



KARACHI WATER & SEWERAGE BOARD

GREATER KARACHI SEWERAGE PLAN- S-III

CONTRACT PACKAGE MS – 6

**Construction of New HDPE Rising Main and
other Allied Works along Manzoor Colony Drain
(From TP-II to MS-3)**

BIDDING DOCUMENTS

VOLUME-II

**SPECIFICATIONS GENERAL
SPECIFICATIONS PARTICULAR**

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WATER & ENERGY DIVISION

GREATER KARACHI SEWERAGE PLAN (S-III)

SPECIFICATIONS

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GENERAL SPECIFICATIONS

CHAPTER 1 – GENERAL

1.01 Purpose and Location of the S-III Project

Greater Karachi Sewerage Project (S-III) has been proposed to address the sewage disposal problems of Karachi city. The existing sewage disposal system not only lacks adequate treatment facilities but also requires conveyance network for the sewage currently disposed off into natural Nullahs and rivers, to divert it to the existing, and where required, new Treatment Plants.

The S-III comprises the Construction of interceptor/trunk sewers Rehabilitation / expansion existing sewerage treatment plants and installation of new sewerage treatment plants.

Generally the S-III project includes the following components.

- (i) Interceptor / Trunk Sewers Inside Lyari River for both sides catchment.
- (ii) Interceptor / Trunk Sewers Inside Malir River for both sides catchment.
- (iii) Rehabilitation / expansion of the existing treatment plants TP-I (Site Town and TP-III (Mauripur Keamari Town).
- (iv) Diversion of Sewage falling at TP-II to Malir River Interceptor through HDPE Rising Main.
- (v) New TP-IV at Korangi

The construction of trunk / interceptor sewers along the Lyari and Malir Rivers is to be awarded in sections of suitable lengths under separate construction contracts. Similarly, separate contracts will be awarded for the works of Treatment Plants.

1.02 Description of the Works (From TP-II to RCC Interceptor at MS-3)

The works under the Contract comprises of the Construction of New HDPE Rising Main and other Allied Works along Manzoor Colony Drain from TP-II to MS-3 as shown in Drawings. At EBM Causeway, the new Rising Main is to be connected to the proposed trunk sewer along Malir River, which will be constructed under a separate Contract. The Contractor shall coordinate his work with the work of the Contractor for the following section of trunk sewer to ensure proper connection

- a) The details of this contract are shown in the drawings. List of Drawings is attached in Volume-III.
- b) Other Contracts

There will be separate Contracts for the Construction of sections of New RCC Interceptors / Trunk Sewers and other Allied Works along Malir River. The works of the construction of proposed TP-IV shall also be executed under separate contract.

Malir River is a seasonal storm water channel. Heavy rains in its catchment bring heavy flood flows. During dry season, the untreated sewage disposed from both banks and groundwater, constitutes dry weather flows in a narrow channel in the river bed.

1.03 Standard Specifications

Plant, materials and workmanship shall comply with the requirements of British Standards and Codes of Practice current at the time of bid. Equivalent International Standards will be accepted by the Engineer provided their requirements are no less stringent.

Before the work start at site The Contractor shall supply two copies of each BS, EN and BSCP and other approved national or international standards which are referred to in the Specification and of each such other standard which applies to materials which are being supplied to, or workmanship which is being executed on the Works. One copy of these standards shall be available to the Engineer, and the remaining copy shall be kept by the Contractor on the Site.

All materials and workmanship not covered by a BS or BSCP or approved alternative shall be of such kind as is used in first class work and suitable for the climate in the area where the works are to be constructed, for which Engineer's decision shall be binding.

1.04 Drawings

Drawings which form part of the Contract are attached as Volume III of Contract Documents.

1.05 Record Drawings

Within twenty-eight days of the issue of Certificate of Completion, the Contractor shall provide 6 copies and one reproducible of all drawings amended to comply with the works as built. These drawings shall include:

- General arrangement drawing of the structures, pipelines and Permanent Works.
- Longitudinal sections of conduit and chambers shall be as shown on the Issued Drawings or as agreed by the Engineer.

1.06 Materials and Suppliers of Materials

Before ordering materials of any description intended for the Permanent Works, the Contractor shall submit for the approval of the Engineer the names of the makers or suppliers proposed, a specification of the materials and details of their place of manufacture. The Contractor may be required to supply to the Engineer for his retention, a copy of each order placed.

Materials used in the Works which are, or can be in contact with the untreated waste water shall be suitable for such use and shall not contain any matter which could react with the organic and inorganic matter present in the waste water resulting any damage or deterioration of the works and shall be in accordance with standard of the National Water Council of the UK or American Water Works Association or any other internationally recognized standard for conveyance system of waste water.

1.07 Climatic Data

The Contractor shall take account of the climatic conditions at the Site of the Works. The following information is provided as a guide to the climatic conditions likely to be encountered on the site to assist the Contractor, but this shall not relieve him of his responsibility under the Contract.

- (1) Monthly average temperatures:
 - a) Maximum 35 degree C
 - b) Minimum 18 degree C

- (2) Extreme Temperatures

47 degree C in June
2 degree C January

- (3) Annual Average Rainfall

192 mm per year, the majority falling in the monsoon months of July and August. On average there are 10 rainy days per year. Storm intensities can be high with storm totals reaching 200mm, with normal durations of 1 to 2 days.

- (4) Monthly Average Relative Humidity

- a) Maximum = 90%
- b) Minimum = 40%

The climatic data given above are based on limited records and their accuracy cannot therefore be guaranteed.

1.08 Other Works

(Deleted)

1.09 Programme

Before commencing the Works the Contractor shall submit to the Engineer for his approval a programme showing the order in which he proposes to carry out the Works. The programme shall be in the form of a bar chart, or any other form as may be agreed by the Engineer, and shall clearly indicate the following:

- (a) the sequence of each activity, the proposed start and completion dates of each activity, the rate of progress and the cumulative quantity or percentage of work expected to be achieved on each activity by the end of each month;
- (b) the time allocated for work by others, including those of the Employer and by utility undertakings;

The programme shall also include details of the following:

- (a) A statement giving the numbers and categories of supervisory and technical staff and skilled and unskilled workers to be employed on the Works.
- (b) A list and type details of major Constructional Plant (including vehicles) which the Contractor proposes to employ on the Works.
- (c) The contractor shall submit to the engineer for his approved detailed method statements for executing all major activities including but not limited to:
 - ♦ Setting out of works
 - ♦ Excavation dewatering , shoring
 - ♦ Disposal of suitable and unsuitable excavated materials.
 - ♦ Concrete batching, mixing, transportation, placing, compaction, finishing, curing.
 - ♦ Protective coating and backfilling
 - ♦ Placing reinforcement, forming construction and expansion joints and treatment.
 - ♦ Laying and jointing of pipes.
 - ♦ Materials and equipment to be used.
 - ♦ Expected daily or weekly production and time required for completion.
- (d) A statement giving the proposals for location or locations and sizes of base camps, accommodation, offices, workshops and stores.
- (e) Details of the programme for the Works from the date of receipt of the Engineer's order to commence the Works including a complete resources allocation showing the number of units and allotted times for each unit of Constructional Plant, materials and labour allocated to each part of the works.

1.10 Notice of Operations

The Contractor shall give written notice of all important operations to the Engineer sufficiently in advance to enable the Engineer to make such arrangements as he may consider necessary for inspection or for any other purpose. The Contractor shall not commence any important operation without the written approval of the Engineer.

The Engineer's Site supervision staff shall be working 8 hours per day, Monday to Saturday. Expense incurred due to operations beyond above stated time frame which requires Engineer's staff supervision, shall be borne by the Contractor unless otherwise provided in the contract.

1.11 Temporary Works

Not less than fourteen days before commencing any portion of the Works, the Contractor shall, if ordered, submit to the Engineer for his approval complete drawings and calculations for all Temporary Works the Contractor may be proposing for the construction of that part of the Works.

Notwithstanding approval by the Engineer of any design for the Temporary Works, the Contractor shall be entirely responsible for their efficiency, security and maintenance and for all obligations and risks in regard to such Temporary Works specified or implied in the Contract.

1.12 Water and Electricity Supply

The Contractor shall at his own cost make arrangements for the supply of water and electricity for the purposes of the Works. The Employer may allow use of water from its mains, if available in the vicinity, as per commercial tariff applicable per 1000 gallons duly metered.

1.13 Disposal of Water

Water and wastewater derived from the construction, testing and completion of the Works shall be disposed of clear of the Site to the satisfaction of the Engineer so as to cause no damage or complaint.

1.14 Contractor's Facilities

The Contractor shall provide all site facilities including offices with telephone, workshops, stores, accommodation, washing, latrines etc. necessary for use by his own staff.

The Contractor shall be responsible for making all arrangements for drainage from his site facilities and shall be responsible for payment of all charges in connection therewith. Arrangements for the supply of electricity, water and gas shall be the responsibility of the Contractor.

Works Areas for the Contract in addition to those defined as Site of the Works shall be agreed with the Engineer/ Employer.

1.15 Latrines

Throughout the period of construction of the Works the Contractor shall provide maintain and cleanse suitable and sufficient latrines for use by his employees; he shall ensure that his employees do not foul the Site but make proper use of the latrines. Where practicable the latrines shall be connected to the nearest sewer, or if this is not practicable the Contractor shall provide an adequately sized septic tank and soakaway.

1.16 Meetings and Reports

Representatives of the Contractor, approved by the Engineer, shall attend monthly progress meetings on Site or at the offices of the Employer /Engineer at any other place. In addition, approved representatives of the Contractor shall attend further meetings in cases of emergencies or for other reasons when called upon by the Employer/Engineer.

The Contractor shall submit to the Engineer each month a report on his progress in the performance of the Contract. The report shall include a copy of the approved programme with the current progress for each activity shown. No separate payment shall be made for this item. THE PROGRAMME SHOULD BE

UPDATED TO SHOW HOW COMPLETION WILL BE ACHIEVED IF THEY ARE BEHIND PROGRAMME

1.17 Contract Signboard

The Contractor shall supply and erect three or more contract signboards at locations agreed by the Engineer. The signboards shall be of substantial construction to the approval of the Engineer and the lettering, in both English and Urdu, shall be black on a yellow fluorescent background.

The layout and dimensions of the signboard shall be with the approval of the Engineer's Representative.

1.18 Level Datum

All levels stated shall be related to bench-marks established for design and shown on Drawings (Plan & Profile).

1.19 Contamination of Water Supplies

Before any person is engaged on work involving a risk to the purity of potable water supplies or deemed to involve such a risk by the Engineer, he shall be tested to indicate that he is not a carrier of typhoid or other waterborne disease and he shall be informed of the dangers of contamination. The Contractor shall notify the Engineer of any person who has been certified by a doctor as suffering from an illness associated with the looseness of the bowels, and no such person shall be employed on such work until the Employer's medical adviser is satisfied that it is safe for him to be so employed.

The Contractor shall comply with the provisions of National Environmental Quality Standards in the operation and management of his work.

1.20 Construction and Maintenance of Access Roads during the Works

On commencement of the Contract the Contractor shall be solely responsible for the construction and maintenance of the required access roads within the Site. This responsibility shall continue until the contract completion date, or until such earlier date as the Engineer may advise the Contractor in writing. In Preparing his tender, the Contractor shall take into account that the access roads under his control will also be used by the Employer and his staffs vehicles and also those of other contractors. Such work shall include general up-keeping, and any necessary repairs to damaged road surfaces, pavement, drainage, associated slopes, etc (whether caused by the Contractor's activities or not) to a reasonable standard. Any damage to access roads caused by Storm Water or by floods in the river shall be promptly made good using suitable materials. During the carrying out of reasonable maintenance work, the Contractor shall make arrangements to maintain through passage for the Employer's and his, staff's vehicles and also those of other contractors over these access roads, which may comprise temporary diversions all to the approval and satisfaction of the Engineer.

The Contractor shall not run tracked or unsprung vehicles on surfaced roads without the express approval of the Engineer who may require that planking or some other protective material be used to protect the road surface.

1.21 Existing Installations

The Contractor shall execute the Works in such a manner as to avoid interruption and interference with the operation of the existing water and sewerage conveyance system, treatment works, pumping stations and distribution systems, roads, highways existing quarters and mosques located adjacent to the Site.

Access to the existing facilities, private or public properties and businesses shall be maintained, to the satisfaction of the Engineer, at all times.

The Contractor shall apply to the Engineer in writing at least 28 days before starting any work which involves interference with existing structures, equipment, etc or otherwise interfere with or interrupt the normal operation of the existing conveyance system, pumping and treatment works, and distribution system or the traffic on public roads. The Contractor shall not execute such work until he has received permission to proceed, in writing from the Engineer.

The Contractor shall ensure that no earth, debris or rock is deposited on existing conduits, structures, public or private roads or rights of way as a result of the Works and all vehicles leaving the Site shall be cleaned accordingly.

The Contractor shall be responsible for the safety and security of existing services encountered during the course of execution of works and any damage to existing installation and services due to Contractor's operations shall be made good at his risk and cost. The Contractor shall gather the information of all services which require protection and relocations, falls within the area of works, from SSGC, KESC, PTCL, KW&SB, Local, Provincial and National Authorities responsible for the roads and highways along or across the site and any other agencies. The contractor shall strictly comply with the safety and precautions requirements as deemed necessary by the owner of the services.

1.22 Units of Measurement

All designs, drainage, specifications and manuals shall use SI (kg m s) units and all measurements, dimensions and performance data shall be quoted in those units.

1.23 Languages

All drawings, instructions, signs, notices, name-plates etc. for use in the operation and maintenance of the completed works shall be in English.

Warning signs shall be in Urdu and English.

1.24 Location of the Conduit adjacent to existing conduit

The contractor will ensure the safety and integrity of the existing conduit, Treatment Plants and services adjacent or crossing, against any damage. Sufficient equipment and materials shall always be at hand where any work is in

progress to deal with any damage to or leaks from existing conduit or other pipelines / services, all as agreed with Engineer.

1.25 Advertising

The Contractor shall not use any part of the Site for any form of advertising without the prior written approval of the Engineer.

1.26 Site Investigation Records

The site investigation if deemed necessary by the Engineer, during the execution of the work shall be carried out by the Contractor, as provided for in the Contract.

1.27 Safety and Environmental Regulations on Site

The Contractor shall comply with all statutory and other regulations concerning the safety of his site staff, operatives, staff of the Employer and Engineer and members of the public and protection of Environment, as a result of his operations. He shall obtain copies of all the relevant regulations, and shall make them available for inspection by the Engineer.

1.28 Work Affecting Water Resources

The Engineer/ Employer shall be notified in writing 14 days in advance of any intention to start any part of the works affecting a water course, canal, lake, reservoir, borehole , aquifer or catchment area.

Water courses including land and/ or road drainage within the site shall be maintained in effective working condition at all times.

All practicable measures shall be taken to prevent the deposition of site or other material in, and the pollution of, or damage to , any existing watercourse , canal, lake, reservoir, borehole , aquifer or catchment area arising from operation and acts of vandalism.

Approval shall be obtained for all temporary discharges, crossing or diversion to watercourses from the Environmental Agency, Sindh Environmental Protection Agency or other appropriate bodies, and the work shall comply in all respects with their requirements.

Any construction equipment and vehicle which, in the opinion of the Engineer/Employer, present a risk of affecting a water courses shall be removed from site.

1.29 Water Supply Hygiene

Before any person is engaged on work described in the Contract as involving Restricted Operations, they shall be notified of the need for personal hygiene and the danger of contamination, shall complete a medical questionnaire provided by the Employer and, where there is a need , shall be tested to indicate that they are not a carrier of typhoid or other waterborne disease. The Engineer/ Employer shall be notified of any person who has been certified by a doctor as suffering from an illness associated with looseness of the bowels and no such person shall be employed on such work until the Employer medical adviser is satisfied that it is safe for them to be so employed.

The requirements of the 'Principles of Water Supply Hygiene and Technical Guidance Notes' documents published in 1996 and supplemented in 1998 by Water UK shall be complied with.

1.30 Traffic Requirements

There shall be full compliance with the code of practice 'Safety at Street Works and Road Works' issued by the Provincial Roads and Highways Departments. Additionally, there shall be full compliance with the relevant provisions of the Traffic Safety Measures for Road Works, as continued in the Traffic Signs Manual Published by the National Highway Authority.

Before any work in , or affecting the use of , any highway or road is commenced, the proposed method of working, including any special traffic requirements , shall be agreed with, and confirmed in writing to, the Engineer and the Highway or Roads and Police Authorities.

All construction concerning works in, or access to, the highway or road shall be carried out in co-operation with the highway or roads and police authorities. The Engineer shall be informed of any requirements of, or arrangements made with, the highway or roads and police authorities.

Where the diversion or closure of any existing carriageway , foot way or public rights of way is temporarily necessitated by the Works, then an alternative shall be provided and maintained which shall be operational before any interference with the existing way takes place.

Where ramps are required, they shall be provided and maintained to a standard suitable in all respect for the class or classes of traffic or pedestrians requiring to use them.

All reasonable steps shall be taken to prevent vehicle entering and leaving the site, depositing mud or other debris on the surface of adjacent roads or footway, and any materials so deposited shall be removed expeditiously.

Emergency vehicle access to all properties shall be maintained at all times.

1.31 Environment and Sustainability

Construction of Civil engineering works shall be carried out in accordance with the environmental and sustainability policies as per Sindh Environmental Protection agencies guidelines. Particular note shall be taken of all mitigation measures proposed in any associated environment assessment to ensure that the construction work is carried out fully in accordance with these measures. All site operations shall be managed to minimize waste of construction materials and maximize the recycling of suitable wastes.

1.32 Diversion of sewage flows and connection to new culverts/ chambers/ structures.

Atleast 28 days before executing above works the contractor will submit his methodology for the same for review and agreement of the Engineer and the Employer. Only on their agreement of the methodology, the work shall be executed with due care, diligence and without delay.

For diversion of existing flows in the river.nullahs the contractor will propose the alignment of diversion channel along with survey of existing ground level and the cross sections of existing channel at the two ends of diversion for the approval of the Engineer. The excavated material from the diversion channel may be used for making temporary protective bunds along the channel but shall ultimately be removed and disposed off site.

The diversion channel shall be constructed of adequate dimensions. The Contractor shall proposed the X-Section of the diversion channel taking into account normal dry weather flows for review and approval of the Engineer. The diversion channel to be properly maintained throughout the construction works under the Contract.

1.33 Costs

The costs for complying with this section of specification and for all other works and services specified in the Specifications or shown on Drawings and for which there is no separate item in the Bill of Quantities, no separate payment shall be made directly and the cost thereof shall be deemed to be included in the unit rates and prices of other items in the Bill of Quantities.

CHAPTER 2 - THE SITE

2.01 Site

The extent of the Site is defined in specifications and the drawings. The Contractor shall not use the Site for any purpose not required by the Contract.

The site of proposed works is located from TP-II to Malir River Interceptor (MS-3), along Manzoor Colony Drain in Mahmoodabad.

2.02 Areas outside the Site

For the Contractor making use of any land for his temporary facilities, special or temporary wayleave or accommodation acquired by him or any tip for the disposal of surplus materials he shall obtain the written consent of the owner, occupier or authority having charge of the land in which such facilities wayleave, accommodation or tip is to be situated and shall make a record agreed by the owner, occupier or authority as aforesaid of the condition of the surface of that land before entering thereon.

The Contractor shall permit the Employer and the Engineer and any person authorized by the Employer or the Engineer access for the purposes of the Contract to any such special or temporary wayleave or additional accommodation.

In the event of the Contractor making use of any such land, special or temporary wayleave or accommodation made available to him by the Employer for the purpose of the Contract, the land in which such facilities way leave or accommodation is situated shall be deemed to be part of the Site as defined is Clause 2.01 hereof.

