



NYERI WATER AND SANITATION COMPANY LIMITED

Volume II- Specification Document for Procurement of Works

For

THE PROPOSED CONSTRUCTION OF SEWER PUMPING STATION AND LAST MILE CONNECTIVITY FOR SEWER EXTENSION PROJECT IN KIAMWATHI-NGANGARITHI-RURINGU-SKUTA- MISHA AND THUNGUMA ESTATES, NYERI COUNTY LOT 2

TENDER REF NO: NWSC/OT/002/2025/2026

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2025/2026

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IN ITS ENTIRETY BEFORE MAKING ANY BID**



ISO 9001:2015 Certified

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TABLE OF CONTENTS

1	GENERAL (PRELIMINARIES).....	11
1.1	INTRODUCTION	11
1.2	LOCATION AND PROJECT SCOPE	11
1.3	EXTENT OF CONTRACT.....	11
1.4	CONTRACT DRAWINGS	11
1.5	STANDARDS	12
1.6	PROGRAMME OF THE EXECUTION OF WORKS	12
1.7	SUBSTANTIAL (PRACTICAL) COMPLETION	14
1.8	METHOD OF CONSTRUCTION.....	15
1.9	NORMAL WORKING HOURS	15
1.10	NOTICE OF OPERATIONS.....	15
1.11	NOMINATED SUB-CONTRACTORS AND NOMINATED SUPPLIERS	16
1.12	ENTRY UPON LAND, WORKING SITE AND ADJOINING LANDS	16
1.13	PRESERVATION OF SURVEY BEACONS.....	17
1.14	RELOCATION OF EXISTING SERVICES	18
1.15	DAMAGE TO EXISTING SERVICES.....	18
1.16	TEMPORARY ROADS AND TRAFFIC CONTROL.....	18
1.17	USE OF PUBLIC ROADS	18
1.18	ROAD AND RAILWAY CROSSING AND TRAFFIC CONTROL	19
1.19	PROTECTION FROM WATER.....	19
1.20	WEATHER CONDITIONS.....	19
1.21	PROTECTION FROM WEATHER.....	19
1.22	EXPLOSIVES AND BLASTING	19
1.23	LIAISON WITH POLICE AND LABOUR OFFICE	20
1.24	PROVISION OF WATER.....	20
1.25	TEMPORARY LIGHTING AND POWER	20
1.26	SANITATION	20
1.27	SAFETY OFFICER.....	21
1.28	SIGNBOARDS	21
1.29	SETTING OUT	22
1.30	DRAWINGS PRODUCED BY THE CONTRACTOR	22
1.31	BACKFILLING OF HOLES AND TRENCHING FOR TEMPORARY WORKS	23
1.32	INSPECTION OF WORKS.....	23
1.33	JOINT MEASUREMENTS	23
1.34	CLEANING UP OF SITE	24
1.35	TESTING OF WATER-RETAINING STRUCTURES.....	24
1.36	TESTING OF ROOFS.....	24
1.37	CLEANING AND STERILIZING WATER-RETAINING STRUCTURES.....	25
1.38	SAMPLING AND ANALYSIS OF CLEAN WATER IN THE SYSTEM.....	25
1.39	CONTRACTOR'S SUPERINTENDENCE	25
1.40	TRANSPORT OF WORKMEN	25
1.41	NORMAL WORKING HOURS	25

1.42	ACCOMMODATION FOR CONTRACTOR'S WORKMEN	26
1.43	STORAGE SPACE: SHEDS	26
1.44	OFFICE FOR THE CONTRACTOR	26
1.45	COMMUNICATION	26
1.46	HOUSES AND OFFICE, FOR THE ENGINEER'S STAFF	26
1.47	MAINTENANCE OF THE ENGINEER'S OFFICES, FURNITURE AND EQUIPMENT	28
1.48	INSURANCE AND OWNERSHIP OF THE ENGINEER'S STAFF HOUSES, OFFICES, LABORATORIES, FURNITURE, AND EQUIPMENT	28
1.49	PROVISION OF PROJECT VEHICLES	28
1.50	REMOVAL OF CAMPS	28
1.51	SITE MEETINGS.....	29
1.52	MISCELLANEOUS ACCOUNTS	29
1.53	PAYMENT OF OVERTIME FOR ENGINEER'S JUNIOR STAFF	29
1.54	WATER PROOFING	30
1.55	MEASUREMENT AND PAYMENT.....	31
2	MATERIALS AND TESTING OF MATERIAL	34
2.1	INFORMATION FROM EXPLORATORY BORINGS AND TEST PITS.....	34
2.2	QUALITY OF MATERIALS AND WORKMANSHIP	34
2.3	TRADE NAMES	35
2.4	SAMPLES.....	35
2.5	TESTING.....	35
2.6	TESTING AT AN INDEPENDENT LABORATORY	36
2.7	STANDARDS.....	36
2.8	MEASUREMENT AND PAYMENT.....	40
3	SITE CLEARANCE AND TOP SOIL STRIPPING.....	41
3.1	SITE CLEARANCE AND GRUBBING	41
3.2	CUTTING TREES	42
3.3	THE DISPOSAL OF MATERIAL	42
3.4	REMOVAL OF TOPSOIL	42
3.5	MEASUREMENT AND PAYMENTS.....	43
4	EARTHWORKS.....	45
4.1	GENERAL	45
4.2	DEFINITIONS OF MATERIALS	45
4.3	SCOPE	45
4.4	EXCAVATION	46
4.5	GROUND LEVELS AND RECONSTRUCTION CROSS SECTIONS	47
4.6	TOPOGRAPHICAL AND GEOLOGICAL SURVEY AFTER EXCAVATION	47
4.7	TOLERANCES	48
4.8	DISPOSAL OF EXCAVATED MATERIAL.....	48

4.9	SPOIL BANKS.....	48
4.10	USE OF EXPLOSIVES.....	48
4.11	PRE-SPLITTING	49
4.12	EXCAVATIONS IN QUARRY	49
4.13	CHANGE IN QUARRY	50
4.14	EXCAVATION OF EARTH FILL MATERIAL IN BORROW AREA	50
4.15	ROADS.....	50
4.16	TRENCH EXCAVATIONS	51
4.17	EXCAVATION TO BE KEPT FREE FROM WATER.....	52
4.18	EXCAVATION IN HARD MATERIAL	52
4.19	FOUNDATION FOR STRUCTURES	53
4.20	TRENCH EXCAVATIONS	53
4.21	BACKFILLING WITH SAND OR IMPORTED SUITABLE MATERIAL.....	54
4.22	REINSTATEMENT OF SURFACES.....	54
4.23	REMOVAL OF SURPLUS EXCAVATED MATERIAL.....	55
4.24	BORROW PITS.....	55
4.25	ROCK FILL BELOW STRUCTURES.....	56
4.26	GRASS PLANTING AND TOP SOIL	56
4.27	ANT-PROOFING.....	56
4.28	STONE PITCHING.....	57
4.29	GABIONS.....	57
4.30	MEASUREMENT AND PAYMENTS.....	58
5	CONCRETE WORKS.....	62
5.1	GENERAL.....	62
5.2	DEFINITIONS	62
5.3	MATERIALS FOR CONCRETE	62
5.4	THE DESIGN OF CONCRETE MIXES.....	67
5.5	MIXING CONCRETE.....	74
5.6	HAND MIXED CONCRETE.....	76
5.7	TRANSPORT OF CONCRETE.....	76
5.8	PLACING OF CONCRETE.....	76
5.9	COMPACTION OF CONCRETE	79
5.10	CURING OF CONCRETE.....	80
5.11	PROTECTION OF FRESH CONCRETE.....	81
5.12	CONCRETING IN HOT WEATHER.....	82
5.13	FINISHES ON UNFORMED SURFACES.....	83
5.14	MORTAR	84
5.15	CONCRETE FOR SECONDARY PURPOSES.....	84
5.16	RECORDS OF CONCRETE PLACING	85
5.17	CONSTRUCTION JOINTS.....	85
5.18	EXPANSION AND CONTRACTION JOINTS	86
5.19	WATERSTOPS	86
5.20	GROUTING OF POCKETS AND HOLES AND UNDERPINNING OF BASE PLATES.....	88

5.21	FORMWORK FOR CONCRETE	88
5.22	CONSTRUCTION OF FORMWORK AND FALSEWORK	89
5.23	PREPARATION OF FORMWORK	90
5.24	REMOVAL OF FORMWORK.....	90
5.25	SLIPFORM FOR CONCRETE FACE	92
5.26	SURFACE FINISHES.....	93
5.27	TOLERANCES	94
5.28	REMEDIAL WORK TO DEFECTIVE SURFACES.....	94
5.29	REINFORCEMENT FOR CONCRETE.....	95
5.30	STORAGE OF REINFORCEMENT	96
5.31	BENDING REINFORCEMENT	96
5.32	FIXING REINFORCEMENT.....	96
5.33	PRECAST CONCRETE	97
5.34	MOULDS FOR PRECAST UNITS.....	97
5.35	REINFORCEMENT FOR PRECAST UNITS	98
5.36	CASTING OF UNITS.....	98
5.37	CURING PRECAST UNITS.....	98
5.38	DIMENSIONAL TOLERANCES OF PRECAST UNITS.....	98
5.39	SURFACE FINISH OF PRECAST UNITS.....	98
5.40	HANDLING AND STORAGE OF PRECAST UNITS	99
5.41	TESTING PRECAST UNITS.....	99
5.42	MEASUREMENT AND PAYMENT.....	100
6	STRUCTURAL STEELWORK.....	104
6.1	GENERAL	104
6.2	APPLICABLE STANDARDS.....	104
6.3	MATERIALS.....	104
6.4	STORAGE OF MATERIALS.....	105
6.5	FABRICATION	105
6.6	PREPARATION OF EDGES AND ENDS OF PLATES	105
6.7	WELDING	106
6.8	BOLTING.....	107
6.9	TRANSPORTATION HANDLING AND ERECTION	108
6.10	SURFACE PREPARATION OF STEELWORK	109
6.11	PAINTING.....	109
6.12	PAINT SYSTEMS	110
6.13	DAMAGED SURFACES.....	110
6.14	INTERNAL BRACINGS AND BRACKETS:	110
6.15	FASTENERS:.....	110
6.16	JOINT MATERIALS:.....	110
6.17	FITTINGS:.....	111
6.18	PRESSED STEEL TANKS AND TOWERS.....	111
6.19	MEASUREMENT AND PAYMENT	112

7	PIPEWORKS.....	113
7.1	MATERIALS	113
7.2	HANDLING AND STORING MATERIALS.....	113
7.3	LAYING AND JOINTING,	114
7.4	PIPES AND FITTINGS	117
7.5	PROTECTION OF PIPES	121
7.6	VALVES AND SPECIALS	122
7.7	PENSTOCKS OR SLUICE GATES.....	124
7.8	AUXILIARY WORKS.....	125
7.9	TESTING OF PRESSURE MAINS	126
7.10	WATER PRESSURE TEST.....	126
7.11	TESTING OF DISTRIBUTION SYSTEM	127
7.12	TESTING-OF SEWER PIPES	128
7.13	CLEANING AND STERILIZATION OF WATER SUPPLY PIPES	129
7.14	MEASUREMENT AND PAYMENTS	129
8	BUILDING STONE.....	130
8.1	STONE DUST	130
8.2	MURRAM.....	130
8.3	WATER FOR CEMENT TREATED MATERIALS.....	130
8.4	CEMENT MORTAR	131
8.5	HYDRATED LIME.....	131
8.6	CALCIUM CHLORIDE	131
8.7	LIME MORTAR	131
8.8	CEMENT-LIME MORTAR.....	131
8.9	CEMENT GROUT	131
8.10	CAST STONE	132
8.11	STRUCTURAL STEEL FOR WELDED WORK.....	132
8.12	WATERPROOF UNDERLAY.....	132
8.13	PREFORMED JOINT FILLER	132
8.14	JOINT PRIMER	132
8.15	JOINT SEALING COMPOUND.....	132
8.16	CONCRETE SLABS FOR OPEN DRAINS	133
8.17	TIMBER.....	133
8.18	WATER BARS	134
8.19	MEASUREMENT AND PAYMENT	134
9	EXTERNAL WORKS.....	135
9.1	ROADS AND PAVED AREAS	135
9.2	FENCPLYING	135
9.3	CONCRETE POSTS.....	135
9.4	CHAIN LINK.....	135

9.5	GATES.....	135
9.6	MEASUREMENT AND PAYMENTS.....	136
10	MECHANICAL AND ELECTRICAL WORKS.....	137
10.1	SCOPE OF WORK	137
10.2	TRADE NAMES	138
10.3	SPARE PARTS	139
10.4	STORAGE OF MATERIALS.....	139
10.5	TESTING.....	139
10.6	DRAWINGS.....	140
10.7	DESCRIPTION OF SERVICES	140
10.8	MAINTENANCE	140
10.9	INITIAL MAINTENANCE PERIOD	141
10.10	MAINTENANCE AND SERVICING AFTER INITIAL DEFECT NOTIFICATION PERIOD	141
10.11	MAINTENANCE MANUAL	141
10.12	MOTORS	142
10.13	GENERATOR	142
10.14	PRESSURE GAUGES	143
11	ELECTRICAL WORKS	143
11.1	GENERAL	143
11.2	REGULATIONS	143
11.3	EXTENT OF ELECTRICAL WORK WITHIN CONTRACT	144
11.4	MATERIALS.....	144
11.5	WORKMANSHIP	146
11.6	WORKING DRAWINGS	147
11.7	RECORD DRAWINGS.....	147
11.8	TESTING.....	147
11.9	MAIN SWITCHBOARD.....	148
11.10	M.V. SWITCHBOARD	149
11.11	SWITCHGEAR	149
11.12	MOTOR STARTERS	150
11.13	DISTRIBUTION BOARDS.....	150
11.14	WIRING.....	150
11.15	GENERAL WIRING	151
11.16	CABLE AND CONDUCTORS.....	154
11.17	CONDUITS.....	154
11.18	BOXES	156
11.19	LIGHT FITTINGS	156
11.20	SECURITY LIGHT FITTINGS	156
11.21	LIGHT SWITCHES	156
11.22	LIGHTING SWITCHES.....	157

11.23	SOCKETS AND SWITCH SOCKETS.....	157
11.24	METER BOXES	157
11.25	POWER INSTALLATION.....	157
11.26	EARTHING AND BONDING	158
11.27	TESTING	159
11.28	HANDING OVER.....	160
11.29	MAINTENANCE AND DEFECTS NOTIFICATION PERIOD.....	160
12	ELECTRO-MECHANICAL EQUIPMENT.....	161
12.1	SCOPE OF SUPPLY	161
13	MASONRY.....	164
13.1	GENERAL	164
13.2	WORKMANSHIP	164
13.3	MEASUREMENT AND PAYMENT	164
14	DRAINS, SEWERS AND MANHOLES.....	165
14.1	EXCAVATION FOR DRAINS, SEWERS AND MANHOLES	165
14.2	SUPPORTS FOR PITS, TRENCHES AND OTHER EXCAVATIONS...	165
14.3	ROCK CUTTING IN TRENCHES FOR PIPES	165
14.4	WATER IN TRENCHES FOR PIPELINES.....	166
14.5	LAYING AND JOINTING RIGID JOINTED CONCRETE PIPES.....	166
14.6	PIPES LAID WITH OPEN JOINTS	167
14.7	CAST IRON PIPES	167
14.8	DRAINS TO BE LEFT CLEAN ON COMPLETION	167
14.9	REFILLING TRENCHES.....	167
14.10	CONNECTIONS OF EXISTING SEWERS AND DRAINS	167
14.11	MANHOLES AND INSPECTION CHAMBERS	168
14.12	PRECAST CONCRETE MANHOLES	168
14.13	GULLY CONNECTIONS.....	168
14.14	SURFACE BOXES, COVERS ETC.....	169
14.15	GULLIES.....	169
14.16	COMPLETION OF DRAINAGE WORKS	169
14.17	TEMPORARY STOPPERS	169
14.18	PROVISION FOR FUTURE CONNECTION TO MANHOLES	169
14.19	SURROUNDING OR HAUNCHING OF PIPES WITH CONCRETE ..	169
14.20	INVERT BLOCK AND STONE-PITCHED DRAINS.....	170
14.21	TESTING OF JOINTED PIPES AND MANHOLES	170
14.22	PIPES WITH RUBBER RING JOINTS.....	171
14.23	LAYING, JOINTING AND BACKFILLING FOR FLEXIBLE JOINTED PIPES	171
14.23.1	FLEXIBLE RUBBER RING JOINTS	171
14.23.2	EXPANSION GAP	171

14.23.3	SOLVENT CEMENT JOINTS.....	172
14.24	MEASUREMENT AND PAYMENT.....	172
15	DAYWORKS	172
15.1	MEASUREMENT AND PAYMENT.....	172
16	TRAINING OF EMPLOYER’S PERSONNEL	173
16.1	MEASUREMENT AND PAYMENT.....	173
17	PRE-COMMISION TEST	174
17.1	TECHNICAL DOCUMENTATION (ON COMPLETION).....	174
17.1.1	GENERAL INFORMATION.....	174
17.1.2	AS-BUILT DRAWINGS (AS APPROVED BY THE ENGINEER)	175
17.1.3	TEST CERTIFICATES	175
17.2	TESTING OF EARTHWORKS	175
17.2.1	GENERAL	175
17.2.2	MAIN TESTS AND STANDARDS.....	175
17.2.3	COMPACTION OF SOILS	175
17.2.4	TESTING OF COMPACTION	176
17.3	INSPECTION AND TESTING OF STRUCTURAL WORKS.....	176
17.3.1	INSPECTION PRIOR TO COMMENCEMENT OF WORKS.....	176
17.4	TESTING CONCRETE WORKS.....	177
17.4.1	CONCRETE WORKS, TEST CERTIFICATES	177
17.4.2	CONCRETE WORKS, INSPECTIONS	177
17.4.3	SAMPLING AND TESTING OF AGGREGATES.....	177
17.4.4	SAMPLING AND TESTING OF CONCRETE.....	178
17.4.5	COMPLIANCE WITH SPECIFIED REQUIREMENTS	178
17.5	INSPECTION AND TESTING OF PIPES FOR MAINS.....	180
17.5.1	TESTING AT PLACE OF MANUFACTURE	180
17.5.2	PRESSURE TESTING OF MAINS	181
17.5.3	DISINFECTION	182
17.5.4	TEST OF WATER TANKS / RESERVOIRS	182
17.5.5	TEST DURING COMMISSIONING	183
17.6	INSPECTION, TESTING AND PRE-COMMISSIONING OF FACILITIES, MECHANICAL AND ELECTRICAL WORKS.....	183
17.6.1	GENERAL	183
17.6.2	COST FOR TESTING DEEMED TO BE INCLUDED.....	184
17.6.3	TEST INSTRUMENTS AND EQUIPMENT.....	184
17.6.4	FACTORY TEST	185
17.6.5	FACTORY INSPECTION AND TESTING OF SPECIAL VALVES.....	185
17.6.6	VESSELS, PIPES, VALVES	185
17.7	SITE TEST	186

17.7.1	GENERAL.....	186
17.7.2	COMPOSITE HYDRAULIC SYSTEMS SUBJECT TO TEST DURING INSTALLATION.....	186
17.8	MEASUREMENT AND PAYMENT.....	186
18	WORKS COMPLETION	187
18.1	TESTING AND COMMISSIONING.....	187
18.1.1	GENERAL.....	187
18.1.2	TEST AND COMMISSIONING REPORTS	188
18.1.3	TESTS ON COMPLETION FOR WORKS	189
18.1.4	TESTS AFTER COMPLETION.....	190
18.2	FACILITIES, MECHANICAL AND ELECTRICAL WORKS SUBJECT TO COMMISSIONING	190
18.2.1	BUILDING SERVICES	190
18.3	MEASUREMENT AND PAYMENT.....	190
	APPENDIX I: DRAWINGS	190
	APPENDIX II: ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN - ESMP	191

1 GENERAL (PRELIMINARIES)

1.1 Introduction

This document outlines the specifications for the construction of **The Proposed Construction of Sewer Pumping Station and Last Mile Connectivity for Sewer Extension Project in Kiamwathi-Ngangarithi-Ruringu-Skuta-Misha and Thunguma Estates, Nyeri County - Lot 2.**

The specifics are detailed in the accompanying drawings and are further itemized in the Bills of Quantities. These specifications must be interpreted in conjunction with the Contract Documents referenced in the Instruction to Tenderers.

All references included within this document are intended solely to facilitate the understanding and navigation of the documents above. However, it is crucial to note that these references do not limit the applicability of other clauses contained within the documents. The Engineer retains the discretion to determine any provisions that may be relevant to the matters at hand, ensuring a comprehensive approach to the project that upholds the highest standards of construction and compliance.

1.2 Location and Project Scope

The proposed project is situated in Nyeri Town, Nyeri County, and will serve areas including parts of Ngangarithi, Skuta, Ruringu, Misha and Thunguma areas. The scope of the work will consist of, but is not limited to, the following:

1.2.1 Construction of sewage pumping station including civil and electromechanical works

1.2.2 Construction 2000 no household connections

1.3 Extent of Contract

The works specified under this contract shall include all general works, preparatory to the construction of the works and materials and work of any kind necessary for the due and satisfactory construction, completion and maintenance of the works to the extent as shown on the drawings and these specifications and any other instructions that may be issued by the Engineer from time to time whether specifically mentioned or not in the clauses of this specification.

1.4 Contract Drawings

Two sets of full sized drawings will be issued to the Contractor, at the commencement of the Contract to facilitate the construction of the Works in complete conformity with and to the full intent of the Contract. Additional copies of these drawings that the Contractor may require can be obtained from the Engineer, in which case the Contractor will be required to reimburse the cost of producing such additional copies.

The Engineer may from time to time in order to enable the satisfactory completion of the Works, revise, amend, or supersede any of these drawings. It shall be the Contractor's responsibility to construct all Works in conformity with the latest

revision, amendment or superseding drawings, provided that the Engineer has given to the Contractor in writing such reasonable prior notices of intention to revise, amend or supersede as the nature of the intended change requires and the relevant drawings have been issued to the Contractor.

The Contractor may be required to demolish, alter and/or correctly rebuild at his own expense any part of the Works not in conformity with the drawings currently forming part of the Contract at the time of construction of such Works, provided always that such current drawings had previously been issued to him.

1.5 Standards

In the Specifications, Bills of Quantities, and Drawings reference has been made to relevant British Standard Specifications and Codes of Practice – to which the materials and workmanship should comply with. However, the materials and workmanship complying with equivalent Kenya Bureau of Standards (K.E.B.S.) or International Standards Organisation (ISO.), for that particular material or workmanship will also be acceptable.

Mixture of different Standards in one trade will not be allowed. Standard, then all the pipes for the works are to be to ISO standard.

The Contractor may propose that the materials and workmanship be defined in accordance with the requirements of other equivalent Standards and the Contractor may execute the works in accordance with such other Standards as may be approved by the Engineer. A copy of the Standard, together with its translation into the English language if the Standard is in another language, shall be submitted to the Engineer with any request that it be adopted.

Where the dimension in one standard does not completely correspond to the dimension of the other standard, which is being used for construction of works, ruling of the Engineer will be sought and any decision given by the Engineer will be final and binding upon the Contractor.

1.6 Programme of the Execution of Works

Under Sub clause 26.1 of the conditions of contract, within the time stated in the SCC, after the date of the Letter of Acceptance, the Contractor shall submit to the Project Manager for approval a Program showing the general methods, arrangements, order, and timing for all the activities in the Works. In the case of a lump sum contract, the activities in the Program shall be consistent with those in the Activity Schedule. The Contractor shall together with his work programme supply an expenditure chart showing monthly anticipated expenditure.

If at any time it should appear to the Engineer that the actual progress of the Works does not conform to the programme referred to above, the Contractor shall produce, at the request of the Engineer, a revised programme showing the modifications to the approved programme necessary to ensure completion of the Works within the time for completion as defined in the Conditions of Contract.

In addition, the Contractor shall extract from the main program and provide a 90 days' program showing works he intends to execute within every 90-day period and submit the program within the first week of each quarter.

The programme shall be deemed to have taken into account normal variations in climatic conditions to provide for completion of the works in the order and within the times specified therein.

The various operations pertaining to the Works shall be carried out in such a progressive sequence as well as will achieve a continuous and consecutive output of fully complete pipeline works inclusive of all appurtenances, treatment plants and all installations within the time limits specified in the Contract. Generally, the Contractor shall progress continuously without leaving any isolated section incomplete, provided that the land upon which the works are to be constructed has been acquired in the entirety and the encumbrances and services thereon removed.

The Contractor shall carry out the Contract in accordance with the programme agreed with the Engineer. Still, he shall in no manner be relieved by the Engineer's approval of the programme of his obligations to complete the Works in the prescribed order and by the prescribed completion date. He shall from time to time review his progress and make such amendment to his rate of executions of the works as may be necessary to fulfil these obligations.

Once the Engineer approves the proposed programme the Contractor shall not depart from the programme without the written consent of the Engineer.

In the event of unforeseen difficulties or disturbances arising, which force the Contractor to depart from the approved Programme of Works, he shall advise the Engineer in writing of such occurrences without delay and submit proposals for any necessary remedial measures, for which he shall obtain the Engineer's approval before putting such measures into effect.

The Contractor shall provide the Programme in a CPM format and it shall include but not limited to, the following requirements: The CPM program shall include as a minimum but not be limited to the following categories:

- i. Preparatory Works.
- ii. Engineering services and project management.
- iii. Manpower, equipment and machineries required for the execution of each task.
- iv. Procurement of goods.
- v. Construction works.
- vi. Operation and maintenance work.
- vii. Demolish, disconnect, dismantle and abandonment existing facilities.
- viii. Quality assurance program.
- ix. Safety precautions for the work; and
- x. Required safety equipment and materials which shall be used in conducting the work.

The Contractor shall submit the critical path management (CPM) schedule with details (colour print, A1-size paper) in two (2) original copies and two (2) compact discs, which illustrate the progress of contract works for the review and comment of the Engineer.

The CPM program shall be revised and periodically updated as required by the Engineer and to his satisfaction.

The CPM program shall include but not be limited to the following detailed plans and shall be subject to Engineer review and comment:

- i. Detailed plan of management progress works, such as reports, submittals, manpower categories, inspection requirements, forms, and all other works specified in the contract requirements.
- ii. Detailed plan for mechanical, electrical, instrumental and civil works required by the Contract showing dates of start and completion, equipment, tools and materials needed, pumps, safety equipment, dewatering system, heavy duty mobile equipment or machinery to carry out the works, techniques, methods and procedures of executing works to the satisfaction of the Engineer as specified in the contract documents.
- iii. Detailed plan for provision, installation, test, commissioning and maintenance of preventive maintenance proposed by the Contractor and other related required works to the satisfaction of the Engineer as specified in the contract documents.
- iv. Detailed plan for maintenance and painting works of existing designated equipment, pumps, buildings, panels, substations, and other related required works as specified in the contract documents.
- v. Detailed plan of rehabilitation of soil and other related works as specified in this Technical Specification.
- vi. Detailed plan of clearing the sites, landscaping, removal of all debris, waste and surplus materials off the sites. All cleaning work shall be to the Engineer's satisfaction.
- vii. Detailed safety plans, equipment, and materials shall be used in conducting the Works in accordance to specifications and standards of government regulations; and

Details of staff categories experience and curriculum vitae of all Contractor's staff. For laborers, the Contractor may submit only a list of their names.

1.7 Substantial (Practical) Completion

Substantial or Practical Completion of Works is to be understood as a state of completion, which leaves out only minor outstanding items that can be readily completed within a period of less than 1 month without interfering with the normal operation of the Works.

The works will not be considered as substantially or practically completed without the works being capable of being used by the Employer in accordance with the purpose of the works.

1.8 Method of Construction

The Contractor shall submit to the Engineer not later than 28 days from the date of award of the Contract a general description of his proposed arrangement and method for execution of the works, including inter alia temporary offices, buildings, access roads, deviations, constructional plants and its intended production output, working shift arrangements, power arrangements, supply of materials, stone crushing, aggregates production and storage, cement handling, pipe handling and storage, Concrete mixing and handling, method of excavation, dealing with water, testing methods and facilities.

During execution of the works, the Contractor shall also submit to the engineer full and detailed particulars of any proposed amendments to the arrangement and method submitted in accordance with the foregoing.

In addition to providing a step-by-step description of the work (in sequential order) method statements shall also clarify the following:

- i. Scope of works covered
- ii. References (procedures or standards)
- iii. Subcontractors utilized
- iv. Products required
- v. Tools, equipment and machinery required
- vi. Plan of progress works, starting date of the activities and the Period activities to be completed
- vii. Personnel required and designated responsibilities
- viii. Safety Hazards and Precautions to be taken
- ix. Quality Control Measures
- x. Procedure (step by step sequence of work)

1.9 Normal Working Hours

The Engineer's Normal working hours shall be Monday to Friday, 8.00 a.m. to 5.00 p.m., and Saturday, 8am to 1pm. with all Public Holidays set aside as required. Suppose the Contractor wishes to execute permanent works outside these hours. In that case, he shall obtain a written permission of the Engineer at least one full working day in advance to enable the engineer to make provision for supervision of such work.

1.10 Notice of Operations

No operation shall be carried out without full and complete notice having been given to the Engineer by the Contractor sufficiently in advance of the time of the operation to enable the Engineer to make arrangements as he may deem necessary for its inspection and checking.

The Contractor shall give the Engineer not less than 1 full working days' notice in writing of his intention to set out or give levels for any part of the works in order that arrangements may be made for checking.

1.11 Nominated Sub-Contractors and Nominated Suppliers

The Contractor shall be responsible for Nominated Sub-Contractors in every respect. In particular, it shall be the Contractor's responsibility to ensure that each Sub-Contractor commences and completes the work in a manner so as to conform to the working programme, as specified above.

Sub-Contractors and Suppliers in the project area shall be given preference in sub-contracts as far as they meet the requirements for such sub-contracts.

It is also the responsibility of the contractor to ensure a satisfactory progress of the works and to ensure that the works are completed to a standard satisfactory to the Engineer.

The Contractor shall accept liability for and bear the cost of General and Specified Attendance on Nominated Sub-contractors which shall be deemed to include for: -

- (i) Allowing the use of standing scaffolding, providing special scaffolding, maintenance and alteration of all scaffolding, retention of all scaffolding until such time as all relevant Sub-Contractor's works are complete and removal of all scaffolding on completion.
- (ii) Providing equipment and labour for unloading and hoisting Sub-Contractor's materials.
- (iii) Providing space for office accommodation, and for storage of plant and materials: allowing use of sanitary accommodation; the supply of all necessary water, power, lighting and watching and clearing away all rubbish.

Before placing any orders with nominated Sub-Contractors or nominated Suppliers, the Contractor should enter into an agreement with the nominated Sub-Contractor /nominated Suppliers to ensure that the conditions and delivery of materials to site comply with the Conditions of Contract and the working programme.

Particular clause should be inserted in the agreement with the nominated Suppliers ensuring the validity of the rates for the supply of materials as per the delivery schedule.

Nominated Suppliers who are unable to meet the delivery schedule will not be given allowance for any increases in prices incurred after the delivery time agreed in the delivery schedule.

1.12 Entry upon Land, Working Site and Adjoining Lands

The Employer shall provide land, rights-of-way, and way-leaves for the Permanent Works specified in the contract only.

The Employer shall make available free of charge to the Contractor all land on, under or through which the permanent works are to be executed or carried out all as indicated in the book Drawings or as detailed in the Specifications. Such land shall exclude land required by the Contractor for his own camps, Borrow sites, offices, houses, temporary works or any other purpose.

The Contractor shall give notice to the Engineer at least 30 days before he wishes to enter on to the land required to carry out the permanent works under the Contract. The Contractor shall not enter on to any land or commence any operations until such time as he receives formal confirmation from the Engineer that all necessary compensation formalities have been completed and that permission has been obtained from the land owner to enter the land and commence operations. Should the Contractor enter on to any land and commence operations without first obtaining this confirmation, he shall be liable in whole or in part, at the sole discretion of the Engineer, for all additional costs and/or legal charges which might arise there-from.

The Contractor shall on his own accord obtain rights of admission, and rights of using all other areas which are necessary for storing and manufacturing or for setting up site offices and Resident Engineer's office or whatsoever will be necessary including borrow sites. No separate payment will be made to the Contractor on account of these items and the Contractor must make due allowance for them in his rates.

The Contractor shall take care to prevent injury, damage and trespass on lands, fences and other properties near and adjacent to the works and must in this connection make all necessary arrangements with adjoining landowners, or in the case of Government Property with officers appointed for this purpose, and ensure the workmen's observance of all Government rules and Ordinances regarding game protection and other matters and provide, maintain and clear away on completion of the Works all temporary fencing which may be required for execution of the Works.

Before completion of the Works the Contractor must make good or compensate any such injury, damage or trespass on lands, fences and other properties which have not otherwise been provided for in the Contract.

1.13 Preservation of Survey Beacons

Ordinance Survey Beacons, Benchmarks, etc., on or around the site of the Works shall not be disturbed unless permission has been obtained by the Engineer from the Survey of Kenya.

In the event of unauthorized disturbance of such beacons, benchmarks, etc., in the course of the Works being carried out the Contractor shall be responsible for reporting same to the Engineer and the Survey of Kenya and for payment of any fees due to said Survey of Kenya for replacement of such disturbed beacons, benchmarks, etc. The Contractor shall not replace such disturbed beacons benchmarks, etc. on his own accord.

1.14 Relocation of Existing Services

Drains, pipes, cables and similar services encountered in the course of the Works shall be guarded from damage by the Contractor at his own costs to safe guard a continued uninterrupted use to the satisfaction of the owners thereof, and the Contractor shall not store materials or otherwise occupy any part of the site in a manner likely to hinder the operation of such services.

If the interests of the Works shall, in the opinion of the Engineer, so require, the Contractor shall on the Engineer's direction arrange for the construction of permanent or temporary diversions of the said drains etc., together with reinstatement, if temporary, by the respective Department, Bodies, Corporations or Authorities and, the cost of such works or diversions including reinstatement shall be charged against the appropriate Provisional Sum provided in the Bills of Quantities.

It is the responsibility of the Contractor to inform the Engineer immediately any existing service is exposed.

1.15 Damage to Existing Services

The Contractor shall be held liable for all damage and interference to mains and pipes, to electric cables or lines of any kind either above or below ground caused by him or his Sub-contractors in execution of the Works, whether such services are located on the Contract Drawings or not. The Contractor must make good or report to the appropriate authorities the same without delay and do any further work considered by the Engineer or owner.

If the Contractor fails to reinstate the damaged services within the time considered as reasonable by the Engineer's Representative, then the Engineer's Representative shall be empowered to get the damaged services reinstated by any other contractor and charges thereof shall be deducted from any money due to the Contractor.

1.16 Temporary Roads and Traffic Control

The Contractor shall provide and maintain all temporary roads, bridges and other works to maintain free and efficient access to services affected by Construction of permanent works, the cost of necessary temporary traffic control signs, barricades, beacons, flagmen, lighting and watching required for the normal control of traffic. No payment shall be made for compliance of this item.

1.17 Use of Public Roads

Where a road used by the Contractor for delivery of any material used in the works is closed under Section 71 of the Traffic Ordinance Act 1962, the Contractor shall obey such closure order and use alternative roads.

The Contractor shall keep all roads used by his equipment and project vehicles in well maintained condition including watering and periodic grading/ gravelling as may be instructed by the Engineer from time to time. The items shall be provided in the Bills of quantities and the rate shall include watering, periodic grading,

temporary traffic control, traffic signs, barricades, flagmen, lighting and watching required for control of normal control of traffic.

1.18 Road and Railway Crossing and Traffic Control

Wherever the water pipeline is crossing the classified roads and railway line the Contractor will contact the relevant authorities well in advance and obtain necessary permission to dig across the road and railway line in accordance with requirement of the authorities concerned and shall pay any royalties connected with this work, and the Contractor will provide temporary detour road together with any warning signs necessary. There will be no separate payment for this and cost of all expenses connected with road and railway crossing for which no separate items have been included in Bills of Quantities is deemed to have been covered by the unit rates included in the Bills of Quantities.

1.19 Protection from Water

Unless otherwise mentioned the Contractor shall keep the whole of the Works free from water and allow in his rates for all dams, coffer dams, pumping, piling, shoring, temporary drains, sumps, etc. necessary for this purpose and shall make good at his own costs all damage caused thereby.

1.20 Weather Conditions

The Contractor shall be deemed to take into account all normal weather conditions when preparing his tender and he shall not be entitled for extra payment by the reason of the occurrence or effect of high winds, excessive rainfall, temperature or any other meteorological phenomena occurring during normal seasons in Kenya.

1.21 Protection from Weather

All materials shall be stored on site in a manner approved by the Engineer's Representative and the Contractor shall carefully protect from the weather all works and materials which may be affected thereby.

No separate payment will be made for this and the Contractor will allow in his rates for this.

1.22 Explosives and Blasting

For works requiring the use of explosives, the Contractor shall employ men experienced in blasting, and these men must be in possession of a current blasting certificate. The purchase, transport, storage and use of explosives shall be carried out in accordance with the most recent explosives Ordinance and Rules issued by the Government of Kenya and the Contractor shall allow in his rates for excavation and quarrying for all expenses incurred in meeting these requirements, including the provision of suitable stores. Blasting operations shall be carried out with as little interference as possible to traffic or persons.

In all cases permission from the Engineer must be obtained before commencing any blasting operation. Such approval shall not relieve the Contractor from his responsibility for the damage of the works and adjoining or adjacent structures,

roads, places and things, injury, loss, inconveniences and accidents to persons, animals and property consequent on the use of such explosives. The Contractor shall be entirely liable for any accident which shall occur and shall save the employer harmless and indemnified from all claims arising therefrom.

If, in the opinion of the Engineer, blasting would be dangerous to persons or property, or it is carried out in a reckless manner, the Engineer can prohibit any further use of explosives without entitling the Contractor to any extension of time occasioned by corresponding delays.

1.23 Liaison with Police and Labour office

The Contractor shall keep himself in close contact with the Police, Labour Officers and other officials of the areas concerned regarding their requirements in the control of workmen, passage through townships, or other matters and shall provide all assistance and/or facilities which may be required by such officials in execution of their duties in connection with the Works.

Any instruction given by the Traffic Police concerning fencing off of open trenches or other excavations must be followed explicitly.

1.24 Provision of Water

The Contractor shall provide water for use in the Works. He shall supply all hydrants, hose, cocks, vessels and appliances necessary for the distribution thereof and shall provide pumps, tanks, carts, vessels and appliances, transport and labour when and wherever it is necessary for water to be carted for use at the Works. All water used in connection with the Works shall if possible be obtained from a public water supply and the Contractor shall make all necessary arrangements and pay all the charges for connections to main and for water used. No separate payment will be made for this and the Contractor will allow in his rates for this.

1.25 Temporary Lighting and Power

The Contractor shall provide all artificial lighting and power for use on the Works, including all Sub-Contractors' and Specialists' requirements and including all temporary connections, wiring, fittings, etc., and clear away on completion. The Contractor shall pay all fees and charges and obtain all permits in connection therewith. No separate payment will be made for this and the Contractor will allow in his rates for this.

1.26 Sanitation

The Contractor shall provide and maintain sufficient sanitary conveniences for all operatives and site staff engaged on the work. These shall be in accordance with any requirements and applicable regulations and subject to the approval of the Engineer. The ground shall be thoroughly disinfected at the end of the Contract.

The Contractor shall ensure that all operatives and site staff are aware that all personnel must use the sanitary conveniences, and the Engineer reserves the right

to require the dismissal of any person committing a nuisance on or about the site by failing to use the conveniences provided.

The Medical Officer of Health or other Sanitary Authority shall be informed when Works are about to commence. The instructions of the Medical Officer or other Sanitary Authority shall be complied with by the Contractor at his own expense.

The site shall be kept in a clean and proper sanitary condition. No nuisance shall be committed on or around the work, and latrines for the workmen and staff shall be provided in accordance with the requirements of the Medical Officer or Sanitary Authorities. The Contractor shall be responsible for the sanitary discipline of his labour.

The Engineer's Representative has the right to order any labourer, who in the opinion of the Engineer's Representative does not have a satisfactory sanitary discipline, off the site with immediate effect.

The Contractor shall follow the safety rules set down by the Factories Inspectorate, Ministry of Labour. No separate payment will be made for this and the Contractor will allow in his rates for this.

1.27 Safety Officer

Contractor's attention is drawn to Legal Notice No. 79 of 22nd September 1978 by which it is mandatory that every Contractor employing more than twenty people should appoint (in writing) a safety supervisor. A safety supervisor advises the management on all matters regarding safety, hygiene and welfare of the people affected by the Contractor's undertaking on the site. The safety officer may in addition carry out other duties.

The contractor shall provide adequate first-aid equipment on the site, and ensure that at least four of his site staffs are competently trained in first-aid. No separate payment will be made for this and the Contractor will allow in his rates for this.

1.28 Signboards

The Contractor shall provide, erect and maintain signboards to the layout, colours material and dimensions shown on the drawings.

The Contractor shall erect 3No. Signboards as shown on the drawings in prominent positions adjacent to the Works to the satisfaction of the Engineer. These signboards shall be erected at sites to be selected by the engineer.

The signboards are to be erected within one month of the date of commencement of the contract. The Contractor shall remove the signboard at the end of the period of the maintenance

Two additional special Permanent signboards shall be erected at the end of the Contract clearly showing the project name and the Employer's name to the satisfaction of the engineer.

1.29 Setting Out

The Contractor must before commencing any construction work, make sure that levels shown in the drawings correspond with levels found on the site.

Should any discrepancy be discovered between the levels shown on the drawings and those found on the site, which may affect the levels and dimensions of any part of the Works, the Contractor shall notify the Engineer, who, if necessary, will issue drawings showing the amended levels and dimensions.

The Contractor shall clear the site and set out the Works well in advance to enable the Engineer to inspect and approve the setting out prior to commencement of the Works. The Contractor shall amend at his own cost any error due to inaccurate setting out.

Any checking or approval by the Engineer of the setting out, benchmarks, plans or schedules will not relieve the Contractor of his responsibilities under the Contract.

The Contractor shall provide a site plan showing the position of his site offices, storage sheds, accommodation, Engineer's Representative's office etc., in relation to the permanent works for the approval of the Engineer before commencing erection of his camp.

After completion of the setting out and site clearance, the Contractor shall take ground cross sections along the pipeline at 25m interval and along the centreline of all structures. These shall be plotted in A3 paper, agreed and signed by the Engineer's Representative and Contractor prior to commencement of any excavation works and shall be used for measurement.

1.30 Drawings produced by the Contractor

Where the Contractor is to design any part of works, to the extent specified in the Contract, the Contractor shall submit seven copies of its drawings, excluding those to be returned to the Contractor.

All drawings submitted by the Contractor to the Engineer for approval shall be on ISO standard size sheets with a maximum size of A1. Every drawing shall have a title box in the bottom right-hand corner showing:

- i. Employer's name
- ii. Title of scheme
- iii. Number of Contract
- iv. Contractor's name
- v. Title of works element
- vi. Subject of drawing
- vii. Drawing number
- viii. Date
- ix. Author

- x. Signature of Contractor (to the effect that the drawing (whether his own, his sub- contractor's or from any other source) has been checked by him before submission to the Engineer).

Each drawing shall also have a separate revision box with space for up to 6 revisions, including revision number, revision date, and revision description and revision check.

Drawings shall be drawn to specified scales or to such scales as are appropriate for clearly detailing and conveying the Contractor's proposals. Scales shall generally be 1:2, 1:5, 1:10 or multiples of 10 thereof. The appropriate measuring scales used shall be shown on the drawings.

Drawings shall include cross-references where appropriate and key information such as vital levels and dimensions. All general layout plans shall show the "north" direction.

Original drawings shall be drawn in black ink. Prints of drawings shall show dark and fade- proof linework on a light and non-darkening background. Prints shall be on durable paper of good quality and 80-g/m² minimum weight. Negatives shall be on 75-micron durable plastic film.

