

VOLUME 5

BILL OF QUANTITIES

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PART A

PREAMBLE TO BILL OF QUANTITIES



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1.10 GENERAL

The Bill of Quantities is not and does not purport to be either exhaustive or explanatory of all the obligations and duties of the Contractor who shall be deemed to have satisfied himself as to the correctness and sufficiency of the rates and prices entered by him in the Bill of Quantities all of which shall cover all his obligations under the Contract (including those in respect of the supply of goods, materials, plant or services or of contingencies) and all matters and things necessary for the proper execution and completion of the Works and the remedying of any defects therein and which may reasonably be inferred to be necessary for the Works as described in the Contract whether expressly mentioned therein or not.

1.11 ITEMS DESCRIPTION

A detailed description of the items and of the conditions under which and the manner in which the work is to be done and measured is not set out in each item of the Bill of Quantities. Reference should be made to this Preamble and all other documents forming the Contract.

1.12 DEFINITIONS OF BILL OF QUANTITY CATEGORIES

The Bill of Quantities is divided into several categories, listed below, to group the prices under the following:

- A) Transmission Pipelines works – Civil & electromechanical works
- B) General works

1.13 TRANSMISSION AND DISTRIBUTION PIPELINES

The relevant activities shall comprise, but not be limited to, a complete topographic survey, trial tests and as-built drawings.

Besides, the pipe works shall mainly consist of the supply of the required pipes with all necessary fittings, trench excavation, preparation of suitable bedding and surrounds, pipe laying and trench backfilling. Special provision shall be made for stretches of pipes crossing highways, railways, and bridges.

Furthermore, the Works relating to transmission and distribution pipelines shall include the supply and installation of hydraulic accessories, such as gate valves, butterfly valves, air release valves, control valves, watermeters and others... along with the valve chambers, their frames and their covers.

The concrete works form an important element of these activities, especially regarding pipe supports, anchor blocks, thrust blocks, and others.

Moreover, the testing and commissioning of the pipes, besides road reinstatement where necessary, are also required.

1.14 RATES AND PRICES

The Contractor shall be deemed to have inserted against each item in the Bills such rates and prices as he may deem necessary to cover the requirements of the Contract. Where neither price nor rate is entered against an item or if the term "included" or any such similar term is used it shall be deemed to have been included in the other priced items in the BOQ and measured accordingly. All rates and prices entered against any item in the BOQ shall be deemed to include all the detailed requirements of the General and Particular Specifications.

Rates and prices shall be inserted in the unit rate column of the Bill of Quantities. Each part of the Bill of Quantities shall be totaled and the totals carried to the Summary and Grand Summary.

1.15 MEASUREMENT

The Bill of Quantities includes items as lump sum and others as measured quantities.

1.15.1 Lump Sum

The lump sum items shall not be subject to re-measurement, and shall include the prices for all necessary equipment, construction, installation, testing and commissioning among others. The lump sum entered in the Bills shall include the price for a complete installation as described in the specifications.

The prices shall include all work necessary for completion of the Works and shall include the prices for all necessary building work such as forming box outs, supports plinths, cable trenches, and the like and all necessary safety and access works including guards, handrails, firefighting equipment and the like.

1.15.2 Measured Quantities

All measurements in the Bill of Quantities are taken strictly net. The principle of net measurements shall apply to all Works executed. All quantities measured for payment shall be measured by the Contractor and checked and approved by the Supervisor on the basis of actual net quantities of Work fixed in position. Item not used shall neither be measured nor included by the Contractor in his statements.

The quantities given in the Bill are the estimated quantities. In no sense shall such quantities be considered as limiting or extending the amount of the work to be done by the Contractor and of the materials to be supplied by him. The Contractor shall be responsible for checking quantities and for making any necessary surveys and investigations prior to placing any order for materials.

1.16 DEFINITIONS

The following definitions shall apply to items in the Bill of Quantities.

- **Extra - Over**
Any "Extra-Over" (EO) item shall be measured and paid for in addition to the measurement of the basic item to which it relates.
- **Included**
Where the term included is used in the Preamble or in the Bills any items stated to be included within another item shall not be subject to measurement and their costs shall be deemed to be included within the rates of the billed item.

1.17 DEALING WITH WATER

Items in the Bills of Quantities shall be deemed to include the prices for dealing with water flows and keeping the Works free of water.

1.18 WATER AND POWER

Unless otherwise explicitly stated in the Contract, water and power for the purpose of constructing, cleaning, and testing the Works shall be provided by the Contractor at his own expense, and shall not be measured separately.

1.19 RECORD 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 type of soil, dimensions and location of structures, size of existing pipelines and cables encountered during excavation.

The cost of preparing the shop 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 Supervisor, on CD/DVD and shall be paid for separately.

1.20 TRAFFIC REGULATION CONTROL AND SAFETY PROVISION

The provision of traffic control, safety equipment, signs, diversions, control systems including obtaining approvals and liaison with third parties for work in public roads and streets or in private sector will not be measured separately but shall be included in pipes rates, and shall include but not by way of limitation:

- Preparing all necessary plans, details and schedules and submission to the contracting authority/supervisor to obtain all necessary approvals.
- Liaison with third parties.

- Erecting, maintaining, moving and removal of safety barriers, signs and traffic control equipment.
- Establishment and management of road diversions.
- Watching and lighting.
- Maintaining, roads and streets clean and free from construction debris.

BILL A – transmisson pipelines

2.10 GENERAL

The hydraulic design of transmission and distribution pipelines is based on topographic surveys done during the design period. However, some or all topographical points like stakes or benchmarks may have disappeared due to works executed on the road after this period.

For this reason, the Contractor shall be deemed to have covered himself for checking quantities and for making any necessary surveys and investigations prior to placing or ordering for materials.

2.11 TOPOGRAPHIC SURVEY

The price shall cover performing land surveying of the designed networks layout. The surveyor shall start from approved benchmarks and shall mark the stations shown on drawings, using steel pegs and high-quality paint. Distance between two stakes or pegs shall not exceed 30 m.

Moreover, the Contractor is supposed to visit the site to check and be familiar with the present status of the survey.

EDM devices shall be used exclusively.

New longitudinal profiles shall be issued on transparent paper and AutoCAD files and shall be submitted to the Engineer's approval.

Vertical scale 1/200 and horizontal scale 1/2000

Measurement of topographic survey shall be in horizontal kilometers.

Trial pits shall be measured by number and shall include for excavation in any material, any type of soil and rock, to a depth not exceeding 3 m, hand excavation as necessary, backfilling, reinstatement of the surface to its original condition and reinstatement of road surfaces.

Payment will only be made for trial pits ordered in writing by the Engineer. Any measures taken by the Contractor to locate existing services or determine ground condition shall be included within the respective excavation item, whether separately itemised or not, and shall not be measured for payment.

2.12 TRIAL PIT

Trial pits shall be measured by number and shall include for excavation in any material, any type of soil and rock, to a depth not exceeding 3m, hand excavation as necessary, backfilling, reinstatement of the surface to its original condition and reinstatement of road surfaces.

Payment will only be made for trial pits ordered in writing by the Engineer. Any measures taken by the Contractor to locate existing services or determine ground condition shall be included within the respective excavation item, whether separately itemised or not, and shall not be measured for payment.

2.13 TRIAL TRENCH

Trial trenches shall be measured by linear meters and shall include for all requirements as stipulated in item 'Trial pit' above.

2.14 AS-BUILT DRAWINGS

As-built drawings shall be measured by horizontal kms and shall consist of new profiles, plans and details on scale similar to the design drawings scale.

Pipes, manholes, and accessories shall be shown clearly as well as effective cover depth of the crown of the pipe and distance between pipe axis and carriage edge or sidewalk, and between manhole cover center and electric pylons or buildings corners. Adequate number (minimum one for each road or 250 m which is less) of transversal sections showing all existing underground utilities/or facilities, should also be submitted.

Payment shall only be made for as-built drawings approved by the Engineer and submitted on paper and AutoCAD files.

2.15 SUPPLY OF ductile iron pipes including all necessary fittings

Ductile iron pipes shall be classified for payment according to their preferred C class (Unless otherwise noted), their diameter and shall be measured in linear meters of pipeline supplied and stored in good conditions.

The price shall cover all fittings, bends, tees, reducers, detachable joints, flanges, bolts, nuts, as well as fittings, joints and jointing material.

Only pipes, fittings, junctions, bends, etc... supplied and stored in good conditions and accepted by the Engineer shall be taken into account for payment.

2.16 SUPPLY OF HDPE PIPES INCLUDING ALL NECESSARY FITTINGS

Pipes shall be classified for payment according to diameter and material and shall be measured in linear meters of completed pipeline in place measured along the crown of the pipeline and the price shall include but not be limited to:

- * Supply and transport of pipes.
- * Removal of any abandoned pipework within the excavation.
- * Distributing pipes along the trench.
- * Checking and cleaning pipe from dirt, oil, grease, etc...
- * Supply of temporary or final supports & brackets.
- * Laying of pipes.
- * All necessary types of jointing.
- * Checking pipe alignment and elevations using topographical instruments.
- * Supply and installation of all fittings bends, tees, reducers dismantling joints, flanges, couplings, bolts, nuts, as well as, hauling, transport, unloading, and staking of pipes, fittings, joints, and jointing material.

The length measured for payment shall include the lengths of all fittings, valves and accessories installed in the line. Only pipes, fittings, junctions, bends, etc... actually laid, jointed and tested and accepted by the Supervisor shall be taken into account for payment.

2.17 TRENCH EXCAVATION

The price shall be calculated in terms of linear meters of dug trench only. The minimum width of trench is shown on the corresponding Contract drawings (refer to standard drawings).

This price shall include but shall not be limited to:

- * Excavating in any type of soil, rock, structural fill, contaminated fill, clay or others.
- * Excavating by hand or machine.
- * Excavating in asphalted or non-asphalted roads, in fields, in valleys, in accessible or non-accessible areas, including the execution of temporary access roads if needed.
- * De-watering operations necessary for keeping the excavation free from water whether rain water or any other sources.
- * Extra excavation depth carried out as shown on the longitudinal profiles or under the direction of the Engineer.
- * Extra excavation carried out in width for laying of the HDPE duct.
- * Transport of unsuitable backfilling materials to disposal sites approved by the Engineer.

