against slips, falls, or subsidence in the excavations, but if any slips, falls, or subsidence should occur the Contractor must at once make good the same including all surface restoration and reinstatement, all at his own cost. Should any such fall, slip or subsidence disturb or weaken any foundation or support to the Works or to any adjacent structure or facility, or create empty spaces and gaps near the new works, the Contractor shall carry out such additional works as the Engineer may require in consequence thereof, such as filling the gaps so caused with concrete or other suitable material as the Engineer may direct, all at the Contractor's own expense.

Steel sheet piling may be used by the Contractor in his supporting, bracing and dewatering operations, as specified above, of his own choice or at the direction of the Engineer, or where shown on the Drawings as a permanent part of a structure. The sizes and types of sheet piles used for temporary supporting and bracing shall be determined by the Contractor but will be subject to the Engineer's approval. Where sheet piles form a permanent part of a structure, their sizes and types shall be as shown on the Drawings or as directed by the Engineer.

The Contractor shall take all the necessary precautions during the excavation to protect his workmen and the public. This may include, but shall not be limited to the supporting of the sides of the excavations, fencing the areas, providing warning lights and providing watchmen.

The Contractor shall be entirely responsible for the proper dewatering, supporting, fencing, lighting, watching, etc. of excavations, trenches and pits and shall not be relieved of his responsibilities under the Contract even though no objection has been raised by the Engineer to the conditions of the work.

Unless specific items are included in the Bill of Quantities, the cost of dewatering, supporting, bracing and timbering (including steel sheet piles), fencing, lighting, watching, etc. of excavations, trenches and pits and any extra earthworks and labour, materials and apparatus required for them shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

201.1.5 Use of Explosives

The Contractor shall use explosives only with the written express permission of the Engineer's Representative and all blasting shall be carried out by properly licensed and qualified workmen under experienced supervision. When using explosives, the Contractor shall abide by and conform to all the Laws pertaining to the purchase, transportation, storage and handling of explosives and shall obtain all required licences from and make all necessary arrangements with the relevant authorities prior to commencing blasting operations.

When blasting operations are in progress, all precautions shall be taken to protect all persons and livestock, the Works, and any other property from injury or damage.

The Engineer's Representative shall have the power to regulate, restrict or prohibit blasting if in his opinion it is necessary to do so for the safety of persons or property, or to safeguard the foundations or sides of the excavation, and the Contractor shall have no claim against the Employer in respect of such regulations or prohibitions. Explosives shall not be used within 20 metres or any other distance as the Engineer's Representative may direct, of concrete in permanent structures.

Notwithstanding anything said in this Sub-Section, the Contractor shall be held solely and entirely responsible for any injuries to persons and livestock and damage to public or private property.

201.1.6 Programme and Methods of Work

In addition to the information furnished by the Contractor with his Tender, the Contractor shall, after award of Contract but no later than two weeks prior to commencement of Works, submit for the Engineer's approval detailed proposed methods of excavating, transporting and placing earthfill material, watering and compacting and any subsequent modifications thereof, together with a detailed list of quantities and type of plant to be used for all these operations. Amendments shall be made by the Contractor in accordance with any instructions issued by the Engineer before commencement of works and from time to time.

201.1.7 Excavated Materials - Handling and Disposal

As far as practicable and as determined by the Engineer's Representative, all suitable materials from excavations shall be used in the permanent construction required under the Contract.

The Contractor's operations in excavations shall be such as to yield the maximum of suitable materials for construction purposes, and shall be subject to the approval of the Engineer's Representative. Where practicable, and as determined by the Engineer's Representative, suitable materials shall be excavated separately from those considered unsuitable, and the suitable materials shall be segregated by loads during the excavation operations and shall be placed in the designated final locations either directly from the excavation, or shall be placed in temporary stockpiles for later placing in the designated locations, all as directed by the Engineer's Representative.

Excavated materials that are considered unsuitable or are in excess of those required for permanent construction, shall be removed from the Site. The Contractor shall be entirely responsible for the removal of all surplus excavated material from the Site to such disposal areas as he shall have obtained at his own cost and responsibility and shall keep the Employer indemnified against any claims, charges or proceedings arising out of the transportation and disposal of such surplus excavated material.

Spoil heaps shall be located where they will not interfere with the progress of the Works, or with the flow of water in natural streams or drainage courses, and where they will neither detract from the appearance of the completed project and environment, nor interfere with access to the structures. Spoil heaps shall be levelled and trimmed to reasonable regular lines, as determined by the Engineer's Representative.

The cost of complying with all requirements of this Sub-Section shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

201.1.8 Earthworks in Urban Areas

When working in urban areas, under heavy traffic conditions (pedestrian and/or vehicular), the Contractor shall pay particular attention to all safety measures necessary to avoid accidents resulting from open trenches, construction materials and/or equipment stored in the streets, etc. without adequate protection. The Contractor shall arrange temporary crossovers to all open excavations. The Contractor shall co-ordinate his work with the traffic police, public transport companies and municipal authorities and make proper and adequate traffic and safety arrangements for the duration of the Works. The Contractor shall take into account the restrictive urban and specific local conditions and shall make due allowance in his rates in respect thereof as no claim arising from this clause or contingency will be either admitted, entertained or considered.

When excavating trenches along city streets, the storage of excavated material along the trench may be impossible or prohibited by the authorities. In such cases the Contractor shall remove the excavated materials to areas of his own choice and at his own responsibility and shall bring such materials back when required for backfill or shall import instead other suitable material for backfill from some other source. The entire cost of such removal and return or replacement of backfill material irrespective of the hauling distance shall be

included by the Contractor in his unit rates for trench excavation and shall not be paid for separately.

201.1.9 Restoration of Waterways and Pipelines

The Contractor shall clean out and restore to their original condition all waterways or pipelines which may have been cut by the excavation or in any way damaged or silted up as a result of his operations.

Unless specific items are provided in the Bill of Quantities the cost of all additional work involved in crossing under or cutting through any waterways and pipelines and reinstating to their original condition shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

201.1.10 Restoration of Surfaces

The Contractor shall be responsible for the temporary and permanent restoration of all surfaces of roads, fields, paths, gardens, verges etc. whether public or private which are affected by his operations.

Temporary restoration shall be carried out immediately after the excavations have been refilled by returning the excavated material to the position from which it was removed and adding such suitable materials as may be required and consolidating the various materials as the work proceeds in order to provide a surface that is adequate for the purpose that the original surface fulfilled. Temporary surfaces shall be maintained in a condition satisfactory to the Engineer and responsible Authority until the permanent reinstatement is made.

The Contractor shall be responsible for the permanent reinstatement of all surfaces already described including asphalt surfaced public roads as specified in Section 201.3.11.

Should, at any time, any trench become dangerous, the Engineer will be at liberty to call upon the Contractor to restore it to a proper condition at three hours notice and, should the Contractor fail to carry out the work, have it done at the Contractor's expense.

The Contractor shall include in his rates for all materials and labour which he may have to employ in reinstating the trenches and surfaces to the satisfaction of the responsible Authority concerned.

Restoration shall be deemed to be included by the Contractor in his various unit rates for earthworks and shall not be paid for separately, except where specific items have been provided in the Bill of Quantities.

201.1.11 Equipment for Earthworks

Generally, equipment for earthworks, shall be of a modern type and of a design suited for each specific purpose. Only equipment and machinery approved by the Engineer shall be used in the Works.

Grading equipment shall be of any type of earthmoving equipment the Contractor may desire or has at his disposal, provided the equipment is in a satisfactory condition and of such capacity that the programme can be maintained. The Contractor shall furnish, operate and

maintain such equipment as is necessary to control uniform layers, section and smoothness of grade for compaction and drainage.

Compacting equipment shall be of a design, weight and quantity so as to obtain the required density.

Pneumatic Roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least 150 cm. and shall give a compression of at least 130 kg. per cm. of width of tread when fully loaded. The tires shall be uniformly inflated.

Smooth Roller shall be self-propelled or power roller and shall weigh at least 10 tons and may be of the tandem or three-wheel type. The wheels of the roller shall be equipped with adjustable scrapers.

Other equipment, such as vibrating machines, may be used for compacting and consolidating the embankments, subgrades, and other areas, upon approval of the Engineer. Such equipment shall be routed over the area being compacted and shall be operated until the required density is obtained.

Watering shall be carried out by means of tank wagons, tank trucks, or distributors equipped with a suitable sprinkling device. Satisfactory equipment shall be maintained on the site at all times when embankment construction is in progress.

201.2 CLEARING AND STRIPPING

201.2.1 Clearing

The areas upon which new construction is to take place, the rights-of-way along which pipelines are to be laid and all other such areas as may be designated by the Engineer and/or indicated on drawings as required for auxiliary purposes, (site offices and workshops, transport and machinery yards, borrow pits, stockpile sites, etc.), shall be cleared of all vegetation, shrubs and small and large trees, together with their roots, and from all other foreign and deleterious matter that may affect and interfere with the progress of the Works.

Trees and shrubs shall be cut or burnt down under strict control to ground level, the roots grubbed up to a depth of not less than 1.0m and removed from the area. All other scrub, vegetation, rubbish, etc., shall be cleared or burnt down to ground level and removed from the area to any distance.

All trees shall remain the property of the Employer and the Contractor shall collect these trees and store them until required by the Employer. All trees near to and about the Works except such as are to be removed, shall be carefully protected from damage by the Contractor during the period of maintenance and no trees shall be removed without the prior consent of the Engineer.

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

Unless otherwise specified in the Contract, clearing shall be measured by square meters. The unit rate shall include for all operations required under this Sub-Section, including removal of trees (see also Sub-Section 201.2.2 hereafter).

No clearing shall be carried out without prior written approval of the Engineer's Representative and only such areas approved or ordered to be cleared shall be measured and paid for.

201.2.2 Removal of Trees

Clearing as defined in Sub-Section 201.2.1 shall include the removal of small and of large trees. Trees of a girth of 40 cms. or less when measured at a height of 1.0m above ground shall be classified as small trees. Trees of a girth exceeding 40 cms when measured at a height of 1.0m above ground shall be classified as large trees and shall be removed only at the express order of the Engineer's Representative.

The removal of large trees, except where a specific item is provided in the Bill of Quantities, and the removal of small trees will be deemed to be included in Clearing and will not be paid for separately.

Where a specific item is included in the Bill of Quantities for the removal of large trees, they will be measured for payment by number.

201.2.3 Stripping

Areas on which compacted fill is to be placed and areas of excavations from which material for fill is to be extracted, including borrow areas, shall be stripped of top soil containing organic or otherwise deleterious and objectionable matter to a depth of at least 15 cm. or to such greater depth as may be determined by the Engineer. The stripped soil shall be stored in separate dumps for subsequent re-use in covering the slopes of embankments or the borrow areas after excavation therein has been finished, or shall be otherwise disposed of as directed. Under no circumstances shall such stripped material be used as compacted fill.

Stripping shall not be carried out unless the Contractor is able to proceed immediately with the further earthworks upon the stripped areas. Overstripping shall be backfilled and compacted, at the Contractor's own expense, to the satisfaction of the Engineer.

Stripping shall be measured in cubic metres, computed by multiplying the area stripped by the depth of stripping. The unit rate shall include for all excavation, stacking-re-spreading and running excess to spoil.

No stripping shall be carried out without prior written approval of the Engineer's Representative and only such areas approved or ordered to be stripped shall be measured and paid for.

Unless otherwise specified, stripping of borrow areas shall not be measured for payment and the cost of such stripping shall be deemed to be included by the Contractor in his unit rates for earthwork in the Bill of Quantities.

201.3 EXCAVATION AND BACKFILL FOR PIPELINES

201.3.1 Surface Excavation to Reduce Levels

Where shown on the Drawings or required or approved by the Engineer, the Contractor shall execute surface excavation in advance of trench excavation, to the lines and grades shown on the Drawings or ordered by the Engineer.

Any surface excavation not shown on the drawings and not ordered by the Engineer that the Contractor may wish to execute for the convenience of his work shall be subject to the Engineer's approval, but shall be done entirely at the Contractor's expense.

Surface excavation shall be measured in cubic metres according to the dimensions, lines and levels shown on the Drawings or directed by the Engineer. The unit rate shall include also for hauling the excavated material to fill areas, at any distance, and spreading them in layers of thickness not exceeding 20 cm. after compaction and disposal of the surplus material, all in accordance with the Drawings or as directed by the Engineer.

201.3.2 Trench Excavation for Pipelines

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

The trench invert shall, at any location, be at the proper level and trench width of the proper dimensions to allow for sand and/or concrete bedding or surrounds as shown on the Drawings and directed by the Engineer. Where pipes are laid directly on the bottom of the trench, the latter shall be straight and even so as to provide a good support for the pipe over its entire length and shall be free of roots, stones, lumps and other hard objects that may injure the pipe or its coating.

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

The length of trench to be kept open at one time shall be determined by the Engineer and shall in no case be exceeded. Should there be any danger that trenches may erode, then sections shall be left unexcavated for as long as possible and the laying and backfilling of pipelines shall follow excavation as soon as possible.

The excavated material shall be placed alongside the trench in such a manner as not to interfere with the work and to prevent its falling into same.

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

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

with concrete. This work shall be paid for by the Employer provided that the unsuitability of the formation is not due to the method of working of the Contractor, in which case the Contractor shall carry out the work at his own expense.

Trench walls excavated in rock shall be as nearly vertical as possible, and the Contractor shall consolidate the walls wherever they have been loosened by blasting or other reasons, and shall remove all loosened material. If rock occurs at a level higher than the required level of the trench bottom, the clearance between the pipe and the trench sides and bottom shall, where in rock, be made to the dimensions shown on the Drawings or directed by the Engineer, to allow for sand or concrete bedding or surround.

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

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

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

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

Unless otherwise specified, items for trench excavation shall apply to all kinds of soil, including rock, and the excavation will be measured for payment in linear metres measured along the centreline of the pipeline, classified by pipe diameter and for each section by average depth to invert of pipes. The average depth of a section shall be the average between adjacent manholes or as directed by the Engineer's Representative. The cost of trench excavation shall be deemed to include for excavation, drilling and blasting, to the required width and depth to underside of pipe barrel, finishing the trench bottom as specified, digging boreholes where required, removing excavated material and storing it alongside the trench for backfilling whenever permitted, removal of material that may result from land slides, removal of loosened earth or rock, removal and disposal of all excess spoil to any distance, timbering and dewatering as and where required if no specific items have been provided in the Bill of Quantities.

201.3.3 General Backfill

The excavated material or selected material which can be classified as suitable for backfilling shall be in accordance with the requirements of Section 201.5.

Where necessary, excavated material shall be sieved or sorted to remove large stones, rocks, or other particles which, in the opinion of the Engineer's Representative, may impede compaction.

201.3.4 Type A Fill

Type A fill shall be good hard well graded material screened and crushed as necessary to lie within the grading envelope given in Table 1.1. The material shall have a CBR greater than 25%.

The liquid limit should not be more than 25% and the plasticity index should not exceed 6%.

The minimum value of the sand equivalent should be 50%. The maximum value of abrasion test should be 40%.

Table 1.1: Grading Envelope for Type A Fill

Sieve Size	% by Mass Passing
75 mm	100
37.5 mm	85 - 100
10 mm	45 - 100
5 mm	20 - 65
600 microns	8 - 45
75 microns	0 - 20

201.3.5 Type B Fill

Type B fill shall be clean hard fill free from deleterious material and free from stones greater than 150mm in size. The material shall have a CBR greater than 15%. The liquid limit should not be more than 40% and the plasticity index should not exceed 10%.

201.3.6 Hardcore

Hardcore shall consist of broken stone or other suitable hard material. It shall be free from clay, dust or other deleterious matter, shall not contain pieces exceeding 100mm and not more than 5% of the material shall pass through a 20mm sieve.

201.3.7 Beddings and Surrounds - Sand and Granular Material**(a) Sand Bedding and Surrounds for Concrete, A.C. and Metal Pipes -**

Where shown on Drawings, pipes shall be laid in sand bedding or surround.

The bedding and surrounds material shall be fine, uniformly graded sand (sand comply with BS 882 grading zone c), clean and free of stones, rubbish, clay or organic matter. Free draining, incompressible, fine granular material may be used instead of sand, subject to written approval of the Engineer.

The beddings and surrounds up to 30 cm above the pipe shall be wetted and thoroughly compacted in layers not exceeding 15 cm in thickness after compaction. Special care shall be taken to obtain proper compaction under and around the pipe.

Sand beddings and surrounds at any depth shall be measured in linear metres of trench in which surround has been placed, classified by diameter of pipe. The unit rates inserted in the Bill of Quantities for surrounds shall include the additional excavation in trench bottom, supplying the necessary materials, spreading, levelling and compacting the materials.

(b) Granular Material Beddings and Surrounds for P.V.C. and G.R.P. Pipes

All P.V.C. and G.R.P. pipes shall be laid in suitable granular material bedding or surround. Suitable bedding and surround material shall be broken stone or gravel from 3/8" (9.5 mm) to 3/16" (4.8 mm) size, sand (as specified in Section 201.3.7(a)) or other material having a compaction factor not exceeding 0.1. The compaction factor shall be obtained by the following test:

Equipment

1. Open-ended cylinder 225 mm long and 150 mm internal diameter (a pitch fibre or P.V.C. pipe is suitable).
2. Metal rammer with striking face 40 mm diameter and weighing 0.9 to 1.1 kg.
3. Rule.

Method

Obtain a representative sample more than sufficient to fill the cylinder viz. about 11.5 kg. It is important that the moisture content of the sample should not differ materially from that of the main body of material at the time of its use in the trench.

Place the cylinder on a firm surface and gently pour the sample material into it, loosely and without tamping. Strike off the top surface level with the top of the cylinder and removal all surplus spilled material. Lift the cylinder up clear of its contents and place on a fresh area of flat surface. Place about one-quarter of the material back in the cylinder and tamp vigorously until no further compaction can be obtained. Repeat with the second quarter, tamping as before, and so on for the third and fourth quarters, tamping the final surface as level as possible.

Measure from the top of the cylinder to the surface of the compacted material. This distance divided by the height of the cylinder (255 mm) is referred to as the Compaction Factor.

Interpretation of Values

<u>Compaction Factor</u>	<u>Suitability for Use</u>
0.1 or less	Material suitable
Over 0.1	Material unsuitable

For each batch of material, three (3) Compaction Factor tests shall be made and the average value used. Material sufficient for the surround of two hundred linear metres of pipe shall be considered to comprise one batch.

The granular material bedding and surround shall be wetted and thoroughly hand-tamped in layers not exceeding 15 cm in thickness after compaction. Special care shall be taken to obtain proper compaction under and around the pipe.

Granular material beddings and surrounds for pipes, at any depth, shall be measured for payment in linear metres of pipe, classified by diameter. The rates shall include additional excavation in trench bottom, supplying the necessary material, spreading, levelling, compacting and carrying out Compaction Factor tests.

201.3.8 Beddings and Surrounds - Concrete

Where required, pipes shall be bedded on or surrounded by concrete, to the dimensions, lines and levels shown on the Drawings or determined by the Engineer. All concrete used for bedding and surround of pipelines shall comply, in all respects, with the provisions of Division 202 hereafter. Plain concrete and reinforced concrete shall be of Grade C20P.

Pipes shall be supported and jointed at the correct level, clear of the trench bottom upon two blocks of precast concrete of suitable height, each supporting one end of the pipe. Concrete shall then be poured and rammed beneath and around the pipes in one operation and finished off to the level and dimensions shown on the drawings.

The precast blocks shall first be properly set on the trench bottom and boned to the correct position and level. The pipes shall then be laid on the blocks and properly centred, socketed and finally brought to the correct gradient by the application of wooden wedges one on each side of the pipe and between the pipe and the concrete blocks. These wedges shall remain left-in whilst the pipes are jointed and tested, as herein specified and during the pouring of the concrete beneath and around the pipes. Where the concrete while being poured would otherwise cause the pipes to float, pipes shall be effectively anchored to prevent such flotation.

The Contractor may, according to his own choice, pour concrete either with or without forms. Whatever the Contractor chooses; the concrete for payments shall be measured as per Drawings and no extras shall be paid for dimensions in excess of those required according to the Drawings.

Concrete beddings and surrounds shall be measured for payment in linear metres, classified according to diameter of pipe and according to type of bedding and surround. The rates shall be valid for any depth and shall include all additional excavation in trench bottom, concrete, reinforcement, formwork, materials, labour, etc.

201.3.9 Backfilling of Pipe Trenches

Backfilling of pipe trenches (except at joints) shall be done as soon as practicable after the pipes have been satisfactorily laid in position and jointed and in no case shall more than five pipe lengths be left uncovered after laying. Where shown on Drawings, the first stage of the backfill, up to 30 cm above the crown of the pipe, shall consist of selected material. Selected material shall be granular, free from stones, rubbish, clay and organic matter. It shall be free-draining and readily compactable. This backfill shall be spread in layers not exceeding 15 cm

in thickness after compaction, and compacted at least to 92% of modified A.A.S.H.T.O. density as defined in Part 2 Section 201.7.

The remainder of the pipe trench (from 30 cm above the crown of the pipe to the sub-base coarse of the road or to the top of the trench) shall be backfilled, after the completion of testing, by one of the following methods:

- (a) Where the pipeline crosses or runs underneath roads or pavements, backfilling shall be of type B, type A will be used when directed by the Engineer or shown on the Drawings, and shall be placed in layers not exceeding 15 cm after compaction, wetted as necessary and compacted at least 90% of modified A.A.S.H.T.O. and the last 60 cm below the road sub-base course shall be compacted at least 95% of modified A.A.S.H.T.O. density as defined in Section 201.7.
- (b) In open areas, where the requirements of para. (a) do not apply, the second stage backfill may be done with excavated material dumped into the trench by means of a bulldozer or similar equipment, provided that the fill material does not contain any large stones, that the trench is completely filled without leaving any voids, and the fill is finished with a neat mound raised to about 30 cm above the trench edges to allow for future subsidence.

All joints and other accessories shall be left uncovered until after the pipeline shall have passed any pressure or leakage tests that may be prescribed by the Specification.

Where the backfill cover over the pipes is less than 70 cm, the travel of the tracks or wheels of heavy equipment thereon will be strictly prohibited, and the Contractor shall use suitable small compactor, and shall be responsible for any damage caused to the pipe by non-compliance with this requirement.

The Contractor shall be responsible for any subsidence of trench backfill and shall make good any damage to road or structures caused thereby during the Period of Maintenance.

Where lengths of trench are excavated partly in rock, stony ground, or in other material unsuitable for backfilling, there may not be sufficient suitable material available from the excavation for backfilling as specified above and in such cases the Contractor shall transport suitable material from other parts of the work or from borrow areas.

The Contractor shall make arrangements for sites for tipping the spoil and shall include in his rates for excavation the cost of haulage and tipping of spoil and all expenses in connection with the obtaining of suitable backfilling material.

Backfilling of pipe trenches will be measured for payment in linear metres along the centreline of the pipeline, classified by pipe diameter and for each section by average depth to the top of surrounds material which is placed to 30 cm above the top of the pipe. The average depth of a section shall be the average between adjacent manholes in case of gravity pipelines, and the average between adjacent stations in case of pressure pipelines. The cost of trench backfilling shall be deemed to include supplying of material and compaction in layers not exceeding 15 cm after compaction.

201.3.10 Cased Borings

Where shown on the Drawings or instructed by the Engineer, pipes shall be installed in casings inserted into horizontal borings across embankments at existing installations or in road crossings. The casing pipe shall be of sufficient strength to withstand the forces acting on it during insertion in the bore and the external pressure of the earth, and shall have a nominal diameter as shown on Drawings but at least 6" larger than that of the line pipe. Where the soil is sufficiently cohesive and stable, the casing may be pushed into a bore previously drilled through the embankment to a diameter slightly larger (by 2-3 cm) than the external diameter of the casing. Where the nature of the soil does not permit such a procedure, the casing shall be jacked through the embankment or under the road with simultaneous drilling and removing the material from the interior of the casing pipe. In both cases, the casing pipe may be inserted in successive sections welded to each other as the work proceeds. The Contractor shall choose the most suitable and efficient method for drilling and casing and shall submit the procedure proposed by him for the Engineer's approval. Drilling and casing shall be done at the exact locations and to the lines and grades shown on the drawings or determined by the Engineer. After the casing has been installed in position and approved by the Engineer, the line pipe shall be installed therein. To protect the line pipe and especially its coating against abrasion and other injury or damage during installation and thereafter, the Contractor shall use specially designed spacers of timber or plastic or shall produce such spacers. The distances between spacers of either kind shall not exceed 3.00 m. After the line pipe has been installed in its final position, the annular space at each end of the casing shall be filled with a mixture of bitumen and sand to seal off the interior of the casing against the entry of water, mud, small animals, vermin and other foreign bodies.

Cased borings shall be measured, separately for each diameter of casing, in linear metres by the actual length of cased boring through embankment as approved by the Engineer.

The unit rates for cased borings shall include: open-cut excavation and preparation of work area at both ends of boring, drilling through embankment, supply of casing pipe, welding of casing pipe sections, inserting of casing pipe in bore, installation line pipe in casings, supply and placing of spacers and sealing of openings at the ends, supply, transport and removal from Site of boring equipment and backfill of open-cut excavation connected with boring.

201.3.11 Road Reinstatement

a) Cutting into Paved Areas

Where pipes have to be laid under existing paved areas such as roads or sidewalks, cutting into the pavement shall be done with appropriate tools, to ensure straight and neat cuts. The trench shall be vertical and its width across the top edges shall not exceed the following values:

MAXIMUM WIDTH OF THE TRENCHES AT THE TOP IN PAVED AREAS

(IN m)

Depth of trench from paved surface to pipe invert (m)	Maximum width of trench at the top in paved areas (m)
≤ 1.50	O.D(*) + 0.55
1.51 - 2.50	O.D(*) + 0.85
2.51 - 3.50	O.D(*) + 1.15
3.51 - 4.50	O.D(*) + 1.45
4.51 - 5.50	O.D(*) + 1.85
5.51 - 6.50	O.D(*) + 2.25
6.51 - 7.50	O.D(*) + 3.00

(*)O.D = Outer diameter of pipe barrel.

The Contractor shall take all necessary measures, such as shoring, bracing, etc. to keep the width of the trenches within the limits given in the table.

Cutting into paved areas will be measured for payment in linear metres of cut pavement.

b) Reinstatement of Surfaces

All surfaces whether public or private which are affected by the Works shall be reinstated in two stages, the first stage shall be carried-out in the first instance, and when the ground has consolidated fully the Contractor shall proceed with the second stage at the order of the Engineer.

First stage and second stage reinstatement of all surfaces, affected by the operations of the Contractor shall be carried out and maintained to the satisfaction of the Engineer and the responsible authority or owner.

First stage reinstatement shall be carried out immediately the trenches are backfilled.

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

For the purposes of first and second stage reinstatement in bitumen and surfaced roads the surface width of trenches shall be increased by recutting 15cm on each side of the trench for a depth of 8 cm to provide a solid abutment for the surfacing material.

Reinstatement of surfaced roads shall be carried out to the approval of the relevant authority.

The responsible authority shall have the right to carry out final reinstatement at the Contractors expense.

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

In verges and other grass surfaces and after the backfilling has been thoroughly consolidated the topsoil shall be relaid rolled and planted with grass or other vegetation as-directed by the

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

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

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

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

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

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

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

c) Safety of Excavation in Roads

Where the surface of the road (other than that which lies immediately above the trench) is damaged either by the concentration of traffic caused by an open trench, by subsidence or other causes arising from the operations of the Contractor, he shall permanently reinstate the whole of the surface so damaged to its original condition.

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

d) First Stage Reinstatement

In all paved roads the trenches shall be refilled and compacted to the underside of the sub-base layer of the road at 48 cm below the road finished level.

A sub-base layer of 20 cm thick shall then be laid consisting of approved free draining granular material conforming to section 218.1.3 requirements.

A base layer of 20 cm thick shall then be laid consisting of approved crushed limestone material conforming to section 218.1.3 requirements.

Prior to application of the first stage reinstatement the surface of the road foundation shall be cleared of all dust, debris and other deleterious matter and shall then be primed with one application of prime coat MC-70 or similar approved. All joints with adjacent road surfacing shall be cut straight and vertical and primed.

The road surfacing of the first stage consists of 5 cm thick of finished asphalted concrete layer.

The surface shall be maintained with the end of the period of Maintenance or until instructions are given for the final reinstatement to be carried out.

f) Reinstatement of unmade roads

In all unmade roads the trenches shall be refilled and compacted as specified in the Contract to within 15 cm of the surface.

The trench shall be surfaced with 15 cm compacted thickness of base layer material as specified above.

The surface shall be maintained until the end of the Period of Maintenance and shall not be topped up above the level of the original surface to allow for settlement.

e) Second Stage Reinstatement

Second and final reinstatement consists of a wearing course of 4 cm compacted thickness of 14 mm nominal size dense wearing course macadam. The laying and finishing of the coated macadam shall be carried out so as to achieve a dense, smooth and even surface using a roller of not less than 12 tonnes mass.

201.4 EXCAVATION FOR PONDS AND CANALS

Excavation for ponds and canals shall be carried out and finished to the lines, grades and dimensions shown on the Drawings and to the tolerances specified hereafter.

Excavated material shall be used for earthfill in embankments and in other locations, as shown on Drawings, except for material rejected by the Engineer as unsuitable, which shall be run to spoil. Under this Section, suitable material shall be excavated, moved to fill areas, dumped and spread, as specified. The Engineer shall be entitled to designate the earthfill where individual loads of material shall be deposited.

The Contractor shall take all necessary precautions to prevent excavation beyond and below the lines and levels indicated on Drawings. Any damage to the work due to the Contractor's operations, including shattering of the material beyond the required depths and lines, shall be made good by the Contractor at his own expense. Any and all excess excavation for the convenience of the Contractor or any overexcavation performed by the Contractor for any purpose or reason, except as may be directed by the Engineer in writing, shall be at the expense of the Contractor. Where required to complete the work, all excess excavation and overexcavation shall be refilled, consolidated and made good with materials provided by the Contractor at his own expense, as directed by the Engineer's Representative.

Unless otherwise specified, items for excavation for ponds and canals shall equally apply to all kinds of soil, including rock, and excavation shall be measured by cubic metres of excavated material, to the lines and levels shown on the Drawings or as directed by the Engineer. The unit rate shall include for excavation, drilling and blasting, stacking, hauling excavated material in fill areas, and disposal of spoil material, all as specified in this Section.

201.5 EXCAVATION AND BACKFILL FOR STRUCTURES

All excavation for structures shall be carried out to the dimensions, lines and grades shown on the Drawings or directed by the Engineer.

Excavations on or against which concrete or compacted fill is to be placed, shall be clean and free from stones, clods, debris and other loose material. Where the bottom of an excavation does not provide a solid basis for casting concrete, it shall be consolidated by tamping and/or watering as necessary until the required density is obtained.

Any overexcavation in the bottom of the structure shall be cleaned and backfilled with concrete or selected backfill compacted to the density of the adjacent natural soil. Overexcavation in rock shall be backfilled with the concrete of the structure or with dry stone pack, as directed by the Engineer. Any and all excess excavation for the convenience of the Contractor for any purpose or reason, except as may be directed by the Engineer in writing, and all refilling of such overexcavation as specified, shall be at the expense of the Contractor.

Where possible, concrete foundations and blocks shall be cast against the undisturbed sides of the excavation. Where overexcavation beyond the lines of the structure is unavoidable due to the nature of the ground, because of the shape of the structure or for any other reason, the space between the structure and the faces of the excavation shall be backfilled to the original ground level (whether natural or reduced) as specified hereafter for backfilling.

Excavated material, to the extent that it is required and suitable, shall be put aside for use in backfill. Surplus excavated material shall be either used for backfill in other locations on the site, or shall be otherwise disposed. Wherever required, the Contractor shall obtain suitable material for compacted backfill from borrow areas.

Backfill shall be carried out to the lines and grades shown on the Drawings. The backfill material shall be placed in horizontal layers not exceeding 15 cm in thickness after compaction. The backfill material shall completely and firmly fill the spaces between the excavation lines and the structure without leaving any voids, and shall be compacted to the density of the adjacent natural earth. The sides and bottom of the excavation shall be moistened before backfilling and so shall the backfill material, in order to obtain the moisture content necessary for the required compaction. Every layer shall be compacted by pneumatic tampers approved by the Engineer.

Unless otherwise specified, items for excavation and backfill for structures shall equally apply to all kinds of soil, including rock.

Excavation shall be measured by cubic metres to the neat lines and dimensions of the structures, as shown on the Drawings or described in the Specification, with no allowance whatsoever so actual side-slopes, working space, etc. The unit rates for excavation shall include for excavation, drilling and blasting, stacking, hauling of excavated material to any distance, spreading and compacting and running surplus to spoil.

Backfill will be measured for payment by cubic metres, and the unit rates for backfill shall include for supplying of material, spreading and compaction of material in layers not exceeding 15 cm after compaction.

201.6 EXCAVATION FROM BORROW AREAS

Wherever required or directed by the Engineer, the Contractor shall obtain suitable material for compacted fill from borrow areas. Such suitable borrow material shall be excavated, moved to fill areas and spared as specified. The locations and boundaries of the borrow areas as well as the depths and slopes of excavation therein shall be as determined or approved by the Engineer's Representative. Before commencing to extract filling material from any borrow area, the Contractor shall strip its surface as specified in Sub-Section 201.2.3 above and shall also remove therefrom all material which is, in the Engineer's opinion, unsuitable for filling. The surface of the borrow shall be left in a reasonably smooth and even condition, as approved by the Engineer's Representative.

No excess borrow material shall be brought to fill areas. Unnecessary material shall be rejected and dumped and shall not be measured for payment.

Measurement for payment of excavation in borrow areas shall be made only for excavation of borrow material actually used as fill, to the lines and dimensions prescribed by the Engineer's Representative. Measurement shall be by cubic metres and the unit rate shall include for stripping (which shall not be measured and paid for) and for removing unsuitable material, hauling to fill areas at any distance. All materials from borrow pits placed in embankments and compacted backfill will again be included for payment under the applicable rates of the Bills of Quantities for compacting such earthwork. Provided always that the cost of borrowed material has not been specified to be included in those relevant pay items for which the same borrowed material is to be supplied.

201.7 EMBANKMENTS AND COMPACTED FILL

201.7.1 General

Wherever the term "embankment" is employed it shall also mean "compacted fill", unless the distinction between those two terms is clearly emphasized.

Embankments shall be constructed to the lines and grades shown on the Drawings. Where grassing is required, a compacted fill embankment shall be constructed up to the underside of the layer of top soil, as shown on the Drawings.

No brush, roots, sod, or other perishable or unsuitable materials shall be placed in the embankments. The suitability of each part of the foundation for placing embankment materials thereon and of all materials for use in embankment construction will be determined by the Engineer. The Contractor shall maintain the embankment in an approved manner until the final completion and handing over of all the Works.

The embankment operations shall be so conducted and the various soil strata shall be placed so as to produce a soil structure as shown on the typical cross sections, or as directed by the Engineer. The slopes of the division lines between zones and/or portions of the embankment are tentative and shall be subject to variation, at any time prior to or during construction, and the Contractor shall be entitled to no additional allowance above the unit rates in the Bill of Quantities, by reason of such variations. The embankment for each portion shall be maintained approximately level throughout the entire length of each layer from abutment to abutment. All openings through the embankment required for construction purposes shall be subject to approval, and such openings shall be constructed so that the slope of the bonding surface between embankment in place and embankment to be placed is not steeper than 1:4. The bonding surface of the embankment in place shall be prepared as provided for embankment foundations.

The Contractor shall be responsible for the stability of all embankments made under the contract and shall replace any portion which, in the opinion of the Engineer, has become displaced due to carelessness or negligence on the part of the Contractor.

Where excess spoil, or other material for which compaction is not specified, is dumped and spread, the Contractor shall route his equipment, both when loaded and when empty, to travel over the entire area of the above mentioned material. No payment will be made for this operation, and its cost shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities.

When the state of the weather is such that it would adversely affect the placing of fill, all embanking shall be stopped. In particular, embanking work will not be permitted during rain nor for such time afterwards as the Engineer may judge to be necessary to allow the upper layers in the embankment to dry to their correct moisture content as directed by the Engineer.

At all times during dry weather, whether embanking is taking place or not, the surface of the embankment is to be watered everywhere as directed by the Engineer, or protected to his satisfaction to prevent undue cracking of the surface. Watering is to be done by means of tankers, sprinklers or other methods approved by the Engineer.

Any material not complying with the specified density or moisture content shall be replaced in the embankment at the Contractor's own expense notwithstanding the fact that it may be overlaid by more recently placed material.

201.7.2 Preparation of Foundation

No material shall be placed in any section of the embankment until the foundation for that section has been suitably prepared and approved by the Engineer's Representative.

All excavation made for test pits or other subsurface investigations, and all other existing cavities found within the area to be covered with earthfill which extend below the established lines of excavations for the embankment foundations shall be filled with compacted earthfill. The foundation for earthfill, where in clayey soil, shall be scarified, wetted and compacted as specified for the earthfill to be placed thereon. Where the foundation is granular material it shall be compacted by vibrating rollers to a depth of not less than 30 cm to the same density as specified by the overlaying earthfill. Surfaces upon or against which the earthfill portions of the embankment are to be placed shall be cleaned of all loose and objectionable materials in an approved manner by hand-work or other effective means immediately prior to placing the first layer of earthfill. The surfaces of each portion of the foundation, immediately prior to placing the earthfill, shall have all water removed from depressions and shall be properly moistened and sufficiently clean to obtain a suitable bond with the earthfill. Where compaction of fill is to be started, or continued after the previous layer has been in place for over 6 hours, the area shall be harrowed to a depth of 20 cms, wetted and compacted to the required degree of compaction.

201.7.3 Compaction Control

Compaction shall be controlled by field density and field moisture tests, or by such other tests as prescribed by the Engineer.

The densities of the compacted earth materials shall be defined as follows:

- (a) Modified A.A.S.H.T.O. Density shall mean the maximum dry density obtained from the compaction test in accordance with the A.A.S.H.T.O.-T-180-61 (method D) test or the (identical) A.S.T.M.-D-1557 (method D) test.
- (b) Relative Density shall be defined by the following formula (in accordance with the U.S. Bureau of Reclamation Earth Manual Designation E-12):

$$D_d = \frac{Y_d \max (Y_d - Y_d \min)}{Y_d (Y_d \max - Y_d \min)} \times 100$$

where

- D_d = Relative density
 $Y_{d\max}$ = greatest dry density obtained by laboratory
 $Y_{d\min}$ = least dry density obtained by laboratory
 Y_d = the dry density at which the soil is to be placed or the in-place dry density

The field density of compacted material in place shall be determined by the A.A.S.H.T.O.-T-191-61 method or by the identical A.S.T.M.-D-1556-64 method. Field moisture content shall be determined by the A.S.T.M.-D-2216-63-T method.

Samples of all fill materials, both before and during placement, shall be taken for testing at frequent intervals. The following tests shall be performed:

- (a) Tests to determine the maximum dry density and the optimum moisture content. The number of samples for these tests shall be as determined by the Engineer but not less than one sample per 1,000 m³ of fill shall be taken.
- (b) Field density tests. The number of samples for these tests shall be as determined by the Engineer, but not less than one sample per 1,000 m³ of compacted fill or one sample per day, whichever is larger.

For the performance of all the above-mentioned tests, the Contractor shall provide a fully-equipped field laboratory and the necessary trained personnel for sampling and testing, all subject to the Engineer's prior approval. All costs for providing the field laboratory and the necessary personnel and for sampling, testing, transportation, etc., shall be deemed to be included by the Contractor in his unit rates for the various items of earthworks in the Bill of Quantities and shall not be paid for separately.

201.7.4 Placing and Compacting - General

Embankment materials shall be deposited in horizontal layers over the entire width of the embankment and compacted to the required densities as shown on the Drawings or as specified.

Embankments shall be formed of satisfactory materials. The thickness of each layer shall not exceed the thickness shown on the Drawings or as specified. In the construction of embankments, starting layers shall be placed in the deepest portion of the fill, and as placement progresses, layers shall be constructed approximately parallel to the finished grade line.

The material in the layers shall be brought to the optimum moisture content before rolling is started to obtain the prescribed compaction. Wetting or drying of the material and manipulation to secure a uniform moisture content throughout the layer shall be required. Should the material be too wet to permit proper compaction or rolling, all work on all portions of the embankments thus affected shall be delayed until the material has dried to the required moisture content. Sprinkling shall be done with sprinkling wagons, pressure distributors, or other approved equipment that will sufficiently distribute the water. Sufficient equipment to apply the required water shall be available at all times.

The optimum moisture content shall be determined by the Engineer and the actual content shall not vary from the required one by more than plus 4 or minus 2 percent. This optimum moisture content, determined by the Engineer as required for compaction purposes, shall be uniform throughout each layer of the earth-fill prior to and during the compacting.

The distribution of materials shall be such that the compacted fill be homogeneous and free from lenses, pockets streaks or other imperfections.

The number of successive passes of the compacting equipment over each and every point in any layer shall be not less than six (6). The overlapping of two adjacent passes shall be not less than 30 cm. The Engineer's Representative shall have the right to test every layer. However, the Contractor shall not be permitted to start work on the successive layers without the Engineer's Representative's permission, irrespective of whether tests have been made or not.

Where due to small width of required fill or any other reason, compaction of material in horizontal layers by sheeps foot rollers or pneumatic rollers will in the Engineer's opinion be impracticable, the Engineer may permit the use of other equipment and procedures such as compaction by mechanical tampers or spreading the material in small quantities in layers parallel to the slope and compacting same by cylindrical rollers applied along the slopes, or otherwise. Compaction shall be carried out to the Engineer's satisfaction and to the specified density.

After compaction has been completed as specified, all surfaces and slopes shall be trimmed and smoothed to accuracy specified hereafter. The cost of such trimming and smoothing shall be deemed to be included in the various rates for construction of embankments.

201.7.5 Compaction of Clayey and Silty Materials

Clayey and silty materials shall be deposited in horizontal layers of thickness not exceeding 15 cm, after compaction. The excavating and placing operations shall be such that the materials when compacted will be blended sufficiently to secure the best practicable degree of compaction, impermeability and stability. Prior to and during compaction, the materials shall have the optimum moisture content as determined by the Engineer, and the moisture content shall be uniform throughout each layer.

Insofar as practicable, as determined by the Engineer's Representative, moistening of the material shall be performed at the site of excavation, but if necessary shall be supplemented by sprinkling at the Site. Should the actual moisture content not be within the limits prescribed in Subsection 201.7.4 above, compacting operations shall not proceed until the layer has been brought to optimum moisture content, whether by wetting or scarifying and drying. No additional payment shall be made on account of any operation by the Contractor in drying or wetting the materials or on account of delays occasioned thereby.

When the filling material has been conditioned as specified, it shall be compacted by tamping with sheeps foot rollers having staggered and uniformly spaced knobs and of sufficient weight for proper compaction, by tyre rollers, by hand or power tampers, or by other compacting equipment approved by the Engineer. When tamping rollers are used, the tamping knobs and cleaner bars shall be properly maintained and the space between the tamping feet shall be kept clear of anything which may impair the effectiveness of the roller. Unless otherwise specified, the dry density of the soil fraction in the compacted material shall not be less than 92 percent of the Modified A.A.S.H.T.O. Density as defined in Subsection 201.7.3 above.

201.7.6 Compaction of Cohesionless Free-Draining Materials

Cohesionless free-draining materials, such as sand and gravel, shall be deposited in horizontal layers of not more than 15 cm if compacted by tampers or rollers, not more than 30 cm if by treads of crawler-type tractors, surface vibrators or similar equipment and not more than the penetrating depth of the vibrator if compacted by internal vibrators.

Unless otherwise specified, the relative density of the compacted materials, as defined in Subsection 201.7.3 above, shall be not less than 70 percent.

201.7.7 Compaction of Intermediate Soil Types

Unless otherwise specified, in borderline cases between clayey and silty soils and those that fall under the definition of cohesionless free-draining materials, the density shall be either 92 percent of the Modified A.A.S.H.T.O. Density or 70 percent relative density, whichever value is the higher.

201.7.8 Pipelines and Structures in Embankments and in Compacted Fill

Where pipelines are to be laid in embankments or in compacted fill, the embankment or fill will first be constructed to the lines and levels shown on the Drawings, to a height of 1.5 m above the crown of the pipe or to the top of the embankment or fill. After the embankment or fill have been constructed to the height specified above, the Contractor shall excavate in the compacted fill a trench to the Typical Trench Cross Sections; shall lay, joint, etc., the pipes in it; shall backfill the trench, as specified, to the top of the embankment and shall complete all other operations of constructing and covering the pipeline. After all the above operations have been completed, the Contractor shall resume, where necessary, the construction of the embankment or fill and its compaction.

Where steel pipes are to be laid in compacted embankments, the work shall be carried out as specified above, except that the embankment shall be completed to a level of 50 cm above the crown of the pipes.

Where structures, such as manholes, chambers, channels, etc., are to be constructed in compacted embankments or fill, the embankment or fill will first be completed to the lines and levels shown on the Drawings. The required excavation for the structures shall then be made and the structures constructed in it. After the completion and testing of such structures, the excavation shall be backfilled and compacted to the specified density.

201.7.9 Methods of Measurement and Payment

The supply of fill material, including its hauling and spreading and running of surplus to spoil, shall not be paid for separately and shall be deemed to be included in the relevant pay items for excavation, whether from borrow areas or from excavations for pipelines, structures, etc.

Compaction of Embankments shall be paid for separately and measured by cubic metres of the volume of compacted fill in place. No payment shall be made for additional material required to be added due to Settlement, and the Contractor shall make due allowance for this in his rates. The unit rate shall include wetting and compacting and the performance of all field and laboratory tests as specified. The unit rate shall also cover all additional costs of scarifying, harrowing, etc., where and when needed and trimming and smoothing of surfaces.

No additional payment shall be made in case of stockpiling of excavated materials and later rehandling of such material if directed by the Engineer in order to produce the specified embankment structure and the cost thereof shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

201.8 TOLERANCES OF FINISHED EARTHWORKS

All earthworks shall be finished to the dimensions and elevations shown on the Drawings. Unless otherwise specified, the following variations shall be acceptable:

- (a) Embankment width - not more than 20 cm over the specified widths and not more than 10 cm less than the specified widths. Embankment elevations - not more than 5 cm.
- (b) Elevations of bottoms of ponds - no more than 5 cm.
- (c) Channel invert elevations - not more than 3 cm, provided a continuous slope is maintained in the direction of flow so as to prevent the formation of puddles on bottom of channel.
- (d) Irregularities in surfaces of all earthworks - not more than 1.5 cm when checked by a straight edge.

201.9 SOIL INVESTIGATIONS

The Contractor shall carry out soil investigations according to BS 1377 (Methods of test for soil for civil engineering purposes) at the stations, buildings, reservoirs and water towers construction site, whenever he is requested to do so by the Contract and as directed by the Engineer's Representative. These investigations shall comprise various boreholes (according to the nature of the soil) as well as reports determining the specifications of the layers, the bearing capacity of the soil, the nature of foundations and the retaining structures if needed.

201.9.1 Borings

According to the nature of the soil or rocks, one of the three following borings shall be carried out:

- a) Alluvial soils

(loose soils or slightly to fairly consistent)

Borings shall be:

- Either, penetrometric borings performed by a penetrometer ≥ 100 KN, static-dynamic with a measurement of the cone resistance and the lateral friction.
- or, core-borings $\varnothing \geq 76$ mm performed with core samplings and in-situ-SPT. The number of borings is conditional upon the area of the structures, and shall be carried out at the rate of one boring for every 200 m^2 , with a minimum of two borings. Depths shall be conditional upon the nature of the soil and the loads, and shall be fixed according to each site but shall not, in principle, exceed 15m.

In case underground water was found at a slight depth, a piezometer shall be installed. Moreover, in some cases, a trench shall be dug with a mechanical shovel down to 1 to 2 m beneath the aquifer and a permeability test performed by pumping shall be carried out (watertable drawdown and recovery).

b) Calcareous rocks

Destructive soil investigation shall be carried out with a measurement of the rate of drilling progress and the pressure exerted on the bit. These borings aim at locating the fractures and fissures in rocks, since these fissures and not the hardness of the rocky matrix limit the bearing capacity of the foundations. Borings shall reach 5 m beneath the level of the foundation.

The number of borings shall be conditional upon the surface of the structures and shall be carried out at the rate of one boring every 100 m^2 , with a minimum of five borings. In case borings show cavities or considerable cracks, supplementary and closely distributed borings shall be carried out after the beginning of earthworks.