The Engineer will not give approval to any unclear or ambiguous drawings.

1.31 Backfilling of Holes and Trenching for Temporary Works

The Contractor shall immediately upon approval of any work at his own expense and to the satisfaction of the Engineer backfill all holes, trenches and temporary quarries which have been made, level all mounds or heaps of earth that may have been raised or made and clear away all rubbish caused by the execution of the work. The Contractor shall bear and pay all costs, charges, damages, and expenses if any kind whatsoever which may occur by reason of holes and trenches connected with the Works or materials or tools or plant being left or placed in improper situation.

1.32 Inspection of Works

No part of the Works shall be built in or covered over until it has been inspected and approved by the Engineer and the Contractor must give due notice in writing to the Engineer's Representative when any part of the Works is ready for inspection.

1.33 Joint Measurements

All measurements shall be taken jointly by the Contractor and the Engineer as and when the latter so directs and shall be made in accordance with the Specification and Preamble to Bills of Quantities notwithstanding local or other customs.

1.34 Cleaning up of Site

The Contractor shall keep the site clean during the entire contract performance period. And before final acceptance upon the completion of the Works the Contractor shall, at his own expense, remove and dispose of all rubbish and remove all equipment, surplus materials, camps and buildings, which the Contractor has provided, and temporary works ordered by the Engineer and shall leave the Site absolutely clear thereof and in good order and condition to the entire satisfaction of the Engineer.

1.35 Testing of Water-Retaining Structures

All water-retaining structures shall on completion be tested for water-tightness in the following manner. The structure shall be filled with potable water in stages and held at each stage for such time as the Engineer may require. Should any dampness or leakage occur at any stage the water shall be drained off and the defects made good. The procedure shall be continued and finally the structure shall after a period allowed for absorption remain full for seven days. Within those seven days the level of the surface of the water should be recorded and measurements made at intervals of 24 hours. The total leak must not exceed 0.3% of the total volume of water in the tested structure.

If the structure does not satisfy the conditions of the test, and the daily drop in water level is decreasing, the period of test may be extended for a further 7 days, and, if the specified limit is then not exceeded, the structure may be considered as satisfactory.

Should any dampness or leakages or other defects occur they shall be made good and the structures re-tested until the water-tightness is approved by the Engineer.

Faces of submerged structures may not be covered before testing.

The Contractor shall allow in his rates for all expense and shall provide water and all necessary labour and materials for testing the structure.

1.36 Testing of Roofs

Where structures are used for the storage of potable water, adequate precautions should be taken to ensure that the roof is watertight in order to give protection against a potential source of pollution.

The roof should be tested by lagooning the concrete slab to a minimum depth of 75mm for a period of 3 days; the roof slab should be regarded as satisfactory if no damp patches occur on the soffit. The roof screed should be completed immediately after testing.

All water, labour and materials for the test are to be provided by the Contractor who shall allow for this in his rates.

1.37 Cleaning and Sterilizing Water-Retaining Structures

The interior of all potable water-retaining structures shall be thoroughly cleaned and washed after the water-tightness test has been approved by the Engineer in order to remove all contamination.

The structure shall then be filled to overflow level with clean water containing 50 parts per million of chlorine and left for a period of at least 24 hours. The chlorinated water shall then be drained away and the structures refilled with clear water from which samples shall be taken for bacteriological examination and for tests of residual chlorine. If any of the results of the tests are unsatisfactory when compared with those of the control sample of the supply water the sterilizing process shall be repeated until the results of the tests are satisfactory.

The Contractor shall allow for in his rates: providing water, all labour, materials, chemicals and other things necessary for cleaning and sterilizing the water-retaining structures.

1.38 Sampling and analysis of Clean Water in the System

The costs of the initial sampling, analyses and preparing reports on the bacteriological quality of the water shall be borne by the Employer, but should the initial reports be unsatisfactory the costs of any subsequent sampling analyses and preparing reports shall be borne by the Contractor.

1.39 Contractor's Superintendence

The Contractor shall give or provide all necessary superintendence during the execution of the Works and as long thereafter as the Engineer may consider necessary for the proper fulfilling of the Contractor's obligations under the Contract. The Contractor or his competent and authorized Agent or Representative approved in writing by the Engineer (which approval may at any time be withdrawn) is to be constantly on the Works and shall give his whole time to the superintendence of the same. If such approval shall be withdrawn by the Engineer, the Contractor shall after receiving written notice or such withdrawal; remove the Agent from the Site within the time stated in the notice and shall replace him by another Agent approved by the Engineer.

1.40 Transport of Workmen

The Contractor shall include in his rates for all transport of staff and workmen to and from and in connection with the various parts of the Works, and all costs incurred in recruiting and transporting labour to the site, where such labour is from outlying areas and costs of returning labour on termination of the Contract.

1.41 Normal Working Hours

These shall be taken as Monday to Friday 8.00 a.m. to 5.00 p.m. and Saturday 8am to 1pm. with all Public Holidays set aside as required. The Contractor shall allow for observance of Sabbath or any other religious days to his staff.

Where the Contractor wishes to work outside these hours he shall request the Engineer in writing at least 24 hours in advance for consideration. The Contractor shall bear the cost of overtime for all Engineers' support staff associated with such works.

1.42 Accommodation for Contractor's Workmen

The Contractor shall provide and maintain suitable shelters and mess facilities for his workmen and supervisory staff. The facilities shall be of sufficient size and to a standard considered satisfactory by the Engineer.

The Contractor shall throughout the contract provide an adequate supply of potable water for the Workmen.

1.43 Storage Space: Sheds

Suitable temporary stores and workshops shall be erected and later removed on completion of the works. All buildings shall be adequate for protection of the equipment of materials to be kept therein and shall be constructed and located to the satisfaction of the engineer.

1.44 Office for the Contractor

The Contractor shall erect an office near the Works on a site to be approved by the Engineer. This office shall be kept open at all hours during which the work is in progress.

Any notice to be given to or served upon the Contractor shall be deemed and taken to be effectively given or served upon by the delivery thereof at such office on the Site.

1.45 Communication

The Contractor shall, if so instructed by the Engineer, provide mobiles phones and airtime as necessary for the duration of the contract and, VSAT internet connection, post office, courier, radio communication for the exclusive use of the Engineer. The model and make of the mobiles phones shall be approved by the Engineer.

Failure by the Contractor to provide or maintain the same shall make him responsible for all costs that may be incurred as a result of the Engineer's staff using alternative means of communication, including delays in supervision and approval of the works.

Payment for complying with this requirement is included in the bill of quantities.

1.46 Houses and Office, for the Engineer's Staff

The Contractor shall provide and maintain houses and offices for the Engineer and his staff as shall be instructed from time to time and as provided in the Bill of quantities.

All houses and offices to be provided under the contract shall be handed over to the engineer in finished and fully habitable condition not later than thirty days after the Engineer's order to commence work.

Any delays to the Contractor or the Contractor's activities caused by the Engineer being unable to perform survey work, field or laboratory tests due to the Contractor's failure to supply and/or maintain the said equipment, houses and accommodation shall be deemed to have been caused by the Contractor's actions, and any consequences of such delays shall be interpreted as such.

1.46.1 Housing Accommodation for the Engineer's Staff

The Contractor shall provide, and maintain houses for the Engineer's staff as specified in Item 1.01 and 1.02 of the contract BoQ and as directed by the Engineer

1.46.2 Engineer's Offices

The Contractor shall maintain the Engineer's offices for the duration of the Contract as provided in Item 1.05 of the BoQ.

The office for the Engineer's Representative shall be completely separate from that of the Contractor and fully secured.

Toilets and washrooms graded to staff seniority, together with drinkable water supply and water borne sewage disposal, shall be provided for the office. The Contractor shall also provide 24 hours a day electricity supply to the offices and shall allow for any water and electricity consumed and for any statutory charges associated.

Unless the offices are accessible via an existing paved road, the Contractor shall also provide an access road at least 4m wide to the office. A 100 square meters covered car parking area. Both access road and car park shall be surfaced with at least 150 mm of consolidated gravel properly graded, cambered, drained, and culverted.

The offices shall be provided with day and night watchmen and security lights, the cost of which shall be deemed to have been included in the rates for the offices.

1.46.3 Engineer's office furniture

Furniture and equipment for the Engineer's office shall be as listed in Appendix A and item 1.07 of the contract BoQ. It shall also be the Contractor's responsibility to replenish consumables when instructed by the Engineer. The Engineer's office furniture will revert to the Employer on completion of the contract.

1.46.4 Survey equipment

The Contractor shall provide, and maintain in a good state of repair for the duration of the Contract, survey equipment for the Engineer's use

Any delays to the Contractor or the Contractor's activities caused by the Engineer being unable to perform survey work, field or laboratory tests due to the Contractor's failure to supply and/or maintain the said equipment shall be deemed

to have been caused by the Contractor's own actions, and any consequences of such delays shall be interpreted as such.

The laboratory and survey equipment shall revert to the Employer on completion of the contract.

1.47 Maintenance of the Engineer's Offices, Furniture and Equipment

The Contractor shall keep all buildings, accesses, services and facilities provided by him, for the use of the Engineer and his staff, in a well maintained, clean and fully habitable condition, 24 hours per day until the issue of the Taking Over Certificate for the whole of the Works, and if required for a period thereafter until the Contractor has completed any outstanding work.

The Contractor shall also provide constant electricity, water and an adequate refuse collection service for all houses and offices.

1.47.1 Provision of Maintenance and Security

The contractor shall provide cleaners, groundsmen, and day and night watchmen for the housing camp and offices as directed or instructed by the Engineer on site, the cost of which shall be included in the rates for providing houses, offices, and laboratory.

1.48 Insurance and ownership of the Engineer's Staff Houses, Offices, Laboratories, Furniture, and Equipment

All buildings, furniture, and equipment provided by the Contractor for the Engineer's staff shall be insured by the Contractor against loss or damage by accident, fire, theft, and other risks ordinarily insured against for the duration of the Contract.

1.49 Provision of Project Vehicles

The vehicles to be provided shall be new, right-hand drive, diesel-powered, and equipped with an air conditioner and power steering as described below.

New Turbo diesel propelled 4WD, 5 door 7-seater station wagon vehicle of minimum engine capacity 4164cc, 285Nm/2200rpm torque, 96kW/3800rpm power, 130ltrs fuel tank capacity fitted with all the necessities mentioned in paragraph one of this clause for the exclusive use of the Engineer.

1.50 Removal of Camps

On the completion of the Contract, the Contractor shall if so requested take down and remove all structures connected with his camp, and shall take up all pipes, drains and culverts, backfill trenches, fill up all latrine pits, soak ways and other sewage disposal excavations, and shall restore the site as far as practicable to its origin condition and leave it neat and tidy to the satisfaction of the Engineer.

1.51 Site Meetings

Site meetings will be held monthly, but will be called for whenever the progress of the works so require or when demanded by the Engineer.

The Contractor shall at all meetings be represented by a responsible representative other than the Site Agent, who has the powers to commit the Contractor in all matters concerning the contract.

In the event no responsible representative of the Contractor is present at the meetings, any decision take by the Engineer at the meeting will be binding upon the Contractor.

1.52 Miscellaneous Accounts

The Contractor may be instructed by the Engineer to make payments of general receipted accounts for such items as stationery, stores, furniture and equipment, claims and allowances for supervision personnel and any miscellaneous claims or the Engineer may direct the Contractor to purchase or pay for the above. The Contractor will, on provision of receipts, be paid under appropriate items in the Bill of Quantities

1.53 Payment of Overtime for Engineer's Junior Staff

The Engineer may instruct the Contractor to make payments for overtime worked by the Engineer's junior staff. The Contractor shall be reimbursed for such payments in accordance with the relevant items of the contract except when any overtime worked by the engineer's junior staff is incurred by the need for the engineer to inspect work which, owing to earlier default by the contractor, has resulted in such work being performed outside the normal working hours as defined in clause 1.37 of this specification then the full cost of such overtime including the specified percentage for administrative overheads shall be paid by the Contractor to the Engineer.

- (i) Suppose the Contractor wishes to execute permanent work outside the Engineer's normal working hours, as stated in Clause 1.37 of this Specification. In that case, the payment for the overtime for Engineer's support staff shall be reimbursed in full by the Contractor to the Engineer. For purposes of this clause, in addition to the support staff provided by the contractor, the following shall also constitute part of the Engineer's junior staff
- (ii) If the Contractor wishes to execute permanent works on a regular basis outside the Engineer's normal working hour, (Clause 1.37 of this Specifications) over a prolonged period, the Engineer may, if he deems it necessary, employ additional supervisory staff for which the required salaries, plus twenty (20) percent additional amount to cover for the Engineer's overheads shall be reimbursed in full by the Contractor to the Engineer and the Contractor shall provide the required accommodation facilities for such staff at his own cost.
- (iii) Payment of Allowance on Duty Trips. The Contractor is required to pay for hotel accommodation and allowances for his staff seconded to the Engineer on official duty trips outside the base camp.

The Contractor shall not be reimbursed any of these costs (i.e. i, ii, iii)

1.54 Water proofing

The Consultant shall work carefully with waterproofing manufacturers and obtain constructability input from the contractor prior to giving any instructions on the type of waterproofing system and components to be used. It is recommended that the Product Performance, Application Techniques and General Condition factors listed in here below be carefully considered in reviewing and selecting the appropriate waterproofing system.

The following shall be important Waterproofing Specifications factors to be considered

- i. Qualifications of the Applicator,
 - ii. Submittals - Evidence of Applicator Qualifications,
 - iii. Manufacturer's Certificate of Conformance, Catalog,
 - iv. Application Data, and Samples,
 - v. Delivery and Storage of Materials,
 - vi. Environmental Conditions,
 - vii. Carefully review the Physical Performance, Application,
 - viii. Ensure that product materials comply with these requirements, the structural design and other design criteria.
- Membrane should be impermeable to water but allow water vapor to pass,
 - Membrane should provide a continuous film without areas of weakness and lend itself to the design details of the structure,
 - Materials selected must be compatible,
 - Ensure that surface to be treated has been prepared to provide a positive bond to minimize the lateral migration of water,
 - Application of the waterproofing products must be specified in accordance with the manufacturer's requirements,
 - The membrane selected should maintain its physical properties, such as elasticity and durability, over wide range of environmental conditions,
 - Quality control specifications should be reviewed to ensure that each phase is properly inspected and tested prior to proceeding with the next phase. Testing of the installed waterproofing system prior

to and after backfilling, by the continuous application of water over extended periods of time, is essential and should be specified,

- The waterproofing system should be guaranteed for both material and performance by the installing contractor. Manufacturers' representatives should also be required by specification to be on site during the installation of their product.

1.55 Measurement and payment

No separate measurement and payments shall be made for the cost of complying with the requirements of clauses 1.1 to Clause 1.10, Clause 1.12, Clause 1.14 to Clause 1.33, Clause 1.35 to Clause 1.40, Clause 1.43, Clause 1.44, Clause 1.46, Clause 1.47 and Clause 1.50 of this specification and the Contractor shall be deemed to have allowed elsewhere in his rates and price for all such costs.

- a. No Preliminary item has been included in this Contract. All Contractor's mobilization and general costs shall therefore be included in relevant rates in the Bill of Quantities.

b. *Clause 1.11: Relocation of Existing Services*

Unit: Prime Cost

Plus % for Contractors overheads and profits

Reimbursement for the removal of or alteration to existing services which are affected by the works shall be on a prime cost basis plus a % for overheads and profits. This percentage shall be deemed to include for all costs incurred in liaising with the appropriate bodies and for programming and coordinating work to enable any removal or alteration to the service to be carried out and complying with the requirements of clauses 1.11 and clause 1.20 of this specification.

c. *Clause 1.14: Use of Public roads*

Unit: Provisional Sum

Reimbursement for use and maintenance of public roads, and other works required for construction of permanent works shall be on a provisional cost basis and payments shall be on daywork basis. This costs incurred shall include for liaising with the appropriate bodies and for programming and coordinating work and complying with the requirements of Clause 1.14, Clause 1.15, and Clause 1.20 of this specification.

d. *Clause 1.25: Signboards*

Unit: No. of each type

The rate shall include the cost of complying with clause 1.25 and costs incurred in liaising with the appropriate bodies and levies as may be applicable under relevant local and national laws.

e. *Clause 1.34: Sampling and analysis of clean water in the system.*

Unit: Prime Cost

Plus % for Contractors overheads and profits

Reimbursement for the costs of the initial sampling, analyses and preparing reports on the quality of the water shall be on a prime cost basis plus a % for overheads and profits. This percentage shall be deemed to include complying with the requirements of Clause 1.33 and Clause 1.34 of this specification.

f. Clause 1.41: Engineer's Communication.

Unit: Prime Cost

Plus % for Contractors overheads and profits

Reimbursement for the costs of providing and maintaining mobiles telephones, VSAT internet connection, post office, courier, radio communication shall be on a prime cost basis plus a % for overheads and profits. This percentage shall be deemed to include for all costs incurred in liaising with the appropriate bodies for licensing, registering, erecting and maintenance of the communication services and the cost of complying with the requirements of Clause 1.42 of this specification.

g. Clause 1.42.3 Engineer's Office:

Engineer's office shall be measured by the number instructed to be built. The rate of the Engineer's office shall include for the cost of providing the office, electricity, water, telephone charges and heating in accordance with instructions issued by the engineer and shall comply with the requirements of Clause 1.42 and clause 1.43 of this specification.

Payment for the engineer's office shall be made in instalments in accordance with clause 1.50 (g) of this Specification.

h. Clause 1.45.1 Contractor's Vehicles for the Engineer use

i) Unit: V. month for each type of vehicle

Provision of vehicles for the engineer shall be measured by the vehicle month (V. month) for each month, or part thereof, that the vehicle is provided for the engineer.

Payment for the vehicles (up to 4,000km per Veh.month) shall be by vehicle months.

ii) Units : Kilometers

Payment for mileage above 4,000km per vehicle month shall be at a rate per kilometer. The rate shall include for all fuels, lubricants, servicing insurance, maintenance, driver and repairs. The km rate shall include any overtime the driver might be due or any other allowances in addition to the normal working hours. Payment shall be under appropriate items in the Bill of Quantities.

In addition, the rate for running costs of vehicles shall also include:

- (i) Cost of any repairs necessary as shall be required to meet roadworthiness and compliance with registration requirements

(ii) Any other repairs as shall be instructed by the Engineer

The rate shall include for the cost of complying with the requirements of clause 1.45 of this specification.

i. Clause 1.48 Miscellaneous account

Unit: Prime Cost Sum

Plus % for Contractor's overheads and profits

The Contractor, on provision of receipts, will be reimbursed on a prime cost basis for miscellaneous accounts plus a percentage for overhead and profits. This percentage shall be deemed to include for all costs in proving the items in the miscellaneous account including purchase, transport to site and complying with the requirements of clause 1.48 of this specification.

j. Payment of overtime for the Engineer's junior staff

Unit: Prime Cost Sum

: Plus % for Contractor's overheads and profits

Reimbursement for the payments of the Engineer's junior staff overtime shall be on a prime cost basis plus a percentage for overhands and profits. This percentage shall be deemed to include for all costs of complying with clause 1.49 of this specification.

2.1 Information from Exploratory Borings and Test Pits

2.1.1 Factual Materials Report

The Factual Materials Report for this Contract does not form part of the Contract Documents. However, the Report will be made available for the **Contractor's information only**, and any conclusions on issues such as suitability of materials, location of borrow pits, material quantities etc., made by the Contractor on basis of the Factual Materials Report, will be at his own risk and at no extra cost to employer.

2.1.2 Trial Sections

The Contractor shall allow in his programme for constructing trial sections and carrying out tests upon them as directed by the Engineer. Trials would normally be required at the start of each structure, and if changes of materials, method, or equipment are deemed necessary, as directed by the Engineer. The time for completion of the Contract shall not be extended because of the time needed to construct trial sections and evaluate the tests on them.

No variation in the construction procedure, mix proportions, size, grading or source of any of the constituents shall be made without the agreement of the Engineer.

Trial sections, if found satisfactory, will be paid for under the rates in the Bill of Quantities for the appropriate items, as if the trial sections were part of the normal work. No separate payment will be made for trial sections and testing.

The Contractor shall make good, at his own expense; any trial sections that fail to meet the specified standards. The standards shall include, but not be limited to, material quality, layer thickness, levels, and compaction.

2.2 Quality of Materials and Workmanship

The materials and workmanship shall be of the best of their respective kinds and shall be to the approval of the Engineer. In reading of these Specifications, the words "to the approval of the Engineer" shall be deemed to be included in the description of all materials incorporated in the Works, whether manufactured or natural, and in the description of all operations for the due execution of the Works.

All works or parts thereof shall be in accordance with the latest edition of either Kenya Bureau of Standards (K.E.B.S.) Specifications, or International Standards Organization (I.S.O.) Specification or British Standard (B.S.) Specifications and British Codes of Practice (C.P.) as published by British Standards Institution.

All materials shall be of approved manufacturer and origin and the best quality of their respective kind, equal to sample and delivered on to the Site a sufficient period before they are required to be used in the Works to enable the Engineer to take such samples as he may require for testing or approval, and the Contractor shall furnish any information required by the Engineer as to the quality, weight,

strength, description, etc. of the materials. No materials of any description shall be used without prior approval by the Engineer and any condemned as unfit for use in the Works shall be removed immediately from the Site by, and without recompense to, the Contractor.

2.3 Trade Names

Trade Names and Catalogue References are given solely as the guide to the quality and alternative manufacturers of the materials or goods of equivalent quality will be accepted at the discretion of the Engineer.

2.4 Samples

As soon as possible after the contract has been awarded, the Contractor shall submit to the Engineer a list of the suppliers from whom he proposes to purchase the materials necessary for the execution of the Works. Each supplier must be willing to admit the Engineer or his representatives, to his premises during ordinary working hours for the purpose of obtaining samples of the materials in question. Alternatively, if desired by the Engineer, the Contractor shall deliver the samples of the materials to the Engineer's office without charge.

The information regarding the names of the suppliers may be submitted at different times, as may be convenient, but no source of supply shall be changed without the Engineer's prior approval once a supplier, source or material has been approved.

Samples of materials approved will be retained at the Engineer's office until the completion of the contract. Samples may be tested to destruction.

Samples of all materials shall be deposited with the Engineer and approved prior to ordering or delivery to site. The Engineer reserves his right to test any sample to destruction and retain samples until the end of the maintenance period. No payment will be made for samples and the Contractor must in the rates of prices allow for costs of samples. All materials delivered to site shall be equal or better in all respects than the samples delivered to the Engineer.

All sampling of materials on the site must be done by or in the presence of the Engineer. All other samples will be deemed not to be valid under the Contract.

Any material delivered to the site or intended for the works not equal or better than the samples approved by the Engineer shall be removed and replaced at the Contractor's expense.

2.5 Testing

As provided in Clause 7 of the Conditions of Contract and in accordance with the Specification quoted for any material used on works of this Contract, tests may be called upon by the Engineer to be carried out at the place of manufacture or on the site. The Contractor may assume that the tests will be required on soils, workmanship, and materials whether natural or manufactured to verify their compliance with the specifications. Samples of all such materials and

manufactured articles together with all necessary labour, materials, plant and apparatus for sampling and for carrying out of the tests shall be supplied by the Contractor at his own expense.

2.6 Testing at an independent laboratory

A prime cost item has been included in Bills of Quantities for testing of materials and workmanship as directed by the Engineer at an Independent Laboratory. The Contractor will be reimbursed receipted cost of testing carried out by the laboratory if the workmanship or materials pass the tests. However, if the result of tests shows that material is defective then the Contractor will bear the cost of testing.

2.7 Standards

Summary of British Standards Applied in the Final Design and Specifications are as follows. It should be noted that the latest version of each of the following standards are the applicable version under this contract.

BS 4 Part 1:	1972	Hot-rolled sections
Part 2:	1969	Hot-rolled hollow sections
BS 12: Part 1	1958	Portland cement (Imperial units)
Part 2	1971	Portland cement (Metric Units)
BS 21:	1973	Pipe threads for tubes and fittings where pressure-tight joints are made on the threads
BS 143:	1968	Malleable cast iron and cast copper alloy screwed pipe fittings for steam, air, water, gas and oil.
BS 416:	1973	Cast iron spigot and socket soil, waste and ventilating pipes (sand cast and spun) and fittings
BS 437:		Cast iron spigot and socket drain pipes and fittings
BS 437: Part 1:	1970	Pipes, bends, branches and access fittings.
BS 449:		The use of structural steel in building.
BS 449: Part 1:	1970	Imperial units
BS 449: Supplement No. 1(P.D. 4064) to BS 449: Part 1:	1970	The use of cold formed steel sections in building. Addendum No. 1 (1975) to BS The use of cold formed steel sections in building
BS 459:		Doors
BS 459: Part 2:	1962	Flush doors
BS 459: Part 4:	1965	Matchboarded doors
BS 534:	1966	Steel pipes, fittings and specials for water, gas and sewage.

BS 556:		Concrete cylindrical pipes and fittings including manholes, inspection chambers and street gullies.
BS 556: Part 2:	1972	Metric units.
BS 639:	1976	Covered electrodes for the manual metal-arc welding of carbon and carbon manganese steels.
BS 743:	1970	Material for damp proof courses. Metric units.
BS 747: Part 2:	1970	Roofing felts. Metric units.
BS 864: Part 2:	1971	Capillary and compression tube fittings of copper and copper alloy. Metric units
BS 882:	1992	Aggregates from natural sources for concrete (including granolithic)
BS 882: Part 1:	1965	Imperial units
BS 882: Part 2	1973	Metric units
BS 890:	1972	Building lines
BS 952:	1964	Classification of glass for glazing and terminology for work on glass.
BS 1010:		Draw-off tops and stopvalves for water services (screwdown pattern)
BS 1010: Part 1:	1959	Imperial units
BS 1010: Part 2:	1973	Draw-off taps and above-ground stop valves M
BS 1030:	1943	Schedule of cast iron drain fittings, spigot and socket type, for use with drain pipes to BS 437.
BS 1142:		Fibre building boards
BS 1142: Part 3	1972	Insulating boards (soft boards)
BS 1184:	1976	Copper and copper alloy traps.
BS 1186:	1975	Quality of timber and workmanship in joinery
BS 1186: Part 1	1967	Quality of timber
BS 1186: Part 2:	1971	Quality of workmanship
BS 1212:		Ball valves (excluding floats)
BS 1212: Part 1:	1971	Piston type
BS 1212: Part 2		Diaphragm type (brass body):
BS 1256	1953	See BS 143
BS 1377	1970	Methods of test for Soil for Civil Engineering purposes

BS 1387		Steel tube and tubular suitable for screwing to BS 21 pipe threads
BS 1722:	1975	Fence
BS 1722: Part 1	1972	Chain link fences Supplement No. 1 (1974) to BS 1772 part 1 fences, gates and gate posts used in conjunction with chain link fences
BS 1881:		Methods of testing concrete
BS 1881: Part 1:	1970	Methods of sampling fresh concrete
BS 1881: Part 2:	1970	Methods of testing fresh concrete
BS 1881: Part 3:	1970	Methods of making and curing test specimen.
BS 1881: Part 4:	1970	Methods of testing concrete for strength.
BS 1881: Part 5:	1970	Methods of testing hardened concrete for other than strength
BS 1881: Part 6	1971	Analysis of hardened concrete
BS 2028:	1968	Precast concrete blocks
BS 2494:	1976	Materials for elastomeric joint rings for pipeworks and pipelines
BS 2871:		Copper and copper alloys, Tubes.
BS 2871: Part 1:	1971	Copper tubes for water, gas and Sanitation
BS 2871: Part 1:	1972	Tubes for general purposes
BS 2871: Part 3:	1972	Tubes for heat exchangers.
BS 3148:	1959	Test for water for making concrete
BS 3248:	1967	Polythene pipe (Type 50) for cold water services
BS 3416:	1975	Black bitumen coating solution for cold application
BS 3505:	1968	Unplasticised PVC pipe for cold water services
BS 3601:	1974	Steel pipes and tubes for pressure purposes: carbon steel with specified room temperature properties.
BS 4133:	1967	Flanged steel parallel slide valves for general purposes
BS 4164:	1967	Coal tar-based hot applied coating materials for protecting iron and steel, including suitable primers where required.
BS 4190:	1967	Isometric black hexagon bolts, screws and nuts
BS 4254:	1967	Two-part polysulphide-based sealants for the building industry.

BS 4320:	1968	Metal washers for general engineering purposes
BS 4360:	1972	Weldable structural steels.
BS 4449:	1969	Hot rolled steel bars for the reinforcement of concrete.
BS 4461:	1969	Cold worked steel bars for the Reinforcement of concrete.
BS 4466:	1969	Bending dimensions and scheduling of bars for the reinforcement of concrete
BS 4483:	1969	Steel fabric for the reinforcement of Concrete.
BS 4505:		Flanges and bolting for pipes, valves and fittings. Metric series.
BS 4505: Part 1:	1969	Ferrous.
BS 4772:	1971	Ductile iron pipes and fittings.
BS 4848:		Hot-rolled structural steel sections.
BS 4848: Part 2:	1975	Hollow sections
BS 4848 Part 4:	1972	Equal and unequal angles
BS 5135:	1974	Metal-arc welding of carbon and carbon manganese steels
BS 5151:		Cast iron gate valves for general Purposes
BS 5153:	1974	Cast iron check valves for general purposes
BS 5155:		Cast iron and carbon steel butterfly valves for general purposes
BS 5163:	1974	Double flanged cast iron wedge gat valves for waterworks purposes
BS 8007:	1987	Code of practice for the structural use of concrete for retaining aqueous liquids (formerly BS 5337)
BS 8110:	1985	The structural use of concrete.
BS 5328:	1985	Method of specifying concrete including ready mix concrete
EN 12201-1	2002	Plastics piping systems for sewerage under pressure -water supply, and for drainage and Polyethylene (PE) - Part1: General
EN 2201-2	2011	Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE) - Part 2: Pipes
EN 12201-3	2011	Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE) - Part 3: Fittings
EN 12201-5	2011	Plastics piping systems for water supply, and for drainage and sewerage under

		pressure polyethylene (PE)
BS 5268:		The structural use of timber
CP 112: Part 3:	1973	Trussed rafters for roofs of dwellings.
CP 231:	1966	Painting of buildings
CP 301:	1971	Building drainage
CP 308:	1974	Drainage of roofs and paved areas
CP 310:	1965	Water supply
CP 2010:	1971	Pipelines
CP 2010: Part 1:		Installation of pipelines in land
CP 2010: Part 2:	1970	Design and construction of steel pipeline in land
CP 2010: Part 3:	1972	Design and construction of iron pipeline in land

2.8 Measurement and payment

Except where payment items are provided for certain materials and required tests, no separate measurement and payment shall be made for materials and tests and the cost thereof shall be included in the appropriate tendered rates.

3.1 Site Clearance and Grubbing

Site clearance shall generally be restricted to the areas under permanent works without any provision for working allowance and/or as instructed by the Engineer. No separate measurement and payment will be made for site clearance of areas cleared by the Contractor for the Storage of Construction materials, camps, housing, workshops, stores, quarries, temporary works, and working space. The contractor's rates and prices are deemed to include for this work.

Clearing shall involve the following:

- The removal of all trees and bushes (complete with roots), other vegetation, rubbish and all other material that may interfere with the construction of the Works.
- The removal of all rocks and boulders of up to 0.15 m³ in size, which are lying on the surface to be cleared or which are exposed during the clearing operations.
- The disposal of all material produced by the clearing.
- The removal and disposal of structures which encroach upon or may otherwise obstruct other work on the Site and which can be cleared by means of a bulldozer with a mass of approximately 20 t and a flywheel power of approximately 130 kW. (Structures that cannot be so cleared shall be dealt with as directed by the Engineer.)

Unless instructed, the site clearing for trenches shall only be for the width allowed for trench excavation.

The moving of a certain amount of soil or gravel may be inherent in or unavoidable during the clearing process. No extra payment will be made for the removal of such soil or gravel.

Areas that are cleared in strips for the purpose of constructing fences shall be cleared over the full length of the fence to a width as specified in the drawing and as instructed by the Engineer. Surface irregularities shall, in the case of fencing, be so graded that the fence will follow the general ground contour.

All stumps and roots exceeding 75 mm in diameter shall be removed to a depth of at least 100 mm below the original ground level. Where a construction bed or any other area has to be compacted, all stumps and roots including matted roots shall be removed to a depth of at least 200 mm below the cleared surface.

All material produced by the grubbing shall be disposed of.

Except in borrow areas, cavities caused by grubbing shall be backfilled with approved material and compacted to a density equal to at least that of the surrounding ground.

3.2 Cutting Trees

a. Protection of persons, animals and structures

The Contractor shall take the necessary precautions to prevent injury to persons and animals and damage to structures and other private and public property.

Where necessary, trees shall be cut in sections from the top downwards.

b. Branches overhanging boundaries

The branches of trees to be left standing shall be so trimmed as not to encroach upon the space (to a height of at least 7 m) vertically above any carriageway, railway formation, or other designated area.

c. Preservation of trees

No tree shall be cut down and no branches shall be trimmed off any of the trees to be preserved until the Engineer has given written authorization for such work to commence. Individual trees indicated and marked by the Engineer as trees to be preserved shall be left standing and undamaged.

3.3 The Disposal of Material

Any material obtained from clearing and grubbing, the demolition of structures, the re-clearing of vegetation and the cutting of trees shall be disposed off in borrow pits or other suitable places indicated by the Engineer. Where no such place for the disposal of material is indicated by the Engineer, the Contractor shall make his own arrangements to provide a suitable place which complies with the requirements laid down by the Engineer. The disposal or burning if specially permitted of combustible material on the Site may be done only with the prior written approval of the Engineer. Care shall be taken to observe the air pollution under EMCA 1999.

All tree trunks and major branches shall be sawn into transportable lengths before removal from the Site.

No haulage will be payable to the Contractor for the disposal of material obtained from clearing and grubbing, the demolition of structures, the re-clearing of vegetation, and from the cutting of trees.

Materials from stripping such as suitable topsoil shall, if instructed by the Engineer, be stacked in approved areas. All other non-combustible materials shall be buried in approved disposal area; covered with a minimum of 0.5m of excavation spoil. These disposal areas shall be left with neatly graded surfaces and stable slopes that assure drainage. Alternatively, the non-combustible material shall be removed from the area by the Contractor.

3.4 Removal of Topsoil

Topsoil shall be removed to spoil or stockpile where and as directed by the engineer. Spoil material shall be deposited in compliance with the relevant national and local laws and regulations. Measurement shall be the net area in square metres removed as directed and shall allow for stripping topsoil to a depth

of 200mm. Should the Engineer instruct that a greater depth than 200mm be removed, payment for the additional material shall be made under the item for excavation in the Bills of Quantities.

The topsoil shall be removed from over the full width of the trench to a depth of 200 mm or if rock occurs closer than 200 mm to the existing natural surface. On completion of backfilling, the topsoil shall be replaced in its original position.

Should the Contractor strip to depths greater than those instructed by the Engineer, then the Contractor shall replace the material with suitable fill material at his own expense.

3.5 Measurement and payments

a. Clause 4.1. Site Clearing and grubbing

Unit: Areas square metre (m²)

The unit of measurement for clearing and grubbing is the square metre or metre.

Only those areas or strips designated by the Engineer under Clause 4.1 of this specification shall be cleared and grubbed in accordance with the requirements of Clause 4.1 and Clause 4.3 of this specification shall be measured for payments.

The tendered rates shall include full compensation for clearing the surface, removing boulders with a size of up to 0.15 m³, cutting trees with single or multiple trunks each with a girth of 0.5 m or less, grubbing the stumps and roots of such trees, cutting trunks and branches into transportable lengths, backfilling cavities, demolishing structures, and removing, transporting and disposing of material thus cleared, grubbed, cut and demolished. Boulders exceeding 0.15 m³ in size shall be dealt with as set out in Earthworks Section of this Specification.

b. Clause 4.2 Cutting and removing large trees with a girths exceeding 0.5m

Unit: Exceeding 0.5m and up to and including 2m number (No)

Exceeding 2m and up to and including 3m number (No)

The unit of measurement shall be the number of tree trunks cut and removed in each size group. The girth of a tree trunk will be measured at the narrowest point of the trunk in the first metre of its height above ground level.

The tendered rates shall include full compensation for cutting the trees and grubbing the stumps, for cutting the trunks and branches into transportable lengths, and for removing, transporting and disposing of all such trees, stumps, trunks, branches and associated material.

c. Grubbing and the removal of the stumps and roots of large trees with a girth exceeding 0.5m

Unit: Exceeding 0.5m and up to and including 2m number (No)

Exceeding 2m and up to and including 3m number (No)

The unit of measurement shall be the number of tree stumps and associated roots of which were grubbed and removed in each size group.

The tendered rates shall include full compensation for grubbing the stumps and roots, backfilling holes, cutting the stumps and roots into transportable pieces, and removing, transporting and disposing of all such stumps and roots and associated material.

The girth of a tree trunk will be measured at the narrowest point of the trunk in the first metre of its height above ground level.

d. Clause 4.4 Removal of top soil

Unit m²

Removal of topsoil shall be measured by the square meters calculated as the plan area measured from cross-section taken in accordance with clause 1.26 of this specification.

The rate for removal of top soil shall include for the cost of all hauls as necessary and compliance with the requirements of Clause 4.3 and Clause 4.4 of this specification

4.1 General

Excavation shall be made to such lengths, depths and inclinations as may be necessary for the construction of the works or as shown on the drawings or as the Engineer may direct.

4.2 Definitions of Materials

For the purpose of these Specifications materials of earthworks are classified as follows:

- (a) Hard material: Material which can be excavated only after blasting with explosives, or barring and wedging or boulders of more than 0.5m³ occurring in soft material shall be classified as hard material.

or

Rock is defined as solid masses, layers, or ledges of such hardness that it cannot be effectively loosened or broken by ripping with a track type tractor minimum flywheel power 250KW (335 HP) equipped with a single shank ripper and operating in low gear.

- (b) Soft Material: All earth materials, which do not meet the requirements of hard material as defined in above.

- (c) Overburden means soil as defined here above

Where it is impractical to prove hard material by the above method, then the quantity of hard material, if any, shall be determined by the engineer.

4.3 Scope

All the excavations covered in this section are open cut excavation also termed surface excavation in this contract:

- Excavation for cuttings (soil and rock).
This covers mainly excavations under the embankment dam, excavation for cofferdam, excavation for the spillway.
- trench excavation for the plinth (soil and rock)
This covers the excavation of the trench for the embankment dam with its adjacent filter and transition,
- Excavation for culvert (soil and rock)
This covers the excavation of the trench for the culvert, the intake tower and the downstream valve chamber.
- Small size excavation (soil and rock) See BoQ for definition
- Excavation of earth fill material in borrow area
- Excavation of overburden in rock quarry This covers the excavation of the soil cover in the quarry
- Excavation of rock fills R1, R2 (and R5 in the alternative).

4.4 Excavation

4.4.1 General

The excavations (except in the quarry and borrow area) shall be made to the lines, grades and dimensions shown on the drawings.

The Contractor shall take all necessary measures to ensure the stability and safety of excavations,

Excavations needed by the Contractor installations shall be submitted to the approval of the Engineer,

All open out excavation shall be performed in accordance with this section to the lines, grades and dimensions shown on the drawings or as directed by the Engineer.

All necessary precautions shall be taken to preserve the material below and beyond the lines of all excavation in the soundest possible condition.

Where, in the opinion of then Engineer, the surface of the excavation has become soft or unsuitable due the Contractor's method of working, the Contractor shall at his own expense remove and replace the unsuitable material with class 15 concrete or other approved material as instructed by the Engineer.

Any and all excess excavation for the convenience of the Contractor for any purpose or reason, except as may be ordered in writing by the Engineer and whether or not due to the fault of the Contractor, shall be at the expense of the Contractor. Where required to complete the work, all such excess excavation and over-excavation shall be filled with compacted concrete class 15 or as directed by the engineer, furnished and placed at the expense of and by the Contractor.

All excavations shall be kept clean and free from water, and the Contractor shall dig diversion channels, erect coffer dams or otherwise dewater the excavations

If excavations are carried out in roads, footpaths, separators, or within 5m of buildings the Contractor is required to execute the work in a way that will minimize damage and disturbances.

All open excavations shall be clearly marked or covered by the Contractor to protect the public from any damage or injury. All costs arising from injury or damage to property or persons due to the Contractor's failure to protect open excavations and shall be borne fully by the Contractor.

The Engineer's approval to the final excavated surface shall be obtained prior to the laying of pipelines or construction of structures.

The sides of pits, trenches and other excavations shall, where required, be adequately timbered and supported, and all such excavations shall be sufficient size to enable the pipe and the concrete to be laid accurately and proper refilling and compaction to be carried out.

Where instructed by the engineer, shoring and supporting timber shall be left in trenches or other excavations.

Where ground conditions are such that a satisfactory foundation cannot be achieved the Contractor shall, if instructed by the Engineer remove the unsuitable material either until a suitable material is encountered or to the depth and width instructed by the Engineer. The Contractor shall backfill the resultant excavation with approved material to the satisfaction of the Engineer. Approved material may include rock fill and/or selected backfill material as directed by the Engineer.

The Engineer reserves his right to direct the Contractor as to the lengths of trenches or parts of bulk excavations which shall be opened up at any one time.

Where trenching, pipe-laying operations and culvert construction are carried out in built-up areas, the work shall be completed as quickly as possible so as not to unduly inconvenience the public. In the case of excavations in roads, and in other places which in the opinion of the Engineer are likely to cause interference to the public, then the works shall be completed as quickly as possible so as not to unduly inconvenience the public

No permanent work shall commence until the Engineer has inspected and approved the excavation.

The Contractor shall carefully set aside the various suitable materials encountered so that they may be reused for backfilling. If the excavated materials are unsuitable the Contractor may spoil the material only after approval by the Engineer. No extra claim will be allowed for setting aside surface material or topsoil for reuse or spoil.

4.5 Ground Levels and Reconstruction Cross Sections

Before the commencement of any earthworks the sites shall be surveyed in conjunction with the Engineers Representative to establish existing ground levels and these agreed ground levels shall form the basis for the calculation of quantities of any subsequent excavation and filling.

4.6 Topographical and Geological Survey After Excavation

A topographical survey of the excavated areas (except earthfil borrow area) shall be carried out by the Contractor at his own expense under the control of the Engineer. On the topographical map obtained the Contractor shall draw any geological accident, fault, and seams with all their details.

These indications shall be reported under the control of the Engineers geologist.

In order to facilitate the inspection of the excavation surfaces, the Engineer is entitled to request that these surfaces shall be cleared, washed and dried in order to enable a geologist to carry out a geological survey in the best conditions. In any case the earth filling or concreting of the excavation will not be carried out before they have been inspected and approved by the Engineer.

After his inspection the Engineer is entitled to request a deeper excavation. The earth filling or concreting shall not be carried out before another inspection has been done and the excavation approved.

4.7 Tolerances

For the excavations to be covered by concrete, or adjacent filter and transition the tolerances shall be as follows: -

- for the vertical dimensions $\pm 100\text{mm}$
- for the horizontal dimensions $\pm 1\text{m}$

4.8 Disposal of Excavated Material

In so far as they may be suitable and comply with the Specification, materials arising from excavations may be used in the Works. All surplus or unsuitable excavated materials shall be disposed to spoil banks at locations shown on the drawings or accepted by the Engineer.

4.9 Spoil Banks

All necessary measures shall be taken not to obstruct natural drainage courses with the spoil banks

Spoil banks shall be graded to a neat appearance with outer slopes not exceeding 3H/IV.

Suitable slopes shall be given to the surface to ensure drainage.

The maximum allowable height of the spoil banks shall be fixed by the Engineer.

4.10 Use of Explosives

Permission to blast shall only be carried out on those sections of the works for which permission in writing shall have been given by the Engineer. If blasting is necessary adjacent to any structure the Contractor shall provide a seismography and demonstrate that:

- For concrete or grout in place more than four hours but less than 60 hours, the maximum particle velocity as determined by seismographic measurement shall not exceed 10 mm/s.
- For concrete or grout in place less than four hours and greater than 60 hours, the maximum particle velocity shall not exceed 60 mm/s, except that for structures with a top width greater than their height and consisting of mass concrete or concrete having only nominal reinforcing, maximum permissible particle velocity may be increased to 80 mm/s with approval of Engineer.