- * Levelling or grading and compacting the bottom of excavations.
- * Supporting, protecting and maintaining existing services and utilities.
- * Temporary or permanent supports to sides of excavation, roads or structures as required by the Engineer (soil supports, sheet piling, etc...) or other method proposed by the Contractor and approved by the Engineer (micro-tunnelling, concrete piles, etc...).
- * Traffic regulation and safety provisions.
- * Repairing of all damaged utilities caused by the execution of the works.

Any excavated quantity will not be paid by the Employer under this item, if it is dumped or accidentally falls in the valley or in the field.

2.18 SAND BEDDING AND SURROUNDS

The sand bedding and sand surrounds shall be classified for payment according to pipe diameter and shall comply with the corresponding contract drawings (refer to standard drawings), and shall be measured by linear meters of completed pipeline.

Price shall include supply of material, backfilling, testing and compaction.

2.19 LAYING OF PIPES

Laying of pipes shall be classified for payment according to diameter and shall be measured in linear meters of completed pipeline in place measured along the crown of the pipeline and the price shall include but not be limited to:

- Removal of any abandoned pipework within the excavation.
- Distributing pipes along the trench.
- Checking and cleaning pipe from dirt, oil, grease, etc..
- Supply of temporary or final supports.
- Laying of pipes.
- All necessary types of jointing, welding, etc...
- Checking pipe alignment and evaluations using topographical instruments.
- Installation of all fittings, bends, tees, reducers, dismantling joints, flanges, couplings, bolts, nuts as well as hauling, transport, unloading, and staking of pipes, fittings, joints, and jointing material.

The length measured for payment shall include the lengths of all fittings, valves and accessories installed in the line.

Only pipes, fittings, junctions, bends, etc... actually laid, jointed and tested and accepted by the Engineer shall be taken into account for payment.

2.20 BACKFILLING OF TRENCHES

1-Backfilling of trenches (for main roads – refer to Ministry of Public Works decree No. 13495 dated 5/11/1998 – Volume 4 - Annex 1) shall be classified for payment according to pipe diameter and shall be measured by linear meters along the crown of the pipeline (refer to standard drawings).

Sand Backfilling shall include for:

- * Supply of imported materials.
- * Backfilling in layers and compaction.
- * Testing and compaction
- * Supply and installation of the warning tape (Marker Tape)

2-Backfilling of trenches shall be classified for payment according to pipe diameter and shall be measured by linear meters along the crown of the pipeline (refer to standard drawings).

Backfilling shall include for:

- * Supply of materials.
- * Backfilling in layers and compaction.
- * Testing and compaction
- * Supply and installation of the warning tape (Marker Tape).

2.21 ACCESSORIES

2.21.1 Supply and installation of air release valves

Air valves shall be measured by number for each air valve size, and nominal pressure, and shall include gate valves, riser pipe, flanges, bolts, nuts, supports and all necessary components to provide a complete installation. Reinforced concrete chambers, covers and frames shall be measured separately by number. Cutting and reinstatement shall also be measured separately.

2.21.2 Supply and installation of washouts

Washouts shall be measured by number for each washout size and pressure class and shall include gate valves, duck foot bends, tees, flap valves, drain pipe UPVC or D.I. pipes for washout with the needed length (excavation, bedding, supply, laying and backfilling) and all necessary items to make a complete washout.

Reinforced concrete chambers, covers and frames shall be measured separately by number. Cutting and reinstatement shall be also measured separately.

2.21.3 Connection to existing manholes and pipelines

Connection to existing pipes and existing manholes shall be classified for payment according to diameter and material and shall be measured in number of completed connection unit installed in place and the price shall include but not be limited to:

- Extra excavation works to locate the existing pipe.
- Removal of any abandoned pipework within the excavation.
- Distributing pipes along the trench.
- Checking and cleaning pipe from dirt, oil, grease, etc...
- Supply of temporary or final supports.
- All necessary types of jointing, welding, etc...
- Checking pipe alignment and elevations using topographical instruments.
- Transport the material from the warehouse and/or storage area to site.
- Supply and installation of all fittings bends, tees, reducers dismantling joints, flanges, couplings, bolts, nuts, as well as, hauling, transport, unloading, and staking of pipes, fittings, joints and jointing material.
- Reinforced concrete manhole including cover and frame.

The Unit measured for payment shall include all fittings, accessories installed in the line.

Only pipes, fittings, junctions, bends, etc... actually installed, jointed and tested and accepted by the Engineer shall be taken into account for payment.

2.21.4 Supply and installation of bridge crossing

Bridge / culvert crossing shall be classified for payment by number of completed crossing unit installed in place and the price shall include but not be limited to:

- Extra excavation works.
- Removal of any abandoned pipework with the excavation.
- Distributing pipes along the structure.
- Checking and cleaning pipe from dirt, oil, grease, etc...
- Supply of temporary and/or final supports including supply and installation of metal works needed to support the pipe.
- All necessary types of jointing, steel support works, beams, welding, etc...
- Checking pipe alignment and elevations using topographical instruments.
- All related concrete works (concrete footings, mass and/or reinforced concrete encasement, etc.).
- Any reinstatement works
- All necessary materials or tasks needed to accomplish the works.

The contractor shall present calculation notes based on design assumptions and shall include calculation reports for connection detail and shop drawing.

2.22 VALVE CHAMBERS AND SURFACE BOX UNITS

2.22.1 Construction of pre-cast or cast in situ, reinforced concrete valve chambers

Valve chambers where not included in another item, shall be measured by number according to chamber internal length and width and shall include for excavation, formwork, concrete, mass concrete, blinding etc..., reinforcement, rendering, external damp-proofing, painting, backfilling, floor drain, soakaway, step irons access ladders, compacted gravel, sub-base and base layers, asphalt, etc... and all necessary items to make a complete chamber according to the contract drawings.

2.22.2 Supply and installation of valve chamber cover and frame

Valve chamber cover and frame shall be measured by number and shall include all necessary materials and equipment including installation, labour, painting etc... in order to get an installed cover and frame according to the specifications.

2.22.3 Supply and installation of surface box units

Surface box units shall be measured by number and shall include for spindle guards, extension spindles, caps, couplings, covers, surface box units, and all necessary items to make a complete surface box unit.

2.23 CONCRETE WORKS

Cast in situ or precast concrete shall be measured by net volume shown on drawings.

Concrete, whether included in another item or separately measured, shall include for:

- All material, equipment, labor, transport, admixtures (retarders, plastisizers, waterproofness,) batching, mixing, placing, vibrating, curing, testing.
- Formwork (Formwork shall be "sawn" finish to all buried external faces of concrete below a line 200mm below ground level and shall be "wrought" finish to all other faces).
- All needed excavation in all kinds of soils and rocks, use of all adequate equipment, transport of soil to disposal sites approved by the Engineer, labor, dewatering, temporary and/or final retaining structures for trenches or open digs, backfilling, compacting, cutting of asphalt.
- Forming of chamfers (25mm x 25mm) to all exposed external angles.
- Forming expansion, contraction, movement and construction joints and for all waterstops, jointing materials, sealing compounds and formwork necessary for forming such joints;
- Building in of all pipes and fittings, bolts, frames, iron and steelwork and the like.
- Finishing of surfaces.
- Reinforcement.
- All necessary items to have the concrete works according to the specifications.

2.24 REINFORCED CONCRETE WORKS grade c30/37

The price per cubic meter shall include all material, equipment, labor, transport, admixtures (retarders, plasticizers, waterproofing materials, ...) batching, mixing, placing, vibrating, curing, testing, finishing, scaffolding, reservations for equipment, formwork, wrought formwork (fair face), surface leveling with mechanical float, etc. Dosage of cement shall be 400 kg/cu.m. for reservoirs and retaining aqueous liquid structures. All joints or sealing systems shall be included in the price. Measurement shall be determined according to the geometric shapes indicated on the layout drawings and/or buildings drawings; any quantity executed in excess of the indicated dimensions shall not be paid for. Any quantity less than that required in the Contract drawings and according to the specification documents shall be deducted or completed according to the instructions given by the Engineer.

The price shall also include all materials, equipment, labor, transport, storage, placing, bending, scaffolding, etc. of reinforcing steel supplied, placed, bended, etc. with all needed materials, accessories and tasks to achieve the works in perfect conditions. Detailed bar bending schedules and sheets should be submitted for approval before placing and installation.

The price shall also include all needed works, labor, material, transport, formwork, etc... to execute a fair faced concrete for interior and exterior walls and ceilings.

2.25 ASPHALT WORKS

The price per square meter of asphaltting for structures and access roads layout shall include earthwork, sub-base preparation (scrapping, leveling, compaction), sub-base material layer (hard stones, gravel), base course material (hard crushed aggregate) bituminous tack coats, asphalt and all material, equipment, supply, transport labor, expenses, drainage system, testing, quality control, hauling, spreading and compaction, and all necessary tasks for laying, jointing and a perfect execution and shall include, but not be limited to:

- Base course supply, and transport of materials, earth work, scraping, levelling, compaction, labor, final thickness after compaction 20 cm, testing quality control and all necessary tasks for a perfect execution.
- Asphalt: supply and transport of materials, bituminous, tack coat, asphalt and all necessary materials, labor, expenses, testing, quality control, hauling, spreading and compaction and all necessary tasks for laying, jointing and a perfect execution.

2.26 TESTING AND COMMISSIONING OF POTABLE WATER PIPES

Testing and commissioning shall be measured by linear meters along the pipe crown. The price shall include all the material, equipment and labor (water, pumps, barrels, manometers, valves, labor, power supply, etc...) and no payment shall be made before getting the Engineer's approval.

For service connections only, testing and commissioning shall be measured by number.

2.27 ROAD REINSTATEMENT

2.27.1 Cutting

Cutting of paved roads shall be measured by linear meters along the pipe crown. It shall include for asphalt cutting at both sides of the trench, and removal of excavated material to disposal sites.

Cutting and breaking of concrete pavements shall be measured by square meters, it shall include for cutting and breaking out of concrete pavement (the width of the cut trenches will be as shown on standard drawings) and removal of excavated material to disposal sites.

The price shall include cutting works and removal of material of widening of trench for chambers or other ancillary structures and fittings.