In case groundwater was found, a piezometer shall be installed.

c) Extremely consolidated soils or very soft rocks (Sandstone, marl, clay)

Continuous core samplings shall be performed with a double core-driller. The diameters of borings shall be 76mm as a minimum.

A representative sample of each layer and boring shall be taken from the core-samples and shall undergo unconfined compression tests. Some samples shall eventually undergo free swelling tests.

The number of borings shall be conditional upon the surface of the structures, and shall be carried out at the rate of one boring every 200 m^2 , with a minimum of two borings.

The depths shall be conditional upon the nature of the soil and the loads, and shall be fixed according to each site, but shall not in principle, exceed 15m.

In case underground water was found, a piezometer shall be installed.

201.9.2 Report

After carrying out borings and taking measurements, a report shall be drawn. It shall treat of the following issues:

- Opening and stability of excavations and the drainage methods.
- Treatment of the foundations soil, if need be.
- The permissible constraint exerted on the soil, in terms of the nature of foundations and differential settlements.
- Special recommendations concerning problems such as drainage, etc...

201.9.3 Methods of Measurement and Payment

The soil investigation shall be measured for payment by linear metre of borehole depth, the unit rate shall include mobilisation and demobilisation of equipment, labor, boreholes, tests, report, etc...

202 - CONCRETE WORKS

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202 CONCRETE WORKS**202.1 STANDARDS, GRADES, COMPOSITION AND TYPES****202.1.1 General**

This division describes the quality of materials and workmanship of concrete and reinforced concrete works cast in situ in all parts of structures below or above ground in all site locations.

The Specification shall apply to concrete prepared on site as well as ready mixed concrete and small precast concrete elements. Generally, it is based on CP 110 Part I 1972 and on BS 4881, 5328 and 5337.

In case of discrepancy or contradiction, the requirements of this Specification shall rule over any standard.

202.1.2 Standards and Codes

The current ruling Standards and Codes of Practice, detailed below, are made by reference part of this Specification.

BS	12	Portland Cement (ordinary and rapid hardening)
BS	146	Portland - Blastfurnace Cement
BS	410, 1796	Test Sieves and Test Sieving
BS	882, 1201	Aggregates from Natural Sources
BS	1305	Batch Type Concrete Mixers
BS	1370	Low Heat Portland Cement
BS	1881	Methods of Testing Concrete
BS	1926	Ready-Mixed Concrete
BS	3148	Tests for Water for Making Concrete
	4027	Sulphate Resisting Portland Cement
BS	4251	Truck Type Concrete Mixers
BS	4449	Hot Rolled Steel Bars for the Reinforcement of Concrete
BS	4461	Cold Worked Steel Bars for the Reinforcement of Concrete
BS	4466	Bending Dimensions and Scheduling of Bars for the Reinforcement of Concrete (Plain round mild steel or high yield steel)
BS	4482	Hard Drawn Mild Steel Wire for the Reinforcement of Concrete
BS	4483	Steel Fabric for the Reinforcement of Concrete
BS	5075	Concrete Admixtures
BS	5135	Metal Arc Welding of Carbon and Carbon-Manganese Steels
BS	5328	Methods for Specifying Concrete Part 1 to Part 4
PD	6440	Accuracy in Building
BS	6588	Portland Pulverised - Fuel Ash cement
BS	8007	Design of Concrete Structures for Retaining Aqueous Liquids
BS	8102	Protection of Structures against Water from the Ground
BS	8110	CP 110 Part 1 and Part 2 Structural use of Concrete
ASTM Standard	C309	Liquid Membrane Forming Compound for Curing Concrete
ASTM Standard	C260	Air Entraining Admixtures for Concrete

In case of discrepancy or contradiction, the requirements of this Specification shall overrule any standard.

202.1.3 Classification and Composition

Concrete of all grades shall consist of coarse and fine aggregate, cement, water and additives. Generally, the grades of concrete shall be detailed as described in the following table. However, other grades may be required in the Particular Specification.

Table 2.1 Concrete grades and Classifications

Grade/Class of Concrete Per B.S. 5328	Characteristic Compressive Strength (Kg/cm ²)	Minimum Cement Content (Kg per m ³) of Ready Concrete	Characteristic Use
C 7P	70	150	Lean Concrete
C10P	100	200	Non-Reinforced Concrete
C15P	150	200	
C20P	200	280	Reinforced Concrete
C25P	250	280	
C30P	300	280	
C40P	400	300*	Prestressed Concrete and Concrete for Special Purposes
C50P	500	300*	
C60P	600	300*	

* For prestressed concrete the following maximum cement contents shall not be exceeded:

Grade C40P - 375 kg per 1.0 m³
Grade C50P, C60P - 450 kg per 1.0 m³

The relationship between grade of the concrete and its characteristic strength shall be as given in BS 5328. The grade of concrete to be used in particular locations shall be as given in Table 2.2 unless noted otherwise on the Drawings.

Table 2.2 Concrete strength requirements

Location	Maximum Coarse Aggregate Size (mm)	Grade of Concrete (BS 5328)
Blinding Concrete - General Structures - Liquid Structures	20 or 40 20	C15P C20P
Blinding concrete - Sulphate Condition	20	C25P
Substructures thickness less than 400 mm	20	C25D
Substructures, walls and slabs more than 400 mm	20	C25D
Superstructures normal concrete	20	C25D
Liquid retaining structures	20	C35D
Fine concrete	10	C25D
Precast concrete	10 or 20	C30D

In the above table suffix P means a prescribed mix, D means a designed mix and A means a design mix complying with the requirements of BS 8007.

The specific grades of concrete to be employed in the different structures or parts of structures shall be as shown on the Drawings or indicated in the Specification Bill of Quantities. The quantity of cement in the ready concrete shall in no case be less than the minimum quantities detailed in the above table.

The Contractor shall have trial mixes for the various structures designed by an approved laboratory. The mixes shall be designed with the objective of producing concrete having suitable workability, density, impermeability and required strength.

Proportions shall be determined in accordance with the "Design of Normal Concrete Mixes" published by the United Kingdom Department of The Environment and obtainable from:

Building Research Establishment and Bookshop
Garston
Watford
WD2 7JR
ENGLAND

or other approved methods, for the requirements set out in this Specifications.

The amount of water used in the concrete shall be changed as required to secure concrete of the proper consistency and to adjust for any variation in the moisture content or grading of the aggregates as they enter the mixer. Addition of water to compensate for stiffening of the concrete before placing will not be permitted. The mix to be used in every part of the Work shall be subject to the Engineer's approval and the Engineer shall have the right to demand the mix proportions and water-cement ratio to be changed during the progress of the work if in his opinion such changes shall be necessary to secure the required quality of the concrete as detailed above.

The mix proportions shall be selected to ensure that the workability of the fresh concrete is suitable for the conditions of handling and placing, having regard to the structural element being constructed, the disposition of reinforcement, and taking full account of the environment to which it will be subjected.

The minimum cement contents and maximum water/cement ratios of designed mixes shall be as given in Table 2.3. In the event of sulphate exposure precautions requiring lower cement content than those required for normal conditions the latter requirements shall prevail.

**Table 2.3 Minimum cement contents
Normal Conditions**

Type of Structural Element	Exposure Conditions (BS 8110)	Minimum Cement Content (kg/m ³)			Maximum Water/Cement Ratio
		Maximum Aggregate Size			
		40 mm	20 mm	10 mm	
Liquid Retaining Structures, Shafts and Tunnel Linings	Severe	295	325	356	0.55
All Foundations and Buried Structures	Moderate	270	300	340	0.60
Building Super-Structure	Moderate	270	300	340	0.60

Additional requirements when exposed to sulphate conditions (all structural concrete)

Concentration of Sulphates		Type of Cement	Minimum Cement Content (kg/m ³)			Maximum Water/Cement Ratio
In Soil (Total SO ₃)	In Ground Water Parts per 100,000		Maximum Aggregate Size			
			40mm	20mm	10mm	
< 0.2	< 30	OPC	NORMAL CONDITIONS			
0.2 - 0.5	30 - 120	OPC	300	330	370	0.50
		SRPC	250	280	320	0.55
0.5 - 1.0	120 - 250	OPC	Not Permitted	330	370	0.50
		SRPC	300			
1.0 - 2.0	250 - 500	OPC	Not Permitted	370	410	0.45
		SRPC	340			
> 2.0	> 500	SRPC	Ditto but with protective coating			0.45

202.1.4 Types of Concrete

a) Ready-Mixed Concrete

The use of ready-mixed concrete will be permitted provided the production, transportation, sampling and testing of the ready-mixed concrete shall conform to the requirements of B.S. 1926 and that the concrete meets the requirements of this Specification as to strength, cement content, impermeability and other properties. The methods and equipment used and the speed required for transporting concrete shall be such that concrete having the required composition and consistency will be delivered into the work, without objectionable segregation, loss of slump, and delay.

The Contractor shall notify the Engineer of the supplier from whom he intends to purchase the ready-mixed concrete and shall obtain the Engineer's approval in writing of such supplier. Prior to the commencement of concrete production, the Engineer shall be given notice to enable him to check the composition and cement content of the concrete about to be produced at the supplier's plant. However, the Engineer's approval of the supplier and his inspection of the concrete production shall not relieve the Contractor of his sole responsibility for the

quality concrete, and the Contractor shall make good any damage and shall indemnify the Employer against losses caused by concrete not meeting the requirements of the Specification. The Engineer may at any time and at his own discretion prohibit the use of any ready-mixed concrete which in his opinion does not meet the requirements of the Specification, and in such an event the Contractor shall discontinue the use of such ready-mixed concrete and shall at no extra cost to the Employer supply concrete mixed on the site, or ready-mixed concrete from another source meeting the Engineer's approval.

b) Lean, Blinding and Cyclopean concrete

Concrete shall be proportioned to 200 kg of cement per 1 m³.

Stones for cyclopean concrete shall be wetted and cleaned from any deleterious matter prior to batching. Stones with a maximum size of 20 cm and covered with concrete shall be added to fresh concrete.

The proportion of concrete shall not be less than 60% of the total volume. Stones shall not be in contact with one another, nor with the formworks or trenches sides. The minimum distance between two stones or between one stone and the side of the formwork is 5 cm. Aggregates shall not form honeycombing in the surface of concrete. Should such defect be found after the removal of formworks, the concerned parts shall be demolished and cast anew at the expense of the Contractor. Cyclopean concrete surfaces shall be thoroughly finished. The location of these types of concrete shall be indicated on the drawings. In all cases the Engineer must give his written approval for concreting.

c) Porous Concrete

Porous concrete is made of single-core coarse aggregates and practically no-fines. It produces a low slump and has a low water/cement ratio; just enough cement is used to bind the aggregates into a mass resembling popcorn. The ratio of aggregate to cement shall be 8:1 by volume or 10:1 by mass.

It is characterized by 20% to 35% of voids, and a high permeability allowing a free water flow.

Porous concrete will be used in hydraulic structures where drainage is desired. It is also used to allow the recharge of groundwater by water penetration through concrete.

To maintain the required permeability properties, concrete surfaces should not be stopped nor sealed. No finishing work even with a trowel shall be required. The compressive strength of the various mix proportions vary from 3.5 to 27.5 Mpa. Drainage velocity ranges between 100 and 900 liters/mn/m².

The concrete shall be mixed by machine or by hand to a uniform color and consistency before placing. The quantity of water used shall not exceed that required to coat all of the aggregate particles without forming excess grout.

d) Shotcrete concrete

Shotcrete concrete shall be mortar or concrete conveyed through a hose and pneumatically applied using either the dry mix process or the wet mix process.

The dry mix process shall consist of thoroughly mixing a proportional combination of dry fine aggregate and portland cement; conveying the mixture through a delivery hose to a special nozzle where water is added and mixed with the other materials immediately prior to its discharge from the nozzle. The wet mix process shall consist of premixing by mechanical methods a proportional combination of portland cement, aggregate, and water required to produce mortar or concrete; conveying the mortar or concrete through the delivery hose to the special nozzle where additional compressed air is added at the nozzle prior to discharge.

Shotcrete proportions shall be selected that allow suitable placement procedures using the delivery equipment selected and shall result in finished in place hardened shotcrete meeting the required strength.

The surfaces on which shotcrete is to be placed shall be finely graded to the lines and grades shown on the drawings. The surfaces shall be thoroughly compacted and shall be uniformly moistened so that water will not be drawn from the freshly placed shotcrete.

e) Chuted concrete

Chuted concrete is a plain concrete to which is added at the end of mixing a superplasticizer giving it a flowing consistency (slump at Abram's cone test = 20 to 24 cm). This concrete is especially used for heavily reinforced reservoirs or those having complex shapes. However, the following precautions should be taken:

- Check beforehand the efficiency of the superplasticizer (plasticity modification, effect on strength, duration,...)
- Mix concrete as close as possible to its final position, since this type is more prone to segregation than plain concrete.
- Use resistant formworks because chuted concrete transmits pressures (height of concrete in formworks) better than plain concrete (reduced internal friction).

f) Fibre concrete**General**

Fibre concrete contain appropriate quantities of metallic fibres as to form a composite and homogeneous mixture and shall be designed according to British Standard.

The main characteristics of metallic fibre concrete are:

- Strong cohesion which gives a high strength to shocks.
- Important ductility with small cracks (< 8mm) which reduces construction cracks.
- Resistance to rupture.

Materials

Metallic fibres are machined directly from the steel slab. They are triangular, twisted, curved and have a smooth side and a rough side.

Fibres shall be stored in a dry place.

The percentage of fibres shall vary between 20 and 40 kg per cubic meter of concrete.

Cement shall be chosen according to BS 12.

Granular materials shall comply with BS 882.

Sand shall be graded 0 to 3mm or 0 to 5mm and contain 15% of fines ($\leq 0.315\text{mm}$). Grading shall be continuous as far as practicable with a maximum grain size of 25mm.

The water shall comply with BS 3148.

Addition of water on site shall not be permitted.

The admixtures permitted to be used with fibre concrete are:

Super Plasticizer

Super Plasticizer are used to increase the workability of fibre concrete, at the time of placing without addition of water.

Plasticizers-water reducers

They are used to increase the plasticity of concrete (especially pumped concrete) at a constant quantity.

Prior to adding fibres, concrete shall have an ultimate bending-tensile strength equal to 3.4 MPa, in order to allow the good anchoring and performance of fibre.

Concrete fluidity shall be measured by the Abram's cone (slump test).

Fibres decrease greatly the workability of concrete. Therefore, fluidizers shall be added directly on site in the truck mixer in order to facilitate placing while the water/cement ratio is kept constant.

Two types of concrete may be used:

1) Chuted concrete

This is the best solution.

Slump:

- | | | | |
|----|-------------------------------------|---|-------------|
| a) | Prior to adding fluidizers | : | 4 to 6 cm |
| b) | After adding fluidizers | : | 15 to 18 cm |
| c) | After adding fluidizers and fibres: | | 10 to 14 cm |

Chuted concrete allows to decrease the quantity of water ($0.4 \leq W/C \leq 0.5$), and, therefore, develops good mechanical resistances and ensures a considerable workability.

Fluidizers shall be added on site.

2) Plasticized concrete

Slump:

- a) Prior to adding fibres : 9 to 12 cm
 b) After adding fibres : 6 to 8 cm

Plasticized concrete requires no addition of water on site. Given its low workability, it is difficult to place this type of concrete.

The performance of metallic fibre concrete is measured by the ultimate tensile bending strength test after 28 days. The average common performances are tabulated hereunder:

Proportion	20 kg/m ³	25 kg/m ³	30 kg/m ³	35 kg/m ³	40 kg/m ³
Performance MPa (maximum stress)	4	4.5	4.9	5.2	5.5

Placing

Fibres shall be mixed directly with concrete without forming “urchins”.

No “dosing-untangling” device shall be needed.

Placing shall be done:

- either, in the truck mixer on site, with an additional mixing of 6mm at 14 r.p.m.
- or, at concrete factory with aggregates or, at the end with an additional mixing of 4mm.
- or, in the concrete mixer on site, with an additional mixing of 6mm.

The concrete should be adequately consolidated. The vibration method is conditional upon the type of concrete.

- Chuted concrete requires almost no vibration. It is placed by means of vibrating rulers or even without any external vibration (evenness is controlled by a laser level).

Chuted concrete allows concreting large surfaces without any construction joints.

- Plasticized concrete or admixtures free concrete shall be consolidated by means of a vibrating ruler.

In the event of fair-faced concrete surfaces, fibres shall be properly integrated in concrete through adequate mechanical or manual troweling.

No particular precautions are required for other traditional finishings (sprinkling, incorporated or added finish). A curing product shall be applied to the finished surface of concrete slab to prevent rapid desiccation.

Should surfaces be painted, concrete may be cured by sprinkling with water.

Joints shall be formed in fibre concrete. However, given the plasticity and coherence of this type of concrete, it is preferable to place it continuously and, then, form contraction joints by sawing.

Joints are formed each 8m x 8m outdoors or in non covered surfaces (at the time of execution) or each 10m x 10m, and even 12m x 12m indoors. In the latter case, the proportion of fibres shall be 30 kg/m³.

1. Construction joints
They shall be either keyed or dowelled, with or without angle iron. However, chuted concrete allows the concreting of large surfaces without needing to form construction joints.
2. Contraction joints
Joints are sawn over $\frac{1}{4}$ of the thickness minimum.
3. Separation joints
Joints shall be formed around hard zones: stringers, footings, columns.
4. Expansion joints
Expansion joints shall be avoided, as far as practicable, in covered slabs where no major temperature variations are observed.

Design of concrete pavement

According to each case, the Engineer shall determine the sizing of works.

- Westergaard modulus of subgrade reaction
- Exact definition and location of applied loads.

The maximum strengths used for calculation of concrete are conditional upon the proportion of reinforcing fibres and tabulated hereunder:

Proportion	20 kg/m³	25 kg/m³	30 kg/m³	35 kg/m³	40 kg/m³
Allowable σ (MPa)	2.8	3.2	3.5	3.7	3.9

Controls

The user of metallic fibre concrete shall establish a self-control procedure concerning the following:

1) Taking over of support ground

The user shall take over the foundation ground in order to make sure that the slab is homogeneous and true to the adopted assumptions.

(Westergaard modules $> 30 \text{ MPa/m} = 3 \text{ bar/cm}$)

A membrane may be placed to prevent contamination with fine particles especially in silty soils or saturated with water.

It may be necessary to insert a polyethylene sheet (150 microns minimum thick) between the foundation ground and the slab to:

- a) separate the slab from the foundation ground and facilitate sliding
- b) avoid infiltration of water or laitance into the foundation ground.
- c) avoid rising of underground water

2) Concrete quality

The user shall check the composition of concrete at the time of manufacture in the batching-mixing plant or when delivered on site, and make sure that grading curves are consistent with the present technical specifications document.

The user shall check the workability of the various types of concrete mentioned above through a slump test prior to and after placing of fibres.

According to the placement method, the user shall carry out a self control on the quantity of used fibres with regard to the volume of placed concrete, and verify that concrete is free of “urchins”.

3) Mechanical strengths

Verifications shall be performed according to “the Professional Rules for Pavement Works”. The user shall namely verify:

- Quality of plain concrete (tensile bending strength ≥ 3.4 MPa)
- Mechanical strength of concrete; the performances level defined above being checked out.
- Tests shall be carried out on prismatic samples 4cm x 14cm x 56cm

- Such verifications shall be carried out:
 - at the concrete factory during the self control. The proportion of added fibres shall be determined on the delivery notes.
 - and, on site, by the Contractor, prior to placing concrete as per the Technical Specifications.

Workmanship

The works shall be carried out by the Contractor. The Contractor shall comply with the technical specifications and the Special Specifications provided by the manufacturer.

The pavement slab shall not be used before:

48 hours after placing concrete for light pedestrian traffic

7 days after placing concrete for light traffic

28 days after placing concrete for normal traffic.

All workmanship details shall be in accordance with the requirements of all concrete sections mentioned in these specifications.

202.2 MATERIALS FOR CONCRETE -

202.2.1 Cement

Cement shall comply with one of the following sub-Clauses (i) to (iv) below:

- (i) BS 12 (Ordinary and rapid-hardening Portland cement).
- (ii) BS 146 (Portland-blastfurnace cement).

- (iii) BS 4027 (Sulphate resisting Portland cement).
- (iv) BS 6588 (Portland pulverised-fuel ash cement) provided that sub-Clause (vii) below is complied with.
- (v) A mixture of BS 12 (Portland cement) and BS 3892: Part 1 (Pulverised-fuel ash for use in structural concrete) provided that the amount of pulverised-fuel ash is not less than 15% nor more than 35% by weight of the total cement and sub-Clause (vii) below is complied with.
- (vi) A mixture of BS 12 (Portland cement) and BS 6699 (Ground granulated blastfurnace slag for use with Portland cement) provided that the amount of slag is not more than 65% by weight of the total cement.
- (vii) The pulverised-fuel ash used shall have a maximum colour index of 6 (Colour Comparator disc reference No. 296570) when measured using the Lovibond Colour Comparator system as recommended in BS 3892: Part 1 Appendix H, Clause H8.

The Concrete Cement used for Concrete Structure in contact with wastewater shall be Sulphate resisting Portland Cement and in accordance with BS 4027.

Consignments of any cement shall be used in the order in which they are received. Any cement stored on the site over three months may be rejected by the Engineer. Should the quality of the cement be adversely affected by dampness or any other cause the cement shall be removed from the site.

Each shipment of cement shall be stored so that it may readily be distinguished from other shipments. The cement shall be free form lumps and shall be otherwise undamaged when used in concrete.

Sacked cement shall be delivered to the Site in the sound original bags of the manufacturer and shall be stored in a watertight and weatherproof shed on a floor raised at least 15 cm from the ground. Stacking cement bags to excessive heights they may cause damage to cement or is otherwise undesirable, as determined by the Engineer, will not be permitted.

Bulk cement shall be stored in weatherproof bins or silos to be approved by the Engineer. The bins shall be emptied and cleaned at reasonable intervals as directed by the Engineer.

The quality of each consignment of cement shall be verified by manufacturers' certificates showing the results of tests, as per B.S. 12, appropriate for cement to be used in tropical climates. Where the Engineer so orders, the Contractor shall perform at his own cost additional tests on samples selected by the Engineer, all in accordance with B.S.12.

202.2.2 Water

The water used for mixing concrete shall be of potable quality, free from harmful materials such as clay, loam, acids or trade effluent. River water may be used after its suitability is ascertained beyond doubt by tests according to B.S. 3148. Periodic tests shall be carried out to keep a continuous check on the suitability of such water. The source of the water shall be subject to the Engineer's approval.

202.2.3 Admixtures

Usually the water proof concrete specifications are written aiming to achieve a watertight concrete structures.

But practically the concrete can sometime be very difficult to place.

If agreed by the Engineer, the contractor will be permitted to use concrete with more plastic consistency helping to produce a smoother and denser floor and wall finishes requirements.

In heavy reinforced structures, a good and long workability is also important.

It is impossible to meet the water/cement ration > 0.5 and a good workability requirements at the same time unless concrete admixtures are used.

Contractor may use admixtures and shall use if required by the Engineer admixtures such as:

- Retarder
- Accelerator
- Plasticizer or super plasticizer
- air entraining agent
- water proofing admixtures
- Fluid admixtures
- Anti freeze admixtures

Plasticizer and super plasticizer gives good workability and correct consistency (even for pumped concrete with extended working times) to enable the concrete to be compacted as fully as possible in as short a time as possible with a high reduction in the water/cement ratio.

Retarder

- By the use of suitable retarder the Contractor must obtain that the start of the setting process be delayed from a few hours to a day or more.
- This will permit to fresh concrete to be transported, poured and vibrated over longer periods of time.
- The controlled retardation of the initial set, must not be in no way slow down the subsequent hardening process.
- The period of time during which the concrete can still be vibrated is known as the retardation time.
- The choice of retarder dosage will be made by referring to the dosage chart of the furnisher, preliminary trials may be asked by the Engineer to ascertain the correct dosage for planned retardation.
- Dosage can varies with the type of structure (foundation slab or walls...) and with temperature (ambient air and/or concrete) the Contractor must consult with the Engineer

to either avoid construction joints (cold joints) or to work out a concreting schedule where entire mass of concrete is required to set simultaneously.

Water proofing concrete admixture

A concrete admixture in liquid or powder form can be used by the Contractor as highly efficient water proofing principal agent with a secondary function as plasticizer.

The dosage will correspond to % of the weight of cement.

The admixture must be compatible with the type of cement.

The admixture will be dispensed directly into the mixing water (liquid admixture) prior to its addition to the aggregates /or/ added directly to the dry mixed aggregates.

Other Admixtures

The Contractor will relate to the technical specifications of the admixtures Supplier. Admixtures that contain chlorine will be forbidden.

Admixtures used shall be furnished by the Contractor and the cost of the materials and all costs incidental to their use shall be deemed to be included by the Contractor in his unit rates for concrete and shall not be paid for separately.

202.2.4 Aggregates

Fine and coarse aggregates shall be as defined by and be of the quality and nature required by BS 882 and BS 1201 whichever is applicable. In addition they shall be chemically inert to alkali reaction.

Prior to acceptance of an aggregate as inert to alkali reaction the report of a qualified geologist, appointed by the Engineer on the suitability or otherwise of materials shall be obtained following examination of all types of material that the proposed sources will yield during the course of the contract. The Engineer may require that samples be taken from boreholes and for large contracts or contracts extending over a long period then more than one report is to be obtained.

Aggregates shall conform to the requirements of the "Acceptance Standards" of Table 2.4.

Table 2.4 Sampling, Testing and Acceptance Standards

Materials	Test	Site Sampling	Testing	Accepted Standards	Remarks
1	2	3	4	5	6
CEMENT	Ordinary Portland Rapid Hardening Sulphate Resisting		BS 4550	BS 12 BS 12 BS 4027	Manufacturer's Test Certificates
AGGREGATES	Description and Classification		BS 812 Section 2	BS 882	Whichever is applicable
	Particle size	BS 812 Sec.1	BS 812 Sec.3	BS 882)
	Particle Shape	BS 812 Sec.1	Visual & BS 812 Sec.3) Mix Design
	Sp. Gravity	BS 812 Sec.1	BS 812 Sec.3) Requirements
	Density	BS 812 Sec.1	BS 812 Sec.3)
	Voids	BS 812 Sec.1	BS 812 Sec.4)
	Absorption	BS 812 Sec.1	BS 812 Sec.4	BS 8007 CI. 6.2.2.	See Freeze-thaw Test in this Table
	Organic Impurities	BS 812 Sec.5			
	Moisture Content	BS 812 Sec.5			For adjustment of added water for concrete making
	Mechanical Properties	BS 812 Sec.6	BS 882		Ten per cent fines value
WATER	Suitability	BS 3148	BS 3148	BS 2138	Not required for potable water
CONCRETE	Compacting Factor	BS 1881	BS 1881 Pt 103)) Workability Test
	Slump	Pt 101	BS 1881 Pt 102))
	Crushing		BS 1881	BS 5328, BS 8110	Cube test
	Water Absorption		BS 1881 Pt 122	BS 340 Para 19 (b)	Precast concrete CI. 3.8
	Freeze-thaw	BS 1881			Durability test for aggregate not complying with moisture absorption requirements of BS 5337 CI, 21.2
	Electrolytic Efflorescence				As required for salt containing aggregate or saline water
	Cores	BS 1881 Pt 6 BS 1881	BS 1881 Pt 6 BS 1881	BS 1881 Pt 120 with strength specified on drawings	
ADMIXES with cement	Compatibility by Laboratory	As required			Tests to be carried out by independent Laboratory as required.

(a) General:

Aggregates for concrete shall be fine aggregate and coarse aggregate and shall be supplied by the contractor from approved sources, but the approval of any source by the Engineer shall not be construed as approval of all materials taken from that source, and the Contractor will be held responsible for the specified quality of all materials used in the work and for their being equal to the approved samples.

The Engineer, at the Contractor's expense, will test the aggregates and the Contractor shall provide such facilities as may be necessary for procuring representative test samples. The Contractor shall submit, for preliminary tests and approval, representative samples of 100 kg each of fine aggregate and of each size of coarse aggregate proposed for use in the work at least 30 days before the aggregates are required for use.

Should the Engineer reject any sample furnished by the Contractor, the Contractor shall immediately supply a sample or samples from some other source until all samples are approved by the Engineer.

Those samples which have been finally approved by the Engineer as meeting the requirements of the Specification shall be kept on the Site until the completion of all

concrete work and all aggregates brought to the Site shall be compared with such approved samples.

Any aggregate rejected by the Engineer shall be immediately removed from the Site, unless the Engineer shall permit its use after undergoing further treatment by washing and or screening in order to bring it up to standard.

The aggregates shall be brought to the Site in separate loads, each containing aggregates of one size. The aggregates shall be stored in such a way as to prevent aggregates of different sizes from being mixed together in storage. Aggregates mixed either in transport or on Site will be rejected.

(b) Fine Aggregate:

Fine aggregate for concrete shall be natural sand (but not beach sand) or a mixture of natural sand and fine crushed stone. It shall meet the requirements of B.S. 882 and its grading shall be within the limits of one of grading zones 1, 2 or 3 given in Table 2 of B.S.882. In addition, it shall have a specific gravity of not less than 2.5, shall not contain more than 5 percent by volume of shells or shell fragments. The fine aggregate delivered to the batching plant shall have a uniform and stable moisture content.

When necessary, or when required by the Engineer, all fine aggregate shall be washed in clean water, before being incorporated in the Works.

(c) Coarse Aggregate:

The coarse aggregate for concrete shall be natural gravel or crushed stone. It shall consist of hard, dense, durable uncoated rock fragments and shall meet the requirements of B.S. 882.

Coarse aggregate for reinforced concrete shall be either graded aggregate or made up of a number of single size aggregates, with the largest particles not exceeding the following sizes:

- (a) 40mm, or
- (b) 1/3 of the smallest thickness of concrete members, or
- (c) 3/4 of the smallest space between reinforcement bars, whichever is the smallest.

Coarse aggregate for non-reinforced concrete may contain particles up to 3"

The grading of coarse shall lie within the limits given in Table 1 of B.S. 882. The exact sizes of the coarse aggregate and the grading to be used shall be determined as part of the mix design in accordance with Subsection 202.1.3.

All aggregates shall be approved by the Engineer.

202.3 BATCHING AND MIXING

202.3.1 Batching

The Contractor shall provide equipment and shall maintain and operate the equipment as required to accurately determine and control the amount of each separate ingredient entering the concrete. For concrete Class C20P and higher, the amounts of sand, bulk cement and each size of coarse aggregate entering each batch of concrete shall be determined by weighing, and the amount of water shall be determined by weighing or volumetric measurement. Where sacked cement is used, the amount of cement entering the mixture shall be determined on the basis of integral sacks of cement and the use of cement from torn bags shall not be permitted.

For concrete Class C15P and lower, the Engineer may permit volumetric measurement of aggregates.

All weighing equipment shall be subject to the Engineer's approval. An accuracy to within 0.4 percent of the scale capacity will be satisfactory, and the equipment shall be capable of ready adjustment for compensating for the varying weight of any moisture contained in the aggregates and for effecting changes in concrete mix proportions. The Contractor shall make such adjustments, repairs, or replacements as may be necessary to meet the specified requirements for accuracy of measurement. Each dial, indicator and other measuring device shall be in full view of the operator.

Where batching by volume is permitted by the Engineer, only precisely dimensioned gauge boxes approved by the Engineer shall be used for the sand and different sizes of aggregates. After filling the box the aggregate shall be struck off level with the brim. Sand shall be poured or shovelled into the gauge boxes without compacting. All gauge boxes shall bear marks in red oil paint showing the kind and size of aggregate for which each box is to be used. No boxes similar in shape and appearance but different in volume from the approved gauge boxes shall be kept on the Site.

202.3.2 Mixing

The materials shall, unless otherwise directed by the Engineer, be mixed in approved mechanical batch mixers. In each case, the number and capacity of mixers employed shall be sufficient for the concreting operations being undertaken, shall allow for sufficient reserve capacity at all times and shall be subject to the approval of the Engineer.

The mixing shall continue until there is a uniform distribution of the materials and the mass is uniform in colour and consistency, but in no case shall the mixing be for less than 2 minutes after all the ingredients are in the mixer. Water shall be added prior to, during and following the mixer-charging operations. Overmixing requiring the addition of water to preserve the required concrete consistency will not be permitted.

No dry material shall be introduced into a mixer until all material from the previous batch has been removed and the interior of the mixing drum has been cleaned of encrustations of concrete or mortar. Remixing of concrete or the addition of water to a mixture that has already begun to set or that is otherwise unsuitable for casting shall not be permitted and such concrete shall be wasted. When a concrete mixer has been out of use for more than 20 minutes, or when the type of cement is changed, the mixer shall be thoroughly cleaned before a fresh batch of concrete is made in it.

The Engineer may in exceptional cases permit hand mixing of lean and other non-reinforced concrete. No hand mixing shall be done unless authorised in writing by the Engineer. The batches in hand mixing shall not exceed 1/6 of a cu.m. Hand mixed concrete shall not be used until the mixing of the whole batch has been completed and the concrete is of uniform colour and consistency. Hand mixing shall be done twice on dry aggregate, and at least twice wet, on a clean and even surface, which will prevent the loss of water during mixing. The water added shall be measured in order to prevent the use of an excessive quantity of water.

When mixing by hand, the quantity of cement shall be increased by 10% above that specified above in Section 202.3.

202.4 PLACING AND CURING

202.4.1 Preparations for Placing

No concrete shall be placed until the Engineer has approved the formwork and reinforcement. The Contractor shall give at least 48 hours notice to the Engineer of the times he proposes to concrete and no concreting shall take place unless either the Engineer or his Representative is present.

Concrete shall be placed only in the presence of the Engineer or his duly authorized Representative, unless written permission has been given by the Engineer to place concrete without himself being present or represented. The Contractor shall give the Engineer not less than 48 hours notice before the day on which he intends to commence placement of concrete in any structure or substantial part thereof.

No concrete shall be placed until all reinforcement, formwork, parts to be embedded, and preparation of surfaces involved in the placing have been approved.

All surfaces of forms and embedded materials shall be clean and free from dried mortar which may have encrusted them from previously placed concrete.

All surfaces of foundations and areas upon or against which concrete is to be placed shall be free from standing water (except for concrete required to be placed under water), mud, debris, oil, objectionable coatings and loose, semi-detached or unsound fragments. Absorptive surfaces shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete. On surfaces of rock upon or against which concrete is to be placed, a 2 cm layer of 1:3 cement mortar shall be spread immediately prior to placing concrete and shall be well worked into the surface with the aid of brushes. Care shall be taken that the mortar does in no case set before concrete is placed on it. The cost of such mortar and its spreading shall be deemed to be included in the rates for concrete.

202.4.2 Transporting and Placing

The methods and equipment used and the speed required for transporting concrete shall be such that concrete having the required composition and constancy will be delivered into the work, without objectionable segregation, loss of slump, and delay. Except as otherwise specified for ready-mixed concrete, the time elapsed between the first wetting of concrete ingredients and the completion of placing the concrete in the work shall in no instance exceed 30 minutes. Retempering of concrete will not be permitted. Any concrete which has become so stiff that proper placing cannot be assured shall be wasted.

Concrete shall be deposited as far as practicable directly in its final position and shall not be placed in a manner permitting or causing segregation. The Contractor shall provide suitable openings in the formwork and/or drop chutes and baffles to confirm and control the falling of concrete, and to limit its free drop to a maximum of 1.50 meters.

Except as intersected by joints, all formed concrete shall be placed in continuous approximately horizontal layers, the depths of which shall not exceed 60 cm, in such a manner that no layer of concrete will begin setting before the next layer is placed on top of it. In no case shall the delay between the placing of any two adjacent layers be such that the vibrating unit will not readily penetrate of its own weight the concrete placed before the delay.

Concreting shall be carried out continuously between and up to joints, the position and arrangement of which shall be predetermined and no interruption of placing other than at these joints will be permitted. To this end, the Contractor shall take all necessary measures, such as preparing a sufficient stock of materials, stand-by equipment, shift-work, lighting for night-work, etc.

In the event of unavoidable stoppage in positions not predetermined, the concrete shall be terminated on horizontal planes and against vertical surfaces and construction joints shall be prepared according to Subsection 202.5.1. Where required the Contractor shall also provide keyways, dowels, and/or waterstops to ensure a perfect bond and/or watertightness at the joint.

Where the concrete abuts against earth or any other material liable to become loose, the greatest possible care shall be taken to avoid falls or run of such or other materials upon the surface of the concrete, and if any such falls or runs occur the surface of the work soiled thereby shall be removed until a new and clean surface shall have been obtained, and all spaces left by such falls or runs beyond the prescribed dimensions of the work, or caused by the negligence or for the convenience of the Contractor, shall be built up with concrete at the discretion of the Engineer, and the additional cost so incurred shall be held to be included in the Contractor's rates in the Bill of Quantities for work within the original Contract limits.

No concrete shall be placed in water, except with the written permission of the Engineer, and the method of depositing the concrete shall be subject to his approval. Concrete shall not be placed in running water and shall not be subjected to the action of running water until after the concrete has hardened.

Surfaces of rock upon or against which concrete is to be placed, shall be prepared and cleaned as specified and placing of concrete shall be carried out as detailed below for construction joints.

No concrete shall be placed when the ambient temperature at the time of placing and/or 2 hours thereafter is expected to be below 4°C. The temperature of the concrete when being placed shall not exceed 32°C.

In hot weather when the temperature of the concrete is liable, in the opinion of the Engineer, to rise above 32°C, the Contractor shall, at his own expense, employ effective means, to the satisfaction of the Engineer, for reducing the temperature in the mix, such as sprinkling of water on the aggregate, protection of the water lines from the sun, painting of mixers and water tanks with light-reflecting paint and/or placing them in shadow, or by adding crushed

ice to the water in a proportion not exceeding 50% of the water. The addition of ice will be permitted only if it has been proved to the satisfaction of the Engineer's Representative that all other means for the reduction of temperature are insufficient.

1) Hot weather concreting

Heat accelerates the hydration reaction of cements, thus it increases the heat of hydration and accordingly, shrinkage and cracks are likely to occur. It is necessary to abide by the following measures:

- a) Use concrete as compact as possible.
- b) Use cement of low heat of hydration.
- c) Reduce the cement dosage as far as practicable according to the requested characteristics of concrete.
- d) Use a water reducing plasticizer in order to reduce the quantity of mixing water (0.5 to 0.75 in weight of cement).
- e) Use a setting retarder which increases the heat of hydration time.
- f) Cool concrete constituents. This is an expensive method, but gives the best results.
- g) moisturize the hardened concrete on which fresh concrete shall be placed in order to avoid loss of water.
- h) Cover the structures after concreting, in order to prevent water evaporation from fresh concrete.
- i) Use Antisol-E which protects concrete from desiccation (suppress the use of damp coverings, watering, etc...).

2) Cold weather concreting

When concreting in cold weather, and in order to prevent having a frozen and porous concrete, plasticizers and water reducing admixtures shall be used to reduce the quantity of mixing water, while preserving the workability of fresh concrete at an acceptable degree.

Low temperature slows down the reaction of hydration of cement and therefore, delays formworks removal. The following precautions shall be taken:

- a) Use a quick setting cement
- b) Increase the C/W ration (plasticizer - water reducer)
- c) Heat the materials (water + aggregates). However, the temperature of concrete shall not exceed 30°C.
- d) Use isolating formworks (wood, panels coated with expanded polystyrene, etc..)
- e) Protect fresh concrete with thick dry covers.
- f) Heat concrete eventually (hot formworks).
- g) Use antifrost products (1% in weight of cement).

No concrete shall be placed when the ambient temperature is -0°C.

Placing concrete at a temperature below + 5°C is allowed provided that the above mentioned precautions are respected and upon the prior approval of the Engineer.

3) Concreting under water

When fresh concrete is to be placed under a water in motion (currents, waves,...) adequate measures shall be taken to prevent the washing out of concrete and carrying away of mortar.

Concrete shall be conveyed via a tight chute avoiding the contact of concrete with water and placed inside an underwater formwork. In this way, only the upper section of concrete shall be wasted out and it is removed once hardened by a pneumatic drill.

While concreting, the Contractor shall control the height of concrete at the bottom of the formwork and in the chute as well as the length of chute entering in the poured concrete mass in order to prevent any sudden depositing of concrete which might cause water intrusion and stoppage of work. Throughout concreting works, the chute shall be raised progressively.

4) Concreting under sea water

Sea water has two major effects on works:

- a) Dynamic effect of waves
- b) corrosive effect of salt on concrete and reinforcing bars.

Structures shall be oversized and designed to have high strength. Massive elements shall be concreted. Thin walls and frail beams are to be avoided. A thick sufficient cover of a compact concrete shall be provided around reinforcement in such a way as to ensure waterproofness and avoid capillary attraction.

The cover shall be at least equal to 4 cm, and may be increased if this minimum distance cannot be ensured in all points. Concrete shall be richly batched with a minimum cement proportion of $c \geq \frac{700}{\sqrt[5]{D}}$

Sulfate in sea water reacts with tricalcic aluminate in cement and form Candlot salt which attacks concrete. Therefore, a sea water concrete containing a high proportion of clinker cement shall be used in lieu of Portland cement.

Sharp arises and peaks which are attacked easily by sea water shall be bevelled and their angles rounded off. While placing, segregation and excess water which increase porosity and contraction shall be avoided. A plasticized concrete shall be preferably used provided it does not have a too high slump and can be adequately consolidated by a proper vibration.

The external surface of concrete shall not receive any further treatment like roughening, sandblasting, washing... As far as practicable, concreting shall not be interrupted. Should stoppages be unavoidable, the surfaces of joints shall be rendered with an epoxy based mortar or Thiokol.

The cost of all work described in this Subsection shall be deemed to be included by the Contractor in his unit rates for the various items of concrete work in the Bill of Quantities and shall not be paid for separately. The Contractor shall not be entitled to any additional payment over the rates bid for concrete by reason of any limitations in the placing and concreting required in this Subsection.

202.4.3 Consolidation of Concrete (Vibration)

Each layer of concrete shall be consolidated to the maximum practicable density, so that it is free from pockets of coarse aggregate and closes snugly against all surfaces of forms and embedded materials.

Concrete Class C15P and less may be consolidated by spading, hand-tamping, or by mechanical vibration as described below. All concrete Class C20P and higher shall be consolidated by power-driven immersion (“needle”) type vibrators having a frequency of not less than 9000 oscillations per minute. The vibrators shall be inserted into the concrete at intervals not exceeding 50 cm and shall be allowed to penetrate and revibrate the concrete in the upper portion of the underlying layer.

On slabs not exceeding 25 cm in thickness the use of flat surface tamping vibrators with a frequency of not less than 5000 oscillations per minute will be permitted, provided that it is supplemented by immersion vibrators adjacent to the forms and to concentrations of reinforcement bars.

On walls not exceeding 20 cm in thickness external vibrators, fixed to the forms, will be permitted. External vibrators shall be raised in lifts as the filling of the forms proceeds each lift being not more than the height of concrete visibly affected by the vibration. They shall be placed horizontally, at distances not greater apart than the radius through which the concrete is visibly affected.

The types, sizes and numbers of vibrators shall be subject to the approval of the Engineer.

At least one stand-by unit of each vibrator type and ample spare parts for all types employed shall be available on Site during placing of concrete to ensure continuous placing with no stoppage due to breakdowns.

The vibrators shall be applied in each position for as long as required for the concrete to become uniformly plastic and shall be withdrawn as soon as water appears on the surface. Systematic spacing of insertion of the vibrators in the concrete shall be established to ensure that no concrete remains unvibrated. Care shall be exercised to avoid contact of the vibrating heads with the surfaces of the forms and the reinforcing bars or other embedded material. The vibration shall everywhere be supplemented by hand spading. Vibration shall never be used to cause concrete to flow in a lateral direction, as this will lead to segregation.

The cost of all consolidation shall be deemed to be included in the Contractor’s rates for concrete.

202.4.4 Finishing of Concrete Surfaces

Formed concrete surfaces, i.e. surfaces cast against forms, shall receive the required smoothness and texture by the use of appropriate forms as specified under Section 202.10. After removal of forms and the specified curing all fins and offsets caused by misaligned or defective form boarding shall be removed. Tie wires shall be cut back to at least 15 mm below the concrete surface and the resulting depressions as well as the holes left after the removal of tie rod fasteners shall be filled with non-shrinking cement mortar and finished flush with the surrounding areas.

Where the concrete surfaces will be permanently exposed to view, the ground and filled areas shall have the same colour, texture and degree of smoothness as the surrounding concrete surfaces. Honeycombed areas and other major defects in concrete shall be repaired as specified in Section 202.7 hereinafter, and the repaired areas given the required finish.

Unformed concrete surfaces that are to be covered shall require no other finishing than sufficient levelling and screeding to produce an even uniform surface. Unformed concrete surfaces that are to remain permanently exposed shall be given a floated surface, unless a trowelled finish as described below is required. Floated finish shall consist of levelling and screeding to even and uniform surfaces followed by floating without the addition of any topping as soon as the screeded surface has stiffened sufficiently. Floating shall be done to the minimum required to produce a surface that is free from screed marks and is uniform in texture. The finish shall be given a final touch-up with a wooden float at an appropriate time after completion of the initial floating.

Trowel finish shall be applied to unformed concrete surfaces that will be in contact with liquids and elsewhere as shown on the Drawings or ordered by the Engineer. When the surface screeded and floated as described above has hardened sufficiently to prevent excess of fine material to be drawn to the surface, steel trowelling shall be started. Steel trowelling shall be performed with firm pressure, such as will flatten the sandy texture of the floated surface and produce a dense uniform surface, free from blemishes and trowel marks. Where required, trowelling shall be done with the addition of a certain amount of cement as specified in the Particular Specification or Bill of Quantities.

Unless otherwise specified or shown on the Drawings, all exterior angles shall be chamfered to the approval of the Engineer. The cost of Floated Finish, Trowel Finish and Chamfers shall be deemed to be included in the unit rates for concrete work and shall not be paid for separately.

202.4.5 Curing of Concrete

From casting until the end of the specified minimum curing period, the concrete shall be kept constantly moist and adequately protected against damage due to fluctuation in surface temperatures. Immediately after casting, the exposed surface of the concrete shall be covered to prevent drying and to minimize temperature variations, until the commencement of curing at an age of not more than 20 hours. Curing of formed surfaces shall commence as soon as the formwork is removed. During curing the concrete shall be kept suitably moist by:

1. Direct application of water at ambient temperature, e.g. by spray or by ponding, or,
2. Covering with absorptive material, e.g. sand or hessian, kept constantly damp.
Ventilation of any gap between the material and the concrete should be prevented so as to maintain nearsaturated conditions in the air within the gap, or
3. When specifically permitted in writing by the Engineer, by sealing the surface of the concrete, before it has lost any of its original water by evaporation, by means of a sealing membrane which will effectively prevent any loss of water from the concrete. The sealing compound shall be white-pigmented and shall conform to Standard Specification for Liquid Membrane forming Compound for Curing Concrete, ASTM Designation C309 latest edition, or to another standard acceptable to the Engineer. The type and make of sealing compound and its form of application and use shall be subject to the approval of the Engineer. Membrane curing shall not be used on surfaces upon or against which concrete is to be cast or which are to be plastered or painted.

The cost of curing shall be deemed to be included by the Contractor in his unit rates for concrete and shall not be paid for separately.

202.5 CONTRACTION AND EXPANSION JOINTS

202.5.1 Contraction Joints

The position of construction joints will be as specified in the drawings by the designer. If there is a need on site to revise any specified position /or/ to have additional construction joints the proposed positions should be agreed with the Engineer.

Full structural continuity must be assumed in design at a construction joint. Reinforcement will be fully continuous across the joint, and the concrete is taken to be as nearly monolithic as possible.

The concrete at the joints should be bonded with the one subsequently placed against it, without provision for relative movement between the two.

Concrete should not be allowed to run to a feather edge, and vertical joints should be formed against a stop end. Particular care should be taken when framing the joint.

The surface of the first pour should be roughened to increase the bond strength and to provide aggregate interlock.

With horizontal joints, the joint surface should be roughened without disturbing the coarse aggregate particles, by spraying the joint surface approximately 2h to 4h after the concrete is placed, with a fine spray water and/or brushing with stiff brush.

Vertical joints can be treated similarly, if the use of a retarder on the top is authorised, to enable the joint surface to be treated after the stop end has been removed.

If the joint surface is not roughened until the concrete has hardened, the larger aggregate particles near the surface should be exposed by sand blasting or by applying a scaling hammer or other mechanical advice.