For the purposes of this Clause, 'accommodation' shall be deemed to include housing, offices, workshops, warehouses, storage areas concrete batching plant, casting & fabrication yards and disposal areas etc.

2.03 Access to Site

Access to the Site from different places is as shown in the Plan and / or as indicated in Section 1 of General Specifications.

The Contractor shall where necessary provide access to and through the site to adjacent properties as well as to other agencies / Contractor who might be executing any development work for the city Govt. Karachi or for any other agencies and coordinate his work with these agencies / Contractor.

Before the commencement of any part of the Works, the Contractor shall make temporary access tracks including temporary diversions, approach roads, temporary roads inside river and along existing roads for movement of vehicles, transporting Pipe lines and other Construction material during execution of the work with approval of the Engineer. The Contractor shall maintain such access tracks in a condition suitable for the safe and easy passage of plant, vehicles and pedestrians required for the purpose of the Contract.

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

2.04 Clearance and Reinstatement of Site

The Contractor shall clear the Site of all vegetation, trees, hutments, obstructions, temporary structures, any organic / inorganic waste, heaps, dumps etc. to the extent required by the Engineer for checking the setting-out. The Contractor shall also ensure that the parts of the Site to be occupied by the Permanent Works are clear and maintain the remainder of the Site as may be required for access and Temporary Works areas.

The existing flows from drains/ sewers entering the Lyari River shall be maintained until completion of permanent works. Where required diversion channels shall be constructed to clear the area for construction of works. Some parts of the river bed may be under cultivation. No standing crops and the irrigation channels will be damaged or blocked by the construction operations unless suitable diversion of channel has been provided with the consent of owners of such cultivation.

Work along roads shall not obstruct the traffic or block access to properties. Where required temporary diversion with safety signs and warning lights shall be provided in consultation with the concerned roads/ highway department / agency.

The Contractor shall remove the material arising from site clearance and dispose off it in a manner and at a location, away from the site and inhabitant areas, no obstruction shall be caused to the existing traffic and adjacent properties and no excavated material shall be dumped or stock pile at site but removed directly to disposal areas identified by the Contractor, to the approval of the Engineer.

No heavy equipment plant whether mobile or stationery shall be allowed to come nearer than 1.5 m of the existing water, gas and sewage conveyance Pipeline/ structures. For this purpose such structures and pipelines shall be protected by erecting warning fence or barricades.

The Contractor shall fill and make good with appropriate materials those cavities and losses of soil which result from clearing the parts of the Site not subsequently to be occupied by the Permanent Works.

The Contractor shall not clear the Site of any structure without the prior written permission of the Engineer.

2.05 Condition of Site

The Contractor shall maintain the Site in a neat, tidy and healthy condition for the whole of such time as he is responsible for the care of the Works.

2.06 Site Records

The Contractor shall make records of the position and extent in the excavations of every type of service, stratum and obstruction encountered during the construction of the Works.

2.07 Permits

The Contractor shall be fully responsible for obtaining necessary permits and permissions, except those normally obtained by the Employer or Engineer, prior to commencement of the Works.

2.08 Protection of Works against Flooding

Part / whole of the site is located in a riverbed prone to flooding by storm water. The Contractor shall ensure the protection of all temporary and permanent works including plants, materials and equipment against flooding caused by Storm Water flow in river / nala as well as recurrent rains or any other reasons, during the course of execution of works. Before the commencement of works the Contractor will submit its detail work methodology, for Engineer's approval, showing manners to divert the existing flows in the river/nala away from the work area to be acquired in orderly state. The Contractor shall maintain such flow diversions in part or as a whole till the works have been completed or covered in accordance with drawing, specifications or as directed by the Engineer.

In addition to above, if water or sewage from any other source, whether within working site or from adjacent areas, affects the site & works, the same shall be diverted / removed safely away from the site by the Contractor. If any damage to works occurs on such accounts the same shall be made good by the Contractor.

During floods the entire site within the river is affected by storm water floods, the Contractor will need to complete sections and backfill the same for protection with proper plug wall at both ends before the onset of rainy seasons and shall allow for the same in his program of works and his bid price.

2.09 Costs

The costs for complying with this section of specification shall not be paid separately and shall be included in the Contractor's rates and prices of the Bill of Quantities unless other wise specified or provided for in the Bill of Quantities.

CHAPTER 3- MATERIALS AND WORKMANSHIP

3.01 Standard Specifications

Except where otherwise specified plant, materials and workmanship shall comply with the requirements of the relevant British Standards and Codes of Practice (hereinafter referred to as BS or CP) issued by the British Standards Institution. Other equivalent National or International Standard Specifications may be substituted at the sole discretion of the Engineer or as may have been agreed in the Contract. All standards used will be the current version at the time of bidding.

The Contractor shall obtain at least one copy of each BS, CP or other approved standard and reference work which is referred to in the Specification, and of each other standard which applies to materials which are being supplied to, or workmanship executed on, the Works. These standards and reference works shall be supplied to the Engineer within 60 days of the Engineer's order to commence the Works and will be available to the Contractor at all reasonable times.

All materials and workmanship not fully specified herein or covered by an approved standard shall be of such kind as is used in first class work and suitable to the climate in the project area, for which Engineer's decision is a binding.

A list of standards and other publications referred to in the Specification is given in respective sections.

3.02 Suppliers of Materials

Before ordering material of any description intended for the Permanent Works, the Contractor shall submit for the approval of the Engineer the names of the maker or supplier proposed, a specification of the material and details of the place of origin or manufacture. If it is found necessary, tests regarding its compatibility with specifications be carried out and approved at external facility. If requested by the Engineer the Contractor shall supply to the Engineer for his retention, a copy of any such order placed.

All materials used in the Permanent Works must be new, unless the use of old or refurbished material is expressly permitted by the Specification or the Engineer.

3.03 Natural Materials

The Contractor shall make all arrangements for locating, selecting, and processing natural materials to comply with the Specification and shall submit to the Engineer for approval full information regarding the proposed quarry/ source location well in advance of commencement of use of the material. Approval of a source shall not imply that all material in that location is approved.

3.04 Sampling

The Contractor shall provide the Engineer with samples of materials necessary for testing in accordance with the Contract. Unless expressly excused the Contractor shall also provide samples of all manufactured items required for the Permanent Works, or alternatively the Contractor shall submit trade literature where the provision of samples, in the first instance, is impracticable.

All material, samples of which are rejected by the Engineer shall be removed from Site. All approved samples shall be stored on Site by the Contractor for the duration of the Contract, and any materials or manufactured items subsequently delivered to Site for incorporation to the Permanent Works shall be of a quality at least equal to the approved sample.

3.05 Laboratory Facilities

The Contractor shall, for the duration of the Contract, supply maintain and operate a materials testing laboratory at site necessary for sampling, preparing and testing materials as specified. The Contractor may also use an off-site testing laboratory to perform certain of the specified tests. Calibration certificates shall be provided for testing apparatus. Both the laboratory and the tests shall be to the approval of the Engineer, such approval shall not be given if significant delays in obtaining results are likely, or if the results may be unreliable. The Contractor shall make all the necessary arrangements and provide all transport and labour for conveying the samples to the approved laboratory, and shall ensure that any results are conveyed to the Engineer's Representative promptly. The Engineer's approval will be withdrawn if the service proves in any way unsatisfactory.

The Contractor shall provide trained and qualified Material Engineer, technicians and skilled labour to carryout specified tests to the satisfaction of the Engineers representative. The Material Engineer and technicians shall be approved by the Engineer. In case of unsatisfactory performance such approval will be withdrawn and the Contractor shall arrange for suitable replacements for approval by the Engineer's representative.

The Engineer and his supervisory staff shall have access to the laboratory to supervise testing and to witness verification tests ordered by the Engineer or his staff.

The Contractor shall keep records of all tests he conducts in connection with compliance with, and as required by, the Specification, and shall supply copies of the results of such tests to the Engineer's Representative as soon as practicable after each test is made.

Notwithstanding the above the Contractor shall supply, maintain and operate all the necessary apparatus for certain tests which shall be carried out within the Permanent Works or elsewhere on the Site as directed by the Engineer; these tests are as follows:

Concrete Tests

- | | | |
|-----|--|----------------------|
| (a) | Slump test | to BS 1881: Part 102 |
| (b) | Aggregate moisture test
for determination of water/cement ratio | to BS 812 : Part 2 |
| (c) | Concrete cube crushing strength test | to BS 1881 |
| (d) | Elongation and flakiness of aggregate | to BS 812 : Part 1 |
| (e) | Gradation of Aggregates | |
| (f) | Soundness of the aggregates | to ASTM C 88 |

The Contractor shall be responsible for making and curing test cubes in accordance with BS 1881: Part 109 and for measuring the temperature of atmosphere, formwork, concrete constituents and concrete itself as directed by the Engineer from time to time, and shall provide and maintain the equipment for so doing.

Soil Compaction Tests

- | | | |
|-----|--|---|
| (a) | Determination of the dry density/moisture content relationship of soil | to BS 1377 (Test Nr 12 – 2.5 kg rammer) |
| (b) | Determination of the dry density of soil | to BS 1377 (Test Nr 15) |
| (c) | Sand replacement test | to BS 1377 |
| (d) | Determination of organic matter content in soil | to BS 1377 |
| (e) | Atterberg limit tests | to BS 1377 |
| (f) | Soil gradation analysis by mechanically vibrated sieves (all sizes as per BS 410) | to BS 1377 |
| (g) | Soil gradation by Hydrometer (longstem type calibrated at 20° C) | to BS 1377 |
| (h) | Determination of sulphates content as SO ₃ | to BS 1377 |
| (i) | Determination of Gypsum (CaSO ₄ . 2H ₂ O) content in soils | to BS 1377 |
| (j) | Testing of water samples for electrical conductivity, soluble Cations and Anions, PH and dissolved solids etc. | to BS 1377 |

In addition the following equipment will also be required:

- 1 Nr drying oven of a type approved by the Engineer and suitable for soil testing;
- 1 set Speedy Moisture Tester with balance and soil moisture absorbent, complete set in wooden case (for soil sample, 13 grammes);
- Spare Speedy Moisture absorbent, Calcium Carbide

3.06 Costs

The costs for complying with this section of specification shall not be paid separately and shall be included in the Contractor's rates and prices of the Bill of Quantities.

PARTICULAR SPECIFICATIONS

CHAPTER 4 - EARTHWORKS

4.01 General

The Contractor shall make excavations and dispose off excavated materials all as specified here in, shown on Drawings or ordered by the Engineer and referred to herein as earthworks.

No heavy equipment shall be allowed on top of and within 1.2m of the existing sewer conduit nor any material shall be allowed to be stored within this area. The contractor shall exercise all care and take special measures to avoid any damage due to his operations to the existing services. Any harm to the existing services or development of any cracks from it shall be promptly notified to the Engineer and immediate control measures shall be taken to prevent aggravation of the damage. Necessary repairs shall be carried out as directed by the Engineer before proceeding further with the work. Before starting the excavation works, the contractor shall arrange, provide and store at site materials and equipment which may be required to deal with any such emergency situation, in consultation with the Engineer.

Any damage caused to the existing services or structures due to contractor's negligence shall be remedied and made good at no cost to the Employer.

Investigations to establish soil characteristics and ground water levels are to be undertaken by the Contractor. The investigation shall at least include:-

- Sufficient number of boreholes to minimum 3.0 m depth below the formation level or as directed by the Engineer.
- Sampling
- Insitu and Laboratory Testing.
- Trial pits in the roads or vicinity to locate existing sub surface utilities / services.

Where water levels are found to be higher than 1.0m below a structure's formation the Engineer may instruct the water depths in the borehole to be monitored daily for up to a month.

4.01.1 Excavation in Roads

Excavation in or across roads and streets shall be carried out with the permission of and in accordance with the operating procedure of the concerned road or Highway Agency/ Department.

4.01.2 Supporting excavations

The sides of excavations shall be adequately supported at all times and, except where described in or permitted under the Contract, shall not be battered.

4.02 Notice of Earthworks

Before commencing any earthworks on the Site the Contractor shall give the Engineer at least 7 days written notice of the proposed date, which shall not be less than 7 days after the appropriate part of the site has been cleared. Within this period the Contractor shall make a record of the ground levels and topography to the satisfaction of the Engineer for the measurement of the Works.

4.03 Ground Level

For the purpose of the Specification the term ground level shall refer to the ground surface at the time of commencement of the work. The ground levels will be recorded jointly with the Engineer after clearance of site as per Clause 2.04.

4.04 Excavation of Unsound Material

If any unsound material occurs in the bottom of any excavation, the Contractor shall remove it and dispose off it to the satisfaction of the Engineer. Unless otherwise specified or ordered by the Engineer, the Contractor shall fill the voids so formed with concrete Class 10/20 in the formation to structures, with the same material as that which comprises the sides of excavation and with suitable granular material to the approval of the Engineer in the case of pipelines formation.

If the Contractor encounters material which to his opinion may be unsound, he shall immediately inform the Engineer, who will instruct the Contractor in writing as to whether the said material shall be treated as unsound, provided that the Engineer will give no such instruction except in accordance with Conditions of Contract. The omission by the Engineer to give an instruction shall not relieve the Contractor from any responsibility for defects in the work, if, prior to construction, the Contractor shall have failed to request the Engineer in writing to inspect the exposed foundation.

4.05 Safety of Excavation and Adjacent Structures

The proposed Trunk Sewers/Conduit of different sections are to be constructed in the vicinity the existing services / structures. The Contractor shall provide support necessary to ensure the stability of the excavation and the existing services and other structures.

Unless otherwise approved (e.g. when both foundations are in sound rock), where separate excavations are made to different depths for parts of the works close to each other, whether concurrently or not, then the foundation of the one shall be deepened and filled with concrete Class 10/20 or the backfill to the other made with concrete Class 10/20, whichever shall be constructed first, such that foundation pressure stress lines drawn at 40 degrees to the horizontal lie either entirely in undisturbed ground or in concrete Class 10/20 or better.

4.06 Slips, Falls and Excess Excavation

The Contractor shall prevent slips and falls of material from the sides of the excavation.

The Contractor should make sure the availability of adequate resources at site to deal with any slips or falls situation. In the event of slips or falls occurring in the excavations, and where excavations are made in excess of the dimensions of the permanent works, the voids so formed shall be filled by the Contractor. When such voids, in the opinion of the Engineer, may affect the stability of the ground for the support of the works, or of the adjacent structures and services, the Contractor shall fill the void solid with concrete Class 10/20. In other cases the Contractor shall fill the voids with selected excavated material placed and compacted to the approval of the Engineer. Filling of voids with concrete Class 10/20 or with selected excavated material, shall be done at no additional cost to the Employer.

There shall be no additional payments for preventing slips, falls and excess excavation, beyond the excavation pay-line shown on drawings, and it deemed to be covered in relevant BOQ pay item for excavation.

4.07 Dewatering

The Contractor shall keep all concrete works and pipeline excavation clear of water during construction. Water shall not be allowed to pond anywhere within excavations. Any drainage sumps required shall, where practicable, be sited outside the area excavated for the Works and shall be refilled with appropriate material to the level of the adjacent permanent works. In the case of structures being constructed in saline groundwater having total dissolved solids content in excess of 5000 mg/l, for such further period as may be necessary to avoid the submersion of concrete within 3 days of its being placed. The method of keeping excavations clear of water, dewatering, and disposal of water, shall be subject to the approval of the Engineer.

The Contractor shall ensure that sufficient standby plant is on Site at all times to avoid any interruption in continuity of the dewatering. In the vicinity of the existing services and other structures, dewatering shall be carried out by establishing well points, lowering of the groundwater level to below the required excavation level and maintaining the same till concrete is cast and is minimum 3 days old.

The well points for dewatering shall be located at safe distance from the foundation of existing services to avoid any settlement or other damage to the same. All necessary precautions shall be taken to prevent any adjacent ground from being adversely affected by loss of fines through any dewatering process.

The contractor shall submit his dewatering plan with details of equipment, for approval of the Engineer minimum 28 days in advance of excavation work.

4.08 Preparation of Formations for Structures

All excavation within 600mm of existing services and other structures shall be carried out very carefully by hand. Where the formation of any excavation, being other than rock, is to support the foundations or floor of a structure, the bottom 150 mm thereof shall be carefully excavated and trimmed immediately before placing the permanent work upon it. Formation in granular material shall be compacted using suitable type compactors.

The standard compaction requirement will be 95% of Maximum Dry Density unless otherwise specified or shown on the drawing. All testing shall be in accordance with BS 1377.

4.09 Backfill and Fill

Unless otherwise specified or approved the material used for backfill and fill shall be material selected from the excavated material of particle size not exceeding 100 mm.

Backfilling against the permanent work shall be selected, and free from boulders, cobbles, rock fragments and the like greater than 50 mm nominal size, unless otherwise specified or approved.

Backfilling shall not commence until the Works to be covered have achieved a strength to withstand all loading imposed thereon. After approval has been given by the Engineer for filling or backfilling to commence, the operation shall start immediately and shall continue until the work is completed in the part of the Works for which the approval is given.

4.10 Scarification

The Contractor shall scarify to a depth of 150 mm the ground upon which compaction of fill is specified. He shall ensure that no vegetation remains in the area to be covered by the Works, and shall if necessary bring the moisture content of the specified surface material to its optimum value before placing and compacting any fill thereon.

The Contractor shall similarly treat the surface of any fill which in the opinion of the Engineer has been exposed too long before the placing of subsequent fill thereon.

4.11 Compaction of Fill and Backfill

Unless otherwise specified or shown on the drawing, the Contractor shall deposit fill or backfill in layers of uniform depth not exceeding 200 mm thick and shall compact it by methods and with the use of such Constructional Plant as are necessary to achieve the degree of compaction specified. The layers shall have a slight cross-fall away from the permanent work. Where no degree of compaction is specified the fill or backfill shall be compacted by the even distribution over it of the passage of earthmoving plant and labour.

Where the degree of compaction is expressed as a percentage, it is the percent ratio of the dry density of the compacted material to the maximum dry density as determined by the compaction test in BS 1377 (Test No. 12-2.5 kg rammer). At least one month before commencing such compaction of the fill in the Works, the Contractor shall submit to the Engineer details of the method and Constructional Plant proposed to be used, and shall make such tests of the materials before and after compaction as the Engineer considers necessary, both of the trials and of the permanent work, to ascertain to his satisfaction that the degree of compaction specified is achieved. The standard compaction requirement will be 95% of

Maximum Dry Density unless otherwise specified or shown on the drawing. All testing shall be in accordance with BS 1377.

The Contractor shall if necessary wet the fill material prior to and during compaction so that its moisture content lies within a range of values suitable for the fill material and the adopted method of compaction as may be established by prior trials on Site.

4.12 Hardcore Filling

Hardcore shall be clean, broken stone that will pass in all directions through a 100 mm ring. Hardcore shall be well packed and compacted to a CBR value of at least 25% as measured in accordance with Test Nr 16 of BS 1377. Sand may be added to hardcore to achieve this degree of compaction.

Reinstatement

For Reinstatement of roads and unpaved land the requirements of Section 8 of the specifications shall be complied with.

4.13 Allowance for Settlement

The Contractor shall make due allowance for consolidation and settlement of fill and compacted fill such that the levels and dimensions of the finished surfaces at the end of the Period of Maintenance are not less than those specified, shown on Drawings or ordered by the Engineer.

4.14 Location of Borrow Pits

The Contractor shall select for himself the sites of borrow Pits for obtaining suitable material for fill or back fill subject to the written approval of the owner or concerned local authority.