2.27.2 Reinstatement

Reinstatement of asphalt pavement shall be classified for payment according to type of roads, as for main roads two layers of asphalt shall be applied, and one layer for the other roads, and shall be measured by square meters of completed asphalted and reinstated trench, according to the quantity actually executed but not to exceed the quantities shown on standard drawings for trench reinstatement, the price shall include for:

- Transport of material.
- Recutting works.
- Base and sub-base courses, material.
- Compaction.
- Laying and application of material,
- Tests.
- Repairing of all defects, asphalt or concrete collapse.
- Etc..

The width of asphalt layers shall be in accordance with the standard drawings.



Reinstatement shall also include for any re-cutting works of asphalt or concrete required by collapse of trench edges and for base and sub-base courses and compaction according to drawings and complying with the specifications.

Reinstatement of concrete and concrete stair cases shall be measured by square meters of completed asphalted and reinstated trench, according to the quantity actually executed but not to exceed the quantities shown on standard drawings for trench reinstatement, the price shall include for:

- Transport of material.
- Recutting works.
- Base and sub-base courses, material.
- Compaction.
- Laying and application of material,
- Tests.
- Repairing of all defects, asphalt or concrete collapse.
- Etc...

3 BILL B – GENERAL WORKS

3.10 NOTICE BOARDS

Notice board shall be paid by unit and the price shall include manufacturing, transportation, installation (including concrete, excavation, equipment, labour, etc...) and removal prior and after completion of the works (refer to particular Specifications paragraph 101.15) and any other works to make a complete installation of the boards.

3.11 INSURANCES

This item shall be paid as a lump sum and the price shall cover, during the contract duration and the defects liability period, the insurance of Contractor's personnel and staff, employer and his representative(s) and all equipment in accordance to the Contract.

3.12 SITE PREPARATION AND MOBILIZATION-DEMobilIZATION

The rate shall include the full mobilization / demobilization of all resources and equipment necessary for the execution and completion of the works. The rate shall also include the design and construction of offices, stores, workshops, clinics and all other facilities required for the completion of the works under this Contract. The price shall be paid as a lump sum and the works shall include but not be limited to the following:

- Protection of public and private properties
- All necessary procedures for the supply and testing of material in conformity with the specifications and as directed by the Engineer,
- Temporary works and site protection, watching, fencing and lighting,
- Supply of the required equipment in order to execute all the required works including but not limited to:
 - Transport of material and equipment to the different parts of the project,
 - Ensuring storage areas and disposal sites,
 - Supply of water and power to complete the works,
 - Keeping the site free of water for excavation, backfilling and concrete works,
 - Supply of compressed water (not less than 2 bars),
 - Accomplish excavation including removal of excavated material and backfilling,
 - Installation of wrought steel
- Management, operation and maintenance of site equipment,
- Indemnification and remedying of all damages caused by the execution of the works to the private or public properties,
- Guiding and protecting traffic and pedestrians through areas of construction including the erection of signs, barriers and lighting,

- Removal of utilities, plants, machinery and all other facilities after completion of the works, including reinstatement to the Engineer's satisfaction,
- Ensuring that all parts of the project are operating as required after the completion of the works and after testing and remedying of all defects that may appear while testing,
- Completion of all procedures necessary for the taking over and commissioning,
- All items necessary to complete the mobilization / demobilization including all related costs.
- The rate shall also cover all costs related to providing facilities for the engineer's representative as stated in the particular specifications paragraph 101.12.

3.13 ACCESS TO SITE

This item shall be paid on a Lump Sum basis and shall include all necessary equipment or labor for the site access to deliver material needed for the good installation of the PV system. The price shall include for all safety measures and equipment for the safety of labour, equipment and materials.

This item shall also include the preparation of a temporary access road to the site(s). Access road shall be constructed prior to the beginning of the works and shall be kept in good condition for traffic for the whole duration of the project. Maintenance of access roads and all costs pertaining to this matter shall be deemed to be included by the Contractor in his unit rates for this item and shall not be paid for separately.

3.14 HEALTH AND SAFETY REQUIREMENTS

Health and Safety requirements shall be paid as a lump sum and shall include but not be limited to the following:

- PPE including safety boots, gloves, safety vests, helmets, masks ...
- Safety barriers.
- Safety lights, signs and cones.
- Firefighting equipment.
- COVID 19 health & safety measures (refer to particular specs paragraph 205.2)
- Etc...

Health and safety requirements shall also include an induction training for all personnel. Refer to Conditions of Contract.

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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 payline 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 publics. 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 related legal authority 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.

101.1.8 Earthworks in Urban Areas (Not Applicable)

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.

101.2 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.

101.3 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	201 -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

(i) 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.

(ii) 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

Compaction Factor

0.1 or less

Over 0.1

Suitability for Use

Material suitable

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:

- (i) 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.
- (ii) 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 over-excavation 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. Over-excavation 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 over-excavation 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 over-excavation 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.

101.7 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:

- (i) 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.
- (ii) 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_{dmax} = greatest dry density obtained by laboratory
 Y_{dmin} = 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:

- (i) 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.
- (ii) 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:

- (i) 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.
- (ii) Elevations of bottoms of ponds - no more than 5 cm.
- (iii) 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.
- (iv) 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 m², 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 100m², 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 m², 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 1 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	
C25P	250	280	
C30P	300	280	Reinforced Concrete
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	20 or 40	C15P
- Liquid Structures	20	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 Six			
		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/m3)			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 300	330	370	-
		SRPC				0.50
1.0 - 2.0	250 - 500	OPC	Not Permitted 340	370	410	-
		SRPC				0.45
> 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:

- i) Prior to adding fluidizers : 4 to 6 cm
- ii) After adding fluidizers : 15 to 18 cm
- iii) 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:

- i) Prior to adding fibres : 9 to 12 cm
- ii) 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 concreted 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 though 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 ¼ 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/m ³	25 kg/m ³	30 kg/m ³	35 kg/m ³	40 kg/m ³
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:

- i) separate the slab from the foundation ground and facilitate sliding
- ii) avoid infiltration of water or laitance into the foundation ground.
- iii) 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 $\geq 3.4 \text{ MPa}$)
- Mechanical strength of concrete; the performances level defined above being checked out.
- Tests shall be carried out on prismatic samples $4\text{cm} \times 14\text{cm} \times 56\text{cm}$
- 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 from 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:

- (i) 40mm, or
- (ii) 1/3 of the smallest thickness of concrete members, or
- (iii) 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 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 $+5^{\circ}\text{C}$ 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 (Not applicable)

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 near-saturated 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.

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” (Not Applicable)

202.7.3 Concrete Repairs in News 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 expansion.

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 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 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 1 cm 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 build 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 (Not Applicable)

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 $\frac{1}{4}$ in, the depth should be $\frac{1}{4}$ 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 $\frac{1}{2}$ in
 - a) for joints $\frac{1}{2}$ 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 $\frac{1}{2}$ 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 a 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 now allow the solvent to air-dry without wiping. Wipe dry with a clean dry cloth or lintless paper towels. Permanent clothings 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 (≈ 5°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, cares 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°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 exerce 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 (Not applicable)

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.

213 - DAMP-PROOFING

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213DAMP-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 an retaining walls where water infiltration pressure is low (permeable earth foundation) and where the performation 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 diluated 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

- Deliver material in original, unopened packages and containers.
- Containers are to be labeled with manufacturer's name, product name, description and identification.
- Store materials between 60° and 80° F. If exposed to lower temperatures, store at 60°F. minimum temperature for three days before using.
- 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 Cut-off 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 cut-off Mastic to stay very flexible.

Water Cut-off 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:

Propriety		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.		
Permitivity 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 multifilament 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:

Propriety		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.		
Permitivity 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 bituminous 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 m^2 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, bituminous 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 m^2 of flexible membrane and geotextile placed and fixed for the cut-off walls.

217 - PIPELINES AND PIPEWORKS

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217 PIPELINES AND PIPEWORKS

217.1 Scope

This part of the specification shall apply to the supply, delivery, laying, jointing and testing of all pipes, fittings and accessories, and includes:

~~Concrete pipes~~
~~Asbestos-Cement pipes~~
~~Steel pipes~~
Cast Iron and ductile Iron pipes
~~G.R.P. pipes~~
~~P.V.C. pipes~~
HDPE pipes

202.2 Cast Iron and Ductile Iron Pipes and Fittings

217.2.1 Quality Requirements

All cast iron and ductile iron pipes and fittings to be supplied under this Specification shall be obtained from approved manufacturers. They shall be of the class and shall have joint ends as shown on the Drawings or as specified and shall otherwise comply in all respects with B.S. 4622 - Grey Iron Pipes and Fittings, and B.S. 4772 - Ductile Iron Pipes and Fittings.



- External Coating: pipes and fittings shall be given an external coating of zinc in accordance with ISO 8179 or BS 4772 and a finishing coating of either cold applied bitumen complying with the performance requirements of BS 3416 Type II material, or hot applied bitumen to BS 4147 Type I Grade C.
- Internal Lining: All pipes and fittings shall be lined internally with cement mortar and shall comply with ISO 4179 or BS 4772. The inside of the sockets shall be coated with bitumen as used for the finishing coating to the pipes.

While the pipes are still suspended over the trench before lowering or before mounting, they shall be inspected for defects and rung with a light hammer to detect cracks. Defective pipes shall be dismantled, removed from the site and replaced by flawless pipes. Only pipes inspected and accepted on the site by the Engineer shall be incorporated into the works.

217.2.2 Hauling and Handling of Pipes

The Contractor shall check each pipe before loading and shall reject all damaged or defective pipes. The Contractor shall load and properly secure the pipes on the vehicles and take all necessary measures to prevent any damage to the pipes during transport. The Contractor shall be responsible for the quality of the pipes and for their condition upon and after delivery to the site, and shall immediately remove from the site any damaged or defective pipes and replace them at his own expense.

No pipes or fittings shall be allowed to drop, roll freely or strike objects which are likely to damage them. Special care shall be taken not to spoil the tar or bitumen coating.