Care should be taken that the joint surface is clean immediately before the fresh concrete is placed against the old one. It may need to be dampened prior to the new concrete being placed, to prevent excessive loss of mix water into it by absorption.

Particular care should be taken in placing of new concrete close to the joint to ensure that it has adequate fines content and is fully compacted and dense.

N.B. When instructed by the Engineer in designing construction joints for retaining aqueous liquids it is necessary to incorporate waterstops in properly constructed joints.

Construction joints shall be formed only in the positions shown in the drawings or indicated by the Engineer and concreting shall be carried out continuously between and up to joints.

All intersections of construction joints, permanently exposed, shall be made absolutely straight and level or plumb and matching with adjacent members.

Construction joint shall be formed at right angles to the axis of the member concerned, by the insertion of rigid stopping-off forms in the case of horizontal or inclined members.

The upper surface of lifts of concrete in walls and columns shall be horizontal.

The surface of the stopping-off form /or/ the horizontal surface shall be indented to produce a key the old and new work.

The face of the horizontal joints brushed and roughened shall be rendered with a 1.0 to 1.5 cm thick layer of cement-sand mortar having the same relative proportions of cement and sand (without coarse aggregate) and the same water-cement ratio as the concrete to be placed upon it, and the new concrete shall then be laid immediately upon it and thoroughly punned in.

Where joints will be permanently visible, the mortar shall be kept back at least 25mm from the exposed face.

In the case of vertical joint the face shall be rendered with a coat of neat cement placed immediately before each fresh lift of new concrete.

NB: No Day Joints /or/ Stopping-off joints will be permitted in water retaining structures. Pouring operations shall be continuous between joints as shown in the drawings.

The Contractor shall have sufficient materials and standby equipment to meet these requirements.

Where due to accident or breakdown it is impossible to continue concreting, the Engineer /or/ his Representative shall be immediately notified and his verbal instructions which shall be confirmed in writing as soon as possible, regarding either the making of a construction joint /or/ the taking out of new concrete back to the last construction joints, shall be complied with immediately.

Construction joints in wall

Where the wall is designed to be monolithic with the base slab, a kicker should be cast at the same time as, and integrally with the slab.

The height of the kicker should be at least 75mm to enable the next lift of formwork to fit tightly and to avoid leakage of cement grout from the newly deposited concreted.

The joint in this position will be a construction joint, and although it is recommended that wall panels are cast in one lift, any necessary extra horizontal joints will be construction joints when approved by the Engineer on site.

Circular Structures retaining liquid

One of the predominant forces from the liquid pressure is horizontal hoop tension (circular tension). For structural design purposes the horizontal reinforcement should be completely continuous at vertical joints.

A central waterstop should be used together with sealing compounds on both faces, whether or not any attempt is made to achieve concrete continuity.

Joints in roof

Roof slab when designed as flat slab has generally all interior joints treated as construction joints so that the slab is structurally monolithic and early thermal effects and subsequent temperature effects should be considered.

If the roof is connected monolithically to the wall the subsequent temperature effects may be disregarded.

If provision is made by means of sliding joints for movement between the roof and walls, correspondence of joints in roof and walls is not to be considered eventually.

Temporary open sections in rectangular tank

When structural continuity is required in the final structure (wall of a rectangular tank) the amount of reinforcement required to control early thermal effects may be reduced by the use of temporary open sections by the contractor after obtaining the agreement of the Engineer for such operation.

The width of the open section between adjacent panels should be no greater than 1000mm.

Properly formed construction joints should be provided at each end of the temporary open section with the longitudinal reinforcement from each adjacent panel, lapping in this area.

Sufficient time should be allowed for all the early thermal movement to take place before the open section is infilled by the Contractor.

The surface of the concrete first placed at a contraction joint shall be coated, before the concrete on the other side of the joint is placed, with an approved bituminous paint or with a sealing compound as specified in Subsection 202.4.5 . Where a water stop is inserted in the contraction joint, great care should be taken to prevent any paint or sealing compound from coming into contact with the half of the waterstop width protruding from the first-placed concrete. Any paint or sealing compound which will come into contact with the waterstop shall be immediately cleaned off.

202.5.2 Expansion Joints

For concrete structures retaining aqueous liquid, all eventual expansion joints are designed to accommodate repeated movement of the structure without loss of liquid.

The joint is designed to suit the characteristics of the material available and should also provide for the exclusion of grit and debris that would prevent the closing of the joint.

Detailing of places where the joint changes direction /or/ intersects with another joint should be uncomplicated.

The expansion joint:

At an expansion joint the Contractor shall provide a complete discontinuity in both reinforcement and concrete.

An initial gap should be provided between adjoining parts of the structure to accommodate the expansion /or/ contraction of the structure.

Waterstop, joint fillers and joint sealing compounds are essential.

The Joint Filler

An elastic joint filler material cut in sheets of the thickness specified and/or shown on the drawings, shall be:

- either placed in the forms before the first placed concrete is cast.
- or, may be attached to the first placed concrete surface means approved by the Engineer.

The elastic filler materials shall be of a quality approved by the Engineer and shall conform to US Federal Specification H-H-F-341a, or to a similar approved standard.

Where the exposed sides of the joint are filled with an elastic joint sealant approved by the Engineer, sheets of foamed polystyrene may be substituted for the above described elastic filler.

The sheet of filler material, shall be cut to fit the entire contact surfaces of the complete side of the joint.

Where a waterstop is installed in the joint, the filler materials shall be placed on both sides of the waterstop so as to fit snugly about the bulb of the waterstop.

Except where a groove for joint sealant is to be formed, the edges of the filler materials shall be placed flush with the finished surface of the concrete /or/ the bottom of the chamfers.

Joints in the filler shall be made tight so that mortar from the concrete will not seep through to the opposite concrete surface.

N.B.: Joint sealing compound cannot be expected to provide a liquid-tight seal for more than a proportion of the life of the structure and waterstops should always be provided in movement joints by the Contractor and installation must follow the recommendations of the manufacturer.

202.5.3 Elastic Joint Sealant

Where shown in the Drawings, the groove formed on the exposed side of contraction or expansion joints shall be filled with an elastic joint sealant meeting the requirements of ASTM Designation D-1850. The joint sealant is supplied in two components, base and accelerator, which are mixed together only immediately before use. Flow type sealant shall be used on horizontal or nearly horizontal surfaces, and heavy type on inclined and vertical surfaces. If required by the manufacturer, a suitable primer shall be applied on the joint surfaces prior to the filling of the groove and the time elapsing between the application of the primer and the placing of the joint sealant shall not exceed the maximum prescribed by the

manufacturer. Care shall be taken that the mixed compound is used before the expiry of its pot-life as indicated by the manufacturer.

Prior to the application of the primer (if any) and the placing of the joint sealant, the groove shall be thoroughly cleaned, flushed with a jet of water and finally cleaned and dried with compressed air. The joint sealant shall be placed immediately after mixing of the two components, by means of a caulking gun so as to fill the joint groove completely and tightly, without leaving any depressions, voids or air bubbles. The joint filling shall be finished neatly and flush with the concrete surfaces by means of a spatula or similar tool.

202.5.4 Payment for Joints

Unless specific items are included in the Bill of Quantities, the cost of all work and materials for making construction, contraction and expansion joints shall be deemed to be included in the rates for the concrete work and shall not be paid for separately.

202.6 TOLERANCES FOR CONCRETE STRUCTURES

The maximum permitted variation from the design dimension shown on the Drawings or ordered by the Engineer shall be as follows :

- | | |
|--|--|
| 1. Variation from the plumb : | |
| a- In the lines and surfaces of columns, piers, walls and arises | In any storey or
5 m maximum 10 mm
15 m or more 25 mm |
| b- For exposed corner columns, construction-joint grooves, and other conspicuous | 1/2 of the above amount |
| 2. Variation from the level or from the grades indicated on the Drawings : | |
| a- In floor and beam soffits | In 3 m 5 mm
In any bay or
5 m maximum ... 10 mm
In 10 m or more 20 mm |
| b- For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines | 1/2 of the above amount |
| 3. Variation of the building lines from established position in plan and related position of columns, walls and partitions | In any bay or
5 m maximum 5 mm
In 10 m or more 20 mm |
| 4. Variation in the size and location of sleeves, floor openings and wall openings | 10 mm |
| 5. Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls | Minus 5 mm
Plus 5 mm |
| 6. Footings : | |

a- Variation of dimensions on plan	Minus 10 mm Plus 10 mm
b- Misplacement or eccentricity	2 percent of the footing width in the direction of misplacement but not more than 50 mm
c- Reduction in thickness	Minus 5 percent of specified thickness but not more than 50 mm
7. Placing of Reinforcement Steel :	
a- Variation of protective cover	With cover up to 8 cm 5 mm 8 cm and more 10 mm
b- Variation from indicated spacing, provided that average spacing and total quantity of steel are not affected 25 mm

202.7 REPAIR OF CONCRETE

202.7.1 General

Repair of concrete where permitted by the Engineer shall be performed. The Contractor shall correct all imperfections on the concrete to the satisfaction of the Engineer.

202.7.2 Concrete Repairs in “Rehabilitation Works”

Many factors can lead to defects in old concrete structures which will manifest themselves sooner /or/ later depending on the aggressivity of the environment.

The visible manifestation of the defects is commonly referred to a damage.

- A defect exists where a structure, member, or building material is permanently subjected to stresses or aggressive conditions which exceed its load bearing capacity or resistance.
- The damage is the consequence of that defect and normally manifests itself at the surface of the concrete, it may however lie concealed beneath the undisturbed surface of the concrete.

The Contractor is invited not to simply repair the damage because this does not by itself suffice to eradicate the defect which caused it.

Precautions must therefore be taken by the Contractor to prevent a recurrence of damage caused by the same defect.

In most cases this is achieved by treating the surface of the concrete with an additional form of protective treatment: Repair protection: is the formula for successful remedial actions.

The Contractor must visit all the site and for each structure:

- Identify the various stress factors that can cause damage to concrete structure.
- Give guidance in the diagnosis and assessment of such damage.

- Suggest “method of treatment” aiming to eradicate the primary cause or defect.

The Contractor must obtain full agreement from the Engineer for each of these steps.

The Contractor must obtain also previous approval from the Engineer for:

- The products.
- The remedial treatment of concrete.

N.B.: Repairs systems designed to render concrete and reinforced concrete impermeable to water, in existing water retaining structure may be used by the Contractor applying these same procedures.

The main zones to be assessed by the diagnosis can be resumed to:

- 1) Corrosion of steel reinforcement:
 - a) Carbonation
 - b) Infiltration of harmful substances.
 - c) Thickness of concrete cover to the steel reinforcement
- 2) Mechanical influences on concrete:
 - a) Abrasion
- 3) Chemical influences:
 - a) Erosion by dissolution of the material.
 - b) Disruption caused by internal expansion
- 4) Physical influences.
- 5) etc..

a) Objectives and Options of the remedial work

The basic objectives of any remedial work may be defined ideally as the reinstatement of the structure to its original condition and the prevention of future damage arising from the same cause.

Reinstatement means the eradication of damage both visible and invisible and the restoration of the affected member to its original section by making good with new concrete or patching mortar.

Prevention means eradicating the defect by strengthening the affected member, protecting the surface of the concrete and the steel reinforcement or eliminating the stresses that are causing the damage.

The Contractor must minimise the total cost of concrete repairs by:

- Starting the remedial treatment at the earliest possible opportunity.
- Making a correct assessment of the extent of the remedial work required.

A close cooperation with the Site Engineer will facilitate the Contractor options and will minimise the total cost involved.

b) Diagnosis and Analysis of Damage

The first requirement for a lasting repair is to establish the cause and extent of the damage. Unless the cause of damage is known, it is not possible to eradicate the defect.

By establishing the precise extent of the damage the Engineer and the Contractor are in a position to assess the need and urgency for repairs.

The analysis must determine:

- the rusting steel reinforcement zones,
- the depth of carbonation,
- the presence of harmful substances,
- the thickness of the concrete cover,
- the damage to concrete surface,
- the cracking,
- etc...

c) Repairs and Reinstatements

The basic operations involved in repairing concrete damage by the Contractor are as follows:

1) Preparing the concrete substrate by:

- Testing the surface of the concrete,
- Preparing the substrate by:
 - Sand blasting
 - Torching
 - Grinding, scabbing
 - Steam cleaning
 - Water pressure jetting
 - Acid etching.
 - etc...

d) Protecting the steel reinforcement against corrosion

- Derusting of steel reinforcement,
- Preparation of the surface (wire brush, sand blast..)
- Anti-corrosion coating.

e) Patching or resurfacing

- Small areas will be patched,
- Large surfaces will be resurfaced by special non Shrinkable mortar application or by grouting.

f) Crack repairs

Cracks may be treated by:

- filling by injection, or
- impregnating and sealing them with the same material.

g) Protecting concrete against further damage

Concrete can be directly protected against further damage by eradicating the original cause of the damage; however this is rarely accomplished without difficulties, and:

- Protective coating can be applied to the surface of the concrete (preventive action)
- Additional reinforcement can be added to the structure.

202.7.3 Concrete Repairs in New Concrete Works

Any concrete which in the opinion of the Engineer fails to comply entirely with this specification shall be declared defective and shall be cut out, removed from the site and replaced, and any steelwork reinforcement or other material damaged by the cutting and shall be replaced, all at the Contractor's expense.

The Contractor will submit to the Engineer, details of his proposal for rectifying the defects, and shall comply with the Engineer's instructions, regarding the procedure of carrying out the work.

Notwithstanding the Engineer's approval, should the remedial work prove unsatisfactory, the Contractor shall make good the work and bear the whole cost occasioned by the defective work.

Immediately after the forms have been removed, all fins and projections and all timber works at joints shall be removed and rubbed smooth with a carborandum block.

All holes and honeycombing in the surface shall be cleaned out and roughened up to give a good key. These holes shall then be filled with 1:2 cement/sand mortar and after it has thoroughly hardened, the surface shall be rubbed down with a carborandum stone to an even finish.

Concrete filling shall be used for holes extending entirely through the concrete, for holes in which no reinforcement is encountered, and which are greater than 0.20 m² and deeper than 10 cm and for holes with reinforcement concrete which are in area greater than 0.05 m² and which extend beyond reinforcement.

Plastering of smooth concrete surfaces will not be permitted.

All mortar and concrete filling must be non shrinkable and shall be kept constantly moist and protected from drying due to surface temperature and natural ventilation.

All materials, procedures and operations used in the repair of concrete shall be subject to the Engineer's direction. All fillings shall be bonded tightly to the surface of the holes and shall be sound and free from shrinkage cracks and drummy areas after the fillings have been cured and dried.

All repairs of concrete executed by the Contractor shall be deemed to be included in the unit rates for concrete work in the Bill of Quantities and shall not be paid separately.

202.8 TESTING OF CONCRETE

202.8.1 General

Prior to the commencement of work, trial mixes shall be prepared and preliminary tests for workability, compressive strength and impermeability (where required) will be made at an authorized laboratory. The results of these tests will be used in specifying the mix design to

be used by the Contractor. During the progress of work, daily slump tests will be made to ensure that the concrete is dense and of an adequate workability.

With the commencement of concrete placement and on each day concreting, samples shall be taken for testing for compressive strength at the ages and frequencies as prescribed hereafter. Where required, samples shall be taken for impermeability tests. The Engineer shall determine the elements from which concrete samples shall be taken for testing.

202.8.2 Slump Tests

The slump measured in accordance with B.S. 1881 shall not exceed 5 cm in concrete for foundations and horizontal or inclined slabs and shall not exceed 10 cm in other parts of the structures, unless otherwise specified or directed by the Engineer. Slump tests shall be made as directed by the Engineer.

202.8.3 Compressive Strength Tests

For testing the compressive strength of concrete, samples of fresh concrete shall be taken and used for preparing test cubes. The cubes shall be tested for compressive strength after 7 days and 28 days. The dimensions of the cubes and the methods of sampling and testing shall be in accordance with B.S. 1881. The cubes shall be marked and dispatched to the laboratory according to the instructions of the Engineer and at such intervals as may be specified by him.

Unless otherwise specified or directed by the Engineer, at least three samples shall be taken from different batches on the same day of casting. Out of every sample, at least two test cubes shall be prepared for testing at 7 and 28 days, respectively. The number of samples taken from hardened concrete which for any reason was not taken while the concrete was fresh or of which the strength obtained did not meet the requirements, and taking and testing of such samples shall be in accordance with B.S. 1881.

The average strength of the cubes or more tested at each age may be taken as the works cube strength of the concrete. This works cube strength may be accepted as complying with the specified requirement for works cube strength, if none of the compressive strengths of any of the cubes is below the specified works cube strength, or if the average strength is not less than the specified works cube strength and the strength of the weakest cube is not less than that listed in the following table. The table details the required cube strengths of work cubes and trial mixes for the various grades of concrete.

Compressive Strength Requirements (for all types of Concrete)

Grade	Characteristics compressive strength (kg/cm ²)	Cube strength at 28 days (kg/cm ²) **		
		Works cubes *		Trial mixes *
		Average	Weakest Cube	Average
C10	100	133	85	
C15	150	200	128	215
C20	200	275	170	315
C25	250	325	213	365
C30	300	375	255	415
C40	400	475	340	515
C50	500	575	425	615

* Strength requirements may be adjusted in accordance with CP110, if and as detailed in the Particular Specification.

** Concrete may be provisionally accepted on the basis of the days' cube strength, provided the average strength is at least 70% of the required 28 days strength and provided 28 days' cubes will be tested and will meet the requirements.

If for any part of a structure the works cube strength does not reach the required values at the age of 28 days, or if the concrete has hardened and samples have not been taken while the concrete was still fresh, the Engineer may permit the cutting of at least six cylinders out of the same part of the structure, and the cylinders shall be tested in accordance with the requirements of B.S. 1881. The concrete shall be deemed to comply with the specification if its strength, as deduced from the cylinder tests, meets the compressive strength requirements detailed in the above table and the results of the previous samples shall not be taken into account. Should the concrete also fail to meet the requirements in the testing of the cylinders as above, all the concrete from which the samples have been tested will be considered defective. In such a case, the Engineer may at his own sole discretion, order the carrying out of additional tests by any method he may deem fit, and if such additional tests show the concrete meeting the requirements he may accept it. Should the concrete not meet the strength requirements in the test of samples as above, or in the additional tests that the Engineer may have permitted, then it shall be dealt with according to one of the following two methods, chosen at the sole discretion of the Engineer.

- (a) The Contractor shall demolish and re-construct the part of the structure made of the defective concrete.
- (b) The Engineer will accept the defective concrete but reduce its price as defined hereinafter. This provision shall apply only to concrete in which the average compressive strength of the samples taken is not less than the Characteristic Compressive Strength listed in the table. In such an event, the Engineer may accept the concrete, but reduce 2% of the unit rate per cubic meter of the defective concrete for every kg/cm² of the difference between the required strength and the average strength. (For example: C130 concrete was required. The strengths of all samples were above 255 kg/cm² but the average strength of the samples was 367.5 kg/cm² instead of 375 kg/cm². In this case the Engineer may, at his sole discretion, accept the concrete and reduce its unit rate by 15%).

Concrete that has not met the requirements as stated above and concrete that the average compressive strength of the samples of which is below the nominal strength shall be rejected in every case. The part of the structure made of the rejected concrete shall be demolished and re-built by the Contractor at his own cost.

202.8.4 Impermeability Tests

Where required on the Drawings or the Specification, or where directed by the Engineer, the concrete shall be tested for impermeability. Samples for the impermeability tests shall be in the form of 20x12 cm plates and shall be prepared, cured and tested in accordance with DIN 1048. Unless otherwise stated in the Particular Specification or elsewhere in the Contract, the requirement for impermeability shall be that, when a water pressure of 2 kg/cm² is applied to one side of the test specimen, no moisture shall appear on the other side.

202.8.5 Payment for Tests

The costs of sampling and performing the tests in accordance with this Section, including all labour, equipment, transportation and ancillary works, shall be deemed to be included by the Contractor in his unit rates for concrete and shall not be paid for separately, unless specific items for testing are included in the Bill of Quantities.

202.9 STEEL REINFORCEMENT

202.9.1 General

Reinforcement steel for concrete shall meet the requirements of the relevant British Standards listed in Subsection 202.1.2 of this Specification.

The Contractor shall supply the Engineer with certificates from the makers of the steel showing that it has complied under test with the appropriate Standard Specification, stating the process of manufacture and if required the chemical analysis, and such test sheets shall be forwarded to the Engineer one week before the dispatch of such steel to the Works.

The steel shall be stored off the ground and kept scrupulously clean and free from loose mill scale, loose rust, oil and grease or other harmful matter. Any bar adversely affected by storage or for any other reason shall be cleaned or removed from the Site and replaced by the Contractor at his own expense.

202.9.2 Bar Schedules

Where reinforcement bar schedules are shown on the Drawings to assist the Contractor in preparing and placing the steel reinforcement, the Contractor shall carefully check such bar schedules for compliance with the structural drawings and shall correct the bar schedules as necessary. Where no bar schedules are incorporated in the Drawings, the Contractor shall prepare such schedules at his own cost and responsibility. In any case, the Contractor will be solely responsible for the correct preparation and placing of steel reinforcement in accordance with the Drawings. Any bars bent and prepared according to incorrect schedules, and not suitable for placing in the structure will be rejected and will not be paid for.

202.9.3 Bending Reinforcement

All bending shall be done cold, by an approved bending machine, in a manner that will not injure the material. Welded joints shall not be permitted in any bar. Only experienced steel benders, to the approval of the Engineer, shall be employed in bending. All bending shall be

in accordance with British Standard 4466. The internal radius of all cranks and bends shall be at least three times the diameter of the bar. Heating of mild steel bars only to facilitate bending, especially of large diameter bars, will be permitted, provided the temperature of the steel does not exceed 850°C (cherry-red heat) and provided further that the cooling rate is low and uniform (normal still-air cooling). Quenching of hot-bent bars in water will not be permitted. Reinforcement bars depending on cold working for their strength, such as cold drawn or twisted bars shall not be bent hot.

202.9.4 Placing Reinforcement

The number, size, form and position of all steel bars, ties, links etc.. shall be in exact accordance with the Drawings and in the placing and fixing the function of each bar shall be borne in mind.

The greatest care shall be taken to ensure that the steel is laid out correctly in accordance with the Drawings and fixed rigidly within the forms. Sufficient temporary ties of annealed iron wire shall be provided to prevent any displacement before or during the placing of concrete and to ensure that the specified amount of cover is everywhere maintained. Concrete shall be rammed firmly with spatulas around the steel and compacted against it and against the shuttering.

No pieces of metal or blocks or wood shall be used on the bottom surface or against the sides of formwork to keep the reinforcing bars in position. For this purpose specially prepared precast concrete blocks shall be used of a thickness equal to the concrete cover specified hereafter. The use of plastic spacers is also accepted.

Unless otherwise shown on the Drawings or directed by the Engineer, the cover reinforcement, including cover stirrups and distribution bars, shall be at least equal to the diameter of the principal reinforcement bars plus

- at least 1 cm in the case of solid interior slabs, or
- at least 1.5 cm in all other cases, or
- at least 1 cm in addition to the above in the case of elements exposed to climatic influences.

In any case, all parts of a structure in direct contact with the earth or water shall have at least 3 cm cover over reinforcement, including stirrups and distribution bars.

The minimum cover stipulated above shall be increased, if necessary, up to 5 cm wherever a structure is particularly liable to danger of corrosion or abrasion, and up to 8 cm where concrete is placed directly against earth, without formwork.

Bars, generally, shall be of the required lengths and the lapping of main bars will not be permitted, except as indicated on the Drawings. Where bars are required or permitted to be lapped, the parts along the lap shall have a clear space between them equal to 1cm or the diameter of the bar, whichever is the greater. The minimum length of overlap will be 40 times the diameter of the bars for hooked bars and at least 60 times the bar diameter for bars without hooks. Laps of adjacent parallel reinforcement bars shall be staggered. Ends of ties shall be cut back 1.5 cm from face and covered with mortar. Fabric reinforcement shall be lapped at least 40 diameters or two squares, whichever is the greater.

All laps of bars are to be tied tightly with six laps of 1.5 mm annealed iron wire at intervals of ten diameters of the bars. All crossings of steel are to be secured with three laps of wire. Splicing of bars by butt welding will be permitted, provided that the resulting joint is not

inferior in strength to the rest of the bars. Bars depending for their strength on cold drawing or twisting shall not be spliced by welding. Crossings of steel bars may be secured by tack welding instead of tie-wires, provided that burning or other damage to steel at tack-welds is prevented. All welds shall be done in a thoroughly workmanlike manner by qualified welders either by the oxy-acetylene method to BS 693 or by the metal arc method to BS 5135. Splices of bars having a diameter of 26 mm and more shall be done by butt-welding only.

The Contractor shall not pour any concrete before the Engineer has inspected and approved the placement of reinforcement. Such approval shall, however, not affect the Contractor's responsibility for the correctness of the reinforcement in accordance with the Drawings, reinforcement schedules, Specifications and/or directions given by the Engineer.

202.10 FORMWORK

202.10.1 General

The Contractor shall design, supply and fix all necessary formwork, together with its attendant scaffolding, timbering, shoring, strutting, etc., required for the placing of the concrete.

The Contractor will be permitted to use timber boarding as formwork or forms lined with plywood, hardboard of approved manufacture or steel sheets. Where timber boarding is used, the formwork surfaces coming in contact with wet concrete shall be made of properly seasoned timber. Full size plywood or hardboard sheets shall be used except where otherwise required or where smaller pieces will cover the entire area. Forms shall be so placed that markings shall be symmetrical.

All formwork shall be of sufficient strength to resist movement of men or equipment and the pressure of the wet concrete while it is being placed and vibrated, without distortion. Where plywood, hardboard or steel lining is used, particular care shall be taken to ensure that the forms are adequately braced and stiffened.

The formwork for successive vertical lifts must make such perfect contact with concrete in the preceding lift that there shall be no excrescences, bulges, tears or other outward signs of faulty junction. The formwork must be constructed so that there shall be no leaked of mortar. Whenever it is unavoidable, the Contractor shall prevent leakage of any kind through open joints by means of suitable caulking.

The repeated use of forms of all descriptions will be at the discretion of the Engineer, who will require the forms to be reconditioned or surfaced from time to time. After repeated use, the old forms will be replaced with new ones at the direction of the Engineer.

All exposed concrete shall have the external angles chamfered 20 mm or as directed by means of moulding strips fixed to the formwork. Interior angles on such surfaces and edges at formed joints will not require bevelling unless requirement for bevelling is indicated on the Drawings.

The height of all erected at any one time shall be subject to the approval of the Engineer.

The surface of the forms shall be free from encrustation of mortar, grout, or other foreign material. Before the form panels or boards are erected in place, the surfaces of the forms shall be oiled with an approved commercial form oil that will effectively prevent sticking and will not stain the concrete surfaces.

202.10.2 Types of Forms

The surfaces of formwork to give a desired finish of formed concrete will be classified as follows :

- (a) Unwrought Formwork of unwrought timber will be permitted in formwork for concrete surfaces or portions thereof which will receive plaster or other facing, or which will be covered up below ground level.
- (b) Wrought Formwork (for Smooth Internal and External Surfaces) made of new plywood or new steel sheets or timberboarding planed on both sides to equal thickness, shall be used on all exposed concrete surfaces except where plaster or another facing or fairface concrete are provided for. The formwork shall ensure that a regular and smooth finish is obtained, free of excessive bulges, irregularities or unsightly markings or defects of any kind.
- (c) Fair-face Concrete Formwork shall be employed where shown on the Drawings, required in the Specification or directed by the Engineer. This type of formwork shall include use of new plywood or new steel sheets equal thickness, joined by torque and groove joints in parallel and vertical or horizontal alignment, arranged so as to achieve concrete surfaces of the textures and patterns required.

Where the surfaces formed in wrought or fair-face formwork are defective, the Engineer may order repairs to be made in accordance with Section 202.7 above and, if large surfaces should be found honeycombed or otherwise impaired, he may order all such surfaces to be plastered with cement plaster. Repairs to fair-face concrete, where required, shall be made in accordance with Section 202.7 above, but if in the Engineer's opinion such repairs would be insufficient to restore the external appearance of the surface, he shall order surfaces destroyed and cast anew.

The cost of all above-mentioned repairs to concrete surfaces, including application of cement plaster, and re-casting shall be deemed to be included in the unit rates for concrete work in the Bill of Quantities and shall not be paid for separately.

202.10.3 Form Ties

Embedded metal rods or sleeves used for holding forms shall remain embedded and shall terminate not less than 2½ cm from the face of the concrete. Embedded wire ties for holding forms will not be permitted in concrete walls which are to come into contact with liquids or where the concrete surfaces through which the ties would extend will be permanently exposed. Wire ties may be used for concrete walls to be plastered, stone faced or covered with earth. Wire ties shall be cut back at least 1.5 cm from the face of the concrete. The holes left in the concrete surfaces after cutting back of wire ties and removal of fasteners or holding rods or sleeves, and the insides of sleeves where sleeves are used, shall be completely filled with an approved non-shrinking mortar, and the mortar shall be finished flush with the concrete surfaces. This operation will be carefully carried out. The hole formed by the cutting process will be thoroughly cleaned and wetted before filling. Time mortar will be of damp, not wet, consistency. The patch will be properly towelled smooth to match the surrounding concrete surfaces and shall be thoroughly cured by keeping it moist continuously for at least three days. After the patch has hardened, the Engineer may require the patch and the adjacent

concrete surface to be ground down smooth. Any patches that are loose or hollow on completion must be re-done. Water stop tie rods shall be used for liquid retaining structures.

All costs for complying with the requirements of this Subsection shall be deemed to be included in the unit rates for formwork and shall not be paid for separately.

202.10.4 Embedded Metal Parts

Parts of metal work, such as fixtures for wall brackets, hooks and similar parts that are to be embedded in the concrete shall be attached to the forms in their proper position prior to placing of concrete.

All costs for and in connection with the installation of metal parts shall be deemed to be included in the unit rates for formwork and for concrete and shall not be paid for separately, except where specific items shall be included in the Bill of Quantities.

202.10.5 Striking of Forms

To facilitate satisfactory progress with the specified curing and to permit earliest practicable repair of surface imperfections, forms shall be struck as soon as the concrete has hardened sufficiently to prevent damage by careful form removal. Forms shall not be struck until the strength of the concrete is such that form removal will not result in perceptible cracking, breaking of surfaces, or other damage to the concrete and that the concrete can sustain the loads to be borne at the time of striking. Forms shall be struck with care so as to avoid injury to the concrete, and any concrete so damaged shall be repaired at the Contractor's expense.

No forms shall be removed without the express permission of the Engineer's Representative, but the Contractor shall, nevertheless, accept sole responsibility for the removal and consequences thereof.

In no case shall forms to soffits be struck until test cubes from the actual concrete concerned have yielded the 7 days strengths specified.

As a guide to the Contractor and subject to the foregoing requirements the followings minimum striking times, from the completion of concrete placing, may be assumed:

- For sides of Foundations, slabs, etc. - 24 hours
- For sides of Beams in suspended work, sides of walls and columns - 48 hours
- For sides of Retaining Walls - 36 hours
- For soffits of Beams and Slabs in suspended works (spans up to 3 meters) - 10 days
- For soffits of Beams and Slabs in suspended works (spans 3 to 6 meters) - 12 days
- For soffits of Beams and Slabs in suspended works (spans over 6 meters) - 14 days
- For the soffits of beams having a span of more than 5.0 m, at least one support and for those of slabs having a span exceeding 6.0 m, at least one row of supports shall be left in place for an additional period of seven days.

If the striking times stated above are not sufficient to permit the unsupported concrete to sustain superimposed loads (such as support for the shuttering of an upper floor, storing of building materials, etc..). Such loads will require special supports to sustain them.

202.11 MISCELLANEOUS CONCRETE WORKS

202.11.1 Openings and Holes in Concrete

Openings in concrete walls or slabs or reservoirs shall be predetermined and subject to the approval of the Employer. No openings shall be made after formworks removal. The Contractor shall be responsible for the co-ordination of all requirements of his sub-contractors as regards provision of openings, holes and fixings, and prepare shop drawings.

Holes left after the removal of formwork shall be filled with a compensating epoxy-based mortar or any similar product. For water retaining structures water stop tie rods shall be used when filling the holes to ensure watertightness.

Where it is impracticable, as determined by the Engineer's Representative, to install metal parts in the forms as required under Subsection 202.10.4 suitable holes or recesses shall be formed in the concrete structure into which the metal parts can be placed and grouted in. The shape and dimensions of such holes shall be as shown on the Drawings or as determined by the Engineer's Representative, and they shall be formed with wooden core boxes, fabricated in such a manner that they can be completely withdrawn or broken up and removed after the concrete has set. All such core boxes shall be set with great accuracy with the aid of templates and securely fixed to prevent displacement during concreting. The supply and installation of all such core boxes and their removal when the concrete has hardened sufficiently shall be deemed to be included in the unit rates for formwork and concrete work and shall not be paid for separately.

Where the holes or openings have not been formed in the concrete during placement, the Engineer may either order the tearing down and rebuilding of the structure or the part thereof concerned, or permit such holes or openings to be cut in the hardened concrete to the dimensions shown on the Drawings or as directed by the Engineer. Such cutting shall be kept to the minimum necessary dimensions and shall be done by drilling, chiselling or the use of a power tool, all as approved by the Engineer and in such a manner as not to cause any damage to the concrete structure.

Reinforcement bars passing through such holes or openings shall not be cut without the express written permission of the Engineer's representative.

Where the forming of the openings or holes has been omitted by the Contractor's neglect, all tearing-down and rebuilding or cutting of holes and openings in the hardened concrete as aforesaid shall be done by the Contractor at his own expense, in all other cases the cost thereof shall be borne by the Employer and shall be paid for as extra work under Clause 51 of the Conditions of Contract.

202.11.2 Manholes and Chambers

Manholes and chambers shall be constructed in the positions and to the details shown on the Drawings. The grades of concrete and types of formwork shall be as shown on the Drawings, as required in the Specification or as directed by the Engineer. The inside dimensions, unless otherwise specified, will be after plastering or to otherwise finished surfaces.

A base slab of concrete, supporting the walls, shall be cast on firm ground foundations (so as to prevent any differential settlement), on a blinding layer of Lean Concrete (Grade C10). Where shown on the Drawings, smoothly constructed U-shaped channels, to carry and direct the flow, shall be formed integrally with the concrete base, or may be constructed separately by benching. Adjacent floor areas shall slope to drain to the channel with a gradient of about 5% to 10%. All transition curves shall be smooth.

The whole of the floor areas and channel surfaces shall be finished with a smooth coat of cement mortar.

The walls of the manholes shall be made of cast-in-situ concrete or of precast concrete rings, all as shown on the Drawings. The construction of walls shall not start sooner than 24 hours after slab had been cast. Cast-in-situ concrete and precast concrete shall be Grade C30 for floors, walls; ceilings and Grade C15 for benching. Precast concrete Chamber and Shaft rings shall conform to requirements of B.S. 556, shall be of the tongue and groove type and shall be assembled with cement-mortar joints to ensure complete water tightness of the joints.

Internal surfaces of Manholes and Chambers shall be absolutely smooth. This shall be achieved by the use of wrought formwork or by plastering with cement mortar 1:1½ and steel trowel finish with the addition of cement in the proportion of 1 kg per square meter as shown on the Drawings or as directed by the Engineer.

Aluminium or galvanized steel steps, or a ladder if so shown on the Drawings, shall be provided in all manholes 1.25 m deep and over. The steps shall be staggered and spaced at about 25 cm vertically, or as shown on the Drawings. They shall be solidly embedded in the walls prior to the plastering. The top step shall always be located to accommodate the right foot. Step irons for manholes shall comply with B.S. 1247 type A and shall be hot-dip galvanized. All steps shall be built in as the work proceeds. Cutting out completed work for inserting steps or other fittings shall only be permitted where it is impossible to built them in as the concrete is being cast. Unless otherwise specified, in manholes with depths greater than 5.25 m, ladders shall be installed instead of steps. The ladders shall comply with the Drawings or shall be as specified or directed by the Engineer.

Where shown on the Drawings or directed by the Engineer, pipe stubs for future connections shall be installed. The stubs shall extend at least 50 cm beyond the outside of the walls of the manhole and shall be plugged watertightly. Appropriate channels for the future connections shall also be prepared in the benching.

Unless otherwise indicated, manhole and chamber covers shall be suitable for heavy duty and shall be made of cast-iron to B.S. EN124 or concrete with cast-iron frames, of a type approved by the Engineer. Suitable lifting keys of mild steel shall be provided with the covers at a rate of 1 set of keys for each 10 covers. After the completion of the work, cast iron parts of the covers and the frames shall be thoroughly cleaned and painted with bitumen paint.

Manholes shall be watertight. The Contractor shall, if so required, test them in the presence of the Engineer. The Contractor shall provide all water labour, drains, stoppers, bends and other needful appliances for carrying out tests and no manholes or other work must be covered up until they have been seen and passed by the Engineer. The test to be applied to manholes and chambers shall be their filling with water to 10 cm below the slab or to finished ground level and after allowing due time for saturation of the concrete, by topping up to the original level. Thereafter the loss of water shall not be greater than the equivalent of 2 cm over the whole area of the chamber in 24 hours.

202.11.3 Thrust and Anchor Blocks

Concrete thrust and anchor blocks shall be formed at bends, tees and valves in accordance with the details shown on the Drawings or as directed by the Engineer. Excavation shall be made after pipelaying, and the blocks concreted immediately after excavation. The back of supports and blocks shall abut on to solid ground with all loose material being removed before concreting.

No pressure shall be applied in any section of main until the concrete has achieved adequate strength and at least three day's curing.

Flexible joints shall not normally be cast in. Where the size of the block does not make this possible, additional flexible joints shall be provided no greater than half a pipe diameter beyond each face of the block.

202.11.4 Concrete Surround to Pipes

Where pipelines pass under streams and rivers or where directed by the Engineer, the pipeline shall be surrounded with concrete as shown on the Drawings.

Concrete surround shall be broken at all pipe joints to retain flexibility in the pipeline. No joints shall be concreted in without the prior approval of the Engineer.

202.11.5 Precast Concrete

All precast concrete members to be used in the works, such as covers, lintels, sills, slabs, stairs, etc., shall be manufactured on site or obtained from approved manufacturer. In either case casting shall be done under the supervision of the Engineer, whose approval of the place and method of casting must be obtained before starting work. If casting is done on the site, the Contractor shall prepare a suitable area near the structure for which the precast parts are intended, and samples of the precast work shall be submitted to the Engineer for approval before proceeding with the manufacture on site. Casting of the precast parts shall be completed in due time so as not to delay the completion of the structures and everything connected therewith.

Unless otherwise directed, precast elements shall be of concrete Grade C30P. All precast elements shall be true to dimensions and shapes as shown on the Drawings. Concrete surfaces shall be smooth and all corners square or chamfered, as shown on the Drawings or directed by the Engineer. Lifting lugs and similar metal parts, whether part of the reinforcement steel or not, shall be incorporated in the elements during manufacture. Precast elements shall not be transported or otherwise handled until the end of the curing period, which shall be at least 14 days.

Any precast concrete element becoming defective during casting or placing or from any other cause, and rejected by the Engineer, shall be removed from the Site by the Contractor who shall cast new elements to replace the rejected ones, and all expenses in connection therewith shall be borne by the Contractor.

202.11.6 Cast-in-situ Reinforced Concrete piles

The piles shall be cast in boreholes of the required diameter and depth drilled into the ground. The exact depth will be fixed in-situ by the Engineer. The deviation of the centre of the pipe from its exact location as shown on the Drawing shall be no more than 3 cm and the deviation of the completed shaft from its true vertical alignment shall not exceed 1%.

A number of drill core samples shall be taken and a log-book kept providing the required profile data. The shaft shall be filled with concrete as soon as it has been bored and the reinforcement has been placed. In the event that concreting cannot be done on the same day as the boring, the boring of the last meter of the pile shall be postponed till the next day. In any event, the last meter of boring shall always be done just before concreting.

The reinforcement cages shall be provided as shown on the Drawings. They shall be prepared in appropriate lengths, but not longer than 12.0 m. Consecutive lengths shall be welded together by the electrical fusion method. The cages shall be carefully placed with the aid of a crane and kept in position before and during placement of the concrete. Appropriate arrangements, to be approved by the Engineer's Representative, shall be made so as to ensure the required distance between the cage and the inner surface of the shaft, which shall be not less than 5 cm, if not otherwise specified.

The Contractor shall submit to the Engineer's approval a complete description of the method and equipment he proposes to use for pile construction. The whole work of pile construction shall be carried out by skilled and experienced workmen under expert supervision, and if the Contractor is not himself a piling specialist, he shall employ one as a sub-contractor.

The method of pile construction, whether the dry shaft or wet shaft, shall be chosen according to subsoil conditions on the site, with which the Contractor shall be well acquainted.

a) Dry Shaft method:

The dry shaft method may be used where subsoil conditions so permit. Generally, drilling shall be done through a steel casing which shall be continuously lowered into the borehole. The casing shall consist of sections that can be easily jointed and separated to permit lowering and raising of the casing as required.

In special cases when the boring is done in soil possessing high cohesion and plasticity, the boring may be done without a temporary casing. However, the top 1.5 m shall always be cased and the casing allowed to project at least 0.3 m above ground level. After concreting, this casing shall be withdrawn.

When the pile borehole has been bored to its correct depth, great care shall be taken to ensure that the bottom of the shaft is clean. A small bailer can be used for the last dig to do the job.

The concrete used in piles shall be Grade C20P or stronger as specified; its slump shall be 10 to 15 cm. Concrete shall be cast into the shaft through a circular tremie, the mouth of which shall be near the level of the cast concrete or immersed in it and in any case no more than 0.5 m above the top level of the concrete at any time. The tremie shall be built up of separate sections which can be easily disconnected to be taken off as the concrete rises in the shaft. The casing shall be gradually extracted as the concrete is cast, so that the shaft is well filled with concrete. During casting of concrete, the lower end of the casing shall remain immersed in the concrete for at least 3 m at any time.

b) Wet Shaft Method

The wet shaft method shall be used whenever required due to the presence of artesian water and may be used elsewhere if preferred over the dry-shaft method.

Under the wet-shaft method, the shaft is filled during the excavation and concreting stages with a bentonite suspension, the volume weight of which shall be between 1.03 to 1.08 t/m³ so as to be : (1) sufficiently high to keep the soil from caving into the shaft and prevent any groundwater inflow; and (2) sufficiently low in order not to intermingle with the concrete. The bentonite level in the shaft shall always be higher than the underground water level existing at the site.

The dry bentonite particle size distribution shall be characterized by 90% particles smaller than 2 microns. The bentonite mixture shall be such that, in a laboratory sample mixture made with clean potable water, no decantation will occur after a time equal to the expected time of bentonite mixture presence in the shaft, nor after two hours, whichever is longer.

At the top of the shaft a protruding section of a temporary casing of about 1.0-2.0 m length shall be provided, and shall be withdrawn after concreting has been completed. Before concreting starts, the bottom of the shaft be cleaned from sand and any drill cuttings, using a mud or air-lift pump. The recirculated bentonite shall be passed through a vibrating sieve or settling tanks till no more fragments are discharged by the pump.

The concrete shall be cast through a tremie, as specified above, except that before concrete placement begins, the bottom of the tremie shall be lowered to a distance above the shaft bottom equal to 0.5 to 1 times the diameter of the tremie. It shall be kept in this position till the concrete rises about 4-5 m, whereupon the withdrawal of the tremie shall begin. Generally, the bottom of the tube shall be submerged in the concrete for about 3 m and in no instance less than 1.5 m.

The concrete slump shall be 15 to 20 cm so as to ensure good workability.

At the start of concrete casting a quantity of foamed polystyrene chips shall be introduced into the tremie to prevent segregation of the first batch of concrete reaching the bottom of the shaft shall lift and drive up the bentonite suspension, as well as any sand and silt that may have accumulated at the bottom of the shaft.

Pouring of concrete shall continue until the shaft has been completely filled with concrete and any sand, drill cuttings and silt have been driven out at the top of the temporary casting and until clean concrete will appear.

202.11.7 Hourdis Slabs

A Hourdis slab is a monolithical reinforced concrete slab consisting of embedded beams and ribs separated by rows of hollow blocks (Hourdis blocks).

The reinforcement bars of the beams and ribs as well as the hourdis blocks shall be placed on the formwork prior to start concreting.

The hourdis slabs shall be carried out in accordance with the details and dimensions shown on the Drawings.

202.12 JOINT SEALS WITH ELASTOMERIC SEALANTS

202.12.1 Major Components

The major components of a good joint seal are:

- The substrate,
- The joint filler,
- The bond breaker, and
- The sealant.

a) The substrate:

The more common substrates are masonry concrete, metal, and glass; these are generally classified as porous /or/ non porous.

- Some substrate may not be suitable for achieving a bond unless, treated mechanically, chemically, or both.
- When the substrate has a coating, this coating must be compatible with the sealant and its bond to the substrate and sealant must be adequate.
- The Contractor must consult both substrate and sealant manufacturers for suitable joint preparation methods and primers to be used before applying joint materials.
- Adhesion testing of trial applications in the site is recommended.
- Surface laitance and incompatible or bond-inhibiting form release agents on concrete surfaces, must be removed.
- Substrates must be clean, dry, sound, and free of loose particles, contaminants, foreign matter, water-soluble material, and frost.
- Joints in masonry and concrete should be sealed before cleaning exposed surfaces and applying required protective barriers.

b) Primer:

The purpose of a primer is to improve the adhesion of a sealant to a substrate. Many sealant require primers on all substrate; some on only certain substrate or on none at all. Most require a primer for maximum adhesion to concrete and masonry surfaces.

c) Joint Fillers:

A joint filler is used to control the depth of sealant in the joint and permit full wetting of the intended interface when tooled.

Some joints fillers may be incompatible with the substrate and sealant, causing stains, on either one of them or both. Some may be factory coated with a suitable material that provides a barrier to staining.

The Contractor must confirm this suitability, i.e. that the barrier coating must be acceptable to both, the sealant and the joint filler manufacturers.

Joint filler for vertical application may be flexible, compatible, closed cell plastic foam /or/ sponge rubber rod stock, and elastomeric tubing of such materials as:

- neoprene,
- butyl, and
- E.P.D.M.

They should resist permanent deformation before and during sealant application, be non absorbent to water or gas, and resist flowing upon mild heating since this can cause bubbling of the sealant.

- Open cell sponge type materials such as urethane foam may be satisfactory, provided that their water absorption characteristics are recognised. The sealant should be applied immediately after joint filler placement to prevent water absorption from rain.
- Elastomeric tubing of neoprene, butyl, or EPDM may be applied immediately as a temporary seal until the primary sealant is put in place, after which they serve to a limited degree as a secondary water barrier.

Joint filler for horizontal application (for floors, pavements, sidewalks, patios and other light-traffic areas may be compatible, extruded, closed cell, high density flexible foams, corkboard, resin-impregnated fiber board /or/ elastomeric tubing /or/ rods).

- These joint fillers should remain resilient in cold temperature, exhibit good recovery, not cause the sealant to bubble in the joint because of heat, and be capable of supporting the sealant in traffic areas.
- They should not exude liquids under compression, which could hydraulically cause sealant failure by forcing the sealant from the joint.
- Combination of joint filler may be used to form a joint in concrete and an additional filler material may be installed under compression across the width and to the proper depth just before the sealant is applied to provide a clean, dry, compatible backup.

d) Bond breaker:

A bond breaker may be necessary to prevent adhesion of the sealant to any surface or material where such adhesion would be detrimental to the performance of the sealant.

- The use of a joint filler to which the sealant will not adhere may preclude the need for a bond breaker.

- The bond breaker may be a polyethylene tape with pressure-sensitive adhesive on one side /or/ various liquid applied compounds, as recommended by the sealant manufacturer.

e) Sealant

Sealants are classified as:

- single component /or/ multicomponent
- non sag /or/ self leveling,
- traffic /or/ non traffic use

as well as according to movement capability.