4.15 Works at Borrow Pits

The Contractor shall prepare and submit in detail for the approval of the Engineer his proposal for the use of borrow pits and shall give notice to the Engineer in writing at least one month before the proposed date of starting earthworks at the site of each borrow pit.

4.16 Disposal of Surplus Material

Surplus material shall be disposed of away from site all at contractors risk and cost. No surplus material shall be left or dumped in the beds of river, drains, channels.

4.17 Surplus Material Dumps

surplus materials may be dumped at sites designated by Local Authorities/ City Govt for the purpose and according to their instruction.

4.18 Construction Methods

Construction of the RCC conduit or laying of trunk sewers shall be carried out using only suitable excavation equipment of such types and in such numbers as is appropriate to a contract of the scale and complexity of this Contract, all subject to the approval of the Engineer. Use of vibratory or pneumatic equipment for excavation is not permitted unless specifically permitted by the Engineer. The heavy earthmoving equipment shall not be brought within a distance of 1.2 meter from the face of the existing / sewer conduit/ service and no equipment shall be allowed over these. Full details of the Contractor's proposed method of working and earth moving plant shall be provided in accordance with the instructions for bidding.

4.19 Excavation and Disposal

The Contractor shall prepare a plan of earthworks operation for each particular part of the Works to be constructed at any one time, detailing the location and programme of excavation and of disposing the spoil etc. The Contractor shall submit his proposed plan at least 28 days before his intended date to commence earthworks on each particular part of the system for Engineer's approval.

4.20 Embankments

Backfill or fill for ramps shall unless otherwise specified be formed from the suitable material excavated from the site of the Permanent Works, if available. Where material is required additional to that available from such excavated, or where so specified, it shall be obtained from borrow areas under the terms of Clause 4.14.

The Contractor in consultation with the Engineer will maintain a frequency and pattern of compaction testing to ensure that the Contractor is maintaining a working cycle which achieves the required compaction.

4.21 Rock

During construction of conduit / laying of trunk sewers under S-III project, where rock is required to be excavated, before commencement of excavation in rock the Contractor shall demonstrate to the satisfaction of the Engineer his inability to excavate without resort to heavy percussion tools complete with rock bits, or hydraulic wedges. Where reasonable progress can be made with the aid of ripping tools the material will not be considered to be rock.

Use of jack hammers, and vibratory tools in proximity of existing services/structures shall only be allowed by the Engineer after determining the contractor inability to excavate such portion with the aid of ripping tools. Any such approval shall not relieve the contractor from his obligations under clause 4.05 of Technical Specifications. No blasting is permitted within the limits of site.

Prior to the commencement of the excavation of any material which the Contractor considers may be rock, the Contractor shall advise the Engineer of the presence of such material and the said material shall not be classified as rock unless the Engineer has agreed to such classification before excavation commences. The Engineer's agreement shall be subject to reservations on the extent of the rock so

classified and the extent of the rock excavation shall be determined after examination of the excavated faces. Excavations where rock has been encountered and classified as such shall not be backfilled before examination of the excavated faces by the Engineer to enable the extent of the rock excavation to be determined.

4.22 Rubble and Loose Rock

Where stone pitching rip-rap or scour protection and rock fill on existing services and structures are to be removed, the stones shall be stockpiled outside the work area for later use in the same works. Additional quantities of stone and granular filter layer shall be provided by the contractor to complete the work as shown on Drawings.

Where backfill or fill is shown as "rubble" or "loose rock", for example for soak away from septic tanks, the material shall consist of durable gravel, broken stone or crushed concrete with a particle size not exceeding 100 mm. The grading of the material shall be such that there is no migration of fines into the fill and not more than 10% of material shall pass a BS sieve with 5 mm apertures.

The method of placing shall be to the approval of the Engineer and shall ensure that fines separating out during transportation are discarded or selectively placed.

There shall be no compaction or working of the material except that necessary to give a stable fills.

Before covering rubble or loose rock with other fill the surface shall be blinded with a layer of selected fill that closes the surface voids only. The initial layer of covering fill shall not be watered.

CHAPTER 5 - CONCRETE & REINFORCEMENT

The reinforced concrete conduits and appurtenance structures have been designed in accordance with recommendations contained in BS EN 1992-3:2006 and BS EN 1992-1-1:2004. Construction of reinforced water retaining and other structures will in general comply with the relevant provisions of BS EN 1992-1-1:2004 and BS EN 1992-3:2006. The specific requirements made in this Chapter take precedence over those in BS EN 1992-1-1:2004 or BS EN 1992-3:2006.

5.01 Cement

(a) General

Unless otherwise specified the cement used in the Works shall be ordinary Portland cement (OPC) complying with BS EN 197-1:2000. Where specified or ordered Sulphate Resisting Cement (SRC) complying with BS 4027 shall be used. For the purpose of BS EN 197-1:2000, the Site shall be deemed to be at a tropical climate. The Contractor shall supply the manufacturer's test certificate for each consignment of cement received at the Site as provided for in Clause 10 of BS EN 197-1:2000. He shall maintain a record, available for inspection by the Engineer, of the locations of concrete from each consignment.

The Contractor shall supply samples of cement, when requested by the Engineer's Representative, both from any store on Site and the place of manufacture. All cement supply should be consumed within three (3) months from the date of its production, cement aged more than three (3) months from the date of its production, shall not be permitted to be used in permanent works.

The Contractor shall ascertain whether the alkali content of proposed cement is greater than 0.6% calculated as $\text{Na}_2\text{O} + 0.658 \text{ K}_2\text{O}$. For alkali contents greater than 0.6% the Engineer may require tests in accordance with BS 4550: Part 2 to determine the alkali content of the cement.

The necessary apparatus shall be maintained on Site to conduct preliminary and works tests as required by the Engineer to determine fineness, compressive strength (mortar cube), initial and final setting time and soundness of the cement, as described in BS 4550 : Part 3.

(b) Other cementitious materials

Pulverized fuel ash (PFA) to be used as a cementitious material in concrete shall comply with BS 3892 Part 1. PFA shall not be used in conjunction with sulphate resisting cement.

Ground granulated blast furnace slag (GGBS), to be used as a cementitious material with Portland cement, shall comply with BS EN 15167-1:2006 and BS EN 15167-2:2006.

5.02 Aggregates

Aggregates for concrete shall comply with the current BS EN 12620:2002 at the time of use.

Fine aggregate shall consist of natural sand. The Engineer will permit the addition of suitable crushed rock fine aggregate, as necessary, to the sand where in his opinion it is impracticable to obtain the specified grading of the combined aggregate, otherwise other than by such addition. The maximum quantities of clay, silt and Fine dust shall, in any event, not exceed 3 % by weight when using the test given in Clause 7.2.4 of BS EN 932-5:2000: Part 1.

Coarse aggregate shall comply with the requirements in Table 4 of BS EN 12620:2002 for single sized aggregates to the nominal maximum size specified for the appropriate class of concrete and shall be made up of the following grading.

- (a) 40 mm single sized
- (b) 20 mm single sized
- (c) 10 mm single sized

The shape of the aggregate shall be rounded, or irregular or angular as defined in BS EN 932-5:2000: Part 1. The flakiness index, as determined in accordance with BS EN 932-5:2000: Part 1, shall not exceed 35 and the 10% fine value, as determined by BS EN 932-5:2000: Part 3, shall be greater than 50 kN.

The aggregates shall be such that concrete when made and tested in accordance with Building Research Establishment Digest 35 (2nd series) shall not show a drying shrinkage greater than 0.065%.

The water absorption of aggregates to be used for class C35A concrete for water retaining structures shall not exceed 3 % when measured in accordance with BS812: Part 2.

The soundness of the aggregate, as determined in accordance with ASTM C 88 using magnesium sulphate with 5 cycles, shall not show a loss of greater than 15% for fine aggregate and 18% for coarse aggregate.

Immediately after commencement of the Works, the Contractor shall supply samples of proposed aggregates for preliminary tests of compliance with the Specification to the satisfaction of the Engineer before the Engineer will give approval to the source of aggregates proposed by the Contractor. Alternatively, and subject to the approval of the circumstances by the Engineer, the Contractor may submit a Certificate from an independent laboratory acceptable to the Engineer.

Where 40 mm nominal maximum size coarse aggregate is specified it shall consist of a mix of 40 mm single sized aggregate, 20 mm single sized aggregate and 10 mm single sized aggregate.

During the performance of the Contract, the Contractor shall supply samples of aggregates when required by the Engineer for testing (the samples shall be taken in accordance with BS EN 932-5:2000). Testing of all specified requirements will be performed weekly for each source at each grading approved by the Engineer, unless otherwise instructed by the Engineer.

Any rejected aggregate shall be removed from Site within 3 days.

To determine the potential reactivity of the aggregate and the cement aggregate combinations, the Contractor shall carry out tests in accordance with ASTM C 227 and ASTM C 289.

Should the results of the tests prove unsatisfactory the Contractor shall make provision for the employment of low-alkali content cement to the approval of the Engineer.

5.03 Water

The water used for making and curing concrete shall generally be of drinking water quality and shall be from a source approved by the Engineer and at the time of use shall be free from polluting matter in any quantity which,

- (a) affects the initial setting time of the cement by more than 30 minutes or reduces the compressive strength of test cubes by more than 20% when tested in accordance with BS EN 1008:2002,
- (b) prevents the achievement of the specified test cube strengths at 28 days for the appropriate class of concrete,
- (c) produces discoloration or efflorescence on the surface of the hardened concrete.

The water shall be free from hydrocarbons and from suspended organic matter. Inorganic matter in solution shall not exceed 500 mg/l by weight and in suspension shall not exceed 50 mg/l by weight.

The water which the Contractor proposes shall be tested to the approval of the Engineer before use in the permanent works.

Regular tests of the water shall be made during construction of the Works. The water shall be sampled at the point of discharge into the mix and the frequency of sampling shall be as approved by the Engineer. The Contractor shall supply two copies of each test result to Engineer's Representative.

5.04 Admixtures

Concrete shall be made from cement, aggregates and water as specified. No other ingredient shall be mixed with the concrete or mortar without the Engineer's approval.

If the Contractor proposes to use retarding or workability agents then the manufacturer's literature must be supplied giving typical dosage, effects of incorrect dosage, the amount of air entrainment associated with its use, and the chloride ion

content by weight of admixture. The Engineer's approval to the use of admixtures shall be subject to the following conditions:

- (a) No reduction of target mean strength compared with additive-free concrete of the same class.
- (b) No change in specified cement or effective water cement ratio.
- (c) No corrosive effect on reinforcement steel.
- (d) Dosage and admixture strictly in accordance with the manufacturer's instruction in respect of the specific conditions obtaining. Dosage to be by approved dispenser, to within 5% of the required amount.

If air entrainment is approved the air content shall be 4% for concrete with a maximum aggregate size of 40mm and 5% of concrete with maximum aggregate size of 20mm, an allowable tolerance of $\pm 1.5\%$.

The method of determining the air content shall be in accordance with BS 1881: Part 106 and the Contractor shall supply the necessary apparatus so that the Engineer may check the air content. If the average air content is greater or less than that specified or the range is greater than 2%, before any further concrete is used in the Works the Contractor shall take such steps as may be agreed with the Engineer to adjust the air content of the concrete or improve its uniformity.

5.05 Chemicals in Concrete Materials

The total sulphate content, whether as gypsum or more soluble salts of concrete ingredients when measured as sulphur trioxide shall together not exceed 4.0% of the weight of cement in the concrete.

The chloride content of concrete ingredients when measured as Cl shall together not exceed 0.3 % of the weight of cement in concrete using OPC cement and 0.06% of the weight of cement in concrete using SRC.

The sulphate and chloride contents shall be established using the following tests:

	Sulphate	Chloride
Aggregate	BS 1377, Test 9	BS EN 932-5:2000 : Part 4
Cement	BS 4550: Part 2 Clause 12	BS 4550: Part 2 Clause 17
Water	BS 1377, Test 10	BS EN 932-5:2000 : Part 4

The contribution of any admixture must also be included. Testing will be weekly, or as directed by the Engineer. When the acid soluble alkali content of the cement is greater than 0.6% (calculated as $\text{Na}_2\text{O} + 0.658 \text{ K}_2\text{O}$) the Contractor must demonstrate that no adverse alkali-silica reaction is likely. This may be done by determining the alkali content of cement, in accordance with BS 4550: Part 2 and establishing the alkali content of the concrete. Any concrete containing less than 3.0 kg/m³ may be considered not at risk. In the event of higher alkali contents a sample

of aggregate from each source must be tested in accordance with ASTM C 227. Any aggregate source showing an expansion greater than 0.05% at 3 months shall not be approved.

5.06 Reinforcement

All Reinforcement shall be high yield deformed bars conforming to ASTM A-615 with minimum yield strength of 420 N/mm².

The Contractor shall supply the Engineer's Representative with certificates of the manufacturer issued in accordance with the requirement of ASTM A-615, for all the required tests including the rebend test in respect of each consignment delivered to Site.

Steel fabric reinforcement shall comply with BS 4483.

The reinforcement at the time of incorporation in the Permanent Works shall be clean and free from damage, oil or grease, loose mill scale and loose rust. Bars which have become bent shall not be straightened or reheat for incorporation in the Works without the approval of the Engineer.

Steel reinforcement shall be stored clear of the ground and supported to prevent distortion. The Contractor shall supply samples of reinforcement from the stocks on Site and arrange to test these for tensile strength as per ASTM A-615 in presence of Engineers Representative at a laboratory approved by the Engineer.

5.07 Reinforcement Details

The Contractor shall ascertain for himself from the information given on the Drawings and in the Specification the precise requirements of steel reinforcement to be obtained for the Permanent Works. The Contractor shall prepare bending schedules and submit them to the Engineer at least 28 days prior to fixing the respective reinforcement.

All concrete other than that described on the Drawings or in the Bill of Quantities as mass, blinding or screed, shall be assumed to be reinforced.

5.08 Waterstops

The Contractor shall supply and fix waterstops to all expansion, contraction and construction joints where shown on the Drawings and as directed by the Engineer.

The number of joints made, on Site shall be kept to a minimum. Any jointing of PVC waterstops on Site shall be by the process of heat fusion using an appropriate jig and heating blade all in accordance with the manufacturer's recommendations.

The minimum dimensions of water-stops shall be as tabulated below (all dimensions in mm):

Width	Web	Edge bulb*	Centre bulb*	Edge bulb**
-------	-----	------------	--------------	-------------

Thickness	diameter	int. diameter	height	
250	4.5	12.5	8	-
250	4.5	12.5	8	-
250	4.5	19	10	22

Notes; * Internal waterstop only

** External waterstops only

Unless otherwise shown on the Drawings, the width of the waterstop shall be at least equal to the thickness of the concrete member to which it is embedded, up to a maximum width of 250 mm.

The edge bulb section of internal waterstops shall be circular or semicircular. The centre bulb should be hollow or as directed by the Engineer.

The waterstop shall be carefully maintained in the position shown on the Drawings and properly protected from damage and the harmful effects of light and heat during all stages of construction. The stop-boards on each side of the waterstop shall be accurately brought to match the profile of the waterstop. The concrete shall be carefully compacted under and around the waterstop so as to leave no cavities.

The Contractor shall supply the manufacturer's test certificates for each consignment of waterstop delivered to Site and shall if requested supply to the Engineer sufficient samples of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate standard test procedure.

The PVC for PVC waterstop shall be high grade virgin polyvinyl chloride containing no filler, reclaimed or scrap material. It shall comply with the requirements of BS 2571 for type A3 of Class 1 but shall have improved tensile qualities. The minimum tensile strength shall be 12.5 N/mm² and the minimum elongation at break shall be 285%.

5.09 Joint Filler

The Contractor shall supply and fix premoulded joint fillers in all expansion joints and where shown on the Drawings. Unless otherwise specified the joint filler shall be of resin or bitumen bonded cork or impregnated fiberboard. Impregnated fiberboard shall not be used in water retaining structures. Material shall be obtained from manufacturers approved by the Engineer and shall be stored and fixed in accordance with the manufacturer's instructions. The joint filler of the material and thickness specified shall be cut to shape and fixed to fill the whole space between the concrete faces to the joint not otherwise filled by waterstop and joint sealer. Abutting pieces shall be placed in close contact and the joints covered on each side to prevent the passage of cement grout.

The Contractor shall supply the manufacturer's test certificate for each consignment of each type of joint filler delivered to Site and shall supply to the Engineer sufficient samples of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate standard test procedure.

The filler shall comply with the following American Society for Testing and Materials Specification:

- | | | |
|-----|---|------------------------|
| (a) | Resin Bonded Cork | ASTM D 1752-67 Type II |
| (b) | Bitumen Bonded Cork and
Impregnated Fiberboard | ASTM D 1751-73 |

5.10 Bituminous Sealer

Bituminous sealer shall be obtained from manufacturers approved by the Engineer and shall be appropriate for the prevailing climatic conditions.

The hot poured rubber/bitumen compound for sealing horizontal joints shall comply with BS 2499 for Type AI. For sloping, vertical and soffit joints a bituminous putty shall be supplied which shall not slump in a vertical joint 25 mm wide and 25 mm deep at a temperature of 80°C.

5.11 Polysulphide Sealer

Polysulphide sealer shall comply with BS EN ISO 11600:2003. It shall be obtained from manufacturers approved by the Engineer and shall be appropriate for the prevailing climatic conditions.

In conjunction with this type of sealer an approved bond breaker such as a self-adhesive polythene strip shall be positioned against the exposed edge of the joint filler prior to application of the joint sealer. The bond breaker shall be resistant to attack from any primer used to bond the polysulphide sealer to the concrete.

5.12 Polyurethane Sealer

Polyurethane joint sealer shall meet the performance requirements of U.S Federal Specifications TT-S-00277E, Type II Class A or as approved by the Engineer and shall be compatible for use in specific works limitation.

Its usage shall strictly be in accordance with manufacturer's recommendations.

5.13 Bituminous Paint

Bituminous paint shall comply with BS 3416, Type 11 for materials in contact with raw or treated water and Type I for all other cases.

Prior to application of the bituminous paint the concrete faces must be clean and dry. A minimum of two coats of paint shall be applied and each coating shall be a dry film mass of 35 ± 5 g/m² after 48 hours drying.

5.14 Bond Breaking Compound

Bond breaking compound shall consist of 66% of 200 pen bitumen blend hot with 14 light creosote oil and, when cold brought to the consistency of paint by the addition of 20 % solvent naphtha or other approved compound meeting the following requirements:

- (a) It shall not retard or in any other way affect the setting of concrete.

- (b) The average bond stress on bars coated with the compound with half their length cast into concrete specimens and subjected to pull out tests at 7 days shall not exceed 0.13 N/mm^2 and the total movement of the dowel bar relative to the concrete specimens shall be not less than 0.15 mm at that stress. The concrete specimens shall be $150 \text{ mm} \times 150 \text{ mm}$ in section and 450 mm long and made with the same mix proportion as used in the Works.

5.15 Slip Membrane for Sliding Joints

Slip membrane material used for sliding joints shall consist of two thicknesses of low friction plastic material which shall be non-toxic and suitable for use with potable water, compatible with any other materials used in conjunction with them, non-extruding and durable. The coefficient of friction between the two strips shall not exceed 0.20 when subjected to a load of 220 kN/m^2 . The maximum bearing pressure for the material shall not be less than 250 kN/m^2 .

The lower layer shall be self-adhesive and the concrete surface to which this is fixed shall be smooth, clean and free from dust and be finished with a steel or wood float to provide a smooth true surface.

5.16 Classes of Concrete

The class of concrete is defined by the characteristic cube crushing strength and the nominal maximum aggregate size, with additional suffix defining any additional requirements. The requirements for each class of concrete are given in Table 5.1.