217.2.3 Laying and Jointing

- Laying - Before C.I. or Ductile pipes are laid, all dirt and foreign matter shall be removed from inside and all lumps blisters, excess coal tar, oil, grease and moisture shall be eliminated from the surfaces of the joints. After the pipe is laid and mounted, care shall be taken to avoid entrance of dirt, water and foreign matter from the trench or from elsewhere by the use of tight bulkheads.
- Jointing of cast iron pipes and fittings - Joints shall be flanged; or mechanical joints; or rubber gasket "push-in" flexible joints, all as specified and/or shown on Drawings.
- Jointing of ductile iron pipes and fittings - Joints in ductile iron pipes and fittings shall be of one of the following types according to the Drawing and the Particular Specification:
 - Spigot and socket joint with rubber gasket
 - Flanged joints
 - Mechanical joints

All joints shall conform to B.S. 4772.

217.2.4 Testing

Testing instructions and requirements for Cast Iron and Ductile Iron pipelines shall be as specified in Subsection 217.4.12 for steel pipelines.

217.2.5 Methods of Measurement and Payment

Cast Iron pipes and Ductile Iron pipes and fittings shall be classified for payment according to type, diameter and class and shall be measured in linear meters of completed pipeline in place, measured along the crown of the pipeline. The length measured for payment shall include the lengths of all fittings, valves and specials installed in the line.

The price for fittings, bends, junctions, specials, detachable joints, flanges (when not integral part of pipe or fitting) etc. shall be considered as included in the cost of pipes, unless otherwise specified in the particular specifications or the B.O.Q.

Alternatively, if so stated in the Particular Specification and/or in the Bill of Quantities, C.I. and Ductile Iron pipes and fittings may be measured by number of pipes of defined net lengths and by number of fittings.

The payment for C.I. and Ductile Iron pipes and (under separate items) for fittings, bends, junctions etc. shall include:

- Supply, hauling, unloading and stacking of pipes and fittings including all necessary joints and jointing materials.
- Removal from stacks, hauling and stringing alongside the trench, laying and jointing of pipes and fittings at any depth of trench, connections to manholes and/or chambers and final cleaning and flushing of pipeline. The unit rates for this item for each type, class and diameter of pipe and fitting shall be the same for all depths of trench in which the pipes and fittings are to be installed.
- Testing of completed pipeline
 - For pressure and gravity pipelines shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

Only pipes, fittings, junctions, bends etc. actually laid, jointed and tested and accepted by the Engineer shall be taken into account for payment under items and no allowance whatsoever will be made for any breakage, loss, etc. Excavation and backfill, special beddings, surrounds and manholes and chambers shall be paid for under separate items in the Bill of Quantities, unless otherwise noted.

202.3 HIGH DENSITY POLYETHYLENE PIPES (HDPE)

217.3.1 Quality Requirements

HDPE pipes and fittings shall comply in all respects with the following standards.

BS 6572 Specification for blue polyethylene pipes up to nominal size 63 for below - 1984 -ground use for potable water.

WIS 4-32-02 Specification for polyethylene pressure pipe for cold potable water (underground use).

WIS 4-32-04 Specification for polyethylene socket and spigot fittings, saddles and drawn bends for fusion jointing for use with cold potable water PE pressure pipes.

WIS 4-32-06P Specification for polyethylene electrofusion couplers and fittings for cold - 1989 -potable water supply for nominal sizes up to and including 180.

WIS 4-32-13P Interim specification for higher performance blue polyethylene (PE/MRS 100) - 1991 - pressure pipes (nominal sizes 90 to 500) for underground or protected use for the conveyance of water intended for human consumption.

(WIS Water Industry Specifications UK).

DIN 8074/ DIN 8075 or the most recent ISO standards or European Norms (EN12201 part 1 and part 2).

All pipes and fittings shall be manufactured from approved raw materials and shall be supplied by approved manufacturers. Manufacturers shall have and maintain permanent Quality Control program and records.

Unless otherwise stated, pipes with OD up to 63mm must be produced from PE80 (MDPE) or PE100 (HDPE) material. Pipes with OD 75 mm and up must be produced from PE100 (HDPE) material. Pressure class for all diameters should be PN16.

Pipes with OD up to 63mm shall be supplied in coils where the inside diameter of the coil is 30 times OD. Pipes with OD 75mm and up shall be supplied in coils if possible or in straight length not less than 6 m.

The pipes shall be clearly and indelibly marked to show the name of the manufacturer, nominal diameter, wall thickness, PE designation, pressure class, standard (BS, DIN, EN, ...) and date of manufacture. The marking shall remain legible during normal handling, storage, installation, and service life and shall be applied in a manner that will not reduce the strength nor otherwise damage the products. The marking shall not initiate any defects in the surface and will not provide leakage channels when elastomeric gasket compression fittings are used to make joints. Both hot tape marking and Ink Jet printing are acceptable.

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

For applications other than potable water, i.e. Irrigation and drainage, pipes are to be colored black.

Pipes and fittings intended to be used for the conveyance of potable water shall be approved by an internationally recognized independent water authority such as WRC, DVGW, KIWA, Lyonnaise Des Eaux, etc... The effect on water quality test shall fulfill the requirements of BS 6920 or equivalent.

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

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

217.3.2 Hauling, Handling and Storage

Rough handling of pipes shall at all times be avoided, especially at low temperature, and care should be taken to prevent damage to pipes and fittings at all stages of handling, transporting and storage.

Pipes must be transported by a suitable vehicle and properly loaded and unloaded. Straight pipes should be supported along their full length.

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

During storage, care must be taken to ensure that pipes do not become distorted or damaged. This can occur if pipe stacks are not properly constructed and are not limited in height. Pipe stacks must not exceed 1.5m and storage areas must be flat throughout the entire length of the pipe.

Pipes must be protected from materials which may soften or damage polyethylene, such as strong solvents.

Pipes must not be dragged across ground, which might damage the surface.



Similar precautions should be taken with fittings and these should be kept in protective wrappings until required for use. This is particularly important for all electrofusion fittings, each one of which should be individually wrapped and sealed immediately after manufacture.

It is similarly important to protect spigot ends of pipes and fittings to be jointed by Electrofusion or Mechanical jointing methods.

217.3.3 Weathering

Blue and yellow polyethylene should not be permanently installed above ground where it is exposed to direct UV light.

217.3.4 Laying

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

All pipelaying shall be carried out by experienced pipe-layers, well skilled in this work and in the presence of the Engineer unless prior permission has been received.

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

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

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

Additional general installation details for HDPE duct for telemetry cables

The line and level of the duct formation shall be kept as straight as possible. Bends will be required for duct formations to be routed around corners at intersecting roads. (For safety reasons manholes shall usually be planned and located away from intersections).

The configuration of the duct formation shall be as shown on drawings.

All ducts shall be located in accordance with applicable roads and municipal Standards. In the absence of relevant Standards, the Engineer must be consulted to ensure compliance with the appropriate standard which may vary depending upon the nature of the undertaking.

Ducts shall be watertight between manholes. Installation methods shall prevent sand and soil from entering the ducts.

At manhole, the bond between the outside surface of the duct and the wall shall be watertight.

Ducts shall be terminated flush to manhole inside walls. Edges shall be bevelled off.

Ducts entering manholes, shall be plugged and watertight. The plugging mechanism or material shall be readily removable to allow for future cable installation.

Ducts shall leave a manhole in a standard formation and enter the subsequent manhole with each duct in the same relative location.

At location between manholes where the duct formation must be modified due to obstructions the formation shall be altered to minimize the movement of each duct.

The separation either longitudinal or perpendicular, to other services, should be minimum 150mm. Where such is not possible a separating/retaining layer of 50 mm of concrete is required.

The Engineer shall have the authority to change the construction method to HDPE in concrete or steel ducts, should the circumstances indicate such a requirement.

If two ducts are to be laid, they shall be supported by spacers so that the formation will maintain the standard spacing between ducts throughout the length of the installation. Sand, to the appropriate highway specification, shall be placed to fill all spaces between ducts, and compacted.

The duct formation shall be covered with 200 mm of sand. This is to be followed by approximately 200 mm of suitable backfill and a plastic warning tape. Warning tape shall be 70mm wide, yellow PVC, durably marked with the text 'WARNING - TELEMETRY CABLE' at no more than 50 cm intervals. Backfill and compaction shall follow.

HDPE tubes shall have minimum 2" inside diameter and minimum 5mm thickness with manholes maximum 100 meters apart.

217.3.5 Jointing

Jointing of HPDE can be one of the following systems:

a) Electro-fusion Fittings and Saddles

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

- All fittings shall be injection moulded from recognised top quality PE 100 or PE 80 resin.
- All fittings must conform with the requirements of the related standard EN, BS, ..
- All fittings must be packed in such a way to allow instant use on site without additional cleaning.
- Each protective package must clearly indicate its contents.
- The heating coils contained in each individual fitting and saddle should be so designed that only one complete process cycle is necessary to fully electro-fuse the fitting to the adjoining pipe or pipes.
- No heating coil may be exposed and is to be fully imbedded into the body of the fitting for protection purposes during assembly.
- The pipe fixation device shall be an integral part of the fitting body in the sizes up to and including nominal diameter 63 mm.
- An individual magnetic card containing a magnetic strip and an appropriate barcode for data transfer purposes must be supplied with each fitting.
- All fittings must have moulded-in identification and product information.
- Process voltage of all fittings must not exceed a maximum of 40 volts.
- Insulated contacts for the terminal pins are to be provided.
- Terminal pin size shall be 4 mm in diameter.
- A limited path style fusion indicator acting for each fusion zone as visual recognition of completed fusion cycle should be incorporated in the body of the fitting.
- The design of the indicators must prevent the escape of fusion melt.
- All couplers in the sizes up to and including nominal diameter 160 mm must have an easily removable center stop not requiring tools for removal.
- All internal or externally threaded transition adaptors in the nominal sizes up to and including 2" must be designed with an integral polyethylene collar form PE 100 or PE 80 not relying on rubber or synthetic seals.
- Threaded adaptor bodies may be from brass or stainless steel and should be of the modular principle not being supplied moulded into an electro-fusion fitting socket.
- Electro-fusion machines used in the electro-fusion process must be supplied by the same manufacturer of fittings. It is strictly forbidden to fuse one manufacturer fitting with another manufacturer machine.