- Characteristics of common elastic sealants are listed in the following Table 2.5:

Table 2.5

CHARACTERISTICS OF COMMON ELASTOMERIC SEALANTS

	ACRYLIC (SOLVENT RELEASES)	POLYSULFIDE		POLYURETHANE		SILICONE
	(ONE PART)	TWO-PART	ONE-PART	TWO-PART	ONE-PART	(ONE PART)
Chief ingredients	Acrylic terpolymer, inert pigments, stabilizer, and selected fillers	Polysulfide polymers, activators, pigments, plasticizers, inert fillers, gelling, and curing agents		Polyurethane prepolymer, inert fillers, pigments, plasticizers, accelerators, activators, and extenders	Polyurethane prepolymer, inert fillers, pigment, and plasticizers,	Siloxane polymer pigment, and selected fillers
Percent solids	85-95	95-100	95-100	95-100	95-100	95-100
Curing process	Solvent release and very slow chemical cure	Chemical reaction with curing agent	Chemical reaction with moisture in the air	Chemical reaction with curing agent	Chemical reaction with moisture in all, also oxygen	Chemical reaction with moisture in all
Curing characteristics	Skins on exposed surface; interior remains soft and tacky	Cures uniformly throughout; rate affected by temperature and humidity	Skins over, cures progressively inward; final cure uniform throughout	Cures uniformly throughout; rate affected by temperature and humidity	Skins over, cures progressively inward; final cure uniform throughout	Cures progressively inward; final cure uniform throughout
Primer	Generally not required	Manufacturer's approved primer required for porous surfaces, sometimes for other surfaces		Manufacturer's approved primer required for most surfaces		Required for most surfaces
Application temperature (°F)	40-120	40-100	60-100	40-120	40-120	0-120
Tackfree time	1-7 days	6-24 hr	6-72 hr	1-24 hr	Slightly tacky until weathered	1 hr or less
Hardness, Shore A Cured 1 to 6 months Aged 5 years	0-25 45-55	15-45 30-60	25-35 40-50	20-40 35-55	25-45 30-50	20-40 35-55
Toxicity	Nontoxic	Curing agent is toxic	Contains toxic ingredients	Toxic; gloves recommended for handling		Nontoxic
Cure time (days)	14	7	14-21	3-5	14	5
Joint movement capability (max.)	± 12.5%	± 25%	± 15%	± 25%	± 15%	± 25% high modulus ± 50% low modulus
Ultraviolet resistance (direct)	Very good	Poor to good	Good	Poor to good	Poor to good	Excellent
Dirt resistance cured	Good	Good	Good	Good	Good	Poor
Use characteristics	Excellent adhesion; poor low-temperature flexibility; not usable in traffic areas; unpleasant odor 5-12 days	Wide range of appropriate applications; curing time depends on temperature and humidity	Unpleasant odor; broad range of cured hardnesses available	Sets very fast; broad range of cured hardnesses; excellent for concrete joints and traffic areas	Excellent for concrete joints and traffic areas, but substrate must be absolutely dry; short package stability	Requires contact with air for curing; low abrasion resistance; not tough enough for use in traffic areas

202.12.2 Joint Design

The design geometry of a joint seal is related to numerous factors including:

- desired appearance,
- spacing of joints,
- anticipated movement in joint,

- movement capability of sealant to be used,
- required sealant width to accommodate anticipated movement,
- and tooling methods.

a) Sealant width

The required sealant width relative to thermal movement is determined by:

- the application temperature range of the sealant
 - the temperature extremes anticipated at the site location
 - the temperature at the time of sealant application, and
 - the movement capability of the sealant to be used.
- 1) In the absence of specific application temperature knowledge, an ambient application temperature from 4°C to 38°C (40° to 100°F) should be assumed in determining the anticipated amount of joint movement in the design of joints.
 - 2) Although affected by ambient temperatures, anticipated joint movement must be determined from anticipated building material temperature extremes, rather than ambient temperature extremes.
 - 3) Many other factors can be involved in building joint movement including but not limited to:
 - a) material mass
 - b) color
 - c) insulation
 - d) differential thermal stress (bowing)
 - e) residual growth or shrinkage of materials
 - f) building sway and
 - g) seismic forces
 - 4) The design joint width should be calculated taking all possible movement and tolerance factors into consideration.
 - 5) A simplified method (but no as accurate) is to use the accompanying graph.

b) Joint depth:

The sealant depth, when applied, depends on the sealant width; the following guidelines are normally accepted practice

- 1) For a recommended minimum width of ¼ in, the depth should be ¼ in
- 2) For joints in concrete, masonry, or stone, the depth of the sealant may be equal to the sealant width in joint up to ½ in
 - a) for joints ½ in to 1 in wide, the sealant depth should be one-half of the width.
 - b) for joints 1 to 2 in wide, the sealant depth should not be greater than ½ in.
 - c) for widths exceeding 2 in, the depth should be determined by the sealant manufacturer.

- 3) For sealant widths over $\frac{1}{4}$ in and up to $\frac{1}{2}$ in in metal, glass and other nonporous surface joints the minimum of $\frac{1}{4}$ in in depth applies, and over $\frac{1}{2}$ in in width the sealant depth should be one-half the sealant width and should in no case exceed $\frac{1}{2}$ in.

When determining the location of the joint filler in the joint, consideration should be given to the reduction in sealant depth with concave and recessed tooled joints, and the joint should be designed accordingly.

202.12.3 Application

To obtain proper adhesion, it is essential that:

- the sealant comes in direct contact with the substrate,
 - the sealant wets the surface of the substrate
 - the substrate is strong enough to provide a firm anchor for the sealant.
- If any of these conditions is not met, poor adherence will usually result.
- The sealant should be installed in such manner as to completely fill the recess provided in the joint.

Against a porous material, the sealant must enter the pores if good adhesion is to be obtained. Sealants used for this application are thixotropic and will resist flow into the pores unless an external force is applied. Proper filling of the recess accomplishes this, in part, and proper tooling ensures it.

a) Joint preparation:

For a joint to receive sealant it must be cleaned out and raked to full width and depth required for installation of joint seal materials. Thoroughly cleaning all joints is by removing all foreign matter such as: dust, paint (unless it is a permanent protective coating), oil, grease, water proofing or water-repellent treatments, water, surface dirt and frost.

- Clean porous materials such as: concrete, masonry and unglazed surfaces of ceramic tile, by brushing, grinding blast cleaning, mechanical abrading, acid washing or a combination of these methods to provide a clean, sound substrate for optimum sealant adhesion.
- The surface of concrete may be cut back to remove contaminants and expose & clean surface when acceptable to the purchaser.
- Remove laitance from concrete by:
 - Acid washing
 - grinding or
 - mechanical abrading
- remove all form of oils from concrete by blast cleaning.
- remove loose particles originally present or resulting from
 - grinding abrading or

- blast cleaning
- by blowing out joints with oil free compressed air (or vacuuming) prior to application of primer or sealant.
- Clean nonporous surfaces, such as metal, glass, porcelain enamel and glazed surfaces of ceramic tile chemically or by other means that are not harmful to the substrate and are acceptable to the substrate manufacturer.
- Remove temporary coatings on metallic surfaces by a solvent that leaves no residue. Apply the solvent with clean oil free cloths or lintless paper towels. Do not dip cleaning cloth in the solvent. Always pour the solvent on the cloth to eliminate the possibility of contaminating the solvent. Do not allow the solvent to air-dry without wiping. Wipe dry with a clean dry cloth or lintless paper towels. Permanent coatings that are to be remain must not be removed or damaged.

b) Masquing Tape:

Install masquing tape at joint edges when necessary to avoid undesirable sealant smears on exposed visible surfaces. Use a non staining, non-absorbent, compatible type.

c) Primer and Joint Filler:

Install primer when and as recommended by the sealant manufacturer for optimum adhesion.

Install compatible joint filler uniformly to proper depth without twisting and braiding.

d) Sealant:

Install sealant in strict accordance with the manufacturer's recommendations and precautions. Completely fill the recess provided in the joint. Sealants are more safety applied at temperature above 40°F ($\approx 5^{\circ}\text{C}$)

e) Tooling:

- Tooling nonsag sealants is essential to force the sealant into the joint and eliminate air pockets and should be done as soon as possible after application and before skinning or curing begins. Tooling also ensures contact of the sealant to the sides of the joint.
- Plastic or metal tools can be used. Most applicators use dry tools but they may be surface-treated to prevent adhesion to the sealant and may be shaped as desired to produce the desired joint profile. Dipping tools in certain liquids decreases the adhesion of the sealant to the tool. All liquids should be first tested and accepted for by the manufacturer. The use of some liquids may result in surface discoloration. In using tooling liquids, care should be taken to ensure that the liquid does not contact joint surfaces prior to the sealant contacting the joint surface. If the sealant overlap the area contaminated with the liquid, the sealant bond may be adversely affected.
- Tool sealant so as to force it into the joint, eliminating air pockets and ensuring contact of the sealant with the sides of the joint. Use appropriate tool to provide a concave, flush, or recessed joint as required.
- Immediately after tooling the joint, remove masking tape carefully if used, without disturbing the sealant.

f) Field testing

In case where the building joints are ready to receive sealant and the question of adhesion of the sealant to novel or untried surfaces arises, it is advisable to install the sealant in a 1.5m (5 feet) length of joint as a test.

- It would be good practice to do this as a matter of standard procedure on all sites even though unusual conditions are not suspected.
- Following instructions of the sealant manufacturer and using primer as and when recommended, the Contractor will install the sealant in the joint and examine for adhesion after cure to determine whether proper adhesion has been obtained.

202.12.4 Bituminous sealant to waterproof horizontal joints

Once the joint sealant are approved by the Engineer, the Contractor shall submit for approval the application procedures.

Application conditions

- 1) Prior to filling the joints, the Contractor shall:
 - a) make good damaged joints,
 - b) grind or saw joints which are narrower than required,
 - c) clean by grinding and brushing joint sides,
 - d) clean with compressed air.
- 2) Bituminous sealants are hot applied under temperature ranging from 100°C to 130°C, and with a caulking gum. The nozzles shall be kept at the bottom of the joint to ensure a complete and tight filling.
- 3) In the event of a mastic creep in horizontal joints, the Contractor shall re-fill tightly the surface.

202.12.5 Surface strip joint seal (combiflex type or similar)

Surface strip joint seal, is applied, where shown on the drawings or indicated by the Engineer.

- 1) Many joints can be reliably and durably sealed with a system based on an elastomeric strip bridging the joint and bond on both sides of the joints with a special epoxy adhesive.
 - a) This is a flexible water proof seal for joints. The strip is highly flexible and fully weather-resistant elastomeric membrane (neoprene, hypalon or E.P.D.M)
 - b) The width of the strip varies from 100mm minimum to more than 500mm.
 - c) The thickness varies from 1 to 3mm.
 - d) In some cases the strip must be protected.

- 2) The Contractor shall apply the whole system in accordance with the manufacturer technical data sheet.

202.13 ELASTOMERIC SUPPORT

202.13.1 General

Elastomeric supports must comply with the following criteria:

- 1) to be of simple design under normal execution procedures.
- 2) to permit:
 - a) horizontal displacement due to any cause,
 - b) rotation of the support due to bending under permanent loads, working loads and the effects of hydraulic shrinkage and thermal phenomena, without building liable stresses outside the elastomeric support.

The elastomeric support can fill all the substrate surface of the wearing walls /or/ only a part of this surface; the unoccupied surface. In this case must be filled by a compressible material to avoid the intrusion of concrete grout between the various elements of the elastomeric support.

202.13.2 Material and Application

The elastomeric support is generally constituted by a non-hooped elastomeric polychloroprene (neoprene) which under various movements and loads will sustain deformation, transmitting to the underneath wearing walls, vertical and horizontal efforts.

a) Evenness of the wearing substrate

The substrate wearing surface must be evened to avoid any accidental contact outside the designed contact surfaces; anyhow the wearing zones must be made horizontal.

The Contractor must furnish to the Engineer all necessary justifications concerning the elastomeric support and the procedures for the execution of the wearing surface.

b) Minimal characteristics

The following minimal characteristics must be submitted by the Contractor for the Engineer's approval:

- Maximal constraint which varies with the type of material used (around 30 bars /or/ 3 MPa for the non-hooped polychloroprene = neoprene)
- Minimal constraint to be obtained and which is needed to respect the condition of non-slipping of the elastomeric support on its substrate (around 15 bars or 1.5 MPa for the non-hooped polychloroprene = neoprene)

This condition may result for the elastomeric support to have a maximal dimension implicating sometime the impossibility to design a continuous linear elastomeric support. Thus needing to consider the use of strips or pads of elastomeric material.

A continuous break of ties must be then insured between the pads by incorporating between the pads of neoprene of a compressible material (polystyrene type) and making the joints between pads and polystyrene water tight to avoid concrete grout intrusion.

c) Minimal thickness of the Elastomeric Support

The required thickness of the neoprene support shall depends on the loads, the amount of sliding and permissible rotations.

The Contractor shall submit technical certificate from the manufacturer to the Engineer allowing him to control and approve the chosen sizes and thickness of the elastomeric support.

The minimal thickness is conditioned by two factors:

- the maximal distortion of the neoprene (α) which must not exceed $\alpha \leq 0.5$ radians.
- the thickness must be large enough to permit rotation of the support avoiding contact in the maximum compression corner zones.

d) Determination of the Horizontal stresses

As an example, horizontal stresses may be controlled by the following formula (DTU.20.12)

$$H = G \times S \times \frac{U}{e}$$

e = thickness of the support

S = surface of the support in contact with the substrate

G = Transversal elasticity coefficient of the neoprene (around 0.8 to 1.3 MPa or 8 to 13 bars depending of the neoprene quality)

U = displacement

The admissible displacement (U) in relation with the thickness (e) can be first estimated as follows:

Thickness (mm) e =	5	10	15	20
Displacement (mm) U =	2.5	5	7.5	10

e) Other approved elastomeric support

The elastomeric constituting the pad may be a mix vulcanised based on Ethylene - Propylene - Diene - Monomer (E.P.D.M) which has the following average characteristics:

- A shore hardness of 60 ± 5
- Specific weight 1.06 ± 0.02 g/ml
- Ultimate resistance (rupture) ≥ 15.0 MPa
- Maximum elongation (Rupture) $\geq 400\%$
- Tearing resistance ≥ 15.0 MPa
- Permanent deformation after 24 hours at $70^{\circ}\text{C} \geq 20\%$
- Module "G" of transversal elasticity 0.8 ± 0.1 MPa

f) Compression Sollicitation

The admissible load over an elastomeric linear pads support depends of the dimensions and number of elastomeric pads constituting the support.

The average admissible constraint on every single pad is obtained for example by using the following formula

$$\text{average} = 1.2 \times \beta \leq 5 \text{ MPa}$$

Where β (form factor) = $\frac{a \times b}{2xt(a+b)}$

t = thickness of the elastomeric support

a,b = dimensions (in plan) of the elastomeric support

g) Special dispositions

In case the horizontal effort is greater than the value of friction of the interface between the elastomeric support and the substrate, the following dispositions must be taken by the Contractor:

If not otherwise specified by the Engineer the Contractor may stick the pads to avoid uncontrolled displacement when setting the different elements.

A special glue approved by the Engineer must be laid on the primed substrate and on the back side of the pad. After a maturation time, the pad shall be applied on the glued substrate with force.

202.13.3 Slip membrane

This slip membrane is constituted generally

- a protection sheet
- a slip plate around 3mm thick
- a silicone lubrication or similar
- an elastomeric pad recovered with special slipping cover adhering to it.

This system fulfills most of the usual functions of elastomeric support as:

- uniform distribution of vertical loads
- horizontal displacement by slipping of the supported construction over it.

This system will permit under small thickness, wide horizontal displacement with minimum limitation of the horizontal stresses transmitted and after the displacement it does not exert any underpinning stress on the construction at the contact interface.

The Contractor is asked to submit all technical specifications to the Engineer for approval before any purchase of the material.

202.14 METHODS OF MEASUREMENTS

202.14.1 General

Except where otherwise specified, cast-in-situ concrete will be measured and paid for by volume. Separate payment will be made for reinforcement steel (by weight) and formwork (by area).

The following items shall be measured and paid for as specified hereafter :

- Manholes and chambers - by completed units.
- Precast concrete elements - by completed units, or by length or area.
- Cast-in-situ reinforced concrete piles - by linear meters.

A detailed description of the methods of measurements and payment for the different concrete works is given in the following subsections.

202.14.2 Cast-in-situ Concrete

Concrete will be classified for payment in accordance with grades, structural elements and location in the structure.

Except as otherwise specified, all cast-in-situ concrete will be measured by volume to the neat lines and dimensions shown on the Drawings or determined by the Engineer. The volume of all openings, holes and shown on the Drawings or determined by the Engineer. The volume of all openings, holes and recesses not actually filled by concrete will be deducted, but no deduction will be made for the volume of reinforcing steel or small openings (less than 0.1 sq.m. in surface area) and metal parts embedded in the concrete. No payment will be made for concrete that has been rejected or for concrete used to fill over-excavations.

Floors and intermediate and roof slabs will be measured over the external walls. Columns will be measured from top of foundation to first floor soffit and between floor slabs. Beams will be measured between columns or walls in length, and to floor soffits in height.

The unit rates for concrete shall include for : supply and transport of all materials to the site; batching, mixing, placing, vibrating and curing of concrete; testing of concrete; finishing of concrete, except as otherwise paid for under specially provided items in the Bill of Quantities.

Binding layers of lean concrete will be measured by square meters to a stated thickness. Cyclopean concrete will be measured by cubic meters including stones.

The shotcrete concrete will be measured by cubic meters including all means of application.

The Fiber concrete will be measured by cubic meters including all necessary metallic fibers.

202.14.3 Reinforcement Steel

Reinforcement steel will be classified for payment in accordance with the type of bars or fabric.

Measurement for payment of reinforcement bars will be made only of the weight of the bars placed in the concrete, on the basis of the net lengths and sizes, in accordance with the Drawings or as directed. Overlaps not shown on the Drawings will not be measured for payment. Payment for reinforcement bars will be made at the unit rates per kilogram (or ton) bid therefore in the Bill of Quantities, which unit rates shall include the cost of furnishing the reinforcement bars, furnishing and attaching tie rods and fasteners, wire ties and metal supports, if used, and of delivering, unloading, hauling, storing, sorting, cutting, bending, cleaning, welding if necessary, placing, and securing and maintaining in position all reinforcement bars, as shown on the Drawings or as directed, as well as waste and overlaps not shown on the Drawings.

Fabric reinforcement, required, will be measured on the basis of the area of work covered and will be paid for at the unit rates per kilogram (or ton) bid therefore in the Bill of Quantities, which unit rates shall include the cost of furnishing the fabric, cutting it to the required sizes, bending, placing, binding, supplying and placing all supports that are required, as well as the cost of all laps and waste.

202.14.4 Formwork

Formwork shall be measured for payment in m², classified by type (unwrought, wrought and for fairface concrete). Measurement for payment shall be of the net area of contact of concrete with the forms, after deduction of all openings and gaps exceeding 0.25 m² in area. The unit rates shall include for the use and waste of timber and of other materials and the supply of nails, tie-wires and fasteners; erection of forms, including scaffolding, shoring and shuttering; forming of levels, fillets, rebates, recesses, openings, etc.; removal of forms and for all materials (including waste), labour and equipment necessary for obtaining the required finish of the surfaces. It will also include temporary structures necessary for execution of all structure works.

Where no specific items for formwork are inserted in the Bill of Quantities, the cost of formwork as above shall be deemed to be included by the Contractor in his unit rates for the various items for concrete work and shall not be paid for separately.

202.14.5 Manholes and Chambers

Chambers shall be measured and paid for as defined in the Particular Specification.

Sewer manholes shall be measured by the number of complete units, classified according to type and depth as defined in the Bill of Quantities. For this purpose the depth shall be taken as the difference between the level of the manhole cover and the invert of the lowest pipe where it leaves the manhole. The unit rates of manholes shall each include : the cost of the required

excavation in all kinds of soil; the blinding layer under the concrete floor; construction of the floor, walls, and ceiling, inclusive of reinforcement, all in accordance with the Drawings and as specified in the Bill of Quantities; supply and fixing of hooks, step irons and/or ladders; the construction of inlets and outlets; benching of the floor as shown on the Drawings; applying the specified finish to all internal surfaces including lastering where required; supply and installation of frames and covers; supply and fixing of pipe stubs for future connections; compacted backfill around the structure and removal of all surplus spoil, and all ancillary works required to complete the manholes in accordance with the Drawings and specifications and to the Engineer's satisfaction.

The unit rates for manholes will not include for external drops, which will be measured and paid for as an extra over the rates of manholes and chambers. They will be measured by number and classified by diameter only, irrespective of depth. The unit rates shall include for the supply of all materials and all work necessary in the construction of the external drop to the details shown on the Drawings.

202.14.6 Thrust and Anchor Blocks

The thrust and anchor blocks shall be measured and paid for per cubic metre of concrete to the dimensions shown on the Drawings. The unit rate per cubic metre shall include excavation, erecting formwork, placing steel reinforcement, pouring concrete, backfilling works and all other related works.

202.14.7 Precast Concrete Elements

Precast concrete elements will be measured by number, length or area as detailed in the Bill of Quantities. The unit rates shall include for the costs involved in complying with all requirements of Section 202.11.3 and in addition all material, labour and equipment required in the manufacture, transport and placing the precast units in the structure, including also reinforcement steel and other metal parts that are part of the precast element.

202.14.8 Cast-in-situ Reinforced Concrete Piles

Cast-in-situ reinforced concrete piles will be measured by linear meters of concrete piles cast in boreholes, classified according to the depth and diameter of the borehole as specified in the Bill of Quantities.

The length of the pile will be measured from the bottom of the borehole to the bottom of the beam or column. The bottom of the borehole shall be taken as shown on the Drawings and/or determined by the Engineer. Lengths exceeding those shown on the Drawings or required by the Engineer shall not be measured.

The unit rates inserted in the Bill of Quantities shall include for : boring the hole for the pile and removal of the excavated material, protection of the borehole against caving in by installation and use of steel sheet casings and/or bentonite suspensions, supply of all materials for concrete, mixing and placing of concrete and all other works required according to the specifications.

Supply and placing of reinforcement cages will be measured and paid for separately according to Subsection 202.14.3 above.

202.14.9 Joint Seals

Joint seals will be measured by length, and will be paid per linear metre.

The unit rates for joint seals shall include the cost of supplied materials and all necessary works to complete the joint sealing.

202.14.10 Elastomeric Support

Elastomeric supports will be measured by units and will be paid separately for each specified support as shown on the drawings.

202.14.11 Hourdis Slabs

Hourdis slabs shall be measured and paid for per cubic metre of finished monolithical slab measured to the dimensions shown on the Drawings.

The unit rate per cubic metre shall include for formwork, steel bars, hourdis blocks placing concrete and all related works unless otherwise specified in the bill of Quantities.

203 - BRICKWORK AND BLOCKWORK

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203 BRICKWORK AND BLOCKWORK

203.1 GENERAL

All brickwork and blockwork to be constructed under the Contract shall comply with the provisions of this chapter. The use of the terms “brick” or “block” and their compounds shall not be limiting and the use of one term or both in the specification shall, where applicable, be interchangeable.

203.2 MATERIALS

203.2.1 Bricks and Blocks

Bricks and blocks shall comply with the provisions of the following standards and codes of practice :

Concrete Bricks and Fixing Bricks	B.S. 1180
Precast Concrete Blocks	B.S. 2028 and 1364
Brick and Block Masonry	C.P. 121 Part 1

All bricks and blocks shall be new and unused, free from any defects, and entirely in conformity with samples submitted to and approved by the Engineer. Where no specific instruction is given as to grade of block, the Contractor shall supply blocks of the highest quality.

Blocks and bricks used in fair-faced walls (“neat” brickwork) shall be specially chosen by the Contractor, to ensure uniformity of aggregate size, colour, shape and freedom from defects, and the block manufacturer shall be advised of their intended use.

Special decorative blocks shall conform in all respects with approved samples as submitted to the Engineer prior to commencement of the work.

Hollow or blind concrete blocks shall be of first grade quality manufactured in an approved factory, made of vibrated and compressed concrete and thoroughly watered.

Hollow concrete blocks shall be mechanically manufactured on site or in an approved factory by means of moulds.

Mix proportion : 50 kg of cement
 120 l of stone chippings
 90 l of sand

Characteristics : Weight : 1500 to 2000 kg/m³

Concrete blocks shall be left to dry for nearly one month in a well ventilated shelter. They shall have the thickness specified on the drawings.

Concrete blocks shall be 40 days old minimum and show, after 28 days, a crushing strength (measured on the whole block surface) equal to 40 kg/cm².

203.2.2 Sand for Mortar

The sand shall be natural sand, or sand from crushed stone, which in respect of quality and classification, shall comply with the provisions of B.S. 1200.

203.2.3 Water

The water for mortar shall be of potable quality in accordance with B.S. 3148.

203.2.4 Cement

The cement shall be Portland Cement complying with B.S. 12.

203.3 MORTAR FOR BRICKWORK

203.3.1 Proportions for Mortar

The different types of mortar shall be proportioned by volume as follows, unless otherwise specified :

Cement Mortar, 1:3 - One part cement, and three parts sand or other fine aggregate.

The type of mortar to be used shall be as specified hereafter and as directed by the Engineer. For the purpose of proportioning by volume, a sack of cement shall be assumed to be 37 litres in volume (50 kg in weight).

203.3.2 Mixing of Mortar

The dry ingredients shall be measured in suitable containers and mixed by hand or by mechanical mixer and then the required quantity of water shall be added in the form of a spray. Mixing by hand shall be done in special boxes. Mixing shall not be done on the bare earth. Cement mortar shall be used within one hour of mixing.

203.4 BRICKLAYING WORKMANSHIP

203.4.1 General

All bricks and blocks shall be thoroughly wetted before use, except where the capacity of absorption of concrete bricks or blocks is less than 5% by weight, and the Engineer is so informed in advance.

A perfectly rectilinear wooden ruler, a plumb line and an air level shall be permanently kept on site for verification of masonry. The Contractor shall demolish and re-build at his own expense every wall that is not in accordance with the stipulated requirements.

According to the used material, and whether masonry will be rendered or kept exposed, surface evenness tabulated hereinafter shall be measured by means of:

- 10 m long line
- 2 m ruler
- 0.20 m ruler

203.4.2 Workmanship

Bricklaying shall progress upwards in an orderly and continuous manner, and so that no portion will rise more than one meter above adjacent sections, unless special considerations rule otherwise. Should it be necessary to stop work without the courses being completed, courses shall be racked back at an angle of 45°. On resumption of work, the top course shall be cleaned and wetted prior to laying of additional brickwork. All courses shall be horizontal, and vertical joints shall be staggered, alternate joints being in one vertical line. The use of broken blocks will not be permitted, but half-blocks, specially prepared will be used when and as required. Wherever a closing piece not to standard dimensions is required, the closing shall be done by neatly casting concrete. The bond will be as shown on the Drawings; where not shown, English Bond shall be used unless otherwise approved by the Engineer.

Masonry using exposed concrete blocks

Exposed surfaces shall meet the following tolerances:

- Total evenness measured with a 10.00 m line : 2 cm
- Alignment of horizontal joints lines (over 10.00m) : 1 cm

Masonry with concrete blocks to be rendered

There are two types of masonry:

- ordinary workmanship
- wrought workmanship

Ordinary workmanship shall be reserved to walls which do not require any wrought finish or those which shall receive either a traditional thick rendering or a finish applied indirectly to the surface.

The wrought workmanship shall have the same application as the ordinary one but its workmanlike quality limits eventual coating works.

Type of workmanship	Overall evenness under 2.00 m ruler (cm)	Out of flush and local evenness under a 0.20 m ruler (cm)	Appearance
Ordinary	1.5	1	Levelled joints Repair of scratches or accidental lack of material that cannot be concealed with traditional rendering works After repair, residual local imperfections that can be concealed with normal rendering works shall not exceed 10% of placed blocks.
Wrought	1	0.7	Idem, but the percentage of defective blocks equals 5

203.4.3 Joints

All joints shall be filled with mortar to a thickness of 10 mm over their entire surface of contact. The thickness of the mortar shall be even throughout the joint. The variation in thickness of any joint from the determined thickness shall not be greater than 2 mm. The overall height of any four courses shall be equal to the nominal height of four building elements (blocks or bricks), plus four times the specified thickness of the joint, ± 2 mm.

During the laying of bricks (or blocks) the joints shall be wiped flush with the face of the wall. Racking out of joints in preparation for pointing, or for forming special facing joints, shall be done after partial setting of the mortar. Special facing joints shall be formed at the time of racking out.

203.4.4 Scaffolding

Scaffolding shall be stable and conform entirely with all requirements of the law. No building work at a height of more than 2 meters shall be carried out without scaffolding. Scaffolds shall be secured to the wall through holes left in it by omission of blocks. These holes shall be carefully filled with blocks after the scaffolds have been removed.

203.4.5 Blockwork Filled with Concrete

Hollow or channel blocks intended to be filled with concrete so as to serve as pillars or beams shall be accurately laid to allow easy placing of reinforcement steel. The bars be tied to the reinforcement of the building framework. Joints shall be made in accordance with Subsection 203.4.3.

203.4.6 Cavity Walls

Cavity walls shall be built in cement mortar or cement-lime-mortar, in accordance with the Drawings. Walls of less than one brick thickness shall be constructed in stretcher bond. During construction precautions shall be taken to prevent course for cleaning purposes, shall not be filled in until the completion of the wall.

In the absence of any special detail for the drainage and ventilation of the cavity, every third vertical joint in the bottom course of the outer wall shall be left open. Precautions shall be taken that these joints remain open plastering.

The ties between the walls shall be made in accordance with details shown on the Drawings or approved by the Engineer. Where ties consist of bricks or blocks, their ends projecting into the inner wall shall be covered with bitumen to prevent the passage of moisture from the outer leaf. Metal ties shall be of non-rusting material, or shall be protected against corrosion.

203.4.7 Fair Face Work

Fair-face brickwork shall be built of specially selected bricks or blocks. Only straight, clean flawless blocks shall be chosen. The blocks shall be inspected again immediately prior to laying and any damaged blocks shall be rejected.

Joints in fair-face blockwork or brickwork shall be pointed according to the details shown on the Drawings or to the Engineer's instructions. Pointing shall be done with an approved special tool using a special cement mortar (2: 3) made with white or coloured cement and with added pigments as required or directed by the Engineer. Pointing of joints shall commence at the top of the wall, shall proceed downwards and shall be carried out immediately prior to the removal of the scaffolding. As the pointing progress the wall shall be thoroughly cleaned of all excess mortar. All joints shall receive the same treatment and final shape and colour in order to present a neat uniform appearance.

203.4.8 Chases

Pipe chases shall not be cut in lime-sand brick partitions of half brick thickness or less and shall not be cut in walls until the mortar in the joints has hardened sufficiently. The chases shall be filled with 1:3 cement mortar, after the pipes have been fixed in them.

203.5 BUILDING JUNCTIONS

203.5.1 Junctions Between Walls and Partitions

Unless otherwise specified, corners and junctions between walls and/or partitions with courses of the same height shall be built in continuity in proper bond across the corner or junction.

When the walls and/or partitions meeting at the corner or junction are not built in continuity or if their courses are of different heights, the junction shall be formed by a concrete column, jointed to the walls by tothing the blockwork in accordance with the detailed Drawings. The concrete junction column shall be cast in sections as the walls progress in height.

203.5.2 Junctions Between Brickwork Walls and Concrete Columns

Where the column is to be cast after the wall has been built, a suitable gap shall be left in the wall which shall be finished in tooth formation on both sides of the gap. The column shall be cast between formboards fixed to either side of the wall. The gap in the wall shall be such as will leave the minimum required width of the column between protruding teeth. The depth of

the socket between teeth shall be at least 10 cm. Where the wall is to be built after the concrete column has been cast, especially if the depth of the column is larger than the thickness of the wall, the junction shall be effected in accordance with the details shown on the Drawings, either by leaving a groove in the side face of the column into which the bricks or blocks are built, or by casting a small connecting column between the main column and the toothed end of the wall as described in Subsection 203.5.1 above.

203.5.3 Junctions Between Walls and Concrete Soffits

The gap at the joint between the top of the top most course and the concrete soffit shall not be greater than 1.5 cm and shall be filled with 1:3 cement mortar. The wall shall be secured to the joint. The filling of the joint and the wedging shall be done after the mortar in the wall has properly set and hardened and, preferably, just before plastering.

203.6 MISCELLANEOUS BRICKLAYING WORK

203.6.1 Brick facing on walls

Bricks and blocks for wall facing (remaining exposed to view) shall be selected as required under Subsection 203.4.7 for fair face walls. The mortar used for laying facing bricks shall be cement lime mortar 1:2:6 or cement mortar 1:3. Making and pointing of joints shall be done as required in Subsection 203.4.7. Bricks or blocks used in facing shall be fixed to the wall by means of mortar having as dry a consistency as possible. Where anchors are shown on the Drawings they shall be of non-corrosive metal and shall penetrate at least 3 cm into the wall.

203.6.2 Composite Walls

Walls consisting of brickwork or blockwork with a concrete backing, shall be built as required in Section 203.4, except that they shall be constructed in lifts not exceeding 5 courses of blocks or 10 courses of bricks. Bricklaying in any lift shall not begin until the backing concrete in the lift below it has been allowed to set. Unless otherwise specified, the backing concrete shall be Class C15P in accordance with Division 204.

203.7 PREFABRICATED AND PRECAST ELEMENTS

203.7.1 General

This section shall apply only to those prefabricated and precast elements which have no structural function and are not part of the load-bearing structure. Included are those elements of concrete, asbestos-cement and similar materials, used as ventilating louvers, light partitions in bathrooms, banisters to stair-ways and balconies, etc..

203.7.2 Supply and Erection

The Contractor shall supply the required elements only after samples submitted by him to the Engineer have been approved.

Elements such as ventilation louvers shall be supplied and built in during building of the wall. All elements supplied shall be clean, free from flaws and complete in all details in accordance with the Drawings or instructions and shall include anchor damage during the course of the work.

203.7.3 Concrete Elements

Concrete for precast elements shall be Class C15P at least, unless specifically stated otherwise. Reinforcement shall be included as required, in order to facilitate safe haulage, erection and use.

203.8 METHODS OF MEASUREMENT AND PAYMENT

203.8.1 Walls and partitions

Brick and block walls and partitions will be measured by m² or built area according to the Drawings and classified by type and thickness of wall, all openings, beams, columns, precast elements etc.. being deducted from the area measured; however, tooth work as required under Section 203.5 will not be deducted. The cost of making all openings in the brick or blockwork shall be deemed to be included in the rates for the brickwork and shall not be paid for separately.

Unit rates shall be deemed to include for supply of all building materials such as blocks, bricks, cement, sand, etc.. and the waste involved in their use, the erection and removal of scaffolding, the cost of making all openings and connections to the walls, partitions and concrete structures. Where connection of blockwork wall to an existing building (i.e., one not built under this Contract) is required, payment will be made for the connection measured in accordance with the net length of the connection between one old and the new structures.

203.8.2 Columns and Beams

Columns and beams of hollow blockwork filled with concrete will be measured and paid for extra over the prices for blockwork. Measurement will be in accordance with the net lengths of the columns or beam and the unit rate shall cover all costs of special blocks, concrete work, steel reinforcement, etc..

203.8.3 Fair face

Neat work (fair face) will be measured separately by area, in m², extra over the unit rates for brick or blockwork; neat work on both faces will be paid for at the same unit rate, for each face separately.

203.8.4 Precast Elements

Precast elements will be paid for separately in accordance with size and type of complete elements. The unit rate will include for the supply of the elements and all accessories required for building-in as well as the actual erection of the element. The unit rate for precast units shall allow for cement wash rendering should the Engineer request it, in order to obtain a more uniform and harmonious appearance to the wall in which the element is built.

204 - MASONRY AND STONEMWORK

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204 MASONRY AND STONEMWORK

204.1 GENERAL

This chapter deals with all stone work with or without mortar bedding, constructional and/or decorative, such as retaining walls, pavings, filters, rip rap, gabions, etc., covering the supply of all specified materials as well as laying, jointing and constructing of all elements shown on the Drawings and described in the Specifications.

Stones shall come from selected quarry layers to the approval of the Engineer. They shall be homogeneous, frost resistant, flawless, free of any crack, solid, and of equal grain and shall have the required qualities to give a regular facing. They shall give out a clear sound when hit with a hammer. Those which give out a dull sound due to soft parts and crumble into sandy grains instead of breaking into sharp splinters shall be rejected.

Stones shall have a minimum density of 2.5, bear a crushing load superior to 600 kg/cm² and conform to the approved sample submitted by the Contractor. Stones shall have sizes (length or width) reaching 20 to 50 cm. Their width shall be as shown on the drawings, and they shall have beds and joints perpendicular to the facing.

204.2 MASONRY CONSTRUCTION

204.2.1 Masonry in Mortar

Where shown on the Drawings, retaining walls, abutments, wing walls and similar structures shall be constructed of masonry in mortar.

All building stone shall be free of decomposition, ironbands, sandholes, flaws and other imperfections. All building stone shall be approved by the Engineer before use. Stratified stones shall be laid in their natural bedding planes when incorporated in the Works.

Mortar shall be cement-mortar, as specified in Section 203.3 of the Specification.

All stones shall be thoroughly wetted before use and shall be laid in full mortar beds. They shall be placed so as to bind firmly in all directions. Selected stones roughly pitched to line shall be used at all corners. The rear face of wingwalls, abutments and retaining walls shall present an approximately plane surface and no voids shall be permitted in any part of the walls shall not exceed 2 cm in depth and vertical joints shall not exceed 2 cm in width.

Within twenty-four hours after construction all exposed faces shall be raked clear of loose mortar. The walls shall be kept moist during this operation and for a period of three days thereafter.

Weepholes shall be constructed of the size and in the positions shown on the Drawings or as directed on Site. Construction and Expansion joints shall be inserted in the positions and to the details shown on the Drawings or as directed by the Engineer.

204.2.2 Grouted Rubble Masonry

Where shown on the Drawings or directed by the Engineer, grouted rubble masonry shall be used in pavings, slope protection and similar works.

Grouted rubble masonry shall consist of approved building stone thoroughly wetted and laid in full mortar beds each course being grouted with 1:3 cement mortar as specified in Section 203.3 of the Specification.

204.2.3 Dry Rubble Masonry

Dry rubble shall consist of approved building stone, selected stones with flat faces as nearly parallel as practicable being used for this work. The different sizes of stones shall be evenly distributed over the whole face of the wall, generally the largest stones being placed in the lower part of the wall.

The work shall be well bonded using as many long stones as can be obtained and shall present a reasonably true and smooth surface free from large holes or projections. Retaining walls of dry rubble shall be built in advance of the embankments.

Natural stones masonry

Natural stones shall be laid on a mortar bedding proportioned at 1:3 cement mortar. Mortar must now flow out to the external surface of the wall; it shall be brushed and removed before setting.

For painting the joints in a wall, the following directions shall be respected:

- 1) while building, the joint shall be raked out to a depth of 4 cm
- 2) before pointing, clean again and wet the joints
- 3) fill the joint well with a rich plastic mortar (400 kg of cement per each cubic meter of clean, coarse sand)
- 4) smooth the mortar with a pointing blade
- 5) as soon as the mortar slightly dries out, gently scrape the mortar with a brush or a dry cloth in order to remove the marks left by the trowel and to roughen the joint
- 6) once the mortar is set, brush the stone surfaces with a metal brush.

In any case, the construction shall be carried out according to the general and detailed drawings, to the satisfaction of the Engineer and true to a sample of built wall, approved by the Engineer and kept at the site until the completion of masonry works.

204.2.4 Methods of Measurement and Payment

Masonry construction shall be measured for each type by area or square meters to the neat lines and dimensions shown on the Drawings. The area of all openings, holes and recesses, except for weepholes will be deducted. The unit rates for masonry construction shall include for the supply, on site of all stone, mortar, grout and all other required materials; erection and dismantling of scaffoldings, where required; and wetting of stone, spreading of mortar beds, and laying, jointing and grouting of masonry.

Unless otherwise specified, all excavation required for masonry construction shall be deemed to be included in the various unit rates and shall not be paid for separately.

204.3 RUBBLE STONE PAVING

204.3.1 General

Rubble stone paving shall consist of layers of stone placed on a gravel blanket, to the lines and thickness shown on the Drawings or directed by the Engineer. The stones shall conform to the requirements of Subsections 204.3.2 and 204.3.3 hereafter and the gravel blanket to the requirements of Section 204.4 hereafter.

204.3.2 Quality of Stone

Rubble stone for paving shall consist of clean frost resistant, hard sound and durable natural cobbles or quarried stone fragments of roughly cubic shape. The stones shall be free of cracks, seams and other defects. Elongated and flat slablike stones shall not be permitted. Not less than 75% of the stones shall have the dimensions of the faces perpendicular to the paved surface approximately equal to the nominal thickness of the paving and none shall be smaller than three quarters of the nominal thickness in the said direction. The stones shall be approved by the Engineer before laying.

204.3.3 Laying

Before laying the stone paving, earthworks shall be completed to final grades and lines, and the bedding shall be excavated and compacted to the finished slopes and levels. The gravel bedding shall then be placed and compacted as specified in Sub-section 204.3.4. The stones for rubble paving shall be placed on the gravel blanket and shall be hand packed as closely as possible to each other with their smallest side parallel to the paved surface and the exposed face flush with it. The joints shall be broken and no through joints will be allowed. The stones shall be bonded on all sides. The spaces between stones shall be filled either by a 1:3 cement-mortar or with rock chinking hammered into place. The paved surface shall be stable and reasonably flat and even, without any abrupt projections and/or depressions.

204.3.4 Gravel Blankets

Gravel blankets shall be placed as beddings under rubble stone pavements or, by themselves, as surfacing on soil areas, as shown on the Drawings or as directed by the Engineer. Material for gravel blankets and surfacings shall consist of natural river gravel or crushed stone in accordance with requirements of B.S. 882, Part 2 and to the satisfaction of the Engineer. Unless otherwise shown on the Drawings or directed by the Engineer, the size of the gravel, as specified in B.S. 882, Part 2, table 1, for single sized aggregates, shall be as follows:

- (a) For gravel blankets under rubble stone pavements - nominal size of 40 mm
- (b) For gravel surfacings on Soil areas - nominal size of 20 mm.

The gravel shall be placed in layers not exceeding 15 cm in thickness on a well-levelled and compacted subgrade. Each layer shall be thoroughly consolidated and compacted to the

satisfaction of the Engineer. The finished blanket shall have a stable and even surface and be true to the lines and grades shown on the Drawings.

204.3.5 Methods of Measurement and Payment

Rubble stone pavements shall be classified by thickness of gravel blanket and stone layers and shall be measured for payment by m² of surface area of completed pavement. Unit rates for rubble stone pavements shall include for all materials and labour required for the completed pavement in place, including all excavation; supply and spreading of gravel blanket; supply and laying of stone and filling of joints with cement-mortar of rock-chinkings; and all other works and materials required to make the pavement complete.

Gravel surfacings shall be classified by thickness of gravel layer and shall be measured for payment by m² of surface area of completed surfacing. The unit rates for gravel surfacings shall include for all materials and labour required for the completed surfacing in place, as specified in this Subsection, above, for rubble stone pavements.

204.4 GRAVEL AND SAND FILTERS

204.4.1 Materials

Filter materials shall be supplied by the Contractor from approved sources and shall consist of natural washed sand and gravel or clean broken rock which does not break down into finer particles when it is placed. They shall be free from silt, clay and organic matter or other impurities or deleterious substances. Filter materials shall conform to the requirements of B.S. 882 - Coarse and fine aggregates from natural sources. The grading shall be as shown on the Drawings and as defined in the Particular Specification, and shall always be such that all permitted sizes are represented and there is no undue preponderance of any one fraction.

The Contractor shall furnish for testing and shall test, at his own cost, such representative samples of filter materials as may be required by the Engineer and shall have them tested in approved laboratories. The Engineer reserves the right to inspect the sites from which filter materials are obtained. The approval of materials from a particular source shall not be construed as constituting an approval of all materials taken from that source, and the Contractor will be held responsible for the specified quality and gradation of gravel and sand delivered to the work site. If, in the Engineer's opinion, the filter material supplied by the Contractor fails to meet the requirements he shall be entitled to instruct the Contractor to take remedial steps such as washing the material, re-sieving it, etc., or to reject it completely and have other material brought in by the Contractor, at no additional cost.

204.4.2 Workmanship

The filters shall be made to lines, shapes and dimensions shown on the Drawings.

Overexcavation will not be permitted and any material outside of the required lines which has been distributed shall be removed and replaced and the level made up again under the direction of the Engineer with sound and suitable soil material carefully compacted or with concrete, solely at the Contractor's expense.

Placement of filters shall be carried out in the dry. When dewatering will be needed it shall continue and the water level kept below the level of the excavation until the placement of

filters, pipes, if any, and every other appurtenance has been completed and the Engineer has inspected the works and signified his approval for stoppage of dewatering. Dewatering shall be carried out in accordance with the requirements of Section 201.1 and Subsection 201.1.4 and any other directions given in the Particular Specification, and/or by the Engineer.

The sand and gravel shall be placed and tamped so as to prevent segregation and/or mixing of sand with gravel in the filter or with foundation or backfill material.

In placing horizontal filters, soil will be levelled and smoothed, but not compacted, before the first layer is placed. The top of each layer shall be smooth and levelled before the succeeding layer is placed. In placing vertical filters, the different layers shall be separated by vertical forms or boards which shall be gradually lifted as the placing of the filters progresses.

After the graded sand and gravel in the filter have been shaped and compacted to the required depths, surfaces of the filter shall be protected from entry of foreign matter into the filter, as shown on the Drawings. Filter surfaces over which concrete is to be placed shall be covered with a layer of 1:3 cement-sand mortar 2.5 cm thick to prevent the filter material from being displaced during the pouring of the concrete. The mortar coating shall be applied carefully to the required thickness. The consistency of the mortar and methods of application shall be such as to avoid unnecessary filling of the voids in the filter material.

204.4.3 Methods of Measurement and Payment

Filters shall be measured for payment by cubic meters of filter material placed to the lines and dimensions shown on the Drawings. The unit rates shall be uniform for all sizes of filter material and for vertical and horizontal filters and shall include for supply of filter material and its placing and shaping as specified and shown on the Drawings.

The cost for supply and placing of filter material shall be deemed to include excavating and digging out the material at its source; crushing, screening, mixing, washing, hauling, and dumping on the site of the work; placing, tamping, levelling and smoothing the layers of material; supplying installing and lifting forms and boards; supplying and spreading mortar layers and all other work and materials required to complete the filter in place.

Unless specific items for excavation and/or dewatering are included in the Bill of Quantities, excavation for the filters and dewatering as specified shall be deemed to be included in the unit rates for supply, placing and shaping of filters and shall not be measured and paid for separately.

204.5 DUMPED RIP-RAP

204.5.1 General

The work consists of covering the areas and slopes, shown on the Drawings and indicated by the Engineer, with dumped Rip-Rap, on a graded gravel filter blanket placed on finished surfaces of earthworks, as shown on Drawings.

204.5.2 Materials

The materials for the filter blanket shall comply the requirements of Subsection 204.4.1 of this Specification.

The material for the rip-rap shall consist of hard, dense, durable rock, resistant to weathering and water and wave action, with the following physical properties (to B.S. 812) :

- Minimum bulk specific gravity (dry in air) - 2.6
- Maximum absorption - 3%
- Maximum abrasion - 25%

The rip-rap shall consist of angular fragments of quarried rock with the cobbles, flat slabs and elongated pieces shall be rejected.

The grading of the filter material and of the rip-rap stones shall be as shown on the Drawings, as specified in the Particular Specification and as directed by the Engineer to meet the gradation requirements. A quantity of gravel and stone spalls sufficient to fill the voids between the stones shall be included in the material.

204.5.3 Workmanship

After completion of earthwork the gravel blanket shall be placed avoiding segregation as far as possible. The blanket shall be compacted to the satisfaction of the Engineer, and when completed, shall be free draining.

Rip-rap of stones or rock fragments shall be dumped on the gravel. The stone of rip-rap need not be compacted, and shall be dumped and graded off in such a manner as to ensure that when completed, it will be well interlocked and stable, without tendency to slide. The rip-rap stones are to be uniform distributed with sizes of stones increasing toward the top, and the small fragments and spalls shall serve to fill the spaces between the larger stones. The completed rip-rap shall have a reasonable even surface and the required thickness.

204.5.4 Methods of Measurement and Payment

Rip-rap and gravel blankets under rip-rap shall be paid for under separate items in the Bill of Quantities. The rip-rap and the blanket shall be measured for payment by square meters of completed surface actually placed in position to the lines and dimensions shown on the Drawings or as directed by the Engineer and shall be classified according to thickness of layer. The unit rates shall include for excavation and removal of surplus soil, supply,

transportation, dumping and spreading of all gravel and stone, compaction of gravel blanket, and all materials and labour necessary to complete the work to the satisfaction of the Engineer.