The main classes of concrete used will be as follows:

Location	Class	Grade
Construction of manholes /Grating chamber	35/20 or 35/20(S)	C 35 A
Conduit structure	35/20 or 35/20(S)	C 35 A
Conduit Blinding	10/20 or 10/20(S)	10
RCC Pipe protection	30/20 or 30/20(S)	30
Man Hole Benching	30/20	30

TABLE 5.1

Concrete class	Grade	Maximum Aggregate Size (mm)	Cement type	Workability*
35/20	C35A	20	OPC	High
35/20S	C35A	20	SRC	High
30/40	30	40	OPC	Medium
30/20	30	20	OPC	High
30/10	30	10	OPC	High
30/40S	30	40	SRC	Medium
30/20S	30	20	SRC	High
10/20	10	20	OPC	-
10/20S	10	20	SRC	-
7/40	7	40	OPC	-
7/40S	7	40	SRC	-
Porous concrete				
10/40P	10	40	OPC	-
10/40SP	10	40	SRC	-

Note: *High workability : slump 65 to 135 mm
 Medium workability: slump 50 to 100 mm

Quoted slump values are a guide only and may be varied subject to the approval of the Engineer.

The concrete grade is defined as the 28 day cube crushing strength (N/mm²) below which no more than 5% of results are expected to fall.

Except where otherwise specified herein, the mix design, concrete ingredients, manufacture, testing and workmanship shall conform to the requirements of Sections 6 and 7 of BS EN 1992-3:2006:1987 and Sections 6 and 7 of BS EN 1992-1-1:2004 Part 1.

Adjustments to the concrete mix proportions shall be made during the contract if in the opinion of the Engineer, such adjustments are necessary. The Contractor shall neither alter the mix proportions nor the source of supply of any of the ingredients without prior approval of the Engineer.

5.17 Concrete Exposed to Sulphate or Chloride Attack

Before commencing any concreting on Site the contractor shall conduct tests to the satisfaction of the Engineer to determine the concentration of sulphate and / or chloride in the soil and groundwater in order to determine the concrete exposure class. The frequency of such test will be one test at every 100 m interval.

The Contractor shall ensure that all concrete susceptible to sulphate / chloride attack shall be designed to satisfy the additional requirements for the particular exposure class.

SRPC cement shall be used for the following minimum concentration of sulphates in soil and ground water if approved by the Engineer.

- i) In soil : 0.2% or more
- ii) In groundwater : 0.3 g/l or more
- iii) In 2:1 water
Soil extract : 1.0g/l or more

If approved by the Engineer, cement blended with GGBS in the ratio of 3:1 shall be used where concentration of chloride in ground water is greater than 1000 ppm.

5.18 Lean Concrete

An additional class of concrete specified as 'Lean Concrete' shall consist of ordinary Portland cement and combined coarse and fine aggregate mixed in the proportion by dry weight of one part of cement to 12 parts of aggregate. The amount of free water in the mix shall be about 6% of the total dry weight of materials, the actual quantity being decided on Site after the trial mixes have been made so as to permit optimum compaction. 150mm concrete cubes shall be made at such intervals and times as the Engineer may direct. The cubes shall be made, cured and tested in accordance with the methods described in BS 1881 except that the cubes shall be compacted by means of an electric or pneumatic hammer provided with a square or rectangular foot having an area of between 100 and 150 cm², using sufficient pressure directly on to each of the three layers of material filled into the mould to result in the material being compacted to refusal.

The 7-day or 28-day compressive strengths of the concrete cubes shall not be less than 7.0 N/ mm² or 10.0 N/mm² respectively. If the strengths fall below these specified values the Engineer may require the use of different materials, mix proportions, Constructional Plant or methods notwithstanding any approval which may have previously been given.

The average density of material placed in the Permanent Works obtained from groups of three determinations carried out in accordance with BS 1377 shall be not less than 95% of the theoretical density of material as compacted to zero air content calculated from the specific gravities determined in accordance with BS EN 932-5:2000 and the nominal proportions of the constituents, including the water. If more than one average density in any consecutive five such averages fails to meet this requirement, the Engineer may require the removal of the concrete represented by the low densities and its replacement with further material to the requirements of this Clause.

Unless otherwise approved the grading of the aggregates shall be within the following limits:

Sieve Size	Percentage by weight passing
50 mm	100
20 mm	45 to 80
5 mm	25 to 45
600 micron	10 to 25
150 micron	0 to 8

5.19 Concrete Mix Design

The Contractor shall determine to the approval of the Engineer the actual proportions of ingredients for each class of concrete to be used to the Permanent Works.

The concrete shall meet the requirements given in Table 5.2

TABLE 5.2

Requirements of Classes of Concrete

Class	Cement content (kg/m ³)		Maximum W/C ratio	Cube crushing strengths (N/mm ²)		
	Mini- mum	Maxi- mum		Target	Minimum mean of 4	Minimum
35/20	370	400	0.45	46.5	38.2	29.8
35/20S	370	420	0.45	46.5	38.2	29.8
30/40	320	400	0.50	41.5	33.5	25.5
30/20	360	440	0.50	41.5	33.5	25.5
30/10	410	460	0.50	41.5	33.5	25.5
10/20	240	-	0.70	16.0	12.0	8.5
7/40	170	-	0.70	11.0	8.5	6.0
30/40S	380	420	0.48	41.5	33.5	25.5
30/20S	420	460	0.48	41.5	33.5	25.5
10/20S	300	-	0.70	16.0	12.0	8.5
7/40S	225	-	0.70	11.0	8.5	6.0
Porous						
10/40P	220	-	0.70	16.0	12.0	8.5
10/40SP	270	-	0.70	16.0	12.0	8.5

Water/cement (W/C) ratio is the ratio of weight of free water to cement in the mix based on aggregates being in a saturated surface dry condition (SSD).

Unless otherwise specified or agreed by the Engineer, for concrete Grade 30 and above the proportions of coarse and fine aggregates shall be selected to achieve one of the grading curves defined in Table 5.3, within an allowable tolerance of generally 5%. A change from a maximum positive tolerance to a maximum negative tolerance in consecutive sieve sizes should be avoided. Class 10/40P and 10/40SP shall have a fine aggregate content of 15% of the coarse aggregate.

The Contractor shall submit details of the source of all material and the proposed quantities of each ingredient per cubic meter of fully compacted concrete. The Contractor shall then make trial mixes for each class of concrete using the same type of Constructional Plant and the same materials as are proposed for the Permanent Works. The Contractor shall give 24 hours notice of such trials to enable the Engineer's Representative to attend. For each trial mix, three separate batches of concrete shall be made by the Contractor and will be tested at 28 days all in accordance with BS 1881. Such trial mixes shall not be the first batch through the plant in any one sequence of concrete production.

The Contractor shall not commence concreting in the Permanent Works until details of trial mixes and test results for each class of concrete have been submitted to, and approved by, the Engineer.

A trial mix design will be approved by the Engineer with respect to strength if the average compressive strength of the nine cubes so tested is more than the target mean strength appropriate to the class as given in Table 5.2.

For concrete of Grade 20 and over the Contractor shall cast sample wall panels in two phases. In the first, three different mixes from adjacent aggregate grading curve zones shall be cast into wall panels. When the Contractor has demonstrated that the mix from the middle of the three grading zones is the most practical mix he shall proceed with phase two on the basis of this preferred mix. In the second phase two batches, mixed 48 hours apart, utilizing the preferred mix, shall be cast in two equal lifts to form a wall panel having one horizontal construction joint formed to the manner proposed by the Contractor for the Works. The top surface of the second lift shall have a Type U3 finish. The panels shall not be touched up after stripping.

The panels shall be 300 mm thick and 1.5 m long by 1.5 m high. The Contractor shall not commence concreting to the Permanent Works until the test panels have been approved by the Engineer.

The Contractor shall not alter the approved mix proportions nor the approved source of supply of any of the ingredients without having previously obtained the approval of the Engineer.

During production the Engineer may require trial mixes to be made before a substantial change is made to the materials or in the proportions of the materials to be used.

TABLE 5.3**Combined Aggregate Gradings****40 mm maximum aggregate size
grading curves**

Sieve size	1	2	3	4
50	100	100	100	100
37.5	95	97	99	100
20	50	59	67	75
10	36	44	52	60
5	24	32	40	47
2.36	18	25	31	38
1.18	12	18	24	30
0.60	7	12	17	23
0.30	3	7	11	15
0.15	0	0	2	5

**20 mm maximum aggregate size
grading curves**

Sieve Size (mm)	1	2	3	4
37.5	100	100	100	100
20	95	97	99	100
10	45	55	65	75
5	30	35	42	48
2.36	23	28	35	42
1.18	16	21	28	34
0.60	9	14	21	27
0.30	2	3	5	12
0.15	0	0	0	1.5

**10 mm maximum aggregate size
grading curves**

Sieve Size (mm)	1	2	3	4
10	95	97	99	100
5	30	45	60	75
2.36	20	33	46	60
1.18	16	26	37	46
0.60	12	19	28	34
0.30	4	8	14	20
0.15	0	1	3	6

5.20 Storage of Materials

The Contractor's arrangements for storing and handling the materials for concrete shall be to the approval of the Engineer. Such arrangements shall be directed towards preventing the deterioration or adulteration of the various materials or segregation of the ingredients thereof.

5.21 Control and Mixing of Ingredients

The Contractor shall measure the moisture content in the aggregates and so determine the amount of water to be added to each batch of fresh concrete. Such determinations shall be to the approval of the Engineer and the results and calculations shall be available for inspection by him. The frequency of such determinations shall be as directed by the Engineer and shall depend on the quality of control of storage and handling, weather conditions and variability of aggregate supplied.

The Contractor shall proportion the ingredients of each batch of concrete by weight. The measuring equipment should give an accuracy of $\pm 3\%$ for each ingredient. The water shall be added to the aggregates and cement in a mechanical batch mixer; it shall not exceed the maximum ratio with regard to cement given in Table 5.2 hereof, and shall otherwise be the minimum amount necessary consistent for complete compaction. The device for measuring the water shall show accurately the weight required with a given moisture content of the aggregate and shall be so designed that the water supply will be automatically stopped when the correct quantity has been discharged into the mix. The concrete ingredients shall then be thoroughly mixed.

The minimum mixing time shall be:

- (i) For mixes of 1.5 m³ Capacity or less: 1-1/2 minutes.
- (ii) For mixes of larger capacity than 1.5 m³ the time shall be increased by 15 seconds for each additional 0.75 m³ capacity. For intermediate sizes the time shall be assessed by proportion.

In special circumstances, for quantities not exceeding one cubic meter and at the sole discretion of the Engineer, the proportioning of materials by volume may be approved. In such circumstances the cement content of the concrete shall be increased by 10% over the amount in the approved mix. The boxes used for proportioning shall be deep and narrow to the approval of the Engineer, and shall be separately constructed for each class of concrete to be proportioned by volume.

5.22 Concrete Sampling and Testing

The temperature of concrete, concrete constituents, reinforcement, formwork and the atmosphere shall be monitored continuously for every concrete pour. All sampling and testing of fresh and of hardened concrete shall be carried out in accordance with the provision of BS 1881 unless such provision is at variance with the Specification.

Table 5.4 gives the programme for sampling and testing of concrete for each class of concrete from each batching centre in each active day.

The Contractor shall establish a plan for sampling and testing to the approval of the Engineer. Samples shall be taken at the place of deposition from each class of concrete at random. The frequency of sampling shall in general be in accordance with Table 5.4, but the actual rate of sampling may vary with the approval of the Engineer and shall be increased when ordered by the Engineer in appropriate circumstances. From each such sample three 150 mm concrete cubes shall be prepared; each cube shall be marked indelibly for identification when it is in the mould. After retention at the site for 24 hours the cubes shall be delivered to the testing laboratory for curing and testing.

TABLE 5.4

Programme for Works Sampling and Testing

	Grade 20 and Above.	less than Grade 20
Workability (slump test)	1	0
Workability (compacting factor test)	2	0
Compressive strength	2	3

Where:

- 0 - no testing required
- 1 - every batch at point of deposit
- 2 - one sample from every 10 batches, one sample per 20m³ of concrete or one sample from each day's concrete, whichever involves the maximum number of samples.
- 3 - one sample from every 50 batches, one sample per 50m³ of concrete or one sample from every three day's concrete, whichever involves the maximum number of samples.

5.23 Compliance with Specified Concrete Requirements

Of the three cubes made from each sample of fresh concrete in accordance with the Specification, one will be crushed at 7 days and the other two at 28 days. The average of the two 28 day strengths will be taken as the test result. Compliance with the specified strength requirements shall always be judged on the 28 days test results.

Concrete shall be considered to have failed to comply with the Specification:

- (a) if a test result is less than the testing plan minimum specified in Table 5.2 for that class of concrete, to which case the concrete which it represents shall be broken out and disposed of away from the Site by the Contractor unless at his sole discretion the Engineer approves otherwise;

- (b) if the average of four consecutive test results for that class of concrete shall have failed to exceed the minimum mean of 4 as specified in Table 5.2 in which case no further concrete of that class shall be placed in the Permanent Works until the Contractor shall have discovered the cause of such failure and rectified it to the satisfaction of the Engineer.

If a mix fails to achieve the requirements for fresh concrete the batch shall be rejected and no further concrete of that class shall be placed in the Permanent Works until the cause of failure has been rectified.

If test results for strength of concrete of any class are consistently and significantly in excess of the target mean strength the Engineer may on the application of the Contractor agree to a reduction in the cement content in the mix for that class, provided the cement content is not lowered below the minimum specified for that class, nor the maximum water/cement ratio exceeded.

5.24 Transporting, Placing and Compacting Concrete

The concrete shall be handled so that at the point of deposition it is of the specified quality and approved consistency, nothing having been added to it or lost from it since leaving the mixer. Any free water shall have been removed from the section to be concreted before concrete is deposited.

The Contractor shall obtain the approval of the Engineer to the arrangements he proposes to use for concreting before commencing concrete work.

The Contractor shall regard the compaction of the concrete as work of fundamental importance and shall produce a watertight concrete of maximum density compatible with the approved mix. Compaction shall be assisted by the use of mechanical vibrators of the immersion type (Poker vibrator), but shall not involve the vibration of reinforcement or shutters except that vibration of shutters may be allowed in precast concrete, with the approval of the Engineer. Vibrators shall be inserted at least to the full depth of the newly deposited concrete, kept in position for about a quarter of a minute and then slowly withdrawn to prevent the formation of voids. The procedure shall be continuous with points of insertion 150 to 225 mm apart. The number and type of vibrators available for use during each period of concreting shall be to the approval of the Engineer, which will not be given if sufficient stand-by vibrators in good working order are not readily available. If concreting is in the dark, ample lighting shall be provided at the mixing stations and at every place where concrete is being deposited.

Concrete without a retarder which is not deposited in the Works within 30 minutes after the start of mixing shall not be used unless the Engineer approves otherwise.

Concrete may be pumped provided the mix design and the nature of pumping comply with the recommendations given in the 'Guide to Concrete Pumping' as published by the Building Research Establishment (UK) and are not in conflict with any specified requirements.

The first batch of concrete to be made every time work is commenced shall contain 10% more cement than the normal amount.

Concrete shall be placed continuously up to positions of joints prepared prior to commencement of concreting. No concrete shall be dropped or chuted into the shuttering in such a manner as to cause segregation of the ingredients. In no case the concrete shall be allowed to fall freely from a height of 1.2 m or more. The deposited layers of concrete shall not exceed 600 mm in thickness. Shallow beams may be concreted to full height in one operation as directed by the Engineer. Care shall be taken to ensure that reinforcement projecting from concrete recently placed is not shaken or disturbed.

Where steps, splays and kickers occur these shall be cast in one with the slab and additional care shall be taken in the vibration and finishing techniques and procedures to ensure that thorough compaction is achieved and the unset concrete is not subjected to tension and no cracks are formed. The techniques and procedures to be adopted shall be discussed with the Engineer's Representative and his approval received before any such concreting is commenced.

Concrete Class 7/40 may be compacted by hand but shall be deposited in layers not exceeding 300 mm in thickness and shall be well worked with special tools and rods until it has settled closely in place and is free from air bubbles.

5.25 Concreting in Unfavourable Conditions

The Contractor shall not place concrete in the Permanent Works:

- (a) During heavy rains or dust storms.
- (b) When the air temperature is more than 32°C.
- (c) When the air temperature is less than 2°C.
- (d) If the temperature of the concrete on discharge from the mixer is less than 4°C or more than 32°C.
- (e) When the air temperature exceeds 25°C, without taking precautions and demonstrating to the approval of the Engineer that the maximum internal temperature of the concrete within 24 hours after casting in place is unlikely to be more than 30°C in excess of the ambient temperature or more than 60°C.
- (f) If the temperature of the shutters or reinforcement exceeds 30°C.

To keep within these limits the Contractor may, among other means, spray aggregates with water, and use chilled mixing water, or add crushed ice direct to the mixer provided that no ice is present in the mix when discharged from the mixer.

When concreting in hot weather all material used shall be kept in the shade. Water tanks, mixers and chutes should be shaded, but where this is not possible they shall be painted white and kept white.

5.26 Concreting Records

A written record of the concrete works shall be made each day by the Contractor and kept available for inspection by the Engineer's Representative. The diary shall contain notes and records of:

- (a) The names of the Contractor's engineers who are responsible for the different phases of the concrete work, and also the names of their assistants.
- (b) The temperatures of air, water, cement, aggregates and concrete, together with the air humidity and type of weather.
- (c) Deliveries to the Site of concrete materials (quantity, brand of cement, etc).
- (d) Inspections carried out, tests performed, etc, and their results.
- (e) Times of commencement and completion of different parts of the concrete works, and times of erection and striking of forms.
- (f) Quantity of cement, fine and coarse aggregate and admixture used for each section of work, and the number and kind of test samples taken on these ingredients and water.

5.27 Shuttering

The terms shuttering and formwork shall be interpreted as meaning one and the same thing, namely Temporary Works set up to obtain the required profiles and surface textures of the concrete. Shuttering shall be such that it remains rigid during the placing and setting of the concrete and prevents the loss of any concrete ingredients.

The shuttering shall be fixed in correct alignment and to the true shape and dimensions of the Permanent Works and shall be designed so that it can easily be removed for curing of concrete to commence as soon as practicable. Where necessary, shuttering should be so arranged that the soffit form, properly supported on props only, can be retained in position for such periods as may be required to allow the concrete to mature as specified in Clause 5.35. A method of support which would involve holes or tie wires extending the whole width from face to face of work to be concreted will not be permitted, unless authorized by the Engineer in writing. No plugs, bolts, wire ties, holdfasts or any other appliance whatsoever for the purpose of supporting the shuttering or reinforcement shall be fixed permanently into the structure so that they have less cover than that specified for the reinforcement or in any way impair the strength or appearance of the work, nor shall they be placed in such a manner that damage to the work would result in the removal of the same at the time of striking the shuttering.

Before the concrete is placed the retaining surfaces shall be cleaned of sawdust and shavings, dirt, other debris and standing water.

The inside of shuttering shall be coated with a release agent of non-staining mineral oil, mould cream emulsion or with other approved material. Adjacent concrete or reinforcement shall not be contaminated. The release agent must be compatible with any applied finish.

Temporary openings for cleaning and inspection before concreting shall be provided at the base of column and wall shuttering and where necessary. Shuttering for walls

or other thin sections may have openings where approved by the Engineer for the placing and compacting of the concrete.

No concreting shall be started before the shuttering has been inspected by the Engineer's Representative. Unless otherwise approved, top shuttering shall be provided to concrete faces where the slope exceeds one vertical to three horizontal. Exposed edges shall be formed with a chamfer measuring 20 mm x 20 mm.

5.28 Surface Finishes

The faces of all concrete shall be left sound, solid, free from voids and to the class of finish specified.