Additional Requirements for Electro-fusion Saddles

- All saddles up to nominal diameter 250 mm should be designed with two separate halves having a single hinge type attachment and are to be correctly processed without specialized external spring-loaded tooling.
- The top half of the saddle shall be equipped with an outlet which can accept various other system components such as tapping tees, adopters, valve tees, stop-off attachments etc., that are simultaneously fused together with the saddle to mains joint in one operation.
- Each branch outlet is to be equipped with an integral clamping device.
- The branch spigot of tapping tees must be long enough to allow a second joint if necessary.
- All pipe saddles sizes above nominal diameter 63 x 20 mm are to allow a 360° rotation of the branch outlet.
- Safe tapping into a main must be possible under the defined allowable maximum water pressure according the respective pipe series and ambient temperature.
- The tapping saddle cutter is to be designed to seal-off the central passage in the uppermost position.

b) Butt-fusion:

Butt-fusion jointing is a thermofusion welding process which involves the simultaneous heating of the annular end surfaces of two components to be joined until a melt state is attained on each contact surface. The two surfaces are then brought together under controlled pressure for a specified cooling time and a homogeneous weld is formed upon cooling.

The resultant joint is end thrust resistant and has comparable performance under pressure to the unwelded pipe.

In the fabrication and installation of a butt-welded polyethylene system, it is essential that all items which are to be butt-welded are made from compatible material.

The compatibility is dependent upon the process of manufacture, density and melt flow index.

It is also important that proper butt-welding machines are used to make welds and that these are maintained in good condition as welding pressures and temperatures are critical to achieving satisfactory welds.

c) Compression Fittings

All fittings must be manufactured of pure virgin compounded PP ensuring the best performance as to mechanical properties and flexibilities.

- All fittings must be Push-fit type: to assemble, the installer must just cut the pipe square and clean (no need to chamfering), loosen the nut, push the pipe all the way through the stroke and close the nut. The fittings should be easily disassembled without the need for a special tool.
- All fittings must have a floating split clamp ring to compensate thermal and mechanical stress on the pipe. (Ring must be made of acetalic resin or C-PVC).
- All fittings must have a heavy-duty thrust ring to ensure axial compression of the gasket on ovalized, undersized and scratched pipes.
- All fittings must have a gasket. giving the gasket a broader contact surface with the pipe, allowing a tighter grip and a higher resistance in case of vacuum or suction. Also, permitting higher protection against pipe pullout (Gasket must be made from EPDM or NBR Rubber).
- All female offtakes must be reinforcing with metal rings (Rings must be made of stainless steel).
- All fittings must have an easy traceability of the production batch. The production date must appear on the fitting's body and/or nut.

Certificates and Approvals:

All fittings must pass the testing requirements of ISO 3458/3459/3501/3503. At the time of submission, Manufacturers of fittings must hold valid certificates of conformity in respect to the following:

Toxicological requirements:

- | | |
|--------|---|
| • WRc | * Low sensitivity to bacteria migration |
| • DVGW | * Low sensitivity to chlorine absorption |
| • KIWA | * Alimentary compatibility as ATA test for color, odor, taste and toxic components in concentrations - BRL-K533 |

Ageing Test requirement:

- DVGW * 95° C - 1,000 hours - 0.5 x Nominal Pressure (PN)

Pullout Test requirement:

- WRc * For sizes up to 63 mm Diam.
- UNI9562 * for sizes greater than 63mm Diam.

Pressure test requirement:

- IIP * 3 x Nominal Pressure (PN) - 1 hour - 20°C Water Temperature

Clamp Saddles

All clamp saddles must be manufactured of pure virgin compounded PP ensuring the best performance as to mechanical properties and flexibility.

- Clamp saddles could be used on distribution lines of 63mm and below, for section rated at PN16 bars or less.
- All saddle off-takes must be reinforced with metal stiffeners.
- All saddles must have a feature to prevent bolt's rotation during assembly.
- All saddles over 40 mm and outlets ½" to 2" must have flat gasket to ensure added flexibility on ovalized, undersized or scratched pipes and to prevent gasket's pulling-out in case of water hammer.
- All bolts and nuts should be from stainless steel (series 400).

217.3.6 Testing

Testing instructions and requirements for HPDE gravity pipelines shall be as specified in Subsection 217.2.6 except that the leakage under test shall not exceed 0.08 litre/m² of internal wall pipe area/hour. Testing instructions and requirements for HPDE pressure pipelines shall be as specified in Subsection 217.3.10 (b) for A.C. pressure pipes, except that the Hydrostatic pressure test can commence 24 hours after the completion of filling if permitted by the Engineer. Manufacturer's recommended procedure of testing should be submitted to the Engineer who could accept to take it into consideration or not.

217.3.7 Methods of Measurement and Payment

HPDE pipes shall be classified for payment according to type, diameter and class and shall be measured in linear meters of completed pipeline in place, along the crown of the pipeline, as follows:

- In gravity flow lines: between internal surfaces of manholes or chambers.
- In pressure flow lines: between stations.

The length measured for payment shall include the length of all fittings, valves and specials installed in the line.

Payment for HPDE pipes and for fittings; specials etc. include:

- Supply, hauling, handling, unloading and staking of pipes and fittings including all necessary HPDE joints and jointing materials for pipes and all HPDE joints and jointing materials for fittings, specials, valves, etc.
- Removal from stacks; hauling and stringing alongside trench; laying and jointing of pipes and fittings, at any depth of trench; connections to manholes and/or chambers and final cleaning and flushing of pipeline. The unit rates for this item, for each type, class and diameter of pipe and fitting, shall be the same for all depths of trench in which the pipes and fittings are to be installed.
- Testing of completed pipeline
 - For gravity pipelines: the cost of testing shall be included in the unit rates for pipes and shall not be paid for separately.

- For pressure pipelines: the cost of testing shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

Only pipes, fittings, junctions, bends etc. actually laid in trench and tested and accepted by the Engineer can be measured for payment under the above items, and no allowance whatsoever will be made for any breakage, loss, waste, etc.

Excavation and backfill, special beddings, surrounds and manholes and chambers shall be paid for under separate items in the Bill of Quantities, unless otherwise stated.

218 – ROAD WORKS

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218 road works

218.1 Roads and Paved Areas

218.1.1 General

Road construction under this division shall include construction of new roads and paved areas and repairs to existing roads and paved areas where such repairs are necessitated by the performance of the Works, and the term “road” as used in this division shall also include other areas on which a road surfacing is required.

All roads shall be constructed to the lines, levels and cross-sections shown on the Drawings and as detailed in the Particular specification. Road surfacing may consist of compacted local soil, gravel, laterite or similar suitable material, with or without a stabilizing spray of bitumen, or of asphalt concrete placed on a bearing course of compacted gravel, laterite or other suitable base course material.

All roads shall be fitted with a stormwater drainage system, sidewalks, etc.

218.1.2 Earthworks for Road Construction (Subgrade)

All excavation and fill required for road construction shall be carried out in accordance with the applicable requirements of Division 201. The materials to be used and the degree of compaction to be obtained in each layer of the road structure shall be as shown on the Drawings or as required in the Particular Specification.

218.1.3 Sub-Base and Base Courses

Sub-base preparation shall consist of the following:

- Scraping of the natural ground
- Earthworks and levelling of the surface
- Compaction with a pneumatic roller.

Unless otherwise specified, sub-base material shall consist of hard, durable particles or fragments of stone or gravel, screened and crushed to the required size and grading or an equivalent material, subject to the Engineer's approval. The material shall be free from vegetable matter, lumps or balls of clay and other objectionable matter.

The sub-base shall be levelled, watered, rolled and compacted to 96% of the Modified AASHTO Density. In case it consists of non-rock ground, the California Bearing Ratio CBR shall be greater than 30. The Material shall have a specific weight greater than 2.45 kg/dm³.

If the bearing of the foundation soil be inadequate, the top soil shall be stripped to a 20cm depth. The stripped area shall be backfilled with material that meets the requirements and have a minimum CBR of 15 when compacted to 96% of Modified AASHTO Density. The frequency of tests shall be determined by the Engineer.

The sub-base course material layer shall conform to the following grading:

A.S.T.M.Sieve Designation	Percentage by Weight Passing Square Mesh Sieves
1 ^{1/2} "	100%
1"	60-100
3/4"	55-85
No. 4	35-60
No. 10	25-50
No. 40	15-30
No. 200	0-15

The material shall have the following properties:

- Plasticity Index (AASHTO T90) 4-8
- Plastic Limit (AASHTO T89) 25 maximum
- Sand Equivalent (AASHTO T176) 50 minimum

Unless otherwise specified, base course material shall be crushed aggregate which shall consist of hard, durable particles or fragments of stone or gravel crushed to the required size, and a filler of sand or other finely divided mineral mater. When produced from gravel, not less than 50 percent by weight of the coarse aggregate shall be particles having at least one fractured face and, if necessary to meet his requirement or to eliminate an excess of filler, the gravel shall be screened before crushing. All suitable oversize material less than 10 inches in diameter shall be crushed. The material shall be free from vegetable matter, lumps or balls of clay and other objectionable matter.

The sub-base and base courses shall consist of a minimum of 20 cm thick each course of compacted layers of screened and crushed material.

The sub-base shall be watered prior to the placing of the base course. The material shall then be laid, watered and compacted with a pneumatic roller to 98% of Modified AASHTO Density.

The last base course shall be levelled to ± 1 cm according to the levels shown on the drawings or specified by the Employer. Newly placed base courses shall not be opened to traffic.

The base course material shall have a specific weight greater than 2.45 kg/dm^3 and shall conform to one of the following gradings:

A.S.T.M.Sieve designation	Percentage by Weight Passing Square Mesh Sieves								
	A	B	B-1	C	C-1	D	D-1	E	E-1
3 inch	100	-	-	-	-	-	-	-	-
2 inch	-	100	100	-	-	-	-	-	-
1 1/2 inch	-	-	70-100	100	100	-	-	-	-
1 inch	-	-	55-85	-	70-100	100	100	-	-
3/4 inch	-	-	50-80	-	60-90	-	70-100	100	100
3/8 inch	-	-	40-70	-	45-75	-	50-80	-	-
No. 4	15-45	20-50	30-60	25-55	30-60	30-60	35-65	35-65	45-80
No. 10	-	-	20-50	-	20-50	0	25-50	-	30-60
No. 40	-	-	10-30	-	10-30	0	15-30	-	20-35
No. 200	0-10	0-10	5-15(*)	0-10	5-15(*)	0-10	5-15(*)	0-10	5-15(*)

(*) For gradings B-1, C-1, D-1 and E-1, the fraction passing the No. 200 sieve shall not be greater than two-thirds of the fraction passing the No. 40 sieve.