The Contractor is warned that material for rip-rap and blanket which will comply with the gradings specified may not be found in their natural state. The Contractor shall therefore make allowance in his rates for the fact that it may be necessary to sieve and make trial mixes or quarry for rock to obtain the correct grading by crushing rock with or without mixing with materials obtained from natural sources, all as directed by the Engineer, and at the Contractor's cost.

204.6 HAND PLACED RIP-RAP

204.6.1 General

The work consists of hand placed rip-rap paving to the dimensions shown on the Drawings, laid on a graded gravel filter blanket on areas as shown on the Drawings and as directed by the Engineer.

204.6.2 Materials

The quality, grading and all other requirements for gravel blanket shall be as specified in Subsection 204.5.2 for the rip-rap shall consist of angular fragments of quarried rock, roughly squared, with minimum dimensions as shown on the Drawings. Quality of stone shall be as specified in Subsection 204.5.2.

204.6.3 Workmanship

The area to be paved shall be excavated to a depth equal to the combined thickness of the gravel blanket and rip-rap stone, so that the face of the stone of the completed rip-rap paving shall be flush with the neat lines of the area, as shown on the Drawings. The gravel blanket shall be laid as specified in Subsection 204.5.3. The rip-rap stones shall be carefully placed by hand in a definite pattern, with a minimum amount of voids and with the top surface relatively smooth. Joints shall be broken, as much as possible. Openings to underlying blanket shall be avoided by carefully arranging the various sizes of stones and filling the openings with rock chinking hammered into place.

204.6.4 Methods of Measurement and Payment

Hand placed rip-rap and gravel blankets under hand placed rip-rap shall be measured for payment and paid for as detailed in Subsection 204.5.4. The unit rate shall include for all work and materials, as detailed in Subsection 204.5.4 as well as hand placing of stone and closing of joints, as specified.

204.7 GABIONS

204.7.1 General

Gabion walls are gravity retaining walls, disregarding the role of the gabions which give them a higher safety coefficient due to their tensile stress.

Gabions retaining structures are classified in 4 categories:

- 1) Gravity retaining structures
- 2) Half gravity retaining structures
- 3) Embankment structures
- 4) Thin anchored to ground walls with hexagonal mesh structure.

Gabion-baskets are parallelepipedic structures consisting of metallic double twisted hexagonal wire meshes filled with broken stones of suitable grading.

Where shown on the Drawings or directed by the Engineer, the Contractor shall erect box or mattress gabion structures, consisting of galvanized wire mesh baskets filled with rocks or stones of suitable sizes and mechanical properties.

Each unit shall be firmly tied to the others using wires so as to form a monolithic structure.

204.7.2 Materials

The baskets shall be manufactured of hot dip galvanized or galvanized and plasticized wire double twisted hexagonal mesh. Wires shall comply with B.S. 443 - "Galvanized coating on wire" - and B.S. 1052 - "Mild steel wire" and shall have the following characteristics:

- high mechanical strength
- high resistance to corrosion
- good deformation ability
- good resistance to the undoing of meshes.
- good resistance to the undoing of meshes

Following are the characteristics of standard gabions:

Galvanized Gabions		
Mesh	Wire Ø mm	Thickness m
10 x 12	2.40	0.50
	2.70	
	3.00	
8 x 10	2.40	
	2.70	
	3.00	
6 x 8	2.20	1.00
	2.70	
5 x 7	2.00	
	2.40	

Width : 1.00 - 2.00

Length: 2.00 - 3.00 - 4.00 for 1 m. wide gabions/
3.00 - 4.00 - 5.00 for 2 m. wide gabions.

The gabions shall be provided with diaphragms to divide the boxes in compartments with a maximum dimension in any direction of 1 meter. Diaphragms shall be manufactured of the same wire as gabions and shall stiffen the structure and facilitate assembling. Gabions can be 1 or 2 meters wide.

Mechanical and quality properties of wires (breaking load, elongation at rupture, galvanization characteristics, etc...) must be consistent with the most strict standards.

Lacing and binding shall be done by means of hot dip galvanized wire of 2.2 mm minimum thickness, which will be supplied with the gabions and will have the same characteristics of gabions wires (hot dip galvanized annealed mild steel, double twist and hot galvanized, long term corrosion and oxidation resistance).

Filling materials for gabions shall be stones or others provided their weight and characteristics meet static, operation and duration requirements of the structure.

Rockfills shall consist of hard broken stones. It is advisable to use materials with a high specific gravity especially in the event of gravity retaining or submerged structures or works subject to the living force of waters. To ensure a long life time of the structure, stones should not be friable, soluble in water but frost resistant, hard dense and durable with a minimum bulk specific gravity (dry in air) of 2.6, maximum absorption 3% and maximum abrasion 25% (tests according to B.S. 812)

Dimensions of rock fills shall vary between 1 and 1.5 times the size D of the wire mesh, which prevents rock losses. The use of small-size rockfills (1-1.5xD) allows a better and a more economical filling, and therefore, a good load distribution and a high adaptability to deformation.

Boulders, rounded cables, flat slabs and elongated pieces shall be rejected.

204.7.3 Workmanship

The gabions shall be delivered to the site, folded and packed. Delivery of assembled gabions shall not be permitted. On the site, the gabions shall be opened up and laid flat on the ground, any unnecessary creases shall be straightened and the ends of diaphragms shall be lifted into a vertical position and placed together with binding wire to form the box. Adjacent arises shall be laced together and diaphragms fixed to lateral sides. The binding shall be carried out in a continuous lacing operation, the wire being passed through each mesh and around both edges which must be tied together, with two round turns after every second mesh.

Assembled gabions shall be placed in position for filling singly, or wired together in groups suitable for man-handling. All adjacent gabions shall be securely wired together at all corners and edges in the same manner as described above. Where there are more than one course of gabions, the ones in the upper course shall be laced to those below. Adjacent gabions shall be laced together afterwards.

To avoid bulging on the outside of the structure, tie wires (of the same material and thickness as building wires) shall be fitted inside the gabion compartments between the outer and inner

skins. The tie wires shall be passed around at least two meshes on each side of the compartment. Vertical ties shall be fixed to the bottom of the gabion prior to filling and tied down to the lid on completion. Two ties at least shall be used per square meter of surface. Horizontal ties shall be placed either perpendicular to the sides or diagonally across the corners.

The disposition of gabions is conditional upon adopted types and required characteristics of the structure.

Filling shall be carried out manually and mechanically, with minimum of voids. Packing of the stones shall be as tight as practicable. After filling the gabions slightly over-full to allow for subsequent settlements, the lid shall be laced down with binding wire to the tops of all the sides and diaphragms.

A design calculation note shall be submitted in terms of the type and geometry of the structure and shall determine the required properties and dimension of gabions walls, taking into account the technical constraints of each site.

204.7.4 Methods of Measurement and Payment

Gabions shall be measured for payment by cubic meters of gabions in place, to the lines and dimensions shown on the Drawings. The unit rates shall include for any necessary excavation and disposal of surplus soil, supply and erection of the gabions, the supply and filling of stone and all materials and labour, required to complete the gabions in place as specified, as shown on the Drawings, and to the satisfaction of the Engineer.

204.8 ROCKFALL PROTECTION NETTING

204.8.1 General

The rocks may fall by different ways and for different causes, the shape of the individual rocks and the angle of inclination of the slope are the major determinants of the way in which the rocks fall. The methods of protection must take into account two basic factors:

- a) The dimensions of the rocks involved
- b) The speed at which the rocks accumulate at the base of the slope.

Wire mesh netting is used to prevent rocks and debris from falling on to roads or installations.

Laying sheets of mesh over a rock slope may be classified as an active or passive protection and several practical variations are possible to improve the effectiveness of the protection, this include reinforcing grids, sealing the face by means of sprayed concrete, etc..

204.8.2 Materials

Sheets of hexagonal mesh offer a wide range of options to resolve the protection problems against rock falls. Hexagonal wire mesh shall have a long service life and high resistance which should meet the strict requirement for the construction of the works.

The mesh shall be manufactured with double twisted joints of the wires. The rolls or panels shall feature a selvage wire of larger diameter than that used for manufacturing the mesh, which is mechanically attached.

The mesh shall be woven from heavily zinc coated galvanized wire which can be coated additionally with a continuous P.V.C. sheet 0.40 to 0.60 mm thick in conformity with A.S.T.M. standards.

All the wires used in making the mesh and in lacing it together (at least 2.20 m diameter) shall meet the BS 1052-1980. The zinc coating protecting the core is applied in accordance with BS 443-1982.

Following table showing minimum quantities of zinc in relation to wire diameters.

Nominal wire diameter (mm)	Minimum quantity of zinc (g/cm ²)
	BS 443-1982
2	240
2.2	240
2.4	250
2.7	260
3.0	275
3.4	275

The characteristics of the hexagonal wire mesh shall ensure a structural integrity over a long service life, and shall meet the site particular requirements.

204.8.3 Revetting of rock slopes with hexagonal wire mesh netting

The sheets of mesh are fixed at the top and along the slope with anchors, which must be suitably dimensioned in relation to the type of terrain or rock and it shall be useful to construct a ditch at the foot of the slope for collecting fallen rock and this should be adequately dimensioned.

The top anchorages securing the hexagonal mesh netting at the summit of the slope are formed of steel bars firmly embedded in the ground and the underlying rock which is being covered.

Anchorages can either point (mechanical) anchors or distributed ones.

Mechanical anchors are constituted of a head expanded mechanically within a drilled hole, causing compression in the rock. The pressure induced by the expansion of the anchor should be related to the ultimate strength of the rock.

Distributed anchorages consist of steel tendons which are grouted and sealed in the anchorage hole.

The anchoring effect is produced by the adhesion between the tendons and the grouting medium and between the latter and the rock or ground. The grout used may be a cement mortar, or polyester, or epoxy resins.

204.8.4 Details of construction

a) Anchoring at the top

The distribution of top anchorages must be calculated on the basis of the maximum load that may occur at each anchorage, bearing in mind the breaking strain of the double twist netting.

The top of the netting must be firmly anchored to the ground and possibly folded back upon itself for 0.30-0.50 m.

The most common cases of anchors system to be provided:

- fissured hard rock not subject to deterioration: simple and/or double expansion bolts of diameter varying 10 and 20 mm and at 1.00-2.00 m centres.
- compact rock subject to deterioration: it is advisable to make a series of holes into the rock at least 0.50 m deep at 1.5-2.0 m centres into which hooked steel reinforcing bars are inserted (14-24 mm dia) and then anchored by filling the holes with mortar or special resins.
- compact soils: drive steel reinforcing bars (dia. 20-30 mm) length 1.00-1.50 m into the ground and fit these too with a hook to which the netting is to be tied.

In all the cases described above it is preferable to link the individual anchorages with a steel rope which must be tied to the mesh.

- Organic and soft soils: in this case it is recommended that the anchor bars (dia. 14-24 mm at 2.00-3.00 m centres) be buried in concrete and the mesh tied to them by means of a continuous steel rope.

b) Treatment at the foot

Treatment at the foot is particularly important in the case of netting blanketing rock slopes.

One practical solution is to leave the sheet open for between 0.30 and 0.60 m making it terminate in a collection ditch of suitable dimensions which is cleaned out from time to time.

The bottom of the ditch must be covered with material suitable for damping the residual energy of the falling rock, thus limiting the danger of its rebounding on to the carriage-way. This material could be sand, fine aggregates, etc.

The ditch shall be 3.00 m minimum wide and 1.5 m deep.

In some cases, where space is limited, a vertical safety barrier can be erected close to the roadside, to make up for the lack of an adequate ditch.

when only a small amount of material is likely to collect the top of slope, the following alternatives can be adopted:

- simply leave the lower end of the netting open, about 0.30 m, to facilitate removal of the detritus deposited;
- close the netting at the foot to contain the loose material. the bottom fixing must allow for periodic removal of the accumulated material as necessary, after which the netting must be anchored again.

c) Anchoring on the face

On the rock face the sheets of netting (varying from 1.00 to 4.00 m in width), must be securely and continuously laced together using bind wire of diameter equal to, or less than that of the wire of which the mesh is made, or with metal stakes of various types. In considering the layout with regard to the morphology of the face, and especially for curved sections, it is advisable to overlap sheets rather than to cut them, to reduce fixing time and avoid weakening the cover. When it is necessary to keep the sheets close to the face to prevent fragments of rock from rolling or for other reasons, suitable anchorages must be provided at the rate of one unit every 15-30 m² of covered surface.

The type of anchorage will be defined in relation to the characteristics of the slope.

204.8.5 Reinforced netting

The sheets of netting can be strengthened with reinforcing elements to increase their ability to contain rocks which may become detached from the face. The series of panels or sheets of hexagonal mesh wire laid flat on the slope shall be reinforced with vertical cables, a diamond pattern of cables, quick fastening connecting rings with intermediate anchoring units and whilst locking plates.

Sprayed concrete treatment

A cover of sprayed concrete, between 60 and 150 mm thick, is usually applied over the hexagonal wire mesh (sometimes a double layer) anchored to the face as described previously. The main purpose of this treatment, which is usually employed on sub-vertical faces, is to hinder rock deterioration due to atmospheric action (splash erosion) and to contain the superficial cracks in the face.

it is advisable to arrange drainage holes at intervals along the covered face, for pressure relief.

One way in which a sprayed concrete blanket can be applied is as follows: first the section of the slope in question is prepared and cleaned, and any existing vegetation is removed. Then the first layer of double twist wire netting is laid, and anchored by means of bolts along the face and supporting anchorages at the top. Calculations are based on the anchorages supporting the entire weight of the structure, disregarding the friction between the face and the blanket.

Next the sprayed concrete is put in place using a special machine, for dry or wet mixes, fixed to the slope by a suitable service platform. After a first light spray, fixing a second layer of netting is carried out, and this is then completely covered with another blanket of sprayed concrete. The double covering ensures adequate elasticity and a good distribution of any stresses induced by temperature variations. The use of a ferric-pozzolanic type of cement

ensures both good mechanical strength and resistance to atmospheric agents, together with a colouring that blends with the vegetation cover.

Another application of sprayed concrete reinforced with hexagonal wire mesh netting is in combination with a series of reinforced concrete beams arranged horizontally and vertically along a slope in order to distribute the stresses along its entire surface, included by the tie-rods used for strengthening the slope.

Those areas of the slope that are enclosed by the beams are covered with sprayed concrete reinforced with wire netting which is sunk below the beams along the edges. Again, drainage holes are left to avoid the formation of pressure from ground water.

204.8.6 Workmanship

The phases of work required for placing netting laid flat on the face can be described to 4 main stages:

- preparation of the surface to be blanketed (clearing scrub etc. and if necessary removing loose surfaces);
- placing the netting sheets over the surface to be protected by lifting the rolls to the top of the face and then unrolling them; or else by lifting one end and placing the sheet directly against the face;
- fixing the sheets to the wall and tying them together;
- finishing and final fastening of the netting at the top, the foot and if necessary to the face.

These operations, especially when performed on medium or high faces, must be carried out by skilled workers used to moving about on vertical faces, making use of spelogical and alpine methods and equipment; these methods have considerable advantages both as regards the speed of execution of the work and for ensuring the safety of the workmen.

There are two main systems for spreading the rolls of netting over the faces to be blanketed.

- a) The *first method* consists of transporting the rolls to the top of the face and, after aligning them on the upper edge, opening them, fixing them at the edge and allowing them to unroll downhill; depending upon the site conditions and the height of the faces, they may be transported by grader or crane or winched up.
This method is used when there is some access road to the top or when there are obstacles such as telephone or electricity cables or a railway line at the foot of the face.
- b) The *second method* involves leaving the roll at the foot of the face, coupling a bar to it and lifting it up to the top of the face where it is to be fixed; this eliminates the problem of positioning the roll manually at the top of the face and any joints between rolls which have to be made if those of standard lengths are too short; in addition the sheets are positioned on the face in the one operation. A winch, a crane or any other means, such as a lorry, grader, etc., can be used to raise it. These can stay on the road and lift the sheets with a cable passing through a pulley fixed at the top of the face when using a road-based power source with cable and pulley, the anchorages at the top of the slope must be very robust, able to withstand considerable shearing stress.

204.8.7 Methods of measurement and payment

A design calculation note, made by specialists, shall be submitted in terms of the type of the structure, anchoring systems, methodology of execution, reinforcing,... Taking into account the technical constraints of each site.

Rockfall protection netting sheets shall be measured for payment by square meters of mesh in place, to the lines and dimensions shown on the Drawings.

The unit rates shall include preparation of the surface, transporting and placing the netting sheets over the surface to be protected, fixing the sheets and tying them, anchorages, sprayed concrete and all materials and labour required to complete the finishing of the stabilization of the slope as specified, as shown on the Drawings and to the satisfaction of the Engineer.

205 - PLASTERING

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205 PLASTERING

205.1 GENERAL

205.1.1 Miscellaneous Requirements

Surfaces

a) Nature of surfaces

Plasterworks specified in this Section shall be applied to the following surfaces:

- traditional masonry made of stones, bricks, concrete blocks, traditional floors or with precast small girders.
- ordinary aggregate concrete or lightweight concrete.
- plaster tiles and plates including cellular plaster tiles.
- Plaster plates and perforated cardboard.
- metal lathing.

b) Condition of Surfaces

All surfaces to be plastered shall be dry, clean, free from soot, efflorescence, dust and oil. They shall be rough and unevenness of joints shall not exceed one third the plastering thickness.

Plastering frozen surfaces is not permitted.

Plastering work shall be classified into internal and external work, each of which may be applied in one-coat or two-coat work as indicated on the Drawings and/or in the Particular Specification or as directed by the Engineer.

The Contractor shall not carry out any plastering on days of extremely dry weather without the prior approval of the Engineer, who may require special precautions to be taken by the Contractor to prevent the early drying out of the plaster. Each layer of plaster shall be wetted prior to placing the next layer and at least 24 hours shall elapse before an additional layer is placed. All corners, whether internal or external, shall be neat and true, special care being taken to ensure a true, straight line at the junction of walls to the ceilings. All finished plastered surfaces shall be even, smooth, straight, plumb, with true angles (except where curved surfaces are shown on the Drawings) and free from trowel marks, cracks and other blemishes. Plane surfaces shall contact a 3 m straight edge with not over 3 mm deviation either way. Plaster showing cracks, blisters, pits or discoloration will not be accepted. It shall be removed by the Contractor and made up again at his own expense to the complete satisfaction of the Engineer.

205.1.2 Samples

Samples of each type of plaster to be used in the Works shall be prepared, each sample covering at least 1 square meter. Each sample shall be subject to approval by the Engineer, prior to actual commencement of plastering.

205.1.3 Scaffolding

Scaffolding shall be of sturdy and stable construction. Where a decorative spray or thrown finish is required to the plaster, the scaffolding shall not be connected to the wall to be plastered.

205.1.4 Repairs to Finished Plaster

Repairs of plaster, at skirting and elsewhere, as for instance around pipework, passages and channels, after the completion of other trades, shall be done in a neat manner so that all repairs will have a uniform appearance, indistinguishable from the general area of the plaster.

205.1.5 Levelling Course

A levelling Course shall be applied under all plasterwork and where called for on the Drawings and/or in the Particular Specification or directed by the Engineer, in order to straighten or correct imperfections in the base (brickwork, concrete, etc.). The levelling course shall consist of a cement-sand mix containing not less than 400 kg cement per meter cube of material. The course shall be applied as a thick paste with the aid of trowels, the minimum thickness being not less than 3 mm. Should the thickness be 10 mm or more, reinforcing wire mesh shall be used.

205.2 MATERIALS

Lime shall comply with the requirements of BS 890.

Lime shall be stored in a dry place protected from excessive temperature and wind.

Water shall be of potable quality, clean, fresh, free of salts, chemicals and impurities.

Sand shall be natural sand or quarry sand, free from dust, dirt and organic and foreign matter, complying with B.S. 1198 and 1199. Quarry sand shall not contain fines passing a No. 200 sieve in a quantity exceeding 6% - 8%. The sand for the first coat in two-coat work shall be coarse and graded. For the top-coat the sand shall be fine and well-screened, except where a special plaster made of coarse sand is required. Dune sand shall only be used for the top-coat of smooth internal plaster. The sand shall be supplied to the Site and stored according to type, each type separately. Sand in storage shall be placed on a layer of suitable material or any other stable surface in order to prevent contact and mixing with earth. The use of siliceous sand instead of calcareous sand is advisable.

Additives to control the workability or setting time of plaster may be used only with the prior approval of the Engineer, and shall be suited, in quality and quantity, to the type of cement used. No additional payment will be made to the Contractor for the use of any additive.

Coloured plaster shall be obtained by adding pigmenting powders to white or gray cement or by using coloured cement. Such cement shall comply in all respects with the requirements of the standards for ordinary Portland cement. Pigmenting powders shall be mineral oxide of metals. The use of compounds of organic origin will not be permitted. The pigmenting powders shall be obtained from approved manufacturers. They shall be thoroughly mixed with the dry cement before being introduced into the mixing machine.

Metal Lathing for plastering on false ceilings and partitions shall be expanded metal (XPM), at least 0.6 mm thick, with mesh size openings of at least 12 mm and the opened mesh weighing at least 1 kg per square meter. Wire Mesh used for plastering chases in brick or block work shall be XPM as above or chicken wire with a thickness of 0.7 mm and a mesh of at least 12 mm.

205.3 WORKMANSHIP

205.3.1 Preparation of Surfaces

Plastering shall be done only after all other finishing works such as window sills, terrazzo work, electrical work, drain pipes, etc., has been completed. Only with the Engineer's consent in writing will the Contractor be allowed to carry out plaster, prior to the completion of all other works. In exterior plasterwork, care shall be taken to avoid staining or damaging any completed elements of the building.

No plastering shall be done until at least two weeks have passed since completion of the brickwork or concrete on which the plaster is to be placed. All surfaces to be plastered shall be thoroughly brushed down with stiff brushes to remove any efflorescence and all loose and flaky particles. Grease and oil patches must be removed.

Prior to commencement of plastering, all necessary repairs shall be made to the base, protrusions shall be removed and any exposed steel reinforcement shall be covered with a 1:3 cement-sand mortar.

Considerable holes or local unevenness shall be patched with mortar, plaster mortar or plaster. Where holes or local unevenness exceed 5cm, they shall be filled with parts of brick and hollow blocks, as well as, with lime mortar or plaster mortar.

Patching on plaster masonry shall be carried out with plaster or plaster mortar.

Junctions between two different materials (e.g., concrete and blockwork) shall be covered with 15 cm wide strips of XPM mesh. No mesh will, however, be required where junction between brickwork and concrete is toothstepped.

Pipe chases containing two or more pipes shall be covered with wire mesh, the mesh being stretched across the chase with a 5 cm minimum overlap on each side, and fastened down with galvanized nails. The mesh shall be covered with a 1:3 cement-sand mortar. Minor chases, holes, etc., need not be covered with wire mesh, but shall be carefully filled with a 1:3 cement-sand mortar, the face of which shall be slightly roughened.

All repairs shall be thoroughly cured and allowed to dry, and moistened prior to commencing the plastering.

All smooth surfaces, such as concrete, shall be scarified in order to increase the bond of the plaster to the wall or ceiling. In blockwork the joints shall be raked out to a depth of 1 cm and all exterior surfaces shall be spatterdashed in 1:2 cement sand mortar to provide a key for the plastering. The spatterdash shall be wetted an hour or two after application to ensure adequate hydration and shall be allowed to harden thoroughly for 3 days during which time it shall be covered up for protection against the sun and kept moist by watering.

Surfaces to be plastered shall be cleaned and moistened, prior to application of plaster. Where necessary, ingrained dirt and other foreign materials shall be removed by wire brushing. Twenty-four hours prior to application of plaster the surface shall be soaked with a light spray of water, but not to an excess causing water to flow down the face of the wall to be plastered. During warm, dry weather the area shall be lightly wetted for a second time immediately before commencing the plastering.

205.3.2 Plastering

a) General

It is not allowed to re-mix plastering having began to dry out with or without adding fresh plaster.

Plaster mix shall consist of the following:

- cement mortar: 300 to 350 kg of cement per cubic meter of dry sand
- lime mortar: 350 kg of mix (one part of lime to two parts of cement) per cubic meter of dry sand
- plaster mortar: 300 to 350 kg of plaster per cubic meter of dry sand.

Smooth surfaces shall be roughened and cleaned from loose particles or treated with a sand cement or plaster sand mix to which an admixture is added to increase the bond (acetate or vinyl propionate).

b) Type of Plastering

Plastering shall be applied and smoothed by hand in two coats to a metal lathing.

c) Application of fine structural plaster or coarse structural plaster rendering

Plastering shall be applied in two coats, the first is a coarse structural plaster. The mix contains at least 100 kg of plaster per 100 liters of water.

The base coat shall be applied to the levelling course with a trowel but not smoothed. As soon as this coat hardens it shall be scarified with a special tool and the top coat applied.

The mix of the second layer shall be at least equal to that of the first applied. The total thickness shall reach 12mm with a tolerance of 2mm. Where a metal lathing is to be placed plastering shall be 6mm thick.

205.3.3 Condition of surfaces

After the surface preparation (wire brushing and removal of loose particles) plastered surfaces shall show no cracks, holes flakes nor streaks of more than 1mm deep. Moreover, the number of holes and streaks of less than one mm deep shall also be limited. Surface unevenness shall be repaired by traditional surface preparation work taken into account the type of paint to be applied and the required finishing quality.

The deflection under a 0.20m long ruler drawn over the surface in all directions shall not exceed 1mm (local evenness). A two meters long ruler drawn over the surface shall not show a deflection exceeding 5mm (general evenness).

The tolerance on verticality shall be 5mm maximum for one floor.

205.3.4 Reinforcement of Corners

External corners at intersections of plastered surfaces shall be reinforced by means of special approved angle beads of galvanized steel, aluminium or plastic, all as specified or shown on the Drawings. The height of the angle beads shall be not less than 1.8 m measured above the top of the skirting. The angle beads shall be securely fastened to the base wall under the plaster by use of galvanized nails. Plaster of the type used on the wall shall be carefully filled under and around the angle bead. The apex of the angle shall coincide exactly with the edge of the corner with regard to position and plumb.

205.4 METHODS OF MEASUREMENT AND PAYMENT

205.4.1 General

The unit rates for plastering shall include for the use of all tools scaffolding, labour and materials, including supply, processing and use of cement lime - slaked or otherwise - sands, gravels, additives and colouring pigments, mica flakes, and including for metal lath, all as specified and as applicable. Unless otherwise specified, the unit rates shall include for the use of ordinary Portland cement. The unit rates shall also include for all cleaning and wetting of all surfaces prior to plastering and the protection and curing of the plaster, inclusive of all surface treatments required.

205.4.2 Measurement

Measurement will be in all cases be net in square meters, as measured on the Drawings, all openings, tiling, skirtings and other areas not covered by plaster being deducted with no allowance for waste, overlap, etc. Reveals, jambs, and rebates to openings (doors, windows, etc.) will be measured for payment together with the general area of the plaster and no special rates will be paid for them.

For purposes of measuring external plaster, the bottom edge will be taken as being 10 cm below final external ground level, unless otherwise shown on the Drawings.

205.4.3 Payment

Samples, making good to other trades and repairs will not be paid for separately and the cost thereof shall be included in the unit rates for plastering, which shall also allow for the supply of wire mesh for covering pipe chases, etc., where required.

Internal or external plaster will be paid under the same item in the Bill of Quantities.

206 - RENDERING

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206 RENDERING**206.1 GENERAL**

Rendering with hydraulic binders mortars shall be governed by related B.S. Standards. Rendering shall only be carried out on completed masonry works. It shall be made sure that rain and water have no pernicious action on the good hold of the rendering. It is advisable to render only on elements that have completed the major part of their shrinkage.

Rendering works shall not be started prior to the installation of electric and sanitary equipment, woodwork, metalwork, and all metal fittings. Works include, in addition to rendering, the fill-in of holes caused by the installation of electric and sanitary equipments, metal fittings, etc.. Fill-in shall be carried out with a mortar proportioned at 350 kg of cement per cubic meter of sand.

All finished surfaces shall be even and to the thickness required by the Engineer. They shall be, where specified, straight, plumb with true angles. Rendering showing defects shall be removed by the Contractor and made up again at his own expense to the complete satisfaction of the Engineer.

Samples of rendering to be used in the works shall be prepared, each sample covering at least 1 square meter. They shall be subject to the prior approval of the Engineer. Samples shall be kept on site until the completion of works. All finished rendered surfaces shall comply with the samples.

Markers shall be placed at the rate of one marker by square meter of wall to be coated. Rendering shall be carried out using a plumb line and a ruler.

Unless stated otherwise, rendered surfaces shall be brought even and smooth by using a felt. No rough patches, ridges, nor any imperfections shall be accepted. Connection with woodwork, skirtings, or metallic structures etc... shall be neatly finished and flawless.

Rendering shall be conducted and low-angled light will be used so that any flaw such as undulations, ridges, blusters be detected and repaired.

Edges, salient angles, etc... shall be sized and rectified by means of straight wooden or metallic rulers.

Should several elements be set out at a stretch, they must be, after rendering, perfectly aligned and their dimensions rigorously unchanged.

A straight wooden ruler, a plumb line, an air level, a square, and an electric lamp shall be kept continuously on site.

The Contractor shall provide and install at his own expense all scaffoldings and ramps necessary for an easy and safe access to all surfaces to be rendered.

Prior to application of rendering and finishes, surfaces should be thoroughly cleaned and wetted for several hours.

Rendered surfaces shall be wetted after application to ensure adequate hydration and shall be allowed to harden thoroughly for 3 days during which time it shall be kept moist by watering.

Construction joints in rendering works shall be done in a neat manner so that the surface will have a uniform appearance, after having dried and shrunk, indistinguishable from the general area of the rendering.

206.2 MIXING OF MORTAR

Mortar can be mixed either manually or by means of mechanical mixers. Should mixing be done by hand, the dry solid constituents shall be mixed first, before water is added, in a very clean area to prevent contact and mixing with earth or other materials. Sand shall be measured in volumes by means of gauge boxes, in such a manner that each batch requires a whole number of 50 Kgs cement bags. Mortar shall be used half an hour maximum following its preparation.

206.3 RENDERING

Prior to the commencement of rendering, surfaces should be duly prepared.

Rendering generally includes:

- a roughcasting
- an intermediary coat
- a top coat which contributes partially to the structure waterproofing, and could be replaced or covered with a decorative plaster.

206.3.1 Roughcasting

External and concrete surfaces, especially if they are smooth, shall be roughcast. Internal rough surfaces shall not be roughcast (e.g. masonry with concrete blocks). This coat shall consist of a cement-sand mix containing 550 kg Portland cement per cubic meter of sand or one part of Portland cement for three parts of sand.

Grading of sand shall be 0.25/3.15 mm and shall contain 10% of fines maximum. Mortar shall be watered to obtain a good workability, and spatterdashed by means of a broom or a mechanical tool. The surface shall be rough and shall not undergo any other process whatsoever. The roughcast shall cover uniformly the surface. It shall be kept moist by watering for three days at least and shall adhere strongly to the surface. Any roughcast which did not harden thoroughly during the three day time and disintegrates, shall be entirely removed and replaced at the expense of the Contractor. Intermediary and top coats shall be applied, in principle, in two distinct coats.

206.3.2 Intermediary coat

The intermediary coat shall give rendering its final shape, the required evenness and waterproofness. It shall be homogenous and compact and consists of lesser quantities of binders than in the roughcasting coat in order to limit its fissurability. Grading of sand shall be 0.1/3.15mm, contain 5% min. of fines < 0.089 mm and be graded.

Intermediary coat shall consist of 450 kg cement per cubic metre of dry sand graded 0.1/3.1 mm. Moisture expansion of sand which is conditional upon the water content and grading

shall be taken into account when preparing the mix. This coat shall be applied only after the roughcasting coat has partially shrunk.

The intermediary coat shall not be applied until three days at least have passed since completion of the last coat. However, this period is conditional upon the atmospheric conditions.

Mortar shall be proportioned to a thick workable paste. This coat shall be applied either by hand or mechanically on a moistened roughcasting, in two or more passes depending on the thickness. The surface shall be finished with a float to an even and compact surface.

Smoothing the surface with a trowel is not permitted. It shall be roughened by using a ruler and meet the requirements of finished rendering (evenness, straight angles, round grooves etc...).

Average thickness of both roughcasting and intermediary coats shall range between 15mm and 20mm according to the tolerances on the substrate in such a way as to cover the entire surface by 10mm at least.

206.3.3 Top coat

Top coat or finishing coat is decorative but also protects the intermediary coat and preserves its waterproofness.

Since the colour of grey content is not always uniform, it is advisable, to provide cement from the same source and date of manufacture in order to improve the uniformity of shades. The same applies to sand.

This coat shall be made with an ordinary or decorative hydraulic binders mortar.

Grading of sand shall be 0.1/2mm and contains fines in considerable quantities and free form impurities (clay, gypsum, coal, organic matters, etc...)

The coat shall consist of 350 kg or 400kg of binder per cubic meter of dry sand graded 0.1/2mm.

The top coat shall not be applied until eight to fifteen days have passed since completion of the intermediary coat (average atmospheric conditions).

top coat shall cover the surface uniformly and, in no case, improve the evenness. Troweling, as well as powdering with lime or cement shall not be permitted.

The thickness of the top coat will be 5 to 7 mm.

206.3.4 Rendering on metal lathing

The metal lath shall be well blasted 24 hours at the latest after application of the roughcasting coat and securely fastened using rustproof staples or other suitable fasteners. The metal lath shall be a rustproof wire mesh with square openings of at least 30mm x 30mm.

206.4 INTERIOR RENDERING

Interior rendering shall comply with previous clause requirements and consist of 350 kg of cement per cubic meter of sand.

It consists of two-coat rendering applied as follows; roughcasting and top coat.

206.5 EXTERIOR RENDERING

It consists of three coat rendering applied as follows; roughcasting - intermediary coat-top coat.

206.6 EXTERIOR ADMIXED RENDERING

It shall have the same characteristics and specifications as those of the ordinary rendering coat (see rendering) and shall consist of 450 kgs of cement per cubic meter of sand and an additive to control plasticity and waterproofness according to a technical sheet and a technical certificate submitted for approval prior to commencing the works.

This coat shall mainly protect external walls subject to infiltrations and run-offs.

206.7 COLOURED CEMENT RENDERING

Coloured cement rendering shall consist of:

- a roughcasting coat
- a first coat, 10 mm thick, containing 400 kg of white cement per cubic meter of sand, scratched in both directions.
- a second coat, 8mm thick maximum, containing 400 kg of white cement per cubic meter of chippings, powder and pigments where called for on the Drawings and as directed by the Engineer.

Mix proportions, quality and colours of chippings, powder and pigments shall be determined subsequently by the Employer. Rendered surfaces shall be smooth and even as shown on the Drawings and as specified by the Employer.

The second coat shall be wetted three days after application to ensure adequate hydration.

Any rendered surface showing imperfections such as: unevenness, cracks, disintegration of white cement mortar, scratches (especially along arises) etc... shall be removed and re-rendered at the expense of the Contractor and under his responsibility. Repair or rendering shall be done in a neat manner so that all repairs have a uniform appearance, indistinguishable from the general area of the rendering.

Coloured white cement rendering shall be consistent with the approved sample kept on site until completion of the works.

206.8 DECORATIVE SPATTER MORTAR (TYROLEAN)

Top coat of mortar shall be applied by hand (Tyrolean brush) or mechanically. The top coat shall be applied in two or three layers, having an average thickness of 3 to 5mm. The finished surface is conditional upon the water content, the number of layers, the spatter angle and any eventual finishing treatment. Top coat shall have the same mix proportion as that used in a coloured or white cement top coat, and be applied as follows:

- a roughcasting coat
- a second coat
- a third coat with decorative mortar

Mix proportions are as mentioned previously.

206.9 RENDERING OF BASEMENT WALLS

N.B: Rendering applied to basement walls shall take into account the destination of the premises delimited by the walls, the soil nature and shape, as well as climatic conditions, the nature of support surfaces and the structure design.

Rendering of buried surfaces

General

Rendering applied to external facing of buried basement walls shall comply with the following paragraph.

Technical Specifications for exterior rendering

Minimum layers:

Rendering shall consist of at least:

- a roughcasting coat
- an intermediary coat

Minimum thickness:

Each coat shall be 8 to 15mm thick. The average thickness of both coats shall be 20 to 25mm according to the tolerances of each type of surface so as to ensure a uniform covering of at least 15mm.

Rendering

Rendering shall be applied by hand or mechanically. It shall consist of 450 to 550 kg of cement per cubic meter of dry sand. A waterproofing admixture shall be used according to the manufacturer specifications. Rendering applied to buried structures shall extend to about 20 cm above ground level.

Specifications for interior rendering

Interior rendering shall be ruled by the same conditions specified for 3 or 2 layer-rendering.

Rendering of non-buried surfaces

Rendering non-buried surfaces of basement walls shall comply with the conditions set for rendering exposed surfaces.

206.10 RESPONSIBILITY OF THE CONTRACTOR

All rendering which have started to set before application shall be removed from site. Those falling, cracking or suffering any damage whatsoever in the year following the taking over shall be removed and made up again at the expense of the Contractor. He shall take all necessary measures during surface preparation, rendering and setting time so as to ensure quality work, namely, by protecting rendered surfaces with dampened hessian coverings if need be.

These constraints are included in the incidental expenses of the Contractor.

N.B: The use of lime as a plasticizer shall only be permitted upon the written approval of the Employer.

206.11 CHARACTERISTICS**Tolerance**

Tolerance is checked by measuring deviation under a 2.00m ruler or a 0.20m ruler. The deviation shall not exceed the following values.

	Under 2.00 m ruler	Under 0.20 m ruler
Spatter rendering	1 cm	-
Between wall lines	0.5 cm	0.2 cm

Plumb

Rendering applied to vertical surfaces shall have a maximum tolerance of 0.01m for each three meters.

This tolerance is only applicable to renderings between wall lines.

Bond

Rendering shall bond to the surface and shall not give a hollow sound when hammered. The rate of bond shall be equal to 0.3 megapascal (3 bars) after 28 days of application.

Three core samples crossing the whole rendering thickness shall be taken randomly from surfaces 50m² at least. The rate of bond shall be the arithmetic average of rates of bond measured in the various points. (The rate of bond shall never be less than 0.2 megapascal (2 bars)).

206.12 METHODS OF MEASUREMENT AND PAYMENT**206.12.1 General**

The unit rates for rendering shall include for the use of all tools scaffolding, labour and materials, including supply, processing and use of cement, or otherwise - sands, gravels, additives and colouring pigments, mica flakes, and including for metal lath, all as specified and as applicable. Unless otherwise specified, the unit rates shall include for the use of ordinary Portland cement. The unit rates shall also include for all cleaning and wetting of all surfaces prior to rendering and the protection and curing of the render, inclusive of all surface treatments required.

Measurement

Measurement will be separate for the various types of render, and in all cases be net in square meters, as measured on the Drawings, all openings, tiling, skirtings and other areas not covered by render being deducted with no allowance for waste, overlap, etc. Reveals, jambs, and rebates to openings (doors, windows, etc.) will be measured for payment together with the general area of the plaster and no special rates will be paid for them.

For purposes of measuring external plaster, the bottom edge will be taken as being 10 cm below final external ground level, unless otherwise shown on the Drawings.

206.12.2 Payment

Samples, making good to other trades and repairs will not be paid for separately and the cost thereof shall be included in the unit rates for rendering, which shall also allow for the supply of wire mesh for covering, etc., where required.

Types of render will be itemized separately in the Bill of Quantities. The types will be further subdivided into render on plane surfaces and on curved surfaces.

Types of render to be paid for under separate items include (but are not limited to):

- a) Interior rendering
- b) Exterior rendering
- c) Exterior admixed rendering
- d) Coloured cement rendering
- e) Decorative spatter mortar
- f) Basement wall rendering.

207 - PAINTING

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207 PAINTING

207.1 MATERIAL & APPLICATION

The following subsections deal with paint work on all exposed surfaces such as walls, ceiling, woodwork or metalwork both indoor and outdoor. The term “paint” as used herein shall include:

- Stains,
- Varnishes,
- Emulsions,
- Enamels,
- Pain washes,

and all materials as:

- Oils,
- Putties,
- etc..

All paint materials shall meet the requirements of the relevant British Standards and shall be of an approved manufacturer.

- a) The entire paint system used for painting a structure shall be of the same manufacturer. Mixing of paints of different manufacturers on the same structure shall not be permitted.
- b) All paints used shall be subject to prior approval of the Engineer’s Representative.
- c) The Contractor shall submit for the Engineer’s approval a detailed list of the paints he intends to use on the job, stating:
 - the name of the manufacturer
 - the type of paint
 - full specification of manufacturer including directions for handling and use, instructions for thinning (if any) and minimum drying time.

All paints shall be kept on the job site in the original unopened factory containers and shall be protected against the entry of air, water, dirt, or any other foreign matter.

- Paint shall be stored at shaded locations. Storage of paints, their mixing, thinning, etc., shall be carried out in a special paint shed provided by the Contractor for this purpose; on no account will the building under construction be used as paint store.

All paint work shall be performed by experienced and qualified painters, in accordance with the standards of practice.

- Prior to commencement of painting the Contractor shall clean the area and its surroundings and remove all waste building materials, cement bags and dirt. Care will be taken to avoid dropping paint on floors, sanitary installations, and other areas or objects not intended to be painted. All such areas and objects shall be covered for this purpose with sacking or other suitable protective material. Freshly painted surfaces of metal and woodwork shall be suitably protected.

Ironmongery, fittings and other attached fixtures such as:

- doors knobs,
- fasteners,
- locks,
- electric fittings,
- signs,
- etc.,

will be removed whenever possible from all windows, doors, walls, etc., and suitably stored until completion of the paint work and then be properly re-attached to their original positions.

Application of final coats of paint shall be done only after completion of all other building works. No work will be undertaken under adverse weather conditions, in heavy mist, during dust storms, or in case of external paint work, during or immediately following rain.

The choice of every type of paint material shall be in conformity with the specific recommendations of the manufacturer specially concerning the different finishing conditions requested and nature of substrate.

207.1.1 General conditions of intervention

Norms applicable are the relevant British Standards requirements, the paintworks include but limited to the following works:

- the preparation of surfaces,
- the material supply needed for the paint work execution
- the supply of the necessary stock of tools, ladders and scaffoldings etc.,
- the paint application on reference surfaces and sample specimen.
- the application of paint on all prepared substrates in conformity with BS, and the prescriptions of these specifications.
- obtaining of the required quality, the finishing aspect, the degree of brilliance, the coloring and the necessary set off colors as prescribed in the specifications.
- the cleaning of all dirt, caused by the painter intervention.
- etc.

207.1.2 General co-ordination

The Contractor is instructed to maintain a perfect co-ordination between his paintworks and the other concerned works, in particular the woodworks and glazery works etc., aiming to execute in the right time all necessary scheduled works.

- All supply and application constraints shall be due for a complete finishing as defined in the specifications.
- It is strictly forbidden to the Contractor to start the paintworks before the execution of the tile-flooring and the first passage of the pouncing machine being executed and before all having dried perfectly. Final painting works must be done after the completion of exterior woodworks and glazery works.

- Only the wall preparation and the first paint coats (primer) can be executed before the pouncing machine passage be done. The Contractor can achieve the ceiling paints and wall paints leaving the last coat (only on walls) to be achieved once the polishing of tile-flooring is done.
- A perfect co-ordination must be achieved between all involved parties.

207.1.3 General execution conditions

The Contractor must insure a perfect execution of all paintworks

- All paint material and products used and their application procedures must be of such quality to satisfy the Engineer requirements.
- In particular the Contractor must present to the Engineer approval and before any commencement of paintwork a sample of each approved material to use. The Engineer preserve for himself the right to proceed to testing and analysing of the materials at the reception and in the course of execution.
- If the controls operated reveal defects in the quality of products used or in the procedures of application, the Contractor must proceed to the complete reparation at his own cost and responsibility of all the disapproved works.
- The Contractor must bear all execution costs of such works as necessary sampling to determine on the job site the tint to be chosen after agreement of the Engineer.

207.1.4 Particular execution conditions

The application of paints, varnishes, emulsions, mastics etc., shall start only when surface to be painted has thoroughly dried out, provided that at least one dry (or summer) month and two wet (or winter) months have elapsed since plaster or concrete have been placed.

- Ambient temperature of application must be higher than 18°C and the ambient atmosphere must not be too humid favouring condensation or too dusty.
- The substrate must not be overheated or frozen.

Cement renders and concrete shall not be painted before at least one week after the execution.

Ceilings in particular, receivant oil paint must receive previously a layer of isolation product necessary to avoid absorption difference in the render substrate and uneven discoloration in careful finishing.

All ironmongery works must be chemically clean before painting with no trace of calamine, rust, humidity, grease and dirt, etc.,

- Decalamination must be obtained by natural oxidation, it must be later on followed by hammering and rubbing down.
- Calcium deposit shall be removed by hammer or abrasive disc if necessary.

- Rust must be cleared of by dry rubbing with a metal brush, by hammering, by rotative brush or by glass-paper.
- Mortar dirt must be cleaned by rubbing down with a metal broom.
- Grease will be removed by cleaning with “white spirit”.
- Pouncing will be done with pouncing stone, so that it does not subsist on the surface no grain or roughness.
- No painting will be applied unless on a surface perfectly brushed, and all sandy particles or any non adherent mortar or any trace of dust has been removed.
- During painting works, the Contractor must ensure a suitable and complete protection of the soil, woodworks, glazery, piping system, etc., and the gradual cleaning of all finished works.
- When instructed by the Engineer and for carefully finished surface, the paint will be applied on these surfaces with special preparation such as:
 - refitting,
 - filling up of all cracks, holes, pits or other surface imperfections,
 - cleaning all dirt and concrete traces,
 - etc.,

207.1.5 Cleaning after painting

At the end of painting works, and when reception of these works is made possible, the contractor must proceed to the complete and perfect cleaning of all construction elements such as:

- floors
 - glazery
 - walls
 - woodworks
 - plinth
 - pipes
 - etc...
- All precautions must be taken by the Contractor to avoid damaging the places, using procedures or products nonadapted to a perfect execution of the cleaning works. If the cleaning is not realised as instructed, detailed and approved, the Engineer will reserve for himself the right to undertake new cleaning works by another special enterprise of his choice, all expenses for these operations being beared by the Contractor.

207.1.6 Selection of paint materials

All paints to be used shall comply with the requirements of the relevant British Standards, or where specified in any other standard or specification, and shall be subject to prior approval of the Engineer’s Representative.

- The Contractor shall attach to his approval request a detailed list of the paints he intends to use on the site. This list shall contain the following informations:
 - name of manufacturer
 - type of paint
 - full manufacturer original specification, including directions for handling and use, instructions for thinning (if any) and minimum drying time.
 - full original catalogue of the whole products form the manufacturer.
 - etc.,
- All paints shall be kept on the job site in the original unopened factory containers and shall be protected against the entry of air, water dirt, or any other foreign matter.
- Paints shall be stored in shaded locations.
- Thinning of paints will not be permitted except to manufacturer's instructions, if any.

Manufacturer's instructions as to storage, handling, thinning and application of paints shall be strictly adhered to.

- The entire paint system used for painting accessories of the same installation unit or structure shall be of the same manufacture.

Choice of product by the Contractor must take in account:

- the aptitude of the product to fulfil its function,
- the kind of protection needed,
- the finishing surface projected,
- all prescriptions of the specifications.

The following requirements shall apply to the different types of paints: (steel pipe installations and steel structures)

No.	Type of paint	Standard	Drying time
1	Oil-based red lead primer	/BS/2521 and /B.S./2523	24 hours minimum
2	Synthetic red lead primer	Federal specification: TT-P-86G type II	24 hours
3	Iron oxide paints	B.S./2524	12 hours minimum between coats
4	Aluminium paints for cover-coats	M/69	24 hours minimum
5	Cover-coats paints, (other than Aluminium paint)	These paints shall be synthetic paints for steel structures, and shall meet the requirements of the relevant B.S. standard and shall be of an approved manufacturer	As specified in Particular Specification and/or directed by the Engineer

N.B.: When more than one coat is specified (of primer or of the same paint) successive coats shall be of different, easy distinguishable tints.

Generally all surfaces to be painted shall be:

- clean,
 - dry,
 - smooth and
 - free from dust, grit, and other foreign matter
- All nails shall be countersunk and stopped with putty, prior to painting.