No treatment to the finished concrete other than that specified in the class of finish shall be carried out unless approval to do so has been given by the Engineer.

Bolt bobbin holes shall be filled with cement and suitable fine aggregate mortar to match the colour of the concrete. The mortar shall be well worked in and thoroughly cured.

Classes for formed surfaces:

Class F1- This finish requires no special treatment and is for surfaces which will remain hidden in the permanent Works.

Class F2 - This finish is for all exposed surfaces unless otherwise shown on the Drawings. The formwork shall be faced with plywood or equivalent material in large sheets rigidly supported so as to prevent distortion under load. The sheets shall be arranged to coincide with architectural features, or changes in direction of the surface. All joints between panels shall be straight and either vertical or horizontal unless otherwise directed and the joints between panels to slab soffits shall be parallel to the supports. Suitable joints shall be provided between sheets to minimize joint marks and to maintain accurate alignment in the plane of the sheets. Facing sheets shall be free from blemishes which would affect the concrete surface.

Class F3 - This finish is identical to Class F2 finish except that the permitted deviations for irregularities are more stringent as given in Table 5.5.

Where a surface is partly below and partly above the final ground level the finish for exposed surfaces shall extend for 500 mm below the final ground level.

Classes for unformed surfaces:

Type U1 - This finish is for surface, where a superior finish is not required. It is also the first stage for finishes U2 and U3. The finishing operations shall consist of grading, tamping and screeding the concrete to produce a uniform, plain or ridged surface.

Type U2 - This is a smooth matt finish such as may be achieved by a wood trowel, as required, inter alia, to receive mastic paving, or block or tile paving, bedded in mastic. Smoothing shall be done only after the concrete has hardened sufficiently,

and may be by hand or machine. Care shall be taken that the concrete is worked no more than is necessary to produce a uniform surface free from marks.

Type U3 - This is a smooth steel-trowelled finish for surfaces of concrete paving,, tops of walls, copings and other members exposed to weathering or water, surfaces to receive thin flexible sheet, tile paving, bedded in adhesive, and seatings for bearing plates and the like where the metal is in direct contact with the concrete. Trowelling shall not commence until the moisture film has disappeared and the concrete hardened sufficiently to prevent excess laitance from being worked to the surface. The surfaces shall be trowelled by hand or machine under firm pressure and left free from trowel marks.

5.29 Permitted Deviations in Finished Work

The irregularities in formed and unformed surfaces for the various classes of finish shall be within the target limits shown in Table 5.5. If irregularities exceed the target the Contractor shall take the necessary steps to bring subsequent work within the target. If, however, the irregularities exceed the maximum allowable shown in the table it shall be sufficient cause for the structure, member or section of a member of the structure to be removed and properly reconstructed.

In Table 5.5 the type of irregularity is defined as follows

- (1) Departure from alignment, and grade and dimension shown on the Drawings.
- (2) The cross-sectional dimensions of structural members less than 600mm, such as walls, columns, beams, etc., where, for structural reasons, it is desirable to keep the tolerances within closer limits than those for alignment and grade.
- (3) Gradual irregularities measured from a 3 m long template placed against the concrete.
- (4) Abrupt irregularities such as those resulting from defective or displaced facing or movement of supports.

TABLE 5.5**Permitted Deviations for Irregularities of Concrete Surfaces**

Tolerances in mm
Formed finish

Type Irregularity	Target			Maximum allowed		
	F1	F2	F3	F1	F2	F3
1	± 20	± 5	± 1	± 40	± 10	± 2
2	± 7	± 5	± 1	± 15	± 10	± 2
3	7	5	± 1	15	10	± 2
4	7	3	± 1	10	5	± 2

Unformed finish

Type of Irregularity	Target			Maximum allowed		
	U1	U2	U3	U1	U2	U3
1	± 20	± 10	± 3	± 35	± 20	± 6
2	± 7	± 5	± 3	± 15	± 10	± 6
3	10	5		20	10	6
	3					

5.30 Fixing Reinforcement

Steel reinforcement shall be cut from straight bars free from kinks and bends or other damage, and cold bent by experienced competent workmen. Bars shall be bent in a bending machine approved by the Engineer. Cutting, bending and marking shall be to the tolerances and format given in BS EN ISO 4066:2000 unless otherwise specified or ordered by the Engineer.

The distance between any two parallel bars shall not be less than 5 mm more than the nominal maximum size of aggregate in the concrete, except at approved laps. The length of lap shall be as shown on the Drawings or ordered by the Engineer.

The Contractor shall place and fix steel reinforcement accurately in the positions shown on the Drawings and shall ensure that it remains rigidly in that position during the placing of concrete. Tie wire shall be 1.5 mm (minimum) annealed iron wire. Tack welding shall not normally be permitted, however, in particular cases it may be allowed with the prior approval of the Engineer. Supports, spacers, including PVC spacers, and ties shall be subject to the approval of the Engineer. Concrete spacers shall be made of the same quality concrete as that for the work in which they will be embedded with any tying wires galvanized and located to give a minimum cover specified for the reinforcement. Metallic spacers, fixing clips and tying wire shall be compatible with the material of the reinforcement, and the specified cover shall be maintained.

Spacers should be of such materials and designs as will be durable, not lead to corrosion of the reinforcement and not cause spotting of the concrete.

Reinforcement projecting from previously cast concrete shall not be bent so as to require rebending without the prior approval of the Engineer.

The main wires of adjacent sheets of steel fabric reinforcement shall be lapped at least 300 mm and the transverse wires at least 150 mm.

The Contractor shall not place concrete around reinforcement until the reinforcement has been inspected by the Engineer's Representative.

5.31 Cover to Reinforcement

Except where otherwise shown on the Drawings the nominal concrete cover to the nearest reinforcement (exclusive of concrete blinding and rendering) shall be 40 mm. However, for internal faces in buildings the minimum cover shall be 20 mm exclusive of plaster or decorative finishes. This requirement does not apply to concrete faces in box-outs left for the installation of fixtures.

The actual concrete cover shall not differ from the nominal cover by more than ± 5 mm for bars up to and including 12 mm size and ± 10 mm for bars greater than 12 mm size.

5.32 Construction joints

Where not shown on the Drawings, the details and positions of construction joints shall be submitted to the Engineer for approval before any concreting takes place. They shall be located so that, when considered with the sequence of concreting, the effects of shrinkage and temperature are minimized.

Construction joints shall be watertight. They shall be formed in straight lines with rigid shuttering perpendicular to the principal line of stress and as far as practicable at points of least shear. They shall be the plain butt type unless otherwise specified or approved.

As soon as the exposed concrete has sufficiently hardened the surface of the joint shall be brushed with a stiff brush to expose the larger aggregate without it being disturbed. Roughening of the surface by chipping or hacking will not generally be approved. Before placing fresh concrete against a construction joint all loose material shall be removed and the surface sluiced with water until it is perfectly clean, thereafter all ponded water should be removed.

A period of at least 3 days and not more than 14 days, except under special circumstances and with the approval of the Engineer, shall elapse between the casting of successive lifts of concrete.

In the case of water retaining structures a maximum period of 7 days will be permitted to elapse between casting of the base or footing to a wall panel and the casting of the stem of the wall on such base or footing.

In case any joints have been shown on the Drawings, the Contractor will not be permitted to alter these joints or their positions or to increase or decrease their number.

5.33 Dowel Bar

Where dowel bars are to be provided through movement joints they shall be mild steel plain round bars with sawn cut ends and complying with BS 4449.

In expansion joints the part of the bar to be free to move shall be coated with bond breaking compound as specified, encased in a rigid PVC or metal sleeve and fitted with a compressible cap of joint filler or other materials approved by the Engineer. The diameter of the sleeve should be the minimum necessary to allow free movement of the bar after concreting.

In full contraction joints the part of the bar to be free shall be coated with bond breaking compound as specified.

In joints between roofs and walls of reservoirs vertical dowel bars shall be provided with a rigid PVC or metal sleeve so packed with compressible material so as to allow a free movement of 5 mm in any direction in the horizontal plane.

5.34 Reinforcement at Partial Contraction Joints

Only 50% of the longitudinal reinforcement will be continuous at partial contraction joints in the walls of the conduit.

5.35 Pipes Through Concrete Sections

All pipes passing through concrete to water retaining structures or where a thrust load has to be transmitted to the concrete shall be fixed in position before and rigidly held in position during concreting. Boxing out in either of the above circumstances will not be permitted, unless approved by the Engineer.

5.36 Protection and Curing of Concrete

The Contractor shall take measures to the approval of the Engineer for the protection of concrete from the harmful effects of wind, sun, high and low temperatures, rapid temperature changes, premature loading, deflection, impact and aggressive groundwater. Such measures shall continue from the time of the concrete is placed for a minimum of 7 days.

Concrete shall be cured as follows: Unless otherwise approved by the Engineer, exposed concrete surfaces shall be kept continuously moist after casting for not less than 7 days after placing. Such surfaces, immediately upon exposure, shall be covered with thick hessian or sand or other material as may be approved by the Engineer, which shall be in continuous contact with the concrete and which shall be kept wet to the satisfaction of the Engineer.

For horizontal members such as slabs, exposed to wind and /or sun, special measures to prevent occurrence of shrinkage cracks shall be taken immediately after placing of concrete and until it is hard enough to commence curing as specified above. The measures shall include:

- a) Erection of wind barriers and sun shades of suitable construction to provide adequate protection.
- b) Application of water as a fog spray to keep the concrete surface moist without in any way damaging the fresh concrete or surface finish.

The Engineer may deny permission to place concrete unless necessary arrangements are available at the location of work to ensure compliance with above requirements.

5.37 Removal of Shuttering

Shuttering shall be removed in accordance with principles agreed by the Engineer and with the permission of the Engineer's Representative. Unless the soffit shuttering to beams and slabs has been designed so that it can be struck without disturbing the props, it shall be retained in position for the minimum period given in Table 5.6 for the retention of the props. Great care shall be exercised during the removal to avoid shocks to, or reversal of stress in, the concrete.

Earlier removal of formwork may be permitted by the Engineer by determination of the early strength of the concrete, in accordance with BS EN 1992-1-1:2004 1985 Cl 6.9.3.

TABLE 5.6
Minimum Period Before Striking Formwork

Type of formwork	Minimum period before Striking surface Temperature of concrete	
	16° C	7°C
i) Vertical formwork to columns, walls and large beams	18 hours	24 hours
ii) Soffit formwork to slabs	4 days	7 days
iii) Props to slabs	11 days	14 days
iv) Soffit formwork to beams	8 days	14 days
v) Props to beams	15 days	21 days

5.38 Joint Sealers – General

The Contractor shall construct recesses at expansion and contraction joints on both faces of the concrete work except on the underside of floor or ground slabs. The recesses shall be accurately formed to the lines and dimensions shown on the Drawings.

The Contractor shall prepare the surfaces of the recess and shall supply a joint sealer and fill or caulk the recess completely with it. Joint sealer shall conform to appropriate BS standard or similar approved.

Sealers shall be used in accordance with the manufacturer's instructions inclusive of the supply and application of any priming materials. Joint sealing shall not be

commenced without the approval of the Engineer. In floor joints the sealer shall be poured after construction of roof slab.

Polysulphide sealer shall be used except for buried structures and other structures not subject to direct or reflected sunlight nor to large temperature variations, in which case a bituminous based compound shall be used.

The Contractor shall supply the manufacturer's test certificates for each consignment of each type of joint sealer delivered to Site and shall if requested supply to the Engineer sufficient samples of each type and consignment for confirmatory test to be carried out in accordance with the appropriate test procedure.

Bituminous and polysulphide sealers shall not abut one another.

For joints between new and existing concrete member refer clause 5.42.

5.39 Cement Mortar

Unless otherwise specified the dry ingredients of cement mortar shall consist of one part of ordinary Portland cement to three parts of sand. The sand shall comply with BS EN 197-1:200000 with a grading complying with Table 1 thereof. The cement and sand shall be thoroughly mixed with just sufficient water to make it workable. With the approval of the Engineer a non-shrink admixture may be used subject to the provision of Clause 5.04.

Cement mortar which has begun to set shall not be used or reworked for use in the Works.

5.40 Precast Concrete

Unless otherwise specified or described all precast concrete work shall be of Class 30/20.

Each mould for concrete work which is specified or approved by the Engineer to be precast shall have a different embossed or recessed identification mark in a position to the approval of the Engineer. Each precast unit shall be indelibly marked with the date of casting and after the mould is removed shall not be disturbed for 28 days. Each precast unit shall, where required, be provided with lifting eyes and holes located to avoid excess stress during handling to the approval of the Engineer.

Precast units must be of a sufficient age and handled with sufficient care to avoid permanent damage.

5.41 Building Ground Slabs

The position of all joints shall be indicated on the Contractor's Drawings. The joint types shall be indicated on the assumption that the slabs will be cast in chequer board fashion as defined in Cement and Concrete Association Publication 48.034 'Concrete Ground Floors.

Control joints may be substituted for transverse construction joints to permit the use of long strip casting in accordance with Cement and Concrete Association Publication 48.034 provided that:

- (a) The Contractor can demonstrate previous experience using this technique in ambient conditions similar to those prevailing on Site.
- (b) The joints layout is approved by the Engineer.
- (c) The joint is as detailed by the Contractor and approved by the Engineer and the crack inducer is in one piece between the side forms.
- (d) The groove is straight and sawn before random cracking occurs.

Fabric reinforcement may be located in the top face of a ground slab either by the use of chairs or, provided the concrete remains workable for an adequate period, by placing and compacting the concrete to the design level of the fabric, placing the fabric on the compacted concrete and placing and compacting the top layer of concrete to such a manner as to ensure the mixing of the layers.

The top layer of concrete not exceeding 50 mm deep shall be compacted using a double beam vibrating screed compactor.

Where the surface of a slab is to be sealed at a later date any curing membrane used shall be compatible with the use of the specified sealant.

5.42 Screeds

(a) Concrete Mix

Screeds placed on concrete made with sulphate resisting cement shall themselves be made with sulphate resisting cement. The Engineer may at his discretion direct that the maximum aggregate size be reduced from 20 mm to 10 mm and that the maximum water cement ratio be reduced to not lower than 0.48 at no additional cost.

(b) Mixing

Mixing shall be done in pan or paddle type mixers of a capacity matched to the rate of placing.

(c) Surface Preparation

Where the screed concrete is placed more than 1 hour and less than 12 hours after the base concrete, the base concrete shall be brushed with brooms or wire brushes to remove laitance and expose clean aggregate.

Where the screed is placed more than 12 hours after the base concrete, the base concrete shall be well roughened to give a fresh face over the whole surface. Loose particles and dust shall be cleaned away and the surface then soaked with water. Immediately before placing the screed concrete the water shall be mopped from the surface and a stiff cement/water grout shall be brushed in.

Where the screed concrete is placed less than one hour after the base concrete and provided that no curing compound has been used the screed shall be placed directly on the concrete.

(d) Screed Bay

Screed bays shall whenever possible be rectangular and shall not exceed 15 m², the length of a bay shall not exceed 1½ times its width. Screed bay shall not span joints in base concrete. Alternate bays shall be cast initially and no screed concrete shall be placed against other screed concrete placed less than 48 hours previously.

(e) Screed Battens

Screed battens shall have a thickness the full depth of the adjoining screed and shall be fixed firmly to the base concrete so that they do not move under the action of the screed boards. Fixing shall be such that screed battens can be removed without disturbing the screed concrete. Battens shall not be removed until adjoining screed concrete has been placed for at least 12 hours.

(f) Placing and Finishing

The screed concrete shall be placed as soon as possible after mixing. It shall be worked into place with a screed board having the screed alongside the battens trowelled into the corners. A preliminary pass with a vibrating screed board shall be made if conditions permit. The surface shall be worked with a power float if conditions permit. Unless otherwise shown the finish of screeds shall be Type U3.

5.43 Protective Coatings to Concrete

Where ordered by the Engineer or shown on the Drawings, protective coatings shall be applied to concrete structures in order to protect the concrete against the aggressive effects of saline groundwater. Generally, protective coatings will be applied to surfaces of structures which are close to or in contact with groundwater.

Before applying any coating the surface of the concrete shall be cleaned of all dirt, dust and loose material and where necessary any surface shall be made good so that the surface is smooth and free from air or water holes. No coating shall be applied until the Engineer has approved the preparatory work.

The coating shall be applied using Bituproof bituminous coatings as manufactured by Colas Products Limited, Riverside, Saltney, Chester, UK, or similar approved coatings. The grades of coating and the method of application shall be as follows:

Priming Coat

An application of Bituproof Type 3 diluted with an equal volume of water, shall be well scrubbed into the concrete and allowed to dry.

First Coat

A heavy brush coat of Bituproof Type 5 containing a cement slurry, consisting of 1 volume of sulphate resisting cement, 1 volume of water and 10 volumes of Type 5, shall be laid on in one direction and allowed to dry. To introduce the cement slurry to the Bituproof, the cement shall be mixed thoroughly with the water, the whole being added to the Bituproof, stirring thoroughly to ensure uniform dispersion. The Bituproof/cement slurry mix shall be used within one hour of preparation.

Second and Subsequent Coats

A heavy brush coat of Bituproof Type 5/cement slurry mix prepared as for the previous coat, shall be laid on at right angles to the previous coat and allowed to dry.

The application rate for the above primer and subsequent coats shall provide not less than 0.75 kg of Bituproof per m².

Each coat shall be thoroughly dry before applying a subsequent coat and shall be considered as dry when no staining occurs on a wet finger which is rubbed vigorously over the coating. No coat shall be immersed in water for at least ten days after it is dry.

The coating shall only be applied to the surfaces when shaded from direct sunlight and the coated surfaces shall continue to be shielded until the final coat is dry.

In order to provide protection to the underside of structures, the bituminous coatings shall be applied to the blinding layer before the placing of the structural concrete. The blinding layer shall be given a Type U2 finish.

The blinding and protection shall extend beyond the outer edge of the structural concrete at least 100 mm so that subsequent coatings applied to the structural concrete can overlap the blinding layer and provide unbroken protection. The structural concrete shall not be placed on the blinding layer until the protection is thoroughly dry nor in any case until 60 hours have elapsed following the completion of the protection.

5.44 PVC Lining

PVC lining consists of Polyvinyl Chloride sheeting, which locks mechanically into concrete, is tightly held to the shuttering for walls and soffit of slab prior to placing concrete. The Diamond / Tee shaped Key of the sheet are devised to bond with concrete and ensure composite behaviour. The PVC Liner protects concrete from the aggressive and destructive elements generated from or carried by waste water from either domestic or industrial user.

Continuity of the lining is assured by fusing each individual pipe/ conduit (or Manholes etc.) liner with the net. This result in a lining that is permanently flexible withstands temperature up to 80°C, resists foul gases and has a lower friction coefficient than concrete, has a minimum elongation factor and offers no sustenance to either fungus or bacterial slimes.

Liners are made of high molecular weight PVC resins and are minimum 60 mils (1.5 mm) in thickness. PVC liners shall consist of special blend of resins, approximately 99% of the resin material will be high molecular PVC and the remainder is pigments, plasticizers and stabilizers. Copolymers and recycled resins are not allowed. The liner material can be supplied in either white or black colors.

PVC liners are resistant to acid solutions, diluted solvents, petroleum products, exposure to animal and vegetable oils, alkali chemicals and are bacteria resistant.

Liners will be factory tested to withstand 40 psi (92 foot head) water pressure applied on the back side of the liner material without disbanding of the mechanical interlocking of the material to the concrete.

i) Composition

The PVC Lining sheet (keyed) and all accessories shall be composed of high molar mass polyvinyl chloride combined with plasticisers, stabilizers and pigments compounded to make permanently flexible sheets. Copolymer resins shall not be permitted and polyvinyl chloride shall constitute not less than 99% by mass of the resin used.