On basis of measurements obtained and on basis of observation made of structures after each blast, limits specified herein may be revised by Engineer.

4.10.1 Compliance with laws and regulations

The Contractor shall at all times take every possible precaution and comply with the Explosives Laws of Kenya and regulations relating to the handling, Transportation, storage and use of explosives and shall at all times when engaged in blasting operations sufficient warning flagmen to the full satisfaction of the Engineer.

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

The Contractor shall provide a special store for explosives in accordance with Kenyan Regulations. The Contractor shall provide experienced men with valid Kenyan blasting licenses for handling explosives to the satisfaction of the Engineer and the Authorities concerned.

4.10.2 Submittals

The Contractor shall submit to the Engineer for his approval in advance details of the intended drilling patterns, depths of holes, the amounts of explosives at each location and the method or sequence of firing that the proposes to use.

4.11 Pre-Splitting

4.11.1 General

Pre-splitting comprises drilling a line of holes of appropriate diameter, spaced on centres not more than 10 times the diameter of the drill holes diameter or 30cm whichever is the greater and charging the holes with the appropriate amount of explosives to shear the rock in a surface along the line of drill holes. Either all holes in a pre-splitting row shall be drilled, charged and detonated simultaneously prior to drilling the production holes for the excavation adjacent to the pre-split row or pre-splitting shall be accomplished by delaying the production holes to allow the presplit holes to fire first. It is to be expected that the first row of production holes adjacent to the presplit face will need to be lightly charged to ensure that no damage occurs to the pre-sheared face when the main charge is detonated.

4.11.2 Submittals

The Contractor shall submit to the Engineer for his approval the proposed detailed methodology for presplitting.

4.12 Excavations in Quarry

4.12.1 General

Excavation of the overburden in quarry

The extent of the overburden shall be defined by the Engineer after the site investigation at the beginning of construction. Excavated material shall be sent to soil bank, or if suitable and complying with the specifications can be reused as fill.

4.12.2 Submittals

The planning of exploitation for quarry and method statement shall be submitted to the Engineer one month before starting excavations in the quarry.

4.13 Change in Quarry

When exploiting quarry, the Contractor shall perform all necessary investigations to document the quantity and quality of rock which remains to be exploited and shall inform the Engineer in writing. In case of insufficient quantities use of alternative quarry shall be contemplated.

4.14 Excavation of Earth Fill Material in Borrow Area

4.14.1 Investigations

Before opening excavations in the borrow area for earthfill, the Contractor shall perform a detailed investigation which shall include 1 exploratory pit per 10,000 m² of borrow area. Depth of the pit shall be about 8m. Samples shall be taken every 1.5 m and subjected to the following laboratory tests in the contractor's laboratory:

- natural moisture content
- Atterberg limits
- grading and hydrometer
- standard compaction test

The pits shall be logged as instructed by the Engineer and results shall be submitted to the Engineer.

4.14.2 Submittals

The earthfill borrow area planned exploitation shall be submitted to the Engineer one month before starting excavations in the borrow area.

4.14.3 Miscellaneous

- No borrow area shall be opened at less than 300 m from the upstream dam toe.
- The maximum slope of excavations in the borrow area located within the reservoir shall be 2.5 H to 1 V.

4.15 Roads

4.15.1 General

The Contractor shall construct and maintain the permanent roads comprising the embankment crest road, the access roads on the gravel surfacing on platforms and backfill as shown on the drawings. These permanent access roads are used by the Contractor for access during construction. The Contractor shall reinstate to the satisfaction of the Engineer gravel surfacing to the thickness grade and crossfall as shown on the drawings.

4.15.2 Subbase

The sub base material for access road shall be approved material compacted to 150 mm thickness at 95% of modified Proctor maximum density.

The sub base material shall comply with the following grading requirement:

- - 100% by weight passing 50 mm sieve (square mesh),
- - 75-85% by weight passing 20mm sieve (square mesh),
- - 40-50% by weight passing 5 mm sieve (square mesh).

Before placing the sub base, the foundation shall be scarified and recompacted.

4.15.3 Gravel Surfacing

The gravel surfacing for access roads, embankment crest road, backfill and platforms protection shall be 200 mm average thickness of approved gravel rolled to a smooth even surface.

The term “gravel” used shall be any such material which might be specified for use as a wearing course, e.g. murram, some forms of partly decomposed rock or crushed rock.

Gravel surfacing material shall be spread in a uniform layer across the full width required, spread so that the maximum size of any particle is not greater than one half the compacted thickness of the layer. It shall then be mixed, watered if directed by the Engineer, graded and compacted by at least 6 complete passes of a 10 tonne smooth wheeled roller or other equivalent and graded to final level.

The tolerances on level permitted in the final surface of the wearing course will be:

	Variations permitted		Camber
	Thickness	3 m straight edge	
Gravel wearing Course	25 mm	25 mm	25 mm

4.16 Trench Excavations

4.16.1 Timbering of Excavations

The Contractor shall supply and fix outside the limits of the permanent Works all the timber necessary for support of sides and bottoms of the excavations, for the security of adjacent structures and properties and for every other purpose for which it may be required, all to the satisfaction of the Engineer. The Contractor shall maintain such supports until in the opinion of the Engineer, the works is sufficiently advanced to permit the withdrawal of the support. Such withdrawal shall be executed only under the personal supervision of a competent foreman.

The Engineer may order excavations to be timbered or to be close timbered or may order timbering to be driven ahead of the excavation, or may order the adoption of any other method of supporting the sides and bottoms of the excavations as may appear to be necessary, and the Contractor shall adopt and shall make no charge for executing the adopted method.

The Contractor shall be responsible for any injury to the workers and any consequential damage caused by or arising out of the insufficiency or the support he provides for his excavations or caused by or arising out of the removal of that support, and any advice, permission, approval or instruction given by the Engineer relative to that support or removal thereof shall not relieve the Contractor of his responsibility.

For the purpose of this Clause the words “timber” and “timbering” shall be construed to include trench sheeting and steel or concrete sheet piling or any other means adopted by the Contractor for supporting excavations. All the costs for compliance with the provisions of this clause shall be deemed to have been included in the Contractor’s rate for excavation

4.17 Excavation to be Kept Free from Water

Where excavations are required below the existing water level, the Contractor shall make arrangements to keep the excavation dry and shall produce drawings and written explanations of the method to be used to enable the Engineer to determine the adequacy of the method, before commencing the excavation.

The Contractor shall give due regard to the possibility of floods and provide all pumps, timbering, coffer dams, sheet piling and other equipment necessary for keeping the excavations free from water.

Every precaution shall be taken not to diminish the bearing capacity of the soil below foundation level. Wall-points or pump pits are to be outside the foundation area to prevent flows in upward direction.

All sumps and drains are to be filled in or otherwise made good as directed by the Engineer on completion of the relevant part of the Works.

The costs of all the above precautions shall be at the contractor’s expense.

4.18 Excavation in Hard Material

Where hard material is encountered in trenches for pipe lines it shall be excavated so that no hard material protrudes within 100mm of the pipe surface. A regulating layer of 150mm sand or other approved material shall be placed on the excavated hard material surface to provide a firm but flexible bed for the pipe.

The Contractor shall notify the Engineer on each occasion when he encounters hard material prior to excavation of such materials. No payment for excavation in hard material shall be made unless the Engineer has inspected the excavation and certified in writing that the material meets the classification of hard material and the quantities involved.

The Contractor shall trim all rock faces in cutting to accord with the dimensions shown on the drawings and upon completion leave them safe from rock falls to the satisfaction of the Engineer.

The Contractor’s blasting and other operations in excavation shall be such that they will yield as much suitable material as possible for the construction.

4.19 Foundation for Structures

4.19.1 Soft material:

The bottom and side slope of soft material upon or against which concrete is to be placed shall be finished accurately to the established lines and grades, and loose materials on surfaces so prepared shall be moistened with water and tamped or rolled with suitable tools and equipment to form a firm foundation for the concrete structure. If, at any point in Soft material, material is excavated beyond the established excavation lines, for any reason except by written orders from the Engineer, then the over-excavation resulting voids shall be filled with concrete class 15 at the Contractor's expense.

4.19.2 Hard Materials:

The bottom and side slopes of hard material upon or against which concrete is to be placed shall be excavated to the required dimensions as shown on the drawings or established by the Engineer. No material will be permitted to extend within the neat lines of the structure. If, at any point in the hard material, material is excavated beyond the limits required to receive the structure, the additional excavation shall be filled solidly with concrete class 15.

All loose material shall be removed by the use of steel brooms and air jets.

4.20 Trench Excavations

The width of the trench to be excavated will depend on the size and type of pipe being laid. Sufficient width must be excavated to allow the pipe to be correctly bedded and aligned, and to allow for the joints to be correctly made. Generally, the grade of the pipe will conform to the lie of the ground, but the excavation must be deepened where necessary to avoid backfills in any section. Generally, the pipeline will slope down towards scour valves and up towards air valves. Minimum gradients are shown on the general drawings.

Width of excavations for trenches for all pipes shall be determined from the following formula

$$W=nD + (n-1)0.3 + 0.6$$

Where:

W= width of the trench to be excavated

n =number of pipes

D = external diameter of the pipe

Trench excavation shall be carried out with great care, true to line and gradient and as near as practicable to the size required for construction of the permanent work.

Excavation for pipe trenches shall be of sufficient depth to give a minimum cover of 900 mm over the top of the pipe and 1.2 below the road crossings.

Where the pipeline is required to be laid at depth, which does not satisfy the minimum cover conditions set out above, the ground surface shall be brought up to the required level by banking the backfill or as directed by the Engineer.

4.20.1 Backfilling with Excavated Suitable Material

No backfilling or refilling shall commence without the Engineer's approval.

The refilling of excavations shall commence as soon as practicable after the permanent works have been tested where so required and inspected and approved by the Engineer. In particular, the backfilling of trenches shall be carried out expeditiously to reduce lengths of trenches open at any one time.

As soon as High Density Polythene pipes are laid and jointed in their final positions they should be protected from possible damage by carefully backfilling of fine granular material brought up to about 150 mm over the top of the pipe, for the full width of the trench, and well compacted.

Joints must be left open for inspection until the pressure test is completed.

Backfilling shall be executed with suitable excavated material in 150 mm layers each layer being well rammed and watered to obtain the maximum compaction. Care shall be taken to ensure that no stone or other material, which could damage pipes or other work.

Water in excess shall not be used in settling of the backfilling.

Backfilling over steel pipes shall be generally as described above, except that the initial protective filling around the pipe is not necessary.

Regardless of the means of backfilling adopted, it is the Contractor's responsibility to ensure that he satisfactorily backfills all excavations and causes no damage to permanent work or adjacent structures, and he shall at his own expense take all steps necessary to comply with this obligation.

The Contractor shall at all times be responsible for damage caused to permanent works through his backfilling operations or through the premature opening to traffic of a backfilled surface.

The minimum cover, where pipelines cross under roads, shall be 1.2 m to the top of the surrounding concrete, or such cover as may be directed by the road authorities.

Any excavated material stored on site for backfilling or other purposes shall be deposited alongside the excavation at a minimum distance of 0.5 m in such a manner that it will cause no damage and as little inconvenience as possible.

The rate for excavation shall include the costs of complying with the requirements of this clause.

4.21 Backfilling with sand or imported suitable material

Where shown in the drawings or instructed by the engineer, the Contractor shall provide and use approved sand or imported suitable material to backfill around pipes and structures to the thickness instructed by the Engineer. A rate in the Bill of Quantities shall be provided for this item.

4.22 Reinstatement of Surfaces

Generally, all trenches and backfilled excavations shall be reinstated to equal surface as before excavation.

Trenches in any existing road shall be refilled to the level of natural soil below the road with sub-soil in 75 mm layers, each layer being carefully tamped with rammers. The remaining top layers shall be filled to the road surface with materials equal in type, quantity and compaction to materials used for the existing road.

The backfilled trench shall then be left to settle for 30 days. At the expiration of this period the surface shall be made up to level and tamped or rolled to the approval of the Engineer, who will decide on the particular surfacing employed in accordance with the existing surface of the road.

Before expiration of the maintenance period the Contractor shall make good any defaults in reinstatement. The rate for excavation shall include the costs of complying with the requirements of this clause.

4.23 Removal of Surplus Excavated Material

Excavated material, which is not needed either for backfilling trenches or other excavations or otherwise, shall be removed and disposed of to tipping places obtained by the Contractor. All rubbish and waste material shall similarly be removed by the Contractor. All surplus excavated material shall be spread and levelled in the tipping places in accordance with such directions as the Engineer may give, and the Contractor's rates for disposal shall include for the costs of such operations.

The Contractor shall take every practical precaution against causing any nuisance, damage, injury or inconvenience in the handling, stacking, carting or disposal of excavated materials or any other operation matter or thing in connection therewith. No excavated material shall be placed in any position where it may be washed away or may be liable to fall or spread into any private property or across a road or footpath, and should such occur, the Contractor shall forthwith remove the same at his own costs.

Should the Engineer direct the Contractor to tip certain surplus excavated materials in a particular place (other than the tipping places obtained by the Contractor) the Contractor shall abide by such instruction and shall make no charge in consequence thereof unless the place specified entails a longer haul than what would be incurred by tipping at the place or places obtained by the Contractor.

The rate for excavation shall include the costs of complying with the requirements of this clause.

4.24 Borrow Pits

No borrow pits will be allowed to be opened within the site of permanent works without the approval of the Engineer.

No separate payment will be made for acquisition, development and operating borrow sites whatsoever as the same is deemed to have been included in the Contractors rates.

All borrow sites will have to comply with national and local laws and regulations governing operations of such borrow sites. The Engineer reserves the right to

order closure and reinstatement of any borrow site that might prove harmful to the public.

4.25 Rock Fill Below Structures

Where shown in the drawings or instructed by the Engineer, the Contractor shall provide and place rockfill below structures. Rockfill shall consist of clean hard broken stone or rubble with measurements not exceeding 150 mm in any one direction with sufficient lateritic gravel added to fill the interstices. The Rockfill shall be well-packed, rammed and where possible rolled with a 5-ton roller. Where rolling is impossible, compaction shall be by hand or by mechanical tampers. Before any concrete is laid on Rockfill, the rockfill shall be levelled and blinded with fine stone chippings, rolled and watered as necessary. The volume of rockfill shall be measured after compaction. A rate in the Bill of Quantities shall be provided for this item.

4.26 Grass Planting and Top Soil

Top soil shall be selected vegetable soil, well compacted and except where otherwise specified be of 150 mm thickness.

The Contractor shall trim the faces of the side slopes to open channels and elsewhere where directed to the dimensions, inclinations and curves shown on the Drawings, remove all excess material and make good all depressions with suitable material.

Where instructed by the Engineer, the Contractor shall plant locally available species of grass or as approved by the Engineer at the rate of 16 plants per m² corresponding to 250 mm c/c. The Engineer shall satisfy himself that natural growth of grass will not take place within a reasonable time before instructing the Contractor to grass specified areas.

The Contractor shall be responsible for obtaining suitable grass plants and for making all necessary arrangements with the owners and/or occupiers of the land from which they are to be obtained. The Contractor shall be responsible for the preparation of the surface for planting, and for maintaining adequate grass cover and necessary watering during the Contract and Maintenance Period.

The Contractor shall be required to rehabilitate all spoil areas at his own cost to the satisfaction of the Engineer.

A rate in the Bill of Quantities shall be provided for this item.

4.27 Ant-Proofing

Where an ant-proof course has been specified or instructed by the engineer, it should be made by application of Rentokil Termite Soil Concentrate or equal diluted one part concentrate to forty parts water (by weight) at the rate of 5 litres solution to 1 square meter to the whole area of the structure immediately before (36 hours maximum) the concrete is poured. Additionally, to all critical areas, i.e. both sides of wall foundations, piers and porches the application should be 5 litres per running metre. Treatment should not be made when the soil is excessively wet. Precautions should be taken to prevent disturbance of the treated areas before they are covered.

4.28 Stone Pitching

Where shown on the Drawings. Or directed by the Engineer the Contractor shall excavate for, trim to line and level, provide and lay stone pitching.

Stone pitching shall be formed of hard stone, roughly dressed square.

The least dimension of any stone shall not be less than 200 mm, and the volume not less than 0.01 m³. No rounded boulders shall be used.

The stones shall be set on edge and securely bedded with the largest dimensions at right angles to the flow of water, fitted closely together so as to leave only a minimum of voids between the stones which shall be filled in with suitably shaped and tightly wedged spalls. The top of the pitching shall be finished flush with the adjacent material.

Where grout is specified, a 1:4 cement: sand mortar shall be rammed into the wetted interstices and smoothed off flush with the pitched face.

4.29 Gabions

Where shown on the Drawings or directed by the Engineer the Contractor shall excavate for, trim to line and level, provide and erect gabions including providing selected rock, crushed if necessary, packed and compacted inside the gabions.

Gabions shall include gabion mattresses and gabion boxes and for the purposes of construction and method of measurement and payment no distinction shall be made between them.

Gabions shall be "Maccaferri" boxes and/or "Reno" mattresses both with diaphragms at 1 metre centres, or similar approved. The maximum mesh size shall be 100 mm x 120 mm for boxes and 60 mm x 80 mm for mattresses. The wire used for the construction of gabions shall unless otherwise instructed by the Engineer comply with the requirements of Table 4-1.

TABLE 4 - 1

		Diameter (mm)	Galvanising (g/m ²)
Mesh	Box Mattress	3.4	275
		2.7	260
Binder	Box Mattress	2.2	240
		2.2	240
Selvedge	Box Mattress	3 .9	290
		3.4	275

All wire shall be to BS 1052 having a tensile strength of not less than 40kg/mm²

Galvanizing shall comply with the requirements of BS 443.

Gabions shall be constructed to the shapes and dimensions as shown on the Drawings or given in the Special Specification or as directed by the Engineer. Gabions, as constructed shall be within a tolerance of +/- 5% on the height or width instructed and +/-3% on the length instructed.

The alignment of the gabion shall be correct within a tolerance of 100mm of the instructed alignment and the level of any course of gabion shall be correct to within a tolerance of 50mm of the instructed level. In addition, adjacent gabions shall not vary by more than 25mm in line and/or level from each other

The surface upon which gabions are to be laid shall be compacted to a minimum dry density of 95% MDD (AASHTO T99) and trimmed to the specified level or shape.

Joints in gabions shall be stitched together with 600mm minimum lengths of binder wire, with at least one stitch per 50mm, and each end of the wire shall be fixed with at least two turns upon itself.

Adjacent gabions shall be stitched together with binder wire along all touching edges.

Gabion boxes shall be laid with broken bond throughout to avoid continuous joints both horizontally and vertically. Pre-tensioning of gabions shall be subject to the approval of the Engineer.

Gabions shall be hand packed with broken rock of 150 mm minimum dimension and 300mm maximum dimension. The sides shall be packed first in the form of a wall, using the largest pieces, with the majority placed as headers with broken joints to present a neat outside face. The interior of the gabion shall be hand packed with smaller pieces and the top layers shall be finished off with larger pieces. The whole interior and to layers shall be packed tight and hammered into place.

Where instructed by the Engineer the Contractor shall place filter fabric ('Terram' or similar approved) behind gabion faces in contact with existing or backfilled ground. The Contractor shall ensure that the filter fabric is not damaged during the construction or backfilling around the gabion works and any damaged or torn fabric shall be replaced at the Contractor's expense. The filter fabric shall be installed in accordance with the manufacturer's instructions and the filter fabric shall not be left exposed to sunlight for more than 3 weeks.

At the back face and ends of completed gabion work or where shown on the Drawings or instructed by the Engineer the existing soil shall be backfilled, thoroughly compacted against the sides of the gabions and finished flush with the top surface of the gabion.

On completion of gabion construction, the exposed joints shall be painted with thick bitumen to the approval of the Engineer to discourage vandalism

4.30 Measurement and Payments

a. Clause 5.21 & 5.23: Excavation in Soft material

I) Excavation for trenches in Soft Material

Unit: m³

Excavation for trenches in soft material shall be measured in cubic meters calculated as the product of the width of the excavation given in clause 4.6 of this specification and the sectional area. The sectional area of the excavation, measured in square meters shall be calculated by the product of the average depth of the excavation and the instructed length of the trench. The average depth shall be measured from the instructed final profile.

The rate for excavation in trenches in soft material shall include for the cost of excavation to any depth, trimming and levelling, backfilling with excavated material or removal excavated material to spoil if it is unsuitable or surplus to requirements, and complying with the requirements of clauses 5.21, 5.22, 5.23, 5.25, 5.26, 5.28 and 5.29 of this specification.

II) Excavation for Structures in Soft Material

Unit: m³

Excavation for structure in soft material shall be measured by the cubic meter, calculated as the product of the net plan area of the foundation to be excavated and the average depth of the excavation. No allowance will be made for working space. The average depth shall be calculated as the difference between the original ground level as agreed in clause 1.26 of this specification between the engineer and the contractor, and the required level.

The rate for excavation for Structure in soft material shall include for the cost of excavation to any depth, Compaction of the foundation level of the excavation, backfilling with excavated material or removing the excavated material to spoil if it is unsuitable or surplus to requirements, and complying with the requirements of clauses 5.22, 5.24, 5.26, 5.28 and 5.29 of this specification.

b. Clause 5.23: Excavation in Hard Material

Unit: m³

Hard material encountered in any excavation shall be measured by the cubic meter, calculated as the product of the average end area measured at intervals agreed with the engineer along the centreline of the excavation. No allowance will be made for working space.

The rate for excavation in hard material shall include for the cost of excavation to any depth, Compaction of the foundation level of the excavation or trimming and levelling, backfilling with excavated material or removing the excavated material to spoil if it is unsuitable or surplus to requirements, and complying with the requirements of clauses 5.23, 5.24, 5.25, 5.26, 5.27, 5.28 and 5.29 of this specification.

c. Clause 5.26 Backfilling with sand or imported suitable material.

Unit m³

Sand or imported suitable material shall be measured by the cubic meter, calculated as the product of the average end area (excluding any pipe or concrete surround) and the length of the suitable backfill material instructed to be placed.

The rate for suitable backfill material shall include for the cost of providing the material, backfilling at any depth, all the hauls as necessary and complying with the requirements of clauses 5.26 and 5.27 of this specification.

d. Clause 5.30: Rock fill below Structures

Unit: m³

Hard-core filling shall be measured by cubic metre calculated as plan area and average depth of hard-core fill instructed.

The rate for hard-core filling shall include for the cost of providing, placing the material, compacting, all the hauls as necessary and complying with the requirements of clauses 5.30 of this specification.

e. Clause 5.31 Grass planting and top soil placing

Unit: m²

Grass planting and top soil placing shall be measured as **plan area** in square meters instructed.

The rate for grass planting and top soil placing shall include for the cost of providing grass and suitable top soil, placing, planting, watering, all the hauls as necessary and complying with the requirements of clauses 5.31 of this specification

f. Clause 5.32 Ant Proofing

Unit: m²

Ant proofing shall be measured as **plan area** in square meters instructed.

The rate for ant proofing shall include for the cost of providing, placing, and complying with the requirements of clauses 5.32 of this specification

g. Clause 5.33 Item: Stone pitching

Unit: m²

Stone pitching shall be measured by the. square metre calculated as the net area, measured on the slope, instructed by the Engineer.

The rate for stone pitching shall include for the cost of excavating, trimming to line and level, grouting. providing and laying the stone and of complying with the requirements of clause 5.33 of this specification. Grouting of stone pitching shall include for providing the sand, cement, mortar, wetting of the stone to be grouted, ramming the grout into the interstices and smoothing off: flush with the pitched face and complying with Clause 5.33 of this Specification.

h. Clause 5.34 Item: Gabion Boxes

Unit: No.

Gabion boxes shall be measured by the Numbers calculated as the net area of material required to construct the gabions, including diaphragms.

The rate for gabion mesh shall include for

- a. the cost of providing and fixing the mesh and the cost of complying with requirements of Clause 5.34 of this Specification.
- b. the cost of excavation to any depth, compaction of the surfaces to receive the gabions, backfilling with the excavated material or removing the excavated material to spoil if surplus to requirements, and complying with the requirements of other Clauses in section 4 of this Specification.
- c. the cost of providing, hauling and placing the rock and the cost of complying with the requirements of Clause 5.34 of this Specification.

i. Item: Filter fabric under and/or behind gabions

Unit: m² of each weight a fabric specified

The filter fabric placed under and/or behind gabions shall be measured as the net area of filter fabric instructed.

The rate for filter fabric shall include for the cost of the preparation of the surface to receive the filter fabric, the provision, transport, storing and laying the fabric in accordance with the manufacturer's instructions, all laps and/or stitching and for complying with the requirements of Clause 5.34 of this Specification.

5 CONCRETE WORKS

5.1 General

All materials and workmanship for concrete shall comply with BS 8110 and BS 8007 where applicable.

This section covers the materials, design of mixes, mixing, transport, placing, compaction and curing of concrete and mortar required in the works. It also covers formwork and reinforcement for concrete.

5.2 Definitions

Structural concrete is any class of concrete which is used in reinforced, prestressed or unreinforced concrete construction, which is subject to stress.

Non-structural concrete is composed of materials complying with the Specification but for which no strength requirements are specified and which is used only for filling voids, blinding foundations and similar purposes where it is not subjected to significant stress.

A **formed surface** is a face which has been cast against formwork.

An **unformed surface** is a horizontal or nearly horizontal surface produced by screeding or trowelling to the level and finish required.

A **pour** refers to the operation of placing concrete into any mould, bay or formwork, etc., and also to the volume which has to be filled. Pours in vertical succession are referred to as lifts.

5.3 Materials for Concrete

5.3.1 (a) General

The Contractor shall submit to the Engineer full details of all materials which he proposes to use for making concrete. No concrete shall be placed in the works until the Engineer has approved the materials of which it is composed. Approved materials shall not thereafter be altered or substituted by other materials without the consent of the Engineer.

5.3.2 (b) Cement

Cement shall comply with the following Kenya Standards: -

- KS1725:2001 CEM 1 42.5N for Ordinary Portland Cement.
- KS02-21 for Rapid Hardening Portland Cement plus all special conditions to its use stipulated by the manufacturer

Cement shall be free flowing and free of lumps. It shall be supplied in the manufacturer's sealed unbroken bags or in bulk. Bagged cement shall be transported in vehicles provided with effective means of ensuring that it is protected from the weather.

Bulk Cement shall be transported in vehicles or in containers built and equipped for the purpose.

Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well-ventilated at all times. The floor shall be raised above the surrounding ground level and shall be so constructed that no moisture rises through it.

Each delivery of cement in bags shall be stacked together in one place. The bags shall be closely stacked so as to reduce air circulation but shall not be stacked against an outside wall. If pallets are used, they shall be constructed so that bags are not damaged during handling and stacking. No stack of cement bags shall exceed 3 m in height. Different types of cement in bags shall be clearly distinguished by visible markings and shall be stored in separate stacks.

Cement from broken bags shall not be used in the Works.

Cement in bags shall be used in the order in which it is delivered.

Bulk cement shall be stored in weatherproof silos which shall bear a clear indication of the type of cement contained in them. Different types of cement shall not be mixed in the same silo.

The Contractor shall provide sufficient storage capacity on site to ensure that his anticipated programme or work is not interrupted due to lack of cement.

Cement which has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the Site.

All cement for any one structure shall be from the same source.

All cement used in the works shall be tested by the manufacturer or the Contractor in a laboratory acceptable to the Engineer. The tests to be performed shall be those set out in Section 2 of this Specification and the Contractor shall supply two copies of each certificate to the Engineer.

Each set of tests carried out by the manufacturer or Contractor shall relate to not more than one day's output of each cement plant, and shall be made on samples taken from cement which is subsequently delivered to the Site. Alternatively, subject to the agreement of the Engineer, the frequency of testing shall be one set of tests for every 200 tonnes of cement delivered to Site from each cement plant.

Cement which is stored on Site for longer than one month shall be re-tested in the laboratory of the Materials Branch of the Ministry of Transport and Communications or at the Kenya Bureau of Standards at the rate instructed by the Engineer.

Cement which does not comply with the Specification shall not be used in Works and it shall be disposed of by the Contractor.

The Contractor shall keep full records of all data relevant to the manufacture, delivery, testing and use of all cement used in the Works and shall provide the Engineer with two copies thereof.

5.3.3 (c) Fine aggregate

Fine aggregate shall be clean hard and durable and shall be natural sand, crushed gravel sand or crushed rock sand complying with BS 882. All the material shall pass through a 5 mm BS sieve and the grading shall be in accordance with Zones

1, 2 or 3 of BS 892. In order to achieve an acceptable grading, it may be necessary to blend materials from more than one source. Fine aggregate for mortar only shall comply with BS 1200.

The fine aggregate shall not contain iron pyrites or iron oxides. It shall not contain mica, shale, coal or other laminar, soft or porous materials or organic matter unless the Contractor can show by comparative tests, on finished concrete as set out in BS 1891, that the presence of such materials does not adversely affect the properties of the concrete.

Other properties shall be as set out below:

Content passing a 75 micron BS sieve shall not exceed 3 per cent for natural or crushed gravel sand or 15 per cent for crushed rock sand.

Chlorides soluble in a 10 per cent solution by weight of nitric acid shall not exceed 0.05 per cent by weight expressed as chloride ion when tested as set out in BS 812, subject also to the further restriction given in the note on total chloride content in Sub-Clause 5.3 (d).

Sulphates soluble in a 10 per cent solution by weight of hydrochloric acid shall not exceed 0.4 per cent by weight expressed as SO₃, when tested as set out in BS 1377, subject also to the further restriction given in the note on total sulphate content in Sub-Clause 5.3.4 (d).

Soundness: After five cycles of the test in AASHTO T104 the aggregate shall not show a weight loss of more than 10 per cent.

Organic impurities: If the test described in Section 2 of this standard Specification shows that more than a trace of organic impurities is present, the fine aggregate shall not be used in the Works unless the Contractor can show by tests on finished concrete as set out in BS 1881 that the presence of organic impurities does not adversely affect the properties of the concrete.

5.3.4 (d) Coarse Aggregate

Coarse aggregate shall be clean hard and durable crushed rock, crushed gravel or natural gravel complying with the requirements of BS 882. The material shall not contain any iron pyrites, iron oxides, flaky or laminated material, hollow shells, coal or other soft or porous material, or organic matter unless the contractor can show by comparative tests on finished concrete as set out in BS 1881 that the presence of such material does not adversely affect the properties of the concrete. The pieces shall be angular rounded or irregular as defined in BS 812 Part 1.

Coarse aggregate shall be supplied in the nominal sizes called for in the contract and shall be graded in accordance with BS 882 for each nominal size.

Other properties shall be as set out below: -

The proportion of clay, silt and other impurities passing a 75 micron BS sieve shall be not more than one per cent by weight.

The content of hollow and flat shells shall not be such as will adversely affect the concrete quality when tested as set out in BS 1881. The total shell content of aggregate shall not be more than the following:

40 mm nominal size and above	2% of dry weight
20 mm nominal size	5% of dry weight
10 mm nominal size	15% of dry weight

Chlorides soluble in a 10 per cent solution by weight of nitric acid shall not exceed 0.03 per cent by weight, expressed as chloride ion when tested as set out in BS 812 but subject also to the further restriction under the note on total chloride content hereunder. Sulphates soluble in a 10 per cent solution by weight of hydrochloric acid shall not exceed 0.4 per cent by weight expressed as SO₃ when tested as set out in BS 1377 subject also to the further restriction given in the note on total sulphate content hereunder.

Soundness: After 5 cycles of the test in AASHTO T104, the aggregate shall not show a weight loss of more than 12 per cent.

When tested in accordance with test C289 of the American Society for Testing and Materials, the aggregate shall be non-reactive.

Flakiness Index when tested in accordance with BS 812 shall be as set out hereunder: -

For 40 mm stone and above, not more than 40

For 20 mm stone and below, not more than 35

5.3.5 (e) Testing aggregates

(i) Acceptance testing

The Contractor shall deliver to the Engineer samples containing not less than 50 kg of any aggregate which he proposes to use in the Works and shall supply such further samples as the Engineer may require. Each sample shall be clearly labelled to show its origin and shall be accompanied by all the information called for in BS 882.

Tests to determine compliance of the aggregates with the requirements of Sub-Clause 5.3 (c) and (d) shall be carried out by the Contractor in a laboratory acceptable to the Engineer. If the tested materials fail to comply with the Specification, further tests shall be made in the presence of the Contractor and the Engineer and acceptance of the material shall be based on such tests.

A material shall be accepted if not less than three consecutive sets of test results show compliance with the Specification.

(ii) Compliance testing

The Contractor shall carry out routine testing of aggregates for compliance with the Specification during the period that concrete is being produced for the Works. The tests set out below shall be performed on aggregates from each separate source on the basis of one set of tests for each day on which aggregates are delivered to Site provided that no set of tests shall represent more than 250 tonnes of fine aggregate nor more than 500 tonnes of coarse aggregate, and provided also

that the aggregates are of uniform quality. If the aggregate from any source is variable, the frequency of testing shall be increased as instructed by the Engineer.

Grading	BS 812
Silt and clay contents	BS 812
Moisture content	BS 812
Check on organic impurities	As directed by the Engineer

In addition to the above routine tests, the Contractor shall carry out the following tests at the frequencies stated:

- (i) Moisture content: as frequently as may be required in order to control the water content of the concrete as required by the Specification.
- (ii) Chloride content: as frequently as may be required to ensure that the proportion of chlorides in the aggregates does not exceed the limit stated in the Specification.

The Contractor shall take account of the fact that when the chloride content is variable it may be necessary to test every load in order to prevent excessive amounts of the chloride contaminating the concrete. For this purpose, the Contractor shall use the rapid field test (Quantab test). In the event of disagreement regarding the results of the field test, the chloride content of the aggregate shall be determined in the laboratory as described in BS 812 (Volhard test).

5.3.6 (f) Delivery and storage of aggregates

Aggregates shall be delivered to Site in clean and suitable vehicles. Different types or sizes of aggregate shall not be delivered in one vehicle.

Each type or size of aggregate shall be stored in a separate bin or compartment having a base such that the contamination of aggregate is prevented. Dividing walls between bins shall be substantial and continuous so that no mixing of types or sizes occurs.

The storage of aggregates shall be arranged so that as far as possible rapid drying out in hot weather is prevented in order to avoid sudden fluctuations in water content. Storage of fine aggregates shall be arranged so that they can drain sufficiently before use in order to prevent fluctuations in water content of the concrete.

5.3.7 (g) Water for concrete and mortar

Seawater or brackish water containing more than 1000 ppm chloride ion or 2000 ppm sulphate ion shall not be used for mixing or curing concrete.

Water shall be clean and free from harmful matter and comply with the requirements of BS 3149.

The Contractor shall carry out tests in accordance with BS 3148 to establish compliance with the Specification.

5.3.8 (h) Admixtures

(i) General

The use of the admixtures in concrete may be required under the Contract to promote special properties in the finished concrete or may be proposed by the Contractor to assist him in compliance with the Specification.

In all cases the Contractor shall submit to the Engineer full details of the admixture he proposes to use and the manner in which he proposes to add it to the mix. The information provided shall include: -

- (a) The typical dosage, the method of dosing and the detrimental effects of an excess or deficiency in the dosage.
- (b) The chemical names of the main active ingredients in the admixture.
- (c) Whether or not the admixture contains chlorides, and if so the chloride ion content expressed as a Percentage by weight of admixture.
- (d) Whether the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage and if so, the extent to which it does so.
- (e) Details of previous uses of the admixture in Kenya.

The chloride ion content of any admixture shall not exceed 2 per cent by weight of the admixture nor 0.03 per cent by weight of the cement in the mix.

Admixtures shall not be mixed together without the consent of the Engineer.

Calcium chloride or admixtures containing calcium chloride shall not be used in prestressed concrete.

(ii) Workability agents

Workability agents shall comply with BS 5075 and shall not have any adverse effect on the properties of the concrete.

5.4 The Design of Concrete Mixes

5.4.1 Classes of concrete

The classes of structural concrete to be used in the Works shall be those shown on the Drawings and designated in Table 5-1, in which the class designation includes two figures. The first figure is the nominal strength at 28 days expressed in N/mm² and the second figure is the maximum nominal size of aggregate in the mix expressed in millimeters.

TABLE 5-1 Concrete Classes and Strengths

Class of concrete	Nominal strength N/mm ²	Maximum Nominal Size of	Maximum water/cement ratio	Trial mixes Target	Early works test cubes
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		aggregate mm	A	B	Mean Strength N/mm ²	Any one cube N/mm ²	Average of an group of cubes N/mm ²
10/75	10	75	0.60	0.55	13.5	9.5	13.3
15/75	15	75	0.60	0.50	21.5	12.8	20.0
15/40	15	40	0.60	0.50	21.5	12.8	20.0
15/20	15	20	0.57	0.50	21.5	12.8	20.0
20/40	20	40	0.57	0.48	31.5	17.0	27.5
20/20	20	20	0.55	0.48	31.5	17.0	27.5
20/10	20	10	0.53	0.48	31.5	17.0	27.5
25/40	25	40	0.50	0.46	36.5	21.3	32.5
25/20	25	20	0.52	0.46	36.5	21.3	32.5
25/10	25	10	0.50	0.46	36.5	21.3	32.5
30/40	30	40	0.48	0.45	41.5	25.5	37.5
30/20	30	20	0.48	0.45	41.5	25.5	37.5
30/10	30	10	0.47	0.45	41.5	25.5	37.5
40/20	40	20	0.46	0.43	51.5	34.0	47.5
40/10	40	10	0.45	0.43	51.5	34.0	47.5

NOTE: Under water/cement ratio, column A applies to moderate and intermediate exposure, and column B applies to severe exposure. See NOTE after Table 5-2.

5.4.2 Design of proposed mixes

The contractor shall design all the concrete mixes called for on the Drawings, making use of the ingredients which have been approved by the Engineer for use in the works and in compliance with the following requirements: -

- (i) The aggregate portion shall be well graded from the nominal maximum size of stone down to the 150-micron size.
- (iii) The cement content shall be such as to achieve the strengths called for in Table 5-1 but in any case not less than the minimum necessary for impermeability and durability shown in Table 5-2.

(iii) The workability shall be consistent with ease of placing and proper compaction having regard to the presence of reinforcement and other obstructions.

(iv) The water/cement ratio shall be the minimum consistent with adequate workability but in any case not greater than that shown in Table 5-1 taking due account of any water contained in the aggregates. The Contractor shall take into account that this requirement may in certain cases require the inclusion of a workability agent in the mix.

(v) The drying shrinkage determined in accordance with BS 1881 shall not be greater than 0.05 per cent.

Table 5-2 Minimum Cement Content

Class of Concrete	Minimum Cement Content - Kg/ m ³ of Compacted concrete		
	Moderate Exposure	Intermediate Exposure	Severe Exposure
10/75; 15/75	200	220	270
15/40, 20/40, 25/40, 30/40	240	270	290
15/20, 20/20, 25/20, 30/20	260	300	330
40/20	300	320	330
20/10, 25/10, 30/10	300	340	390
40/10	310	340	390

NOTE: the minimum cement contents shown in the above table are required in order to achieve impermeability and durability. In order to meet the strength requirements in the Specification higher contents may be required.

The categories applicable to the Works are based broadly on the factors listed hereunder:

Moderate exposure	Surface sheltered from severe rain; buried concrete, concrete continuously under water
Intermediate exposure	Surface exposed to driving rain; alternate wetting and drying; traffic; corrosive fumes; heavy condensation.
Severe exposure	Surface exposed to sea water, moorland water having a pH of 4.5 or less, Groundwater containing sulphates.

5.4.3 Cyclopean Concrete

Cyclopean concrete shall be constructed with a mixture of a 60% plain concrete and 40% large stones (variable size between 10 and 25 centimeters). The plain concrete to be used in this job shall have a minimum resistance of 180 kg/cm² on the 28th day and the materials should be saturated before creating the mixture. Stony materials will comply with the ASTM standard and dosage will be according to concrete design.

In the first step, the contractor shall apply a plain concrete layer of 15 centimeter depth and subsequently a layer of stone shall be placed manually on top. The spaces between the stones will not be less than 5 centimeters in any of the rows and from structure edges. The next step is to place another layer of plain concrete and the same procedure is followed until the desired height is reached.

5.4.4 Trial mixes

At least six weeks before commencing placement of concrete in the Permanent works trial mixes shall be prepared for each class of concrete specified.

For each mix of concrete for which the Contractor has proposed a design, he shall prepare three separate batches of concrete using the materials which have been approved for use in the Works and the mixing plant which he proposes to use for the works. The volume of each batch shall be the capacity of the concrete mixer proposed for full production.

Samples shall be taken from each batch and the following action taken, all in accordance with BS 1881: -

- (i) The slump of the concrete shall be determined.
- (ii) Six test cubes shall be cast from each batch. In the case of concrete having a maximum aggregate size of 40 mm or less, 150 mm cubes shall be used. In the case of concrete containing 75 mm or larger aggregate, 200 mm cubes shall be used and in addition any pieces of aggregate retained on a 53 mm BS sieve shall be removed from the mixed concrete before casting the cubes.
- (iii) Three cubes from each batch shall be tested for compressive strength at seven days and the remaining three at 28 days.
- (iv) The density of all the cubes shall be determined before the strength tests are carried out.

Subject to the agreement of the Engineer, the compacting factor apparatus may be used in place of a slump cone. In this case the correlation between slump and compacting factor shall be established during preparation of the trial mixes.

The average strength of the nine cubes tested at 28 days shall be not less than the target mean strength shown in Table 5-1.

The Contractor shall also carry out tests to determine the drying shrinkage of the concrete unless otherwise directed by the Engineer.

Based on the results of the tests on the trial mixes, the Contractor shall submit full details of his proposals for mix design to the Engineer, including the type and source of each ingredient, the proposed proportions of each mix and the results of the tests on the trial mixes.

If the Engineer does not agree to a proposed concrete mix for any reason, the Contractor shall amend his proposals and carry out further trial mixes. No mix shall be used in the works without the written consent of the Engineer.

5.4.5 Quality control of concrete production

(i) Sampling

For each class of concrete in production at each plant for use in the works, samples of concrete shall be taken at the point of mixing and/or of deposition as instructed by the Engineer, all in accordance with the sampling procedures described in BS 1881 and with the further requirements set out below.

Six 150 mm or 200 mm cubes as appropriate shall be made from each sample and shall be cured and tested all in accordance with BS 1881, two at seven days and the other four at 28 days.

Each sample shall be taken from one batch selected at random and at intervals such that each sample represents not more than 20 m³ of concrete unless the Engineer agrees to sampling at less frequent intervals.

Until compliance with the Specification has been established the frequency of sampling shall be three times that stated above or such lower frequency as may be instructed by the Engineer.

(ii) Testing

- (a) The slump or compacting factor of the concrete shall be determined for each batch from which samples are taken and in addition for other batches at the frequency instructed by the Engineer.

The slump of the concrete in any batch shall not differ from the value established by the trial mixes by more than 25 mm or one third of the value, whichever is the greater.

The variation in value of the compacting factor, if used in place of a slump value, shall be within the following limits:

For value of 0.9 or more	± 0.03
For value of between 0.8 and 0.9	± 0.04
For values of 0.8 or less	± 0.05

- (b) The water/cement ratio as estimated from the results of (a) above, determined by samples from any batch shall not vary by more than five per cent from the value established during the trial mixes.
- (c) The air content of air entrained concrete in any batch shall be within 1.5 units of the required value and the average value of four consecutive measurements shall be within 1.0 unit of the required value, expressed as a percentage of the volume of freshly mixed concrete.
- (d) Until such time as sufficient test results are available to apply the method of control described in (e) below, the compressive strength of the concrete at 28 days shall be such that no single result is less than the value shown in Table 5-

1 under the heading 'early works test cubes' and also that the average value of any four consecutive results is not less than the value shown in Table 5-1 under the same heading.