Concrete and plaster surfaces: concrete and plaster surfaces receiving paint finishes shall be thoroughly cleaned of:

- dirt
 - laitance
 - incrustations, and
 - foreign matters
 - etc...
- Cracks, holes pits or other surface imperfections shall be neatly and smoothly filled.

Timber works: All timber works shall be sand-papered before the application of the primer. All knots shall be dry and sound, and shall be coated with a coat of synthetic resin sealer before applying the primer coat. Loose knots shall be completely removed by reaming and replaced with well driven tight fitting wooden plugs.

the painting shall commence only when the wood is satisfactory dry.

Metalwork: preliminary substrate preparation shall be done in accordance with Section 207.8 of these Specifications.

The primer coat shall be applied to cleaned surfaces within four hours from the completion of the cleaning.

207.1.7 Preparation of Surfaces

a) General

All surfaces to be painted shall be clean, dry, smooth, and free from dust, grit and other foreign matter. All nails shall be countersunk and stopped with putty prior to painting.

b) Concrete and Plaster Surfaces

Concrete and plaster surfaces receiving paint finishes shall be thoroughly cleaned of dirt, laitance, instructions and foreign matter. Cracks, holes, pits or other surface imperfections shall be neatly and smoothly filled.

c) Timber Work

All timber work shall be sand-papered before the application of the primer. All knots shall be dry and sound, and shall be coated with a coat of synthetic resin sealer before applying the primer coat. Loose knots shall be completely removed by reaming and replaced with well driven tight fitting wooden plugs. The painting shall commence only when the wood is satisfactory dry.

d) Metalwork

Preparation of steel work at the works shall be either:

- Hot dip galvanised to BS 729 with a median thickness of 85 microns (0.0034”) or
- Grit blasted to BS 7079 Grade SA 2.5 and zinc sprayed within 4 hours to BS 2569 Part 1 to a thickness of 125 microns (0.005”) followed by one coat of approved etch primer.

Typical finishes (with compatible primers) based on BS 5493 are given below.

- Steel work and ferrous castings exposed above water/sewage level

Either high build micaceous iron oxide or chlorinated rubber to give a minimum total dry film thickness of 300 microns or, one coat of two pack epoxy primer and further coats of epoxy paint to give a total dry film thickness of 270 microns.

- Steelwork below water/sewage level

Either epoxy system as above or coal tar epoxy paint system to give a minimum total dry film thickness of 450 microns.

- Ferrous castings and fittings without substrate below water level.

Coal tar epoxy paint system to give a minimum total dry film thickness of 450 microns. These coatings shall be subject to the Holiday test.

the surface of all non-ferrous parts usually painted shall be cleaned, rubbed down, stopped, filled and given one priming coat of paint.

Anti-corrosion coatings for any steel or iron used in pipework, pumps, valves, etc. in contact with potable water, shall be either a compatible bitumen material to BS 3416 or a polymeric anti-corrosion coating complying with Water Industry Specification WIS 4-52-01.

Any damage occurring to any part of a painting scheme shall be made good to the same standard of corrosion protection and appearance as that originally employed. Any finish coat applied on site shall be considered for decorative purposes only.

Manufactured articles to be galvanised shall be hot dip galvanised after complete fabrication and no bending, cutting, drilling, riveting or threading shall be permitted after galvanising.

The care of galvanised articles when transporting, storing and erecting them shall be in accordance with the recommendations of BS 729. The renovation of small areas of damaged coating not exceeding 40mm² shall be in accordance with Appendix D of BS 729 and subject to the Engineer's approval.

207.2 PAINTING APPLICATION**207.2.1 General**

All paint application shall meet the requirements of the relevant British Standards and shall be applied in conformity with the manufacturer's recommendations.

- All paint cans must not be open before application, the product homogeneity must be insured by extended mixing with appropriated tools.
- In case the product is transferred to another can, it must be mixed before utilisation and it must to remain any deposit in the original can.
- Products shall be delivered with sufficient fluidity to permit normal application.
- Solvent additional or dilution of the product is forbidden unless approved by the Engineer.
- A detailed technical leaflet will be submitted to the approval of the Engineer before any application.
- A quality control of the surface will proceed any paint or primer application.
- All surfaces must be dry and drying time between coats must be respected by the Contractor.

207.2.2 Primer or undercoat application

See preparation of surfaces.

207.2.3 Intermediate coats

These layers aim to constitute a lining which thickness and resistance can insure an effective protection system.

- Mode of application of the intermediate coat is left to the Contractor choice (Brush, roll, gun)
- In the case of several intermediate coats, each coat must be of different color easy to check and the product must ensure good adhesion to the finishing paint coats.

207.2.4 Finishing paint coats

The finishing coat(s) must answer:

By the nature of the applied lining, to the particular conditions of the ambient in which the protected surface exist.

In particular, the immersed surface must be protected against parasitic attacks from animals or vegetals.

By the choice of conventional colors, to the relevant existing security prescriptions. colors fixtily is then required so as to satisfy imposed visibility conditions.

207.3 INTERIOR PAINTS: LATEX BASE CONCRETE AND MORTAR SUBSTRATE

All interior paints must conform to the relevant British Standards.

- The interior room partitions will be covered by a washable LATEX -BASE paints, wherever indicated in the Drawings or ordered by the Engineer.
- The Contractor shall submit samples of the paints he intends to use to the Engineer's approval.
- Paints shall be washable, of a perfect solidity and shall allow a flawless application.
- A perfect resistance of the color so the effect of light is also required.
- Surfaces to be painted shall first be cleaned, and sand papered before the application of the first coat or sealer. A second sanding shall be followed by the application of a primer coat.
- Then two (2) paint coats shall be applied in conformity with the color and sample approved by the Engineer.

207.4 EXTERIOR PAINTS

For exterior surfaces a plastic paint ready to use under the form of a unctuous thixotropic paste will be used.

- This product is composed of vinylmaleate resins or similar, in water dispersion of noble pigment (Titane rutile, or similar), and siliceous charges, and fungicide agents.
- Tints area obtained with pigments resistant to the effects of exterior light (U.V. specify).
- The product must adhere perfectly and be totally waterproof offering a perfect resistance to chemical agents, to heat and fire.
- The Engineer reserve for himself, the right to proceed to any chemical analysis of his choice to insure the quality of all components. All costs to be beard by the Contractor.

Exterior surfaces must be: neat and clean, without grease dustless after brushing.

- Before any commencement of application of the paint, the Contractor shall apply a primer coat (undercoat) acting as substrate surface regulator insuring an homogenous substrate which is extremely important when applying a plastic paint on these surfaces.
- The Contractor shall use in preference an alxeol roll that it soaks in the product paste garnishing all the cells of the roll.
Application must be in thick layer and always starting from down toward upper zones.
The product must be applied in important quantities but not spread.
- A compressor can be used for application of not less than 2.2 kg/m².

A technical detailed leaflet must be submitted by the Contractor to the Engineer approval.

Intermediate coat remains a facultative one when dealing with new works, but the durability of the paint will be improved by the application of:

- One (1) layer when new works are involved.
- Two (2) layers when dealing with rehabilitation works.

The finishing exterior layer aspect will be as approved by the Engineer:

- mat, poach, in elementary finishing
- mat, satinated, poached in current finishing
- mat, satinated or shinning in careful finishing,
- etc.

N.B.: for exterior works, quality criteria for protection and durability will prevale on finishing aspect criteria.

207.5 INTERIOR PAINT - LATEX BASED WITH PUTTYING

This type of paint shall be used in specially neat surfaces and where indicated on the Drawings, the specifications, and where ordered by the Engineer.

- The paints to use shall be of the same type and shall have the same specifications as those in Section 207.3.
- The mastic shall be of a quality approved by the Engineer. It shall be delivered to the site in closed boxes, or composed on the basis of 60 to 70% of zinc and linseed oil.
- After cleaning and sanding the surfaces to be painted a first coat of sealer shall be applied. The mastic shall then be applied in two coats along two perpendicular directions. Once dry the first coat shall be sanded and rubbed with sand paper. Then an undercoat shall be applied, followed by the latex based paint coats as specified in Section 207.3.

207.6 SPECIAL PAINTS

These paints shall be used in places that are exposed to knocks and dirt. They shall be washable, resistant to sand jet No. 1 at a pressure of 125 kg. Their colors shall be permanent and inorganic pigment based, the support being a polyester based synthetic resin without an evaporative solvent or alcoholized or toxic matters, and hardener by polymerisation.

They shall be applied by means of a spray gun or by roller and shall have a granular texture obtained by application of a fiber glass reinforcement. The application shall be in accordance with the manufacturer's instructions. At least two coats shall be applied, not counting the fiber glass reinforcement.

207.7 VARNISHING ON WOOD

All teak wood and teak wood veneering shall be treated as natural wood. The successive operations:

- brushing.
- undercoating with diluted varnish.
- transparent coating to clog pores.
- water sanding, and
- two layers of varnish.

shall be executed by a specialized workmen.

- The finished, semi-mat, resistant and impermeable varnish, shall show the texture and the natural color of the wood.

207.8 OIL PAINT ON WOOD OR PLASTER

All interior wood carpentries such as doors, panels, cupboards, etc.. as well as all surfaces shown on the Drawings or specified, shall be coated with two oil paint coats on the undercoat together with all surface preparations: brushing, sanding, dusting, etc.

Undercoats shall be applied before the installation and after reception of the carpentry by the Engineer. All carpentries shall be perfectly undercoated on all faces, frames, and rebates. All necessary touch-ups shall be executed before starting the works. The paint coats shall be applied successively. Colors shall be as instructed by the Engineer.

Oil paints shall be of the best quality. They shall be composed of zinc oxide, turpentine and well purified linseed oil. Siccatives shall be turpentine-based.

The theoretical composition of paints shall be as follows:

- Fat dye:	
Zinc oxide	0.600
Linseed oil	0.270
Turpentine and siccative	<u>0.130</u>
	1.000
- Thin dye:	
Zinc oxide	0.550
Linseed oil	0.187
Turpentine and siccative	<u>0.263</u>
	1.000

Before installation, all iron fittings shall be coated with red lead paint, after brushing off the rust, degreasing and dusting.

The zinc oxide shall be 98% pure and shall not contain more than 2% of plumbiferous impurities.

The mastic, of an approved composition, shall be applied in two layers spread in opposite directions. Once the wood surface is perfectly equalized, the oil paint is applied in two layers according to the approved color and sample.

207.9 OIL PAINT ON METAL

Metal works to receive oil paint shall be shown on the Drawings, specified herein, or where indicated by the Engineer. They shall include but not limited to sheet metal doors, gratings, metal chassis, balustrades.

- Surface preliminary works shall include:
 - removing the rust
 - degreasing
 - dusting
 - etc.
- Surface preparatory works shall include: two protective coats either of red paint or zinc chromate.

Then, two oil paint coats shall be applied. The shades shall be selected by the Engineer from samples submitted by the Contractor on site.

207.10 LIQUID EPOXY COATING

This coating shall be based on liquid, chemically cured epoxies. The curing agent may be an amine, amine-adduct, or polyamide. Materials used in both the primer and finish coats shall be products of one manufacturer.

The coating shall be suitable for use in irrigation water. It shall be used for:

- steel sluice gates,
- pipes,
- mechanical couplings,
- flanges,
- similar appurtenances for steel pipe fittings, nuts, bolts
- and other items used in conjunction with connections and attachments.

Surface preliminary works

- The surfaces shall be first cleaned to remove:
 - oil
 - grease, or
 - other foreign matters.
- Only approved procedures and solvents (that do not leave a residue) shall be used.
- The surface shall be abrasive blast-cleaned with sand, steel shot or grit to achieve a near white metal surface.

Application of epoxy coating system.

- The coating system shall be applied as recommended by the manufacturer. It shall consist of at least:
 - a two part chemically cured epoxy primer as a preparatory surface coat.

- two coats of a different two components, chemically cured epoxy top coat.

207.11 PAINTING - MEASUREMENT AND PAYMENT

Painting shall be measured for payment by m² of net area of surface which has actually been painted, after the deduction of all openings and areas which have not been painted. Painting shall be classified according to the types of paints and number of coats. Each unit rate shall include for the supply of all paints and materials, cleaning and preparation of all surfaces, application of all necessary painting and all extra work on corners and edges, and for all materials, equipment and labour necessary for the completion of painting in accordance with the Specification and Drawings and to the satisfaction of the Engineer.

Unless otherwise specified, painting of all steel structures, and structural elements, exposed steel pipe installations, non-structural metalwork and wood joinery in buildings shall not be paid for separately and the cost thereof shall be deemed to be included by the Contractor in his unit rates for the supply, installation, erection and fixing of these items.

208 - FLOORING, WALL-TILING AND FALSE CEILINGS

208 FLOORING, WALL-TILING AND FALSE CEILINGS

208.1 GENERAL

Following are the works to be executed under the present Section

- wall tiling
- floor tiling
- flexible flooring
- stone flooring
- industrial flooring
- wearing pavement with hardeners

The contractor shall ensure, among other works, the following:

- co-ordination with other Sections
- supply of materials, transport to the site, temporary storage, handling, installation in one or several operations
- removal of rubbish, waste and packagings
- site cleaning upon completion of works
- all works required for the good execution of the structures or those ensuing from other Sections.

Hereinafter are the Technical Specifications for the works to be executed. However, the Contractor shall carry out any other work necessary for a good execution. Such work is considered to be included in the unit rates of the Bill of Quantities.

The kinds and types of flooring and wall-tiling to be used in the different structures and locations, their limits and levels etc., shall be in accordance with the Drawings, the Particular Specification, the Bill of Quantities and as directed by the Engineer. Where a new structure is added to an existing one, the types, lines and levels of the new flooring and tiling shall correspond to and blend well with those of the existing and adjacent flooring and tiling.

The Contractor shall take all necessary measures to ensure complete protection of tiling works until the taking over (sawdust or plaster coats,...)

The Contractor shall submit to the Engineer samples of required floor and wall tiling. He shall prepare in-situ a representative panel showing each type of such floor or wall tiling.

Cement mortar for wall tiles and skirtings - shall consist of one part cement to three parts sand (by volume).

The cement and sand used for the preparation of mortar shall comply with the following requirements:

- Cement - shall, unless otherwise specified, be ordinary Portland cement in accordance with B.S. 12. Where quality or freshness of the cement is in doubt, the cement shall be tested in an approved laboratory to the satisfaction of the Engineer's Representative.

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- Sand - will be natural sand or quarry sand, clean and free from dirt, dust, clay particles and other foreign matter or impurities, all in accordance with B.S. 1200. Dune or clayey sands shall be strictly prohibited.
- Adhesives
Adhesives shall be approved by a technical certificate of an approved organism. They shall have the required mechanical characteristics and comply with the substrate. They shall be applied according to the instructions of the manufacturers.

208.2 FLOORING

208.2.1 Concrete Tile Flooring

All tiles supplied shall be in strict accordance with the samples submitted to and approved by the Engineer prior to the commencement of the work.

The tiles shall be laid on a layer of cement mortar (not less than 3 cm) spread on an even bedding of compacted sand (in general 3 to 7 cm). The cement mortar layer shall comply with the requirements of Section 208.1 above and shall be continuous under the tiles. The tiles shall be laid with straight, uniform joints, passing in both directions uninterruptedly from room to room and coinciding with joints in the skirtings. Joints between tiles shall be close. Around openings, at corners, along walls, etc., tiles shall be cut to fit as necessary, all cuts in tiles being neatly made with an electric saw. Tiles shall be properly rammed so that water flow back to the sides and up to the surface.

Every tile shall be carefully examined by the Contractor before laying, and every cracked and otherwise defective tile, whether in colour or shape, will be rejected. Defective tiles laid will be removed and replaced as required by the Engineer's Representative, at the expense of the Contractor.

Adjacent to external doors, and at steps, the tiling shall be finished, unless otherwise shown on the Drawings, by an aluminium or brass strip 30/3 mm. carefully anchored into the floor. Expansion joints shall be provided where and as shown.

The laid tiling shall be checked with a straight edge and every tiled surface shall be perfectly level or shall agree accurately with the required slopes, according to the Drawings or the Engineer's instructions. The whole area shall be smooth and no edges of tiles shall protrude one above the other. A test for levelled surfaces shall be made by pouring water on the surface. On completion of the tiling work, joints shall be filled and finished by rubbing with a paste of white cement. All holes in floors not covered with tiles shall be completed in cast-in-situ terrazzo matching the adjacent tiles in colour and texture. Joints between tiles shall be closed.

The skirting shall not be cut to a bevel. The rendering shall be 5 mm max away from the skirting. Where required, concrete and masonry works shall be thinned down. The joint between the rendering and the skirting shall be perfectly straight and right angled. Behind the skirting, the mortar shall be well rammed so as to leave no voids.

No buckling nor deflection exceeding 0.25 mm in tiling shall be allowed. In case tiles protrude and, unless otherwise shown on the Drawings or specified by the Engineer, the two protruding tiles shall be levelled to form a straight joint.

All joints shall be absolutely straight and intersecting at right angles. Joints between skirting pieces shall form a uniform continuation of the floor joints.

Mortar that flows back to the surface shall be well cleaned before setting. Tiles shall be polished with a floor grinder (4 passes).

A perfect execution shall be required; any defect affecting the evenness, the connections and the workmanship in general shall entail the rejection of such works and the demolition and remaking thereof.

Following are the tolerances for a finished flooring:

- maximum deviation under a 2m ruler (evenness) $\leq 3\text{mm}$
- deviation of the finished surface from the specified level (level): 10mm
- maximum deviation under a 2m ruler (joints alignment) $\leq 2\text{mm}$.

The approval of a sample of a tile or a flooring shall in no case release the Contractor from his liability for all materials, labor and execution methods.

No movement, even on planks, over freshly paved or tiled areas shall be allowed for at least 72 hours after completion.

208.2.2 Glued tile flooring

Substrates shall be sound and solid, having a regular surface.

Those that are not sufficiently levelled shall be finished off under the Section of concrete works, provided that such finishing off is compatible with the adhesive used for tiles fixing.

Tiles shall be laid on a 1 to 3 mm maximum adhesive layer spread with a notched trowel. Tiles shall be properly tamped to distribute the adhesive equally.

Adhesives shall be approved by a technical certificate issued by an approved organism.

208.2.3 Thin flooring

It shall be applied upon the completion of the works mentioned in the other Sections.

Substrates shall be sound and solid, having a regular surface. They shall be covered, beforehand, with a levelling underlay approved by a technical certificate from an approved organism. Rendering shall be allowed to dry thoroughly before the flooring is applied.

Adhesives shall be as recommended by the manufacturer and compatible with the substrates. They shall be approved by a technical certificate. Such adhesives shall not impair the initial qualities of glued flooring and shall in no case be used for levelling an uneven floor.

Different Types of Tiles

1) Terrazzo Tiles

The tiles shall comply with requirements of BS 4131. The face of the tiles shall be smooth and shall have received at least two grind polishes after conclusion of their curing. The edges shall be straight and free from defects and neatly bevelled.

2) Ordinary Cement Mosaic Tiles (20 x 20cm) with skirtings (10x20cm)

Mosaic tiles shall be of local manufacture and shall consist of two layers:

- 1- A wearing layer having a minimum thickness of 7 mm and consisting of hard local Granitos No. 0 and 1 limestone mixed with ordinary cement and marble powder, proportioned at 500 kg of cement with 150 kg of powder for 1 m³ of Granitos. The Granitos shall be cleaned and free from all traces of soil or clay. The Granitos mix design, colours and qualities shall be as specified by the Engineer. Mixing shall be done by a special machine to avoid segregation.
- 2- A base layer constituted of a mixture of sand and cement proportioned at 350 kg of cement per 1m³ of sand.

Tiles shall be vibrated for at least 30 seconds and compressed under a load of 350 kg/cm². They shall be kept a whole week time as a minimum in water or inside a room maintained at 100% hygrometric degree.

The minimum thickness of the tiles shall be 20mm. They shall be delivered on site putted and ground. Skirtings shall have a maximum thickness of 15mm. They shall give satisfactory results after abrasion tests conducted by an authorized laboratory:

- * 1000 turns : 3 mm
- * 2000 turns : 6 mm
- * 3000 turns : 8 mm.

or after any other standard test recommended by such laboratory. A sample of a finished tile shall be submitted beforehand for approval.

3) White or Coloured Cement Mosaic Tiles (20x20cm) with skirtings (10x20cm)

Requirement of above paragraph shall apply to white or coloured cement mosaic tiles; save the wearing layer that shall be proportioned at 500 kg of white cement and 150 kg of powder per cubic meter of granite. They shall be ground on site as specified.

4) Natural Stone Tiling

Natural stones used for tiling shall be of a sound texture, white, grey or green coloured and having the same pointing characteristics specified for masonry with natural stone. The stone shall be cut, laid, bonded, then pointed according to the Drawings and the Engineer's instructions.

5) Vitrified Clay, stone wave Tiling (10x10cm or 10x20cm: thin or thick)

Vitrified clay tiles shall be used for the surfacing of floors in kitchens and toilets or other interior surfaces.

Vitrified clay tiles shall be of a first grade quality (grading A) and have the best properties pertaining to the evenness, orthogonality, resistance to abrasion, porosity, etc...

They shall be resistant to acids, bases, grease and hydrocarbons, and compressed under a load of 400 kg/cm² during manufacture.

The Contractor shall bear the costs of all necessary tests in order to certify that the material is in accordance with the required specifications.

Samples of various colours shall be submitted to the Engineer for approval. Skirtings shall be at the dimensions specified by the Engineer.

Any tile showing scratches, cracks or any other defects shall be rejected. No warping shall be allowed on the tiles surface nor at the edges.

Vitrified clay tiles shall be laid according to tile following paragraph. Uniform joints, 1mm thick shall be filled with black cement. Even and straight tiles shall be used to ensure a perfect alignment between tiles. No movement shall be allowed on the tiling for at least 4 days after laying. Tiles shall be cleaned at the expense of the Contractor with diluted hydrochloric acid.

6) White or Coloured Cement Mosaic Stair Treads

The covering of stair treads shall be as shown on the drawings and to the satisfaction of the Engineer. Mosaic treads shall meet the requirements specified in precedent paragraph of this Section. The tread's thickness shall range from 15 to 20mm.

Treads shall be of one piece and have the shapes indicated on the drawings. A sample of each type of treads shall be submitted for approval before any commencement of works.

7) Curbstones of Bush Hammered Fair Faced Concrete

Curbstones are provided for sidewalks and gardens borders. They may either consist of 1.00m precast elements or be cast on site. They shall be installed on a blinding concrete base course (as specified for in the relevant paragraph) on a cement mortar proportioned at 250 kg of cement per 1m³ of sand in case such elements were precast, or otherwise anchored into the base course according to the drawings should the elements be cast on site.

Curbstones shall be of fine bush-hammering (granulated at 100 teeth). A bush-hammered curbstone shall have a perfect facing that shows no potholes. Any defective curbstone shall be removed from the site. They shall be in any case in conformity with an approved sample.

Reinforcement shall be at the rate of 5 high yield steel bars/meter 10mm in diameter and laid in both directions. Contraction joints shall be formed each 25 m² unless otherwise specified on the drawings.

8) Faience Tiles

Enameled faience tiles shall be of first grade quality (grading A) and of local or foreign manufacture. They shall be resistant to acids, bases, grease and hydrocarbons. They shall be even and straight and have a first quality enamel.

The test required to attest the conformity of the chosen material with the required specifications shall be carried out at the expense of the Contractor. Tiles installed at angles and skirtings shall have rounded edges. Standard samples of tiles shall be submitted to the Engineer for approval.

Any tile showing scratches, cracks, scales or any other defect shall be rejected. No warping shall be allowed on the slabs surface nor at the edges.

They shall be either fixed or glued according to the support (concrete blocks, fair faced concrete,...)

Samples shall be submitted for approval prior to any order placing or work execution.

9) Pavement Slabs

Pavement slabs shall be concrete tiles in accordance with B.S. 1197, made of vibrated concrete, with straight edges, clean and free of defects. Each slab shall be marked with the manufacturer's name. Unless otherwise specified, the size of slabs shall be 50 x 50 x 4 cm.

Slabs shall be laid, without mortar, on a bedding of clean sand, at least 10 cm thick, to the levels and slopes shown on the Drawings. Joints will be closed, straight and continuous in both directions. When necessary to complete paving of areas, the Contractor shall use specially sized slabs, triangular or pentagonal in shape, manufactured specifically for this purpose.

208.2.4 P.V.C. Flooring

(a) General - All Polyvinyl Chloride (P.V.C.) flooring shall comply with the requirements of B.S. 3261 for unbacked P.V.C. tiles and sheets and of B.S. 5085 for backed P.V.C. sheets. Flooring of P.V.C. tiles or sheets shall be fungus-resistant and shall be laid only on flat smooth surfaces which are dry and free from dust. All P.V.C. flooring shall be of an approved trademark and colour and asphalt free. The thickness shall be at least 2 mm.

On the area to be covered with P.V.C., the Contractor shall place a minimum of 3 cm. of cement mortar screed containing at least 400 kg. cement per cubic meter. The mortar shall be evenly spread and finished by steel trowelling and shall be completely dry prior to commencement of laying. Where shown on the Drawings or if specifically requested in the Particular Specification, the mortar shall be spread in panels of size and level as shown on the Drawings. Levelling of the surface shall be carried out with screeds and the finished area shall be checked to optical surveying instruments. Prior to laying of the flooring the final mortar surface will be machine ground. No laying of P.V.C. shall be carried out until the moisture content of the cement mortar layer as measured by a hygrometer is below 80%. A self levelling underlay shall be applied to ensure a perfectly level surface before application of the flooring, then the evenness of the support shall be taken over.

Adhesive for attaching the P.V.C. flooring, whether for tiles or sheets shall be a neoprene based compound, to the approval of the manufacturer of the flooring material. The use of the adhesive shall be in accordance with the manufacturer's instructions.

- (b) P.V.C. Sheets - Unbacked P.V.C. sheets, unless otherwise specified shall be at least 2 mm. thick. Backed P.V.C. sheets shall be used only if specifically called for on the Drawings, in the Particular Specification or in the Bill of Quantities, and shall be 4 to 5 mm. thick.

The surface to be paved shall be clean and kept free from dust. A layer of the adhesive shall be spread on both the floor and underside of the P.V.C. sheetings. The sheets shall then be spread on the floor with their edges overlapping, afterwards these edges are to be cut to form a Vee-shaped groove between sheets. Edges shall be cemented down by applying local pressure or by use of hand rollers. Should air bubbles develop under the sheeting, they shall be removed by pricking through the sheeting with a sharp needle until the air is released. After cutting the Vee grooves the edges of adjoining sheets shall be welded together by a special P.V.C. welding machine operated by hot air, using a P.V.C. thread of the same material to "fill in" the gap between the sheets. The gap shall be thoroughly cleaned prior to the welding operation.

- (c) P.V.C. Tiles - P.V.C. tiles shall be laid as specified for P.V.C. sheets by applying the adhesive to both the dust-free floor and the underside of the tile. Finished of the tiling near the wall shall be neatly carried out by cutting the tiles accurately to the required size. After laying, tiles shall be rolled with a hand roller or tapped with sacks of soft sand, special care being taken to ensure pressure being exerted at the corners of the tiles, by the use of a rubber hammer. Tiles as laid, shall have straight continuous joints, closed as far as possible.

208.2.5 Cast-In-Situ Terrazzo

Cast-in-situ terrazzo shall be used for the surfacing of floors in showers, steps, window sills, staircase landings, staircase parapets and other concrete surfaces as shown on the Drawings or directed by the Engineer.

The areas to be surfaced shall be rough, clean, free from dust and loose fragments and prior to casting shall be wetted to saturation but without surplus water.

The terrazzo surfacing shall be applied in 2 layers one following the other: a base layer and a wearing layer. The first layer shall be cast on concrete or other structural elements that are clean and saturated with water. The materials in this layer shall conform with the requirements for concrete materials.

Unless otherwise specified, the thickness of the first layer shall be at least 30 mm. and of the second layer 15 mm.

Mix for the first layer (by volume): one part ordinary Portland cement, two parts coarse sand, two parts small size coarse aggregate (5 mm)

Mix for the second layer (by volume): one part white cement with the addition of pigment of the required colour, one part marble flour, one part aggregate of basalt, marble or other hard stone as specified in the Particular Specification or in the Bill of Quantities.

Terrazzo cast surfaces shall be separated from tiles by brass or glass strips. Areas larger than 2 m² and sills longer than 1.2 m. shall be subdivided by brass or glass strips as above.

The cast terrazzo surface shall be smoothed with a steel trowel after casting, and shall be worked accurately according to the required levels and slopes shown on the Drawings. The face of the hardened terrazzo shall be ground at least twice. The first grinding shall be done the day after casting, using a wet carborundum stone. Prior to the second and any further grindings (if required) the terrazzo shall be covered with a layer of paste composed of white cement with added pigment and rock flour. Grinding shall be carried out with a fine carborundum stone with constant addition of water to the paste and surface being ground.

208.2.6 Skirtings

- (a) Precast Terrazzo Skirting Tiles - Skirting tiles shall be of the same terrazzo mix as the floor tiles with which they are used. The thickness of the skirting will be 1 cm. for skirting tiles 20 cm. long and 1.5 cm. floor longer tiles. Height of skirting to be 10 cm., the upper edge being rounded.

Joints between skirting pieces shall form a uniform continuation of the floor joints. At corners, pillars, etc., the edges of the skirtings shall be cut and ground to a 45° bevel in order to form a neat joint.

Where the walls are not plastered, the upper edges of the skirtings shall be fully formed from terrazzo and fixing to the wall shall be by special adhesive.

- (b) Cast-in-Situ Terrazzo Skirtings - Terrazzo skirtings cast in place shall be of the same mix and workmanship as specified in Subsection 208.2.4 above, exposed corners being neatly rounded.
- (c) Different Types of Skirting - Skirting tiles shall be of the same quality of tiles approved by the Engineer and mentioned on the Drawings. The dimensions of the skirting tiles shall be in accordance with the Drawings.
- (d) Skirting of P.V.C. Flooring - Wherever skirtings are formed from the same continuous P.V.C. sheets as are used on the floor, a rounded mortar fillet shall be formed at the foot of the wall.

Special P.V.C. skirting tiles, where used, shall be carefully glued to both the wall and the floor. Wooden skirtings where used in conjunction with P.V.C. flooring shall be screwed to the wall with rust-proof screws.

Stairs to be covered with P.V.C. shall have all their corners and edges rounded in accordance with detailed given on the Drawings.

208.2.7 Curing and Protection

- (a) Terrazzo and Concrete Floor Tiles - Any flooring laid with mortar cement shall be covered with a layer of clean, moist sand. No movement shall be allowed on the tiling for at least 72 hours and until the cement has hardened. After this period the sand shall be removed by brushing and the tiled surface shall be thoroughly cleaned by scrubbing and polishing until a clean, bright, uniform surface is obtained. Waxing shall only be carried out if specifically required.
- (b) P.V.C. Flooring - P.V.C. flooring shall be protected from the direct rays of the sun for at least 24 hours after laying. At completion of laying, the P.V.C. surface shall be scrubbed clean with water and soap and well dried, after which it shall be protected with a P.V.C. protective paste, to be provided or approved by the manufacturer of the P.V.C. material. The paste shall be well rubbed into the flooring. Finished plastic flooring shall not be exposed to any form or movement until the building is handed over to the Employer.
- (c) Cast-in-Situ Terrazzo - All terrazzo floors, sills, skirtings, etc., whether vertical or horizontal, cast in place or precast, shall be kept damp for at least 6 days after final grinding of the surface layer. Thereafter, the surface shall be protected from any form of dirt or damage and from any direct contact or passage thereon, wooden planks being employed where and as necessary.

208.2.8 Flooring - Measurement and Payment

- (a) Tiles and Tiles Flooring - Tiling and skirting will be classified in accordance with the type and size of the tiling.

Tiling shall be measured for payment in m² of the area tiled as shown on the Drawings, net, all openings, fittings etc. which are not tiled being deducted from the measured area.

Skirtings shall be measured by the net length laid as shown on the Drawings.

Unit rates for Tiles and Skirtings shall include for: supply of tiling and skirting materials of approved type and sizes; materials for the cement mortar (or adhesives) and sand base or screed and laying of same to levels and thicknesses required; laying of tiles or skirting including adjustments of all openings, fittings, edges etc., cutting to shape of tiles and skirtings, filling of joints, cleaning and polishing of tiles, curing etc., all as required in the Specification.

- (b) Pavement Slabs - Pavement slabs shall be measured for payment in m² of paved area, in accordance with the Drawings. The unit rate shall include for: supply of the pavement slabs and the sand; spreading, levelling and compaction of the sand; laying of the slabs, including all works and special slabs required to complete the paved areas.
- (c) P.V.C. Flooring - P.V.C. flooring shall be classified for payment according to type, under separate items for sheets and tiles. Skirtings shall be measured separately. The methods of measurement of flooring and skirtings shall be identical to those of terrazzo tiling and skirtings as per Para. (a) above. The unit rates shall include for: supply of all approved materials and adhesives for P.V.C. flooring and skirting and for the cement mortar; placing cement mortar screed; laying of flooring or skirtings to the required levels and

lines, including adjustments at all openings, fittings, edges etc., cutting to shape of tiles, sheets and skirtings, cleaning, curing, adhesives, etc., all as specified.

- (d) Cast-in-Situ Terrazzo - Cast-in-Situ Terrazzo shall be itemized separately in the Bill of Quantities under areas for showers, stair landings, plinths, skirtings, skirtings for stairs, window sills, etc.

Terrazzo for window sills and skirtings will be measured for payment by linear meters of length, as shown on the Drawings.

Terrazzo for plinths and stair landings will be measured in m² measured net as shown on the Drawings.

Terrazzo in showers will be measured in complete units. The unit rate shall include for total areas of shower inclusive of skirtings.

Unit rates shall include for: cleaning, preparation and wetting of area to be covered with terrazzo; supply of all materials; formwork; placing of base and terrazzo layers to required levels and slopes; finish to edges of the terrazzo surfaces; and all other work necessary to produce the terrazzo surfacing as specified, including supply and placing of dividing strips, polishing, curing and protection.

208.3 WALL-TILING

208.3.1 Terrazzo Wall Tiles

All the requirements of Subsection 208.2.3 (1) above for terrazzo tiles shall apply to terrazzo wall tiles. Unless otherwise specified, the tiles shall be 15/15/1 cm. Along the upper edge and exposed sides of the tiled area, the Contractor shall carefully fill the plaster between the level of the tiles and the wall in a neat and workmanlike manner. The mortar for fixing the tiles to the wall shall be as specified in Section 208.2.5 above. Unless otherwise specified or directed, all tiles shall be placed with vertical joints staggered and horizontal joints continuous. Joints shall be carefully filled with a damp paste of white cement and zinc white together with a pigment to give a colour approximately that of the tiles.

208.3.2 Glazed Ceramic Wall Tiles

Glazed ceramic wall tiles shall meet all requirements of B.S. 1281. Unless otherwise specified, the tiles shall be 150/150/6 mm.

Prior to their use, tiles shall be soaked in water for at least six hours. Each tile shall be carefully checked for evenness, freedom from flaws and cracks, and all defective tiles shall be removed from the site. Any defective tile found on the wall shall be removed and replaced, at the Contractor's expense. The mortar for fixing the tiles to the wall shall be as specified in Section 208.2.5 above. Unless otherwise specified, the tiles shall be placed with continuous horizontal and vertical joints. Exposed edges of tiled areas and external corners shall be of special edging tiles having at least one edge rounded. Where tiles have to be cut to fit, they shall be carefully cut to exact shape with an electric saw. Joints between tiles shall be filled as per Subsection 208.3.1 above.

208.3.3 Glued Wall tiling

The adhesive shall be spread over the whole tile surface. Adjacent tiles shall be separated with thin joints.

Tiles shall be pointed up 24h after tiling by means of a ready for use mortar approved by a technical certificate. Once joints have been executed, tiled surfaces shall be thoroughly cleaned with water and a sponge to eliminate any trace of cement.

The use of sawdust and acid shall not be permitted.

208.3.4 Tile Fittings

All tile fittings, such as soap trays, hooks, toilet-paper holders, etc., shall conform both in colour and quality to the wall tiles with which they are used.

208.3.5 Wall Tiling - Measurement and Payment

Wall tiling, whether of terrazzo or ceramic tiles, shall be measured in m² according to type of tiling as the net area tiled in accordance with the Drawings, with no allowance for waste due to cut tiles at corners or finished edges. Tile fittings such as hooks, soap trays, toilet-paper holders etc., shall be paid for by number extra over tiling prices and their areas shall not be deducted from the tiled area.

The unit rates for wall tiling shall include for all approved tiling materials including special tiles for edging, cement, sand, adhesion and other necessary materials; soaking of the tiles in water, wetting of walls, preparation and application of cement mortar; application of tiles, filling of joints etc.

External Covering

Products shall be guaranteed in writing by the Contractor, in addition to the manufacture guarantee, for 10 years minimum.

Granulite, Granigliato, Sandtex or similar covering shall consist of a mix of synthetic resin and marble or glass granules constituting approximately 90% of the mix total weight. This covering shall be applied by means of a stainless trowel over a white primer that shall cover the whole surface of the black rendering.

It shall adhere totally to the substrate and be waterproof and resistant to chemical reagents and heat.

The Employer may order to carry out at the expense of the Contractor any chemical analysis necessary to prove the compliance of the products with the requirements.

The support shall be perfectly ground, levelled and brushed. The application of two or three coats, according to the manufacture's recommendations to obtain the desired texture, shall be done on any necessary prime coat and to the instructions of the manufacturer, as regards application in wet or cold weather and protection of the covering until complete drying.

External covering - Measurement and payment

External coating shall be measured in m² according to the type of covering as the net area covered in accordance with the Drawings.

The unit rate for external covering shall include for all approved materials including scaffolding, cement, preparation and application of the covering, labour,...

208.4 WEARING PAVEMENTS WITH HARDENERS

- Hardeners are added to a concrete resurfacing to achieve:
 - a higher resistance to abrasion
 - a non skid and dustproof floor.
- Hardeners approved by the Engineer are classified in three categories :
 - quartz based hardeners
 - metallic hardeners
 - carborundum based hardeners.
- The Contractor shall consult the supplier before using the hardener. The following characteristics shall be approved by the Engineer:
 - the type of the hardener
 - procedures of use
 - mix designs
 - spacing and location of joints in the floor
 - thickness to be adopted with due regard to the final destination of the coating.

Following are the basic specifications set by the Employer pertaining to the types of approved pavements that shall be performed on a resistant, durable and level concrete surface.

208.4.1 Quartz based hardeners

The resurfacing shall consist of:

- a base course
 - a wearing course
- a) The base course shall have a medium thickness of 4 cm and shall be, for each cubic meter of concrete, composed of:
- 350 kg of cement
 - 400 liters of sand 2.5/5
 - 800 liters of gravel 25/40
- The minimum possible quantity of mixing water shall be used and the base course shall be well rammed in both directions
 - Joints shall divide the surface into 10x10m sections.
- b) The wearing course

- The wearing course shall be 7mm thick minimum and proportioned at 600 to 700 kg of cement per 1500 kg (1000 liters) of hard crushed stones.

Quartz grading shall vary within the following proportions:

- Heavy traffic - 20% of 0.2/1
 - 40% of 1/3
 - 40% of 3.5/5

For a fair faced resurfacing

- Heavy traffic - 40% of 1/3
 - 60% of 3.5/5

For a washed rough resurfacing

- The minimum proportion of quartz shall equal 1.5 kg per 1mm of the thickness of the wearing course (that is 10.5kg/7mm or 15kg/10mm).

It is recommended to place ebonite joints secured by means of small flashings and which divide the surface into regular squares before the base course is cast; the height of these joints shall be such that they are flush with the wearing course.

208.4.2 Metallic hardeners

The resurfacing consists also of:

- a base course
 - a wearing course
- a) The base course shall have a 20mm minimum thickness ; mix designs shall be as follows:
- 300 kg of cement
 - 400 liters of sand 2.5/5
 - 800 liters of fine gravel 5/15
- The mixing water shall be reduced to the practicable minimum, and the base course well rammed in both directions.
- b) The wearing course shall be batched with the same cement as the base course, but proportioned at 400 kg.
- Special metal flakes (cast iron, steel, iron...) so treated as to become porous shall be sprinkled into the mix.
 - The course shall then be well rammed and smoothed, 25 to 30mm thick. The surface shall be divided by contraction joints formed by brass or ebonite rods.
 - Hardeners quantity per square meter shall be 4 kg, to which may be added a similar quantity of special abrasive provided by the authorized supplier, so as to increase the resistance to abrasion and heavy traffic loads.

208.4.3 Carborundum based hardener

- A cement mortar bed proportioned at 300 kg of cement for 1m³ of sand 2.5/5 shall be laid and simply smoothed with a float.
- Over the fresh mortar (3 hours maximum after placement) a small quantity of carborundum-cement dry mixture shall be spread in order to absorb humidity.
- Finally a 5 to 10 cm thick cement - carborundum mortar shall be spread. This layer shall be well smoothed with a trowel.
- The quantities of carborundum to be used are conditional upon the required resistance to abrasion. For a hard resurfacing 6 kg/m² shall be recommended.
- Contraction joints shall be formed as specified above.

Products shall be delivered to site in ready for use bags.

The product shall be approved by a technical certificate from an authorized Control Office. The hardener colour shall be chosen according to the architectural requirements of each site.

208.5 DUST-PROOFING PRODUCT

It is a ready for use product pulverized over fresh concrete after the final levelling operation. It consists of a water based emulsion of vinyl acetate and vinylic ester cross-polymers. The product prevents the dehydration of the concrete surface and the migration of cement which might form a highly contractible and fragile crust.

This product shall be used with a mass or surface hardener. A technical certificate of an authorized laboratory shall be required.

208.6 WEAVING PAVEMENT WITH HARDENER - PAYMENT AND MEASUREMENT

The weaving pavement shall be measured in m² according to the type of hardener used as the net area in accordance with the Drawing. The unit rate shall include for all approved materials including cement, sand, preparation and application of the hardener, the base course, the weaving course, the dust proofing product, labor, ...

208.7 FALSE CEILINGS

These ceilings are supported by a frame and executed inside or outside buildings.

The term "False ceiling" as used herein includes the components of the ceiling (depending on their nature and manufacture), their mounting and suspension systems to the surface of the bearing structure.

Under the present chapter, the Contractor shall supply and install:

- False - ceilings

- metallic suspended - ceilings
- soundproof panels for walls
- miscellaneous works and accessories

according to the drawings and the Engineer's instructions.

Works under this Section shall be in accordance with relevant regulations and technical documents of B.S. and all technical specifications applicable to hardware and iron works.

The Contractor shall gather all information pertaining to:

- The sizes of structures performed under other Sections and serving as a support for his work.
- The nature and arrangement of materials that constitute the bearing structures (concrete or plasterwork, steel structures, frames, etc...)
- Incorporations (electricity, inspection hatches, ventilation grids, etc...)
- Openings (passage of wires, pipeworks, ducts, etc...)

The Contractor shall summarize all such data on his drawings and take them into account throughout the execution of works. He shall be liable for the good and complete execution of the other Sections works necessary for the perfect performance of his works.

On the basis of the documents of the Contract, the instructions of the Engineer and information collected from other contractors or subcontractors, the Contractor shall draw up:

- Detailed drawings of ceiling boardings and soundproof wall covering, indicating thereon the shapes, nature, dimensions and locations of panels and plates in floors and ceilings, as well as the incorporations (luminaries, ventilation, etc...)
- Shop drawings, with all details.

These documents shall be submitted to the Engineer for approval prior to any manufacture work whatsoever.

The Contractor shall submit:

- samples of finish covering,
- a representative panel of the installation for each type of ceiling and soundproof wall covering.

Manufacture shall not be started unless samples and mock ups were approved by the Engineer.

208.7.1 Materials

Components that are likely to be impaired by atmospheric agents during transport and storage on site shall receive a protective layer.

Following are the treatments for metallic parts:

- steel structures and suspension rods: galvanization or metallization
- rails and steel or aluminium sheets: baked varnish after priming of the substrate according to standards
- non exposed steel sheets: galvanization or galvanization by electroplating.

All accessories, especially those used for fixing purposes shall be treated against corrosion.

208.7.2 Workmanship

Works shall not commence unless shop drawings have been approved, after a meticulous exam so as to ensure an accurate execution and prevent any damage to other works.

Handling and storage:

Unloading and handling of various components shall be carried out under the best conditions to prevent any damage whatsoever to the anti-corrosion protection of materials and the appearance of works.

The temporary storage of material shall be inside a covered and ventilated location. Storage conditions shall be such that parts do not undergo any deformation nor deterioration whatsoever.

Marking

The Contractor shall determine:

- the works location on bearing structures,
- necessary openings provided for in his works for the other Sections works.

Controls prior to installation

The Contractor shall be responsible for the control of:

- the accurateness of bench-marks within the limits of allowed tolerances (levels, spaces between partition walls, axis),
- the conformity to requirements of executed structures that are directly related to those due to be installed.

Installation - Fixings

The Contractor shall carry out all fixing works of suspension rods and bearing structures regardless of the distance between the top of the suspended ceiling and the support, and of the nature of fixing spots.

Suspension spots shall be so set out that no defective clamp causes the ceiling to fall down. Suspension rods shall be metallic, rigid and adjustable. The reinforcement shall consist of main and secondary metal cross-sections.

Finishing works:

Surfaces shall be even and having regular colours. Workmanship shall include:

- installation of peripheral coverings and cross-sections
- sealing works
- installation of components of dropped beams and soffits and the like.

Protection of existing works:

The Contractor shall be liable for the protection of other Sections works likely to get dirty or damaged by his own works.

Protection of finished works:

The Contractor shall be liable for an efficient protection of his works. Such protection shall be kept till the completion of works.

Cleaning

The Contractor shall remove all material, waste or excess or rejected material he had supplied on site. The term "waste" as used herein includes as well all packagings, transport and handling accessories. Prior to taking over, the Contractor shall remove off site temporary protections.

Whenever necessary, he shall proceed to a thorough cleaning of facings.

Upon completion of works, the taking over shall not be carried out unless the Contractor has submitted:

- certificates proving resistance to fire and technical documents.

208.7.3 False Ceiling payment

The false ceiling shall be measured in m² according to the type of ceiling used as the net area in accordance with the Drawings and the instructions of the Engineer.

The unit rate shall include for all approved materials including scaffolding, preparation, fixings, materials, levelling, labor, etc...

208.8 UTILITY FLOORS

These are floors laying on the surface of the bearing structure and executed inside buildings. The term utility floors as used herein includes the components of the floor (depending on their nature and manufacture modalities) their mounting, fixing and installation system. These floors are generally composed of 60x60 cm panels constituted of a galvanized steel frame, a high density plywood panel, a sheet steel cover and a vinyl coating. Panels shall lay on adjustable steel stringers or contact-studs transmitting efforts without impairing the surface's evenness. The floor shall be 8 cm high and shall be earthed.

208.9 UTILITY FLOORS PAYMENT AND MEASUREMENT

The utility floors shall be measured in m² according to net area in accordance with the Drawings and the instruction of the Engineer.

The unit rate shall include all approved materials, preparation of support, fixing, labour, etc..

209 - METALWORK

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209 METALWORK

209.1 GENERAL

209.1.1 Scope

The work required under this Chapter includes doors and windows in buildings, gratings, hand-railings and miscellaneous non-structural metalwork and shall be in accordance with British Standards.

The Contractor shall supply all the metal, ironmongery, paints and auxiliary materials required, shall manufacture the metalwork and shall install them in the required positions and paint them - all in accordance with the Drawings and the Specification, or as directed by the Engineer.

Alternatively, the Contractor shall supply and install standard factory-made elements, approved by the Engineer. Such elements shall also meet all requirements of this Division.

Steel for doors, windows and other metalwork shall be new, first-grade quality mild steel, without mill defects, cracks, grooves or rough surfaces and shall comply with all requirements specified on the Drawings and/or in the Particular Specification.

Hardware, metal fittings and accessories

These elements shall comply with standards and be of first grade quality and approved manufacture. They shall be carefully installed, all notches having the required sizes and depths so as not to impair the solidity of rolled sections.

209.1.2 Metalwork

All shapes, bars and plates shall be cut, drilled, bent and otherwise worked to the exact lines and dimensions shown on the Drawings. All burrs resulting from cutting and drilling shall be neatly removed. Where cutting is done by oxyacetylene torch, cut surfaces shall be clean and smooth.