The PVC sheet and accessories shall be produced by extrusion or injection molding under controlled temperature and pressure conditions. Keyed sheets shall be produced by extruding the key integrally with the sheet and using the same material as the sheet.

During manufacture every sheet produced from a 'batch' of compound shall be permanently marked with the batch identification. The sheet shall be 100% spark tested for continuity, using spark testing equipment which generates a minimum of 10,000 volts.

ii) Fabrication of blankets

Blankets shall be fabricated from individual sheets or part sheets using automatic hot air welders.

The joints shall be formed by lap welding sheets parallel to the keys, with a lap not less than 20mm and a weld width not less than 14mm.

All joints shall be probe tested in accordance with Section (VI) below. The tensile strength of samples taken from the joint and tested transverse to the joint shall be not less than 20 N/mm.

iii) Chemical properties

Using the test method of ASTM D 543 the change in mass of PVC sheet when exposed to the chemicals listed below shall be determined.

Specimens of identical area and with keys in identical positions shall be used in all tests. The change in mass shall not exceed the percentage shown. Sample size shall be 75mm x 25mm by thickness of sheet.

Chemical Agent	Maximum % change in mass of PVC Lining over 7 days at 20°C
Sodium Hypochlorite (1% as available chlorine)	0.20
Ferric Chloride 1%	0.60
Sodium Chloride 5%	0.15
Sulfuric Acid 20%	0.12
Nitric Acid 1%	0.20
Sodium Hydroxide 5%	0.20
Ammonium Hydroxide 5%	0.40
Soap, Detergent Solution 2%	0.40

iv) **Physical Properties**

The PVC sheet shall meet the requirements stipulated herein and each consignment to be provided with test certificates from the factory / manufacturer.

Physical Property	Test Method	Acceptable Limits
Tensile Strength(both longitudinal and transverse to key)	ASTM D 412	15 MPa min
Elongation at Break(both longitudinal and transverse to key)	ASTM D 412	225% min
Hardness	Shore durometer D at 23°C.	54 min. - 62 max
Plasticiser Permanence (24 hours at 90°C on 50mm diam. disc)	ASTM D 1203 Method B	1.0% max.
Water Absorption at 24 hours (sample size 76mm x 25mm by thickness of sheet)	ASTM D 570	0.10% max.
Water Soluble matter at 24 hours	ASTM D 570	0.05% max.
Tear Strength (both Longitudinal and Minimum Transverse to key)	ASTM D 1004 (Grip Speed 8.5 mm/s)	80 N/mm minimum

From each consignment delivered to site, samples shall be taken by the Engineer and tested at an approved laboratory for physical properties and chemical composition all at Contractor's risk and cost.

v) **Incorporation of keyed PVC Lining in cast in situ Structures**

The PVC sheet must cover the areas specified and is secured to the inner formwork face prior to placing the concrete and reinforcement. Formwork used must be suitable for proper attachment of the plastic sheet.

Sheet can be held to steel forms by light metal or plastic bands tightened on to suitable attachments to the forms. Provision must be made to maintain the sheet in close contact with the form during concrete placement.

Bands must be of the type recommended by manufacturer. If the bands cross the keys, provision must be made to ensure that the keys are not bent or distorted.

All pipe or other metal inserts must be held firmly in place on the formwork. Metal form ties shall be kept to a minimum.

Unless otherwise specifically indicated, PVC blankets shall be positioned so that the locking keys are vertical or as near vertical as possible to provide a free escape to the bottom of fluid which may accumulate between the lining and wall of the structure.

Where changes in direction or corners are encountered, the sheet may be bent and secured to the form, provided the radius of the blend is not less than 25mm.

Where sharper corners are specified, a jointing method approved by manufacturer must be used.

For lining joints which do not correspond to joints in the concrete structure, the sheets are butted together, so that the gap between sheets and/or blankets at any position does not exceed 4mm. This gap must be temporarily sealed by a wide PVC tape before placing concrete. After form removal a flat welding strip, centered over the gap, is welded to give a permanent and continuous lining on the inside of the structure.

For PVC lining joints at transverse construction or contraction joints in the concrete structure, manufacture's approved method to be used

All welding and jointing shall be performed and field tested by specially trained personnel.

vi) Testing

Prior to conducting tests, careful inspection shall be made for visible damage and faulty welding. After joint welding of blankets in structures, all welds shall be subjected to the tests specified.

Particular attention must be given to weld beads on both sides of weld strips. After welding, beads should be visible on both sides of the weld strip. The weld must be checked by probing the fillet area with a well worn (i.e. no sharp edges) screwdriver blade. At any place where the probe indicates a weak weld, or enters more than 3mm, a reweld shall be made. If overheating has occurred during welding with charring at the edge of the strip, all charred sections must be replaced.

The lined surface shall be 100% spark tested using an approved spark tester and brush with a potential of at least 10,000 volts. There shall be no separate payment for conducting Spark Test (Holiday Detection Test) at manufacturing plant and at site, its cost is deemed to be included in contract price.

Defective areas found by these tests must be repaired and subsequently retested. Testing must be carried out progressively as the work proceeds to avoid accumulation of defects from faulty workmanship which could have been detected and corrected at an early stage. Spark testing may not detect faults in welds or where sheets overlap, and must be supplemented by the other procedures in order to ensure sound workmanship in these areas.

vii) Shop Drawings

For details at junctions with manholes and pipe inlets, manufacturer of the PVC lining shall provide sketches / drawings detailing the jointing.

viii) Manufacturers' Approval / Recommendations

All work of installing the lining shall be carried out strictly in accordance with these specifications and manufacturer's recommendations by specially trained workers.

5.45 Damp- Tolerant Solvent Free Epoxy Resin Coating Over Trunk Sewers / conduits

A protective coating for RCC works where Concrete surfaces are damp and can not be dried out. The cured film is corrosion, chemical and abrasion resistant. The two coats of epoxy resin achieve a minimum dry film thickness of 400 microns-solvent free epoxy resin should be applied on surfaces which are smooth, sound, free from debris, loose or flaking material, surfaces free from contamination such as oil, grease, dust, loose particles and organic growth. Concrete surfaces must be fully cured laitance free and free from oils and curing compounds.

Solvent Free Epoxy Resin should be approved by site engineer before applying on the conduit / trunk Sewer surface.

5.46 Termination of Conduit at Metrovill

The conduit to be constructed under this contract shall terminate at the start point of proposed section of interceptor from Metrovill Gulshan Yaseenabad to be constructed under a separate contract and will require close coordination with the work of the other contract. This coordination will also include adjustments in the construction schedule of the terminal section to make possible its jointing with the subsequent conveyance system works or as directed by the Engineer.

5.47 Operation of Pre-treatment Works

After commissioning of the works and upto the end of defects liability period, the operation of pre-treatment works shall be the obligation of the Contractor. This will include but will not be limited to:

- Removal and disposal of floating matter from Floating Boom Devices.
- Cleaning, removal and disposal of floating and other matter trapped at the bar screens.
- Training of KW&SB maintenance staff.

The Contractor shall provide adequate tools, labour and supervisors to ensure proper operation of the facility all as agreed with the Engineer.

5.48 References

Following publications have been referred:

British Standard Institution (London);

1. BS EN 197-1:2000: Specification for Portland cement (BS 12).
2. BS EN 932-5:2000: Testing Aggregates. Methods for determination of particle size distribution. Sieve tests (BS 812).
3. BS EN 12620:2002: Specification for aggregates from natural sources for concrete (BS 882).
4. BS 1377: Methods of test for soils for civil Engineering purposes.
5. BS 1881: Testing concrete.
6. BS 2571: Specification for general purpose flexible PVC compounds for moulding and extrusion.
7. BS EN 1008:2002: Methods of test for water for making concrete (BS 3148).
8. BS 3416: Specification for Bitumen-based coatings for cold application, suitable for use in contact with potable water.
9. BS 3892: Specification for Pulverized fuel ash for use in cementitious grouts.
10. BS 4027: Specification for sulfate resisting Portland cement.
11. BS EN ISO 11600:2003: Specification for two-part poly sulphide (BS 4254)
12. BS 4449: Specification for carbon steel bars for the reinforcement of concrete,
13. BS 4550: Methods of testing cement. Physical test. Strength tests.
14. BS EN ISO 4066:2000: Specification for scheduling, Dimensioning, bending and cutting of steel Reinforcement for concrete (BS 4466).
15. BS 4483: Steel fabric for the reinforcement of concrete
16. BS EN 15167-1:2006: Specification for ground granulated blast furnace slag for use with Portland cement (BS 6699).
17. BS EN 1992-3:2006: Design of Concrete Structures for Retaining Aqueous Liquids (BS 8007).
18. BS EN 1992-1-1:2004: Structural Use of Concrete (BS 8110).

American Standard for Testing of Materials;

1. ASTM C227: Standard test method for Potential Alkali Reactivity of cement –Aggregate combination (Mortar – bar method)
2. ASTM C289 : Standard test method for Potential Alkali-silica Reactivity of Aggregates (Chemical method)
3. ASTM D412 : Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

4. ASTM 1751: Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
5. ASTM 1752: Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.

Building Research Establishment (UK): Guide to Concrete Pumping.

Cement and Concrete Association: Publication 48.034 Concrete Ground Floors

CHAPTER 6 - MISCELLANEOUS

6.01 Gabion Mattress & Boxes

(1) Stones

Stones used for gabion mattress shall be clean, natural, hard and durable with a minimum density of 2650 kg/m³. Stones shall be well graded within the limits of 250 mm to 125 mm nominal size. Stone shall be rounded rather than angular.

(2) Wire Fabric

The fabric shall be triple-twisted hexagonal woven steel wire mesh complying with BS 1052. The wire shall be PVC coated or galvanized to BS EN ISO 1461 (BS 729) coated after weaving. The minimum wire thickness shall be 2.0 mm and the mesh size shall be 60 mm x 80 mm.

All gabion boxes and mattresses shall be formed from steel wire mesh divided by partition panels. All wire shall be in accordance with BS 1052 and hot dipped galvanized with a zinc coating to BS EN 10244-2

(3) Method of Construction

The gabion boxes and mattress shall have perimeters and Body Wires thickness not less than 3mm and 2mm, respectively. Diaphragms shall be positioned such as to give compartments 2.0 m x 0.6 m. Adjoining gabions shall be firmly wired together to give a continuous join along all adjacent edges. The compartments shall be filled and the lids stretched tightly over and securely wired in place.

Sizes of gabion mattress and boxes shall be as shown on the Drawings or ordered by the Engineer.

6.02 Stone Soling

Stone Soling shall be hard durable rock from an approved source; it shall be sound, clean, un-weathered, un-fractured and free from impurities such as earth or decomposed rock.

The stones shall weigh not less than 20kg and shall not be less than 200mm in length or width. They shall be roughly hammered dressed so that they fit closely together any vacant space between stones shall be filled with stone of smaller dimension.

6.03 Gravel Bedding or Backing for Gabions or Pitching

Gravel bedding or backing for Gabions or pitching shall consist of approved clean, hard natural gravel or broken stone well graded from 50 mm to 10 mm and shall be laid to the thickness specified or ordered by the Engineer to give an even surface parallel to the exposed face of the mattresses or pitching.

6.04 Manholes and Chambers

Manholes and chambers shall be of the shape and size shown on Drawings

Manholes shall be cast in situ in concrete reinforced with either one or two layers of reinforcement and PVC lining as shown in drawing.

All Manholes shall be watertight.

All Manholes shall project a minimum of 2000 mm above ground level or as shown on drawings.

6.05 Cover Slabs and Manhole Covers

Manhole Cover slabs are precast in Class 30/20 concrete. Unless otherwise shown, all cover slabs shall be reinforced with two layers of reinforcement.

Unless otherwise shown on the drawings all Manholes shall have RCC covers as per drawing and design. Where Manholes project above ground level, covers when in position shall be flush with the adjacent cover slab top surface. For chambers under roads and verges, C.I frames shall be solidly bedded in cement mortar so that the covers when in position are fair and even with the adjacent surfaces. Two sets of the appropriate lifting keys shall be provided for the covers.

6.06 Step-irons

Step-Irons shall be fabricated from 25 mm diameter plane reinforcing bars and galvanized to BS EN ISO 1461. They shall be provided in all manholes and chambers over 900 mm deep from the top of the cover slab to the base of the chamber. Step-irons shall be spaced at 225 mm centres vertically.

Steps for manholes and other chambers shall be Type D Class 1 complying with the requirements of BS EN 13101: 2002

6.07 Inspection Chambers

Not Used

6.08 Washout Supms

Not used

6.09 Concrete Classes

Unless noted otherwise on the Drawings the classes of concrete to be employed in the construction of manholes, chambers and anchor blocks shall be as follows:-

Class 10/20S	-	Blinding General non-structural use
Class 35/20	-	Structural concrete
Class 30/20S	-	Benching to drainage chambers

6.10 Fixing and Building-in

The dimensions of holes and openings left in concrete for the subsequent fixing and concreting-in of steelwork, pipes, etc, shall be the minimum practicable. Holes

shall be tapered where possible (with maximum area of cross section farthest from the fixing surface) to suit the proposed method of fixing and concreting, all as approval by the Engineer. No hole or opening shall be formed nearer than 75 mm to an edge of concrete.

Drilling of holes shall be undertaken using a diamond tipped or other sharp drill.

All holes and openings shall be thoroughly cleaned before use by hacking, wire brushing, water or air under pressure, or other approved means to remove all laitance and expose the aggregate.

All fixing bolts shall be fixed using epoxy resin which shall be made using approved type resin/hardener cartridges, used in strict accordance with the manufacturer's recommendations.

The size or number of resin cartridges shall be determined based on the sizes of the hole and bolt or bar and the length of bond required for maximum strength. After installation and mixing the bolt or bar shall be supported in the precise position required until the resin has set.

Steelwork and other items to be concreted in position shall be firmly secured against movement during concreting, the supports not being removed without the Engineer's approval. Fixing bolts positioned by template shall be similarly screwed in perfect alignment and level until the concrete or grout is set hard.

Frames and flanges to be fixed against the face of concrete shall be supported against the face and separated therefrom by 10 mm packings of a waterproof and durable material to the approval of the Engineer and sufficiently flexible to take up any shrinkage of the filler during final tightening. Immediately before fixing the frame or flange the face shall be carefully cleaned and roughened over the area of contact. Securing nuts shall be lightly tightened to hold the item in position without distortion and the space between the frame or flange and the concrete shall be filled with cement mortar or hard setting butyl mastic. After the filling has hardened the securing nuts shall be finally tightened in a sequence to ensure equal load carrying and freedom from distortion.

Except where otherwise specified, when a metal surface is to be fixed permanently to a metal or other surface, the metal surfaces shall be painted on Site with two coats of bituminous paint immediately prior to fixing.

All steel fixings, nuts, bolts and washers shall be galvanized in accordance with BS EN ISO 1461 (BS 729) unless otherwise stated.

Where the type of fixing is not specified, the Contractor shall obtain the Engineer's approval to the type and position of fixing before proceeding. Proprietary fixings supplied by reputable manufacturers will generally be allowed, subject to their use and loading conforming to the manufacturer's instruction.

6.11 Handrailing

Handrailing shall be constructed from galvanized Grade 43 mild steel. The posts and handrailing shall be 32 mm Nominal Bore (N.B.), 3 kg per meter run. The maximum distance between posts shall be 1.67 meters for a 1.067 meters high standard post. The post connections shall be 60 mm diameter balls with grubs screw fixings. The posts shall be fixed to steel using a bolted cleat as shown on tire Drawings. The posts shall be fixed to concrete using a base plate bolted to the primary concrete using approved bolts.

Removable sections of the handrail shall have half-lap joints secured with a countersunk pin.

Chains across openings shall be fabricated from 10 mm diameter, 3 links per 100 mm stainless steel manufactured from Grade 316 S31 steel complying with BS EN 10083 (BS 970: Part 1). The hooks and retaining eyes shall be securely fixed to the standards.

After manufacture handrailing components shall be galvanized in accordance with Clause 6.06

6.12 Open Type Metal Flooring and Stair treads

Open type flooring complete with cut-outs and in sizes suitable for removal by hands shall be of mild steel and of sufficient thickness to carry a loading of 2.5kN/m'.

The open steel flooring shall be supported by rolled steel members built into the concrete piers.

The open steel flooring shall be secured to frames by means of stitching bolts as recommended by the manufacturer the top of the open steel flooring shall be flush with the top of piers. The open steel flooring and cross supporting members shall be removable and of a convenient size for handling.

Galvanized open steel flooring shall be 'Safetread', as supplied by Messrs Allan Kennedy Company Limited, Stockton-on-Tees, UK, or other similar approved type.

Any supporting structures to flooring shall be designed and supplied by the Contractor.

6.13 Metal Plate Decking

Metal plate decking complete with cut-outs and to sizes suitable for removal by hand shall be of galvanized mild steel and of sufficient thickness to carry a loading of 3 kN/m² but not less than 5 mm thick. This shall be measured excluding the pattern, which shall be raised self draining non-slip pattern, and with the finishes as specified.

The metal plate decking shall be set in mild steel rebated surround frames built into the floor. The metal plate decking shall be supported where necessary by rolled steel joists of size not less than 76.2 mm x 76.2 mm.

The metal plate decking shall be secured to the surround frames and supporting joints by means of countersunk stainless steel pins or set-screws and the top of the metal plate decking shall be flush with the adjacent floor. Suitable separators between the dissimilar metals shall be used. The metal plate decking and supporting joists shall all be removable and of a convenient size for handling. Lifting holes shall be provided in each plate and the Contractor shall supply two sets of lifting keys.

6.14 Ladders and Step Irons

Ladders shall be fabricated of mild steel and galvanized as specified. The stringers shall be flat section 65mm by 10 mm spaced 400 mm apart. Top stays welded to stringers shall be flanged and drilled for wall fixing. The bottom of the stringers shall be flanged and drilled for floor fixing. Fixing bolts and nuts shall be specified herein.

Rungs shall be 20 mm diameter solid at 250 mm centers shouldered at each end and securely riveted into countersunk holes. Rungs shall not be less than 240 mm from the walls.

Ladders shall have intermediate stays at not less than 1.7 m unless otherwise approved.

Step irons shall be formed from 25 mm dia mild steel solid bar, bent to shape and galvanized as specified. The steps shall be 300 mm wide and project 200 mm from the wall face. They shall be built into the wall a minimum depth of 100 mm and shall have their ends bent through 90 degrees to run parallel to the wall face by 150 mm to form an anchorage. Unless otherwise directed by the Engineer step irons shall be spaced at 300 mm intervals vertically and in-line.

6.15 Fencing

Fences shall be constructed with plastic coated chain link mesh on concrete posts set in concrete with cranked top to take barbed wire all generally to BS 1722 : Part 1.

The post type shall be GLC 180C but with top cranked through 45 degrees to take three strands galvanized barbed wire to BS 4102.

The fencing shall be heavy duty plastic coated chain link mesh. The erection shall be in accordance with BS 1722, Section 3.

The double opening gates shall be manufactured to match the fencing as shown on the Drawings and shall be provided with all hinges, bolts, fastenings and padlock with two keys.

Gates and frames shall be galvanized in accordance with BS EN ISO 1461 (BS 729).

6.16 Cleaning of the Conduit

On completion, all water retaining structures shall be carefully cleaned by sweeping and brushing with stiff brooms, first with the minimum use of water and subsequently with water hosing, to the approval of the Engineer. The water shall

be run off, bailed or pumped out after cleaning and any sediment removed to the satisfaction of the Engineer.

6.17 Testing of the Conduit

Hydraulic testing of conduit is not required.