The 7-day cube result may be used as an early strength indicator, at the discretion of the Engineer.

When test cube results are available for at least 20 consecutive batches of any class of concrete mixed in any one plant, the average of any four consecutive results at 28 days shall exceed the nominal strength by not less than half the current margin (see table below) and each individual result shall not be less than 85 per cent of the nominal strength.

The current margin shall be defined as 1.64 times the standard deviation of cube tests on at least 20 separate consecutive batches produced from one plant over a period exceeding five days but not exceeding six months or on at least 50 separate consecutive batches produced from one plant over a period not exceeding 12 months. If both figures are available, the smaller shall be taken.

The current margin shall in any case at be less than the figure given below: -

	Minimum current margin for		
	10N/mm ²	15N/mm ²	20N/mm ² and above
After 20 batches	3.3	5	7.5
After 50 batches	1.7	2.5	3.8

(e) Failure to comply with requirements

If any one test cube result in a group of four consecutive results is less than 85 per cent of the nominal strength but the average of the group of which it is part satisfies the strength requirement, then only the batch from which the failed cube was taken shall be deemed not to comply with the Specification.

If more than one cube result in a group of four consecutive results is less than 85 per cent of the nominal strength or if the average strength of the group of which it is part fails to satisfy the strength requirement then all the batches between those represented by the first and last cubes in the group shall be deemed not to comply with the Specification, and the Contractor shall immediately adjust the mix design subject to the agreement of the Engineer to restore compliance with the Specification.

After adjustment of the mix design the Contractor will again be required to comply with sub-(clauses 5.4 (b) and 5.4 (c) of this Section of this Specification.

The Contractor shall take necessary action to remedy concrete which does not comply with this Specification. Such action may include but is not necessarily confined to the following: -

- (i) Increasing the frequency of sampling until control is again established.
- (ii) Cutting test cores from the concrete and testing in accordance with BS 1881.
- (iii) carrying out strengthening or other remedial work to the concrete where possible or appropriate.
- (iv) carrying out non-destructive testing such as load tests on beams
- (v) removing the concrete

5.5 Mixing Concrete

Before any plant for batching, mixing, transporting, placing, compacting and finishing concrete is ordered or delivered to site, the Contractor shall submit to the Engineer full details including drawings of all the plant which he proposes to use and arrangements he proposes to make.

Concrete for the works shall be batched and mixed in one or more central plants unless the Engineer agrees to some other arrangement. If the Contractor proposes to use ready mixed concrete, he shall submit to the Engineer for his approval full details and test results of the concrete mixes. The Engineer may approve the use of ready mixed concrete provided that:

- a. The proposed mixes, the material to be used and the method of storage and mixing comply with the requirements of the specification; and
- b. Adequate control is exercised during mixing.

Approval to the use of ready mixed concrete may be withdrawn if the Engineer is not satisfied with the control of the materials being used and control during mixing.

Batching and mixing plants shall be modern efficient equipment complying with the requirements of BS 1305 and capable of producing a uniform distribution of the ingredients throughout the mass. Truck mixes shall comply with the requirements of BS 4251 and shall only be used with prior arrangement with the engineer. If the plant proposed by the contractor does not fall within the scope of BS1305, it shall have been tested in accordance with BS 3963 and shall have a mixing performance within the limits of Table 6 of BS 1305.

All mixing operations shall be under the control of an experienced supervisor.

The aggregate storage bins shall be provided with drainage facilities arranged so that drainage water is not discharged to the weigh hoppers. Each bin shall be drawn down at least once per week and any accumulations of mud or silt removed.

Cement and aggregates shall be batched by weight. Water may be measured by weight or volume.

The weighing and water dispensing mechanisms shall be maintained in good order. Their accuracy shall be maintained within the tolerances described in BS

1305 and checked against accurate weights and volumes when required by the Engineer.

The weights of cement and of each size of aggregate as indicated by the mechanisms employed shall be within a tolerance of plus or minus two per cent of the respective weight per batch agreed by the Engineer.

The Contractor shall provide standard test weights at least equivalent to the maximum working load used on the most heavily loaded scale and other auxiliary equipment required for checking the satisfactory operation of each scale or other measuring device. Tests shall be made by the Contractor at least once a week or at intervals to be determined by the Engineer and shall be carried out in his presence. For the purpose of carrying out these tests, there shall be easy access for personnel to the weigh hoppers. The Contractor shall furnish the Engineer with copies of the complete results of all check tests and shall make any adjustments, repairs or replacements necessary to ensure satisfactory performance.

The nominal drum or pan capacity of the mixer shall not be exceeded. The turning speed and the mixing time shall be as recommended by the manufacturer, but in addition, when water is the last ingredient to be added, mixing shall continue for at least one minute after all the water has been added to the drum or pan.

The blades of pan mixers shall be maintained within the tolerances specified by the manufacturer of the mixer and the blades shall be replaced when it is no longer possible to maintain the tolerances by adjustment.

Mixers shall be fitted with an automatic recorder registering the number of batches discharged.

The water to be added to the mix shall be reduced by the amount of free water contained in the coarse and fine aggregates. This amount shall be determined by the Contractor by a method agreed by the Engineer immediately before mixing begins each day and thereafter at least once per hour during concreting and for each delivery of aggregates during concreting. When the correct quantity of water, determined as set out in the Specification, has been added to the mix, no further water shall be added, either during mixing or subsequently.

After mixing for the required time, each batch shall be discharged completely from the mixer before any materials for the succeeding batch are introduced.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed and thereafter the first batch of concrete through the mixers shall contain only half the normal quantity of coarse aggregate. This batch shall be mixed for one minute longer than the time applicable to a normal batch.

Mixers shall be cleaned out before changing to another type of cement.

5.6 Hand Mixed Concrete

Concrete for structural purposes shall not be mixed by hand. Where non-structural concrete is required, hand mixing may be carried out subject to the agreement of the Engineer.

The mixing shall be done on a hard impermeable surface. The materials shall be turned over not less than three times dry, water shall then be sprayed on and the materials again turned over not less than three times in a wet condition and worked together until a mixture of uniform consistency is obtained.

For hand mixed concrete the specified quantities of cement shall be increased by 10% and not more than 0.5 cubic metres shall be mixed at one time. During windy weather efficient precautions shall be taken to prevent cement from being blown away during the process of gauging and mixing.

5.7 Transport of Concrete

The concrete shall be discharged from the mixer and transported to the Works by means which shall prevent adulteration, segregation or loss of ingredients, and which shall ensure that the concrete is of the required workability at the point and time of placing. The loss of slump between discharge from the mixer and placing shall not exceed 25 mm.

The time elapsing between mixing and placing a batch of concrete shall be as short as practicable as and in any case not longer than will permit completion of placing and compaction before the onset of initial set. If the placing of any batch of concrete is delayed beyond this period, the concrete shall not be placed in the Works.

5.8 Placing of Concrete

5.8.1 Consent for placing

Concrete shall not be placed in any part of the Works until the Engineer's consent has been given in writing, and the contractor shall give the Engineer at least 1 full working days' notice of his intention to place concrete.

If concrete placing is not commenced within 24 hours of the Engineer's consent the Contractor shall again request consent as specified above.

5.8.2 Preparation of surface to receive concrete

Excavated surfaces on which concrete is to be deposited shall be prepared as set out in Section 4 of this Specification.

Existing concrete surfaces shall be prepared as set out in (clause 5.19. Before deposition of further concrete, they shall be clean, hard and sound and shall be wet but without any free-standing water.

Any flow of water into an excavation shall be diverted through proper side drains to a sump, or be removed by other suitable methods which will prevent washing

away the freshly deposited concrete or any of its constituents. Any underdrains constructed for this purpose shall be completely grouted up when they are no longer required by a method agreed by the Engineer.

Unless otherwise instructed by the Engineer surfaces against which concrete is to be placed shall receive a prior coating or mortar mixed in the proportions similar to those of the fines portion in the concrete to be placed. The mortar shall be kept ahead of the concrete. The mortar shall be well worked into all parts of the excavated surface and shall be not less than 5 mm thick.

If any fissures have been cleaned out as described in Section 4 of this Specification they shall be filled with mortar or with concrete as instructed by the Engineer.

The amount of mortar placed at any one time shall be limited so that it does not dry out or set before being covered with concrete.

5.8.3 Placing procedures

The concrete shall be deposited as nearly as possible in its final position. It shall be placed so as to avoid segregation of the concrete and displacement of the reinforcement, other embedded items, or formwork. It shall be brought up in layers approximately parallel to the construction joint planes and not exceeding 500 mm in compacted thickness unless otherwise permitted or directed by the Engineer, but the layers shall not be thinner than four times the maximum nominal size of aggregate.

Layers shall not be placed so that they form feather edges nor shall they be placed on a previous layer which has taken its initial set. In order to comply with this requirement, a layer may be started before completion of the preceding layer.

All the concrete in a single bay or pour shall be placed as a continuous operation. It shall be carefully worked round all obstructions, irregularities in the foundations and the like so that all parts are completely full of compacted concrete with no segregation or honeycombing. It shall also be carefully worked round and between waterstops, reinforcement, embedded steelwork and similar items which protrude above the surface of the completed pour.

All work shall be completed on each batch of concrete before its initial set commences and thereafter the concrete shall not be disturbed before it has set hard. No concrete that has partially hardened during transit shall be used in the Works and the transport of concrete from the mixer to the point of placing shall be such that this requirement can be complied with.

Concrete shall not be placed during rain which is sufficiently heavy or prolonged to wash mortar from coarse aggregate on the exposed faces of fresh concrete. Means shall be provided to remove any water accumulating on the surface of the placed concrete. Concrete shall not be deposited into such accumulations of water.

In dry weather, covers shall be provided for all fresh concrete surfaces which are not being worked on. Water shall not be added to concrete for any reason.

When concrete is discharged above its place of final deposition, segregation shall be prevented by the use of chutes, downpipes, trunking, baffles or other appropriate devices.

Forms for walls, columns and other than sections of significant height shall be provided with openings or other devices that will permit the concrete to be placed in a manner that will prevent segregation and accumulations of hardened concrete on the formwork or reinforcement above the level of the placed concrete.

When it is necessary to place concrete under water the contractor shall submit to the Engineer his proposals for the method and equipment to be employed. The concrete shall be deposited either by bottom-discharging watertight containers or through funnel-shaped tremies which are kept continuously full with concrete up to a level above the water and which shall have the discharging bottom fitted with a trapdoor and immersed in the concrete in order to reduce to a minimum the contact of the concrete with the water. Special care shall be taken to avoid segregation.

If the level of concrete in a tremie pipe is allowed to fall to such an extent that water enters the pipe, the latter shall be removed from the pour and filled with concrete before being again lowered into the placing position.

During and after concreting under water, pumping or de-watering in the immediate vicinity shall be suspended if there is any danger that such work will disturb the freshly placed concrete.

5.8.4 Interruptions to placing

If concrete placing is interrupted for any reason and the duration of the interruption cannot be forecast or is likely to be prolonged, the Contractor shall immediately take the necessary action to form a construction joint so as to eliminate as far as possible feather edges and sloping top surfaces and shall thoroughly compact the concrete already placed in accordance with (Clause 5.09. All work on the concrete shall be completed while it is still plastic and it shall not thereafter be disturbed until it is hard enough to resist damage. Plant and materials to comply with this requirement shall be readily available at all times during concrete placing.

Before concreting is resumed after such an interruption the Contractor shall cut out and remove all damaged or uncompacted concrete, feather edges or any other undesirable features and shall leave a clean sound surface against which the fresh concrete may be placed.

If it becomes possible to resume concrete placing without contravening the Specification and the Engineer consents to resumption, the new concrete shall be thoroughly worked in and compacted against the existing concrete so as to eliminate any cold joints.

5.8.5 Dimensions of pours

Unless otherwise agreed by the Engineer, pours shall not be more than two metres high and shall as far as possible have a uniform thickness over the plan area of the pour. Concrete shall be placed to the full planned height of all pours except during the use of Concrete pump or placers..

The Contractor shall plan the dimensions and sequence of pours in such a way that cracking of the concrete does not take place due to thermal or shrinkage stresses.

5.8.6 Placing sequence

The Contractor shall arrange that as far as possible the intervals between placing successive. Lifts of concrete in one section of the Works are of equal duration. This duration shall normally be not less than three or more than seven days under temperate weather conditions unless otherwise agreed by the Engineer.

Where required by the Engineer to limit the opening of construction joints due to shrinkage, concrete shall not be placed against adjacent concrete which is less than 21 days old.

When the drawings call for contraction gaps in concrete, these shall be of the widths and in the locations shown on the Drawings and they shall not be filled until the full time interval shown on the Drawings has elapsed.

5.9 Compaction of Concrete

The concrete shall be fully compacted throughout the full extent of the placed layer. It shall be thoroughly worked against the formwork and around any reinforcement and other embedded items, without displacing them. Particular care shall be taken at arises and other confined spaces. Successive layers of the same pour shall be thoroughly worked together.

Concrete shall be compacted with the assistance if mechanical immersion vibrators, unless the Engineer agrees another method.

Immersion vibrators shall operate at the frequency of between 7,000 and 10,000 cycles per minute. The contractor shall ensure that vibrators are operated at beginning pressures and voltages not less than those recommended by the manufacturer in order that the compactive effort is not reduced.

A sufficient number of vibrators shall be operated to the entire quantity of concrete being placed to be vibrated for the necessary period and, in addition stand-by vibrators shall be available for instant use at each place where concrete is being placed.

Where the concrete contains aggregate with a nominal size of 75mm or more, vibrators with a diameter of 100 mm or more shall be used.

Vibration shall be continued at each point until, the concrete ceases to contract, a thin layer of mortar has appeared on the surface and air bubbles have ceases to

appear. Vibrators shall not be used to move concrete laterally and shall be withdrawn slowly to prevent the formation of voids.

Vibration shall not be applied by way of reinforcement nor shall vibrators be allowed to touch reinforcement or other embedded items. The vibrators shall be inserted vertically into the concrete to penetrate the layer underneath at regular spacing which shall not exceed the distance from the vibrator over which vibration is visibly effective.

5.10 Curing of Concrete

(a) General

Concrete shall be protected during the first stage of hardening from loss of moisture and from the development of temperature differentials within the concrete sufficient to cause cracking. The methods used of curing shall not cause damage of any kind to the concrete.

Curing shall be continued for as long as may be necessary to achieve the above objectives but in any case for at least seven days or until the concrete is covered by later construction whichever is the shorter period.

The above objectives are dealt with in sub-(clauses 5.10 (b) and (c) but nothing shall prevent both objectives being achieved by a single method where circumstances permit.

The curing process shall commence as soon as the concrete is hard enough to resist damage from the process, and in the case of large areas or continuous pours, shall commence on the completed section of the pour before the rest of the pour is finished.

Details of the Contractor's proposals for curing concrete shall be submitted to the Engineer before the placing of concrete Commences in the Works.

(b) Loss of moisture

Exposed concrete surfaces shall be closely covered with impermeable sheeting, properly secured to prevent its removal by wind and the development of air spaces beneath it. Joints in the sheeting shall be lapped by at least 300 mm.

If for some reason it is not possible to use impermeable sheeting, the Contractor shall keep the exposed surfaces continuously wet by means of a water spray or by covering with a water absorbent material which is kept wet, unless this method conflicts with sub-clause 5.10 (c).

Water used for curing shall be of the same quality as that used for mixing.

Formed surfaces may be cured by retaining the formwork in place for the required curing period.

If the use of the foregoing methods is inappropriate, surfaces which will not have further concrete bonded to them and which are not to receive an application of a finish may be cured by the application of a curing compound having an efficiency index of at least 90 per cent. Curing compounds shall contain a fugitive dye to enable the extent of the spread to be seen easily.

Curing compound used on surfaces exposed to the sky shall contain sufficient finely divided flake aluminum in suspension to produce a complete coverage of the surface with a metallic finish when applied at the rate recommended by the manufacturer.

Curing compounds shall become stable and impervious to the evaporation of water from the concrete surface within 60 minutes of application. The material shall not react chemically with the concrete and shall not crack, peel or disintegrate within three weeks after application.

If instructed by the Engineer, the Contractor shall, in addition to the curing provisions set out above provide a suitable form of shading to prevent the direct rays of the sun reaching the concrete surfaces for at least the first four days of the curing period.

(c) Limitation of temperature differentials

The Contractor shall limit the development of temperature differentials in concrete after placing by any means appropriate to the circumstances including the following:

- (i) Limiting concrete temperatures at placing as set out in sub-clause 5.12.2 (b);
- (ii) Use of low heat cement, subject to the agreement of the Engineer;
- (iii) Insulation of exposed concrete surfaces by insulating blankets. Such blankets shall have an insulation value at least equivalent to 50 mm of dry mineral wool;
- (iv) leaving formwork in place during the curing period. Steel forms shall be suitably insulated on the outside;
- (v) preventing rapid dissipation of heat from surfaces by shielding from wind;
- (vi) Avoiding the use of water sprays when such use would cause rapid cooling of the surface.

5.11 Protection of Fresh Concrete

Freshly placed concrete shall be protected from rainfall and from water running over the surface until it is sufficiently hard to resist damage from these causes.

No traffic shall be allowed on any concrete surface until such time as it is hard enough to resist damage by such traffic.

Concrete placed in the works shall not be subjected to any loading until it has attained at least its nominal strength as defined under the Clause Design of the Concrete Mix (Clause 5.4).

If the Contractor desire to impose loads on newly-placed concrete, he shall make at least three test cubes and cure them in the same conditions as the concrete they represent. These cubes shall be tested singly at suitable intervals in order to estimate the time at which the nominal strength is reached.

5.12 Concreting in Hot Weather

5.12.1 (a) General

The Contractor shall prevent damage to concrete arising from Exposure to extreme temperatures, and shall maintain in good working order all plant and equipment required for this purpose.

In the event that conditions become such that even with the use of the equipment the requirements cannot be met, concrete placing shall immediately cease until such time as the Requirements can again be met.

5.12.2 (b) Concrete placing in hot weather

During hot weather the contractor shall take all measures necessary to ensure that the temperature of concrete at the time of placing in the works does not exceed 30°C and that the concrete does not lose any moisture during transporting and placing.

Such measures may include but are not necessarily limited to the following: -

- (i) Shielding aggregates from direct sunshine.
- (ii) Use of a mist water spray on aggregates.
- (iii) Sun shields on mixing plants and transporting equipment.
- (iv) Cooling the mixing water. If ice is used for this purpose it should preferably be in flake form. Lump ice shall not be allowed to enter the tank supplying the mixer drum.
- (v) Covering skips closely with polythene sheet so that the latter is in contact with the concrete.

Areas in which concrete is to be placed shall be shielded from direct sunshine and rock or concrete surfaces shall be thoroughly wetted to reduce absorption of water from the concrete placed on or against them.

After concrete in any part of an area has been placed, the selected curing process shall be commenced as soon as possible. If any interval occurs between completion of placing and start of curing, the concrete shall be closely covered during the interval with polythene sheet to prevent loss of moisture.

5.13 Finishes On Unformed Surfaces

Horizontal or nearly horizontal surfaces which are not cast against formwork shall be finished to the class shown on the Drawings and defined hereunder.

5.13.1 UF 1 finish

All surfaces on which no higher class of finish is called for on the Drawings or instructed by the Engineer shall be given an UF 1 finish.

The concrete shall be leveled and screeded to produce a uniform plain or ridged surface, surplus concrete being struck off by a straight edge immediately after compaction.

5.13.2 UF 2 finish

This is a floated finish for roof or floor slabs and other surfaces where a hard trowelled surface is not required.

The surface shall first be treated as a Class UF 1 finish and after the concrete has hardened sufficiently, it shall be floated by hand or machine sufficient only to produce a uniform surface free from screed marks.

5.13.3 UF 3 finish

This is a hard trowelled surface for use where weather resistance or appearance is important, or which is subject to high velocity water flow.

The surface shall be floated as for a UF 2 finish but to the tolerance stated below. When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, it shall be steel-trowelled under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

Table 5-3 Surface Tolerances

Class of Finish	Tolerance in mm. see notes		
	A	B	C
UF 1	Not applicable	10	+ 20 or - 10
UF 2	Nil	10	+ 20 or - 10
UF 3	Nil	5	+ 12.5 or - 7.5

Notes:

1. Col A is the maximum allowable value of any sudden change of level in the surface.

2. Col B is the maximum allowable value of any gradual irregularity of the surface, as indicated by the gap between the surface and a three-metre-long straight edge or correctly shaped template placed on the surface.
3. Col C is the maximum allowable value of the difference in level or position between a three-metre-long straight edge or correctly shaped template placed on the surface and the specified level or position of that surface.
4. Where dimensional tolerances given on the Drawings or in this Special Specification they shall take precedence over those given in Table 5-3.

5.14 Mortar

This clause covers mortar for use ahead of concrete placing, and other uses not covered elsewhere in the Specification.

Mortar shall be composed of fine aggregate complying with sub-Clause 5.3 (c) and Ordinary Portland Cement complying with KS02-21. The mix proportions shall be as stated on the Drawings or elsewhere in this Specification or if not stated shall be one part of cement to two parts of fine aggregate by weight.

Small quantities of mortar may be hand mixed but for amounts over 0.5 m³ a mechanical mixer shall be used.

The water content of the mortar shall be as low as possible consistent with the use for which it is required but in any case the water/cement ratio shall not be more than 0.5.

Mortar which is specified as 'dry pack' shall be mixed with sufficient water for the mix to become cohesive but not plastic when squeezed in the hand. Dry pack mortar shall be rammed into the cavity it is required to fill, using a hand rammer with sufficient force to ensure full compaction.

5.15 Concrete for Secondary Purposes

- (a) **Non-structural concrete (NS concrete)** shall be used only for non-structural purposes where shown on the Drawings.

NS concrete shall be composed of Ordinary Portland Cement complying with KS02-21 and aggregates complying with BS 862 including all-in aggregate within the grading limits of Table 3 of BS 682.

The weight of cement mixed with 0.3 m³ metres of combined or all-in aggregate shall not be less than 50 kg. The mix shall be proportioned by weight or by volume. The maximum aggregate size shall be 40 mm nominal.

The concrete shall be mixed by machine or by hand to a uniform colour and consistency before placing. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted where required.

The concrete shall be compacted by hand or by mechanical vibration.

- (b) **No Fines concrete (NF concrete)** is intended for use where a porous concrete is required and shall only be used where shown on the Drawings or instructed by the Engineer.

The mix shall consist of Ordinary Portland Cement complying with KS02-21 and aggregate complying with BS 882. The aggregate size shall be 40.0 mm to 10.0 mm only. The weight of cement mixed with 0.3 m³ metre of aggregate shall not be less than 50 kg. The quantity of water shall not exceed that required to produce a smooth cement paste which will coat evenly the whole of the aggregate.

5.16 Records of Concrete Placing

Records, in a form agreed by the Engineer, shall be kept by the Contractor of the details of every pour of concrete placed in the works. These records shall include class of concrete, location of pour, date of pour, ambient temperature and concrete temperature at time of placing, moisture contents of aggregates, details of mixes, batch numbers, cement batch number, results of all tests undertaken, location of test cube sample points and details of any cores taken.

The Contractor shall supply to the Engineer four copies of these records each week covering work carried out the preceding week. In addition, he shall supply to the Engineer monthly histograms of all 28-day cube strengths together with accumulative and monthly standard deviations and any other information which the Engineer may require concerning the concrete placed in the works.

5.17 Construction Joints

Whenever concrete is to be bonded to other concrete which has hardened, the surface of contact between the sections shall be deemed a construction joint.

Where construction joints are shown on the Drawings, the Contractor shall form such joints in those positions. The location of joints which the Contractor requires to make for the purpose of construction shall be subject to the agreement of the Engineer. Construction joints shall be in vertical or horizontal planes except in sloping slabs where they shall be normal to the exposed surface or elsewhere where the Drawings require a different arrangement.

Construction joints shall be so arranged as to reduce to a minimum the effects of shrinkage in the concrete after placing, and shall be placed in the most advantageous positions with regard to stresses in the structures and the desirability of staggering joints.

Feather edges of concrete at joints shall be avoided and any feather edges which may have formed where reinforcing bars project through a joint shall be cut back until sound concrete has been reached.

The intersections of horizontal or near horizontal joints and exposed faces of concrete shall appear as straight lines produced by use of a guide strip fixed to the

formwork at the top of the concrete lift, or by other means acceptable to the Engineer.

Construction joints formed as free surfaces shall not exceed a slope of 20 per cent from the horizontal.

The surface of the fresh concrete in horizontal or near horizontal joints shall be thoroughly cleaned and roughened by means of high pressure water and air jets when the concrete is hard enough to withstand the treatment without the leaching of cement. The surface of vertical or near vertical joints shall be similarly treated if circumstances permit the removal of formwork at a suitable time.

Where concrete has become too hard for the above treatment to be successful, the surface whether formed or free is to be thoroughly scrubbed by mechanical means or wet sand blasted and then washed with clean water. The indentations produced by scrubbing shall be not less than 10 mm deep and shall not extend closer than 40 mm to a finished face.

If instructed by the Engineer the surface of the concrete shall be thoroughly brushed with a thin layer of mortar composed of one part of cement to two parts of sand by weight and complying with Clause 5.4 all as set out in Sub-Clause 5.9.2 (b) immediately prior to the deposition of fresh concrete. The mortar shall be kept just ahead of the fresh concrete being placed and the fresh layer of concrete shall be thoroughly and systematically vibrated to full depth to ensure complete bond with the adjacent layer.

No mortar or concrete may be placed in position on or against a construction joint until the joint has been inspected and passed by the Engineer.

5.18 Expansion and Contraction Joints

Expansion and contraction joints are discontinuities in concrete designed to allow for thermal or other movements in the concrete.

Expansion joints are formed with a gap between the concrete faces to permit subsequent expansion of the concrete. Contraction joints are formed to permit initial contraction of the concrete and may include provision for subsequent filling.

Expansion and contraction joints shall be formed in the positions and in accordance with the details shown on the Drawings or elsewhere in the Specifications.

5.19 Waterstops

All references to waterstops include grout stops.

Waterstops shall be of the material and form shown on the Drawings. No water-stop material shall be brought onto site until the Contractor has submitted full details of the materials he proposes to use, including samples, and these have been approved by the Engineer. All samples shall be of adequate length for testing.

Waterstops shall be made of material which are resistant to chlorides, sulphates, or other deleterious substances which may be present in the environment of the Works.

Rubber waterstops may be of natural or synthetic rubber and shall have an elongation at breaking stress of at least 500 per cent at 25°C and shall allow a joint movement of at least 50 mm.

Polyvinyl chloride (PVC) waterstops shall be extruded from unfilled plasticised PVC polymer or copolymer which does not contain any reclaimed or scrap PVC. PVC waterstops shall have an elongation at breaking stress of at least 225 per cent at 25°C and shall allow a joint movement of at least 10 mm.

Low modulus waterstops shall be of rubber or PVC as described above but shall have an elongation of at least 200 per cent at 25°C under a tensile stress of 6 N/mm² and shall allow a joint movement of at least 50 mm.

Waterstops shall be supplied in lengths as long as possible consistent with ease of handling and construction requirements.

In rubber or plastic materials joints other than butt joints shall be supplied ready made by the manufacturer. Butt joints shall be made on site in accordance with the manufacturer's instructions and with equipment supplied for the purpose by the manufacturer.

Waterstop material shall be stored carefully on Site to avoid damage and contamination with oil, grease, or other pollutants. Rubber and plastic waterstops shall be stored in cool well ventilated places away from direct sunlight.

Rubber and plastic waterstops which are embedded in one side of a joint more than one month before the scheduled date of placing concrete on the other side shall be protected from the sun.

Waterstops shall be firmly fixed in the formwork so that they cannot be displaced during concrete placing and shall be completely free of all dirt, grease, oil, etc. before placing concrete. Where eyelets are provided these shall be fully wired to the reinforcement and this will be the only means whereby the waterstop is fixed. In no circumstances shall a waterstop be punctured with nails etc. as a means of fixing.

Concrete shall be placed carefully round waterstops so as to avoid distortion or displacement and shall be fully compacted. Where waterstops lie in a horizontal or nearly horizontal plane the Contractor shall ensure that no voids are left on the underside of the waterstop.

Formwork round waterstops shall be carefully removed to avoid damage. If waterstops suffer any damage which cannot be properly repaired in situ the Engineer may require a section of concrete to be removed and the waterstop replaced.

5.20 Grouting of Pockets and Holes and Underpinning of Base plates

Pockets and holding-down bolt holes shall be thoroughly cleaned out using compressed air and water jet. Holes drilled by a diamond bit shall be roughened. The pockets and holes shall be filled with grout consisting of cement and clean fresh water mixed in proportion of two parts by weight of cement to one part by weight of water. The pouring of liquid grout shall cease as soon as each hole is filled and any excess grout on the surface of the concrete foundation shall be completely removed and the surface dried off before the next operation proceeds.

The space between the top surface of foundation concrete and the underside of base plates shall be filled with a special mortar made up in the following proportions: -

Portland cement... .50 kg

Fine aggregate . . 50 kg

An additive acceptable to the Engineer to counteract shrinkage in proportions recommended by the manufacturer

The special mortar shall be mixed with -the lowest water-cement ratio which will result in a consistency of mix of sufficient workability to enable maximum compaction to be achieved.

The special mortar shall then be well rammed in horizontally below the baseplate and from one edge only until it is extruded from the other three sides. The mortar which has extruded shall then be rammed back to ensure complete support without voids.

5.21 Formwork for Concrete

Definitions

Formwork means the surface against which concrete is placed to form a face, together with all the immediate supports to retain it in position while concrete is placed.

Falsework means the structural elements supporting both the formwork and the concrete until the concrete becomes self-supporting.

A **formed face** is one which has been cast against formwork.

An **exposed face** is one which will remain visible when construction has been completed.

Slip forming or **slipform** construction is a construction method in which concrete is poured into a continuously moving formwork. Slipforming enables continuous, non-interrupted, cast-in-place (i.e. minimum joints) concrete structures for superior performance characteristics to piecewise construction using discrete form elements. Slip forming relies on the quick-setting properties of

concrete, and requires a balance between quick-setting capacity and workability. This method shall be used for the construction of the Concrete face of the dam.

5.22 Construction of Formwork and Falsework

Before construction begins, the Contractor shall submit to the Engineer drawings showing details of the proposed formwork and falsework.

Formwork and falsework shall be so constructed that they will support the loads imposed on them by the fresh concrete together with additional stresses imposed by vibrating equipment and by construction traffic, so that after the concrete has hardened the formed faces shall be in the positions shown on the Drawings within the tolerances set out in Clause 5.26.

Ground supports shall be properly founded on footings designed to prevent settlement.

Joints in formwork for exposed faces shall, unless otherwise specified, be evenly spaced and horizontal or vertical and shall be continuous or form a regular pattern.

All joints in formwork including formwork for construction joints shall be tight against the escape of cement and fines. Where reinforcement projects through formwork, the form shall fit closely round the bars.

Formwork shall be so designed that it may be easily removed from the work without damage to the faces of the concrete. It shall also incorporate provisions for making minor adjustments in position, if required, to ensure the correct location of concrete faces. Due allowance shall be made in the position of all formwork for movement and settlement under the weight of fresh concrete.

Where overhangs in formwork occur, means shall be provided to permit the escape of air and to ensure that the space is filled completely with fully compacted concrete.

Formwork shall be provided for concrete surfaces at slopes of 30° to the horizontal or steeper. Surfaces at slopes less than 20° may be formed by screeding. Surfaces at slopes between 20° and 30° shall generally be formed unless the Contractor can demonstrate to the satisfaction of the Engineer that such slopes can be screeded with the use of special screed boards to hold the concrete in place during vibration. Horizontal or inclined formwork to the upper surface of concrete shall be adequately secured against uplift due to the pressure of fresh concrete. Formwork to voids within the body of the concrete shall also be tied down or otherwise secured against floating.

The internal and external angles on concrete surfaces shall be formed with fillets and chamfers of the sizes shown on the Drawings unless otherwise instructed by the Engineer.

Supports for formwork may be bolted to previously placed concrete provided the type of bolt used is acceptable to the Engineer. If metal ties through the concrete are used in conjunction with bolts, the metal left in shall not be closer than 50 mm to the face of the Concrete.

Formwork shall not be re-used after it has suffered damage which is sufficient to impair the finished surfaces of the concrete.

Where circumstances prevent easy access within the form for cleaning and inspection, temporary openings for this purpose shall be provided through the formwork.

Shear keys shall be provided in all construction joints of the size and shape indicated on the Drawings.

Where precast concrete elements are specified for use as permanent formwork, or proposed by the Contractor and agreed by the Engineer, they shall comply with the requirements of the Specification. Such elements shall be set true to line and level within the tolerances prescribed for the appropriate class of finish in Clause 5.26 and fixed so that they cannot move when concrete is placed against them.

5.23 Preparation of Formwork

Before any reinforcement is placed into position within formwork, the latter shall be thoroughly cleaned and then dressed with a release agent. The agent shall be either suitable oil incorporating a wetting agent, an emulsion of water suspended in oil or a low viscosity oil containing chemical agents. The contractor shall not use an emulsion of oil suspended in water nor any release agent which causes staining, discoloration of the concrete, air holes on the concrete surface, or retards the rest of the concrete. In order to avoid colour differences on adjacent concrete surfaces, only one type of release agent shall be used in any one section of the works. In cases where it is necessary to fix reinforcement before placing formwork, all surface preparation of formwork shall be carried out before it is placed into position. The Contractor shall not allow reinforcement or prestressing tendons to be contaminated with formwork release agent.

Before placing concrete all dirt, construction debris and other foreign matter shall be removed completely from within the placing area.

Before concrete placing commences, all wedges and other adjusting devices shall be secured against movement during concrete placing and the Contractor shall maintain a watch on the formwork during placing to ensure that no movement occurs.

5.24 Removal of Formwork

Formwork shall be carefully removed without shock or disturbance to the concrete. No formwork shall be removed until the concrete has gained sufficient strength to withstand safely any stresses to which it may thereby be subjected.

The minimum periods which shall elapse between completion of placing concrete and removal of forms are given in Table 5-4 and apply to ambient temperatures higher than 10°C at lower temperatures or if cement other than ordinary Portland are involved, the Engineer may instruct longer periods.

Alternatively, formwork may be removed when the concrete has attained the strength set out in Table 5-4, provided that the attained strength is determined by making test cubes and curing them under the same conditions as the concrete to which they refer.

Compliance with this requirement shall not relieve the Contractor of his obligation to delay removal of formwork until the removal can be completed without damage to the concrete.

Table 5-4 Minimum Periods for Formwork Removal

Position of Formwork	Minimum Period for Temps over 10°C	Strength to be Attained
Vertical or near vertical faces of mass concrete	24 hours	0.2 C
Vertical or near vertical faces of reinforced walls, beams and columns	48 hours	0.3 C
Underside of arches beams and slabs (formwork only)	4 days	0.5 C
Supports to underside of arches, beams and slabs	14 days	C
Arched linings in tunnels and underground works	24 hours	4N/mm ²

NOTE: C is the nominal strength for the class of concrete used.

If the Contractor wishes to strip formwork from the underside of arches beams and slabs before the expiry of the period (or supports set out above), it shall be designed so that it can be removed without disturbing the supports. The Contractor shall not remove supports temporarily for the purpose of stripping formwork and subsequently replace them.

As soon as the formwork has been removed, bolt holes in concrete faces other than construction joints which are not required for subsequent operations shall be completely filled with mortar sufficiently dry to prevent any slumping at the face. The mortar shall be mixed in the same proportions as the fine aggregate and

cement in the surrounding concrete and with the same materials and shall be finished flush with the face of the concrete.

5.25 Slipform for concrete face

For pouring of concrete face slab, slipform shall be used and face slab concrete should be poured in skipping sections. The initial triangle block should be poured together with the main slab.

The Slipform shall be designed according to the following principles:

1. The requirements of slab width and slipform evenness shall be satisfied.
2. Adequate strength and rigidity shall be available
3. Adequate counter weight
4. Requirements of vibration and surface compaction shall be satisfied
5. Flexible and convenient for installation, operation and removal
6. Safety measures shall be provided. Braking device on slipform shall be attached to steel net. If the hoist is used as pulling machine, ground anchor shall be safe and reliable.

Side form for face slab pouring may be wooden form or composite steel form. The height of side form shall be compatible with the thickness of face slab. Its segment length and anchoring method shall be convenient for installation and dismantling on slope surface. If side form plays additional role as slipform support structure, it shall be designed as load bearing structure.

Side form shall be installed firmly and reliably, its inner side surface shall be smooth and even, waterstops shall be fixed in position. Allowable installation tolerances are as follows:

1. Deviation from joint design line is ± 3 mm
2. The verticality is ± 3 mm
3. Height of side form shall meet design requirements

Face slab steel bars should be connected by bundling, welding, machine splicing in situ. Prefabricated bar net may be adopted also for integral assembling; they shall be connected firmly with the supporting bars. Supporting bars on cushion layer shall be set according to design requirements.

Concrete pouring shall comply with the following requirements:

1. Concrete shall be poured uniformly in blocks, and thickness of each layer is 250 mm-300 mm. Concrete around waterstops shall be poured additionally by labor, and segregation is strictly forbidden.
2. Vibrating compaction shall be made in time after pouring. While vibrating, vibrators shall not strike slipform, steel bars and waterstops. Vibrator shall work within scope of slip form; the vertical depth for vibrator being inserted into concrete of lower layer should be 50 mm. Vibrator with 30

mm diameter should be used to carefully vibrate concrete around waters tops.

3. During pouring, concrete adhering to forms and steel bars shall be cleaned in time. Over-poured concrete in the front face must be cleaned prior to each lifting.
4. Concrete surfaces after removal of forms shall be flattened and finished in time. The concrete surface within 1 m from the sides of joint shall be checked with 2 m ruler and unevenness shall not exceed 5 mm.
5. Distance of each lifting shall not exceed 300 mm. Time interval between lifting should not exceed 30 min. Average speed of lifting for face slab pouring should be 1.5 m/h - 2.5 m/h.

5.26 Surface Finishes

Classes of finish

The surface finish to be achieved on formed concrete surfaces shall be as shown on the Drawings and defined hereunder: -

5.26.1 (a) Class F1 finish

This finish is for surfaces against which backfill or further concrete will be placed. Formwork may be sawn boards, sheet metal or any other suitable material which will prevent the loss of fine material from the concrete being placed.

5.26.2 (b) Class F2 finish

This finish is for surfaces which are permanently exposed to view but where the highest standard of finish is not required. Forms to provide a Class F2 finish shall be faced with wrought thicknesses tongued and grooved boards with square edges arranged in a uniform pattern and close jointed or with suitable sheet material. The thickness of boards or sheets shall be such that there shall be no visible deflection under the pressure exerted by the concrete placed against them. Joints between boards or panels shall be horizontal and vertical unless otherwise directed. This finish shall be such as to require no general filling of surface pitting, but fins, surface discolouration and other minor. Defects shall be remedied by methods agreed by the Engineer.

5.26.3 (c) Class F3 finish

This finish is for surfaces which will be in contact with water flowing at high velocity, and for surfaces prominently exposed to view where good appearance is of special importance. To achieve this finish, which shall be free of board marks, the formwork shall be faced with plywood complying with BS 1088 or equivalent material in large sheets. The sheets shall be arranged in an approved uniform pattern. Wherever possible, joints between sheets shall be arranged to coincide with architectural features or changes in direction of the surface.

All joints between panels shall be vertical and. Horizontal unless otherwise directed. Suitable joints shall be provided between sheets to maintain accurate alignment in the plane of the sheets. Unfaced wrought boarding or standard steel panels will not be permitted for Class F3 finish. The Contractor shall ensure that the surface is protected from rust marks, spillages and stains of all kinds.

5.26.4 (d) Curved surfaces

For curved surfaces where F2 or F3 finishes are called for, the formwork face shall be built up of splines cut to make a tight surface which shall then be dressed to produce the required finish.

Alternatively, single curvature surfaces may be faced with plastic or plywood linings attached to the backing with adhesive or with escutcheon pins driven flush. Linings shall not bulge, wrinkle or otherwise deform when subjected to temperature and moisture changes.

5.27 Tolerances

All parts of formed concrete surfaces shall be in the positions shown on the Drawings within the tolerances set out in Table 5-5.

In cases where the Drawings call for tolerances other than those given in Table 5-5 the Drawings shall rule.

Where precast units have been set to a specified tolerance, further adjustments shall be made as necessary to produce a satisfactory straight or curved line. When the Engineer has approved the alignment, the Contractor shall fix the units so that there is no possibility of further movement.

Table 5-5 Tolerances

Class of finish	Tolerances in mm (See Note)		
	A	B	C
F1	10	10	+ 25 to - 10
F2	5	10	+ or - 15
F3	2	5	+ or - 10

Note: The tolerances A, B and C given in the table are defined as follows:

A is an abrupt irregularity in the surface due to misaligned formwork or defects in the face of the formwork.

B is a gradual deviation from a plane surface as indicated by a straight edge 3 m long. In the case of curved surfaces, the straight edge shall be replaced by a correctly shaped template.

C is the amount by which the whole or part of a concrete face is displaced from the correct position shown on the Drawings.

5.28 Remedial Work to Defective Surfaces

If on stripping any Formwork the concrete surface is found to be defective in any way, the Contractor shall make no attempt to remedy such defects prior to the

Engineer's inspection and the receipt of any instructions which the Engineer may give.

Defective surfaces shall not be made good by plastering.

Areas of honeycombing which the Engineer agrees may be repaired shall be cut back to sound concrete or to 75 mm whichever is the greater distance. In the case of reinforced concrete, the area shall be cut back to at least 25 mm clear distance behind the reinforcement or to 75 mm, whichever is the greater distance. The cavity shall have sides at right angles to the face of the concrete after cleaning out with water and compressed air, a thin layer of cement grout shall be brushed on to the concrete surfaces in the cavity and it shall then be filled immediately with concrete of the same class as the main body but with aggregate larger than 20 mm nominal size removed.

A form shall be used against the cavity, provided with a lip to enable concrete to be placed. The form shall be filled to point above the top edge of the cavity.

After seven days the lip of concrete shall be broken off and the surface ground smooth.

Surface irregularities which are outside the limits of tolerance set out in Clause 5.26 shall be ground and in the manner and to the extent instructed by the Engineer.

Defects other than those mentioned above shall be dealt with as instructed by the Engineer. '

5.29 Reinforcement for Concrete

Reinforcement which shall comply with the following British Standards, covers plain and deformed bar reinforcement and steel fabric to be cast into concrete in any part of the works but does not include prestressing tendons or any other embedded steel.

- BS 4449 for hot rolled plain bar and high yield deformed bar
- BS 4482 for hard drawn mild steel wire
- BS 4461 for cold worked steel bar
- BS 4483 for steel mesh fabric

All reinforcement shall be from an approved manufacturer and, if required by the Engineer, the Contractor shall submit a test certificate from the manufacturer.

All reinforcement for use in the Works shall be treated for compliance with the appropriate British Standard in a laboratory acceptable to the Engineer and two copies of each test certificate shall be supplied to the Engineer. The frequency of testing shall be as set out in the British Standard.

In addition to the testing requirements described above, the Contractor shall carry out additional tests as instructed by the Engineer.

Any reinforcement which does not comply with the Specification shall be removed from Site.

5.30 Storage of Reinforcement

All reinforcement shall be delivered to Site either in straight lengths or cut and bent. No reinforcement shall be accepted in long lengths which have been transport bent over double.

Any reinforcement which is likely to remain in storage for a long period shall be protected from the weather so as to avoid corrosion and pitting. All reinforcement which has become corroded or pitted to an extent which, in the opinion of the Engineer, will affect its properties shall either be removed from Site or may be tested for compliance with the appropriate British Standard in accordance with Clause 5.28 of this Specification at the Contactor's expense.

5.31 Bending Reinforcement

Unless otherwise shown on the drawings, bending and cutting shall comply with BS 4466.

The Contractor shall satisfy himself as to the accuracy of any bar bending schedules supplied and shall be responsible for cutting, bending, and fixing the reinforcement in accordance with the Drawings.