Hinges and locks shall be secured by means of metal-screws for any eventual unmaking. Other accessories may be welded. Unless otherwise specified, bolts, casement bolts, locks, etc, shall be mortised. Hinges shall be solid and of quantity corresponding to door leaves size and weight. They shall have the exact required sizes and allow an easy setting and replacement. Locking devices such as locks, buttons, crutch handles, bolts, etc.. shall immobilize totally the door leaves in closed positions.

Metal fittings are integral parts of each door or hatch even when not explicitly stated in the work description.

The Contractor shall take on site all dimensions deemed necessary for metalwork and remain wholly responsible for their good adaptation to the concrete and masonry works in the building.

Jointings shall be notched and angles mitred. Electric welding shall be as continuous as possible along the joint after filing the metal elements.

After soldering, burrs and slags shall be trimmed completely. Holes shall be drilled by means of an electric drill fitted with a bit having a smaller diameter than the hole, then with another having the same diameter as the hole.

Distances between holes shall be as follows:

- Distance between hole edge and section edge \geq hole diameter
- Distance between axes of two consecutive holes $\geq 3 \times$ hole diameter
- Axes of aligned holes : a size margin equal to one tenth the hole diameter
- Irregularities in distance between holes $\leq \frac{1}{10} \times$ hole diameter.

The Contractor shall supply and install any material whether specified or not on the Drawings, but necessary for the good execution of the works.

Surface finishing

Surface finishing of works shall be in strict accordance with the General Technical Specification and shall include the protection of materials and the surface treatment.

Exposed surfaces shall have no unevenness, burrs, or metal run-out. Salient angles and projecting parts shall be rounded off. Welds shall be carefully ground. Screws shall be inserted and then painted. Accessible bolts shall be covered. Element showing appearance or assembly defects shall be rejected. It is expressly forbidden to cover and hide these defects.

Protection of metals against corrosion

No metal part shall be accepted on site unless previously protected against corrosion. Elements shall be in-factory protected according to relevant applicable standards. Unprotected iron parts shall be painted after removal of calamine, rust, and oil, with a rust proof zinc chromate paint, 60 microns thick, compatible with the top coat specified in the relevant Section (or eventually with two coats of red lead). Immediately after installation, any painted surface showing imperfections due to impacts or handling shall be wire brushed and repainted.

Contact between different metals

All measures shall be taken to avoid electrolytic corrosion caused by the contact between metal parts and accessories (screws, bolts, washers, etc ...) of various natures.

Greasing

Upon the completion of works, the Contractor shall grease all mobile metal fittings such as hinges, locks, etc ...

209.2 WORKMANSHIP

209.2.1 Manufacture

Details and profiles shown on the Drawings constitute the basic Drawings. Works shall be solid, rigid and have a perfect finish. The components shall be one-piece. Connections shall

be right-angled in such a manner as to resist, without deformation nor rupture, mechanical tests and the efforts imparted to them.

Jointings shall be notched and angles mitred so that sections join at right angles without overlapping. Welding shall be continuous along the joint after bevelling the metal. Holes shall be drilled by means of a drill fitted with a bit having the same diameter of the hole. Elements shall be cleaned of all slag and burrs.

209.2.2 Assembly

Metalworks shall be fixed to their support (concrete and masonry works, partitions) by welded inserted plates, holdfasts, screws and expansion bolts or any other approved system. The use of a stud gun SPIT is prohibited. Anchor bolts shall only be used in concrete works or hollow blocks masonry; only traditional anchoring means are permitted for other surfaces. Anchors shall be screwed, bolted or welded on locks. Their section, shape, length and number are conditional upon the element sizes and installation conditions.

Fixing devices proposed by the Contractor shall be shown on shop Drawings. Fixing devices shall be placed close to hinges in order to diminish stresses.

All welding shall be done by the shielded electric-arc method by experienced welders, to the highest standards of workmanship and to the satisfaction of the Engineer. Electrodes for steel welding shall be of a kind and class approved by the Engineer. All surfaces of parts to be welded shall be well cleaned of dirt, rust, slag, and paint. All slag and splatter adhering to metal shall also be removed.

209.2.3 Installation

Prior to installation, the Contractor shall wedge and adjust the different elements so as to ensure perfect plumb, alignment and levelling.

He shall ensure all required sealings and caulking for fixing the works. He shall set out all his works and verify the location of openings left in the structure.

209.2.4 Tolerances

a) Tolerance on setting out

Maximal variation between the real position of each axis of metalwork and each axis of an opening in a wall shall not exceed 1 cm.

b) Tolerance on installation

Rectitude and plumb errors in door frames, stiles, and posts shall not entail a deviation exceeding 2 mm, provided that stiles and posts be parallel to ± 2 mm in all points and planes.

Rectitude and levelling errors in crosspieces shall not exceed 2 mm for the first meter and 1 mm for each additional meter with a maximum of 4 mm.

c) Tolerances on leaves play

The play between leaves and the finished ground shall vary between 5 and 10 mm regardless of the opening position.

d) Sealing

Air and watertightness between the structure and the metalworks shall be ensured by stable and 10 year guaranteed sealants. They shall be easily replaced. The unit rates of metalwork shall include the cost of all sealants.

209.2.5 Handling and storage

Unloading and handling of elements shall be done without causing any permanent deformation or defect that might impair the good functioning of mobile parts, or their resistance to corrosion.

Elements shall be stored in dry premises on appropriate horizontal and vertical devices avoiding any deformation whatsoever.

209.2.6 Samples and mock-ups

Samples of hardware to be used shall be as shown on Drawings.

Prior to any serial manufacture, a mock-up of each type of work shall be submitted for approval, namely:

- Ventilation grilles
- Handrails
- Guard-rails
- Protection bars
- Etc ...

The Contractor shall submit to the satisfaction of the Employer all varnish samples.

209.2.7 Locks

Locks shall be supplied with 3 keys bearing each a permanent label indicating the premises they are intended for. The loss of a key on the day of taking over entails the changing of the relevant lock at the cost of the Contractor. Prior to installation, all types of locks shall be submitted to the Employer for approval. The outside locks shall be resistant to atmospheric conditions.

209.2.8 Sections, painted wrought iron

Hatches, balustrades, guard-rails, angle-irons for antennas, handrails, stiles, posts and crosspieces, rungs, ladders, etc, ... shall be made of sectional irons, flats, pipes, etc ... and have the dimensions shown on the Drawings. Works shall be carried out according to the above-mentioned specifications. Paint shall be consistent with the specifications mentioned in the relevant Section.

209.2.9 Ladders

Ladders shall be of galvanized tubes or sections to the dimensions shown on the Drawings. They shall be painted according to the relevant Section.

Ladders shall be fixed to the upper platform and to the floor taking into account all works to be performed under other Sections (ex: waterproofing works, ...) as well as all above-mentioned conditions. Where specified, ladders shall be fitted with safety hoops.

209.2.10 Metal shutters

Rolling shutters with fastened metal blades shall be of cold-rolled and galvanized steel, with a minimum thickness of 7/10 mm, with lateral bolting of each blade. The steel curtain should withstand without deformation a load of 400 kg/m².

Scroll axes, gears, winches, etc ... shall be of stainless metals or metals that are especially treated against rust by galvanization or any other approved process.

Guide bars shall be hot-rolled and galvanized channel irons of 30 mm minimum depth and embedded in the masonry or the concrete.

Operation shall be by winch and built-in crank, with a lock system constituted of six-turn brass lock with 35 cm cylinder. The scroll axis shall be fitted with springs that balance the curtain at any height.

The shutter case shall be of galvanized sections and 7/10 mm sheets with all necessary reinforcement to ensure a perfect rigidity and easy dismantling and maintenance. Components shall be galvanized, coated with an epoxy primer and painted, as specified in the relevant Section.

209.2.11 Glazing

All sheet glass shall be of approved manufacture, and samples shall be submitted to the Engineer for approval prior to ordering. Labels shall remain on the glass until final clean-up. Putty shall be of the best quality available and shall be suitable for wood or steel sash glazing as required.

Glass, except where glazing beads are provided shall be back-puttied and face-puttied. In wood sash, the glass shall be secured with metal glazer's points; in steel sash, with metal clips. where glazing beads are provided, the glass shall be bedded.

The sizes of panes indicated on the Drawings are approximate, and the final sizes of panes shall be taken from the actual frames.

Putty shall be neatly and cleanly run in straight lines even with edges of sash members, with corners carefully made. Glazing beads shall be carefully removed and re-set, using every precaution to avoid marking or defacing.

Glass louvre blades shall be accurately cut to the sizes required and to the widths specified by the manufacturer of the blade holder. The edges of the blades shall be cut perfectly straight

and then ground to produce a smooth slightly rounded edge and the blade firmly secured in the clips of the louvre holder.

Prior to final inspection, all broken, cracked, or imperfect glass shall be removed and replaced. All glass shall be washed, cleaned, and polished on both sides prior to final inspection.

209.3 MISCELLANEOUS METALWORK

Miscellaneous metalwork shall comprise grating, handrailing, hatches and other metal parts as shown on the Drawings or directed in the Particular Specification. The work shall be carried out to the exact details shown on the Drawings, to the highest standards of workmanship and to the satisfaction of the Engineer.

209.4 METHODS OF MEASUREMENT AND PAYMENT

Metalwork shall be measured either by number, according to type, size, etc. or by square meter, or by kilogram, all as shown on the Drawings and/or as specified. Each unit rate shall include for the manufacture, supply, transport, handling, fixing, glazing ironmongery, painting, and anodizing, and for all materials, equipment and labour necessary for the completion and installation of all metalwork item in accordance with the Drawings and the Specification and to the Engineer's satisfaction.

210 - ALUMINIUM WORK

210 ALUMINIUM WORK

210.1 GENERAL

Unless otherwise specified in this Section, the works and supplies necessary for aluminium works shall conform to the texts and documents of the British Standards.

Aluminium shall be new, free of defects and unsightly blemishes. The aluminium shapes used for windows, doors and shutter frames shall be of the extruded "solid" or "hollow" type with the main web having a minimum thickness of 2mm. The supplier shall be submitted for approval.

Aluminium work shall be in strict accordance with the Drawings and AI rules basically intended for external works.

All aluminium-parts shall be anodized. The anodic protection shall meet the requirements of B.S. 1615 or B.S. 3987. The colour of anodizing shall be in accordance with samples approved by the Engineer.

Aluminium alloy shall be 50 AGE, anodized over 18 microns, satin silvery colour or any colour as specified.

The Employer may require all necessary tests to be conducted in an approved laboratory to ensure the conformity of the aluminium with the requirements.

Aluminium shall have the following mechanical characteristics:

- Elastic limit at 0.2% 15 kg/mm²
- Breaking load 20 kg/mm²
- Modulus of elasticity 5.700 kg/mm²

210.2 EXECUTION OF WORKS

Prior to the commencement of works, samples shall be submitted to the Engineer for approval.

210.2.1 Workmanship

a) Fixing

Fixing devices shall be submitted to the Engineer for approval.

The use of a stud gun is not allowed.

Fixing devices shall be of stainless metal protected against corrosion either by electric zinking or galvanization.

The aluminium casing shall be screwed, where specified, to the galvanized steel frame or to the frame embedded in the concrete.

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The frame shall be coated with an approved special bituminous paint. Other fixing methods shall be subject to the Engineer's approval.

Installation of aluminium works shall be accurate and to the specified plumb. Sliding parts must slide easily. Once closed, aluminium works shall be perfectly tight.

Aluminium works shall be anchored in the wall.

Where specified, holes and spouts shall be provided for discharging condensation and running water to the outside. Spouts shall be fitted with small screens to prevent direct air inflows or water back-flow.

Sections shall be dimensioned to resist 150 km/h wind velocity, air and rain infiltrations. The following test shall be required to prove the air and watertightness of the system.

A sample of each aluminium work shall be erected on site exactly as for the permanent works.

The different elements shall be subjected to a jet of water from a firehose as specified in test standards.

The Contractor shall provide approved local and foreign laboratory tests on the quality of the used joints (PVC or neoprene) especially with regard to their plasticity and behaviour.

Shapes, sizes and aesthetics of sections shall be submitted to the Engineer for approval.

Where necessary, stiles with metal stiffeners shall be used to ensure the rigidity of the works and their serial assembling as shown on Drawings.

Ball bearings shall be shielded from both sides. The sliding ball shall be of Hard Nylon or of stainless steel. Operation of opening elements shall be practical, easy and silent. Panels shall be rigid when opened or closed.

Friction between aluminium parts shall not be allowed. Prior to commencement of the works, aluminium works and connection and fixing details shall be submitted to the Engineer for approval.

They shall be anchored to reinforced concrete or metal beams or jambs with cement mortar.

All components shall be carefully installed and wedged to the plumb, alignment and exact levelling.

Mobile parts shall be greased, balanced and adjusted prior to the taking over.

b) Tightness of joints

Appropriate sealants shall be used to ensure air and watertightness. They shall be of stable mechanical and chemical characteristics, 10 years guaranteed, easily replaced and consistent with the relevant standards. The unit rates of aluminium works include the cost of sealants.

c) Installation

The Contractor shall take all necessary precautions when installing and wedging the various elements in order to ensure their plumb, alignment, levelling and evenness within the specified tolerances.

d) Contact between different materials and alloys

All precautions shall be taken to avoid electrolytic corrosion.

210.3 TOLERANCES**210.3.1 Tolerance on setting out**

Maximal variation between the real position of each axis of metalwork and each axis of an opening in a wall shall not exceed 1 cm.

a) Tolerance on installation

Rectitude and plumb errors in door frames, stiles, and posts shall not entail a deviation exceeding 2 mm, provided that stiles and posts be parallel to ± 2 mm in all points and planes.

Rectitude and levelling errors in crosspieces shall not exceed 2mm.

The Contractor shall provide for all necessary adjustment elements within the required tolerances.

b) Sealing

Air and watertightness between the structure and the Aluminium works shall be ensured by stable and 10 year guaranteed sealants. They shall be easily replaced. The unit rates of Aluminium works shall include the cost of all sealants.

The Contractor shall provide for all necessary adjustment elements within the required tolerances.

c) Protection

Parts in contact with masonry shall be coated before their installation with bituminous paint or the like.

Accessories made of any material other than light alloy shall be plated with zinc or cadmium. The casing and frame elements shall be protected with a polyethylene sheath during installation. The latter shall be removed from the exposed parts at the time of taking over.

210.4 TRANSPORT

Glazing elements shall be transported with great care to avoid any damage whatsoever.

Elements that are fragile due to their shape shall be stiffened with metal corners and wood distance-blocks.

Components shall be cautiously placed and secured.

Cleats and wedges shall only be used when firmly secured to avoid displacement or loss during transport.

During handling, great care shall be taken to avoid any damage to the parts or to the paint.

When unloaded, aluminium works shall be placed on scaffoldings or cleats to prevent direct contact with soil and water.

The Engineer shall reject damaged parts which shall be replaced at the expense of the Contractor.

The Engineer shall be solely entitled to assess damages and decide of the measures to be taken.

The same applies to accidental damages occurring during installation.

210.5 INSTALLATION

The Contractor shall take necessary measures to avoid damages to reinforced concrete works, and bear the expenses of eventual repairs due to impacts or brutal handling.

In the event of an installation on muddy ground, the Contractor shall take necessary measures to avoid direct contact of the frame with the ground.

Temporary wind bracings shall be installed during installation. Aluminium works shall be clean and in perfect condition prior to taking over.

210.6 DESCRIPTION OF WORKS

Works shall include:

- Supply of materials
- Assemblage in workshops
- Protection of components as specified
- Transport including loading/unloading
- Assemblage and installation on site
- Lifting and handling
- Temporary wind bracings

and in general, all required measures for the completion of the works.

The Contractor shall be responsible for:

- Studies, calculation notes and shop Drawings
- Supply and supervision of the anchors installation in reinforced concrete
- Verification of installation levels after completion of concrete and masonry works
- Supply of certificates of origin and quality.

he shall also attend site meetings, as necessary.

210.7 GLAZING

All sheet glass shall be of approved manufacture, and samples shall be submitted to the Engineer for approval prior to ordering. Labels shall remain on the glass until final clean-up. Putty shall be of the best quality available and shall be suitable for wood or steel sash glazing as required.

Glass, except where glazing beads are provided shall be back-puttied and face-puttied. In wood sash, the glass shall be secured with metal glazer's points; in steel sash, with metal clips. where glazing beads are provided, the glass shall be bedded.

The sizes of panes indicated on the Drawings are approximate, and the final sizes of panes shall be taken from the actual frames.

Putty shall be neatly and cleanly run in straight lines even with edges of sash members, with corners carefully made. Glazing beads shall be carefully removed and re-set, using every precaution to avoid marking or defacing.

Glass louvre blades shall be accurately cut to the sizes required and to the widths specified by the manufacturer of the blade holder. The edges of the blades shall be cut perfectly straight and then ground to produce a smooth slightly rounded edge and the blade firmly secured in the clips of the louvre holder.

Prior to final inspection, all broken, cracked, or imperfect glass shall be removed and replaced. All glass shall be washed, cleaned, and polished on both sides prior to final inspection.

210.8 ALUMINIUM HARDWARE

Hardware for aluminium works shall be first grade quality to B.S. The Contractor shall provide necessary fittings such as handles, hinges, closing mechanisms, locks and stops for swing-doors.

The Contractor shall provide a latch for transom windows. Screws shall be chromium steel or special stainless alloy.

The use of aluminium screws shall not be accepted.

Doors shall be fitted with approved cylinder mortise locks, with anodized aluminium handles of natural shade. For exterior elements, the locks shall be resistant to atmospheric conditions and of first quality.

210.9 WINDOW PANES HOLDING AND SEALING

The space between window panes and frames shall be sealed with PVC strips. Where glazing beads are provided, they shall be designed for easy mounting and replacement. Glazing beads shall be secured with stainless screws. Caulking between concrete work or masonry and the frame shall be done with a plastic mortar ring and, where necessary, with a vinyl ring. Window panes shall be installed on vinyl joints.

210.10 SHUTTER WINDOWS

These windows shall be made of adjustable horizontal glass louver blades. Windows shall be aluminium with an anodic protection of 18 microns.

The approved sash shall include a concealed rod system that requires no maintenance and an efficient stop system. Where the sash is not easily accessible, a remote operation system shall be provided for by ring and hook or any other approved method. An operation rod with a hook shall be provided with each series of these sashes.

The blade holders shall be rigid. No friction shall be allowed between the blade holders and the frame. When closed, blades shall be perfectly tight and no play between two blades shall be permissible.

Pins and axes shall be first grade quality and installed to the best conditions of practice. Pins, axes, fastening screws shall be chromium steel or special stainless alloy. The use of aluminium screws shall not be permitted. Glass blades shall overlap over a width of 10 mm minimum to ensure air and watertightness. They shall be 6 mm thick and shall not be more than 100 cm long. Edges shall be ground on four angles. The blade holder shall be so installed on the window sash as to ensure verticality and evenness, and that glass louvers overlap identically all along their edges and on the four sides of the sash.

Weatherstrips shall be placed on the upper and lower parts of the metallic sash.

210.11 MISCELLANEOUS ALUMINIUM WORKS

Miscellaneous aluminium works shall comprise balustrade, handrailings and other aluminium parts as shown on the Drawings or directed in the Particular Specification. The work shall be carried out to the exact details shown on the Drawings, to the highest standards of workmanship and to the satisfaction of the Engineer.

210.12 METHODS OF MEASUREMENT AND PAYMENT

Unless otherwise specified, Aluminium work shall be measured by number, according to type, size, etc., all as shown on the Drawings and/or as specified. Each unit rate shall include for the manufacture, supply, transport, handling, fixing, glazing, ironmongery, anodizing, and for all materials, equipment and labour necessary for the completion and installation of all aluminium works items in accordance with the Drawings and the Specification, and to the Engineer's satisfaction.

211 - WOODWORK

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211 WOODWORK

211.1 GENERAL

Unless otherwise specified, the materials and joinery products shall meet the requirements of the applicable British Standards, the principals of which are:

- B.S. 186 - Quality of timber and workmanship in joinery
- B.S. 644 - Wood windows
- B.S. 459 - Doors
- B.S. 1567 - Wood door frames and linings
- B.S. 1285 - Wood surrounds for steel windows and doors
- C.P. 151 - Doors and windows, including frames and linings.

All timber used for permanent work shall be the best hardwood approved by the Engineer as suitable for the particular purpose, sound, dry and free from knots, grooves, sap, shakes, dead knots, cracks, or waness. The remaining moisture percentage shall correspond to that of the site. The timber shall be sawn into scantlings of the requisite dimensions not less than one month before use, and in the case of joinery not less than three months before use. Only unused timber shall be employed.

Plywood, unless otherwise shown, shall have a thickness of 5mm, shall be new, whole, and free of any defects.

Ironmongery shall be of high quality and in accordance with details shown on the Drawings and identical with the samples approved by the Engineer.

Formica for surfacing shall be of first-grade quality, equal to samples approved by the Engineer. The colour and/or pattern of the formic shall be as chosen or approved by the Engineer.

The Contractor shall supply and install, at his own expense, all woodwork including coatings and other works such as butt-straps, cornices, casings, etc ... necessary for the finish of assembled units.

He shall ensure the installation, adjustment and wedging of all woodwork. Works shall be executed in perfect co-ordination with other engineering fields, namely, masonry, rendering, and tiling. Rendering and finished tiled surfaces shall be flush with the casings so that butt-straps be perfectly placed.

Any work which is unfinished, of bad quality, defective and non conforming with construction rules or with above-mentioned specifications shall be refused by the Engineer. Such work shall be totally or partially repaired at the expense of the Contractor.

In any event, the Contractor shall be responsible for the good execution and rigidity of woodwork as shown on the Drawings or specified by the Engineer.

The Contractor shall be solely responsible for an efficient and perfect protection of woodwork until the taking over, and shall ensure all necessary adjustments and plays. He shall store woodwork in a dry place.

Alternatively, the Contractor shall supply and install standard factory-made elements, approved by the Engineer. Such elements shall also meet all requirements of this Section.

211.1.1 Facings and joinery

Facings or exposed surfaces shall be trimmed, while the others remain rough. Rough surfaces shall be flushed up. Trimmed facings shall be scraped, smoothed to a plane surface, free from waness and traces of sawing. Parts shall be assembled in a workmanlike manner by mortise and tenon, dovetails, etc ... Joinery made in workshops shall be glued with a synthetic resin based, stable, and moth repellent glue.

Mortise and tenon joints shall be secured with dry and hardwood pins or with metal pins. Junctions shall be executed deeply enough so that tongues do not stick out of grooves. Parts to be jointed by tongue and groove shall be of parallel grain, the void between the slot and tongue shall not exceed 2 mm.

Slip tongues shall be made of hardwood. The beds of the hinges shall be carved with a chisel to a depth of 1 mm minimum.

211.1.2 Installation

All timber shall be accurately set up in position, plumb and level in all directions.

The Contractor shall verify in every case the exact dimensions of the openings and remains solely responsible for the good adaptation of woodwork to the masonry and concrete works.

The dimensions of joinery elements shown on the Drawings shall be the dimensions after planing and finishing. The Contractor shall be solely responsible for agreement of the joinery dimensions with the dimension of the openings actually left in the structure. The planks composing the joinery elements shall be made each of one piece of timber. The parts shall be connected in a first-grade workmanlike manner by tightly fitting mortise and tenon, overlapping etc., as required in each case. Gluing shall be with cold glue and connections shall be made with hardwood, dowels and wedges. Linings and strips shall be fixed with brass screws. All hidden surfaces shall be sawn. The exposed surfaces shall be wrought mechanically and any marks left by the machine shall be wrought by hand and polished with glass paper until a perfectly smooth surface is obtained. Sharp edges shall be chamfered or rounded by light planing.

Timber shall have undergone deformation and dried up prior to being sawn and assembled. No play between mobile parts or between mobile and fixed parts shall exceed 1 mm. Leaves shall close automatically as handles are let go with no need to press on the door.

The openings for doors and windows shall be prepared in advance. The dimensions of the openings shall be accurate while leaving a gap of at least 5 mm. between the rear edge of the frame and the side post. The openings in concrete shall be formed by accurately dimensioned temporary frames. The Contractor shall in every case verify the actual dimensions of the openings and he shall be solely responsible for the accurate positioning of the openings, the accuracy of their dimensions, and for agreement between the frames and the openings. The gaps shall be filled with a 1:3 cement-sand mortar.

Frames shall be accurately set up in position, plumb and level in all directions. To prevent change or distortion, the frames shall be stiffened by temporary vertical and diagonal braces.

Frames shall be fixed to the openings in the walls by not less than fourteen flat iron hold-fasts (3mm x 25mm x 150mm) screwed to recesses at the back of the frames painted with coats minimum and concreted in the openings prepared in advance in the brickwork and/or concrete. Cutting such openings in the completed brickwork or concrete may only be carried out with the permission of the Engineer. Holes may be prepared by building-in bricks or blocks of soft material which can easily be removed after the wall has been cast or built. After the frame has been set in position with holdfasts inserted in the holes, these shall be filled with concrete or cement-mortar with an approved anti-shrinkage additive. Frames must be held firmly in place until the concrete or mortar has hardened. The feet of door frames shall be treated with an approved preservative material prior to anchoring them in the floor.

The back side of frames and any woodwork in contact with concrete surfaces or masonry shall be coated prior to fixing with creonote, oxylophene or the like.

The door leaves shall be produced according to accurate dimensions, lines and planes, and their surfaces shall be prepared as specified for painting and surfacing. The gap between the edge of a door leaf and the recess in the door frame shall not exceed 3 mm. after painting. No gap between the door frame and the recess in the door leaf shall exceed 1 mm. gap. Hangings shall be accurate and vertical, so that the door leaf shall always remain perfectly vertical and always remains in the open position to which it has been brought. All doors and windows shall be weatherproof and watertight when closed. Window sills shall be constructed so as to ensure the free drainage of rain water.

Formica lining shall be applied to wooden surfaces, where shown on the Drawings or specified in the Particular Specification, or where directed by the Engineer.

211.2 HARDWARE

All hardware and fittings shall comply with standard NF P 26-303 published in November 1976. They shall be rigid and of first grade quality.

Samples of all devices shall be submitted to the Employer as soon as possible so that the latter could select the models to be used.

The Contractor shall supply and install all hardware necessary for a perfect finish of the works according to the construction rules.

The Contractor shall provide all locks, hinges, squares, handles, crutch handles, bolts, door closers, automatic door closers, stops, etc ...

Locks shall be of first grade quality: cylinder or mortise safety locks.

1) Internal one-leaf doors in various buildings and floors shall be equipped with:

- a mortise or cylinder safety lock and a master key
- three hinges with 140 mm square end blades and a brass ring
- a pair of handles
- two plates
- a door-closer.

Accessories approved by the Engineer shall be of matt chromium plated brass and comprise necessary rings and washers for a good adjustment and a perfect assemblage of fittings, leaving no play whatsoever.

Two-leaf doors shall be fitted with three hinges for the second leaf, two bolts and covers for fixing holes made in tiled or wooden surfaces.

- 2) Doors of hydraulic installations rooms shall be fitted with aluminium hardware as shown on the Drawings.

211.3 HARD WOOD DOORS

Hard wood doors shall be assembled and installed to the exact details shown on the Drawings, as stipulated in this Section and to the satisfaction of the Engineer.

211.4 LATHED WOOD DOORS

Lathed wood shall be of first grade quality, 45 mm thick, approved by the Engineer. The hard wood components such as frames, casings, casing trims, etc .. shall be of best quality. These doors shall be assembled and installed to the exact details shown on the Drawings, as stipulated in this Section and to the satisfaction of the Engineer. The plywood used shall be 5mm thick and 3 ply type.

211.5 PAINTED FIBERBOARD DOORS

Where specifically called for, internal doors shall be of first-grade quality fiberboard with standard specifications and characteristics. The density of fiberboard shall be 550 kg/m³ with a manufacture margin of 5%. Where non closed-grained wood is used, the real volume of fiberboard (all voids deducted) shall be taken into account in the determination of the density.

The leaf shall comprise a 7 cm wide frame and a 35 cm × 12 cm plate secured longitudinally on both sides of the leaf at the lock level. The frames and plates shall be first-grade quality fir wood, sound, clean and dry.

The leaf shall be 40 mm thick. Frames and casing shall be Canadian red wood of “Clear” type and of first-grade quality, sound, dry and free from fissures, knots or imperfections. Any knotty timber shall be refused and replaced.

Doors: casing, leaf and frame shall be cut to the shapes and exact dimensions shown on the Drawings.

The Contractor shall submit a sample of fiberboard to the Engineer for approval.

211.6 PAINTED FIBERBOARD CUPBOARDS

One-leaf or two-leaf fiberboard cupboards shall be installed. Frames and casings shall be of hard core wood to be specified by the Engineer.

They shall be manufactured and installed to the exact details shown on the Drawings and to the satisfaction of the Engineer. They shall be arranged internally as specified in the Drawings.

211.7 LATHED WOOD CUPBOARDS

Some cupboards shall be of 25 mm thick lathed wood, executed to the exact details shown on the Drawings, as stipulated in this Section, and to the satisfaction of the Engineer. Hardwood shall consist of beech wood. They shall be veneered as specified.

211.8 KITCHEN CUPBOARDS AND SHELVES

They shall be installed beneath and above the kitchen sink in technical buildings. They are made of waterproof melamine panels as specified by the Engineer.

211.9 MISCELLANEOUS WOODWORK

Miscellaneous woodwork shall comprise built-in, cupboards, hatches, and other metal parts as shown on the Drawings or directed in the Particular Specification. The work shall be carried out to the exact details shown on the Drawings, to the highest standards of workmanship and to the satisfaction of the Engineer.

211.10 METHODS OF MEASUREMENT AND PAYMENT

Unless otherwise specified, joinery shall be measured either by square meter or by number, according to type, size, etc., all as shown on the Drawings and/or as specified. Each unit rate shall include for the manufacture, supply, transport, handling, fixing, glazing, ironmongery, painting, and for all materials, equipment and labour necessary for the completion and installation of all joinery items in accordance with the Drawings and the Specification, and to the Engineer's satisfaction.

Formica lining shall be measured separately per m². The unit rate shall include for the supply of formica and adhesive, preparing wood surfaces and attaching the lining.

212 - GLAZING

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212 GLAZING

212.1 GENERAL

All types of glass shall be in accordance with British Standards.

All elements necessary for glazing works shall be supplied and installed by the Contractor.

Window panels shall be placed on internal or external woodwork, aluminium and steel works. The Contractor shall be fully responsible for ensuring a perfect co-ordination among all the Sections concerned by glazing such as woodwork, metalwork and painting. Installation of glazing shall be carried out by experienced workmanship.

Unless otherwise specified on the Drawings, the thickness of glass is conditional upon the panels size and shall be:

- 4 mm for panels which perimeter does not exceed 200 cm
- 6 mm for panels which perimeter is between 200 cm and 450 cm.

Window panels shall be supplied and installed so as to meet the installation requirements of each type of glass and to perform the works under the best conditions of practice.

Prior to glazing, the Contractor shall locate and repair any defect in the rabbet, carpentry, that could jeopardize solidity of glass or installation conditions.

He shall also make sure that elements to be glazed and later painted have already been primed. Should these obligations be unfulfilled, the Contractor shall bear the consequences.

Any work not carried out to the satisfaction of the Engineer shall be rejected and the Contractor shall be bound to resume the work, at his own expense.

Materials shall be stored under the specified conditions and with the usual precautions. The Contractor shall be liable for any broken or damaged glass and shall replace it at his own expense.

212.2 ORDINARY GLASS

Glass shall be of high-grade, approved manufacture, 4 and/or 6 mm thick as specified above.

They shall be free of air bubbles, streaks, scratches, undulation, or other defects. They shall not deform the reflected image or that seen through them; and particularly, images of objects located at 0.25 m and seen at 20° angle.

Samples shall be submitted to the Engineer for approval.

Glass shall be cut to the final sizes taking into account any eventual expansion (the play between the glass and the framework shall not exceed 2 mm). Glass panels shall be mounted on glazing beads with a putty or as shown on Drawings. Glazing beads shall be delivered mounted on the structure.

Putty shall be first grade quality pure linseed oil complying with the various conditions of application. The use of bituminous putty is not permitted.

Wedging of glass is mandatory by means of isolated and small wedges placed between the window rabbet and sill. They shall be made of an elastic material such as softwood. Two wedges maximum shall be placed for each glass support.

After completion of work, all glass shall be washed, cleaned and polished on both sides and the Contractor shall remove all wastes.

All broken, cracked, or defective glass shall be removed and replaced by the Contractor at his own expense.

Glass shall be transparent, translucent, or of special type as specified on the Drawings.

212.3 COLOURED GLASS

Where specified on Drawings, coloured glass shall be installed according to the requirements of both previous paragraphs.

Coloured glass shall meet the required heat absorption and daylight reduction characteristics.

Samples shall be submitted to the Engineer.

212.4 6 MM MIRRORS

Mirrors shall be cut to the sizes required on the Drawings and secured with concealed fasteners. They shall be back-coated with PVC plastified silvering.

Glass used for mirrors shall have at least the same characteristics of above-mentioned glass.

Mirrors shall be installed as shown on the Drawings, in strict accordance with the construction rules and to the satisfaction of the Engineer.

212.5 DOUBLE GLAZING

It is an isolating glazing having specific acoustic and thermal characteristics, composed of two glass sheets separated by a dehydrated air gap. A double peripheric string made of elastic organic binders only shall act as a separator, a dehydrant and a waterproofing element.

It can be replaced by an aluminium separator containing a dehydrant; peripheric waterproofness being ensured by two organic joints.

The nature and thickness of both glass sheets shall be determined according to the required criteria (acoustic and/or thermal and to relevant technical data sheets).

212.6 MISCELLANEOUS GLASS

Miscellaneous glass shall comprise all types of glasses not indicated above and asked for in the Particular Specification and for Drawings. The work and the material shall be carried out to the satisfaction of the Engineer.

212.7 METHODS OF MEASUREMENT AND PAYMENT

In general the price of glass is included in the unit prices of metalwork, joinery or aluminium work. In case of independent glass to be delivered, the glass shall be measured in square meter according to type, thickness, etc., all as shown on the Drawings and/or as specified. Each unit rate shall include for the manufacture, supply, transport, handling, fixing, and for all materials, equipment and labour necessary for the completion and installation of the glass in accordance with the Drawings and the Specification, and to the Engineer's satisfaction.

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213 DAMP-PROOFING

213.1 GENERAL

The provisions of this division shall apply only to the:

- damp-proofing of new or existing building basements, protecting these structures against water infiltration from the ground.
- damp-proofing of back filled new concrete retaining walls against infiltrated water.
- damp-proofing below slab and over walls of concrete structures retaining aqueous liquids against infiltrated water.
- damp-proofing of cut-off walls and tunnels in catchment structures.

N.B.: Damp-proofing under water table pressure (tanking) is not included in this division.

213.2 DAMP-PROOFING MATERIALS

Damp-proofing materials are intended to provide a resistance against water and sometimes against humidity and water vapor.

213.2.1 Bituminous Coating

This material is recommended for use on the exterior wall basement of plant rooms (excluding electrical equipment) in some workshops and retaining walls where water infiltration pressure is low (permeable earth foundation) and where the performance level of protection tolerates some damp patches.

Ground water should be checked previously by the Contractor for chemicals which may have a deleterious effect on the structure or internal finishes.

The Contractor must obtain the previous approval of the Engineer on the support as well on the type of material proposed.

(Type B for reinforced concrete design in accordance with B.S. 8110).

The bitumenous coating for damp-proofing should be cold applied emulsion in two coats (of at least 0.750 kg/m² each) and cross applied.

Bitumen primer should be of the same cold bitumen emulsion compound diluted to 50% with water and applied at a minimum rate of 0,400 kg/m². The damp-proof bitumenous coat shall be applied around 24 hours after the primer application.

213.2.2 Preformed Bitumen Sheeting (SBS or APP bitumenous membranes)

This type of membranes is intended to provide no water penetration and no moisture vapour in basement of workshops and in plant rooms requiring drier or totally dry environment (working areas, archives, stores requiring a controlled environment) etc.

The form of construction must be conformed to type A structure (BS 8102, 1990) or type B reinforced concrete design (in accordance with BS 8007).

The Contractor shall previously obtain the Engineer agreement on the support (type A or B) and the kind of membrane proposed.

213.2.3 Cement Based Waterproof Render

This material is recommended to be applied on the inner side of existing structures or on the external side of the new structures to stop any infiltration or seepage or damp patches.

Cement based damp-proof renders consist of fresh cement, well graded sharp sand, water and a waterproof admixture.

Generally these renders are applied in multi-coats when seepage is widespread, but they can allow some vapour penetration.

213.2.4 New Materials

The Contractor may propose to the Engineer's approval other materials and systems of damp-proofing below ground structures, which are not included in this division.

The Engineer will contemplate then to recommend that inquiries be made regarding the following:

- Certification by the British Board Agreement (BBA)
- Performance characteristics compared with established BBA criteria.
- Certification from overseas national bodies,
- Results from independent test houses,
- Established performance in the U.K. and overseas.

213.2.5 Flexible Sheet

a - Physical properties

The sheets shall be of E.P.D.M. (Ethylene Propylene Diene Monomer) conforming to the following specifications:

PHYSICAL PROPERTIES	ASTM TEST METHOD	SPECIFICATION
Thickness, mm	D751	1 ± 10%
Width, cm	D751	25, 50, 75, 100, 125 ± 5 cm
Length, m	D751	150, 300 ± 30 cm
Tensile Strength, min. Kg/cm ²	D412 Die C	90
Elongation, Ultimate, min. %	D412	300
Tear Resistance, min. Kg/cm	D624 Die C	27
Brittleness Point at -49°F	D2137	Does not break
Ozone Resistance 168 hours/100 PPHM/104°F/40°C./50% ext.	D1149	No cracks @ 7 x magnifications
Water Absorption, max. Mass% 168 hours @ 157°F./70°C.	D471	-2.0, + 8
HEAT AGING 28 DAYS AT 240° F		
Tensile Strength, min Kg/cm ²	D412 Die C	85
Elongation, Ultimate min. %	D412	200
Tear Resistance, min Kg/cm	D624 Die C	23
Linear Dimensional Change, max. %	D1204	± 2

Before the installation of these sheets the Contractor shall submit, for the approval of the Engineer, manufacturer's certificate and the warranty in addition to shop drawings showing all details of installation.

b- Product delivery, storage, handling, and installation

- A. Deliver material in original, unopened packages and containers.
- B. Containers are to be labeled with manufacturer's name, product name, description and identification.
- C. Store materials between 60° and 80° F. If exposed to lower temperatures, store at 60°F. minimum temperature for three days before using.
- D. Store materials in a dry area and protect from water and direct sunlight.
- E. Any materials damaged in handling or storage shall not be used.
- F. The installation made of E.P.D.M. membrane shall be, where possible, fully adhere to Substrates.

c- Related materials

1- Primer activator

Primer Activator shall be a fast drying, solvent based primer designed to prepare E.P.D.M. surfaces for splicing with Seam Tape and/or Splice Adhesive.

Primer Activator shall have the following physical properties:

Base	Synthetic
Color	Clear
Solids - Weight, %	5.00 %
Solids - Volume, %	4.10 %
Viscosity, cps	20 - 120
Brookfield RVT Spindle No. 2 at	50 rpm
Specific Gravity	0.8292
Flash Point °F (SETA)	Less than zero

2- Water cutoff mastic

Water Cutoff Mastic shall be a butyl-based, one component sealer designed to stop water penetration into the roof system. It shall provide a positive water seal when applied between the roofing membrane and the substrates. The solids content shall be high enough to allow Water cutoff Mastic to stay very flexible.

Water Cutoff Mastic shall have the following physical properties:

Base	Butyl
Color	Gray
Solids - Weight, %	85.00 %
Solids - Volume, %	71.00 %
Viscosity, cps	4,000,000
Brookfield RVT Spindle TE at	2.5 rpm
Specific Gravity	1.68
Flash Point °F (SETA)	106° F
Solvents	Mineral Spirits

3- Splice adhesive

Splice Adhesive shall be a black, butyl-base contact adhesive designed for field splicing of E.P.D.M. membrane lap seams and/or membrane flashing details. It shall have a high initial green strength and long term durability.

Splice Adhesive shall have the following physical properties:

Base	Butyl
Color	Black
Solids - Weight, %	24.5 %
Solids - Volume, %	21.00 %
Viscosity, cps	1,800
Brookfield RVT No. 4 at	10 rpm
Specific Gravity	0.86
Flash Point °F (SETA)	Less than 20° F

4- Bonding adhesive

Bonding Adhesive shall be a synthetic rubber adhesive designed specifically for the installation of fully or partially adhered membrane systems. It shall be used to bond E.P.D.M., neoprene and other single-ply membranes to substrates.

Bonding Adhesive shall have the following physical properties:

Base	Neoprene
Color	Amber
Solids - Weight, %	25.00 %
Solids - Volume, %	18.30 %
Viscosity, cps	2,500
Brookfield RVT Spindle No. 3 at	20 rpm
Specific Gravity	0.871

5- Splice wash

Splice Wash shall be designed for thorough cleaning of E.P.D.M. seams and splices prior to the application of primers or splice adhesives.

Splice Wash shall have the following physical properties:

Base	Solvent Blend
Color	Clear
Solids, %	0.00 %
Viscosity, cps	Less than 50
Specific Gravity	0.768
Flash Point °F (TCC)	15° F

6- Seam tape

Seam Tape shall be a black, butyl-based splicing tape for adhering sheets of E.P.D.M. membrane together. It shall be easily applied, avoiding the inherent solvent hazards associated with adhesives.

Seam Tape shall have the following physical properties:

Base	Butyl
Color	Black
Cure State	Cured
Tensile Strength	6 K/cm ² (4 K/cm ² min)
Elongation	1,000 % (800 % min)
Brittleness Temperature	Below - 50° F
Permeability	0.6 perm mils
Heat aging at 300°F	No appearance change after 180 hours

7- Black lap sealant

Lap Sealant shall be a single component elastomeric sealant for sealing exposed edges of field fabricated membrane lap seams against the effect of weathering. It shall provide protection against heat, moisture, ozone resistance and UV light penetration. It shall adhere well to E.P.D.M. membranes and concrete.

Black Lap Sealant shall have the following physical properties:

Base	E.P.D.M. Rubber
Color	Black
Solids - Weight, %	58.00 %
Solids - Volume, %	45.05 %
Solvents	Aliphatic
Viscosity, cps	600,000

Brookfield RVT Spindle No. 2 at
No. TF at 10 rpm
Specific Gravity 0.988
Flash Point °F (SETA) 54° F

8- One sided substrate bonding adhesive

One sided Substrate Bonding Adhesive shall be a fast drying, adhesive designed for bonding single ply membranes to approved substrate. Bonding Adhesive shall be applied to the base substrate only. It shall be a self curing adhesive offering high heat resistance, excellent green strength and high peel and shear values.

One sided Substrate Bonding Adhesive shall have the following physical properties:

Base	Neoprene
Color	Yellow
Solids - Weight, %	38.00 %
Solids - Volume, %	28.90 %
Viscosity, cps	3000 - 4000 cps
Cure time	Complete cure 2-3 weeks

9- Flashing

Shall be 1,5 mm thick uncured E.P.D.M. or Neoprene.

213.2.6 Geotextile

a) Non woven

1-General

The geotextile shall be of the nonwoven type, needle punched or needle entangled and shall consist of long chain polymeric filaments of polypropylene, polyester or nylon. The fabric shall be a stable network of fibers which retain their position relative to each other. Heat bonding on one side is acceptable.

2- Physical properties

The geotextile shall meet the following physical properties:

Property		Test reference
Grab strength *	: 113	ASTM D4632
Kg., Min.		
Elongation, Minimum	: 50	ASTM D4632
(at peak load) % Min.		
Puncture strength	: 52	ASTM D3787
Kg., Min.		
Permittivity Sec ⁻¹ , Min.	: 0.7	ASTM D4491
Burst strength	: 25	ASTM D3786
Kg/cm ² , Min.		
Ultraviolet resist	: 70	ASTM D4355
% strength retained @ 500		

Weatherometer hours

* Minimum roll average in the weakest principal direction

3- Identification

Geotextile shall be furnished in rolls wrapped with protective covering to protect them against ultraviolet radiation and abrasion. Torn wrappers shall be repaired within 48 hours, using an approved protective covering.

Each roll of fabric shall be marked or tagged to identify the manufacturer, type, length, width and production identification number.

b) Woven

1- General

Woven geotextile shall consist of long chain polymeric monofilaments, slitfilm tapes, or multifilaments of tape and nonwoven yarn of polypropylene, polyester or nylon. The fabric shall be woven into a stable network and the edges of the fabric shall be selvaged or surged in such a way that fabric will not unravel or fray during installation or usage.

2- Physical Properties

The geotextile shall meet the following physical properties:

Property		Test reference
Grab strength *	: 123	ASTM D4632
Kg., Min.		
Elongation, Minimum	: 25	ASTM D4632
(at peak load) % Min.		
Puncture strength	: 50	ASTM D3787
Kg., Min.		
Permittivity Sec ⁻¹ , Min.	: 0.02	ASTM D4491
Burst strength	: 35	ASTM D3786
Kg/cm ² , Min.		
Ultraviolet resist	: 70	ASTM D4355
% strength retained @ 500		
Weatherometer hours		

* Minimum roll average in each direction

3- Identification

Geotextile shall be furnished in rolls wrapped with protective covering to protect them against ultraviolet radiation and abrasion. Torn wrappers shall be repaired within 48 hours, using an approved protective covering.

Each roll of fabric shall be marked or tagged to identify the manufacturer, type, length, width and production identification number.

213.2.7 Bituminous Putty

The putty is furnished either in tins or as ovolos. It shall be elasto-plastic conforming to the following requirements:

- Black color
- Temperature for use : 100°C to 130°C
- Stable at : -30°C to 60°C
- Penetration at 25°C : around 55
- Softening temperature : around 145°C
- Practical elongation : 10%
- Non-toxic

a. Application of the sealant:

Before proceeding with filling the joint, the Contractor shall complete the following works:

Widening the joint by grinding or sawing when the joint width is less than required.
Cleaning by grinding and brushing the sides of the joint all along its length.
Final cleaning shall be done by blowing air immediately before starting the filling.

The putty is applied at a temperature ranging between 100°C and 130°C. It shall be filled in the joint from the bottom up. In case the putty spreads slowly when applied, especially in horizontal joints, more material is immediately added until the joint is completely filled.

213.3 DAMP-PROOFING OF BUILDINGS (WALLS & SLABS)

All external building wall bases are to be provided with damp-proof course (d.p.c.) made of special material strip (P.V.C. or bitumenous membrane) of width equal to the total thickness of the wall and any external rendering.

- The d.p.c. is to be lapped with the damp-proof membrane of the substructure and bedded in the mortar specified for the type of block used.
- The greater lengths possible are to be used for the d.p.c. but any end laps required are to be at least 200mm long and made dry without intervening mortar.
- Piers are to have complete d.p.c.'s lapped with the wall d.p.c.

Damp-proof membranes shall be laid, as directed by the Engineer beneath all floor slabs resting on the ground. They shall be composed of single sheets of minimum thickness

0.300mm black polythene sheet film of an approved manufacturer specially made for use as damp-proof membrane.

- The film shall be laid on a sand-course and turned up around all edges of the slab and with 150mm margin above the top of the slab to be tucked into the perimeter wall of the building.
- Where the building size is too large as to exceed the maximum sheet size available, several sheets shall be used and the joints shall be lapped 150mm and fused together using a welding tool designed for that purpose.
- Every care shall be taken by the following trades to prevent perforation of the membrane but in the event of puncture, the perforation shall be covered by a patch of similar material of dimensions exceeding the area of the puncture by 300mm and the two sheets welded together as described above.

213.4 DAMP PROOFING BELOW WATER RETAINING RESERVOIR SLABS

A polythene sheet film of an approved manufacture will be laid over the blinding concrete.

- Damp proof membrane, shall be approved and laid as directed by the Engineer beneath all floor reservoir slabs.
- Damp proof membranes composed of single polythene sheets of minimum thickness 0.3mm shall be laid as specified in Section 213.3

213.5 DAMP PROOFING FOR UNDERGROUND CATCHMENT STRUCTURE

A flexible waterproofing membrane will be placed between two layers of a non woven geotextile in order to achieve the cut-off walls and this before concreting.

Technical sheets must be submitted, all technical points and fixing must be clearly stated. Specifications of the flexible membrane and geotextile shall be determined in preamble to bill of quantities according to drawings.

213.6 MEASUREMENT AND PAYMENT

Damp-proofing shall be measured to payment by m² of net area of surface on which damp-proofing has actually been applied, after deduction of all openings and areas which have not been damp-proofed.