6.18 References

Following publications have been referred:

British Standard Institution (London);

1. BS EN 124 (BS 497): Specification for manhole covers, road gully gratings and frames for drainage purposes. Cast iron and cast steel.
2. BS EN ISO 1461 (BS 729): Specification for hot dip galvanized coatings on iron and steel articles.
3. BS 1052 : Mild steel wire for general engineering purposes.
4. BS 1722 : Specification for anti-intruder fences in chain link and welded mesh.
5. BS 4483 : Steel fabric for the reinforcement of concrete.
6. BS 4102: Specification for steel wire for general fencing purposes.
7. BS EN 10083 (BS 970): Steel for quenching and tempering.

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HIGH-DENSITY POLYETHYLENE PIPES

Part-1: General

7.1 Scope of Work

This chapter covers the laying, jointing and requirements for pressurized High-Density Polyethylene Pipelines and fitting, HDPE-100 Pressurized Pipes of Nominal Pressure of 16 Bars (PN16), primarily intended for the transportation of sewage, either buried or above grade. The sizes are shown in drawings or specified in BOQ.

7.2 General

All polyethylene pipe, tubing and fittings furnished under this specification shall conform to all applicable provisions and requirements of the latest revision of AWWA C901 and ISO 4427 and, by inclusion, all appropriate standards referenced therein.

Pipes and fittings of any one material shall not be supplied by more than one manufacturer except with the approval of the Engineer.

They shall be of the class or grade having a factory or works internal hydraulic pressure test rating not less than the pressure rating as defined in the appropriate Standard Specification.

No pipes or fittings shall be ordered without the agreement of the Engineer.

7.3 Definitions

The following words and expressions shall have the meanings hereby assigned to them except where the context otherwise requires:

'pipeline' shall mean a line of pipes having an appreciable length, it may have branch line, but these would not normally be numerous. It does not include piping systems such as process plant piping within refineries, factories or treatment plant, short connections between adjacent plant and distribution and service mains which are characterised by numerous branch connections. Pipework shall mean all pipes excluded from the definition pipeline.

'pressurized pipelines' shall mean pipelines in which the nominal internal working pressure exceeds 3 m of water (0.3 bar) and such other pipework as may be so designated.

'pipes' shall mean straight tubes having plain ends or ends shaped to form joints.

'flexible pipes' shall mean pipes having a specific stiffness of:

$$E' = (EI)/D^3$$

of less than 11 kN/m per unit length of pipe.

Where E = Young's modulus of pipe wall material

I = moment of inertia of pipe wall per unit length

D = pipe diameter

'fittings' shall mean bends, junctions, reducers, tapers, joint adaptors and similar items which are not joints or flow control equipment.

'internal' shall mean those parts of pipes or fittings which are to be in contact with the liquid being conveyed.

'Flexible joints' shall mean joints made with factory made jointing materials, loose collars, rubber joint rings and the like which permit angular deflections between adjacent pipes.

'chamber' shall mean structures on the pipeline housing pipes, fittings and valves, including fittings through the chamber walls.

'waste water/sewage' is water from sewerage system before it has received any treatment other than that inherent in pumping and conveyance.

7.4 Test Certificates

Each consignment of pipes and fittings delivered to the Site shall have been tested at the manufacturer's works or other approved place in accordance with the appropriate AWWA and British or other approved standard (such test being referred to here as Works tests). The Contractor shall provide the Engineer with the manufacturer's test report for each such consignment before delivery to Site begins.

The Engineer reserves the right to inspect the pipes and fittings to be supplied for the Works at the place of manufacturer and to witness works tests at all contractor cost.

7.5 Compatibility

Contractor is responsible for compatibility between pipe materials, fittings and appurtenances.

7.6 Warranty

The pipe MANUFACTURER shall provide a warranty against manufacturing defects of material and workmanship for a period of ten years after the final acceptance of the project by the OWNER. The MANUFACTURER shall replace at no expense to the OWNER any defective pipe/fitting material including labor within the warranty period.

Part-2: Products and Execution

7.7 Physical Properties of HDPE 100 Pressure Pipe Material

Table 1-1: Physical Properties of Pressurized Pipe Material

PHYSICAL PROPERTIES	UNIT	VALUE	TESTING METHOD
Density (23 OC)	g/cm3	0,950-0,960	ISO 1183
Melting Flow Rate (MFR)190 oC-2,16 Kg	g/10 min	0,04-0,07	ISO 1133
Melting Flow Rate (MFR)190 oC-5,0 Kg	g/10 min	0,2-0,5	ISO 1133
Breaking Elongation	%	>600	ISO 527-2/1B/50,TS 1398
Yield Stress Endurance	MPa	22-27	ISO 527-2/1B/50,TS 1398
Elasticity Module	MPa	950-1400	ISO 527-2/1B/50,TS 1398
Carbon Black Amount (190 oC-5,0Kg)	%	>2	ISO 6964
Hardness	Shore D	59-60	ISO 868
Thermal Endurance	min	>20	EN 728, ISO/TR 10837
Vicat Softening Temperature	OC	126	ISO 306(METHOD A)
Brittleness Temperature	OC	<-70	ASTM D-746
Thermal Conductivity (20 OC)	W/mK	0,4	DIN 52612
Thermal Conductivity (150 OC)	W/mK	0,2	DIN 52612
ESRC (at 50 OC),F 50	hour	>10000	ASTM D-1693

7.8 Pipeline Materials

Polyethylene compounds utilized in the manufacture of products furnished under this specification shall be listed in PPI TR-4, have a grade of PE34 with a minimum cell classification of PE 345444 [C,D, or E] for PE3408 materials, as defined in ASTM D3350.

In conformance with AWWA C906, they shall have a PPI recommended Hydrostatic Design Basis (HDB) of 1600 psi (PE3408) at a temperature of 73.4°F (23°C). All materials which come in contact with water, including lubricants, shall be evaluated, tested and certified for conformance with NSF/ANSI Standard 61, if required by the production standard or requested by the end user. Clean re-work material of the

same type grade, and cell classification generated from the manufacturer's own pipe and fitting production may be used by the same manufacturer as long as the pipe, tubing and fittings produced meet all the requirements of AWWA C906.

7.9 Pipe and Tubing

Pipe and tubing furnished under this specification shall be manufactured using compounds complying with the requirements mentioned above. Dimensional and performance characteristics shall conform to the requirements of AWWA C906. The pipe's DR (Dimension Ratio) and Working Pressure Rating (WPR) shall be as specified by the project design engineer.

7.10 Fittings

Polyethylene fittings furnished under this specification shall be manufactured using compounds complying with the requirements mentioned above, and all appropriate requirements of AWWA C906. Socket type fittings shall comply with ASTM D2683. Butt fusion fittings shall comply with ASTM D3261.

All molded fittings and fabricated fittings shall be fully pressure rated to match the pipe SDR pressure rating to which they are made. All fittings shall be molded or fabricated by the manufacturer. No Contractor fabricated fittings shall be used unless approved by the Engineer.

Electrofusion fittings shall comply with ASTM F1055. Fabricated fittings shall be designed in accordance with the requirements of Section V and manufactured to be as strong as or stronger than the pipe to which the fittings will be joined. Mechanical fittings produced from material not listed in Section II shall be approved only after submission of appropriate test data and service histories indicating their acceptability for the intended service. In all cases, the specifications and requirements for the fittings supplied shall comply with the appropriate sections of AWWA C906.

7.11 Pressure Rating

The Pressure Class of the PE pipe and PE fittings shall be specified on the basis of the Working Pressure Rating of the water system as defined in AWWA C906. Recurring positive pressure surges of up to one half of the pipe's nominal pressure class and occasional pressure surges of up to 100% of the pipe's nominal pressure class may be ignored due to the fatigue endurance of the polyethylene materials. Non-polyethylene fittings shall be specified and used in accordance with the surge tolerance of the particular appurtenance in use.

7.12 Pipe Identification

Pipe and tubing shall be identified by being marked in accordance with either AWWA C906 or whichever applies. Marking shall be legible and shall remain legible under normal handling and installation practices. The following shall be indent printed on the pipe or spaced at intervals not exceeding 5 feet:

- a. Name and/or trademark of pipe manufacturer
- b. Nominal pipe size
- c. Dimension ratio
- d. The letters "PE" followed by the polyethylene grade in accordance with ASTM.
- e. Pressure rating
- f. Manufacturing standard reference, for e.g., AWWA C906
- g. A production code from which the date and place of manufacture can be determined
- h. Color identification, either stripped by co-extruding longitudinal identifiable color markings or shall be solid in color and as follows:
 - (i) Blue – Potable Water
 - (ii) Green – Waste Water

Indent marking may be utilized provided (1) the marking does not reduce the wall thickness to less than the minimum value for the pipe or tubing, (2) it has been demonstrated that these marks have no effect on the long term strength of the pipe or tubing and (3) the marks do not provide leakage channels when elastomeric gasket compression fittings are used to make the joints. Fittings shall be marked on the body or hub. Marking shall be in accordance with either ASTM D2683, ASTM D3261, AWWA C906 or ASTM F1055, depending on fitting type and the standard that applies. Mechanical fittings shall be marked with size, body material designation code, pressure rating and manufacturer's name or trademark.

7.13 Workmanship

Pipe, tubing and fittings shall be homogeneous throughout, and free of visible cracks, holes, foreign inclusions, blisters, dents, or other injurious defects. The pipe, tubing, and fittings shall be as uniform as commercially practicable in color, opacity, density, and other physical properties. Quality Control Pipe, tubing and fittings furnished under this specification shall comply with AWWA C906 or whichever applies.

7.14 Fusion Qualification

The manufacturer of pipe, tubing and fittings supplied under this specification shall establish and qualify heat fusion procedures for the joining of the materials supplied if required. Qualified fusion procedures, with appropriate supporting data, shall be furnished to the purchaser upon request. PPI Technical Report TR-33 is this generic butt fusion procedure for field fusion of polyethylene pipe. This report is also listed in ASTM D2657 Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings.

7.15 Survey of the Pipeline Route

The CONTRACTOR in conjunction with the ENGINEER will set out and agree the final pipeline route and shall undertake a detailed survey of the agreed route prior to the commencement of construction work. The CONTRACTOR shall submit the results of the survey to the ENGINEER in the form of longitudinal sections drawn to a scale to be decided by the ENGINEER. They shall conform to the following:

(i) The length of the route shall be accurately measured and approved type Chainage markers fixed at 50 m intervals and clearly marked with the Chainage at that point.

(ii) Using modern survey equipment approved by the ENGINEER, ground levels shall be taken at intervals agreed with the ENGINEER. Generally a 25 m interval will be acceptable though this is to be reduced as necessary to ensure any abrupt changes in ground level are recorded.

(iii) Levels shall relate to an approved datum, and permanent bench marks shall be established, clear of the proposed pipeline, at intervals along the pipeline route.

The ENGINEER will review the pipeline profile and amend it where necessary including any revisions to the number and positions of air valves and washouts.

At all times the route surveying shall be sufficiently ahead of excavation and pipe laying by at least one further week's work to permit the ENGINEER's review to be carried out and revisions to be issued to the CONTRACTOR on the pipeline between high and low points on the section under construction and the next section to be opened up for construction.

7.16 Laying and Jointing

All the pipes shall be examined for defects before lowering in the trenches. Defective or damaged pipes shall not be used.

Pipe should be handled carefully so as not to damage them in any way. Any pipe damaged due to mishandling during pipes lowering, laying, jointing or at any other stage at site shall not be acceptable for use in permanent works. Laying and jointing of pipe shall be done in accordance with approved procedure keeping in view the integrity of pipes and joints. Adequate side support of acceptable nature shall be provided for the pipeline to keep the pipe at correct level and alignment. The width of excavated trench is as specified in the drawings but in any case it shall not be less than the minimum specified in ASTM D 2321.

Pipes should be laid so that the spigot ends enters the socket of the last pipe that is socket facing against the flow direction with Butt fusion jointing of PE pipes as per instructions of ENGINEER.

Backfilling should be completed as soon as possible after pipe laying, and before the pipes are charged with water to avoid risk of pipes floating if trench is flooded during heavy rain. No pipe line shall or part thereof shall be covered up until all has been inspected by the ENGINEER or his representatives, but such inspection shall not relieve the CONTRACTOR from his responsibilities of delivering over the whole length of pipe line in a watertight, correct and perfect condition. The choice of the backfill material is very important.

7.17 Granular Bedding for Pipes (Class B Bedding)

The contractor shall lay the pipes on granular bedding where indicated on Drawings or directed by the Engineer. This bedding material shall consist of clean coarse sand or as specified by the Engineer or shown on drawings. Thickness of the bedding material below the pipe shall be as shown in the drawing and directed by the Engineer.

If the granular bedding material is contaminated by water, sewage or collapse of the sides of the trench, it shall be removed and replaced with new material before the pipes are laid or re-laid.

7.18 Concrete Bedding and Surround for Pipes

The pipes shall be bedded in concrete, where required, of Class 30/20 as shown on Drawings and where directed by the Engineer.

A typical section of concrete Class 30/20 surround is given in drawings. The Contractor shall provide full encasing of concrete at locations shown on Drawings or instructed by the Engineer.

The pipes shall be laid on a concrete bed of Class 30/20 (Bedding Class A) at locations where directed by the Engineer. The concrete shall be laid on well-compacted and levelled bed.

The material used in the concrete, method used in mixing, laying and curing etc. of the concrete shall be as specified in Chapter 5. S.R. cement shall be used for concrete where required.

7.19 Backfill

The backfill material shall be placed and compacted in 150mm thick layers to achieve the required density uniformly throughout the depth of each layer. Mechanical compaction directly above the pipe shall not commence until at least 200mm of cover is provided when using hand-held equipment or 300mm when using self-propelled equipment.

Trafficable Areas

The backfill material shall be compacted to achieve not less than 95% of the modified Proctor maximum dry density as specified in BS 1377, Test13.

Non-Trafficable Areas

The backfill material shall be compacted to achieve not less than 90% of the modified Proctor maximum dry density as specified in BS 1377, Test13.

7.20 Testing

The CONTRACTOR shall carry out hydraulic test on the pipeline to detect lack of continuity or gross defects and to prove structural integrity in the pipeline section under test. This test may be carried out in sections as construction proceeds.

Pressure testing shall be conducted per Manufacturer's recommendations and as approved by the Engineer. All HDPE rising mains shall be disinfected prior to pressure testing as per specifications. All HDPE mains shall be field-tested. Each main shall be pressure tested upon completion of the pipe laying and backfilling operations, including placement of any required temporary roadway surfacing. All mains shall be tested at 150 percent of the operating design pressure of the pipe unless otherwise approved by the Engineer.

Unless otherwise specified or directed by the ENGINEER pipes of different materials in a pipeline shall be tested separately.

The CONTRACTOR shall supply all labor, equipment, material, gages, pumps, meters and incidentals necessary for carrying out the tests and shall be responsible for all work on the test site and for meeting all the requirements of all relevant regulations.

The hydraulic testing shall be carried out by an experienced specialist sub-contractor or specialist section of the CONTRACTOR's Organization to the approval of the ENGINEER.

A Specialist Test ENGINEER shall be appointed by and specifically named by, the CONTRACTOR to be in full charge of all tests to be performed.

The Specialist Test ENGINEER shall prepare a schedule of operations for the tests stating the responsibilities of his subordinates during all phases of the work. The schedule shall include details of the following:

- (a) Safety precautions to be observed during testing.
- (b) The design and supply of any test fitting required.
- (c) The locations of the test cabin, pumps, air compressors and any other equipment.
- (d) Filling and pressurizing, including sources of water, test connections and vent points.
- (e) Hydraulic testing procedure.
- (f) Depressurising and emptying and details of disposal of water.
- (g) Fully detailed programme giving proposed dates of tests.
- (h) List of nominated personnel supervising tests with dates and time of duty.

The schedule shall be submitted to the ENGINEER for approval at least 28 days prior to commencement of testing and written approval shall be given by the ENGINEER before any testing may commence. Contractor shall notify a minimum of 48 hours prior to test.

Pressure testing procedure shall be per Manufacturer's recommendations or as follows:

- a. Fill line slowly with water. Maintain flow velocity less than 2 feet per second.
- b. Expel air completely from the line during filling and again before applying test pressure. Air shall be expelled by means of taps at points of highest elevation.
- c. Apply initial test pressure and allow to stand without makeup pressure for two to three hours, to allow for diametric expansion or pipe stretching to stabilize.
- d. After this equilibrium period, apply the specified test pressure and turn the pump off. The final test pressure shall be held for one to three hours.
- e. Upon completion of the test, the pressure shall be bled off from a location other than the point where the pressure is monitored. The pressure drop shall be witnessed by the resident project representative and the Engineer at the point where the pressure is being monitored and shall show on the recorded pressure read-out submitted to the Engineer of Record.

If any test of pipe laid disclosed leakage significant pressure drop greater than the manufacturer's recommended loss, the Contractor shall, at his/her own expense, locate and repair the cause of leakage and retest the line. The amount of leakage, which will be permitted, shall be in accordance with AWWA C600 Standards. All visible leaks are to be repaired regardless of the amount of leakage.

7.21 References

Following publications have been referred:

1. BS EN 13476-3:2007: Plastics piping systems for non – pressure underground drainage and sewerage.
2. ASTM D1505: Standard Test Method for Density of Plastics by the Density-Gradient Technique
3. ASTM D1603: Standard Test Method for Carbon Black Content in Olefin Plastics
5. ASTM D3895: Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
6. ASTM D4019: Standard Test Method for Moisture in Plastics by Coulometric Regeneration of Phosphorus Pentoxide

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| 7. | ASTM D2288: | Standard Test Method for Weight Loss of Plasticizers on Heating |
| 8. | ASTM D1238: | Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer |
| 9. | ISO 527-2: | Plastics -- Determination of tensile properties- Part 2: Test conditions for moulding and extrusion plastics |
| 10. | ISO 12091: | Structured-wall thermoplastics pipes -- Oven test |
| 11. | EN 1446: | Plastics piping and ducting systems. Thermoplastics pipes. Determination of ring flexibility |
| 12. | EN 295-3: | Vitrified clay pipes and fittings and pipe joints for drains and sewers. Test methods |
| 13. | ASTM D2122: | Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings |
| 14. | ASTM D2683: | Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing |
| 15. | ASTM D3261: | Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing |
| 16. | ASTM F1055: | Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing |
| 17. | ASTM D2321: | Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications |
| 17. | AWWA C906: | Standard Practice for Polyethylene (PE) Pressure Pipe and Fittings, 4 In. Through 65 In. (100 mm through 1,650 mm), for Waterworks |

CHAPTER-8 VALVES

8.01 DESCRIPTION

- a. This work shall consist of providing, installing, testing, commissioning furnish all labor, equipment, materials, tools, supplies, fittings, including gasket, steel nuts, bolts & washer and appurtenances required for the support, installation, protective coating, and testing of valve in the locations shown, and all appurtenant work, for a complete and workable installation as specified herein, in accordance with the requirements of the Contract Documents (where included in the BOQ), in accordance with these specifications and to the layouts and details, shown on the Drawings and/or as directed by the Engineer.
- b. The items specified under this Section shall be furnished by manufacturers having experience in the manufacture of similar products for a period of at least 5 years.
- c. All valve items shall be manufactured of material suitable for the water, wastewater, sludge and air they serve, and shall be certified for such use on the shop drawings.

8.02 GENERAL REQUIREMENTS

Gate Valves: Gate valves shall be double flanged wedge gate type supplied by an approved manufacturer with non-rising spindles conforming generally to ASTM or EN 1171 Standards with gunmetal or synthetic rubber covered seals. They shall have cast iron bodies and wedges to ASTM A48 or EN 1561 with spindles, spindle nuts and facings on the wedge and body of solid forged bronze or synthetic rubber.