If no specific grading is specified, the grading shall comply with C above.

If fine aggregate or filler in addition to that naturally present in the base-course material is necessary in order to meet the grading requirements or for satisfactory bonding of the material, it shall be uniformly blended with the base-course material at the screening and crushing plant or on the road. The material for such purpose shall be obtained from sources approved by the engineer and shall be free from hard lumps.

That portion of the base course material passing No. 40 sieve shall be nonplastic.

The base course material shall be tested for abrasion in accordance with B.S. 812 and the following maximum values shall be acceptable.

Aggregate fraction	Maximum abrasion (%)
3/4" - 1"	40
1/2" - 3/4"	35
3/8" - 1/2"	30
1/8" - 3/16"	28

Sub-base and base courses shall be placed in layers not exceeding 15 cm in thickness, after compaction. Unless otherwise specified, base course materials shall be placed only by means of spreader boxes or equivalent equipment. Placing base course materials directly by means of trucks, shovel dozers and other loading or hauling equipment will not be permitted. Blending material, where required, shall be added by means of spreader boxes or other approved equipment and the whole base course layer shall be thoroughly mixed to its full depth by means of graders, mixers or other approved equipment.

During placing and mixing, water shall be added in the amount necessary to provide the optimum moisture content for compacting.

Compaction shall be carried out in accordance with the applicable parts of Section 201.7.

Unless otherwise specified, the following densities shall be required:

- For sub-bases: 96% of the Modified A.A.S.H.T.O. Density
- For base-courses: 98% of the Modified A.A.S.H.T.O. Density

218.1.4 Bituminous Prime Coat and Tack Coat

Unless otherwise specified, a prime coat of medium curing cut-back bitumen of grade MC-70 shall be applied on top of finished base course, at the rate of 1.0 kg/m², and a tack coat of rapid curing cut-back bitumen of grade RC-250 shall be applied between asphalt concrete layers (where more than one wearing course is specified), at the rate of 0.25 kg/m².

Bituminous coats shall be applied one day before the next layer is placed on top of them. Prior to applying bituminous coats, the road surface shall be thoroughly cleaned of all dirt, oil, grease and other objectionable matter, to the satisfaction of the Engineer. The bitumen shall be heated in boilers of an approved type and spreading shall be carried out by means of mechanical pressure distributors.

218.1.5 Asphalt Concrete Wearing Courses

The number of asphalt concrete layers to be placed in the road surfacing and the thickness of each of them shall be as shown on the Drawings and/or required in the Particular Specification.

All aggregates and bituminous materials to be used in asphalt concrete shall be subject to approval by the Engineer. Samples of the materials shall be submitted to the Engineer at least 30 days prior to their use.

All aggregates, except natural sand, shall be obtained by crushing natural quarry stone, and the use of river gravel, whether crushed or not, will not be permitted. Coarse aggregate shall be of uniform quality, with the particles as nearly cubiform as possible, clean of dust or foreign matter, and shall comply with the requirements of Subsection 218.1.3 above for base course aggregate. Quarry sand shall be clean and free of clay, silt or other deleterious matter; it shall all pass sieve No. 10 and not more than 10 percent of it shall pass sieve 200. The grading of the aggregates shall be if not specified in the Particular Specification as follows:

A.S.T.M. Sieve Designation	Percentage by Weight Passing Square Mesh Sieves
¾"	100%
½"	80-100
No. 4	50-70
No. 10	32-47
No. 40	16-26
No. 80	10-18
No. 200	4-10

Mix design shall be carried out as follows. The proposed aggregate mixture shall be mixed with 5.5% bitumen (if no other percentage is required in the Particular Specification). This sample shall be subjected to a set of Marshall tests (A.S.T.M.-D-1559 and A.S.T.M.-D-1188) at a laboratory in order to determine the optimum bitumen content. The Engineer may change the grading of the aggregates and the bitumen content according to the results of laboratory tests conducted on samples of materials supplied from time to time by the Contractor at the request of the Engineer.

Placing of asphalt concrete, unless otherwise specified, shall be carried out by means of paving finishers, specially designed for that purpose. The asphalt concrete layers shall be compacted by tandem rollers, heavy pneumatic rollers and three-wheeled rollers, in that order to reach a density not less than 97% of the Marshall density. Parts of the layers inaccessible to heavy mechanical rollers shall be compacted by small vibratory tampers. Rolling shall proceed from the outer edges towards the centre of the road and the whole area shall receive a uniform compaction throughout and shall be finished accurately to the required lines and levels. When asphalt concrete is placed in more than one layer, longitudinal joints shall be staggered by 30 cm and transversal joints by 60 cm between layers. The permissible variations of the top surface from the design levels shall be -0 + 15 mm. The permissible variations from the plane in the top surface shall be 5 mm over a length of 5 m.

Newly paved asphalt concrete surfaces shall be opened to traffic only after permission to do so is given in writing by the Engineer.

Placing of asphalted concrete shall ensure an inclination for drainage of stormwaters in accordance with the drawings and as specified by the Engineer.

218.1.6 Bituminous Surface Treatment

Where shown on the Drawings or required in the Particular Specification, a surface treatment shall be applied to the base course by spraying cut-back bitumen followed by a rolled blinding layer of stone chippings. Unless otherwise specified, bituminous surface treatment shall consist of the following two layers:

- Cut-back bitumen MC-3000 at the rate of 2.8 kg/m², followed immediately by stone chippings of 3/4" - 1" size at the rate of 27 kg/m².
- Cut-back bitumen MC-3000 at the rate of 1.35 kg/m², followed immediately by stone chippings of No. 4 - 1/2" size at the rate of 22 kg/m².

The second layer shall be placed after the first layer has been rolled.

Prior to application of bituminous spray the base course surface shall be checked for accuracy and any irregularities shall be repaired. The surface shall then be swept clean of all loose material, foreign matter, dust and dirt. Areas contaminated by kerosene or diesel oil shall be removed and made good with clean and stable base course material.

The bitumen shall be heated in kettles of an approved type equipped with enclosed thermometers, the heat being conducted by oil or steam. Heating of bitumen in the barrels will not be permitted.

The entire area of the base course shall be sprayed uniformly at the prescribed rate by means of approved mechanical spraying equipment. Pools of excess liquid bitumen shall be sprinkled with fine sand which shall be swept off after it has absorbed the surplus bitumen.

The stone chippings shall be uniformly applied upon the entire sprayed surface. Trucks or other equipment for spreading the chippings shall be operated backwards so that the bituminous spray will be covered before wheels or workmen pass over it. Supplementary spreading and smoothing, where necessary, shall be done manually.

Following spreading and smoothing of chippings, each layer shall be rolled, to the satisfaction of the Engineer.

The completed road surface shall not be opened to traffic until permitted by the Engineer.

218.2 Drainage system

Stormwater discharge channels and drainage systems shall be installed as shown on the drawings.

Excavation limits of channels and pipes as shown on the drawings shall be extended by 10 cm at the bottom and 30 cm on either sides.

Such over excavations shall be backfilled with graded fills and compacted to the satisfaction of the Engineer.

Excavations shall have a longitudinal slope as specified by the Engineer to facilitate water discharge.

The concrete drainage channels shall be either of precast or of cast-in-place concrete complying with the requirements of division 202.

Where specified, construction and expansion joints shall be performed to the details shown on the drawings and as directed by the Engineer.

A collector fitted with a metallic grid shall be mounted on channels and pipes as shown on shop drawings.

218.3 sidewalks

Where specified on Drawings and required by the Engineer, sidewalks shall be executed.

Prior to the construction of sidewalks, the base course shall be prepared as determined in the previous articles. The Contractor shall be held liable for any future settlement of such layer.

Pavement works shall start upon the approval of the Engineer, and as shown on shop drawings.

For concrete paving, the flags shall be of an approved colour and laid in compliance with the requirements of the division 208, and in strict accordance with the lines and levels shown on shop drawings.

218.4 Concrete Kerb-Stones

Precast concrete kerbs, channels, etc. shall be to the types and dimensions shown on the Drawings and/or defined in the Particular Specification. They shall be whole, sound, without cracks, air bubbles or other defects, and shall comply with the requirements of B.S. 340. Where specified, kerbs, channels etc. shall be bedded and backed with C 15 P concrete. Joints between units shall be filled with a 1:2 cement mortar.

All kerbs, channels, etc. shall be aligned in strict accordance with the lines shown on the Drawings. Special terminal units shall be provided at the edges of the alignment. Where required, units shall be cast-in-situ to the lines and dimensions shown on Drawings.

Kerbs, channels, etc. in sharp curves shall be shorter than those used on straight lines, in order to ensure proper alignment.

202.5 testing

218.5.1 Testing on fill materials

All natural fine fills shall conform to the below listed requirements:

- i) Complete Identification Tests
 - Sieve analysis and sedimentometry
 - Atterberg limits (liquid limit, plasticity index, shrinkage)
- ii) Test on organic soils
- iii) Standard Proctor tests with complete determination of compaction diagram
- iv) Modified Proctor tests with complete determination of compaction diagram
- v) CBR tests at 95% of the maximum dry density.

The number of the aforesaid tests shall be as determined by the Engineer.

218.5.2 Tests on Backfill

Placing natural fine fill shall be controlled by the Engineer in the following manner:

Three series of the following tests shall be conducted on each backfilled layer or on every 250 m³ of placed backfills:

Measurement of moisture content
Measurement of compactness (dry density)

218.5.3 CBR tests on natural ground

CBR tests shall be conducted according to relevant standards.

The frequency of tests shall be as determined by the Engineer.

218.5.4 Tests on crushed aggregates

The required tests on crushed aggregates to be used for roads are the following:

- Measurement of the specific gravity
- Measurement of the compressive strength on 7 cm side cube
- Los Angeles test
- Sieve analysis
- tests on organic soils according to French Standards
- Measurement of the sand equivalent.