Bars shall be bent cold by the application of slow steady pressure. At temperatures below 5°C the rate of bending shall be reduced if necessary to prevent fracture of the steel.

After bending, bars shall be securely tied together in bundles or groups and legibly labelled as set out in BS 4466.

Reinforcement shall be thoroughly cleaned and all dirt, scale, loose rust, oil and other contaminants removed before it is placed in the Works.

5.32 Fixing Reinforcement

Reinforcement shall be securely fixed in position within a dimensional tolerance of 20 mm in any direction parallel to a concrete face and within a tolerance of 5 mm at right angles to a face, provided that the cover is not thereby decreased below the minimum shown on the Drawings, or if not shown shall be not less than 25mm or the diameter of the bar, whichever is the greater. Cover on distribution steel shall not be less than 15mm or the diameter of whichever is the greater.

Unless otherwise agreed by the engineer, all intersecting bars shall either be tied together with 1.6 mm diameter soft annealed iron wire and the ends of the wire turned into the body of the concrete, or shall be secured with a wire clip of a type agreed by the Engineer.

Spacer blocks shall be used for ensuring that the correct cover is maintained on the reinforcement. Blocks shall be as small as practicable and of a shape agreed by the Engineer. They shall be made of mortar mixed in the proportions of one part of cement to two parts of sand. Wires cast into the block for tying in to the reinforcement shall be 1.6 mm diameter soft annealed iron.

Alternatively another type of spacer block may be used subject to the Engineer's agreement.

Reinforcement shall be rigidly fixed so that no movement can occur during concrete placing. Any fixings made to the formwork shall not be within the space to be occupied by the concrete being currently placed.

No splices shall be made in the reinforcement except where shown on the Drawings or agreed by the Engineer. Splice lengths shall be as shown on the Drawings.

Reinforcement shall not be welded except where required by the Contract or agreed by the Engineer. If welding is employed, the procedures shall be as set out in BS2640 for gas welding or BS 5135 for metal arc welding. Full strength butt welds shall only be used for steel complying with BS 4449, and if used on high yield deformed bars complying with BS 4449 the permissible stresses in the vicinity of the weld shall be reduced to those applicable to plain bars complying with that specification.

Mechanical splices shall not be used unless the Engineer agrees otherwise.

The Contractor shall ensure that reinforcement left exposed in the Works shall not suffer distortion, displacement or other damage. When it is necessary to bend protruding reinforcement aside temporarily, the radius of the bend shall not be less than four times the bar diameter for mild steel bars or six times the bar diameter for high yield bars. Such bends shall be carefully straightened before concrete placing continues, without leaving residual kinks or damaging the concrete round them. In no circumstances will heating and bending of high yield bars be permitted.

Bars complying with BS 4461 or other high tensile bars shall not be bent after placing in the Works.

Before concrete is placed in any section of the Works that includes reinforcement, the reinforcement shall be completely clean and free from all contamination including concrete, which may have been deposited on it from previous operations.

5.33 Precast Concrete

Precast concrete covers all precast units for use in the Works, whether instructed under the Contract or proposed by the Contractor, and includes prestressed units where applicable.

5.34 Moulds for Precast Units

Moulds for precast units shall comply with the general requirements of Clauses 5.21 to 5.29.

Moulds shall be so constructed that they do not suffer distortion or dimensional changes during use and are tight against loss of cement grout or fines from the concrete.

Moulds shall be set up on firm foundations so that no settlement occurs under the weight of the fresh concrete.

Moulds shall be constructed so that units may be removed from them without sustaining any damage.

Release agents used for de-moulding shall not stain the concrete or affect its properties in any way.

5.35 Reinforcement for Precast Units

Reinforcement in precast units shall comply with the requirement of Clauses 5.28 to 5.31. When preformed cages are used, the cages shall be made up on jigs to ensure dimensional accuracy and shall be carefully supported within the mould in such a way that they cannot move when concrete is placed. Reinforcement complying with BS 4449 may be tack welded where bars cross to provide rigidity in the cage but reinforcement complying with BS 4461 shall not be welded.

Cover to main reinforcement shall be as shown on the Drawings, or if not shown shall be not less than 25 mm or the diameter of the bar, whichever is the greater. Cover on distribution steel shall not be less than 15 mm or the diameter of the bar whichever is the greater.

Bars shall be spaced so that the minimum clear distance between them is the maximum nominal aggregate size plus five millimeters but in any case not less than the diameter of the bars.

Bars may be placed in pairs provided that there are no laps in the paired lengths.

5.36 Casting of Units

Concrete for precast units shall comply with Clauses 5.03 to 5.09 using the class of concrete specified on the Drawings.

If lightweight aggregates are specified, they shall comply with BS 3797.

The area in which the units are cast shall be adequately protected from weather so that the process is not affected by rain, sun or drying winds.

5.37 Curing Precast Units

Requirements for curing shall be generally as set out in Clause 5.10. The Contractor shall ensure that units do not suffer any loss of moisture or sudden changes of temperature for at least four days after casting. If a water spray is used for curing, the water shall be at a temperature within 5°C of the temperature of the unit being cured.

If the Contractor proposes curing at elevated temperature, the method shall be subject to the agreement of the Engineer and shall include means whereby units' are heated and subsequently cooled evenly without sudden changes of temperature.

5.38 Dimensional Tolerances of Precast Units

Units shall be accurately formed to the dimensions shown on the Drawings and within the tolerances set out in BSCP 110 unless closer tolerances are called for in the Special Specification or on the Drawings

5.39 Surface Finish of Precast Units

The formed faces of precast units shall be finished to Class F3 as set out in Clause 5.25 unless another class of finish is specified on the Drawings.

Free faces shall be finished to Class UF2 unless another class of Finish is specified on the Drawings.

In cases where a special finish is required a trial panel shall be constructed by the Contractor which after approval by the Engineer shall be kept available for inspection at the place of casting and production units shall thereafter match the approved pattern.

Those parts of the unit which are to be joined to other units or to in situ concrete shall be brushed with a stiff brush before the concrete has fully hardened. Alternatively, if the concrete has been allowed to harden, the surfaces shall be roughened by sand blasting or the use of a needle gun.

5.40 Handling and Storage of Precast Units

Precast units shall be handled in a manner which will not cause any kind damage and of shall be stored on a hard impermeable base.

Prestressed units and large precast normally rein forced units shall be handled and stored so that no stresses shall be induced in excess of those which they will incur in their final positions in the Works unless they have been designed to resist such stresses.

Units shall be provided with adequate lifting holes or loops, placed in the locations shown on the Drawings or agreed by the Engineer and they shall be lifted only by such holes or loops. Where it is not possible to provide holes or loops, suitable sling positions shall be indicated in paint on the units.

Units shall be marked indelibly with the reference number and date of casting and shall be stacked on suitable packers which will not damage the concrete or stain the surfaces. Not more than two packers shall be placed under each unit and these shall be located either at

The positions of the permanent support points or in positions such, that the induced stresses in the unit will be a minimum.

5.41 Testing Precast Units

Precast units shall be capable of safely sustaining the load which they have been designed to carry. The Contractor shall subject units selected by the Engineer to load tests simulating the working conditions. Details of such tests shall be agreed between the Engineer and the Contractor.

In the case of units subject to bending loads the test piece shall be supported at full span and a loading equivalent to 1.25 times the sum of the live and dead loads which were assumed in the design shall be maintained for one hour without the appearance of any signs of distress. The recovery one hour after the removal of load shall be not less than 75 per cent of the full load deflection.

If the unit fails to meet the above requirements, further tests shall be carried out on two more units. If either of these fail, the whole batch of units will be rejected.

If the Engineer so requires, a test to destruction shall also be carried out which on unit's subject to bending shall be as follows: -

The units shall be supported at full span and a load applied in increments instructed by the Engineer up to 95 per cent of the designed ultimate load. This load shall be held for 15 minutes without failure of the unit. The deflection at the end of this period shall be not more than 1/40th of the span. The load shall then be further increased until failure occurs.

If the unit fails to sustain the required load for the prescribed period or if the deflection exceeds the specified amount, the Engineer may order two further tests, and if either of these fails, the batch of units which they represent may be rejected.

5.42 Measurement and payment

5.42.1 (a) Item : Concrete

Unit : m³ of each class

Concrete shall be measured by the cubic metre of each class calculated from the dimensions given on the Drawings or instructed by the Engineer. No deduction shall be made in the measurement for:

- (i) bolt holes, pockets, box outs and cast in components provided that the volume of each is less than 0.15 cubic metres;
- (ii) mortar beds, fillets, drips, rebates, recesses, grooves, chamfers and the like of 100 mm total width or less;
- (iii) reinforcement

The rate for concrete shall include for the cost of: -

- (i) Provision and transport of cement aggregates and. water.
- (ii) Admixtures and workability agents including submission of details unless specified.
- (iii) Hatching, mixing, transporting, placing, compacting and curing.
- (iv) Class UF1 finish.
- (v) Laying to sloping outfaces not exceeding 15° from the horizontal and to falls.
- (vi) Formwork to blinding concrete.
- (vii) Placing and compacting against excavated surfaces where required including any additional concrete to fill overbreak or working space.
- (viii) Complying with the requirements of Clauses 7.1 to 7.18 inclusive and Clause 7.27 of this Specification.

5.42.2 (b) Item: Blinding concrete

Unit: m³

Blinding concrete shall be measured by the cubic metre calculated as the product of the plan area of the foundation as shown on the Drawings and the instructed thickness. No deduction shall be made for openings provided that the area of each is less than 0.5 square metres. Blinding concrete over hard material shall be measured as the volume used provided that the maximum thickness of 150 mm allowed for overbreak is not exceeded.

The rate for blinding concrete shall include for all costs itemized in Clause 7.41.1 (a) of this Specification.

5.42.3 (c) Item: No fines concrete.

Unit: m³

No fines concrete shall be measured by the calculated cubic metre from the dimensions given on Drawings or instructed by the Engineer.

The rate for no fines concrete shall include: for all costs stated in Clause 7.41.1 (a) of this Specification.

5.42.4 (d) Item: Unformed surface finishes

Unit m² of each class of finish

Unformed surface finishes shall be measured by the square metre from the dimensions given on the Drawings or instructed by the Engineer.

The rate for concrete in Clause 7.41.1 (a), 7.41.2 (b) and 7.41.3 (c) shall include for class UFI finish.

The rate for unformed surface finishes shall include for the cost of complying with Clause 7.13 of this Specification.

5.42.5 (e) Item: Formed surface finishes

Unit: m² of formed Surface for each class of finish for each range of inclinations.

Except as stated below, formed surfaces shall be measured by the square metre of the finished face of the concrete. No deduction shall be made in the measurement for openings, pipes, ducts and the like, provided that the area of each is less than 0.50 square metres.

Formed Surfaces less than 300 mm high to edges of slabs shall be measured by the linear metre in accordance with Clause 7.41.6 (f) of this Specification.

Formed Surfaces required for blinding concrete, to form construction joints and shear keys for future concrete and other construction surfaces shall not be measured and the costs shall be included in the rates for other work.

Formed Surfaces to contraction and expansion joints shall be measured by the square metre on one face only. The rates shall include for the costs stated below and for forming recesses for sealant and channels for grout.

The rates for formed Surface shall include for the cost of submission of details providing and transporting all materials for formwork and falsework, erection including provision of supports, fillets and chamfers 75 mm and less in width, bolts, ties, fixings, cutting to waste, drilling or notching the formwork for reinforcement where required, working around pipes, ducts, conduits and waterstops, temporary openings, cleaning, dressing, stripping, filling bolt holes and any remedial work and for complying with Clauses 7.08, 7.10, 7.17, 7.18, 7.19 and 7.21 to 7.27 inclusive of this Specification.

The rate shall also include for costs of constructing formed surfaces to any inclination, shape or curvature as shown in the drawing or as instructed by the Engineer.

5.42.6 (f) Item Formwork to edges of slabs

Unit: m of each class of finish

Formwork less than 300 mm high to edges of slabs shall be measured by the linear metre.

The rates for formwork shall include for the cost of submission of details providing and transporting all materials for formwork and falsework, erection including provision of supports, fillets and chamfers 75 mm and less in width, bolts, ties, fixings, cutting to waste, drilling or notching the formwork for reinforcement where required, working around pipes, ducts, conduits and waterstops, temporary openings, cleaning, dressing, stripping, filling bolt holes and any remedial work and for complying with Clauses 7.08, 7.10, 7.17, 7.18, 7.19 and 7.21 to 7.27 inclusive of this Specification.

5.42.7 (g) Item: Waterstops

Unit: m of each type

Waterstops shall be measured by the metre run of each type.

The rate for waterstops shall include for the provision installation, jointing, any sealants required at the face of the concrete and for placing and compacting concrete around the water stop.

5.42.8 (h) Item: Mortar

Unit: m²

Mortar used for bedding base-plates and the like shall be measured by the square metre as the area of the base plate at the specified nominal thickness of bedding.

Mortar used in filling bolts pockets and the like shall not be measured separately and the costs shall be included in the rates for the bolts. The rates for mortar shall include for the cost of providing and placing the mortar and of complying with the requirements of Clauses 7.14 and 7.20 of this Specification.

5.42.9 (i) Item: Admixtures, workability and hardening agents

Unit: as per instruction of the Engineer

Where required by the Special Specification admixtures, "Workability and hardening agents will be measured and paid for in accordance with the Engineer's Instructions.

5.42.10 (j) Item: Reinforcement

Unit: tonne of each type for each range of diameters. Reinforcement shall be measured separately for each of the following ranges.

- (i) of diameter equal to or less than 16 mm.
- (ii) of diameter greater than 16 mm.
- (iii) Steel fabric reinforcement shall be measured in accordance with Clause 7.41.11 (k) of this Specification.

Steel plain and deformed bar reinforcement shall be measured by the tonne and shall be the calculated weight of the steel required including splice lengths shown on the Drawings. No allowance shall be made in the measurement for rolling margin or cutting waste. The density of Steel shall be taken as 7,850 kilograms per cubic metre.

The rates for reinforcement shall include for the cost of providing, cutting to length, splice lengths additional to those shown on the Drawings, laps, bending, hooking, waste incurred by cutting, cleaning, spacer blocks, provision and fixing of chairs or other types of supports, welding, fixing the reinforcement in position including the provision of wire or other material for supporting and tying the reinforcement in place, bending reinforcement aside temporarily and straightening, placing and compacting concrete around reinforcement and for complying with the requirements of Clause 7.28 to 7.31 inclusive of this Specification.

5.42.11 (k) Item: Fabric reinforcement

Unit: m² of each type

Steel fabric reinforcement shall be measured by the square metre and shall be the calculated area excluding any allowance for laps.

The rate for steel fabric reinforcement shall include for the costs stated in Clause 7.41 (j) of this Specification.

5.42.12 (1) Item: Precast Units

Unit: no. of each type

Precast units shall be measured by the number of each type instructed unless otherwise specified in the Special Specification.

The rate for precast units shall include for the cost of all the materials, forming, and placing units, complying with the requirements of Clauses 7.32 to 7.40 inclusive and with the relevant Clauses of the Special Specification.

No separate measurement or payment will be made for formwork reinforcement or prestressing tendons to precast units.

6 STRUCTURAL STEELWORK

6.1 General

The fabrication and erection of all structural steelwork shall be under the constant supervision of competent and experienced personnel. All workmanship shall be in accordance with the best modern workshop practice and only skilled workers trained and experienced in steel fabrication and erection shall be employed.

6.2 Applicable Standards

The supply, fabrication and erection of structural steelwork shall be in accordance with the provisions of the relevant clauses of the following British Standards: -

- BS 4 Structural steel sections.
- BS 4848 Hot rolled structural steel sections.
- BS 153 Steel girder bridges,
 Part 1 - Materials and workmanship and
 Part 2 - Weighing, shipping and erection.
- BS 4360 Weldable structural steels.
- BS 4395 High strength friction grip bolts and associated
 Parts 1&2 nuts and washers for structural engineering (metric
 series).
- BS 4604 The use of high strength friction grip bolts in structural
 steelwork.
- BS 2708 Unified Black Square and hexagon bolts, screws and nuts (UNC
 and UNF threads).
- BS 4190 ISO metric black hexagon bolts screws and nuts.
- BS 3692 Isometric precision hexagon bolt screws and nuts.
- BS 4320 Metal washers for general engineering purposes.
- BS 5135: Metal arc welding of carbon and manganese steels.
- BS 638 Arc welding plant, equipment and accessories.
- BS 639 Covered electrodes for the manual metal-arc welding of mild
 steel and medium tensile steel
- BS 4870 Approval testing of welding procedures, Part 1 Fusion welding
 of steel.
- BS 4871 Approval testing of welders working to approved welding
 procedures, Part 1-Fusion welding of steel.
- BS 5493 Protective coating of iron and steel structures against corrosion.

6.3 Materials

All structural steel shall be to the Grade as defined on the Drawings and shall comply with the requirements of BS 4360 in every respect.

Mill certificates shall be supplied to the Engineer in duplicate to confirm the mechanical and chemical properties.

Steel for headed stud shear connectors shall have a minimum yield stress of 385 N/mm² and a minimum tensile strength of 495 N/mm².

6.4 Storage of Materials

Structural steelwork whether plain or fabricated shall be stored above ground on platforms, skids or other supports and in such a way as to prevent pools of water forming on the ground. It shall be kept free from dirt, grease and other deleterious material and shall be protected as far as is practicable from corrosion. The time limits for outside storage of unpainted or primed steelwork shall be as detailed in the Special Specification.

6.5 Fabrication

Fabrication shall generally be in accordance with the requirements of BS 153 Part 1, Workmanship. Rolled material, before being processed, must be straight or flat. Straightening or flattening, where required and where permitted by the Engineer, shall be accomplished by a process not harmful to the material.

The Contractor shall submit to the Engineer for his approval two sets of shop drawings with calculations as appropriate and the Contractor shall not commence fabrication until written approval has been given by the Engineer. The Engineer will give comment or approval within 28 days after receipt of the shop drawings and calculations. Such approval shall not relieve the Contractor of any of his responsibilities under the Contract.

Following approval of the shop drawings the Contractor shall supply to the Engineer a further four copies of each drawing for the use of the Engineer and the Employer.

The components of various members of the structure shall be placed in jigs of approved design and all welding shall be carried out in accordance with Clause 6.7 of this specification. Every precaution shall be taken to prevent distortion.

6.6 Preparation of Edges and Ends of Plates

Edges and ends shall be either:

- (a) left as rolled, sawn, machine cut, machine flame cut;
- (b) hand flame cut and ground to a smooth profile; or
- (c) for stiffeners and gussets not exceeding 12 mm thick, sheared and subsequently ground to a smooth profile.

Where ends of stiffeners are required to be fitted, they shall be ground to be in contact with the flanges over 80% of the area of stiffener.

After shearing or flame cutting of plates, one of the following requirements shall be satisfied:

- (a) The hardness of the out edge shall not exceed 350 HV 30 of BS 427;
- (b) the cut edge is incorporated in a weld;

- (c) the material from the edge is removed by machining or grinding to demonstrate that the hardness of the edge is less than 350 HV 30 of BS 427;
- (d) the edge is softened by an approved heat treatment and is shown to be free from cracks by crack detection procedures; or
- (e) the material is Grade 43 steel and is not greater than 40 mm thick and the edge preparation is by machine flame cutting.

6.7 Welding

Welding will be permitted only where shown on the Drawings and the agreed shop drawings.

All welding operations shall comply with the requirements of BS 5135. The details of all welds shall be arranged to achieve the most satisfactory welding procedure. The details of the welding procedure shall be submitted to the Engineer for his approval and no welding may commence without the prior approval of the Engineer. No departure from an approved procedure may be made without the prior approval of the Engineer. Welding procedure details to be submitted to the Engineer shall include the following: -

- Welding position.
- Fusion face preparation. Pre-heating.
- Electrode make, type and size and mechanical properties. Number and arrangement of runs.
- Welding current.
- Arc energy.
- Method of back gouging and sealing.
- Proposed methods of quality control and testing of welds.

Welding shall be carried out under the supervision of an experienced and competent supervisor in accordance with the requirements of BS

5135. The welders shall be tested in accordance with the requirements of BS 4871 prior to the commencement of the work.

The Contractor shall carry out trials of the welding procedure in accordance with the requirements of BS 4870.

Welding plant and accessories shall comply with the requirements of BS 638 and shall be used in accordance with the manufacturer's instructions. The welding plant shall be capable of maintaining at the weld the current and voltage specified by the manufacturer and in accordance with the welding procedure.

The electrodes shall be selected with regard to the quality of the material to be welded and the optimum performance with the welding procedures and shall comply with the requirements of BS 639. All electrodes shall be stored in their original packets in a dry and preferably heated place adequately protected from the weather and shall be handled with care and in accordance with the manufacturer's instructions. Electrodes and fluxes that show signs of moisture, damage or deterioration shall not be used.

Welds shall be subject to non-destructive examination and testing as specified in the Special Specification.

Welded fabrications and weld quality shall comply with the requirements of the American Welding Society Specification ANSI/AWS D1.1.8L, section 9, PART D

Stud shear connectors shall be subjected to the following tests: -

- a) (a)The fixing of studs after being welded in position shall be tested by striking the side of the head of the stud with a 2 kg hammer and shall pass such test if no part of the weld shows fracture or is dislodged thereby.
- b) Any stud selected by the Engineer shall be capable of being bent by striking the side of the head of the stud with a 6 kg hammer until its head is displaced laterally a distance of approximately 0.25 times the height of the stud from its original position. The stud weld shall not show any signs of cracking or lack of fusion. Satisfactory studs shall not be bent back again.

Studs whose welds have failed the tests given in (a) and/or (b) above shall be replaced according to a procedure to be agreed with the Engineer.

6.8 Bolting

6.8.1 (a) Black Bolts

All mild steel bolts, washers and nuts shall be of the grade as specified on the Drawings and shall comply with the requirements of BS 4190, BS 2708 or BS 3692 as appropriate.

All holes shall be drilled or drilled small and reamed and shall be clean cut without torn or ragged edges. The holes shall be perpendicular to the member and not more than 2mm larger than the nominal diameter of the bolt.

In all cases where the full bearing area of the bolt is to be developed the bolt shall be provided with a steel washer under the nut to avoid any threaded portion of the bolt being within the parts bolted together. Tapered washers of the correct angle of taper shall be provided under all bolt heads and nuts bearing on bevelled surfaces.

6.8.2 (b) High Strength Friction Grip (HSFG) Bolts

HSFG bolts shall comply with the requirements of BS 4395 Parts 1 and 2 and shall be used in accordance with the provisions of BS 4604 Parts 1 and 2.

HSFG bolts, nuts and washers shall be supplied cadmium plated to BS 3382 to a thickness of 5 microns and shall be stamped or otherwise marked with a suitable and permanent mark and the Contractor shall obtain the written approval of the Engineer to the proposed marks before commencement of the work.

Each HSFG bolt shall be supplied complete with its nut screwed on. washers may be supplied on the bolt or separately and bolts and washers shall be packed in the manufacturers works and delivered to site in waterproof containers and stored under cover in these until required: for use.

The method of tightening HSFG bolts shall be either the part turn method, the torque control method or with the use of load indicating washers in accordance with the following: -

HSFG bolts complying with standard	Permissible methods of tightening.
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BS 4604 Part 1 and 2	1) Part turn for bolts M16 and above 2) Torque control. 3) load indicating washers.
BS 4604 Part 2	1) Torque control. 2) load indicating washers.

Whatever method of tightening is adopted, the Contractor shall supply to the Engineer full details of the procedures to be adopted which shall be in accordance with the requirements of BS 4604, together with details of the tools and equipment he will be using at Site and the tests to be carried out to determine the tension characteristics of the tools, bolts and the load indicating washers. No bolting shall commence until the Contractor has carried out sufficient site tests to confirm the load/torque/shank tension characteristics of the tools and bolts.

In the case of torque control tightening methods, calibration of the equipment shall be carried out daily before commencing bolting operations in accordance with the requirements of BS4604.

Where load indicating washers are used they shall be of a type approved by the Engineer and used in accordance with manufacturer's instructions.

The general requirements of BS 4604 shall apply to the assembly and use of HSFG bolts with indicating washers including check testing to confirm minimum shank tension is being achieved.

HSFG bolts that have been slackened off after final tightening by any method shall be removed, discarded and replaced.

6.9 Transportation Handling and Erection

Erection shall be in accordance with BS 153 Part 2, Weighing, Shipping and Erection. Structural steel shall be handled with due care at all times and in such a manner as not to cause damage to the steelwork or its protective coatings.

The Contractor shall submit to the Engineer for his approval two sets of drawings and calculations and details showing his proposed methods for transport, handling and erection of structural steelwork including all plant, temporary supports and bracings required to ensure stability and safety during erection. The Contractor shall erect the steelwork, remove the temporary supports and do all the work required to complete the Works in accordance with the Drawings and this Specification. The work shall be carried out in such a manner as will not injure, overstress or disfigure any part of the structure or the foundations and any part injured, overstressed or disfigured shall be removed and replaced or rectified to comply with the requirements of this Specification.

The steelwork shall be temporarily erected at the fabrication works and be subject to inspection by the Engineer before being dispatched to Site.

Drift pins will be allowed only for bringing together the several parts of the structure, and shall not be used in such a way as to distort the work or enlarge the bolt holes.

Bolts in site connections shall not be finally tightened until sufficient of the structure is properly plumbed, aligned and levelled and no subsequent straining into position will be allowed. Finally, all bolts and connections shall be systematically checked and tightened.

6.10 Surface Preparation of Steelwork

Surface preparation of steelwork shall be by blast cleaning in accordance with the requirements of BS 4232, second Quality. The maximum amplitude of the blast cleaned surface shall not exceed 0.1mm.

Manual cleaning of structural steelwork including mechanical wire brushing, chipping hammers, vibratory needle guns and the like shall not be permitted except for small parts and then only with the prior written permission of the Engineer.

Surfaces shall be painted with the specified primer paint within four hours of having been blast cleaned.

As soon as the first undercoat has dried, a further stripe coat of paint shall be applied by brush to all edges, corners, crevices, exposed parts of bolts, rivet heads and welds. The stripe coat should have the same specification as the undercoat but be a contrasting shade.

Painted surfaces shall be cleaned of dust immediately prior to the application of further paint. All loose paint, dirt and grit shall be removed and areas contaminated with oil and grease shall be cleaned with emulsion cleaners followed by washing and rinsing with clean fresh water and followed to dry thoroughly before paint is applied.

In the case of painted steelwork where the interfaces of HSFG bolts are bare steel, the primer coat shall be taken between 100mm and 20mm inside the perimeter of the joint area.

Where paints are to be applied to parent surfaces before making of a joint they shall be stepped back at 30mm intervals commencing at 80mm from welded joints and 100mm from the perimeter of all other joints.

All bolted joints shall be sealed against the ingress of water. Gaps at joints shall be plugged with approved filler and the perimeter of all joints shall be sealed with subsequent coats of paint.

All joints, welds and surfaces affected by welding shall receive the same protective system as applied to the parent surfaces.

Within 14 days of a joint being made and accepted by the Engineer, the parent material, exposed parts of bolts, nuts and washers, weld and affected areas shall be prepared and painted.

6.11 Painting

All paint used in the Works shall be subject to the approval of the Engineer.

All paint shall be supplied from the store to the painters ready for application. Any addition of thinners must be made in the store under the supervision of the

Engineer and only as permitted by the manufacturer's data sheet. All the requirements of the manufacturer's data sheet shall be strictly complied with.

Paint shall be applied only to surfaces which have been prepared and cleaned in accordance with the requirements of Clause 6.10 of this specification.

The use of rollers shall not be permitted for the application of paint.

Paint shall not be applied under any of the following conditions: -

- (a) When the ambient temperature is less than 4°C.
- (b) When the relative humidity is greater than 90%.
- (c) During fog, rain or mist.
- (d) When any moisture is present or likely to condense on the steel. Each coat of paint shall be free from surface defects.

Successive coats of paint shall have different shades for identification.

The Contractor shall ensure that the proposed application rates shall enable the specified minimum dry film thickness to be achieved. If the total dry film thickness is less than the specified minimum, an extra finishing coat or coats shall be applied until the specified dry film thickness is obtained.

6.12 Paint Systems

The paint system to be used on structural steel work shall be as specified in the Special Specification.

6.13 Damaged Surfaces

Any areas of paint which have been damaged following application shall be cleaned down to bare metal and the full specified painting system shall be re-applied. The new paint shall overlap the existing paint by at least 50mm all-round the affected area.

Galvanized surfaces damaged shall be repaired either by the use of low melting point zinc alloy repair rods or powders made specifically for this purpose or by the use of at least two coats of a good quality zinc rich paint to BS 4652.

6.14 Internal Bracings and Brackets:

Internal bracings and brackets shall be designed to ensure the strength, rigidity and absolute uniformity of each tank depending on sizes.

6.15 Fasteners:

All bolts used in the assembly of the tank shall be of High Tensile Grade 9.8 for rigid holding. They shall be zinc coated to protect against any rust forming.

6.16 Joint Materials:

A non-toxic strip joining material shall be used between the flanges of tank plates, under the internal brackets and for sealing the cover plates to make all joints completely leak proof.

6.17 Fittings:

The steel structure shall be provided with suitable standard nozzles either threaded or flanged depending on the requirements. Sizes and orientations are to be provided by the time of ordering.

The steel structure shall be provided with Inlet, Outlet, Overflow, Drain Vent, Level Indicators and Internal & External Ladder. Any other additional fittings shall be provided on request.

6.18 Pressed Steel Tanks and Towers

The pressed steel tanks (or similar approved), towers and associated materials and fittings shall comply with SRN 909 and SRN 863.

Detailed drawings of the steel tank should be submitted to the Engineer for approval prior to acceptance.

The pressed steel tank to SRN 909 (B.S. 1564 Type A (2) or similar approved) shall be supplied complete with: -

- a) All stays, cleats, bolts, nuts, washers, jointing compound and associated materials and fittings.
- b) Connections for inlet, outlet, washout and overflow.
- c) Galvanised access ladder 450mm wide.
- d) Steel roof cover to fit the tank complete with access manhole and mosquito-proof cowl ventilators.
- e) Water level indicator.

Jointing material to the tank to be a non-toxic plastic compound which does not impart taste, colour nor odour to the water.

Connections to the tank shall be welded to the outside of the tank plate and drilled and tapped to suit flanges to SRN 207, NP 16 unless otherwise stated.

The cover to the tank shall be of mild steel cambered for external use and adequately supported by rolled steel or pressed steel bearers or trusses.

The tank tower shall be supplied complete with: -

- a) Anchor bolts.
- b) Bolts, nuts, washers and associated materials and fittings.
- c) Access ladder 450mm wide extending from ground level to the top of the tank. Safety rings shall be at 1.2m centres.

The supports to the tank shall consist of steel joints designed to carry imposed load under each transverse joint and the two ends of the tank.

The columns of the tank shall consist of rolled steel joist sections or similar. Four such columns shall be provided with adequate bracing.

Internal surfaces of the tank shall be painted with approved non-toxic primer and non-toxic bituminous paint.

External surfaces of the tank and tower shall be painted with approved primer and approved bituminous aluminium paint.

6.19 Measurement and Payment

(a) Item: Structural Steelwork

Unit: tonne

Structural steelwork shall be measured by the tonne and shall be the weight calculated from the approved shop drawings excluding bolts, welds, washers and all other fixings required. No deduction shall be made in the measurement for splay cuts, notches and holes providing that the area of each is less than 0.1 square meters. No allowances shall be made in the measurement for rolling margin or cutting to waste. The density of steel shall be taken as 7850 kilogrammes per cubic metre.

The rate for structural steelwork shall include for the cost of the following: -

(i) Design, submission of orders, fabrication drawings, details, calculations and certificates.

(ii) Provision of all structural steelwork, materials, bolts, nuts, washers, welding rods, and all other fixings; fabrication, including drilling, machining and welding; testing of welds and welders.

(iii) Temporary erection at the fabrication works for inspection by the Engineer.

(iv) Surface preparation, painting with specified paint system. (v) Inspection, and submission of test reports and certificates.

(vi) Marking, handling, packing, transporting and storage.

(vii) Erection, bolting, welding, including temporary bracings, guys, and craneage.

(viii) Complying with all the requirements of Section 8 of this Specification.

7.1 Materials

All pipes, couplings, gaskets, lubricants, seals, coupling machinery etc., necessary for the proper construction of the pipe works as detailed in the Bill of Quantities and drawings shall be supplied by the Contractor.

The Contractor shall be responsible for ensuring that the pipes, couplings and other fittings laid or installed on each section of the work are of the standard and pressure classification specified as appropriate to the circumstances, and are manufactured of the specified materials.

The Engineer reserves his right to refuse any materials that in his opinion is inferior.

The Engineer has the right to test any material upon delivery, and materials found defective shall be replaced forthwith by the Contractor.

If the Contractor procures materials of different specifications in respect of flanges and threads etc. (imperial units-metric units), he shall at his own cost provide all adaptors and other fittings necessary to make connections to the satisfaction of the Engineer.

All materials shall be marked as specified in the relevant current British or ISO Standards for easy identification on site.

Pipes shall be supplied in standard lengths unless otherwise shown on the Drawings.

Specials shall be fabricated to the details shown on the Drawings, using, where applicable, the same materials, welding procedures and protective linings and coatings as are specified for the corresponding straight pipes.

Satisfactory temporary end covers shall be provided for the protection of threads, flanges and the prepared ends of pipes, fittings and specials, and for the prevention of damage to internal linings during transportation and during handling on Site.

7.2 Handling and Storing Materials

The method of transportation, handling and storing of pipes and fittings shall be in accordance with the manufacturer's recommendations.

Pipes, valves, specials and other materials shall be handled, moved, lifted or lowered with the least possible impact. Handling equipment shall be of approved type. In slinging pipes only flat slings shall be used and the use of chain slings, hooks or other devices working on scissors or grab principles shall not be permitted. Pipes shall be slung from two or more points as the engineer may direct and the slinging, lifting and lowering shall be in the hands of a competent and experienced man.

Subject to the requirements of inspection before acceptance, protective bolsters, caps or discs on the ends of flanges or pipes or specials shall not be removed until the pipes or specials are about to be lowered into the trench. Every precaution shall be taken to prevent damage to internal Linings or external coatings.

Pipes in storage shall be supported clear of the ground on approved supports and adequately braced to prevent rolling. They shall not be stacked more than four tiers high without the approval of the engineer. Materials of different classification shall be stored separately.

All pipes and associated material shall at all times be protected from sun and weather to the satisfaction of the Engineer.

The spindle shall not be used lift the valves.

No valves, fittings or specials shall be stacked more than one tier high without the permission of the Engineer, and they shall not be stored in a dirty place or condition and shall not be allowed to become embedded in earth, sand, stone, aggregate, water, fuel, or any other deleterious matter. Great care shall be taken at all times to keep the faces and seats of all valves clean and free from dirt and grit of any kind. No valve shall be closed without at first wiping the faces with a clean cloth dipped in clean oil. The cavity beneath the valve doors shall be thoroughly cleaned by hand. In the event of accidental spilling of bitumen, cement or other matter, they shall be either dissolved or carefully removed by methods that do not involve scraping of the faces.

Valves and their ancillary equipment shall be protected before and after erection against collapse of earthworks, falls of materials, concrete and cement droppings, wood and other matter.

Shortly before laying or fixing any valve, pipe or fitting the Contractor shall in the presence of the Engineer or his representative carefully examine each valve, pipe and fitting to ascertain damage or defect occasioned to the valves, pipes and fittings during loading, unloading, handling, storage and transportation. All damage and all defects revealed by this examination shall be repaired and remedied by the Contractor.

7.3 Laying and Jointing,

7.3.1 Pipes and Fittings

All laying and Jointing of pipes except jointing of PVC and Heavy Duty Polyethylene(HDPE) pipes shall be in conformity with CP 310 and CP 2010.

The bottom of the trench or surface of the bed shall be finished to a smooth even surface at the correct level to permit the barrel of the pipe to rest on the surface throughout its whole length between joint and sling holes. If considered necessary by the engineer, fine screened material shall be placed and consolidated in the trench bottom to provide such a bed.

In general, the preparation of the trench bottom and bed shall be completed for a length of one pipe in advance of the pipe-laying.

The bottom of the trench and pipe bed shall be inspected by the engineer and only when passed as satisfactory shall pipe laying commence.

Each pipe shall be laid accurately to line, level and gradient so that except where otherwise directed, the finished pipe line shall be in a straight line both in horizontal and vertical plans.

The levels and gradients shown on the drawings shall be rigidly adhered to unless otherwise ordered by the Engineer.

Where lines of pipes are to be constructed the Contractor shall provide and fix, at such points as may be directed properly painted and securely positioned sight rails, the levels and positions of which shall be examined and checked by the Engineer before the rails are used and as often thereafter as may be necessary.

There shall at no time be less than three sight rails in position on each length of pipeline under construction to any one gradient, and the sight rails shall be situated vertically above the line of pipes, or immediately adjacent thereto.

Pipes shall be lowered singly into the trench, brought to the correct alignment and inclination bedded throughout their length, and properly jointed strictly in accordance with the manufacturer's instructions.

Notwithstanding any flexibility provided in pipe joints, pipes must be securely positioned to prevent movement during and after the making of a joint. On screw and socket joints threads shall be coated with an approved tape to ensure water tightness.

Long radius curves in the pipeline shall be negotiated by deflections taken up in the joints or pipes of one or more lengths of pipes. The deflection at each of the various types of joint of pipes used in the works shall not exceed the manufacturer's specifications.

The Contractor shall take care that all pipes and couplings are clean and free of foreign matter before subsequent sections are jointed.

The Contractor shall obtain from the manufacturer or other approved supplier the necessary tackle required for the proper jointing of the pipes.

The Contractor shall make himself and his employees acquainted with and comply with the instructions issued by the manufacturers of the various types of proprietary joints and couplings for incorporation in the works. The Contractor shall be responsible for obtaining copies of such instructions.

No person shall be employed on the jointing of pipes that is not thoroughly experienced and skilled in the particular work in hand.

Pipes shall not be cut without the permission of the Engineer.

The cut shall be made with an approved mechanical pipe cutter and the edges of the cut shall be clean true and square. Threading of steel pipes shall be done with an approved device.

The normal continuity of construction may have to be interrupted at joints on the pipelines pending the delivery of certain valves or specials. The exact extent of the temporary gap to be left in such instances shall be predetermined, but shall not be fixed without reference to the Engineer to whom the Contractor shall submit for approval a sketch with dimensions showing details of the pipe and jointing arrangement to be adopted to effect ultimate closure. Special care shall be exercised to preserve the accurate alignment of the pipeline over the extent of the temporary gaps which it may be necessary to leave.

Subject to the permission of the Engineer, pipes shall be covered over with approved fill material upon successful completion of laying and joining. Joints shall be left exposed until completion of the pressure test.

Fill for surrounding and cushioning shall consist of uniformly readily compactable material free from tree roots, vegetable matter, building rubbish and excluding clay lumps retained on a 75 mm sieve and stone retained on a 25 mm sieve.

The materials for bedding shall, where ordered, consist of suitable selected materials obtained from the excavations or from approved borrow pits and transported to the location where they are required.

Adequate precautions shall be taken by way of back-filling or other means to anchor each pipe securely to prevent floatation of the pipeline in the event of the trench being flooded or during concreting.

Upon successful completion of the pressure test the pipeline shall be back-filled as specified.

7.3.2 Valves and Specials

Unless otherwise directed all valves, flow-meters, fittings and specials shall be individually supported and their weight shall not be borne by the pipeline, joints or couplings etc.

All supports for valves and fittings shall be of concrete Class 20 or as specified on the drawings.

Where air valves are to be placed the Contractor shall ensure that the highest point in the main is determined by levelling instrument.

Air valves shall be checked before the main is charged to ensure that the balls and faces are not scored or split, and that there is no dirt or other deleterious materials in the cavities of the body. All air nozzles shall be probed to see that they are clear. No air valve shall be stored before erection in the open in sunlight, or upside down to expose the balls and air cavities.

Scour valves shall be installed at low points in the pipelines as shown on the Drawings. The Contractor shall be in agreement with the Engineer on the exact position of scour valves in particular situations.

Scour valves shall, where possible, discharge in the direction of natural drainage and at such a distance from the Works as to preclude erosion effects.

Unless otherwise directed the controlling valve for a scour shall be installed not more than 1.5 m from the main pipeline.

Ends of all scours shall be protected from intrusion of animals and other foreign matter by suitable screening securely fixed to the pipe end.

Valve penstocks and other fittings shall be securely fixed and where required extension spindles and headstocks shall be properly aligned and fixed in a vertical position unless otherwise directed. They shall be tested for ease of operation and water tightness and valve lands shall be repacked where necessary. Any damaged protective coating shall be made good and they shall be left clean in all respects.

Before each valve is put into service all gears, bearings and spindles shall be oiled with approved oil as recommended by the valve manufacturer. Oil baths shall be topped up to the appropriate levels and all grease nipples charged with grease of approved manufacturer. No deleterious matter shall be allowed to come into contact with the working faces and oil sumps shall be maintained clean.

All valves, fittings, specials shall be fixed with proper sealing tube, gaskets, washers etc. as necessary to the satisfaction of the Engineer.

The rates in the Bills of Quantities shall cover for the supply, storing handling installation and Jointing, together with all bolts, washers, gaskets and lubricants etc.

7.4 Pipes and fittings

7.4.1 Flanges

Where flanged joints are used, flanges shall be in accordance with the requirements of BS 4504: part I or BS 4622 or BS 4772.

The minimum pressure rating shall be for a working pressure of 1.6N/mm² (approximately 160 metres head) corresponding to NP 16 flanges. The hydraulic test pressure shall not exceed 3.0N/mm²

The number of holes shall be as follows:

Diameter(mm)	No of holes
50	4
80 – 150	8
200 – 300	12
350 – 400	16
450 – 600	20
650 – 800	20

Flanges in pipelines with higher pressure rating shall be for a working pressure of 3.0 N/mm² (approximately 300 metres head) corresponding to NP 30 flanges. The hydraulic test pressure shall not exceed 4.0 N/mm².

Bolts, nuts and washers shall comply with the requirements of BS 4190 and BS 4320. Gaskets shall fulfil the requirements of BS 2494 and shall have a minimum thickness of 2 mm.

7.4.2 Steel pipes

The steel pipe shall conform to B.S. 534 1981, B.S 1387, BS 3600 and BS 3601 and pipeline distribution shall be as per CP 2010 part 2, 1970 and unless otherwise stated specials shall be made from pipes that have been manufactured and tested in accordance with B.S. 3601. Joints shall be screwed and socket for nominal diameters up to 50 mm and flanged or socketed for nominal diameter above 50

mm unless otherwise stated. The type of joint used shall be to the approval of the engineer. The Pipes and specials shall be protected from corrosion internally and externally complying with the requirements of BS 539. The type of protection used shall be to the approval of Engineer.

Welds shall be inspected by radioactive non-destructive testing and tensile and weld bend tests as per BS EN 10224.

Steel Tubes and tubulars with screwed and socket joints shall be covered by the requirements of BS 1387.

Flanges shall be as specified in Clause 7.4.1 and threads as specified in BS 21.

7.4.3 Unplasticized Polyvinyl Chloride Pipes

All PVC pipes and fittings shall comply with KS 06-149:1981, ISO 161/1-1976 (E) or BS 3505.

Pipes indicated with a pressure class shall conform to the following minimum working pressures

Class 0.6 MPa-0.6 N/mm² (marking: red) (KS classification: A

Class 0.9 MPa-0.9 N/mm² (marking: blue) (KS classification: B)

Class 1.2 MPa-1.2 N/mm² (marking: green) (KS classification: C)

Class 1.5 MPa-1.5 N/mm² (marking: brown) (KS classification: D)

All fittings shall be of pressure class 1.5 MPa and be manufactured of cast iron, PVC or steel.

Joints to be Solvent Cement Joints for nominal sizes equal to or smaller than 50mm and mechanical joints (rubber ring) for nominal sizes equal to or bigger than 80 mm.

For both types of joints, the manufacturer's jointing instructions, shall be strictly adhered to.