Damp-proofing shall be classified according to destination regardless of the inclination of the damp-proof surface (whether vertical, inclined or horizontal).

Each unit rate shall include for the supply of all materials, cleaning and preparation of all surfaces, application of primer, bitumenous coating or membrane including overlaps and all extra works on corners and edges and for all materials, equipments and labour necessary for the completion of damp-proofing in accordance with the Specification and Drawings and to the satisfaction of the Engineer.

Damp-proofing of catchment structures shall be measured to payment by m² of flexible membrane and geotextile placed and fixed for the cut-off walls.

214 - WATER PROOFING AND THERMAL INSULATION

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214 WATER PROOFING, THERMAL INSULATION AND DISINFECTION

214.1 GENERAL

The provisions of this division shall apply to the:

- a) Waterproofing of the inside surfaces of the new water retaining structures (reservoirs)
- b) Waterproofing of old reservoirs under rehabilitation.
- c) Waterproofing “old or new treatment plants” namely:
 - the decanters,
 - the filtering system
 - the retention basin after filtering.
- d) Waterproofing and eventual thermal insulation of all reservoir covers and building roofs.
- e) Testing and disinfection of liquid retaining structures and roofs.

214.2 WATERPROOFING MATERIALS AND APPLICATION

214.2.1 New Reservoirs

The type of concrete for new reservoirs, is required to be waterproof as well as load bearing.

The inner surface of drinking water reservoirs (slab, walls and under roof) shall receive a surface waterproofing coating based on chemical treatment by crystallization or mineralisation and which will improve the waterproofness of the watertight concrete reservoir.

This surface coating shall be applied after concrete has almost complete shrinkage.

- This coating is applied in liquid and/or sludge form and will penetrate the concrete down to a variable depth depending upon the products, the porosity of concrete, the period of time elapsed since application, etc..
- The penetration develops in a naturally humid or moisturized concrete a chemical reaction between the impregnation compound and concrete free lime and forms insoluble crystals that seal the capillary system.

These products are constituted generally of a mixture of:

- siliceous products,
- active chemical products,
- Portland cement.

These products known under the name of crystallization or mineralization products have a long permanent action specially on concrete from artificial Portland cement C.P.A. which generate a large quantity of free lime during the hydration cycle.

The non-soluble crystals shall be activated to a depth of more than 20mm, depending on concrete compactness.

The Contractor shall contact the manufacturer to obtain all conditions of use and specifications concerning the product and specially:

- the methods for surface preparation,
- the number of vertical and horizontal coats,
- the treatment of all singular points,
- etc...

The products and applications shall be guaranteed for a period of ten (10) years from both the furnisher for the products and the Contractor for the good execution.

The advantages and limits of use of these products can be resumed as follows:

- The coat can be applied on a humid surface,
- Additional or repeated applications are possible,
- Singular points can be coated with special techniques stated in the technical sheet.
- These coats may be applied only on surfaces showing micro-cracks; existing cracks or those which appear after filling the reservoir shall be treated as specified in the technical specifications.
- These coats are deemed to improve the waterproofness of the concrete surface as well as its resistance to chemical actions (condensated water, etc.)

There is a wide range of surface waterproofing products, efficiency of which, must be checked.

Only products which have been subject to satisfactory test by a Control Bureau, shall be proposed by the Contractor to the approval of the Engineer for coating the inner surfaces of the new reservoirs.

The application of the surface waterproofing coats must be done on a duly prepared and sound concrete surface. The products penetrate to the necessary depth that is in relation with several conditions of concrete substrate and water pressure; the development of non soluble crystals (crystallization or mineralisation) allows the concrete to reach a degree of waterproofness that varies with the homogeneity of the concrete (compactness) and the size and pore's structure (capillary).

It is recommended, if approved by the Engineer, that the Contractor eventually backfills the external surfaces of the reservoir before application of the coats to insure a more constant temperature of the inner surface to be coated.

The concrete surface shall be cleaned with a strong water blasting or wet sand blasting to remove all loose particules and open all surface pores, thus facilitating the penetration of the product during application.

The Contractor shall reduce the inside high relative humidity by natural or forced ventilation to obtain a dryer inner condition avoiding eventual condensation (generally 3 days

dehydration are deemed necessary before and after application). The condensation effects often cause water rivulets to seep on reservoir vertical walls washing away the unset coating.

No application must take place when extreme high humidity exist in the inside of the reservoir (> 90%) because this will prevents the adhesion of the coats on a humid substrate.

Condensated water is very soft and adversely affects the cement curing process, and in extreme cases it can prevent the coating material from quick setting and causes it to disintegrate later.

The Contractor is asked to dehumidify the interior of the reservoir before and after placing the inner final coating to prevent condensed water from running down incurred surfaces.

The surface waterproofing coating must provide on the concrete a smooth and homogeneous surface.

That is why qualified personnel under the supervision of an expert from the manufacturer must insure that the products are applied in conformity with the manufacturer's technical specifications.

Special attention shall be paid to coating singular points such as:

- eventual construction joints, and specially,
- pipe penetration, location and treatment of which must be previously agreed with the Engineer.

The Contractor shall follow all the steps and the several phases of application in conformity with the technical specifications of the manufacturer as well as with the site instructions of the Engineer.

In some cases the inner surfaces of potable water reservoirs shall receive a flexible protective and waterproofing slurry. The product shall be composed of a cement based two component polymer modified waterproofing slurry (liquid and powder) and shall be applied to concrete to prevent water infiltrations. The product shall be suitable for external and internal waterproofing. Concrete surfaces must be clean-free from grease, oil and loosely adhering particles and as flat as possible. Application on saturated surfaces of two coats minimum. is always required. Mixing, application, curing and cleaning must be in conformity of technical data sheet of approved material.

214.2.2 Existing Reservoirs Under Rehabilitation

These underlined provisions shall apply to the materials, execution procedures related to the rehabilitation of the existing reservoir's concrete structures.

The waterproofing materials and products concerns mainly: the inner reservoir surfaces (walls, slab and under cover); the exterior surfaces and the upper cover are not included in these provisions).

The rehabilitation of existing reservoirs concerns the execution of the following steps (non limited list)

- the Concrete repairs of the inner surface
- the application of a new waterproofing treatment based on an approved thin ready-mix mortar as a "first layer" and a final protection coating as a "second layer"

a) The concrete repairs and protection to existing reservoir structures

The purpose of damage assessment made previously on existing reservoirs aimed to facilitate to the Engineer and the Contractor the research of the specific causes of the reservoir structural damages, prior to planning the repairs procedures works by the Contractor.

The structural investigation must meet later on, confirmation by the contractor using appropriate methods of analysis to examine the damaged members and zones of the existent reservoir (case by case) and produces a diagnosis to form the basis for successful repairs.

Otherwise specified by the Engineer the Contractor shall follow several defined steps under the supervision of the Engineer.

Step one or site survey : concerns the general description of the structure it consists of the production by the Contractor of the following: (non limited list).

- Plans, sections and elevations of the existing structures (with at least 5 colored photos) by site reservoir,
- Indications on the plans and sections of all zones where cracks, defects, weak points, penetration pipes etc. appears in the reservoir structures.

N.B.: This first step is important and is needed for to confirm and complete previous damage assessments, and most of all to elaborate for each reservoir a basic record which could help to resolve future eventual conflicts.

Step two or structural survey : concerns the preliminary works on the inner surfaces of the reservoir; the works are resumed as follows (non limited list).

- Removing of all existing render and coating and deteriorated concrete substrate from the inner surface of the reservoir.
- Applying a high water jetting pressure on the nuded concrete substrate surfaces aiming to remove all dirts, contamination and loose friable matters (pressure of water jetting ≥ 200 bars)
- A first visual examination or “auscultation” and an analysis must reveal to both the Engineer and the Contractor: the several weak points and singularities, to be treated, as well as the average depth of carbonation of concrete substrate.
- A special attention is to be given by the Contractor when analyzing the ground floor slab, and the foundation of each reservoir to insure that no differential settlement may have been the cause of living cracks.

N.B.: The Contractor must at this stage be able to submit to the Engineer his proposal for the materials to be used and the procedure for repairing, using approved materials.

Third step: concerns the carry on to the repairs after the detection and listing of the various defects in the structure, substructure and cover, and after the approval by the Engineer of the Contractor’s proposal for both the materials and repair procedures.

The common defects and weak points encountered can be resumed as follows: (non limited list)

- Inside cracks in the inner concrete surface (dead cracks, moving cracks, trespassing cracks)
- Construction joints (concreting stopping)
- Blasted concrete zones and corroded steel reinforcement.
- Penetration leaks and other leaks.
- Bad inserts to be removed.
- Bad accessories (cover inlet, ladder)
- etc..

N.B.: The Contractor at the end of this stage must have the approval of the Engineer concerning the substrate's final and good preparation state, and ready to receive the new waterproofing treatment based on the approved thin ready-mix mortar as a first layer before the second application of the second final layer concerning the final protection coating described in part c.

b) Thin ready-mix mortar render

This provision concerns the first inner layer sealing following the approval by the Engineer of the final substrate preparation of the inner concrete support.

This cementitious sealing mortar is normally used to render the internal surfaces of the potable water reservoirs.

This ready-mix mortar render has to meet extremely high standards. This product consists of specially selected and graded sands, special cements and various admixtures. Factory production and continuous inspection are a guarantee of consistent high quality.

The ready-mix mortar specifications must indicate having been tested, to food and drink regulation standards and having been approved for potable water contact.

The pre-batched mortar is delivered to site in palletted bags which take up little storage space (in a dry place). The mortar can be produced using a mixing tank and a small mechanical mixer. Its good workability and laying time for only two layers also helps to reduce the contract time.

N.B.: The Engineer has decided to forbid the in-situ traditional heavy mortar fabrication (applied in 3 or 4 stages) and instruct the Contractor to use the only thin ready mix mortar approved by the Engineer.

The main properties of the thin ready-mix render are the following: (non limited list)

- Two layers are enough generally (unless some specific zones need a thickness that could reach 20mm thick in surface restoration and where more layers may be necessary to render the substrate homogeneous).
- A well balanced water retention capacity in thin layers of fresh mortar is very important, if it is too low the mortar wall dry out quickly. A well balanced water retention capacity (also prevents the formation of shrinkage cracks) greatly improves the waterproofing qualities of the coating. If the water reduction is too great, mortar adhesion may be decreased.

- This thin first seal coat should also be frost-resistant when it is fully set, because it is quite possible (for the empty top section part of a reservoir) to freeze.
- The most important quality of the thin ready-mix render is waterproofing. Practically even a good surface coating does not by itself make a reservoir waterproof. Because zones of weakness are often found at the inserts and construction joints. Therefore the details of the connections at insert pipe entry and at construction joints must be carefully executed and designed by the Contractor because a water reservoir is only as watertight as its weakest point.

c) Final Surface Sealing Coat (second coat)

This final application on the thin ready-mix render must be very precise and accurate in order to produce a high final quality seal and protection.

A clean, sound plaster render is essential for good adhesion; grease, oil residues and other foreign substances must be carefully removed and fins and projection must be scraped off.

Climate conditions are an important factors in the placement of the final surface sealing coat. Ideally the temperature should be around 10°C to 15°C and relative humidity around 70% to 80%.

Condensation in very high humidity is a particular difficulty because adhesion problems may occur if there is too much moisture in the thin ready-mix plaster substrate.

The condensated water is also very soft and may adversely affect the curing process in extreme cases because it can prevent the coating material setting process on the surface and cause it to run off later.

Condensation can also appear sometime in vertical rivulets on the wall which washes away the unset coating.

The Contractor must contact the manufacturer and obtain all latest original technical specifications concerning the material and obtain approval from the Engineer concerning the steps and procedure of execution.

214.2.3 Water Treatment Plants

The underline provisions shall apply to either new or existing water treatment plant under rehabilitation.

New treatment plants consist mainly of:

- Decanters or settling tanks
- Treatment stations or filter zones
- Retention basin after filtering
- etc.

N.B.: The waterproofing materials and application procedures are the same than for the new concrete reservoirs (see 214.2.1) by application of a surface water proofing coating acting by crystallization or mineralisation.

If the substrate is rendered by a mortar, only the kind of product that may change. The Engineer's criteria will in this case prevail in the choice of the materials and the procedures.

214.2.4 Reservoir roof covers and Building roof terraces, Waterproofing and eventual thermal insulation

The provisions here below shall apply to the materials, products and execution procedures concerning the waterproofing of the reservoir roof covers and the building roof terraces.

The Engineer criteria will determine which reservoir cover or roof terrace are to be thermally insulated or not.

Waterproofing approved membranes (for both reservoir covers and roof building terraces) will be one layer of 4mm minimum thickness (minimum 4.7 kg/m² with protection):

- Elastomeric (styrene-butadiene styrene = SBS) (for altitude above 300m) or
- Plastomeric (Atactic Polypropylene = APP) (for altitude below 300m).

The assembly of manufactured sheets will be by torch welding.

These membranes will generally be self-protected from the factory (mineral self-protection).

The general characteristics of the membranes are as follows: (non limited list)

- Elongation at break (for reinforced membrane $\geq 50\%$).

The Contractor shall comply with the technical certificate of SBS and APP membranes defined by the UEATc tests and requirements.

In case of special architectural designed roof (dome) the waterproofing coat could be constituted by a liquid elastomeric bitumen which characteristics must be proposed by the Contractor for the approval of the Engineer. Anyhow a U.V. radiations resistance shall be required in any case.

The particular characteristics of the SBS and APP membranes are resumed here below (non limited list)

- a) SBS elastomeric membranes are classified according to the type of reinforcement.
 - Rolls reinforced with polyester (PY = 180 to 350 g/m²)
- b) APP Polymeric membranes are modified bitumen base sheet with APP polymers.
 - 4mm thick reinforced with polyester min weight 180 g/m² non woven polyester (PY)

The Contractor must in his offer enumerate all the characteristics of the membranes, namely: (non limited list):

- their dimensions (rolls) (1 m x 10m)
- their thickness or their weight (minimum thickness 4mm, minimum weight 4.7 kg/m²)
- the type of bitumen
- the kind and weight of reinforcement (g/m²)
- the surface protection
- their mechanical characteristics

- the overlapping size (overlapping waterproofing membrane shall be not less than 10 cm).
- etc.

SBS and APP membranes shall be applied by the Contractor on site according to the technical sheets specifications of each product and to the manufacturer's prescriptions.

All reservoir roof covers and roof building terraces are deemed to be not accessible unless to repairs necessity.

- Horizontal and vertical exposed membrane will be mineral self-protected.

Thermal insulation

A normal insulation with extruded polystyrene thermal insulation is approved.

- The insulation panels must be protected against weather.
- The Contractor shall propose to the Engineer's approval all insulation material and specific original documentation from the manufacturer, mainly (non limited list):
 - the thermal conductivity ($\lambda \cong 0.029 \text{ w/m } ^\circ\text{C}$)
 - the laying procedure
 - all limitations of use, according to associated waterproofing, destination of reservoir cover or roof terraces.
 - the thickness of the insulation panels with the way this thickness was determined according to the total thermal resistance of the reservoir cover or roof terrace. (thickness $\geq 50\text{mm}$)
 - separation and protection sheet layer (non woven polyester) thermally bounded non woven polypropylene: Mass: $100 - 105 \text{ g/m}^2$.
 - the protection needed (graded gravels, screed, circulation slabs (500 x 500 x 50 mm))

214.3 WATER PROOFING FOR WASTEWATER BEARING STRUCTURES

214.3.1 General

Special performance criteria in sewage treatment is to be achieved by the contractor by the simultaneous use of:

- A high performance concrete, and
- A high performance protection, applied to the concrete substrate

214.3.2 High Performance Concrete in Sewage Treatment Applications

The concrete used in the construction of sewage treatment plants and related structures has to meet a very different set of performance criteria from those that apply in normal civil engineering works. It is usual for the mix-design to be generally determined by the need for strength and specific loading properties. The principal requirements for concrete in sewage treatment industry are more extensive and are as follows:

- a) Resistance to aggressive effluents and sludge.
- b) A dense and unpermeable concrete free from cracks (to protect steel reinforcement against corrosion).
- c) Resistance to wear and abrasion, particularly with regard to overflows energy conversion areas and the bearing surfaces for sludge scrapers, etc...
- d) Smooth and crack-free surfaces (to minimise routine cleaning and maintenance).

The aggressive effect of water-borne waste on concrete depends not only on its chemical constituents and the concentrations in which these are present, but also on such factors as:

- The pH value
- Temperature
- Oxygen supply
- etc...
- Acids with a pH value below 4.5 have a particularly aggressive effect on concrete due to the fact that they interact with the components of the set cement to form salts, which for the most part are soluble.
- However concrete may be attacked by certain alkaline solutions, salts and organic substances (especially vegetable and animal fats and oils).

The speed of the chemical reaction increases dramatically with the rise in ambient temperature.

In the absence of an adequate supply of oxygen (in long enclosed pipe runs, pits, tanks, etc.) fermentation processes may be set up that decisively alter the aggressiveness of the effluent (formation of hydrogen sulphide, sulphurous acid, etc.).

(A) Durability of Concrete is largely determined by its resistance to the ingress of liquid or gaseous substances

- Since nearly all the attack mechanisms to which concrete is subject (including chemical and physical attack, corrosion of the steel reinforcement, etc.) are associated with the transport of moisture, the following may be stated as a general principle: “The more dense and impermeable the set cement, the greater the resistance of the concrete to chemical attack.” It is generally recognised that this is also associated with an increase in compressive strength and improved resistance to wear and abrasion: hence the fact that high compressive strength is frequently equated in civil engineering practice with outstanding durability.

The inference is only valid, of course, if the increase in compressive strength results from a minimization of the capillary porosity of the set cement and a reduction in the diameter of the remaining pores.

- Damage to concrete or the underlying reinforcement via chemical attack is usually caused by the ingress of aggressive substances or water into the capillary pore system of the set cement (or into the contact zones between the set cement and aggregate). The aggressive medium may occur in liquid or gaseous form.
- The transport mechanism is activated by the following:
 - a) An unbalance of pressures (permeation), as in the exerted by water on the wall of a tank or basin.
 - b) Movements of molecules or ions resulting from differences in concentration (diffusion), as in the penetration of carbon dioxide from the air (carbonation).
 - c) The absorption of wetting liquids through porous substances (capillary action), as in the case of rising groundwater in a concrete foundation.
- The principal factors influencing the rate of transport are:
 - the presence of cracks in the concrete
 - its capillary porosity and
 - the size of the pores
- An additional factor in the case of gazes is the moisture content of the concrete (the higher the moisture content, the more difficult the transport of gaz).

214.3.3 Design and production of High-Performance Concrete

The pore structure of the concrete is largely determined by:

- the degree of compaction,
- the entrained air content
- the water content of the fresh concrete, and
- the degree of hydration in the set concrete

In order to maximize the density of the set concrete matrix and thereby achieve a high degree of chemical resistance. The well-compacted concrete must exhibit the following properties:

- a) A proper distribution of aggregate gradings, including a sufficient proportion of fines (particle diameter < 0,125 mm: approximative 350-400 kg/m³)
- b) Low water/cement ration around 0.40 - 0.45
- c) High degree of hydration
- d) Absence of cracks.

- To insure that the concrete remains workable at low W/C ratios and to minimize the entrainment of air bubbles during compaction, the contractor is asked to use a super plasticizer.

The best way to maximise hydration and avoid cracks is that contractor follow the correct curing procedures (keeping the concrete damp for an extended period of time using a suitable curing compound).

- The insistence on a proper distribution of aggregate grading and an adequate fines content has to do with the attempt to maximise the density and uniformity of the internal structure of the set concrete. At the same time correct granulometrie also improve the workability of the fresh concrete and greatly reduces its tendency to bleed. Bleeding produces a localized increase in the water/cement ratio and a corresponding enlargement of the pore structure in the set cement matrix close to the surface of the concrete, thus rendering it specially vulnerable to chemical attack. Many of the sands used have a low fines content (particle size < 0.125 mm) but a relatively high proportion of particles in the 0.125 - 0.25 mm grading zone. Since these require a relatively large amount of water to achieve thorough wetting, but possess only a limited capacity to retain water themselves, the contractor will make mistake to try and make up the deficiency in fines content by overdosing the mix with sand (result: bleeding of the fresh concrete). Instead the contractor's mix needs to be supplemented by a suitable alternative fines content which must be particularly effective.

(A) The use of Silica Fume Products in High Performance Concrete

The Contractor is invited to use a silica fume product (minimum 90% pure latently reactive silicone dioxide) to enhance the performance of structural concrete in a number of significant ways:

- a) Reduction in porosity: silica fume is finer than cement, mineral fillers, (powdered quartz) or commercially available fly ash.

Since the mean particle size of silicate fume is approximately 100 times smaller than a normal grain of cement, it is able to lodge in the interstices between the finest particles in the set cement matrix. The super plasticiser allows low water/cement ratios whilst maintaining good workability. This ensures a dense, tightly packed particle structure even at the micro capillary system.

- b) Increased strength: A pozzolanic reaction takes place between the silica fume and the free lime that is present in the set cement in the form of calcium hydroxide, a natural by-product of cement hydration. As a result of this reaction the weakest and most readily soluble component of the set cement is transformed into solid calcium silicate hydrate, this combined with the low water/cement ration produces significant gains in concrete strength.

As mentioned in 214.3.2(A) the chief requirement for concrete in sewage treatment applications is not so much for compressive strength in the core zone, but rather for a high degree of density and strength in the surface zone: This is the critical factor affecting the durability of structural components under these conditions.

- c) Retarding the process of carbonation : The high alkalinity of the cement provides a measure of natural protection to the reinforcement steel. The pH value of the cement paste is around 12.5 which is sufficient to passivate the steel and prevent it from rusting

even in the event of the ingress of oxygen and moisture. However exposure to carbon dioxide from the atmosphere means that the alkalinity is being constantly reduced as the lime content is neutralised. If the carbonated zone reaches the steel reinforcement, the latter begins to rust. The use of silica fume significantly retards the process of carbonation in concrete.

- d) Increased resistance to abrasion: the use of silica fume products (silica fume/plasticiser technology) in concrete can also effect a marked improvement in its resistance to abrasion. Tests carried out at the French CEBTP in Paris on mortar samples incorporating silica fume demonstrate this very clearly.
- e) Improved workability of fresh concrete: The addition of silica fume products to the mix produces a fresh concrete of outstanding stability and cohesion, with no loss of workability. Bleeding, segregation and sedimentation during transport are effectively prevented even with mixes of very plastic consistency.

(B) Curing procedures for High-Performance Concrete

The chemical reaction of silica fume with the free lime in the set cement generates the same hardening product that is produced during the hardening of cement. The reaction proceeds somewhat more slowly than in the case of cement but is more or less complete after 28 days. In order to achieve a concrete surface offering the maximum resistance to chemical attack, thorough and careful curing of the concrete is an essential requirement and the contractor must take in account the curing time in his construction schedule. At the end of the curing period the strength of the concrete in the surface zone should be at least 50% of the specified cube strength. This normally requires a curing period of at least 3-5 days; under unfavorable conditions (strong winds and sunlight or low relative humidity) the curing period should be extended by an addition 2-3 days in order to prevent premature drying-out of the concrete.

N.B. Concrete that will be exposed to “very severe” chemical attack (as defined, for example, in DIN 4030) for long periods during its service life should be finished with a suitable coating material designed to afford additional protection against the aggressive medium. However the application of such a coating is no substitute for a well-made concrete not least because a high-quality coating material needs a high quality concrete substrate in order to perform effectively. The contractor must in practice furnish a concrete capable to withstand “severe” chemical attack without taking in account the additional protection.

214.3.4 Protection of the Concrete Surface

- a) Substrate preparation

Before applying the protection on the concrete, the concrete surface must receive a preparation to enable this substrate to be ideal for the application of the protective coating. High pressure water jet, pressure stream clearing or wet blast cleaning will be used by the contractor after reception of the concrete surface by the Engineer.

Any joint sealing must be done by the Contractor usually before the application of the protection coating.

Any joint sealing material must receive the early approval of the Engineer.

Any joint sealing will be purchased from the same furnisher than the protective coating.

- b) Pore sealing :

The pore seal is necessary and must allow a rapid application of the coating protection - the pore sealing must be compatible with all the applied products (superplasticizer, silica fume, water stop....) and purchased from the same furnisher it must fill all blowholes and act as a vapour - release intermediate coat.

c) The protective coating :

The known causes of damage to structures in the sewage industry show that the best concrete is still affected by some substances, which should be separated from its surface by suitable coating, or surface protection systems.

Often the concrete cover on the reinforcement does not comply with the standards.

Concrete for sewage must be coated to meet certain long term standards and the surface protection is also required to meet these standards long term.

The protection is also designed for the relevant mechanical constraints and withstand the interaction between concrete substrate and the protection system and also the mechanical, chemical, thermal and other stresses...

The Coating material requirements are:

- Chemical resistance
 - Abrasion resistance
 - Aging and weather resistance
 - Alkali and water resistance
 - Water vapour diffusion or vapour barrier qualities.
 - Impermeability to gase (carbon dioxide, sulphur dioxide)
 - Specific strength properties
 - Adhesion to surface to be coated
 - Crack bridging or sealing function
-
- The protective coating will generally be applied in two or three coats.

As all coating material properties listed above can be influenced by the system and formulation used, the contractor is asked to submit to the Engineer's approval all the coating materials and furnisher specifications concerning the protective coating and glass fabric reinforcement.

- All details arising additional difficulties (pipe connection, openings, angles etc), must receive adequate solutions from the contractor to be submitted to the Engineer's approval before any application.
- The protective system, covers usually:
 - Epoxy resin
 - Epoxy / Tar modified systems
 - Epoxy / polyurethane coating system
 - etc....

Apart from general protection, the protective coat system has to fulfil two functions.

- Restoration and levelling of the concrete surface which may be extremely rough after preparation.
- The formation of a non-porous protective film with possibility to work directly on the damp concrete surface without long waiting times while the structure is drying out.

A very important feature which should not be ignored by the contractor, is the prevention of heating in the structure in areas not in contact with water. This reduces the stresses in the coating system, the concrete and (even more important) at the coating system/concrete interface. Damage can also be avoided by the contractor by choosing the right colour.

The contractor technology must offer the maximum advantages to permit execution of the protection directly on the damp concrete surface without long waiting times while the structure is drying out.

The durability of a correctly applied coating varies considerably. The longest life span can be expected in the underwater section since the protective system is in a constant environment and not exposed to the UV and thermal shock i.e. it can remain in a low stress state.

The durability of coatings is affected by maximum stresses due to several loading, since there are exposed (in addition to high mechanical stress) to additional thermal shock caused by de-icing salts and weather and are used at the most susceptible construction points (areas at risk from cracking).

Systems which are exposed to abrasion and constant water turbulence and are used in water line zone are said to be subject to average stress.

Protective systems in digested tanks suffer the highest stresses.

The contractor is deemed to choose the protection system taken in account the importance of the stresses applied and the water covering situation.

214.3.5 Concrete Additives

The contractor is deemed having made all necessary contacts with the various furnisher of materials related with the project in order to select the best adequate materials such as:

- Superplasticiser
- The water proofing mass additive
- The waterstops
- The silica fume
- The curing material
- etc..

The superplasticiser, waterstop and waterproofing will give high impermeability to the concrete structure.

The superplasticiser and silica fume will insure reduction of porosity, increase in the surface strength, resistance to abrasion, improved workability of the fresh concrete with low water/cement ration.

The curing procedures will achieve a concrete surface offering the maximum resistance to chemical attack.

214.3.6 Sealing Joints in Concrete Construction in Sewage Installation

Although flexible sealant have an important part to play in sealing structural joints in sewage installations, they cannot seal structures containing water without additional measures. Concrete constructed with integral or surface mounted waterstop systems are obviously essential.

The Contractor will submit to the Engineer's approval all joints sealing material and waterstops which specifications must meet the Drawings Specifications.

- a) Flexible Joint Sealant: of the various raw materials normally used in the production of joint sealant (polyurethane, acrylic, silicone and polysulphide) the two-part polyurethane sealant (often containing tar) have proved most effective in sewage treatment applications.

Pouring grade is used for horizontal joints and thixotropic grade for vertical joints.

- b) Flexible Elastomeric Strip: Joints liable to greater movement and construction joints may be sealed with a flexible elastomeric strip (hypalon or butyl rubber) kept in place with a compatible epoxy adhesive. Strip thickness varies from 1 to 3 mm; standard width are : 100 mm, 150 mm, and 200 mm.

The Contractor is asked to submit his solution for sealing the various joints to the approval of the Engineer before any application.

214.3.7 Later Repairs

Effective concrete protection gives long-term security to all structural members, even if the effluent composition changes over time. High performance coatings greatly assist the prevention of damage from a number of sources. That is why detailed advance planning of concrete coating in sewage plants is to be seriously taken into account by the Contractor. If repairs are necessary later, this will be an expensive operation because of costly cleaning and re-preparation of contaminated substrate...

The Contractor must be aware that sewage plants cannot be shutdown and that later repairs and costs are out of proportion to the cost of providing good and effective protective coating on concrete initially.

The cost of all later repairs must be borne by the Contractor.

214.4 WATERPROOFING OF PLANTED ZONES

214.4.1 General

The waterproofing complex will consist in a two-ply waterproofing membrane chosen to resist roots penetration and puncturing by gardening implements .

Waterproofing membranes will be applied to zones intended to be planted such as gardens, roof terraces and flower tubs.

A screed to form a slope shall be executed before applying the waterproofing membranes.

The waterproofing membrane shall consist of:

- a first lower bitumen layer reinforced by a non-woven polyester sheet (NW PY ≥ 180 g/m², weight ≥ 4.7 kg/m²)
- an upper bitumen layer reinforced (non-woven polyester ≥ 180 g/m², weight ≥ 4.7 kg/m²) with anti-root additif.

The application of the waterproofing membrane shall usually be by welding using a propane blowtorch.

The waterproofing shall be applied to an approved substrate and comprise:

- an under layer membrane
- a top layer membrane shall be fully adherent on the first layer.
- a drainage layer (rounded gravels, size > 5mm).
- the agronomic soil.

The design of terrace-gardens and the choice of the agronomic soil thickness shall take into account the type of plants.

Overflows and water gullies shall be designed to limit the height of stagnant water so as to facilitate plants growth.

The substrate slope will generally be between 1% and 5%. The substrate surface shall be after completion, neat, straight and free from foreign matters. The allowable deflections, the surface tolerances, the differences in height between jointed elements shall be defined for each substrate as prescribed in the applicable standards.

214.4.2 Materials

214.4.2.1 Membranes

a) The first layer of the system shall consist of :

- SBS-elastomeric membrane reinforced with non-woven polyester, weight ≥ 180 gr/m².
- Thickness: 4 mm minimum.
- Packing: Rolls of (10 m x 1.00m) - Weight 44 kg.

Characteristics of the under layer:

- Tensile strength: longitudinal L = 900 N/5 cm, transversal T = 700 N/5 cm.
- Elongation at break: longitudinal L = 50%, transversal T = 55%.
- Puncture resistance static L4.

b) The top layer of the system shall consist of:

- SBS-elastomeric membrane reinforced with non-woven polyester, weight ≥ 180 gr/m².
- Anti-roots admixture: Preventol B2 or equivalent, minimal quantity: 20gr/m².
- Thickness : 4 mm minimum.
- Packing: in rolls of (10 m x 1.00 m) - weight 44 kg.

Characteristics of the upper layer:

- Tensile strength longitudinal L = 800 N/5 cm, transversal T = 600 N/5 cm
- Elongation at break: longitudinal L = 45%, transversal T = 50%.
- Puncture resistance static L4.

214.4.2.2 Other Materials**a) The drainage layer**

The drainage layer will be executed by the waterproofing Contractor. This layer shall protect the waterproofing membrane from mechanical stresses and allow the drainage of water.

This layer shall have a minimum thickness of 10 cm and consist of 25/40 gravels.

Other drainage system can be proposed by the Contractor to the Engineer's approval. The drainage layer shall be applied by hand directly to the upper layer of the waterproofing membrane.

b) The percolating filter

The percolating filter has no waterproofing function, it is used generally to prevent the clogging of the drainage layer, retain the nutrients of the soil and distribute humidity required for plants growth. It also keeps the pH of the soil and fertilizers above 3, and ensures that the pressure exerted by the agronomic soil and plants do not exceed that admissible by the bearing surface.

The percolating layer is applied to all the parapets till 10 cm over the highest level of the agronomic soil.

Laps between succeeding rolls shall be 10 cm. The percolating layer may be constituted by any special filtering material having a minimum thickness of 25mm.

c) Waterproofing for expansion joints

An SBS elastomeric membrane shall be applied to expansion joints. Its characteristics are:

- width : 1000 mm
- weight: 4.7 kg/m²
- thickness > 4 mm

d) Agronomic Soil

The agronomic soil layer will be applied by the waterproofing Contractor. Its thickness varies according to the type of plants, it must not however be less than 30 cm before settlement (25% reduction after settlement)

Agronomic soil shall be placed directly on the percolating filter without causing any displacement nor damage to the filtering material.

e) Upstands

The waterproofing membrane shall be raised 15 cm above the graded agronomic soil. The upper part of the parapet must include a device preventing the run-offs from penetrating behind the upstand.

The waterproofing of upstands shall be as follow:

- the first horizontal layer is raised to 10 cm.
- the first vertical layer is applied to the entire upstand and continued 10 cm over the first horizontal layer and welded on both ends.
- the second horizontal layer is raised to 10 cm over the first vertical upstand.
- the second vertical upstand is extended 15 cm over the horizontal second layer.

Joints between horizontal layers and vertical upstands shall be staggered.

Laps between two layers shall be ≥ 60 mm

f) Ancillary works

- All other works as fittings, edges, penetrations, joints, gullies etc.. will be treated in compliance with applicable standards.
- The connection between the waterproofing membrane and the gullies will be made as specified by the manufacturer.
- Water inlets shall be protected by a special device to prevent pipe obstruction.
- Removable paved blocks over the expansion joint must permit the repairs and checking of the joint. These elements must be executed by the Contractor at no additional cost.

g) Flower Tub

- The waterproofing membrane for the flower tub will be identical to that used for terrace-gardens.
- A 1% minimum concrete sloping shall ensure the evacuation of water to the gully.
- The waterproofing of the upstand will be continued over the horizontal section of the flower tub parapet.

NB: Before starting waterproofing works, the Contractor shall submit to the Engineer's approval:

- the material samples
- the execution details in the horizontal parts, upstands, and intersections.
- all details of waterproofing penetration, expansion joints.
- the details of the waterproofing protection (if any).

214.5 WATERPROOFING WORKS ON BURIED WALLS

214.5.1 General

Prior to backfilling, all buried walls shall be waterproofed. The waterproofing product shall be applied to the vertical surface of walls down to the footing of the foundation.

The waterproofing of the foundation walls is conditional upon several parameters, namely:

Nature of the foundation ground (pervious, impervious)

- Nature of the backfilling material
- Existence of a drainage system
- Existence of waterproof structures near the buildings (slabs, sidewalks, ...) or protection of the surroundings of the foundation peripheral wall by protruding structures (protection slabs, protruding roofs, ...)
- Importance of run-offs eventually in contact with the peripheral walls of the building
- Eventual existence of an aquifer

After the excavation of trenches, all measures that bind the Contractor alone shall be consulted beforehand with the Engineer.

214.5.2 Selection of the waterproofing coating

- The specifications given in this Section are applicable only when water is not likely to be in contact with the peripheral walls for a long time, or when no differential settling of the building is expected.
- The choice of the wall coating shall be efficient only if:
 - a drainage system is unnecessary (pervious ground)
 - or, a drainage system is necessary and provided for.

In fact, should the drainage system be necessary but not provided for, the application of the coating shall not be sufficient because water may infiltrate from beneath the foundation or through any crack in the wall. In this case, tanking will be the best solution.

a) No drainage system is required (pervious foundation ground)

Buried walls shall be waterproofed by applying a rendering to the external facing of the wall. Rendering shall consist of:

- A traditional rendering consistent with standards specifications.
- A hydraulic binders based waterproofing coat having a technical certificate that proves its suitability to the type of buried masonry.

In both cases, the coating shall only be applied to the external facing of the buried wall; the waterproofing of the inner side would prevent the capillary rise. In some cases a bitumen coating shall be applied for walls protection.

b) A drainage system is required (impervious or slightly pervious foundation ground)

The waterproofing system shall be reinforced and shall consist of:

- An SBS or APP elasto-plastic membrane applied directly to the substrate or to a rendering and consisting of:
 - Cold-applied primer : 350 kg/m²
 - Hot welded SBS or APP elasto-plastic membrane as specified in 214.4.1.
 - * non-woven polyester (180 kg/m² minimum)
 - * separation layer.

It is advisable to protect the membranes from shocks, especially during backfilling, as well as from any eventual settling of the backfill material. Should the Engineer disapprove the quality of the backfilling material and the workmanship, a 10 cm thick concrete blocks protection shall be obligatorily provided for, with non woven thermally bounded textile separation layer or by 3.2mm thick semi rigid bituminous board.

The application of waterproofing membranes to singular points especially to the footings, etc.. shall be carefully studied (details to be provided by the Contractor).

Prior to any backfilling, the Contractor shall submit to the Engineer's approval the method of laying the drainage system in the bottom of the trench, the quality of filtering material, the size and location of the trench with regard to the building and the foundations, the diameter and length of drains as well as the eventual protection of the drainage layer with a non-woven textile.

214.5.3 Manholes (a drainage system is required)

Manholes shall be constructed:

- At the upstream of the drain
- At each change of direction
- At the connection of two drains.

The manholes shall have such diameters as to allow eventual cleaning operations. The Contractor shall submit for approval the shop drawing of the manhole which is equipped with a cover preventing the intrusion of earth, gravels or any foreign matters.

The Contractor shall submit for approval waterproofing works of buried parts:

- Samples of waterproofing products
- Samples of the drains

as well as all shop drawings of waterproofing and drainage works.

214.6 TESTING AND DISINFECTION

214.6.1 Testing

The Contractor shall perform all cleaning, flushing, testing of all liquid retaining structures, reservoirs and buildings roofs, including conveyance of test water to point of use, and

including all disposal thereof, complete and acceptable, all in accordance with the requirements of the BS 8007 and the contract documents.

All testing operations shall be done in the presence of the Engineer.

a) Roofs

The roofs of liquid retaining structures and buildings should be watertight and be tested by flooding the roof with water. The roof should be considered satisfactory if no leaks or damp patches shown on the soffit. The roof insulation, covering and waterproofing should be completed only, and as soon as possible, after remedial work if needed is done and satisfactory testing.

b) Liquid retaining structures

After construction is completed, the interior of the liquid retaining structures shall be completely hosed and cleaned of all dirt and loose material. Testing shall be done prior to backfilling if any, and shall not be sooner than 14 days after all portions of structure walls and associated roof systems have been completed.

The structure shall be filled to the normal maximum level with the specified liquid at a uniform rate of not greater than 2m in 24 h. The liquid level should be maintained by the addition of further liquid for a stabilizing period which may vary between 7 and 21 days according to the maximum design cracks.

After the stabilizing period and during a 7 days test period the total permissible drop in level, after allowing for evaporation and rainfall should not exceed 1/500th of the average water depth of the full tank or 10mm.

In case of seepage of the liquid or leakage, necessary remedial treatment of the concrete, or joints, holes or cracks shall be carried out from the liquid face (pumped and sealed with a two part water-insensitive epoxy, nontoxic for potable water reservoirs). Retesting after the completion of remedial work shall be carried out according to this clause.

Interior waterproofing if required, shall be applied after satisfactory results.

214.6.2 Disinfection

The Contractor shall perform disinfection of reservoirs and appurtenant piping for potable water. Disinfection shall be accomplished by chlorination and performed in accordance with the relative requirements after completing all repairs and waterproofing works if any. All chlorinating operations shall be done in the presence of the Engineer. Disinfection operations shall be scheduled by the Contractor as late as possible during the Contract time period so as to assure the maximum degree of sterility of the facilities at the time the work is accepted by the Engineer.

Bacteriological analyses shall be performed by a certified testing laboratory acceptable to the Engineer.

a) Chlorination

A strong chlorine solution (about 200 mg/l) shall be sprayed on all interior surfaces of the structure, including the underside of the roof areas. Following this, the structure shall be partially filled with water to depth of approximately 30 cm. During the partial filling operation, a chlorine-water mixture shall be injected by means of a solution-feed chlorinating device in such a way as to give a uniform chlorine concentration during the entire filling operation. The point of application shall be such that the chlorine solution will mix readily with the inflaming water. The dosage applied to the water shall be sufficient to provide a chlorine residual of at least 50 mg/l upon completion of the partial filling operation. Precaution shall be taken to prevent the strong chlorine solution from flowing back into the lines supplying the water. After the partial filling has been completed, sufficient water shall be drained from the lower ends of appurtenant piping to ensure filling the lines with the heavily chlorinated water.

b) Retention Period

Chlorinated water shall be retained in the partially filled structure and appurtenant piping long enough to destroy all non-spore-forming bacteria, and in any event, for at least 24 hours. After the chlorine-treated water has been retained for the required time, the free chlorine residual in the structure and appurtenant piping shall be at least 25 mg/l. All valves shall be operated while the lines are filled with the heavily chlorinated water.

c) Final Filling of Structure

After the free chlorine residual has been checked, and has been found to satisfy the above requirements, the reservoir shall be filled in approximately 2m increments every 24 hours by addition of potable water. The existing chlorinated water, may not be used as part of the final filling. Final filling water, when the water level is raised to its final elevation, shall produce a free chlorine residual of between 1 and 2 mg/l. If the free chlorine residual is less than one mg/l, an additional dosage shall be applied to the water in the structure. If the free chlorine residual is greater than 2 mg/l, the structure shall be partially emptied and additional potable water added. In no case shall water be released prior to the expiration of the required retention period (24 hours).

214.6.3 Bacteriological Analyses

The Contractor shall have a laboratory certified by the Engineer to take samples of water from the tank in order to perform bacteriological analyses according to the relevant section.

If the volatile organic or coliform bacteria levels exceed those allowed, the tank content, shall be drained to waste. The tank shall be refilled at the Contractor's expense, soaked and retested for coliform bacteria and volatile organic until satisfactory test results are obtained. Failure of the reservoir to attain acceptable levels shall be the responsibility of the Contractor and remedial measures shall be at his expense.

214.7 MEASUREMENT AND PAYMENT

214.7.1 Inner Waterproofing of new reservoir, new or existing treatment plants, etc...

Waterproofing shall be measured for payment by square meters (m²) of net area of surfaces to which waterproofing has been applied, after the deduction of all openings and areas which have not been waterproofed.

The unit rates shall include:

- The supply of material,
- Cleaning and preparation of the surfaces as specified,
- Treatment of all singular points,
- Application of the inner coating as specified, to horizontal, vertical and under roof surfaces including all overlaps and extra work on corners, edges and around drain outlet and other structures in walls and slab, and including all materials, equipment and workmanship necessary for the completion of the inner waterproofing of the reservoir in accordance with the Specifications and Drawings, and to the satisfaction of the Engineer.

214.7.2 Existing reservoirs under rehabilitation

Waterproofing shall be measured for payment by square meters (m²) of net area of surfaces to which waterproofing has been applied, after deduction of all openings and areas which have not been waterproofed.

The unit rates shall include :

- The site survey (step one of the specifications) showing the general characteristics of the existing reservoir, pipe chamber, pipes and hydraulic connections, etc...
- The structural survey (step two of the specifications) which includes :
 - the removing of the existing render and coating and deteriorated concrete substrate...
 - the application of high water jetting pressure,
 - the visual examination, the “auscultation” and analysis of all weak points to be treated,
 - the submittal of procedures and materials for rehabilitation and repairing,
 - etc.

- The repairing works (third step of the specifications) as approved by the Engineer,
- The application of the ready mix mortar as specified,
- The final surface seal coating (second coat) as specified,
- Etc.

214.7.3 Waterproofing of roof covers, Building terraces and Eventual Thermal Insulation

Waterproofing shall be measured for payment by square meters (m²) of net area of surfaces on which waterproofing has actually been applied, after deduction of all openings and areas which have not been waterproofed.

The unit rates shall include :

- For the supply of all approval materials.
- Cleaning and preparation of substrates, including the execution of the necessary concrete slopping towards the outlets,
- Application of primer,
- Heating and application by torch welding of the elastomeric or plastomeric membrane 4 mm thick (~ 6 kg/m²) including the overlaps and upstanding extending over the parapet wall, and any reinforcement on the Detailed Drawings approval by the Engineer,
- Any circulating concrete pads necessary for repairs installed over the waterproofing (pads 500 x 500 x 40 mm) as ordered by the Engineer,
- All drain outlets and any extra works around them and around any existing opening or penetration throughout the roof,
- All necessary protection of the waterproofing, and all materials and equipment and labour necessary for the completion of waterproofing of roofs and reservoir covers in accordance with the Specification and Drawings and to the satisfaction of the Engineer.

N.B. Normal or inversed extruded polystyrene thermal insulation shall be installed when directed by the Engineer Thermal insulation ≥ 50 mm thick will be paid for as separate item and will be measured by square meters (m²) of net area of surfaces where thermal insulation is applied.

Normal thermal insulation unit rate is deemed to comprise the cost of furnishing and applying a vapor barrier approved by the Engineer.

214.7.4 Waterproofing Protection for Wastewater Bearing Structures

Waterproofing of external surface of the concrete substrate (Protection of the concrete surface by applying a protective coating) shall be measured for payment by square meters (m²) of net area of surfaces on which waterproofing has actually been laid, after deduction of all openings and areas which have not been waterproofed. The unit rates shall include for :

- The supply of all the approved material,
- Cleaning and preparation of the concrete substrate as specified,
- Supply and execution of all joint sealing,
- The pore sealing as specified,

- The application of the approved protective coating in two or three coats reinforced with the glass fabric material, as specified,
- The treatment of eventual defects encountered throughout the works according to the Engineer's instructions,
- All extra works required for extending the protective layer over all kind of pitched surfaces, around drains, over parapets etc...,
- All furniture for materials, equipment and workmanship necessary for the completion of the protection coating over the total substrate surfaces in accordance with the Specifications and Drawings and to the satisfaction of the Engineer.

214.7.5 Waterproofing of planted zones

Waterproofing shall be measured for payment by square meters (m²) of horizontal net-area of surfaces to which waterproofing has been applied, after deduction of all openings and areas which have not been waterproofed.

The unit rates shall include:

- The supply of all approved materials.
- Cleaning and preparation of substrates, including the execution of the necessary concrete sloping toward the outlets.
- A lower membrane.
- An upper membrane
- A drainage layer
- A percolating filter
- All drain outlets (overflows, water gullies) and any extra works around them and around any existing opening.
- Bridging joints, upstands, waterproofing protections or any other material required to accomplish the work according to the standards.

The agronomic soil shall be measured by cubic meters (m³) according to the Engineer's instructions.

214.7.6 Waterproofing works on buried walls

a) No drainage system is required

The waterproofing shall be measured for payment by square meters (m²) of net area of rendered surfaces.

The unit rates shall include:

The rendering, hydraulic binders based waterproofing coat and eventually two coats of asphalt. It also includes scaffolding, workmanship, expenses, supply, transport, equipment, and all works required for waterproofing.

In case a bituminous coating is required, no extra payment shall be done. The price must be included in concrete works or in backfilling materials.

b) A drainage system is required

The waterproofing shall be measured for payment by square meters (m²) of net area of surfaces where the waterproofing system is applied.

The unit rates shall include:

- The elasto-plastic membranes (primer, membranes, fibreglass and non-woven polyester)
- The membranes protection.
- Singular points and drainage system required (pipes, manholes, gravels, geotextile,...)

All necessary materials, equipment, workmanship, and expenses in order to achieve the waterproofing work.

214.7.7 Testing

All water used in testing the liquid retaining structure and roofs including that used for retesting which requires disposal following such testing, retesting shall be provided and disposed by the Contractor at his hole expense. The price of such work are deemed to be included in concrete works unless otherwise noted and shall include all expenses to reach satisfactory result.

214.7.8 Disinfection and Bacteriological Analyses

All water used in disinfecting the reservoir including that used for retesting and disinfecting shall be provided and disposed by the Contractor at his hole expense. Fees for all laboratory analysis shall be borne by the Contractor.

The disinfection and analyses shall be paid on the basis of a lump sum price unless noted otherwise, and shall include all expenses to reach satisfactory results.

<u>موافق</u> مدير المياه بالإتابة	<u>دققه</u> رئيس مصلحة الدروس بالإتابة	<u>نظمه</u> المكتب الفني للإنماء (BTD)
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