A series of tests shall be carried out on each 500 m³ of aggregates or as directed by the Engineer.

Following are the two density control tests to be carried out on site on each placed crushed aggregate layer:

- Either on each finished layer,
- Or on each 250 m³ of placed aggregates,
- Or as directed by the Engineer.

218.5.5 Tests on concrete asphalt aggregates

Following are the required tests to be carried out on concrete asphalt aggregates:

- Los Angeles Test
- Specific gravity
- Sieve analysis
- Loss in weight
- Sand equivalent
- Any other test as specified by standard ASTM D 693-54.

Three series of tests shall be conducted on each 500 m³ of furnished material or on any volume exceeding by 50% this number, as required in writing by the Engineer.

218.5.6 Tests on bitumen

- Penetration at 25° C
- Penetration at 163° C
- Ductility at 25° C
- Flash point
- Solubility in carbon sulphide at 20° C
- Paraffin content.

Whenever required in writing by the Engineer, the tests above shall be carried out on each furnished bitumen volume prior to manufacture of asphalt concrete, or on bitumen that is being used.



218.5.7 Tests on asphalt concrete mixture

The Contractor shall conduct:

- 1) Tests to determine the grading of aggregates and the bitumen content
- 2) Marshall tests to determine the stability and density of bitumen-covered aggregates.

These tests shall be carried out before the commencement of works and repeated to the satisfaction of the Engineer.

218.5.8 Quality Control Tests

- Control of grading
- Control of moisture content and temperature
- Control of bituminous mixture, 2 samples to be tested daily/mixing plant
- Control of mixing plant.

Grading control shall be conducted once a day on 10 kg of samples of aggregates before putting them in the mixing plant, and whenever required by the Engineer.

Control of moisture content and temperature shall be carried out twice a day; moisture content shall not exceed 0.5% and temperature variations $\pm 5^{\circ}\text{C}$.

The control of bituminous mixture shall be carried out on the bitumen content and grading. Each tested sample consisting of four distinct samplings shall be taken from the mixing plant at short intervals as to ascertain that the proportioning remains unchanged.

The tolerance on bitumen content is relatively $\pm 5\%$ of the measurements daily average.

Permissible tolerances are:

- $\pm 5\%$ of the percentage fixed for the average bitumen content
- $\pm 10\%$ of the percentage fixed for the corrector filler content.

218.5.9 Control of placing asphalt concrete

Throughout placing and compacting aggregates works, the temperature shall be controlled permanently in order to be $\geq 135^{\circ}\text{C}$.

After compaction, density shall be equal to 98% of the Marshall density; one core sample shall be taken of each 1000 m² of finished layer. These samples shall also be used to control the layer thickness.

Where specifically called for, the level and regularity of the surfacing shall be controlled.

No layer shall be executed by the Contractor unless the underlaying one has been duly taken over by the Engineer.

218.6 Roads - Methods of Measurement and Payment

Unless otherwise specified, roads constructed in accordance with the Drawings or on specific instructions of the Engineer, shall be measured for payment. Access and construction roads for the Contractor's own use and reinstatement of paved areas are referred to in Subsection 201.1.10 respectively, and shall not be paid for under this division.

Unless otherwise specified, roads, shoulders and sidewalks shall be measured for payment - each separately - by m² of completed road shoulder or sidewalk, classified by type of surface and/or by cross-section. The unit rates shall include for all necessary earthwork; supply, hauling, spreading and compaction of all sub-base and base materials, bituminous coatings, chippings and asphalt concrete; and for all materials, equipment and labour necessary for completing roads, shoulders or sidewalks, in accordance with the Drawings and the Specification, and to the satisfaction of the Engineer.

Concrete kerbstones, channels etc. shall be measured for payment in linear meters of kerbstone etc. in place, classified by type and size. The unit rates shall include for supply of units and all necessary materials for bedding and support, laying and jointing. The same unit rates shall be paid for both straight and curved alignment.



220 - MISCELLANEOUS SITE WORKS

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219 MISCELLANEOUS SITE WORKS

220.1 Scope

The provisions of this Chapter shall apply to the following kinds of site works:

- Fencing, including gates and wickets,
- Grassing,
- Roads and paved areas.

Other kinds of site works, if required, will be detailed in the Particular Specification.

220.2 Fencing, Gates and Wickets

Wherever shown on the Drawings or directed by the Engineer, the Contractor shall erect fences, gates and wickets. All fences, gates and wickets shall be in accordance with the layout and details shown on the Drawings and/or described in the Particular Specification.

The ground along the fence alignment shall be levelled so as to provide an even gap between the bottom wire and the ground surface.

All main and tie wires, all barbed wires and all other metal parts shall be hot-dip galvanized, unless otherwise specified or directed. The fence shall be stretched and fastened by means of approved fasteners, to the satisfaction of the Engineer. Stretching shall not be commenced until the concrete foundations have sufficiently hardened and in no case before 14 days from the pouring of the foundations.

Unless otherwise specified or directed, the entrance gates shall be double leaf and wickets single leaf, to the widths and heights shown on the Drawings, fabricated from standard galvanized water pipe and fittings including bracing, and covered with 5 x 5 cm wire mesh made of 3 mm diameter galvanized and plastic-coated wire. The gates shall be hinged to gateposts and shall be complete with locks and stops. All wires and metal parts shall be hot-dip galvanized, unless otherwise specified or directed.

Wherever called for on the Drawings or in the Particular Specification, painting shall be carried out in accordance with Subsection 207.1.5.

Fences shall be measured for payment in linear meters of finished fence, as shown on the Drawings. Gates and wickets shall be paid for per unit. The rates under this Section shall include for all materials, equipment and labour required to complete the fences, gates and wickets in place, in accordance with the Drawings and Specification, and to the satisfaction of the Engineer.

220.3 Grassing

Wherever specified or directed by the Engineer, the slopes of earth embankments shall be grassed. Areas to be grassed shall, unless otherwise specified, be covered with a layer of productive topsoil of 15 cm thickness, obtained from stripping as specified in Subsection 201.2.3 above. This topsoil shall be a fine sifted soil or silt, not less than 15 cm compacted thickness, and shall be raked and brought to a fine tilth. Should the stripped material be insufficient or, in the Engineer's opinion, unsuitable for grassing, the Contractor shall supply approved material for this purpose.

Grass shall be a tough, deep-rooted, hardy, local grass, approved by the Engineer. The grass shall be planted in adjacent, parallel, horizontal lines, not more than 20 cm apart. Tussock dibbling with bunches of grass roots will not be permitted. The grass shall be carefully maintained, watered and cut, until a good, healthy growth has been assured and the grass has spread all over the surface. Any roots washed out by rain water, or dead roots, shall be replaced at the Contractor's own expense. Manure and/or ammonium Sulfate shall be used to promote growth, where this is backward.

Grassing shall be measured for payment by square meters of grassed surface, as shown on Drawings. The unit rate shall include the preparation of the protective topsoil layer, planting of grass and its maintenance, cutting, watering and fertilizing, as specified above. The cost of supply and spreading of topsoil obtained from stripping shall be included in the payment for stripping, in accordance with Subsection 201.2.3, and shall not be paid for under this Subsection.

2- جدول الأسعار وتقدير الكميات

VOLUME 5- BILL OF QUANTITIES

BILL A - TRANSMISSION LINES

ITEM Nb	DESCRIPTION	UNIT	QUANTITY	UNIT RATE USD	TOTAL AMOUNT USD
1.0000	General				
1.0001	Site Topographic Survey	km.	6.65		
1.0002	Trial pit not exceeding 3m depth	nb	10.00		
1.0003	Trial trench not exceeding 3m depth	lin.m	20.00		
1.0004	As-built drawings	km.	6.65		
	Sub-Total 1.0000				
1.1000	Pipeworks				
1.1010	Supply of preferred C-Class ductile iron pipes including all necessary fittings (bends, tees, reducers, flanges, etc...)				
1.1011	Supply of 500 mm pipes C30	lin.m	2,450.00		
	Sub-Total 1.1010				
1.1020	Supply of HDPE pipes including all necessary fittings (bends, tees, reducers, flanges, etc...)				
1.1021	Supply of 500 mm HDPE pipes (PN10)	lin.m	4,200.00		
	Sub-Total 1.1020				
1.1200	Trench excavation				
1.1200	Trench excavation for 500 mm DI pipes	lin.m	2,450.00		
	Sub-Total 1.1200				
1.1300	Sand bedding and surrounds				
1.1300	Sand bedding for 500 mm DI pipes	lin.m	2,450.00		
	Sub-Total 1.1300				
1.1400	Laying of pipes				

1.1401	Laying of 500 mm DI pipes	lin.m	2,450.00		
1.1422	Laying of 500 mm HDPE pipes	lin.m	4,200.00		
	Sub-Total 1.1400				
1.1500	Backfilling of trenches on other roads including compaction and testing				
1.1501	Backfilling of trenches for 500 mm DI pipes	lin.m	2,450.00		
	Sub-Total 1.1500				
	Sub-Total 1.1000				
1.2000	Accessories				
1.2100	Supply and installation of Double air release valves				
1.2101	Anti-shock double air release valve including GV PN16, DN 100 mm	nb	8.00		
	Sub-Total 1.2100				
1.2200	Supply and installation of washouts				
1.2201	Washout PN16, DN 250 mm	nb	2.00		
	Sub-Total 1.2200				
1.2300	Supply and installation of Butterfly Valve				
1.2301	Butterfly Valve PN10, DN 500 mm (@ end of tunnel)	nb	1.00		
	Sub-Total 1.2300				
	Sub-Total 1.2000				
1.3000	Valve chambers and Surface box units				
1.3100	Construction of pre-cast or cast in situ, concrete valve chamber (excluding cover and frame)				
1.3101	Valve chamber internal size 200 cm x 200 cm	nb	5.00		
	Sub-Total 1.3100				
1.3200	Valve chamber cover				
1.3201	Valve chamber cover Grade A	nb	5.00		
	Sub-Total 1.3200				