For solvent cement joints it is essential that the solvent cement used is the correct type, i.e. it shall be purchased from the same factory which delivers the pipes.

The rubber ring joints can be either the Polva type, which incorporates only one rubber ring or loose couplers with two rubber rings. In any case the fittings used shall be purchased from the same factory which delivers the pipes.

If the joint is difficult to fix the manufacturer should be consulted immediately. No cutting or scraping in any of the joints components shall take place.

PVC pipes and fittings shall be stored under cover, which fully protects the material from sunlight.

Acceptable nominal pipe diameters for PVC pressure pipes are 75 mm, 90 mm, 110 mm, 160 mm, 200 mm, 250 mm and 315 mm. 75 mm diameters shall only be allowed when a network analyses shows that the water demand for firefighting is satisfied.

All PVC pipes and fittings shall, prior to delivery, be factory-tested to 4.2 times the specified working pressure, and a certificate to this effect shall accompany all deliveries. PVC products shall be stored away from sunlight and shall be backfilled as soon as practicable after having been laid.

7.4.4 Precast Concrete

Precast concrete pipes and fittings shall comply with BS 556: Part 2.

The laying and jointing of the pipes shall comply with CP 301.

The Contractor shall adopt such measures as may be approved by the Engineer to ensure that every newly laid pipe is concentric with previously laid pipes with which it joins.

Unless otherwise approved by the Engineer pipes shall be laid in an upstream direction and the socket ends shall point upstream.

Before commencing the laying operation, the Contractor shall ensure that the parts of pipe which will come into contact with the jointing material are perfectly clean.

Cement mortar joints for spigot and socket pipes shall be made as follows: -

- (1) Before commencing the jointing operation, the socket of the previously placed pipe and the spigot of the new pipe shall be cleaned and thoroughly soaked with water.
- (2) The spigot shall be wrapped one complete lap with tarred hempen spun yarn and the new pipe shall be carefully drawn towards the previously laid pipe so the spigot enters tie full depth into the socket of the previously laid pipe. The new pipe shall then be adjusted and fixed in its correct position in line, level and gradient and the tarred yarn shall be sealed tightly into the socket.

On completion of this operation, the yarn shall not fill more than one quarter of -the total depth of the socket.

- (3) The remainder of the socket shall be completely filled with cement mortar consisting of one part of cement to three parts of sand. The mortar filling shall terminate flush with the socket and shall be neatly trowelled to a smooth finish around the pipe.

To assist the curing of the mortar the contractor shall cover the joints immediately after they are made with a layer of Hessian cloth which shall be kept continuously wet during daylight hours and he shall further adopt such other measures as the Engineer may direct

Provided the Contractor has the Engineer's written consent other means of jointing may be adopted, e.g., rubber ring-joints. The Engineer's instructions in regard to other jointing materials must be strictly complied with.

7.4.5 Glass Reinforced Polyester Pipes (GRP)

The GRP pipes shall be of International Standards Organization ISO 10639 and EN 1796 for potable water transfer. Joint testing shall meet ASTM D4161 AND EN 119 Standards. Long Term Stiffness shall meet ISO 10468 and Long Term Bending shall meet ASTM D5365 Standards. Production of GRP pipes shall be through controlled manual process to ensure high quality pipes.

7.4.6 Double Wall corrugated Pipes (DWC)

Double wall corrugated pipes must be manufactured using two layers or either PP or PE that are bonded in the extrusion process. The pipe will have a corrugated outer skin, forming ribs and bonded to the internal skin of the pipe leaving a smooth inner surface. This inner surface will be free of cracks, deformities and will ensure smooth flow properties throughout the pipeline. The pipe shall be socketed on one side, and have a spigot on the other. The internal colour shall be a light reflective colour to reflect light to ease camera inspection. An elastomeric rubber water sealing ring will be place on the spigot side to create a strong seal between the spigot and socket.

The pipe must have a coextruded line on the pipe of a different colour for easy identification of the fluid within the pipe. **Pipes that do not have this coextruded stripe will not be accepted**

Manufacturing Process

The pipe must be manufactured in a **horizontal corrugator with water cooled mould blocks** that keeps the ovality to a minimum, and contraction consistent. The pipes shall use suitable PP or PE to acquire the required stiffness and deflection characteristics describe below. The pipe will have inline socketing, with the required socket diameter to create a water tight seal with the help of an elastomeric ring.

Corrugated construction

The pipe will have a plain smooth inside surface, with an annular ribbed external surface. As shown in the diagram below:

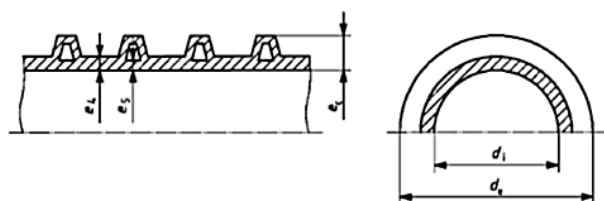


Figure 1 – Corrugation Diagram

PE (Polyethylene) material characteristics described in the table below:

Characteristic	Requirements	Test parameters		Test method
Resistance to internal pressure 165 h ^{a, b}	No failure during the test period	End caps	Type A or B	ISO 1167-1
		Test temperature	80 °C	ISO 1167-2
		Orientation	Free	
		Number of test pieces	3	
		Circumferential stress	4,0 MPa	
		Conditioning period	In accordance with ISO 1167-1	
		Type of test	Water-in-water	
Test period	165 h			
Resistance to internal pressure 1 000 h ^{a, b}	No failure during the test period	End caps	Type A or B	ISO 1167-1
		Test temperature	80 °C	ISO 1167-2
		Orientation	Free	
		Number of test pieces	3	
		Circumferential stress	2,8 MPa	
		Conditioning period	In accordance with ISO 1167-1	
		Type of test	Water-in-water	
Test period	1 000 h			
Melt mass-flow rate	≤ 1,6 g/10 min	Temperature	190 °C	ISO 1133:2005
		Loading mass	5 kg	Condition T
Thermal stability, OIT ^c	≥ 20 min	Temperature	200 °C	ISO 11357-6
Reference density	≥ 930 kg/m ³	In accordance with ISO 1183-1		ISO 1183-1
^a This test shall be carried out in the form of a solid-wall pipe made from the relevant extrusion material.				
^b For injection-moulding compounds this test shall be carried out in the form of an injection-moulded or extruded sample in solid-wall pipe form made from the relevant material.				
^c This requirement is only valid for pipes and fittings intended to be jointed in field by fusing or welding.				

7.4.7 High Density Polyethylene Pipes (HDPE)

The (HDPE) pipes shall be of International Standards Organization ISO 4427 and BS 6437 & 6730 for Potable Water Stress Regression Tests to comply with ASTM D 2837. Density 955kg/ m³, pipe classes and markings shall correspond to those of uPVC pipes. Pressure testing shall be as per manufacturer's recommendation and as approved by the Engineer. All transitions from HDPE pipe to GI, Steel, uPVC or Cast Iron shall be as per manufacturer's recommendation and to the approval of the Engineer

Acceptable nominal pipe diameters for HDPE high pressure pipes are 25 mm, 40 mm, 50 mm, 63 mm, 75 mm and 90 mm. Under no circumstances may saddles be used with PE pipes. Welded adaptors may also not be used with PE pressure pipes.

7.5 Protection of Pipes

The concrete used for bedding, haunching and surrounding the pipes shall be concrete class 15 unless otherwise ordered by the Engineer. The concrete protection shall have total dimensions not less than those given below.

The various types of concrete protection to pipelines are detailed below:

- (i) Bedding concrete shall have a width of at least 300 mm bigger than the external diameter of the pipe and shall support at least the bottom quarter of the pipe circumference. It shall have a minimum depth of 100mm measured under the pipe throughout the cross-section.
- (ii) Bedding and haunching shall comprise a concrete bed with a minimum width of 300mm more than the external diameter of pipe and a minimum thickness of 150mm below the pipe, and haunching with a minimum thickness of 150 mm on both sides the pipe. The top of the haunching to be flush with the top the pipe.
- (iii) Surrounding concrete shall comprise a concrete bed as described above together with 150 mm concrete on both sides and on to the pipe, giving a pipe protection of at least 150 mm concrete everywhere around the pipe.

Concreting of bedding, haunching or surround shall not be done until the pipes have been jointed, inspected and tested. The concrete shall be placed on one side of the pipe only until the flow of material under the weight placed ensures that the concrete is in full contact with underside of the barrel of the pipe throughout its length. The concrete shall be placed in one operation and shall be well worked to a homogeneous mass. The pipe shall be carefully anchored against floatation. All anchorage, haunches, surrounds, etc. shall be placed on and against undisturbed earth or rock as directed by the Engineer.

PVC pipes are laid in suitable bedding material as per drawings. Protection against e.g. load from traffic is carried out by laying of concrete slabs as detailed on the drawings. Special care shall be taken regarding compaction of fill below the concrete slabs.

7.6 Valves and Specials

Where flanged joints are used, flanges shall be in accordance with the requirements of BS 4504: part I or BS 4622 or BS 4772.

Where screwed joints are used, thread shall be complying with BS 21.

Joints shall be flanged for sizes equal to or bigger than nominal diameter 80mm and screwed for small sizes.

The names of manufacturers and the specifications of the products offered shall be provided at the time of tender.

All flexible couplings (Viking Johnson or other approved type) shall be supplied complete with rubber gaskets, bolts, nuts and washers. All couplings shall be coated with red oxide primer and bituminous composition suitable for use with potable water.

7.6.1 Gate Valves and Sluice Valves

Gate (sluice) valves shall comply with BS 5163.

The valves offered shall be with straight through openings and shall be with double faced cast iron wedges and have two machined gunmetal faces securely fixed into machined recesses.

The body of the valves shall withstand a pressure equal to or greater than the test pressure of the line and the valve seat shall withstand pressure equal to or greater than the working pressure of the pipeline. All gate valves and sluice valves installed in sections of the pipeline having a working pressure below 1 N/mm² shall have a rating of PN 10 (100 metres head). Valves installed in sections of pipeline having a working pressure between 1 N/mm² and 1.6 N/mm² shall be valves with a rating of PN 16.

For pipelines having working pressure higher than 1.6 N/mm² BS 5151 shall apply.

Materials shall be Cast Iron for sizes equal to or bigger than 80 mm, with flanged joints, and Cast Iron or brass for smaller sizes with screwed joints.

The valves shall be with rising spindle and shall if not otherwise stated be supplied with hand wheels.

Hand wheels shall be of cast iron, and shall have cast on the upper side of the rim, words "OPEN" with appropriate direction arrows.

7.6.2 Air-Valves

The air valves shall be standard Large combination air valve for wastewater treatment to max. 60°C (temporarily up to 90°C)

Test approvals

Hydraulic test according to EN 1074-1 and 4 / EN 12266

Approved for wastewater

Key Features

- Orifice sizes: Automatic 16 mm², kinetic 5024 mm².
- The large air gap between liquid and sealing system ensures a reliable function even when used with aggressive liquids and liquids carrying solid particles.
- The small orifice in the automatic valve releases small volumes of air when the line is under pressure. The spring between the stem and upper float compensates for slight pressure changes.
- Unique design of the float assembly prevents contact between the wastewater and the sealing mechanism, prevents clogging by floating solids and ensures drip-tight sealing.
- The disc is placed at the top of the valve, keeping the levers and pins away from the corrosive atmosphere in the air valve body.
- The stainless steel float system ensures high corrosion resistance.
- The conical body with funnel-shaped lower body allows maximum air volume within minimum valve length and prevents accumulation of deposits at the bottom.

- The spray guard minimizes liquid spray discharge from the air valve outlet, mainly during rapid pipeline filling conditions.
- The epoxy coated steel body features low weight.
- Drainage and flushing is possible through the drain in the valve's side.
- An exhaust tube can be mounted in the threaded opening on the top of the valve.
- The outlet enables removal of excessive fluids.
- With connection flange.
- Working pressure range: 0.2 – 16 bar.

7.6.3 Fire Hydrants

Fire hydrants shall be in accordance with SRN 509. They shall be for installation underground and shall be in accordance with SRN 509.

The spindle shall be provided with a cast iron cap conforming to dimensions under "Spindle Cap" in SRN 501.

The spindle of the fire hydrant shall be of the non-rising type and screwed so as to close the hydrant when rotated in a clockwise direction viewed from above. The direction of closing shall be clearly cast on the valve cap.

The flanged outlet of the outlet bend shall have a Bayonet Joint Outlet for a 63mm standpipe. The outlet of the hydrant shall be of the hooked type with hooks 112mm apart.

The outlet shall have a gun metal standpipe seating and be covered by a loose cast iron cap which shall be attached to the hydrant by means of a chain.

Both flanges shall be 63mm drilled to requirements of SRN 207.

The outlet bends shall be subject to a hydrostatic test in accordance with procedure set out in SRN 509 and shall be water-tight against a test pressure of 1.85 Pa. head of water.

7.6.4 Marker and Indicator Posts

Marker posts shall be erected at changes in direction of water mains as directed by the Engineer. Indicator posts shall be erected at valves and other fittings as directed

Marker and indicator posts shall be embedded in concrete as shown on drawings and shall be vibrated precast reinforced concrete as per dimensions shown on drawings. They should be painted in colours as indicated on the drawings.

7.7 Penstocks or Sluice Gates

Penstocks shall be single faced cast iron gates with non-rising spindle complete with extension spindle and removable handwheel all of approved manufacture.

7.8 Auxiliary Works

All works specified in this clause shall be with materials and workmanship as specified in Section 3: Builders Works.

7.8.1 Valve Chambers

Unless otherwise directed or detailed all valves, meters and other mechanical fittings shall be housed in chambers with lockable covers.

Valve work shall be so placed in chambers as to facilitate operation, meter reading etc. through the cover opening.

Chambers are measured in numbers and shall be priced as lump sum items covering all composite work as specified on the drawings inclusive of excavation in excess of trench excavation, concrete supports or valves, anchoring walls and backfilling around the chambers.

The depths stated on the drawings are normal depths. Actual depths depend on depth of pipes.

7.8.2 Thrust blocks and Anchors

If not instructed to do otherwise the Contractor shall provide thrust blocks at all bends, tees, ends and wherever shown on the drawings.

Enlargements shall be excavated in sides and bottom of the trench to accommodate anchorages and thrust blocks.

Concrete thrust and anchor blocks shall be formed in accordance with the typical sections shown on the Drawings or as directed by the Engineer. The additional excavation shall be made 'after the bends etc. have been jointed and the concrete shall be placed immediately after the completion of the excavation.

The back of supports and blocks shall abut on to solid ground, all loose material being removed before Concreting.

The concrete used for thrust and anchor blocks shall be of Grade 20 and shall after Placing be kept in view for not less than six hours. No pressure shall be applied in any section of mains until the concrete has cured at least three days.

All PVC material shall be wrapped with two layers of bituminous felt for the entire length in contact with concrete. Thrust blocks are measured in numbers and shall be priced as lump sum items covering all necessary works and materials together with excavation, backfilling and formwork.

Anchoring walls for valves are parts of the valve chambers and are included in the lump sum for valve chambers.

7.8.3 Road-Crossing

When the contractor encounters a road where a road crossing is indicated on the drawings or where to his opinion, such a crossing is required, he shall immediately

inform the Engineer. On receipt of the above information, the Engineer will issue appropriate instructions.

7.8.4 Painting

Painting and other protection of the external and internal surfaces shall be in accordance with, manufacturer's recommendations or as specified in Section 5 of these Specifications.

7.9 Testing of Pressure Mains

Pressure pipelines (together with all specials and valves incorporated in the mains) shall, before being covered, be tested with water as specified in CP 310.

At least two days' notice must be given in writing to the Engineer before pressure testing is commenced.

7.10 Water Pressure Test

The water test pressure to be applied will be 1.5 times the nominal working pressure for the class or pipe being tested. The Engineer however, reserves the rights to alter this figure.

Pressure testing of pipelines is not allowed against a closed valve. Mains shall be filled and tested in section of convenient lengths, which must not exceed 500 metres. Where pipes are laid with steep gradients the length of pipes tested at any one time shall, be as directed by the Engineer.

The ends of pipes under test shall be closed by means of caps or blank flanges provided by the Contractor. Gate valves must not be used for this purpose. All scour valves and air valves shall be replaced by blank flanges before commencement of the test.

After laying, jointing and anchoring, the main should be slowly and carefully charged with water so that all air is expelled, allowed to stand full for several days and then be tested under pressure. The test pressure shall be applied by means of a manually-operated test pump connected to the main and to two parallel installed pressure gauges calibrated at an approved testing laboratory. The test pressure shall be maintained for five hours, and if there is any leakage, it shall be measured by the quantity of water pumped into the main in order to maintain the test pressure.

The permissible leakage of water which is given in imperial units in CP 310 as 0.0375 litres per mm diameter per 1000 m length per 24 hours per 10m head of water.

The above maximum permissible leakage approximately corresponds to the following quantities of water over 100 length of pipe and 100m head 1 N/mm²).

Nominal diameter	Maximum amount of water Pumped of per hour at 100 m head per 100m length of pipe.
	litres
Ø50-mm	0.08
Ø80-mm	0.12
Ø100mm	0. 16
Ø150mm	0.24
Ø200mm	0.31
Ø250mm	0.40
Ø300mm	0.48

Should leakage of water occur at the joints, the joint shall be reassembled to eliminate such leakage or, should this not prove possible, the contractor shall supply and assemble new joints. Should any pipe or joint burst or should water leak or weep through the body of a pipe or joint the contractor shall forthwith remove the faulty pipe or joint and replace it with an un-faulty pipe or joint. In all above cases, the length under test shall be retested as above described and the process repeated, if necessary, until the pipeline satisfactorily withstands the prescribed test

The Contractor shall provide labour, install and work the test pump, pressure gauges and all other equipment required for the test, and he shall fill the pipes with water and subsequently empty them after the test, all to the approval of the Engineer. Water drained from the pipes shall be discharged in a way that does not affect the stability of the Works or adjacent structures.

The Contractor shall allow for all expenses in connection with testing in his rates for pipe laying.

7.11 Testing of Distribution System

If required by the Engineer the Contractor shall carry out and/or assist with the testing of the completed distribution system as directed by the Engineer in order to establish the flow characteristic of the pipelines as built.

The Contractor shall provide all transport, labour and other assistance requested by the Engineer, and the Contractor shall take delivery, install, remove and make good in connection with the installation of gauges and meters etc. for the purpose of the test.

7.12 Testing-of Sewer Pipes

All pipes and fittings shall be tested before being backfilled. The lines shall be tested in lengths between manholes or such shorter lengths as the Engineer may approve and in all cases the tests shall applied in the presence and to the satisfaction of the Engineer or his representative.

The testing shall be carried out as specified in CP301.

The requirements of CP301 correspond to the amounts of water indicated below.

Nominal diameter	maximum amount of water added per diameter of pipe 30 min. per 100 m length of pipe
Ø100 mm	3.0 litres
Ø150 mm	4.5 litres
Ø230mm	7.0 litres

Any length of pipeline which is found to be defective shall immediately be put in a sound and satisfactory Condition by repairing any defective part or if necessary by relaying whole of the defective length and again testing and so on until the test is satisfactory. Any pipe found to be partly or totally cracked after laying shall be replaced by another, unless the engineer approves the adoption of an alternative method of repair.

If the Engineer suspects that a pipeline has been damaged during concreting or backfilling, he may order the Contractor to re-test the suspected length. Should the re-test indicate that the line is no longer capable of withstanding the prescribed tests, the Contractor shall forthwith search for and repair the damage and re-test the pipeline until a satisfactory test is obtained.

All manholes must be constructed to be watertight. In general, manholes will be inspected visually and not be tested, but the Engineer reserves his right to direct the Contractor to test the manholes before backfilling the surrounding excavation in order that any necessary works of repair may be carried out prior to backfilling. Any such tests shall be carried out in accordance with such directions as the Engineer may issue.

The Contractor shall provide ample expanding stoppers for each diameter of pipe to be laid, together with such up stand tubes, U-tubes, pumps, labour and all required testing apparatus to the approval of the Engineer.

The Contractor shall be responsible for adequately strutting stoppers when pipelines are subjected to a water test, and he shall take adequate precautions to ensure against any stopper or strutting being carried into a downstream, pipe when the water is released.

The Contractor shall allow for all expenses in connection with testing in his rates for pipe laying.

7.13 Cleaning and Sterilization of Water supply pipes

The Contractor shall before be handing over and during the Maintenance period clean pipelines, chambers and manholes for all dirt and rubbish.

All pipes shall be thoroughly cleaned and washed out to remove all contamination, and all water from these operations shall be removed and drained away.

Sterilization should be carried out in accordance with CP 310.¹

Following the satisfactory cleansing the Contractor shall with the use of a portable dosage system - or by some other approved method introduce a solution of a sterilizing chemical containing chlorine into the pipeline. The solution shall be introduced at a very slow rate and shall be of such strength as to give a chlorine concentration of not less than 50ppm (parts per million) throughout the Length of the pipelines.

All taps on the distribution pipes shall be opened successively, working progressively away from the Place where the solution is introduced. Each tap shall be closed when the water discharged begins to smell of chlorine. The whole system shall then remain charged for 24 hours, after which a test shall be made for residual chlorine. If no residual chlorine is found, the sterilization process will have to be carried out again, until a satisfactory result is obtained. Finally, the pipes shall be thoroughly flushed out and recharged with supply water.

On completion of the sterilization process the pipes shall be left full of water.

The Contractor shall in his rates for pipe laying include all costs of labour, transport, materials, equipment, chemicals and water necessary for the satisfactory completion of the cleansing and sterilization operations.

7.14 Measurement and payments

a. Pipe- type and size

Unit: m

Different sizes and types pipes shall be measured in linear meter laid. The rate shall include the cost of providing; storing, handling, laying and jointing of pipes. The rates shall include for, cleansing and sterilizing all to the satisfaction of the engineer and complying this specification.

b. Pipe appurtenances and auxiliary works including Anchor blocks and chambers

Unit: No.

Pipe appurtenances and auxiliary works shall be measured by numbers provided and installed. The rate shall include the cost of providing; storing, handling, fixing

and constructing and jointing of appurtenances. The rates shall also include excavation, formworks, backfilling and requirements for complying with the requirements of this specification.

8

BUILDING STONE

All building stone shall be capable of withstanding when wet a crushing stress of 1.4 kg./sq.mm. The source of stone shall be approved by the Engineer and stone supplied therefrom shall be free from Magadi, overburden, mudstone, cracks, sandholes, veins, laminations or other imperfections.

The stone shall be chisel dressed into true rectangular blocks, with each surface even and at right angles to all adjoining surfaces, to the size specified. For exposed stonework the maximum permissible variation of any of the specified dimensions shall be 6mm provided that cut stone, supplied as 'rock face' stone may be hammer dressed on one face only, or on one face and one end, if in other respects it conforms with this specification. Stones shorter than 375mm will not be accepted.

Unless the Engineer allows otherwise the Contractor shall at his own expense provide and dress four 100mm cubes of stone for testing.

The stone shall be sound when tested in accordance with SRN 870 except that:-

- i) The treatment shall be repeated for 10 cycles only; and
- ii) The second criterion of failure shall be amended to allow for a loss of weight of not more than 20% of its original weight.

8.1 STONE DUST

Stone dust for blinding shall be blacktrap screened to the following grading:-

Passing 10mm sieve	100%
Passing No. 4 sieve	85% - 100%
Passing No. 100 sieve	5% - 25%

8.2 MURRAM

Murram shall be from an approved source quarried so as to exclude vegetable matter, loam, top soil or clay. The California Bearing Ratio of the murram, as determined for a sample compacted to maximum density (as defined under SRN 601) and allowed to soak in water for four days, shall not be less than 30%. This C.B.R. is a guide to quality only and the compaction in the work will be judged by density.

8.3 WATER FOR CEMENT TREATED MATERIALS

If water for the works is not available from the Employer's supply the Engineer's approval must be obtained regarding the source of supply and manner of its use. Water to be used with cement or lime shall be free from salt, oil, alkali, organic

matter, and other deleterious substances. If the water is required to be tested, this shall be done in accordance with SRN 114 : Tests for Water for Making Concrete, all to the cost of the Contractor.

8.4 CEMENT MORTAR

Cement mortar shall consist of proportions by volume as specified of Portland Cement and natural sand or crushed natural stone or a combination of both as specified in SRN 135 and SRN 136 : Building Sands from Natural Sources. The constituent materials shall be accurately gauged and mixed in an approved manner.

Cement mortar shall be made in small quantities only as and when required, and any mortar which has begun to set or which has been mixed for a period of more than one hour shall be rejected.

8.5 HYDRATED LIME

Hydrated lime shall comply with SRN 801 : Building Limes, and shall be of the semi-hydrated type.

8.6 CALCIUM CHLORIDE

Calcium chloride shall be of good industrial grade, and shall be obtained from an approved source.

8.7 LIME MORTAR

Lime mortar shall consist of proportions by volume as specified of hydrated lime and naturals and/or crushed natural stone or a combination of both as specified for cement mortar in Clause 729. The constituent materials shall be accurately gauged and mixed in an approved manner.

8.8 CEMENT-LIME MORTAR

Cement-lime mortar shall consist of Portland Cement, hydrated lime and natural sand or crushed natural stone or a combination of both, as specified for cement mortar in Clause 707. The constituent materials shall be accurately gauged and mixed by volume in an approved manner in the proportions specified.

Cement-lime mortar shall be made only in small quantities as and when required. Any mortar which has begun to set or which has been mixed for a period of more than two hours shall be rejected.

8.9 CEMENT GROUT

Cement grout shall consist of Portland Cement and water mixed in the proportion of one part by volume of cement and one and a half parts by volume of water. The grout shall be used within one hour of mixing.

8.10 CAST STONE

Cast stone shall be manufactured by an approved manufacturer to the shapes and dimensions shown on the drawings, and shall conform to the requirements of SRN 871 : Cast Stone. It shall have a dense and even surface of the texture and colour detailed on the drawings or required by the Engineer. Where indicated exposed faces of the stone shall be formed of a specially graded mix. Metal bond ties of approved manufacture shall be cast in with the stone as shown on the drawings. Samples of the completed stone shall be submitted for the Engineer's prior approval.

All stones shall be protected from damage during transport and erection by means of cement slurry coatings or by other approved methods.

8.11 STRUCTURAL STEEL FOR WELDED WORK

Structural steel for riveted and welded work shall comply with the requirements of SRN 125 : Structural Steel, SRN 126 : The Use of Structural Steel in Building and for Welded Work, SRN 125 : High Yield Stress and High Tensile Structural Steel, High Tensile (Fusion Welding Quality) Structural Steel for Bridges, etc. and General Building Construction.

8.12 WATERPROOF UNDERLAY

Waterproof underlay shall consist of either waterproof paper complying with SRN 856 : Waterproof Building Paper, containing approved fibrous reinforcement, or 500 gauge polythene sheeting as stated in the Bill of Quantities.

8.13 PREFORMED JOINT FILLER

Preformed joint filler shall be of the thickness shown on the drawings or as stated in the Bill of Quantities.

The material comprising joint filler shall be as stated on the drawings or approved by the Engineer.

8.14 JOINT PRIMER

Joint priming compound shall be entirely in accordance with the manufacturer's recommendations for the joint sealant to be used.

8.15 JOINT SEALING COMPOUND

Poured joint sealing material shall consist of an approved rubber-bitumen compound, complying with the requirements of SRN 879, or a two component, cold applied compound complying with SRN 879 as stated in the Bill of Quantities. Test Certificates, prepared by an approved testing laboratory, shall be supplied by the Contractor to show that the material does in fact comply in respect of cone penetration, flow and bond with the under-mentioned requirements:

Test Cone Penetration

0.15 kg. for 5 secs. at 25o centigrade using standard grease cone Hot-poured Materials

Penetration not to exceed 9mm Cold-poured Materials

Penetration to be not less than 5mm not more than 27.5mm

Flow

On a plane inclined at 75o to the horizontal, 5 hours at 60o centigrade

Flow not to exceed 5mm

Flow not to exceed 20mm

Bond

25mm wide joint extended 12mm at rate of 4mm per hour at 18o centigrade. No more than one specimen in three to develop a crack separation or other opening more than 4mm deep

Five cycles of extension and recompression

Three cycles of extension and recompression

Approved hot-poured materials shall also comply with a requirement whereby when heated for a period of 6 hours at a temperature of 80 degrees centigrade above recommended pouring temperature or 30 degrees centigrade below the safe heating temperature whichever is the greater shall still comply with the flow requirements of this clause.

In addition to materials complying with SRN 879, the Engineer may approve the use of alternative materials provided that they meet the requirements of this clause relating to cold-poured joint sealing compounds.

8.16 CONCRETE SLABS FOR OPEN DRAINS

Precast concrete slabs for lining open drains shall be manufactured to the detail drawings supplied from concrete Class 20/10 using maximum 12mm size aggregates. If required, cube test certificates shall be supplied by the manufacturer.

8.17 TIMBER

Timber shall be sound, well-seasoned and entirely free from worm, beetle, warps, shakes, splits, and all forms of rot and deadwood. Where required, all timber shall

be treated with creosote, as specified in SRN 872 : Coal Tar Creosote for the Preservation of Timber or an alternative approved timber preservative.

8.18 WATER BARS

Water bars shall be “Dumbell” type and be of natural or synthetic rubber or extruded PVC. They shall be flexible, tough, elastic and durable and of dimensions detailed. They should be unaffected on contact with dilute acids or alkalis. Joints and junctions shall, when possible, be prefabricated by the manufacturer, but if made at site the manufacturer’s instructions including recommended adhesives shall be followed and used. Samples shall be submitted for approval of the Engineer before use of any material.

8.19 MEASUREMENT AND PAYMENT

All items for measurement and payment are provided under the relevant sections of the Bills of Quantities. The rate provided by the contractor in the bill of quantities shall be deemed to cover the cost of complying with all the requirements in this section of the specification.

9 EXTERNAL WORKS

All materials and workmanship not described in this section are deemed to comply to the relevant specifications of the work in hand contained in other sections of these specifications

9.1 Roads and Paved Areas

Work shall be carried out in accordance with the *Standard Specifications referred to in this document is the Standard Specification for Road and Bridge Construction, 1986 Edition published by the Ministry of Transport and Communications. This document shall form part of the Contract.*

9.2 Fencing

All fencing shall be erected in exact vertical position and to straight lines as shown on the drawings. The materials and workmanship shall comply with the recommendations in BS 1722.

9.3 Concrete Posts

Precast concrete posts shall be cast of concrete Grade 20 as specified in Section 4, to the sizes shown on the drawings.

The posts shall be securely placed in preformed holes and cast in concrete to depth as shown on the drawings.

Bracings shall be provided at all corners, and at intervals of not more than 50 metres on straight lines of fencing. Maximum distance between posts is 4.5m concrete posts and bracings are measured in numbers, and the rate shall include for supply, excavation, erection and backfilling.

9.4 Chain Link

The chain link fencing shall be supplied in rolls of 2130mm (7 feet) width and shall be with 65mm mesh of 12 ½ gauge, fitted to 4 rows of line wires with binding wire at 130mm centres.

The cranked top of the posts shall be fitted with 3 strands of 12 ½ gauge barbed wire with four point barbs at 150mm centres. All members of the fencing shall be hot dip galvanized.

Fencing is measured in linear metres and the rate shall include all waste and cutting, as well as fixings to posts and all line wires, barbed wires and binding wires.

9.5 Gates

If not otherwise stated gates shall be 4 metres wide double leaf gates, made from 40mm galvanized steel tube frame (medium class) with 8 gauge galvanized weldmesh welded to the frame. Bracings, hinges, towerbolts and locking arrangement shall be as shown on the drawings or of other approved type. The top

of the gates shall be fitted with 3 strands of 12 ½ gauge barbed wire. The price for the gate shall include for the manufacture, installation, all bolts and padlocks etc. and painting all as shown on the drawing. Gate posts made of rolled hollow square sections as shown on the drawings are measured separately.

9.6 Measurement and payments

Roadworks are measured as covered area in square metres. Lines of paving slabs and kerb stones are measured in linear metres, and the rates shall cover for all cutting, waste and bedding etc.

Fence shall be measured in linear meters constructed. And gates shall be measured in numbers.

10 MECHANICAL AND ELECTRICAL WORKS

10.1 Scope of Work

The work to be performed under this section consists of the assembling and installation of supplied equipment and piping material as shown on the drawings or specified or directed by the Engineer like pumps, vessels, hoists, process equipment, station piping, etc. It shall include transportation, testing, assembling, furnishing, first filling with all needed operation means, of all materials, equipment and accessories required for completing the specified equipment. It shall include, but shall not be limited to, the following parts: All field screws and bolts, electrodes for welding, anchor bolts, protective painting against corrosion, etc.

The Contractor shall strictly observe the related specifications and shall carry out all work in a skilled and workmanlike manner in keeping with modern methods of construction. The Contractor has particularly to observe all instruction for installations defined by the manufacturer/supplier of the equipment.

Only materials approved and accepted by the Engineer shall be supplied and installed. Materials which are rejected shall immediately be removed from the Site at the cost of the Contractor.

The equipment shall be delivered fully cleaned and flushed for immediate service. The equipment shall be properly preserved for transport and storage.

A complete set of pipe work, fittings and jointing materials shall be provided as necessary for all equipment, and unless otherwise specified shall terminate 250 mm outside the building or at the pumping main or other suction or discharge systems with a plain end suitable for connection.

Where the equipment is manufactured to require special tools for maintenance other than those normally available commercially, the Contractor shall supply one complete set of special wrenches or other special tools necessary for the assembly, adjustment, and dismantling of the equipment. All tools shall be of best quality hardened steel forgings with bright, finished heads and with work faces dressed to fit nuts. The set of tools shall be neatly mounted in a labelled tool box of suitable design provided with a hinged cover.

The Contractor shall obtain and submit from the manufacturer a list of suggested spare parts for each piece of equipment which are required for two years of operation. After approval, Contractor shall furnish such spare parts suitably packaged, identified with the equipment number, and labelled. Contractor shall also furnish the name, address, and telephone number of the nearest distributor for each piece of equipment. All spare parts are intended for use by the Employer, only, after expiration of the guarantee period. Any spare parts which the Engineer permits the Contractor to use for start-up activities shall be replaced by the Contractor prior to the Employer's acceptance of beneficial use of the equipment.

Further to the above, auxiliary works to be included in the tender for mechanical and process equipment including associated pipework shall comprise, among others, the following works and commitments:

- i. establishment of shop drawings and all details for any components.
- ii. transportation from manufacturing plant to Site including packing, handling, off-loading, adequate storing and protection against damage and spoiling;
- iii. all erection equipment for assembling the steel structure;
- iv. all connecting components, such as bolts, rivets, nuts, washers, shims, welding rods, etc., required for completing the job;
- v. all drilling, welding, wedging, plumbing, levelling, alignment etc., required for completing the work;
- vi. training of welders, if required;
- vii. provision of all instruments, gauges and other appliances for inspection and testing of the structures by the Engineer or any assigned authority including all ancillary access supports; and

All data plates shall be of stainless steel suitably attached to the equipment. Data plates shall contain the manufacturer's name, main data as e.g. pump size and type, serial number, speed, impeller diameter, capacity and head rating, and other pertinent data

The workmanship and materials covered by this section shall include the supply and installation of all pumps, motors, engines and chemical dosers and ancillary equipment.

All materials and equipment shall be obtained from reputable manufactures, who have well established agents in Kenya. The local agents shall be able to provide an efficient service of the equipment and must have ample stocks of all expendable items such as gaskets, filters, fuses, indicator lamps, coils etc.

The Engineer reserves his right to reject manufactures or agents not fulfilling the above requirements.

It is the responsibility of the Contractor to provide evidence that the equipment is in compliance with these specifications, and that the equipment will operate satisfactorily under the conditions under which it is installed. All equipment offered shall comprise a complete installation such as bolts, gaskets, protective screens, belt guards, exhausters, painting etc. all to the satisfaction of the Engineer.

Details of concrete plinths for pumps and motors shall be supplied by the Contractor at least 6 weeks before he intends to install the equipment for the approval of the Engineer.

10.2 Trade Names

Subject to the provision of the preceding paragraph and anything hereafter to the contrary trade names or manufacturer's catalogue numbers are mentioned in these

Conditions, the reference is intended as a guide to the type of article or quality of material required. The Contractor may use any article or material equal to type or quality to those herein described subject to the prior approval of the Engineer and at his absolute discretion. The onus of proof as to equivalent quality will rest with the Contractor, whose Tender will be deemed to include for the makes described hereafter.

10.3 Spare Parts

The Contractor shall submit with his Tender a guarantee from the suppliers that he will hold a sufficient number of spare parts as recommended by the manufacturer for the maintenance of the equipment

10.4 Storage of Materials

The Contractor shall provide weather-proof lockable sheds for the safe storage and custody of materials for the Works and shall move such sheds and make good damaged or disturbed surfaces upon completion to the satisfaction of the Engineer.

10.5 Testing

The Engineer shall be entitled at all reasonable times during manufacture to inspect, examine and test on the Contractor's premises, the materials and workmanship of all Plant to be supplied under the Contract, and if part of the said Plant is being manufactured on other premises the Contractor shall obtain for the Engineer permission to inspect, examine and test as if the said Plant were being manufactured on the Contractor's premises. Such inspection, examination or testing if made shall not release the Contractor from any obligation under the Contract.

The Contractor shall carry out at his own expense any tests he may deem necessary to satisfy himself upon the quality of materials and workmanship.

Performance tests shall be carried out for all mechanical and electrical equipment to ensure that the equipment comply with the specifications.

The duration of the performance tests shall be 24 hours.

The Contractor shall include for the necessary labour and instruments, for carrying out these tests, and he shall be responsible for the discharge of water during tests.

The Contractor shall give the Engineer reasonable notice in writing of the date on and the place at which any Plant will be ready for testing as provided in the Contract. If the Engineer so desires to witness the testing the Contractor will facilitate necessary arrangements to enable the Engineer to attend.

The Contractor shall submit to the Engineer all the relevant manufacturers certified tests results and certificates for records.

10.6 Drawings

The Works shown on the drawings are for tendering purposes only and it is the Contractor's responsibility to provide detailed drawings of the works he proposes to use. It is the Contractor's responsibility to see that all openings, processes, channels, conduits etc. in the structures are so located and installed as to fit and function properly with the mechanical and electrical installations.

The Contractor shall include in his rates for the preparation of all necessary detail or workshop drawings required for the manufacture and erection of the installation and such drawings are to be submitted to the Engineer for approval prior to the commencement of manufacture or installation.

Upon completion of the Works the Contractor shall submit "as built" drawings to the Engineer for his approval.

The Contractor shall be responsible for any discrepancies, errors, or omissions in the drawings and other particulars supplied by him. If such discrepancies, errors, or omissions are due to inaccurate information or particulars furnished in writing to the Contractor by the Engineer, The Employer shall be responsible. The Employer shall pay any extra cost reasonable incurred by the Contractor due to any alterations of the work necessitated by reason of inaccurate information so supplied to the Contractor.

10.7 Description of Services

The Contractor shall supply, transport, deliver, install, connect, commission and hand over all equipment and materials specified in the Specifications, Drawings and Bills of Quantities, in a clean, complete and in every detail working condition. He shall carry out all tests specified in these Specifications or in relevant British Standards together with any test which might be requested by the Engineer in connection with the use of special materials or equipment. Furthermore, the Contractor shall provide Guarantee, Initial Free Maintenance, instruction Manual and careful instruction to the Employer's staff.

Cost of all the aforementioned materials and services together with all necessary labour, overheads and profits, duties, sales tax, etc. shall be deemed to be included in the rates entered into the Bills of Quantities.

10.8 Maintenance

The Contractor has the liability for defects and maintains all works, equipment and electrical installations for a period of **twenty-four** calendar months from the date that the Works are handed over to the Employer. All expendable items, such as gaskets, filters, fuses, indicator lamps, relays, coils, switches, oils tests etc. are to be supplied by the Contractor.

In case permanent power supply is not made available in time for testing various equipment, the Contractor, if he intends to clear out the site, should make his own arrangement for testing the equipment and should again return to site for final testing when permanent power is made available.

No extra payment will be made for the above.

The Contractor shall be held responsible for and shall make good all defects in materials and workmanship that appear during the maintenance periods. The period of liability shall not end until all defects which appear during the defect notification period have been rectified.

In the event of equipment being out of operation due to breakdown for a duration exceeding one week, the defect notification period for that equipment will be extended with a period of the same duration.

10.9 Initial Maintenance Period

The Contractor shall during the twenty-four months' defect notification period carry out all necessary adjustments and repairs, cleaning and lubricating etc. A report of any work done shall be submitted to the Employer and incorporated in the maintenance records.

The Contractor shall inform the Employer before any routine maintenance inspections are carried out, so the Employer can have staff available to attend. Any item of material found to be defective shall be replaced by the Contractor within seven days of being notified and any results of defective workmanship shall be rectified including the supply of new parts if necessary.

The Contractor shall allow in his contract price for the maintenance and inspection service and shall provide for all labour, tools, instruments and plant and the transportation thereof, as required for the satisfactory execution of these obligations, and for the provision, use and installation of all materials such as oils, greases, etc. and parts which are periodically renewed such as relay contacts or parts which are faulty for any reason.

10.10 Maintenance and Servicing after Initial defect notification Period

The Contractor shall if requested enter into a maintenance and service agreement with the Employer for a period of up to five years from the last day of the maintenance period. Such an agreement shall offer the same services specified above under "Initial defect notification Period".

10.11 Maintenance Manual

Upon completion the Contractor shall furnish to the Engineer six copies of a manual containing all the following items: -

- a. Description of equipment
- b. Full operation and maintenance instructions
- c. Valve operation
- d. Fault-finding chart
- e. Emergency procedure
- f. Maintenance and service periods

- g. Lubricating instruction
- h. Colour code legend
- i. Primary and secondary spares
- j. Recording drawings

The manual shall be specifically written and not a standard manufacturer's manual unless approved by the Engineer.

Tags giving instructions are not sufficient. All instructions shall be written into the manual with reference to the drawings. All valves terminals and controls on the plant shall be labelled to correspond with the maintenance and operation manual.

The works shall not be considered to be complete for purpose of taking over until such instructions and drawings have been supplied to the Employer and approved by the Engineer.

10.12 Motors

All motors shall unless otherwise stated be suitable for 415/240 volts, 3 phases, 50 cycles, 4 wires power supply, and shall be executed for star-delta starters as specified.

The motors shall be constructed in accordance with CP 1015, and shall be protected as specified in section 11 – Electrical Works.

The motor speed shall not exceed 2900 R.P.M. low speed motor especially 1500 R.P.M shall be preferred.

The motor shall be foot mounted, squirrel caged, drip-proof, or totally enclosed suitable for an ambient temperature of 30° C, the motor shall be designed for continuous running. Each motor shall be capable of an overload of 10% above its rated output at the rated voltage for a period of one hour without sustaining damage.

The rated output of the motor shall be the maximum horsepower absorbed by the pump under the described condition of head and discharge, plus an allowance for loss of power in couplings etc.

Electrically driven pumps shall if not otherwise stated be directly couple via flexible couplings to the motors, and motors and pumps shall be fitted to common rigid steel frames bolted to concrete plinths.

Proper alignment of motor and pump must be guaranteed.

10.13 Generator

The generator shall be rated 400V, 50 HZ with a prime rating of 200 KVA and a stand by rating of 223 KVA

The applicable voltage range of 380 to 415 Volts and a speed of 1500 rpm, The Generator shall be obtained from reputable manufactures, who have well established agents in Kenya. The local agents shall be able to provide an efficient service of the equipment and must have ample stocks of all expendable items such as gaskets, filters, fuses, indicator lamps, coils etc.

The engines shall be of the diesel type with a maximum speed of 1500 R.P.M designed for continuous running.

The engines shall be suitable for electric start, couplings, tachometer, hand throttle control, hand stop control, silencer, fuel tank for at least 300 hours running of one of the engines and necessary tool kit for minor repair.

10.14 Pressure Gauges

The pressure gauges shall be mounted on the delivery side of pumps. The gauges shall be in metric units complete with necessary fittings and isolating cock. The Gauges shall be fitted with dampening fluid.