Valves shall be arranged for clockwise closing by cast iron hand wheel on which the direction of closing shall be indicated, valves shall also be provided with a suitable drain plug, and shall have flanges faced and drilled to standard PN 16. Overhead valves shall be provided with chain wheels to enable the valves to be operated from the working level.

Mains isolating valves sited within external valve chambers shall be flange coupled to the rising main in order to retain the static head within the main. Valves of 500 mm dia. and greater installed in horizontal pipe runs shall be provided with their own supports and shall not be supported by the pipe work.

Check Valves: Check valves shall be of the Non-Slam type manufactured to ASTM and AWWA or EN 12334 standards, with dampening action to avoid excessive transient pressures.

The body shall be manufactured from cast iron to ASTM A48 or EN 1561 and shall have gunmetal seating provided on the body. The internal body shall be Nitrile reinforced.

Air Valves: Combination Air Valve for releasing or admitting air during the filling and/or emptying pipelines and the release of air accumulating in pipeline during normal working conditions. Combination Air Valve shall be manufactured to appropriate ASTM and AWWA or EN standards.

The body shall be manufactured from cast iron and shall have integral isolating valves to act as single unit. Resilient Orifices seal shall be of 16 bar working pressure.

Shop Drawings: The CONTRACTOR shall furnish shop drawings of all items and accessories in accordance with the General Requirements. Shop drawings shall include detailed design calculations stamped by a registered engineer, bill of materials listing all valve components, materials, tools, supplies, fittings, and appurtenances, etc., with manufacturer's name, trade and identification marks.

All manufactured items provided under this Section shall be new, of current manufacture, and shall be the products of reputable manufacturers specializing in the manufacture of such products; such manufacturers shall have had previous experience in such manufacture and shall, upon request of the ENGINEER, furnish the names of not less than 5 successful installations of its equipment of comparable nature to that offered under this contract.

All combinations of manufactured equipment which are provided under these Specifications shall be entirely compatible, and the CONTRACTOR and the listed manufacturer shall be responsible for the compatible and successful operation of the various components of the units conforming to specified requirements. All necessary mountings and appurtenances shall be included.

All materials employed in the manufacture and installation of the valves shall be suitable for the intended application; material shall be high-grade, standard commercial quality, free from all defects and avoid imperfection that might affect the serviceability of the product.

Wetted parts of all valves shall be selected by the manufacturer to ensure optimum, corrosion-free, and erosion-free operation for the fluid involved.

Data Requirements: The drawings and data submitted shall include the following:

- a. Name of manufacturer.
- b. Dimensions of Valve.
- c. Data sheet for pressure test.
- d. Equipment weights.
- e. All materials of construction listed and applied coating.

8.03 MANUFACTURER OR EQUAL

- a. Val Matic
- b. SISTAG
- c. KITZ
- d. COSMOS Engineering Co.
- e. KSB

8.04 GENERAL INSTALLATION REQUIREMENTS

General: Valves shall be installed in accordance with procedures submitted with the CONTRACTOR approved shop drawings and as shown, unless otherwise acceptable to the ENGINEER.

Alignment: Equipment shall be field tested to verify proper alignment, operation as specified, and freedom from binding, scraping, or other defects. Equipment shall be secure in position and neat in appearance.

8.05 TESTING AND COMMISSIONING

Each valve shall be test in presence of Engineer according to the manufacture pressure rating. Any kind of leakage from the valve is not acceptable. The valve shall be operate, by the Contractor, to demonstrate, to the satisfaction of the Engineer, that it is working, satisfactorily, in accordance with the specifications.

8.06 MEASUREMENT

Measurement for valve of specified type, materials, characteristics and dimensions will be made in the number of these items, acceptably installed, in accordance with the approved Drawings or directions of the Engineer.

8.07 RATES AND PAYMENT

8.7.1 Payment

Payment for valve, of specified type, materials, characteristics and dimensions will be made for their respective quantities, at the unit rates, tendered in the priced Bill of Quantities.

8.7.2 Rates

The unit rates tendered, for valve, shall be deemed to be inclusive of but not limited to the following:

Providing, installing complete valve, comprising main their support structure, painting/coating works; all fixing & installation accessories including bolts, nuts, washers, gasket, fittings, and leveling materials; and a complete set of special tools, test equipment and essential spare parts etc:

- a. All sorts of transportation involved in the process
- b. All sorts of wastages
- c. Operations including injecting initial charges of lubricant and maintenance, protection and repairs, of the work
- d. Carrying out designs and preparing shop drawings
- e. Carrying out all sampling and testing
- f. All other operations, procedures and requirements necessary to complete the work in accordance with these specifications

CHAPTER 9 - ROADS

9.01 General

Roads shall be either:

- (i) surfaced roads comprising a sub-grade shaped to the formation profile, a granular road base and a dense bitumen macadam wearing course as specified, or
- (ii) unmetalled roads.

They shall be constructed to the levels, grades and dimensions shown on the Drawings or as ordered by the Engineer.

9.02 Sub-grade

The sub-grade shall comprise an earth embankment of material excavated from drainage ditches parallel to the road, fill from approved borrow areas, or rock or earth in cutting. The material for sub-grade shall be placed in horizontal layers of uniform thickness and in conformity with lines, grades, sections and dimensions shown on Drawings or as directed by the Engineer. The layers of loose material other than rock shall be not more than 20 cm. thick unless otherwise allowed by the Engineer after a trial section is prepared and approved.

The area constituting the sub-grade shall be cleared as specified in Chapter 2.

The earthworks necessary to form the sub-grade shall comply with the requirements of the relevant clauses of Chapter 4.

Fill to the sub-grade shall be compacted as specified in Clause 4.08 to produce a dry density not less than 95% of the modified proctor maximum dry density as specified in BS 1377, Test 13. Rock overbreak shall be made good with approved crushed stone.

Where the dry density of the, natural ground within 0.50 m of the formation level is below 95% of the modified proctor maximum dry density as specified in BS 1377, Test 13, the material shall be reworked and compacted as specified above.

The formation level of the sub-grade shall be formed to level, camber or cross fall, as shown on the Drawings.

9.03 Protection of Sub-grade

The sub-grade, after approval by the Engineer, shall be protected and kept well drained. Storage or stockpiling of materials, or passage of Construction Plant on the formation level shall not be permitted.

Traffic will not be permitted to pass over the completed sub-grade until approval of the Engineer has been received.

Prior to construction of the road base, the sub-grade shall be cleaned of all foreign substances. Ruts, soft spots, areas of inadequate compaction or any deviation of the surface from the specified requirements shall be made good to the approval of the Engineer.

9.04 Road Base Material

Granular road base material shall be well graded aggregate. It shall consist of crushed stone or uncrushed gravel and sand, having clean tough and durable particles free from soft or weathered material, dirt or other objectionable matter.

Sources of the material shall be determined by the Contractor and approved by the Engineer. Preliminary approval of a source shall not infer that all material derived therefrom will be acceptable.

The method of grading shall comply with the requirements of BS 1377. The material shall have a grading which is mechanically stable and shall lie within and be approximately parallel to the curves defined by the following limits.

BS sieve size	Percentage by mass passing
50 mm	100
37.5 mm	90-100
20 mm	60-100
10 mm	40-80
5 mm	25-60
2.36 mm	15-45
600 μ m	8-30
75 μ m	5-12

The percentage passing the 75 μ m sieve shall be chosen according to the grading and plasticity of this fraction. If the plasticity index of the fines reaches the upper limit of 6, the fines content shall be restricted to the lower end of the range. For material with non-plastic fines, the proportion passing the 75 μ m sieve shall be not more than 12%.

The base material shall be tipped on the approved sub-grade, spread, leveled and rolled to a minimum thickness after rolling of 150 mm.

9.05 Stockpiling

Approved road base material shall be stockpiled in the manner and at the locations approved by the Engineer. Prior to stockpiling, storage sites shall be cleaned and leveled by the Contractor all at his own expense.

9.06 Weather Limitations

The road base shall be constructed only when weather conditions do not detrimentally affect the quality of the finished course. Any areas of the road base that are damaged by the effects of weather conditions during any phase of construction shall be completely made good to the satisfaction of the Engineer and at the expense of the Contractor.

9.07 Compaction of Road Base

The road base shall be thoroughly compacted by vibrating and/or rolling and sprinkling with water.

All equipment tools and machines employed for the Works shall be subject to the approval of the Engineer and shall be maintained in a satisfactory condition at all times.

The road base material shall be compacted to produce a dry density of at least 98% of the modified proctor maximum dry density as specified in BS 1377, Test 13.

The construction shall proceed in stages so that the compacted thickness of each layer of aggregate does not exceed twice the maximum stone size.

9.08 Grade and Alignment Control

Grade and alignment control stakes shall be furnished, set and maintained by the Contractor, subject to checking by the Engineer, in order that the work shall conform to the lines, grades, and cross-sections shown on the Drawings or ordered by the Engineer. The stakes shall be set in rows on, and parallel with the centre line of, the roadway, and spaced so that string lines may be stretched between them, but in no case more than 10 m apart.

9.09 Tolerances

(i) Tolerances in Surface Levels

Measurements of surface levels shall be taken at points selected by the Engineer at 10 m centres longitudinally and at 2 m centres transversely.

Tolerance in surface levels shall be as follows:

Sub-grade	±20 mm
Road base	±10 mm

(ii) Tolerances in Surface Regularity

The surface regularity shall be tested at points decided by the Engineer with a straight edge 3 m long placed parallel with or at right angles to the centre line of the road. The maximum allowable deviation of the surface below the straight edge shall be 10 mm.

(iii) Rectification

Where any tolerances are exceeded the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the surface of the pavement course or formation as follows:

If the sub-grade level is too high it shall be retrimmed and recompact as specified. If the formation surface is too low the deficiency shall be corrected by the addition of suitable material of the same classification or other approved material laid and compacted to Specification.

The road base shall be scarified to a depth of 75 mm, reshaped, with material added or removed as necessary and recompact all to Specification. The area treated shall be not less than 15 m long and 2 m wide or such area to be determined by the Engineer.

9.10 Sampling and Testing Materials

The sources of material shall be selected in advance of the time when the material will be required in the work and adequate representative samples submitted not less than 30 days before the intended date to use the material.

9.11 Priming Coat

The surface of the road base shall be primed with bitumen and the wearing course laid as soon as practicable after completion of the road base.

Immediately before spraying the primer all dust, dirt, sand and other loose material shall be removed. If required by the Engineer the road base shall be reasonably moist for the use of Emulsified Asphalt. The primer shall be applied uniformly by pressure distribution. The rate of application shall be such that the primer penetrates the surface of the road base to a minimum depth of 4 mm and dries to a matt finish within 24 to 48 hours.

The primer shall be a low viscosity medium curing cut back bitumen to BS EN 13924 (BS 3690) type MC 30 to MC 70 and the rate of application shall be between 0.5 l/m² and 1.4 l/m². The temperature of application shall be 30°C to 60°C for grade MC 30 and 80°C for grade MC 70.

The application of primer is prohibited when the weather is foggy or rainy or when the atmospheric temperature is below fifteen (15) degree C unless otherwise directed by the Engineer. No vehicular movement is prohibited after the application of prime coat. Primed surface shall be kept undisturbed for at least 24 hours, so that the bituminous material travels beneath and leaves the surface in non-tacky conditions. No asphaltic operations shall be allowed on tacky conditions.

9.12 Dense Bitumen Macadam Wearing Course

This material, of 14 mm nominal size, shall comply with BS EN 13108 (BS 4987) for traffic category B. It shall be machine laid and compacted in a single course, in conformity with BS EN 13108 (BS 4987).

Bituminous materials shall be transported in clean vehicles and shall be covered over when in transit or awaiting tipping. The use of dust, coated dust, oil or water on the interior of the vehicles to facilitate discharge of the mixed materials is permissible but the amount shall be kept to a minimum, and any excess shall be removed by tipping or brushing.

The mixed material shall as soon as possible after arrival at the Site be supplied continuously to the paver and laid without delay. The rate of delivery of material to the paver shall be so regulated as to enable the paver to be operated continuously and it shall be so operated whenever practicable.

The rate of travel of the paver and its method of operation shall be adjusted to ensure an even and uniform flow of material across the full laying width, freedom from dragging or tearing of the material and minimum segregation.

Material shall be compacted as soon as rolling can be effected without causing undue displacement of the mixed material and while this has at least the minimum rolling temperature stated in appropriate British Standard.

At least one (1) week prior to asphaltic works, a Job Mix Formula (JMF) shall be established jointly by the Engineer and the Contractor. The JMF shall combine the mineral aggregates and asphalts in such proportions conforming to relevant BS requirements.

Hot asphaltic mixtures shall be placed only when the air temperature is four (4) degree Centigrade or above and no asphalt shall be laid under foggy or rainy weather or over moist surface.

9.13 Pre-cast Concrete Kerbs

Pre-cast concrete kerbs shall comply with the requirements of BS EN 1340 (BS 340), and as shown on the Drawings.

9.14 Unmetalled Roads

Unmetalled roads shall be formed to the dimensions, cross falls and grades shown on the Drawings. The surface shall be formed by either grading the existing surface or by spreading and compacting fill material, all as directed by the Engineer. The final surface shall be well compacted and free of bumps, depressions and ruts.

9.15 References

Following publications have been referred:

British Standard Institution (London);

1. BS EN 1340 (BS 340) : Concrete Kerbs requirements and tests method.
2. BS 1377: Methods of test for soils for Civil Engineering purposes. General requirements and sample preparation.
3. BS EN 13924 (BS 3690): Bitumens for building and civil engineering. Specification for bitumens for roads and other paved area.
4. BS EN 13108 (BS 4987): Coated macadam (asphalt concrete) for roads and other paved areas. Specification for transport, laying and compaction.

CHAPTER 10 – PIPE JACKING

10.1 Trench less Crossings

- A. Where open trench excavation for crossing of roads or railways or existing conduits or any other utility is not allowed, crossings shall be constructed by the use of trench less methods.

10.2 General

- A. Construction by the pipe jacking technique is preferred but suitable alternative methods will be considered by Engineer.
- B. The work shall only be carried out by a specialist Sub-Contractor with proven experience in the particular methods of construction proposed.
- C. The Contractor shall carry out the works to the approval of the Engineer and strictly in accordance with the requirements of the Highway Authority or Railway Authority or the concerned utility agency.
- D. The Contractor shall design the Permanent and Temporary Works to withstand all anticipated dead loads and traffic loading without damage to the pipeline and to prevent any adverse effects on the highway or railway construction by way of settlement or otherwise.

10.3 Method Statement

- A. The Contractor shall submit to the Engineer for approval a fully detailed Method Statement which shall include inter alia all design calculations, details of manufacture and suppliers of materials, details of vertical and horizontal loadings and pressures, means of maintaining control of line and level, type and method of pipe jointing and type and methods of grouting.

10.4 Sleeves

- A. The diameter of the sleeves for jacking shall be larger than the outer diameter of pipe and shall be the smallest possible size to accommodate the pipes and joints and allow free passage for in situ annulus grouting.
- B. The sleeve pipes shall be approved by the Engineer and shall be steel.

10.5 Pipe Jacking

- A. Excavation for pipe jacking shall be undertaken from within a shield equipped with steering jacks for adjustment of alignment. Face boards shall be available for boarding up the exposed excavation.
- B. The Contractor shall provide continuous, experienced supervision of operations in order to maintain the line and level of the sleeve to a tolerance of + 75 mm of the true line and level shown on the Drawings. Adjustment of line and/or level should be gradual and the pipe manufacture's permitted draw or angular deflection shall not be exceeded at any individual joint.
- C. Thrust walls for jacking operations shall be constructed normal to the proposed line of thrust and shall be adequate for installation of the sleeve. Intermediate jacking stations may be used where frictional resistance might result in unreasonably high jacking forces subject to the approval of the Engineer and the relevant authorities.
- D. The Contractor shall maintain up-to-date records of thrusting pressures and line and level measurements for inspection by the Engineer as required.

10.6 Pipeline Installation

- A. The pipeline shall be installed and maintained in position within the sleeve to the line, levels and gradient shown on the Drawings and in accordance with the pipelines of the Specification.
- B. Insertion of the pipeline into the sleeve shall be by towing or jacking using suitable supports and spacers to facilitate installation and to prevent damage to the pipes. Joints between individual pipes shall be made before insertion into the sleeve.

10.7 Grouting

- A. Grouting of the annulus space between the sleeve and the pipeline and between sleeve and the excavation shall not commence until the pipeline has been hydraulically tested to the full specified test pressure and approved by the Engineer.
- B. Mixing shall be carried out in pan or paddle type mixers suitable for the purpose to produce a grout of adequate workability for pumping. Materials shall be batched by the whole bag by weight with particular attention paid to the water content. After mixing the grout shall be transferred to a holding tank before pumping.

- C. Hand mixing of grout will not be allowed without the expressed permission of the Engineer.
- D. Grout shall be pumped continuously in one operation until the annulus space is completely filled.
- E. The amount of grout to be pumped to completely fill the annulus space shall be calculated taking into account an allowance for wastage and the quantity of grout pumped continually monitored to ensure that the annulus is completely filled.
- F. The Contractor shall provide the Engineer with records of grout pressures and quantities pumped during the filling operation.

10.8 Pipelines Under Other Roads

- A. Crossing of roads shall be permitted subject to approval from the relevant Authority and to the provisions below:

10.8.1 Method

- a. The Contractor shall programme the Works to keep disruption to rail and road traffic to a minimum, and before any work commences in existing roads shall:
- b. Obtain the full permission and approval of all Authorities concerned serving notices of intent to start work as may be necessary and observing all the local Laws and Regulation.
- c. Submit details of his proposals, and obtain approval from the Engineer.
- d. Crossing shall be at the angles shown on the Drawings.
- e. Reinstatement shall use the form of construction and materials as ordered by the relevant Authority, generally in accordance with road crossing details as shown on the drawings.
- f. The bedding and jointing shall be as specified by the Engineer and the trench re-filling shall be carried out using granular bedding material and compacted at the sides of the pipes to not less than 95% of the modified proctor maximum dry density as specified in BS 1377, Test 13. Above this a 250 mm layer of Lean mix concrete shall be placed to bring the level of the backfilling up to 300 mm below the finished road surface. The method of backfilling shall extend at least 5m either side of surfaced road carriageways.

10.8.2 Reinstatement of Roads

- a. The replacement of the road surfacing shall be carried out as soon as practicable after backfilling has been completed.
- b. The edges of the trench shall be carried out as soon as practicable after backfilling has been completed.
- c. The edges of the trench shall be cut to a uniform line consistent with the varying width of the trench and the agreed trimming allowances. Any part of the road pavement which has been damaged beyond the width of the trench shall be cut out and made good.
- d. A vertical joint shall be formed between the new work and the existing road surface and shall be painted with hot bitumen, or as approved by the Engineer, and the 2 layer wearing course steeped 75mm.
- e. The finished level of the completed reinstatement shall conform the adjoining carriageway surface. Reinstatement of wearing courses shall match as nearly as practicable the colour of other characteristics of existing surface.
- f. Where the carriageway surface adjoining the trench is of rolled asphalt the Contractor may, with the approval of the relevant authorities and the written approval of the Engineer, lay a temporary wearing course of class 20 concrete 100mm thick. At a later date, to be decided by the Engineer, the temporary wearing course may be removed and replaced with 2 layers of rolled asphalt each 50mm thick.

10.9 Measurement and Payment

Pipe jacking shall be measured in numbers of linear meter and shall be paid for per meter cost quoted in Contract's Bill of Quantities.

The above payment is full compensation for all works specified in this section, BOQ and executed at site for the satisfactory completion of works as required under the Contract and approved by the Engineer.