1.3300	Surface box units for washouts and service connections				
1.3301	Supply and installation of surface box unit	nb	2.00		
	Sub-Total 1.3300				
	Sub-Total 1.3000				
1.4000	Concrete works				
1.4001	Mass concrete - Class C20 for blinding	cu.m	10.00		
1.4002	Mass concrete - Class C25 for pipe supports, thrust blocks, anchors, pipe bedding and surround at river crossing.	cu.m	630.00		
1.4003	Reinforced concrete - Class C25 for pipe anchors, supports, protection slabs, thrust blocks, drainage and irrigation channels	cu.m	40.00		
	Sub-Total 1.4000				
1.5000	Testing and commissioning of potable water pipes				
1.5001	Testing and commissioning of 500 mm DI pipes	lin.m	2,450.00		
1.5002	Testing and commissioning of 500 mm HDPE pipes	lin.m	4,200.00		
	Sub-Total 1.5000				
1.6000	Road Reinstatement				
1.6100	Cutting				
1.6101	Cutting of paved roads for water pipes	lin.m	2,450.00		
	Sub-Total 1.6100				
1.6200	Reinstatement				

1.6201	Reinstatement in one layer of other paved roads including recutting works	sq.m	2,735.83		
	Sub-Total 1.6200				
	Sub-Total 1.6000				
1.7000	Supply and installation of connections to existing pipes				
1.7001	Connection to existing 500mm pipes at madiq and tunnel entry. No chambers required.	nb	2.00		
1.7001	Connection to existing pipe 500mm at the highway (with 2 sectioning BVs) and required chamber.	nb	1.00		
	Sub-Total 1.7000				
1.8000	Supply and installation of bridge crossings				
1.8001	Bridge crossing - The contractor shall present calculation notes based on design assumptions and shall include calculation reports for connection detail and shop drawings.	nb	2.00		
	Sub-Total 1.8000				
2.1000	Reinforced Concrete works Grade C30/37				
2.1001	Construction of the proposed underground reservoir as per drawings, including excavation, disposal of excavated materials, reinforced concrete works, formwork, reinforcement steel, backfilling and compaction, installation of access opening, cast iron frame and cover, and all necessary materials, labor, equipment, and accessories required to complete the works in accordance with the drawings and technical specifications.	L.S	1		

2.1002	Construction of reinforced concrete wall similar to the existing one, including all necessary civil works, materials, labor, equipment, and accessories required for complete execution. Design and shop drawings shall be submitted to the engineer for approval.	cu.m	20		
	Sub-Total 2.3000				
2.2000	Asphalt works				
2.2001	Asphalt road works for approximately 50 linear meter width 6m, including compaction, asphalt and all necessary materials, labor, and equipment (on top and next to the underground reservoir).	sq.m	300		
	Sub-Total 2.4000				
TOTAL BILL A - TRANSMISSION LINE					

BILL B - GENERAL WORKS

ITEM Nb	DESCRIPTION	UNIT	QUANTITY	UNIT RATE USD	TOTAL AMOUNT USD
3.000	General				
3.001	Notice boards	nb	4		
3.002	Insurance	L.S.	1		
3.003	Site Preparation and Mobilization- Demobilization: This item shall be paid as a lump sum value. 65% of the lump sum value will be paid upon mobilization completion, and the remaining 35% after the termination of site clearance upon completion of works	L.S.	1		
3.004	Access to site	L.S.	1		
3.005	Health & Safety Measures including ventilation in the tunnel	L.S.	1		
TOTAL BILL B - GENERAL WORKS					

SUMMARY

	DESCRIPTION	AMOUNT USD
BILL A	TRANSMISSION LINE WORKS	
BILL B	GENERAL WORKS	
GRAND TOTAL		

المجموع بالأحرف:
قيمة الضريبة على القيمة المضافة بالأحرف:
قيمة الصفقة الإجمالية مع الضريبة على القيمة المضافة بالأحرف:

: العارض
 : التوقيع
 : تاريخ
 : طابع أميري





3- تصريح / تعهد

تنفيذ أعمال تمديد خط ناقل للمياه بقطر 500 ملم من محطة المضيق حتى منطقة نهر ابراهيم
وشبكه بخط قائم بقطر 500 ملم على الطريق السريع
(BEIRUT-JBEIL HIGHWAY)

أنا الموقع أدناه
الممثل بالتوقيع عن مؤسسة/شركة
المتخذ لي محل اقامة منطقة حي
شارع ملك
رقم الهاتف مكتب فاكس
البريد الالكتروني

اعترف بانني اطلعت على دفتر الشروط المتضمن التعهد، الشروط الادارية والفنية الخاصة للاشتراك في هذا التلزم التي تسلمت نسخة عنها.

واصرح انني وبعد الاطلاع على هذه المستندات التي لا يمكن باي حال الادعاء بتجاهلها وعلى تفاصيل الاعمال المطلوبة، اتعهد بقبول كافة الشروط المبينة فيها وبالتقيد بها وتنفيذها كاملة دون أي نوع من انواع التحفظ او الاستدراك.
وأنتني تقدمت لهذا الإلتزام للاشتراك ب:

كما اصرح بانني وضعت الاسعار وقبلت الاحكام المدرجة في دفتر الشروط هذا آخذاً بعين الاعتبار كل شروط التلزم ومصاعب تنفيذه في حال وجوده.

كما أتعهد برفع السرية المصرفية عن الحساب المصرفي الذي يودع فيه أو ينتقل إليه أي مبلغ من المال العام، وذلك لمصلحة الإدارة في كل عقد من أي نوع كان، يتناول مالاَ عاماً.

التاريخ
ختم وتوقيع العارض

طوابع بقيمة
مليون ليرة لبنانية

4- تصريح النزاهة

عنوان الصفقة:

.....

مؤسسة مياه بيروت وجبل لبنان

اسم العارض / المفوض بالتوقيع عن الشركة

إسم الشركة:

نحن الموقعون أدناه نؤكد ما يلي:

1- ليس لنا، أو لموظفينا، أو شركائنا، أو وكلائنا، أو المساهمين، أو المستشارين، أو أقاربهم، أي علاقات قد تؤدي إلى تضارب في المصالح بموضوع هذه الصفقة.

2- سنقوم بإبلاغ هيئة الشراء العام والجهة المتعاقدة في حال حصول أو اكتشاف تضارب في المصالح.

3- لم ولن نقوم، ولا أي من موظفينا، أو شركائنا، أو وكلائنا، أو المساهمين، أو المستشارين، أو أقاربهم، بممارسات احتيالية أو فاسدة، أو قسرية أو مُعرقلة في ما يخص عرضنا أو اقتراحنا.

4- لم نقدم، ولا أي من شركائنا، أو وكلائنا، أو المساهمين، أو المستشارين، أو أقاربهم، على دفع أي مبالغ للعاملين، أو الشركاء، أو للموظفين المشاركين بعملية الشراء بالنيابة عن الجهة المتعاقدة، أو لأي كان.

5- في حال مخالفتنا لهذا التصريح والتعهد، لن نكون مؤهلين للمشاركة في أي صفقة عمومية أيّاً كان موضوعها ونقبل سلفاً بأي تدبير إقصاء يُؤخذ بحققنا ونتعهد بملء إرادتنا بعدم المنازعة بشأنه.

إن أي معلومات كاذبة تُعرضنا للملاحقة القضائية من قبل المراجع المختصة.

التاريخ: _____

الختم والتوقيع

5- تعهد برفع السرية عن الحسابات المصرفية المتعلقة بهذا الإلتزام

أنا الموقع أدناه
المتخذ محل إقامة في
محل معترفاً باطلاعي على جدول الأسعار وتقدير الكميات ودفتر الشروط ومرفقاته العائد لـ

**تنفيذ أعمال تمديد خط ناقل للمياه بقطر 500 ملم من محطة المضيق حتى منطقة نهر ابراهيم
وشبكه بخط قائم بقطر 500 ملم على الطريق السريع (BEIRUT-JBEIL HIGHWAY)**

أتعهد، بالاستناد إلى ملف الإلتزام الذي اطلعت عليه، وعملاً بالقرار رقم 4 تاريخ 2020/4/28 الصادر عن مجلس الوزراء اللبناني المتعلق بتطبيق المادة الخامسة من قانون السرية المصرفية التي تجيز رفع السرية عن الحسابات المصرفية المتعلقة بهذا الإلتزام لصالح مؤسسة مياه بيروت وجبل لبنان، بأن أرفع السرية عن الحسابات المصرفية المتعلقة بهذا الإلتزام لصالح مؤسسة مياه بيروت وجبل لبنان، فور تبليغي قرار إسناد الإلتزام إليّ.

ربطاً

مستندات العرض المطلوبة

المتعهد

رقم الهاتف:

طابع أميري /1.000.000/ل.ل.

نُظّم في

6- تصريح بمعاينة مواقع العمل نافي للجهالة للإشتراك بمناقصة:

تنفيذ أعمال تمديد خط ناقل للمياه بقطر 500 ملم من محطة المضيق حتى منطقة نهر ابراهيم وشبكه بخط قائم بقطر 500 ملم على الطريق السريع (BEIRUT-JBEIL HIGHWAY)

أنا الموقع أدناه

بصفتي

ومفوضًا بالتوقيع من قبل

أصرح باسم

بأنني قد عاينت مواقع العمل الخاصة بالتلزم المذكور أعلاه ولن أذرع فيما بعد بالجهل أو بأي عذر آخر متعلق بحالة المواقع المذكورة.

إن المعلومات التي تقدمها سلطة التعاقد (سواء في دفتر الشروط هذا أو في غيره) هي لإرشاد العارضين المحتملين في تحضير عروضهم. على كل عارض بذل جهده الخاص للتحقق من المخاطر التجارية المرتبطة بتنفيذ الالتزام ولا تتحمل سلطة التعاقد أية مسؤولية عن أية معلومات غير صحيحة قد يحصل عليها أي عارض.

إن أية مصاريف أو تكاليف تكبدها أي عارض من أجل معاينة مواقع العمل وتقديم عرضه هي على مسؤوليته الكاملة وليس على سلطة التعاقد أي مسؤولية من أي نوع كانت مرتبطة بذلك.

التاريخ

توقيع وختم العارض

تفيد مؤسسة مياه بيروت وجبل لبنان بأن العارض الموقع أعلاه قد عاين مواقع العمل المحددة في دفتر الشروط الخاص بالصفقة برفقة مندوب من قبل الإدارة.

التاريخ

توقيع وختم سلطة التعاقد