11 ELECTRICAL WORKS

11.1 General

The quality of materials and workmanship specified in this section is for all items forming part of the electrical installation as shown in the Drawings, Bills of Quantities and this Specifications.

11.2 Regulations

All the Electrical Works shall be carried out strictly in accordance with the following: -

- i) The 13th Edition of the "Regulations for the Electrical Equipment of Buildings" issued by the Institute of Electrical Engineers of Great Britain with Kenya amendments.
- ii) The Licensee's By-Laws
- iii) The Government Electrical Specification (G.E.S. No 1 and No. 2).
- iv) The Power Act
- v) Relevant British Standard Specifications and Codes of Practice published by the British Institution (hereafter referred to as BS and GP, respectively).
- vi) The Specifications
- vii) The Contract Drawings and the working drawings, produced by the Contractor and approved by the Engineer.
- viii) The Engineer's instructions

The Contractor shall undertake all modifications demanded by the authorities in order to comply with the regulations, and produce all certificates, if any, from the authorities without extra charge.

After completion of the work, the Contractor shall deliver a complete set of “as built” drawings showing the complete installation including all alternations and modifications. The set of drawings shall include but is not limited to all floor plans and diagrams.

11.3 Extent of Electrical Work Within Contract

The electrical works in the proposed development are required to be complete in all respects as specified herein and shall include all items of equipment, materials, accessories, switchgear, lighting fittings, cables, labour, etc., necessary whether such items are specifically referred in the Contract or not. The Contractor shall be deemed to have included in his Tender, price for all items necessary such that the installations are complete in all respects and left in a satisfactory working order.

The Contractor will be responsible for liaison with the Kenya Power & Lighting Company Limited and the Kenya Posts & Telecommunications Corporation to suit the incoming power and telephone requirements.

The Contractor shall include for all Civil Works, Structures, Foundations, Builder's Works and associated requirements for the mounting, housing and support of all items of plant and equipment supplied and installed under this Contract. The concrete foundation will be to approved manufacturer's details and instructions.

All work and materials are to be of the best quality approved by the Engineer and strictly in accordance with the Specification.

In the event of any portion of the work or materials failing to pass the tests specified herein, or set forth in the Maker's list for that particular item, the Engineer may at his discretion, reject that portion of the work or material entirely.

11.4 Materials

All materials, fittings and accessories are to be new and in accordance with the requirements of the current rules and regulations where such exist, and with the relevant British Standard Specification.

Uniformity of type and manufacture of fittings or accessories is to be preserved as far as practicable throughout the whole work.

Wherever in this Specification the practice is adopted of specifying a particular item as 'similar' to that listed in a particular firm's catalogue, it is to be clearly understood that this is to indicate the type and quality of the equipment required. No attempt is being made to give preference to the equipment supplied by the firm whose catalogue is quoted.

Where particular manufactures are specified herein, no alternative makes will be considered without weighty reasons and the Engineer shall have the right to reject any other makes.

The Contractor shall if required by the Engineer submit samples of materials for their approval before placing an order.

The Contractor will be entirely responsible for all materials; apparatus, equipment etc. furnished by him in connection with his work, and shall take all special care to protect all parts of finished work from damage until handed over to the Employer.

The work shall be carried out by competent workmen under skilled and experienced supervision. The Engineer shall have the right to have any part of the work taken down or changed at the Contractor's expense which is executed in an unsatisfactory manner.

Such materials supplied by others for installation and/or connection by the Contractor shall be carefully examined before installation and connection. Any defects noted shall immediately be reported to the Engineer.

Conduit fittings shall be the same metal as the conduit to which they are connected except that Zinc-alloy OR Aluminium-alloy fittings may be used with steel conduits.

Conduit fittings and accessories shall conform to the appropriate Standard. Conduits shall be mechanically and electrically continuous.

All bends and sets shall be made cold without altering the section of the conduit. The inner radius of the bend shall not be less than two and a half times the outside diameter of the conduit. Not more than two right angle bends will be permitted without the inter-position of the draw-in box. Where straight runs are installed draw-in boxes shall be provided at distance not exceeding 12m. Tees, elbows or sleeves of either inspection or solid type will not be permitted.

Conduits which terminate in fuse gear, distribution boards, adaptable boxes, non-spout switches, trunking, etc., shall be connected thereto by means of screwed sockets and smooth bore brass male bushes.

Where conduits are installed flush in floor slabs or in chases in walls, they shall be held firmly in position by means of substantial pipe hooks driven into wooden plugs. Where conduits are installed on surface they shall be fixed with spacer bar saddles at a distance not exceeding one metre. Conduits shall be installed entirely separate and at least 150mm clear of the hot water and steam pipes and at least 75mm clear of cold water and other services.

The Electrical Contractor shall be responsible to ascertain from site details of reinforced concrete and structural steel work and to check from the Main Contractor's drawings the positions of walls, structural concrete and steel work

finishes, etc. No reinforced concrete or steelwork shall be drilled without obtaining permission from the Structural Engineer.

All the circular conduit boxes shall be of a malleable iron conforming to SRN 052 with 50mm fixing centres fitted with H.G. lids where required. They shall be long spouts internally threaded. Deep boxes or extension rings on standard circular boxes shall be used where necessary in order to bring the front face of each box flush with the ceiling or wall.

Conduit boxes installed externally shall be galvanised and where subjected to direct weather conditions they shall be compound filled.

Where the words or other approved or equal are used, they shall mean any make of equal quality but the written approval of the Engineer for the use of such alternative shall be obtained prior to their use in the installation. In the absence of any such request, the Engineer is entitled to suppose that materials used are specified.

11.5 Workmanship

The routes of services and approximate positions of apparatus are shown on the Contract Drawings, but their exact positions shall be determined by approved dimensional details on working drawings or on site by the Engineer in consultation with the Contractor.

The Contractor shall ascertain on site that his work will not foul other services and in all cases the services through the ducts must be readily accessible for maintenance. Any work which has to be re-done due to negligence in this respect will be his responsibility.

The Contractor will be deemed to have allowed in his tender for locating terminal points of services e.g. lighting switches, socket outlets, lighting points) in positions 1 metre horizontally and vertically from the locations shown on Contract Drawings. Within these limits no variation in the Contract sum will be made unless the work has already been executed in accordance with previously approved working drawings or with the Engineer's approval.

The Contractor will be responsible for the provision of all cable ducts and trenches and for their installation, unless otherwise stated in the Specification or Contract Drawings.

The Contractor shall include in his tender for the plugging of all walls, ceilings and floors to facilitate the fixing of the conduits accessories and all other portions of the electrical installations. Any purpose made fixing brackets shall also be provided and installed by the Contractor.

The Contractor shall also be responsible for ensuring that runs for floor or wall chase, holes to be cut or left, will be marked out at the appropriate stage of the structural works.

The Contractor shall be responsible for all cutting away and making good.

The Contractor shall pay particular attention to the fixing and alignment of switch, socket, telephone and similar boxes.

Where conduits are concealed, the boxes shall be in an exact position relative to the finished plaster or such other finish as may be applied to enable cover plates to be accurately positioned

11.6 Working Drawings

The Contractor shall prepare working drawings as necessary and shall submit to the Engineer for approval.

Working drawings in triplicate shall include, but not be restricted to the following:

-

1. Shop floor drawing or Switchboard and Control Panels.
2. Such other drawings as called for in the Specification or as the Engineer may require.

Approval by the Engineer of the working drawings shall not relieve the Contractor of his obligations under this Contract nor relieve him from correcting any error found subsequently in the approved working drawings.

11.7 Record Drawings

The Contractor shall keep on site at all times a complete set of the drawings relative to this Contract, and as the Contract works are proceeded with, indicate in red colour on such drawings, any variations to the Contract works as executed from those shown on the Contract Drawings. The 'As Built' drawings shall be submitted to the Engineer on completion of works or when demanded in writing. A minimum of three sets of 'As Built' drawings shall be provided.

11.8 Testing

On completion of the electrical installation work the installation shall be subject to the following test as laid down in the I.E.E. Regulations and Electric Power Act in the presence of the Engineer or his representative.

- a) Insulation Test
- b) Polarity Test
- c) Earth Loop Impedance Test
- d) Earth Electrode Test

Any other test which may be required by the Engineer. The results of all the tests shall be recorded on a Test Certificate to be signed by the Contractor and

submitted to the Client for record. The original of the Test Certificate shall be submitted to the Kenya Power & Lighting Co. Ltd. together with a Completion Certificate.

The Contract works shall not be considered complete until all testing has been completed to the satisfaction of the Engineer and the Record Drawings have been approved as installed and all specified spares have been provided.

11.9 Main Switchboard

The main switchboard shall be freestanding type switchboard, with front access.

The switchboard shall be constructed, fully wired and checked out at the factory and shall require a minimum of installation work on site. Modular construction shall be used wherever practicable and provision shall be made for simplified servicing, replacement and maintenance throughout without major dismantling.

The enclosures shall be suitable for containing circuit breakers, motor starters and metering equipment from Kenya Power. Where spaces on the switchboard are provided for future circuit components, all ancillary parts shall be installed initially. Full safety precautions shall be provided in all cases.

The switchboard shall be dust and vermin proof and shall have a flexibility of unit arrangement so that extension in the future is possible

Provision for conduit and cable entries shall be made at both top and bottom.

Removable insulated shields shall be provided for protection against contact live parts. All panel components shall be of a sufficient mechanical strength to withstand the influences of short circuits.

All bus-bars and bus-bar connections shall consist of high conductivity copper or aluminium and be provided in accordance with BS 159. The bus-bars shall be clearly marked with the appropriate phase and neutral colours which should be Red, Yellow and blue for the phases and Black for the neutral. The bus-bars shall be so arranged in the switchboard that extension may be made in the future on both sides. Bus-bars shall be rated at the nominated current of the main switch in their entire length.

All wiring within the panel shall be orderly laced and bonded to the panel structure, wiring insulation being coloured according to the colour code. Where single core cables are used special care shall be taken to prevent hysteresis.

A high conductivity copper earthing bar shall be provided for the full length of the board and all fuse switch units and circuit breakers shall be bonded to this bar.

A wall mounted steel cabinet with a complete set of spare fuses for the main switchboard shall be provided by the Contractor.

All switches, switch fuses, circuit breakers etc. shall be numbered with engraved plastic labels in white letters on black background.

Where wiring passes through holes in metalworks, protection by rubber pushes shall be provided.

11.10 M.V. Switchboard

This shall be self-supporting, floor mounted, totally enclosed, dust-proof, air-insulated cubicle type switchboard complying with SRN 027 designed for use of 415/440 volts, 3 phase, 50 cycles, 4-wire A.C. System and having a short circuit rating of 31 MVA at low power factor. The switchboard shall be fully front access or near access as instructed by the Engineer.

The switchboard shall be completely wired internally using manufacturer's links for connections between busbar and switch fuses.

The switchboard shall be complete with labels and ready for installation. The fuse switch shall be with H.R.C. fuses with fully interlocked front door and conforming to SRN 007 on moulded case circuit breakers conforming to SRN 040.

The busbars shall be of high conductivity copper and shall be manufactured and tested in accordance with SRN 053. They shall be mounted fully enclosed within the main enclosure of the switchboard in separate chamber in accordance with SRN 027. The busbars shall be fully separated from the incoming and outgoing cable areas. Except for instrument, potential or current connections, which shall be clamped in position and of minimum length, no circuit wiring shall be within the busbar chamber. Such wiring shall be protected with fuses where necessary as called for by the Engineer.

Interconnections between busbars and switchgear shall be of minimum length, properly insulated and rigidly supported.

All contact areas of the busbar and the connections fastened to the busbars shall be heavily plated. Joints and connections shall be rigidly made with clamps, bolts and nuts with spring washers.

11.11 Switchgear

Control voltage of all contactors, automatic switchgear and motor protection gears shall be 220V to 250V. The short-circuiting capacity of all circuit breakers, switch gears and motor control gears shall be in accordance with BS 5419.

All fused switch units shall be supplied and installed complete with Class 'Q' H.R.C. cartridge fuse links complying with BS 88, and shall be contained in metal clad, dustproof, gasket sealed individual enclosures with non-detachable steel operating handles which shall be capable of being locked in the 'off' position.

The fused switch units shall have fault ratings at least equal to the fault rating of the switchboard in which they are to be installed.

Moulded case circuit breakers (M.C.C.B) shall comply with BS 4752 and the following requirements:

- a) Each M.C.C.B shall be triple pole with pole internally ganged and operated by one central toggle.
- b) Each pole shall have a separate thermal and separate magnetic tripping mechanism, both of which shall preferably be adjustable. The toggle assemblies of all three poles shall be internally mechanically interlinked for simultaneous isolation of all three poles under fault conditions, and be so arranged that the overload tripping characteristics calibrations of each pole shall be completely unaffected by the loading of its neighbouring pole or poles.
- c) The tripping mechanisms and calibrations shall be unaffected by fluctuating and high ambient temperature. The M.C.C.B.'s shall have a certified short circuit breaking capacity of at least 15,000 Amps (at 480 Volts and 0.3 power factor).
- d) Circuit breakers of 100A frame size larger shall have interchangeable over current trip units and adjustable instantaneous trip units.

11.12 Motor Starters

Motor starters for the backwash pumps shall be automatic star delta type fitted with double pole incoming mechanically interlocked circuit breaker housed in a damp and dust proof steel enclosure.

Overload protection shall be provided by a solid state current operated relay as manufacture Omron or equivalent. Backwash pumps shall be stopped automatically by use of float switch installed inside the elevated tank. Two spare relays together with two current connectors shall be provided by the Contractor.

Terminals shall be easily accessible and have adequate clearances between phase and earth. Each starter shall be fitted with start/stop bush buttons with indicator light for running.

11.13 Distribution Boards

The distribution boards shall be as shown on the relevant drawings. The distribution boards are specified as Crabtree metal-clad for flush or cubicle mounting.

Where the requirement for miniature circuit breakers is indicated on the Drawings, the distribution boards shall be fitted with moulded thermo-plastic units of the combined thermal overload and magnetic short circuit tripping type to BS 3871 Part I having clearly marked 'ON' and 'OFF' positions. MCB's of all ratings shall have a minimum short circuit current breaking capacity of 3,000 A for single pole breakers and 4,000 A for triple pole breakers.

11.14 Wiring

All wiring must be carried out in P.V.C single core, copper cables to British Standard.

The wiring throughout shall be carried out by looping cables from point to point and no tees or other joint will be permitted. The entire wiring shall be so organized that later change and renewal can take place without cutting down structural parts. The Contractor must allow in his Tender for all measures of efficient fixing of all wiring items.

The Contractor shall comply with colour code requirements of the regulations.

Low voltage cables and medium voltage cables shall be enclosed in entirely separate conduits.

All cables shall be drawn-in after the installation of the entire conduit system, and after plaster has dried out. Draw wires shall not be threaded in at the time of conduit installation.

Great care shall be taken to ensure that no crossed cables are allowed to enter conduits.

11.15 General Wiring

The wiring throughout shall be in looping cables from point to point and no tee or other joints shall be permitted. Conductors of the same circuit shall be contained in the same conduit of trunking. At distribution boards, the neutral conductors shall be connected to the neutral bar in the same sequence as the line conductors connected to fuses or circuit breakers so that they can be readily identified.

a) PVC Cables in Conduit

PVC cables in conduits unless otherwise specified shall conform to SRN 055, 600/1000 volts grade, single core PVC insulated. No cable smaller than 1.5mm² shall be used in the installation.

b) Flexible Cord

Flexible cords shall be of 300 volts grade, V.R.I. OR PVC insulated conforming to SRN 056. No flexible cord shall be smaller than 0.72mm² (24/0.20mm).

c) PVC

These cables shall be 600/1000 volt grade, conforming to SRN 024 having standard copper conductors with PVC insulation, cores laid up circular, PVC sheath beading, single wire armour and PVC sheath. The cables shall be terminated on distribution boards, switchboards, trunking or adaptable box with compression type brass gland with locknuts and shroud.

d) PVC Armoured Cables (with Aluminium Conductors)

These cables shall be 600/1000 volt grade, conforming to SRN 063 having cores of solid Aluminium conductors, insulated with PVC, armoured with aluminium strip or steel wire with PVC sheath overall.

e) M.I.C.C. Cables

These cables shall be 440 or 660 volt grade consisting of high conductivity copper conductors embedded in pure and dense, magnesium oxide insulation, contained in a robust yet ductile, seamless, solid drawn copper sheath conforming to SRN 057. Where installed in corrosive situations, they shall be sheathed with PVC sleeving. Terminations of cables shall be provided with sleeves having a temperature rating similar to that of the seals. Terminations shall be made by means of cold screw on pot type seals and in conjunction with ring type universal glands. The greatest care shall be exercised at all times when terminating M.I.C.C. cables and insulation after. All cables shall give infinity test when tested on 1000 volt megger.

Where single core M.I.C.C. cables are used, all necessary precautions shall be taken to prevent Hysteresis. Ferrous plates or structure through which the cables pass shall be slotted and brass glands and sockets shall be used.

f) Wiring System

System A - Cables enclosed in concealed steel screwed conduit or trunking

The wiring shall be carried out in PVC insulated cables installed in steel screwed conduit or trunking concealed in floor slabs, walls of buildings, installed in roof space or concealed in structural beams and columns.

System B - Cables enclosed in steel screwed conduits or trunking fixed to the surface of walls and ceiling

The wiring shall be carried out in PVC insulated cables installed in steel screwed conduit or trunking installed on the surface of the walls and ceiling or in false ceiling spaces.

Conduits shall be screwed in position by means of space bar saddles using brass round head screws fixed with rawlplugs. Where two or more conduits are installed in parallel, multiple saddles which are screwed between each way shall be used. Conduits shall be installed horizontally on the walls and vertically to switches or outlets.

System C - Cables enclosed in concealed non-metallic conduits

The wiring shall be carried out in PVC insulated cables installed in rigid, PVC super high impact heavy gauge conduit concealed in floor slabs, walls of buildings in ceiling space or concealed in structural beams and columns. Each continuity conductor shall be installed throughout the length of the conduit.

System D - Cables enclosed in non-metallic conduits fixed to the surface of walls and ceilings

The wiring shall be carried out in PVC insulated cables installed in rigid PVC super high impact heavy gauge conduit installed on surface of the walls and

ceiling or in false ceiling spaces. Where straight run of conduit in excess of 6m are installed on the surface and approved expansion coupling must be installed at every 6m distance. Switch boxes and lighting point boxes shall be fitted with purpose made earthing connectors. Lighting point outlet boxes shall be fitted with steel insert clips to prevent distortion under load.

System E - M.I.C.C. cables installed on surface of the walls and ceilings in the roof space or concealed in walls and floors

M.I.C.C. cables shall be secured with copper saddles fixed at 375mm centres on vertical runs and 525mm centres on horizontal runs. Termination shall be made by means of cold screw on pot type seals and conjunctions with ring type universal glands. Insulation test shall be taken as described in Clause 1209 above.

System F - cables clipped to the roof members and run in steel conduit or rigid PVC conduit drops concealed in walls

The wiring shall be in PVC insulated and sheathed cables securely fixed to the roof member by means of buckle clips and then to switches and outlets through conduit drop (steel conduit or rigid conduit). Earth continuity conductor shall be run throughout, if PVC single insulated and sheathed cables are used or PVC twin with earth shall be used.

System G - PVC insulated and sheathed cables clipped to the surface of the wall and roof members or to the ceiling

The wiring shall be in PVC insulated and sheathed cables fixed to the roof member, surface of the walls and ceiling only when there is no reasonable access from above. They shall be fixed by means of buckle clips. Where cables pass through holes they shall be bushed.

System H - PVC insulated single wire armoured, PVC sheathed cables laid in ducts or saddled to walls

All the PVC insulated single wire armoured PVC cables laid direct in the ground shall be laid at minimum depth of 600mm, on 75mm bed of sand. Cables shall be suspended on purpose made frames and hangers, drawn through ducts or laid in trenches. Cables suspended on multiple hangers shall be so arranged that one can be removed without disturbing the other. Frames and hangers shall be galvanised or of non-ferrous material and shall not be fixed in contact with which they are liable to set up electrolytic action. All spacing of cable hangers and supports shall not exceed those laid down for the relevant size and type of cables in the I.E.E. regulations. PVC SWA cables laid direct in ground shall be provided with concrete cable tiles marked "Danger", "Hatari", throughout. Cables shall be terminated using brass compression glands and cable lugs of appropriate size.

11.16 Cable and Conductors

All cables shall be delivered to the site in their original packing with all seals intact. Cable dimensions shall comply with the rules and regulations and with the information given on the Drawings or in the Specification.

All cables shall conform to relevant British Standard. No cable dimensions smaller than 1.5sqmm for light and control circuits shall be used.

Where aluminium cables are connected to copper or brass elements in switchboards, etc., an anti-corrosive paste shall be used.

Common saddles shall be used where cables are grouped. All cables shall be terminated with suitable compression type cable glands of the correct size.

All low voltage cables shall be thoroughly soldered or joined with connectors of absolutely reliable type, which hold the conductors in a firm grip, without damaging the wire and without any possibility of vibrating loose.

Underground cables shall be laid in trenches excavated at a minimum depth of 500mm below ground level in the following manner: -

The Contractor shall trim the trench bottom level and if in hard material shall lay 75mm of sand. Cables shall be laid and covered by a further layer of sand to provide 75mm minimum cover. Interlocking concrete or other approved cable covers indelibly marked 'DANGER HATARI' shall be provided and laid on the sand covering by the Contractor. Backfilling of the trench shall then be completed.

Cables shall be separated by minimum 50mm of sand filling and kept a minimum of 250mm from other services.

Cables shall cross roads and enter buildings by means of 100mm diameter pitch-fibre or similar non-corrosive pipes. These shall be laid at a minimum depth of 350mm and extend a distance of 600mm on either side of road, etc. The ducts shall be provided and laid by the Contractor. The Contractor shall supply and install concrete marker posts at each entry into building, each change of direction, each road or pathway crossing and throughout the length of the cable at intervals not exceeding 50 metres. Underground ducts must be trained and ducts entering buildings shall be sealed in the end nearest to the building.

The position of all cable markers shall be agreed with the Engineer before installation.

11.17 Conduits

Plastic conduits shall be of best quality new super high impact grade, heavy gauge Class A rigid PVC, unplasticized conduit, suitable for plain connection. Conduits badly formed or bent or damaged in any way must not be used. Conduits not cast or concealed shall be galvanized steel conduits of heavy gauge class B welded and screwed steel and shall comply with British Standards.

In no case shall conduits smaller than 20mm be used:

Conduits to be concealed in structures cast in situ shall be secured to the steel reinforcement work with heavy binding wire, spaced not more than 900mm to prevent movement of the conduit and conduit boxes during the pouring and vibrating of the concrete. Outlet boxes shall be prevented from ingress of concrete, and all boxes shall be fixed to the shuttering with nails or other measures, which must not be visible after removal of the shuttering unless they later can be concealed, e.g. plaster. Conduit shall be installed after the first grid of steel reinforcement work has been securely fixed.

All open ends of conduct shall be protected by coupling plugged with a suitable non-metallic stopping plug. Conduit run in chases in walls or the like shall be fixed by means of mild steel the hooks or saddles spaced at not more than 900 mm where the conduit is concealed behind the plaster, it shall be sunk to a depth of 10mm below finished plaster level before application of the plaster.

Conduit fixed to the surface of walls or ceiling shall be fixed by spaced bar saddles fixed not more than 900mm apart Surface conduit shall also be fixed at 200 mm from boxes, the boxes themselves being securely fixed. Where such an arrangement of boxes and saddles would prove to be both unsightly and unnecessary short lengths of conduit not exceeding 900mm between boxes need not be secured further than by connection to the adjacent boxes. In such cases, the, engineer reserves the right to insist upon having additional fixings provided, should he for any reason whatsoever consider additional fixings necessary special care shall be taken to prevent dirt and plaster to enter any section of the conduit system.

All bends in conduits shall be formed for any decrease or increase of the cross section diameter of the conduits. The radius of the bend shall not be less than as indicated by the British standards. For concealed work, this radius should be increased. No manufactured tees elbows and bends will be permitted. All conduits shall be thoroughly cleaned for sharp edges. The conduits shall be installed avoiding unnecessary bends or changes in direction. Conduits shall be laid in straight lines. Where straight rows of conduit are installed, inspection boxes shall be placed at not more than 15m intervals. There shall be not more than 4 easy bends or 2 right angle bends between boxes. In surface conduit system, inspection bends may be where it seems convenient to replace inspection boxes but only with permission from the engineer

Not more than 6 final sub-circuit cables shall run in conduits feeding outlet boxes. Not more than 8 cables running straight back to the distribution board shall be enclosed in one conduit.

Sub-mains shall not be enclosed in the same conduit as other circuits Lighting sub-circuits shall not be enclosed in the same conduit as single phase sub-circuits shall not be enclosed in the same conduit as three phase sub-circuits.

11.18 Boxes

All conduit boxes in connection with plastic conduits shall be of plastic.

Boxes installed externally shall be galvanized and where exposed to direct weather conditions, they shall be compound filled.

All metal boxes shall be fitted with an earth terminal.

Deep boxes or extension rings on standard circular boxes shall be used where necessary in order to bring the front of each box flush with the ceiling or wall.

All screws for holding boxes, lids, etc., in position shall be screwed in. Adaptable boxes shall be screwed by minimum four screws. Conduits shall enter such boxes by means of conduit sockets. Joint boxes without connectors will not be allowed.

All boxes shall match to the equipment installed in the box and genuine parts produced by the same manufacturer shall preferably be used.

All necessary screws, plugs, bolts and other fixings for electrical equipment must be supplied by the Contractor and included in his tender. All fixings in concrete or stone structure shall be by means of rawl plugs or similar plugs in elastic.

All spare ways in junction boxes and the like left for possible future extension shall be fitted with stopping plugs.

11.19 Light fittings

All light fittings shall be supplied by the Contractor. The Contractor shall include in his tender for clearing, installation, connection and supply of light sources in accordance schedule of light fittings and drawings or as directed by the Engineer.

Fluorescent fittings shall except where otherwise specified be phase compensated by means of a phase capacitor, LC coupling or M coupling

Where earthing of light fittings is necessary, it is to be effected without using, chains or other rigid supports as conductors. All light fittings shall be cleaned and installed in complete working order before handing over.

11.20 Security Light Fittings

All external security light fittings shall be controlled by a photocell contactor located as shown in the relevant drawings. The photocell unit shall be fixed at 2000 mm above ground level on either north or south of external wall of indicated building.

11.21 Light switches

Light switches shall be 5 or 20 Amp according to the load switched.

They shall be as manufacture Crabtree with ivory colour moulded covers. They shall be suitable for switching inductive loads and mounted in pressed steel boxes on adjustable grids. They shall be installed at a height of 1400mm above finished floor level.

11.22 LIGHTING SWITCHES

Flush Switches

These shall be flush type contained in steel or alloy boxes of the ratings and gangs as specified on the drawings, complete with overlapping ivory or BMA or Matt Chrome cover plates and switch doliies. They shall be as manufactured by "M.K. Electric Limited", grid switch range or other equal and approved to SRN 058

Ceiling Switches

These shall be of the semi-recessed ivory pattern for fixing to, standard conduit boxes as "M.K. Electric Limited" list to 3121 or other equal and approved. Surface ceiling switches shall be ivory pattern as "M.K. Electric Limited" list 3121 or other equal and approved to SRN 058.

Surface Wall Switches

These shall be contained in a steel box with steel cover plate with rating and gangs as specified on the drawings and as manufactured by "M.K. Electric Limited" either dolly-operated or Rocker-operated or any other equal and approved to SRN 058.

11.23 SOCKETS AND SWITCH SOCKETS

These shall be 13 amp., flush pattern in steel box complete with overlapping ivory or BMA or Matt Chrome cover plates.

They shall be 13 amp., 3 pin, shuttered, switched or unswitched as specified on the drawings and as manufactured by "M.K. Electric Limited" or any other equal and approved and as per SRN 059. All sockets or switch sockets shall be with fused plugtop containing a fuse whose rating shall be suitable for the load connected to it. The plugtop shall be as manufactured by "M.K. Electric Limited" or other equal and approved and as per SRN 059.

The surface type sockets or switch sockets or switch sockets shall be in a steel box with metalclad steel cover plates or ivory insulated with ivory mounting block and backplate as manufactured by "M.K. Electric Limited" or other equal and approved and to the SRN 059.

11.24 Meter Boxes

The Contractor shall supply and install a standard single or Dual Tariff Meter box where called for on the Contract Drawings. He shall also provide the necessary conduits for the Kenya Power Ltd, service cable entry.

11.25 Power Installation

The installation for power shall be concealed in walls and floors in PVC conduits. Precise positions of these and control switches shall be ascertained by the contractor.

The Contractor shall supply, fix and connect isolators to equipment as shown below.

The tender price shall be based on the following heights for isolators and socket outlets, unless specifically stated otherwise on the drawings.

Isolators 1400mm above -finished -floor level.

Socket outlets -flush at 250mm above finished floor level.

All socket outlets jointed above worktops shall be flush mounted at 150mm above worktop.

The motor installation shall include isolating switch and terminating box fixed at the wall 1400mm. Flexible cable shall be provided between the box and the terminal box at the motor. The flexible cable shall be installed with sufficient coils to enable "tong-test readings" for each phase.

All adaptors shall be solid bronze or brass pattern with standard thread.

11.26 Earthing and bonding

Earthing and bonding shall be carried out to the requirements of the current 14th edition of the IEE regulations and GES 1 and 2. In particular, attention is drawn to IEE regulation D5, D6, D7 and D29.

An earth electrical system shall be installed at point adjacent to the main supply intake and at every building served by external distribution System.

Each earth electrode shall be a 12mm diameter copper rod driven to 1300 mm. in rocky soil conditions, where this depth is difficult to obtain the Contractor shall obtain written approval from the engineer for an alternative earth electrode system.

The electrode shall be connected via a green PVC insulated copper to an earth terminal adjacent to the incoming supply, to which all cable armouring, conduit, trucking, switchgear etc. shall be bonded, together with all other metallic incoming services, e.g.-water etc. Provision shall also be made for connection with the neutral of the incoming supply.

Where P.M.E. is approved and after the Supply Authority has made its connection, the Contractor shall similarly connect the neutral of each distributor main to earth at its remote end.

The bonding of other services or connections of neutral to earth shall be made after satisfactory completion of earth continuity and line earth loop impedance test. Tests of the resistance to earth of each electrode system shall also be carried out and the results recorded.

The maximum reading shall not exceed that laid down by Kenya Power & Lighting Co. Ltd and in any case shall not exceed 2 ohms.

Means shall be provided, e.g. a test clamp, to isolate the electrode from the system for periodic testing-

Internal earthing and bonding shall comply with the current edition of the IEE Regulations except that insulated switches and Lighting fittings need not be earthed from a safety aspect. Certain fittings however, may require to be earthed to effect proper operation.

All cable glands for SWA underground type cable, where installed, shall be fitted with an approved earthing washer having a tag for the Connection of an earth lead. Every such washer installed shall- be connected by an insulated earthing lead to a proper earthing terminal by means of a lug or washers on the adjacent switcher or other equipment.

11.27 Testing

All tests Prescribed in the 14th edition of the regulations for the electrical Equipment of the institution of electrical Engineers, together with all amendments as applicable, shall be carried out by the Contractor on the completed installation. In addition, testing of all special equipment to the complete satisfaction of the engineer and such other persons or authorities concerned with the installation shall be carried out by the contractor.

Tests may also be required during progress of the Contract for insulation resistance, continuity of a conduit and earth connections and also the ability to withdraw all cables or any, cables from the conduits.

In addition to any tests required by the Supply Company upon completion of the installation, tests for polarity, insulation resistance, earth continuity and adequate operation of all parts of the installation shall as stated above, be carried out by the contractor

The contractor shall provide accurate instruments and apparatus and all labour required for such testing.

All tests must be carried out in the presence of the Engineer or such other person appointed for this purpose, but the Contractor alone will be held responsible to the authorities as to the installations compliance with rules and regulations.

The Contractor will be required to give all notices or details to enable the installation to be tested or inspected. All fees arising from the inspection and in subsequent inspection or re-testing shall be paid by the Contractor.

Duplicate copies of the results of these tests shall be provided within 14 days of the witnessed tests, and the Contractor will be required -to issue to the Engineer the requisite Certificate upon completion, as required under the regulations referred to above.

Any faults, defects, omissions or faulty workmanship, incorrectly positioned or installed parts of the installation made apparent by such inspection or tests shall be rectified by the Contractor at his own expense.

11.28 Handing Over

The Contract works shall be considered complete and the maintenance and defects notification period shall commence only when the Contract Works and supporting services have been tested, commissioned and operated to the satisfaction of the Engineer and officially approved and accepted by the Employer.

The procedure to be followed will be as follows: -

- (a) On completion of the Contract works to the satisfaction of the Engineer, the Contractor shall request the Engineer to arrange for handing over.
- (b) The Engineer shall then arrange a handing-over meeting or a series thereof at the site.
- (c) The Contractor shall arrange with the Engineer and the employer a complete demonstration to be carried out of each and every service and for instructions to be given to the relevant operating staff and other representatives of the Employer.
- (d) The Contractor shall arrange approved Handing Over Certificate and check Lists of all controls and items of equipment, tools, spares and the like.

11.29 Maintenance and Defects Notification Period

The contractor shall maintain the complete electrical installation and associated equipment for a period of minimum 24 months from the date that the installation is handed over to the client. The Contractor shall be held responsible for and shall make good all defects in materials and workmanship that occur during the twenty-four (24) months maintenance period. The period of liability shall not end until all defects which appear during the maintenance period have been rectified. Any item of material found to be defective shall be replaced by the contractor within seven days of his being notified and any results of defective workmanship shall be repaired including supply of new parts necessary immediately upon being notified.

The Contractor shall allow in his tender price for this maintenance and service and shall provide for all tools, instruments, plant and scaffolding, and the transportation thereof, as required for the full correction and full execution of these obligations, and the provision, use or installation of all materials whether they are normal maintenance materials such as oils, greases, sand paper etc. and parts which are periodically renewed such as relay contacts or parts which are faulty for any reason whatsoever excepting always Acts of God such as storm, tempest or flood, lighting and earthquakes; and civil revolt, acts of war and vandalism.

12 ELECTRO-MECHANICAL EQUIPMENT

12.1 Scope of Supply

The scope of supply comprises the complete mechanical equipment, consisting of the following main parts:

- Piping with Accessories
- Internal Water Supply
- Control Measuring and Safety Devices

It is required to supply, erect, and supervises the erection and delivery in good working order the mechanical and electrical equipment and facilities of the water treatment plant as well as to provide its maintenance during the guarantee period.

The works consist of furnishing all equipment to be complete and ready for operation when installation is completed, even if they are not mentioned in the Specifications. All accessories shall be furnished and included in the Tender Price of the Bill of Quantities/Price List. The Contractor shall furnish all foundation materials required to support and hold the diverse equipment as pumps, piping, armatures, etc.

Spare parts in order to obtain a complete, reliable' and operational plant as more fully described hereinafter to get potable water in accordance with the World Health Organization (WHO) Standards.

12.1.1 Piping with Accessories

The scope of works includes all pipes, fittings, valves, connecting and fixing materials with installation. The connecting material (screws, nuts and gaskets) as well as the fixing material (supports, clamps and suspenders) for the equipment which is to be installed in or on the pipes (e.g. valves, dismantling pieces, measurement and control devices) are to be included. Furthermore, the pressure test, the flushing and the disinfection of the pipes is to be quoted with the relevant items of the B.O.Q. (Bill of Quantities).

Further all parts to be embedded in concrete shall be placed according to the drawings or as instructed by the Engineer at site with written approval.

12.1.2 Design Requirements:

The maximum internal pressure of the collecting well piping is the test pressure. The design pressure shall be PN 10 all parts shall be made of steel.

12.1.3 Valves and Accessories

The Contractor shall furnish all valves and other accessories for pipe installation as specified herein and as shown on the drawing and in the Bill of Quantities. All valves and other accessories shall be of the size specified and, as far as possible; all valves of the same type shall be of one manufacturer.

All valves and accessories shall have cast on the body the name of the manufacturer, working pressure, diameter, and direction of flow.

All flanges for pipes, fittings, valves shall comply with DIN 28604 for PN 16.

Stuffing boxes shall be of the “O” ring or packing type, unless otherwise specified.

The Supplier shall submit shop drawings to the Engineer for approval. Shop drawings shall include:

- lists and schedules of materials
- details of joints (and adaptors if necessary)
- Names of manufacturers, size, details, materials, and thickness of all items.

All valves and accessories shall be designed for a working pressure of not less than PN 16, unless otherwise specified. The Supplier shall submit a certificate from the manufacturer certifying that each valve meets the requirements of the specifications.

Valves shall be equipped with hand lever, hand wheel, or as specified. Valve ends shall be flanged, Screws and rubber ring gaskets shall be provided to joint to the valve with the piping.

12.1.4 Gate Valves

Gate valves are to be provided according to DIN 3352 for water up to 40 degrees Celsius with fixed, non-rising hand-wheel. The body shall be of cast iron GG-25 or ductile iron.

12.1.5 Butterfly Valves

Each valve shall consist, essentially, of a cast-iron or ductile iron body with a rubber seat, a disc, a valve shaft, and an operating mechanism.

It shall conform in all respects to DIN 3354, part 2.

12.1.6 Air Release Valves

Air release valves shall have high strength cast or ductile iron bodies. The valves shall contain an integral shut-off valve for use during maintenance.

All moving parts shall be of stainless steel.

Complete unit with gate valve connection of the single and double type shall be provided as shown on the drawings and wherever necessary.

12.1.7 Safety Valve

The safety valve shall be a spring-loaded type with adjustable pressure range as shown in the Bill of Quantity. The safety valve shall be manual releasable by a lever arm.

12.1.8 Non-Return Valves

Non-return device with silent action tight sealing designed for a pressure of PN 16 for streamlined flow and minimum head loss.

12.1.9 Float Outlet Valve

Float-operated level control valve, angle-type body for water reservoirs. Closing with rising water level and opening with sinking water level. Balanced valve piston shall ensure minimum operating forces. A long piston guiding shall prevent canting. Closing action shall be shock-free.

12.1.10 Dismantling Piece

The dismantling piece shall be rigid type and provided with steel middle ring, steel followers, gas and necessary bolts and nuts of galvanized steel. They have to be installed in their medium length.

12.1.11 Pipe Compensator

The pipe compensator shall be of rubber type and provided with flange as specified in the Bill of Quantity. The pipe compensator shall contain anchor sturdy of strength adequate to hold the pipe together under a pull equal to the longitudinal strength of the pipe.

12.1.12 Wall Duct

The wall duct shall be of steel body and provided with rubber/solid gasket, bolt and nuts, and loosed flange according to working pressure as specified in the Bill of Quantity. The length of wall duct shall be suitable of the concrete wall width specified in the Bill of Quantities.

The connecting pipe to be inserted in the wall duct shall have four degrees' deflection without any leaks.

13 MASONRY

13.1 GENERAL

All masonry work shall be constructed from building stone as specified hereunder.

All building stone shall be capable of withstanding when wet a crushing stress of 1.4 kg./sq.mm. The source of stone shall be approved by the Engineer and stone supplied therefrom shall be free from Magadi, overburden, mudstone, cracks, sand holes, veins, laminations or other imperfections.

The stone shall be chisel dressed into true rectangular blocks, with each surface even and at right angles to all adjoining surfaces, to the size specified. For exposed stonework the maximum permissible variation of any of the specified dimensions shall be 6mm provided that cut stone, supplied as 'rock face' stone may be hammer dressed on one face only, or on one face and one end, if in other respects it conforms with this specification. Stones shorter than 375mm will not be accepted.

Unless the Engineer allows otherwise the Contractor shall at his own expense provide and dress four 100mm cubes of stone for testing.

For culvert headwalls and other small works, the stone shall, unless otherwise specified, be rough dressed. For walls, facing and other exposed works the stone shall unless otherwise specified, be medium chisel-dressed.

13.2 WORKMANSHIP

The Contractor shall provide and use proper setting out rods for all work.

Stones shall be well soaked before use and the tops of walls shall be kept wet as the work proceeds. The stones shall be properly bonded so that no vertical joint in a course is within 115mm of a joint in the previous course. Alternate courses of walling at angles and intersections shall be carried through the full thickness of the adjoining walls. All perpends, reveals and other angles of the walling shall be built strictly true and square.

The stones shall be bedded, jointed and pointed in mortar 1 to 3 with beds and joints 9mm thick flushed up and grouted solid as the work proceeds.

All masonry work shall be cured in accordance with the relevant requirements of Clause 5.12.

13.3 MEASUREMENT AND PAYMENT

All items for measurement and payment are provided under the relevant sections of the Bills of Quantities. The rate provided by the contractor in the bill of quantities shall be deemed to cover the cost of complying with all the requirements in this section of the specification.

14 DRAINS, SEWERS AND MANHOLES

14.1 EXCAVATION FOR DRAINS, SEWERS AND MANHOLES

The ground shall be excavated to the lines and depths shown on the drawings or to such other lines and depths as the Engineer may direct. Excavations taken out to a greater depth than is necessary shall be filled to the required level with approved material as specified for the pipe bed at the Contractor's own cost. Trenches shall be of sufficient width to enable the pipes to be properly laid and jointed. In case of pipes of greater diameter than 300mm, the width of trench shall be external diameter of pipe, plus 400mm.

When any excavation has been taken out and trimmed to the levels and dimensions shown on the drawings or as directed by the Engineer, the Engineer shall be informed accordingly so that he may inspect the completed trench and no excavation shall be filled in or covered with concrete until it has been so inspected and the Contractor has been authorised to proceed with the work.

All surplus materials from such excavations not required for refilling shall be carted away to tips, or otherwise disposed of, as directed. All excavations shall be kept dry, and all bailing and pumping, timbering, shoring and supporting of sides that may be required, and any refilling, ramming and disposal of surplus materials necessary in carrying out the excavations and backfilling of trenches shall be taken to provide a solid and even bed for barrels of the pipes and, where a concrete bed is not specified, the floor of the trench shall be properly shaped to receive the sockets and the backfill must be thoroughly rammed along the sides of the pipe.

The rate of excavation in the Bill of Quantities shall include for keeping trenches dry and for all bailing, pumping, timbering, shoring and supporting of sides that may be required.

14.2 SUPPORTS FOR PITS, TRENCHES AND OTHER EXCAVATIONS

The sides of pits, trenches and other excavations shall, where necessary, be adequately supported to the satisfaction of the Engineer, and all such excavations shall be of sizes sufficient to enable the pipes and bedding to be laid accurately, and proper refilling and compacting to be carried out.

The Contractor shall take all precautions necessary for the safety of adjoining structures and building by shoring, opening in short lengths or otherwise, during the time the trenches are open.

14.3 ROCK CUTTING IN TRENCHES FOR PIPES

Where solid rock is met within trenches, it shall be cut out to a depth of 100mm below the intended level of the bottom of the pipes, and replaced with 100mm of approved material as specified. In measuring such rock excavation the Contractor will be allowed a width of 400mm more than the external diameter of the pipes to a level of 100mm below the bottom of the pipes. The price inserted in the Bill of Quantities shall be held to cover all expenses in connection with excavating the

rock, backfilling after laying of pipes and disposing of surplus material as directed by the Engineer.

14.4 WATER IN TRENCHES FOR PIPELINES

Trenches shall be kept free from water at all times during construction of works until, in the opinion of the Engineer, any concrete or other works therein are sufficiently set, and the Contractor shall construct any sumps or temporary drains that the Engineer may deem necessary.

The Contractor shall be responsible for the removal and disposal of all water entering the excavations from whatever source and shall deal with and dispose of such water in a manner approved by the Engineer so as to ensure that excavations are kept dry while ensuring that the disposal of this water does not cause a nuisance to adjacent plot holders or works.

The Contractor shall provide all plant, labour and materials required for such work and all costs incurred shall be deemed to be included in his rates for excavation.

14.5 LAYING AND JOINTING RIGID JOINTED CONCRETE PIPES

Concrete pipes shall be laid true to line and level, each pipe being separately boned between sight rails.

For spigot and socket joints, the spigot of each pipe shall be placed home in the socket of the one previously laid, and the pipe then adjusted and fixed in its correct position with the spigot of the pipe accurately centred in the socket. A ring of tarred rope yarn shall next be inserted in the socket of each pipe previously laid and driven home with a wooden caulking tool and wooden mallet, such yarn when in position shall be 25mm in depth. The socket shall then be completely filled with cement mortar 1 to 2 and a fillet of the same worked all round the side. The fillet shall be levelled off and extend for a length of not less than 50mm from the face of the socket.

For 'Ogee' jointed pipes, the joints shall be thoroughly cleaned before laying, and cement mortar, as shall be applied evenly to the ends for jointing so as to completely fill the joint. The pipes shall then be neatly pointed with a band of cement mortar approximately 125mm wide and 20mm thick. The inside of each joint shall also be pointed up as the work proceeds.

Special care shall be taken to see that any excess of cement mortar etc. is neatly cleaned off while each joint is being made and any earth, cement or other material cleaned out of the pipes by drawing a tight-fitting wad through them as the work proceeds, or by other approved means. A properly fitting plug shall be well secured at the end of the last laid pipe and shall be removed only when pipe laying is proceeding. The trenches, pipes and joint holes shall be kept free from water until the joints are thoroughly set.

Where shown on the drawings or directed by the Engineer, concrete pipes shall be bedded and haunched or surrounded with concrete as specified.

The price inserted in the Bill of Quantities shall include for providing, laying and jointing of pipes.

14.6 PIPES LAID WITH OPEN JOINTS

O.G. porous concrete pipes as specified herein shall be laid unjointed with a space of 12mm between the spigot and the inner end of the socket.

All pipes shall be packed and surrounded as directed by the Engineer with approved broken stone, sand or gravel aggregate, to the gradings as shown on the drawings or stated in the Bill of Quantities. The prices inserted in the Bill of Quantities shall include the trench excavation, providing and laying pipes, supplying and placing graded packing material, refilling trench and disposing of surplus all as specified.

14.7 CAST IRON PIPES

Cast iron pipes and special castings, shall be as specified herein and shall be supplied, laid and jointed with lead wool properly caulked to form perfectly uniform and watertight joints, and when laid and jointed they shall be true to line and level.

Where cast iron pipe drains are laid on unstable ground or ground which is likely to settle appreciably over a period of years they shall be pointed by means of an approved self-adjusting or screwed gland joint as directed by the Engineer.

14.8 DRAINS TO BE LEFT CLEAN ON COMPLETION

On completion, all drains, manholes, etc. shall be flushed from end to end with water from an approved source and left clean and free from obstructions.

14.9 REFILLING TRENCHES

Trenches shall be refilled with suitable excavated material of 100mm surround but not before the work has been measured and approved by the Engineer. For pipes which are not surrounded with concrete, the first layer of filling material shall be free from stones and shall not be thrown directly on to the pipes, but shall be placed and packed with care all round them. All filling shall be deposited and compacted in layers, not exceeding 225mm loose depth, to a dry density not less than that of the adjoining soil. The last 450mm of filling must be returned in the order in which it has been removed. Timber and framing shall be withdrawn ahead of the layer to be compacted, care being taken to keep the sides of the trenches solid and to fill all the spaces left by the withdrawn timber.

14.10 CONNECTIONS OF EXISTING SEWERS AND DRAINS

Where shown on the drawings, existing sewers and drains shall be properly extended, connected and jointed to new sewers, culverts, drains or channels. All such connections shall be made during the construction of the main sewer, drain or other work and a record of their positions kept for future use or reference. Where pipe connections are made to a sewer, stone pitched or lined channel, the pipes shall be well and tightly built into the concrete, or masonry work and be so placed

as to discharge in the direction of the main sewer, drain or channel and with the end of the pipe carefully cut to the necessary angle. Where the connections are between pipe sewers or drains, special connecting pipes as shown on the drawings shall be supplied and be truly laid and properly jointed.

14.11 MANHOLES AND INSPECTION CHAMBERS

Manholes and inspection chambers shall be constructed in accordance with the drawings and in the position shown on the drawings or directed by the Engineer. Foundation slabs shall consist of concrete of the appropriate classes as specified on drawings. The side walls shall consist of similar concrete or building stone as specified in Clause 703 in accordance with the drawings.

The side walls shall be fair faced or rendered internally as specified on drawings. They shall be brought up vertically to receive a precast slab formed of concrete of the appropriate classes specified and reinforced all as shown on the drawings. Cast iron manhole covers and frames as specified in Clause 726 shall be provided and frames shall be bedded in cement mortar 1 to 3 and so set that the tops of the covers shall be flush at all points with surrounding surface of the footway, verge or carriageway, as the case may be. Any slight adjustment of the slab level which may be necessary to accomplish this shall be effected by topping the side walls with concrete integral with the slab.

If required, half channel pipes, bends and junctions as specified in Clause 718 and Clause 719 shall be laid and bedded in cement mortar 1 to 3 to the required lines and levels, and both sides of the channel pipes shall be benched up with concrete of the appropriate class and finished smooth to the slopes and levels as shown on the drawings or directed by the Engineer. The ends of all pipes shall be neatly built in and finished flush with cement mortar 1 to 3. Where the depth of the invert exceeds 1 metre below the finished surface of the carriageway or the adjacent ground, iron steps as specified in Clause 730 shall be built in with alternate steps in line vertically and with such additional hand irons as the Engineer may direct.

All manholes when completed shall be watertight and to the satisfaction of the Engineer. The prices inserted in the Bill of Quantities shall include for excavation, provision of all materials, construction, refilling and disposal of surplus.

14.12 PRECAST CONCRETE MANHOLES

Precast concrete manholes as specified in Clause 728 shall be supplied and laid generally in accordance with Clause 1011 and the drawings.

14.13 GULLY CONNECTIONS

Connections from gullies to sewers and surface water drains or ditches shall consist of concrete pipes and fittings as specified in Clause 718 jointed with cement mortar 1 to 3 as specified in Clause 707. All pipes, bends and junctions shall be laid to the lines and levels shown on the drawings or as directed by the Engineer.

14.14 SURFACE BOXES, COVERS ETC.

Surface boxes, manholes and other covers lying within the site of the works, shall be raised, lowered, altered or removed as directed by the Engineer.

14.15 GULLIES

Gullies complete with gratings and with rodding eyes where necessary all as specified in Clause 727 shall be supplied and laid in accordance with the drawings. Where directed by the Engineer, precast concrete gullies shall be laid on and surrounded with 100mm of concrete of the appropriate grade specified in Table 4.2. The concrete surround is to be brought up to the underside of the frame or flush with the top surface as the case may be. Masonry gullies shall be constructed from 225mm building stone and rendered internally. The rates included in the Bill of Quantities shall include for excavation, provision of all materials, construction, making junctions with connections to main drains, accurate setting of frames to line and level, refilling and disposal of surplus materials. Gullies shall be trapped where leading into foul sewers or into combined foul and surface water sewers.

14.16 COMPLETION OF DRAINAGE WORKS

All sub-soil and surface water drains shall be completed in advance of the construction.

14.17 TEMPORARY STOPPERS

Junction pipes which are laid but not immediately connected to gullies shall be fitted with temporary stoppers or seals, and the position of all such junctions shall be clearly defined by means of stakes or training wires properly marked and labelled.

14.18 PROVISION FOR FUTURE CONNECTION TO MANHOLES

Inlet pipes of the required diameters shall be built into the walls of manholes and elsewhere for future use and shall be of the diameters shown on the drawings. The external ends of all such connections shall be sealed off with temporary stoppers, approved by the Engineer. The pipes shall be laid and jointed as specified in Clause 1005 and during the placing of the concrete they shall be adequately supported.

14.19 SURROUNDING OR HAUNCHING OF PIPES WITH CONCRETE

Surrounding or haunching of pipes shall be carried out using concrete of the appropriate grade specified in Table 4.2. In carrying out this work the Contractor shall take care to pack the concrete under and around the pipes to ensure even bedding and solidity in the concrete and the concrete shall not be thrown directly on to the pipes. The upper surface of the concrete shall be struck off with a wooden screed or template and neatly finished off. The rates shall include for any formwork that the Contractor requires to use under this item.

14.20 INVERT BLOCK AND STONE-PITCHED DRAINS

Precast concrete invert blocks and side slabs shall be formed of concrete of the appropriate grade specified in Table 4.2 to the dimensions shown on the drawings. Each course of side slabs required in the Bill of Quantities shall be interpreted as one complete row of side slabs to one side of the channel concerned. Stone used for channels shall be 225mm x 100mm building stone. Drains should not normally be laid to a radius of curvature less than 10 times the actual width of the drain.

Invert block and stone-pitched drains shall be constructed in the positions and to the levels and dimensions shown on the drawings and laid to true line and even fall. Where under-filling is required it shall be in 100mm maximum thickness layers of compacted murram. The earth sides to such channels shall be neatly finished to a slope of 1 to 1 or such other slope as the Engineer may direct.

Invert blocks and side slabs shall be laid on a 100mm minimum thickness of compacted murram and be neatly jointed with cement mortar 1 to 3 as the work proceeds. The excavation, murram bedding, providing, laying and jointing invert blocks or stone, backfilling and disposal of surplus shall all be as specified and all in-situ connections shall be in concrete of the appropriate grade specified in Table 4.2.

14.21 TESTING OF JOINTED PIPES AND MANHOLES

Sealed jointed drains, up to and including 600mm diameter shall be tested in sections (e.g. between manholes) by filling with water under a head of not less than 1 metre. Drains found to be water-tight after a period of 30 minutes will be passed as satisfactory but the water must be retained in the pipes until a depth of at least 450mm of filling has been deposited and compacted on top thereof. Drains failing to stand the test shall be taken out and the pipes re-laid and re-jointed until completely water-tight.

Drains exceeding 600mm in diameter shall be tested by means of a smoke test before they are covered up. Both ends of the lengths of drain to be tested shall be sealed to the satisfaction of the Engineer, and smoke shall then be pumped into the section from an approved machine. Should any joint in the section show an escape of smoke, the section shall be taken out and the pipes re-laid and re-jointed until there is no further escape of smoke.

Should the Engineer so direct, manholes shall be tested by completely filling with water, and there shall be no appreciable loss over a period of 2 hours.

On completion of the works, or at suitable intervals during construction, infiltration tests will be carried out. The permissible amount of infiltration shall be 1 litre per hour per linear metre of nominal internal diameter.

The Contractor shall provide all labour and apparatus for the above tests.

All testing will be done in accordance with the procedure of the British Standard Code.

14.22 PIPES WITH RUBBER RING JOINTS

Rubber rings complying with SRN 308 will be provided by the Contractor. They will be laid in the socket and the pipes then jointed as specified. The jointing of pipes shall be carried out in accordance with manufacturer's instructions and in conformity with any modifications proposed by the Engineer.

14.23 LAYING, JOINTING AND BACKFILLING FOR FLEXIBLE JOINTED PIPES

The Contractor shall ensure that any hard spots and loose stones are removed from the formation prior to laying of bedding materials. The Contractor shall lay a bed of thickness 100mm consisting of granular material i.e. sand, gravel, or approved soil of friable nature.

After laying of pipes the Contractor shall lay bedding material on the sides of the pipe compacted by tamping into soffit of sewer.

After completion of this operation the Contractor shall lay the bedding material on top of the pipe in 150mm layers to a thickness of 300mm. The material is to be compacted by tamping. However, precautions are to be taken to avoid excessive tamping on top of the pipe. The remaining trench excavation is to be backfilled to comply with Clause 1009 of specification.

The pipes shall be laid with flexible ring seal joints provided that solvent cement joints could be used for fittings where necessary subject to the approval of the Engineer. Pipes and fittings shall be checked for deformities prior to laying. Deformed pipes and fittings shall not be accepted.

14.23.1 Flexible Rubber Ring Joints

The Contractor shall ensure that the spigot end is free from grit, dust or dirt and sealing rings should be seated evenly in the socket groove. Pipe lengths and fittings are supplied with a chamfer on the spigot. Where pipes are to be cut or are supplied without a chamfer on the spigot end the Contractor shall ensure that the pipe is cut square and then form a chamfer on the spigot end with a medium file to an angle of 15 degrees. Remove saw flashing by scraping with a pen-knife.

14.23.2 Expansion Gap

It is necessary to leave a gap between the edge of the spigot end and the base of the socket to allow for expansion. Moulded fittings are supplied with an embossed line indicating the correct depth of insertion. In other cases where the marking is not done, the Contractor shall ensure that an expansion gap of at least 3mm per metre length of pipe or at least 15mm per pipe length is provided. This can be done by marking spigot ends or by pushing spigot fully home, making a small mark on pipe and then withdrawing the pipe by 15mm.

After completing jointing the pipe shall be laid on the prepared bed making sure that a suitable depression is created in the bed for the socket.

14.23.3 Solvent Cement Joints

For solvent cement joints make sure that mating surfaces are clean and free of grease and dirt. Roughen mating surface with sandpaper, clean both surfaces with cleansing fluid using a clean cloth. Apply solvent cement on both mating surfaces. Without delay bring mating surfaces together and hold in position firmly for a few seconds. A layer of cement should be visible at the edges. Joints should not be disturbed for at least 10 minutes after assembly.

14.24 MEASUREMENT AND PAYMENT

All items for measurement and payment are provided under the relevant sections of the Bills of Quantities. The rate provided by the contractor in the bill of quantities shall be deemed to cover the cost of complying with all the requirements in this section of the specification.

15 DAYWORKS

15.1 MEASUREMENT AND PAYMENT

Where items of major equipment listed in the schedule of Dayworks are specified by type (e.g. concrete mixer etc.) the power rating of such items of equipment to be provided by the Contractor shall not be lower than the power ratings of such equipment, manufactured within the last two years prior to the date of Tender. Any item of major plant employed upon Dayworks which has a power rating lower than specified shall be paid for at rates lower than those in the schedule of Dayworks. The reduction in the rate payable shall be in proportion to the reduction in power rating below that specified above.

16 TRAINING OF EMPLOYER'S PERSONNEL

On commissioning of all the Works, the Contractor will be responsible for the operation and maintenance of the Works for 4 weeks, during which period training of NYEWASCO Staff will be done.

During the above training period, the Contractor will deploy specialised persons capable of giving theoretical and practical training to the NYEWASCO's Staff in the following fields:

- operation and maintenance
- mechanical / electrical units

After the training period, the Plant Manager(s) or other Designated Staff by NYEWASCO will take over the operation of the Works.

In the Tender, the Contractor shall outline his proposal for training. An item for such training is allowed for in the Bills of Quantities. Prior to Commissioning of the Works, a detailed training programme shall be submitted to the Engineer for approval. The training shall be divided into four different levels:

1. Training of Management Staff and Department Heads:

Theoretical and Practical Seminar(s)

2. Training of Skilled Personnel:

Short theoretical introduction and practical seminar(s)

The laboratory personnel shall be trained in analysing various parameters and handling of laboratory equipment. Include for training of Plant Operators especially in operation and maintenance of electro/mechanical equipment

3. Training of Unskilled Personnel:

Familiarization with various appurtenances of the Works and daily and routine works associated with maintenance work

4. General Operation and Maintenance of all the Works i.e. daily, weekly, monthly and yearly procedures to be followed, recording of observations, and reporting action plan for any remedial works, etc.

16.1 MEASUREMENT AND PAYMENT

All items for measurement and payment are provided under the relevant sections of the Bills of Quantities. The rate provided by the contractor in the bill of quantities shall be deemed to cover the cost of complying with all the requirements in this section of the specification.

17 PRE-COMMISSION TEST

17.1 Technical documentation (on completion)

Upon the Contractor's Notification on Test on Completion and provision and approval of as built documents and, if applicable, operation and maintenance manuals in accordance with the Specification and in sufficient detail for the Employer to operate, maintain, dismantle, reassemble, adjust and repair this part of the Works, Pre-commissioning Tests shall be carried out on all civil, mechanical, electrical and control components in order to obtain the acceptance of the Engineer. Pre-commissioning Tests shall include but not be limited to the following:

- Tests at the completion of the Civil, mechanical and electrical installations.
- Tests of completed parts of the Works (e.g. tightness tests and functional tests at pumping stations, part of the piping, etc.).

Upon successful Pre-commissioning the Engineer shall issue the Taking Over Certificate subject to relevant Clauses of the Conditions of Contract. Remedy of defects shall be done according to the decision of the Engineer before or during the Commissioning.

Upon completion of work, the Contractor shall submit technical documentation with the following contents subject to approval by the Engineer. Documentation is mandatory for proceeding with Pre-commissioning and issuance of the Construction Completion Certificate:

- General Information
- As-built drawings
- Test Certificates

A register for clarity shall separate the various sections. The numeration given above shall be strictly adhered to. This applies even if individual sections are not used.

The following information shall be included:

17.1.1 General Information

- Numbering and arrangement of the documentation according to the Contractor's bid as well as the Contractor's project number,
- Characteristics of equipment,
- Medium, capacity, delivery head, energy consumption, etc.,
- Details of calculation documents (structural, etc.),
- Details of topographic surveys (benchmarks, protocols, etc.)

17.1.2 As-Built drawings (as approved by the Engineer)

- As-built drawings shall comply with the provisions set forth in this Technical Specifications.

17.1.3 Test Certificates

Certificates of all tests during construction / installation until date shall be submitted, (i.e. compaction tests, pressure tests for pipelines, concrete delivery notes or tests, tightness, tests and loop impedance, lightning protection, potential equalizing and earthing system etc.) together with the appropriate official test-, acceptance- and approval documentation and approval permits (i.e. tests at factories premises, cranes, lifts, electrical equipment etc.). Certificates from the respective manufacturers shall be submitted for each equipment.

17.2 Testing of earthworks

17.2.1 General

The Contractor shall furnish all equipment and materials necessary for collecting samples and carry out field laboratory tests on materials for earthworks.

17.2.2 Main Tests and Standards

The Contractor shall carry out all tests in accordance with ASHTO or BS standards. For the various tests the following (where needed):

- Moisture Test
- Consistency Test
- Proctor Test
- Grading Tests
- Loading Test
- Density Test (solid volume without voids)

17.2.3 Compaction of Soils

The Contractor shall carry out the compaction to safely achieve the specified dry density and control soil compaction during backfilling and filling operation.

Where the sub grade or layers of soil material require moisture conditioned before compaction, the Contractor shall uniformly apply water to the sub grade or layer of soil to attain the optimum moisture content required. The application of water shall be carried out in a manner to prevent free water appearing on surface during compaction operations.

The Contractor shall replace soil material that is too wet for compaction to the specified densities.

17.2.4 Testing of Compaction

The Contractor shall inspect, perform and report all testing and retesting as to ensure that the works conform to the specified requirements. In order to test the degree of compaction, the Contractor shall carry out field density tests in accordance to BS. 1377

For each compacted backfill of trench the required number of field density tests to ensure compliance with specification shall not be less than three passing tests between each 2 manholes or 100 linear meters (whichever is smaller) of filled and compacted trench.

If, in the opinion of the Engineer, the sub grade, backfill and fill layers have been placed and compacted to densities below the specified limits, the Contractor shall provide additional compaction and testing until satisfactory results are attained or remove certain sections of the work and reconstruct them according to the Specifications at his own expense.

All holes made for the purpose of tests shall be restored by the Contractor to conform to the characteristics of the adjacent layers. This work shall be conducted at the Contractor's expense.

The compaction required for various fills shall be as follows:

Compaction requirements

Item of Works	Materials Prescribed	% of Max. Density
Backfill for over-excavation	Granular material	100 %
Formation and bedding layers	Fine granular material	95 %
Crushed stone supporting	Crusher runs	95 %
Final backfills of trenches under roads	Fine granular material	100 %
Backfill of trenches in general	Fine granular material	98 %
	Sandy material	95 %
	Clayey material	93 %
Backfill below structures	Fine granular material	100 %

17.3 Inspection and testing of structural works

17.3.1 Inspection Prior to Commencement of Works

Buildings and other structures in close proximity to the Construction Site that might be damaged by excavation or other work shall be inspected before work is commenced. All parties concerned shall be invited by the Contractor to participate in the inspection. The Engineer and the Contractor shall make the inspection jointly and the Contractor shall, at his own expense, set out an inspection report,

including “preconstruction photos. The report shall describe the conditions of the buildings, roads, footpaths etc. in question.

Any failure or damage caused by excavation or other works, shall be repaired and maintained by the Contractor at his own expense without any delay.

17.4 Testing Concrete Works

17.4.1 Concrete Works, Test Certificates

Unless otherwise directed by the Engineer, the Contractor shall supply and submit to the Engineer:

- Manufacturers test sheets with each consignment of cement and admixture certifying compliance with the relevant standards.
- Certification of the calibration of weighing and dispensing equipment on the batch mixing plant.
- The certified test results for all tests carried out on aggregates, water fresh and hardened concrete.

In case of doubts, new tests shall be executed upon the Engineer’s direction at the Contractor’s expense.

17.4.2 Concrete Works, Inspections

No concrete shall be placed until the Engineer has inspected and approved the surfaces upon which the concrete is placed the formwork and the reinforcing steel. If requested by the Engineer to do so, the Contractor shall institute a “pour card” system in which a card is made out for each lift of concrete and is initialed by the Contractor and the Engineer confirming that the inspections have been carried out.

The “pour card” shall include spaces to identify the concrete being placed and to signify the completion of the inspections by the Contractor and the Engineer in regard to:

- Preparation of surfaces on which concrete is to be placed.
- Formwork;
- Reinforcement;
- Readiness for concrete placing;
- Striking time of formwork
- Inspection after removal of framework (remedial work directed);
- Curing procedures
- Completion of remedial work (if any)

17.4.3 Sampling and Testing of Aggregates

The Contractor shall sample and carry out mechanical analysis of the fine aggregates and each normal size of coarse aggregate in use, employing the method described in BS8110 at least once a week when concreting is in progress and at such more frequent intervals as the Engineer may require.

The grading of all aggregates shall be within specified limits. Should the fraction of aggregate retained on any sieve differ from the corresponding fraction of aggregate in the approved mix by more than 5% of the total quantity of fine and coarse aggregate, the Engineer may instruct the Contractor to alter the relative portions of the aggregates in the mix to allow for such differences.

17.4.4 Sampling and Testing of Concrete

The Contractor shall provide the equipment necessary to determine the compacting factor of freshly mixed concrete at each place where concrete is being prepared and shall determine the compacting factor of the freshly mixed concrete by the method described in BS standards on each location where a set of test cubes is made and not less than once a day or as the Engineer may direct.

Unless particularly specified, for each grade of concrete works test cubes shall be made whenever required by the Engineer but not less frequently than one set of cubes per 25 m³ or part thereof concreted at least one set per day.

Each set of cubes (six cubes per set) shall be made from a single sample of a concrete batch taken by random. Each three cubes shall be tested 7 and 28 days after manufacture.

When requested by the Engineer, additional set of cubes shall be made for testing 3 days after manufacture. Test reports shall be submitted to the Engineer in duplicate.

17.4.5 Compliance with Specified Requirements

(i) Sampling

For each class of concrete in production at each plant for use in the works, samples of concrete shall be taken at the point of mixing and/or of deposition as instructed by the Engineer, all in accordance with the sampling procedures described in BS 1881 and with the further requirements set out below.

Six 150 mm or 200 mm cubes as appropriate shall be made from each sample and shall be cured and tested all in accordance with BS 1881, two at seven days and the other four at 28 days.

Each sample shall be taken from one batch selected at random and at intervals such that each sample represents not more than 20 m³ of concrete unless the Engineer agrees to sampling at less frequent intervals.

Until compliance with the Specification has been established the frequency of sampling shall be three times that stated above or such lower frequency as may be instructed by the Engineer.

(ii) Testing

The slump or compacting factor of the concrete shall be determined for each batch from which samples are taken and in addition for other batches at the frequency instructed by the Engineer.

The slump of the concrete in any batch shall not differ from the value established by the trial mixes by more than 25 mm or one third of the value, whichever is the greater.

The variation in value of the compacting factor, if used in place of a slump value, shall be within the following limits:

For value of 0.9 or more	± 0.03
For value of between 0.8 and 0.9	± 0.04
For values of 0.8 or less	± 0.05

The water/cement ratio as estimated from the results of (a) above, determined by samples from any batch shall not vary by more than five per cent from the value established during the trial mixes.

The air content of air entrained concrete in any batch shall be within 1.5 units of the required value and the average value of four consecutive measurements shall be within 1.0 unit of the required value, expressed as a percentage of the volume of freshly mixed concrete.

Until such time as sufficient test results are available to apply the method of control described in (e) below, the compressive strength of the concrete at 28 days shall be such that no single result is less than the value shown in Table 5-1 under the heading 'early works test cubes' and also that the average value of any four consecutive results is not less than the value shown in Table 5-1 under the same heading.

The 7-day cube result may be used as an early strength indicator, at the discretion of the Engineer.

When test cube results are available for at least 20 consecutive batches of any class of concrete mixed in any one plant, the average of any four consecutive results at 28 days shall exceed the nominal strength by not less than half the current margin (see table below) and each individual result shall not be less than 85 per cent of the nominal strength.

The current margin shall be defined as 1.64 times the standard deviation of cube tests on at least 20 separate consecutive batches produced from one plant over a period exceeding five days but not exceeding six months or on at least 50 separate consecutive batches produced from one plant over a period not exceeding 12 months. If both figures are available, the smaller shall be taken.

The current margin shall in any case at be less than the figure given below: -

	Minimum current margin for		
	10N/mm ²	15N/mm ²	20N/ mm ² and above
After 20 batches	3.3	5	7.5
After 50 batches	1.7	2.5	3.8

(iii) Failure to comply with requirements

If any one test cube result in a group of four consecutive results is less than 85 per cent of the nominal strength but the average of the group of which it is part satisfies the strength requirement, then only the batch from which the failed cube was taken shall be deemed not to comply with the Specification.

If more than one cube result in a group of four consecutive results is less than 85 per cent of the nominal strength or if the average strength of the group of which it is part fails to satisfy the strength requirement then all the batches between those represented by the first and last cubes in the group shall be deemed not to comply with the Specification, and the Contractor shall immediately adjust the mix design subject to the agreement of the Engineer to restore compliance with the Specification.

After adjustment of the mix design the Contractor will again be required to comply with sub-(clauses 5.4 (b) and 5.4 (c) of this Section of this Specification.

The Contractor shall take necessary action to remedy concrete which does not comply with this Specification. Such action may include but is not necessarily confined to the following: -

- (i) Increasing the frequency of sampling until control is again established.
- (ii) Cutting test cores from the concrete and testing in accordance with BS 1881.
- (iii) carrying out strengthening or other remedial work to the concrete where possible or appropriate.
- (iv) carrying out non-destructive testing such as load tests on beams
- (v) removing the concrete

17.5 Inspection and testing of pipes for mains

17.5.1 Testing at Place of Manufacture

Prior to shipment, all material shall be inspected in accordance with the requirements set out this Specification.

All field welds at main diameters exceeding DN 300 or PN10 shall be subject to tests as described in this Technical Specification.

17.5.2 Pressure Testing of Mains

The Contractor shall submit a systematic procedure for testing and method of filling and draining all mains and pipework for approval to the Engineer. The pressure drop method shall be applicable as set forth by EN 805 Chapter 11 or ISO Standards.

Table: Pressure test requirements for water mains

System test pressure STP		
Kind of main	Pressure Class = PN	System Test pressure STP
Local main	PN10, PVC-U	11bar = 6 bar + 5 bar
	PN10, HDPE, SDR 17	12 bar
Principal main	PN10, DI or steel	15bar = 10bar + 5bar
	PN10, HDPE, SDR 17	12 bar
Trunk main	PN10, DI or steel	15bar = 10bar + 5bar
	PN10, HDPE, SDR 17	12 bar
	PN16, DI or steel	21bar = 16bar + 5 bar
	PN16, HDPE, SDR 11	21 bar
	PN25, DI or steel	35 bar
	PN 40, DI or steel	40 bar

The Contractor shall perform the hydrostatic test, on all complete piping, prior to field coating of welds and fittings and prior to backfilling of the joints.

The Contractor shall provide and fit any test heads required, and the Engineer shall be informed in time to make a final check of each section to be tested before test heads are connected. The Contractor shall ensure that any necessary bosses on the test heads or pipework are included as required for filling and venting during Site testing. Fill and vent points in the pipe shall be closed afterwards. Thrust blocks shall be provided and removed after testing. Tests shall not be performed against valves but against blank flanges and test heads exclusively.

Calibrated manometers of class 0,6 160mm shall be used for testing and be placed at the lower end of the test section.

The Contractor shall supply all of the water required for the tests. Water may originate from the existing distribution system through direct connections or through hydrants, where permitted by the Employer in writing and approved by the Engineer or from Contractor's tanker trucks. Before start of test, air must be completely removed from the test section as its presence falsifies the test results.

In the event visible leaks are detected in the test section, the test is declared unsuccessful irrespective of the recorded pressure drop. Pressure drop shall not exceed 20kPa = 0,2bar during 2 hours of main test, otherwise the test has failed.

17.5.3 Disinfection

The disinfections shall be carried out in accordance with the following procedure. This procedure shall be done together with the “main pressure test”.

The disinfection agent can be NaOCl or Ca(ClO₂). The concentration of the disinfection agent per litre in the water must be between 35 and 50 mg/l. The duration of disinfection shall not remain under 12 h. After that period the pipeline shall be flushed with potable water.

The entire disinfection procedure requires documentation in written form and confirmation by the Engineer.

The Contractor shall be responsible to maintain the quality of the works from disinfection to commissioning at his costs.

17.5.4 Test of water tanks / reservoirs

Tightness test shall be carried out before any backfill around the tank / reservoir subject to test takes place. All outside surfaces of the tank / reservoir walls must be cleaned, smoothened and be completely visible and accessible. Each tank of a multi-tank reservoir shall be subject to a separate test.

Filling of a tank / reservoir shall take place during daylight to allow for continuous inspection during filling. Tanks / reservoirs shall be filled up to high water level as indicated on the drawings or as otherwise instructed by the Engineer.

For tanks / reservoirs completely or partially made of concrete shall be maintained full over a period of 7 consecutive days prior to the test to achieve saturation of the concrete exposed to water.

For tanks / reservoirs completely made of steel such saturation period is not required, and the

Contractor shall maintain the tank / reservoir full one day prior to start of test.

A visual check of all concrete wall surfaces shall then take place. If such inspection does not identify visible leakages or wet spots, the test can continue. If such inspection however identifies leakages and wet spots, the test will be terminated and the Contractor shall proceed with repairs of the respective parts as instructed by the Engineer. Thereafter the procedure shall be repeated.

After having successfully passed the visual inspection of the external surfaces, the main test shall be undertaken. The main test shall last 48 hours. During that period of 48 consecutive hours all ventilation hoods and accesses shall be tightly closed and sealed. Water level shall be measured at the beginning and end of the main

test period. If water level drop does not exceed one (1.0) cm or 3/1000 of storage height, whichever is less, the test is successful.

In accordance with 2.2.5 the Contractor shall supply all of the water required for tests.

From start of filling until completion of the test, the Contractor shall monitor the settlements of the tanks through precision levelling on the benchmarks grouted into the concrete as directed by the Engineer, particularly at the four corners of rectangular tanks and every 90° at the circumference of round tanks.

Frequency of levelling and recording formats shall be as instructed by the Engineer.

17.5.5 Test during commissioning

In the event tests carried out earlier on the respective parts of the Works have not been successful or if necessary to proof the tightness between two sections of the Works that have been tested before separately additional Tests during Commissioning shall be carried for any hydraulic system upon request of the Engineer of such parts of the Works.

17.6 Inspection, testing and pre-commissioning of facilities, mechanical and electrical works

17.6.1 General

The Contractor shall request inspection and testing of all items of the facilities, mechanical and electrical works and shall give the Engineer four weeks' notice that the equipment is ready for testing and of his intention to carry out tests.

If any of the tests are beyond the resources of the Contractor or the Manufacturer, The Contractor shall make arrangements for these to be carried out elsewhere on suitable test benches.

The Contractor shall carry out tests as stated in the applicable International Standards (EN, ISO or IEC), for performance tests and such other tests that are expressly stated and as may deemed necessary in the opinion of the Engineer, to proof that the Works comply with the Specifications set forth by the Contract Document as a whole. Each test certificate shall contain concise information of the test, such as: Contract number and details, pay item number, pertinent specifications, manufacturer, type, model, serial number etc. shall be given for unambiguous identification of the material or equipment tested and the extent of the certificate's validity. However, no inspection, release or approval of any part of the Works by the Engineer, shall release the Contractor from any of his obligations under the Contract. Whenever tests and inspections have been completed to the Engineer's satisfaction and when the test certificates (including reports, notes,

tables, graphical representations of results etc. as technical annexes) have been checked and deemed complete, the Engineer shall confirm acceptance in writing.

Where witnessed tests are not required by the Contract or waived by the Engineer, the complete test certificates including technical annexes shall be forwarded to the Engineer:

- either within two weeks after shipment of the respective goods together with any other commercial document issued at the time of shipment; and
- or within 2 weeks after receipt of such waiver.

The Contractor shall bear any extra costs that may arise from a failed test or inspection, or failure to forward unwitnessed test and inspection certificates within the period of time set forth. The Engineer may require the Contractor to remedy a failed test, or inspection may require through supply of new parts from the manufacturer or return to manufacturer's plant of damaged parts for repairs if such repairs are still technically deemed feasible by the Engineer. Any equipment used in testing shall in all respects comply with the appropriate safety regulations and/or requirements regarding electrical apparatus for the safety of the Plant and the men working thereon.

The Contractor shall make sure that all sub-contractors are given copies of the relevant parts of the Specifications. Full details of the testing method proposed for each item shall be submitted to the Engineer.

17.6.2 Cost for testing deemed to be included

The Contract price is deemed to include for all costs of all tests, including temporary works, labour, materials, instrumentation, stores, fuel and power used, as may be required during all inspections and tests and for the provision of certified records and curves whether on site or any other place deemed appropriate by the Engineer.

The Contractor shall also bear all costs of Third Party as may be required from time to time and of the Engineer if required to carry out inspections at places other than on the site or in the Contractor's storage facilities close to the site. Such costs of the Engineer shall comprise the per-day-fee, travel and accommodation cost and all other incidental costs occurring during the performance of test and inspection.

17.6.3 Test Instruments and Equipment

The Contractor or the manufacturer as may be the case shall satisfy the Engineer as to the accuracy of all instruments required for the tests and if requested by the Engineer shall produce recent calibration tests, or otherwise have them calibrated at his own expense by an independent authority.

kW-meters and kVAR-meters shall be checked for correct rotation and creep tests shall be carried out to ensure that the meter is inoperative with voltage alone if the secondary of the current transformers is left connected with the primary current interrupted.

17.6.4 Factory test

Whilst the Engineer shall be provided with facilities to witness testing and/or inspection of all items of equipment at the manufacturer's works, he may at his discretion advise that part of the tests shall proceed in his absence, the tests shall be made as if in his presence.

The Contractor shall submit to the Engineer a duly countersigned copy of the readings of any witnessed test and, within two weeks after completion of any witnessed or unwitnessed tests, a complete test certificate.

The Contractor shall submit to the Engineer unwitnessed factory test certificates where applicable giving a detailed record of all electrical and mechanical tests and its results carried out on the equipment and material.

If after inspecting, examining, or testing any material or equipment, the Engineer shall decide that such items or any part thereof is defective, or not in accordance with the Specification or performance requirements, he may reject the said items or part thereof, giving to the manufacturer within a reasonable time, notice in writing of such rejection, stating therein the ground upon which the said decision is based. Any repetition of an unsuccessful test shall be at the Contractor's expense.

As and when the Engineer is satisfied that the equipment shall have passed the required tests he shall notify the Contractor in writing to that effect. Copies of test certificates shall be included in the Operating and Maintenance Instructions as detailed elsewhere.

17.6.5 Factory Inspection and Testing of Special Valves

All valves shall be factory inspected acc. to ISO 5208 and pressure tested acc to DIN 3230 Part 4. Where special hydraulic performance is specified elsewhere (e.g. head loss), such parameter shall be tested and certified acc. to EN 10204, Table 1 3.1B.

17.6.6 Vessels, pipes, valves

All hydraulic equipment subject to hydraulic tests such as but not limited to: pressure vessels, pipes, fittings and valves, shall be hydraulically tested 1,5 times the maximum working pressure but not less than the test pressure applicable to the PN rating. Such tests shall not be witnesses except if specified elsewhere in the Contract Documents.

17.7 Site test

17.7.1 General

Site testing includes both tests during installation and tests at completion. The Contractor shall prepare and submit to the Engineer a comprehensive and detailed site testing program of all parts of the Works subject to Site testing. This program shall be submitted to the Engineer one month before start of erection / installation and be reviewed and updated as may be required from time to time.

17.7.2 Composite hydraulic systems subject to test during installation

Site testing includes tests during construction and installation, Pre-commissioning and Commissioning.

All joints, pipe foundations and the like shall be inspected during testing and pressure shall be maintained until such inspections are completed or as specified by EN 805 for the duration of testing, which ever lasts longer.

In the event that pressure loss encountered during test is higher than acceptable and / or any visible leak occurs, or any foundation or puddle flange is found to have moved or cracked or appears damaged in any way, or if any pipe barrel or flange shows deformation, the test shall be declared as being unsuccessful.

17.8 Measurement And Payment

All items for measurement and payment are provided under the relevant sections of the Bills of Quantities. The rate provided by the contractor in the bill of quantities shall be deemed to cover the cost of complying with all the requirements in this section of the specification.

18 WORKS COMPLETION

18.1 Testing and Commissioning

18.1.1 General

The testing and commissioning plan is to cover the facilities to verify the performance of the designs, equipment, and construction provided by the contractor as part of their proposal. The contractor is responsible for submitting a detailed test program for the engineer's approval, conducting all tests according to the approved plan and additional tests if requested by the engineer, submitting test reports and certificates, retesting if necessary, and providing all equipment, assistance, documents, electricity, fuel, consumables, instruments, labor, materials, and staff needed to perform the tests. The tests themselves shall be conducted in accordance with the Technical Specification.

The Contractor shall provide for the tests:

- a) All skilled and qualified operating and test staff for the testing of all equipment.
- b) Provisions and disposal of all services, lubricants, and fuels and electricity.
- c) All measuring and testing instruments to demonstrate that the equipment fulfills the requirements, in particular, instruments to monitor transient processes such as surges, etc.

The overall testing program for the Project shall consist of the following:

- a) Shop inspections and testing: these are inspections and tests, at the place of manufacturing. This applies for building materials, mechanical (e.g. pumps) and electrical items of plant (e.g. instruments). The manufacturer shall issue the relevant certificates.
- b) Construction inspections and testing at site: These are routine inspections and tests during construction. Please refer for further details also to paragraph [define]
- c) Tests on mechanical completion: These tests are performed at the completion of the mechanical and electrical installations.
- d) Tests on part completion: These tests are conducted on completed structures (e.g. leak tests at pumping stations) or parts of the Works (e.g. for a part of the drainage network);
- e) Pre-commissioning tests: These tests are performed before putting the Works or part of them into operation.
- f) Performance tests (Test on Completion): Under these tests the Works or part of them shall be operated for a period of 3 days to prove that the specifications and provided performance guarantees (as specified in the GCC) are met; and

- g) Reliability test run (Test on Completion): Under this test the Works, or part of them, shall be operated for a period of time as stipulated in the Contract to prove its reliability.

As a general rule, passing successfully tests on mechanical completion and on partly completion shall be the pre-requisite for starting with pre-commissioning tests. Passing successful tests on pre-commissioning shall be the pre-requisite for the commissioning. At the end of commissioning the performance tests and the reliability test run will be carried out.

After successfully passing the above tests, and after submission of the as-build documentation and of the operation and maintenance manuals, and after submission of all test results (For electrical installations in compliance with Appendix 6 of 16th Edition of the IEE Wiring Regulations – BS7671: 2008. The installation / system shall not be considered complete without this certificate. Suppose the Contractor fails to produce these documents within one month from the date of tests on Commissioning. In that case, the Engineer may employ the services of third party to produce these documents and all costs shall be borne by the Contractor) the Works or parts of them, can be deemed to be completed. The Engineer will issue the Construction Completion Certificate.

18.1.2 Test and Commissioning reports

Reports about Tests and Commissioning shall be prepared and supported by recorded data and calculations. Reports shall be submitted to the Engineer not later than 7 days after the test.

Three (3) months after the Commencement Date, the Contractor shall submit to the Engineer all relevant test documents, which shall include:

- a test program.
- test standards.
- type of inspection and tests.
- tests which are to be witnessed by third parties; and
- quality control procedures.

Three (3) months prior to the proposed start of commissioning the Contractor shall submit to the Engineer:

- a commissioning test program.
- commissioning procedures; and
- tests on partly completion.

Three (3) months prior to the Performance Tests Contractor shall submit to the Engineer

- a test program.
- test standards.

- manpower and deployment schedule of Contractor for performing the tests, forms of test records and report.
- description of instrumentation to be used, including accuracy, and calibration test results.
- method of data recording; and
- method and equations/correction curves used for the adjustment of recorded data to the design conditions.

Upon successful Commissioning the Engineer shall issue the Final Acceptance Certificate.

18.1.3 Tests on Completion for Works

The following gives the general approach concerning Tests on Completion for Works. All tests shall be carried out in accordance with the applicable standards and as per the Contractor's program.

The reliability test run is scheduled for five days, while performance tests will last two days. During the Reliability Test Run, the Works shall be operated continuously or as required by the Engineer. The Reliability Test Run will not be deemed to be completed unless the relevant Performance Tests have been made. In the event of interruptions during the Reliability Test Run, for which the Contractor is responsible, the duration of the Reliability Test Run shall be extended by a period equal to the accumulated time of interruptions. If an interruption of operation of a Pumping Station lasts more than four (4) hours, the Reliability Test Run shall be restarted, after making good the defect. The Reliability Test Run may be interrupted on a maximum of three occasions, provided that no interruption exceeds four (4) hours and that the Engineer is notified of the interruption in good time.

The hydraulic capacity of the transmission pipelines shall be proved during designing, when submitting the hydraulic report. Consequently, the Works shall be certified to be partly completed after passing all tests, including pressure tests, which prove that civil and pipe construction was done in accordance with the design. Pressure mains shall undergo a complete functional test which shall include a test of the surge protection system, partial and full load operation. In addition, the pumps etc. shall pass the manufacturing, reliability and performance tests. The compliance of drinking water parameters will be tested during performance tests.

The power consumption and consumption of consumables which are subject to liquidated damages shall be tested during the performance tests based on the same provisions as described above. After successful passing all above tests, the Works shall be deemed to be completed, and the Engineer shall issue the Certificate on Completion.

18.1.4 Tests after Completion

The Engineer may, at his own discretion, instruct the Contractor to carry out the Reliability Test Run and the Performance test after Completion of Works (Test after Completion).

18.2 Facilities, mechanical and electrical works subject to commissioning**18.2.1 Building services**

The Contractor shall demonstrate that the building services installations conform to the Specification and applicable international Standards. The tests shall include but not be limited to:

- a. Lighting installations
- b. Plumbing
- c. Ventilation and air conditioning

Demonstrate that the illumination levels conform to the specified values.

18.3 Measurement And Payment

All items for measurement and payment are provided under the relevant sections of the Bills of Quantities. The rate provided by the contractor in the bill of quantities shall be deemed to cover the cost of complying with all the requirements in this section of the specification.

Appendix I: Drawings

The drawings referred to in the Conditions of Contract and the Technical Specifications are bound separately in an accompanying folio titled Book of Drawings of the Bid Documents, together with such further drawings and amendments as shall be made and issued by the Engineer during the execution of the contract.

Appendix II: Environmental and Social Management Plan - ESMP

The ESMP referred to in these Technical Specifications was developed from an environmental and social impact assessment and outlines how potential negative environmental and social impacts of the proposed project will be managed throughout its lifecycle. It forms a risk management strategy for projects, ensuring they are implemented in a way that minimizes harm and maximizes positive outcomes for both the environment and the people affected.