Tamilnadu Water Supply and Drainage Board

Hogenakkal Water Supply and Fluorosis Mitigation Project

Package - IV

Volume: 4

Specification for Civil Works

Project Maintenance Division
Hosur.

VOLUME 4

STANDARD SPECIFICATIONS – PART K

CONTENTS LIST

PART K – CIVIL STANDARD SPECIFICATION

K1.0 SITE INVESTIGATION

K1.1 Scope

This section of the specification covers any site investigation which the Contractor may carry out to augment existing information on soil conditions and design parameters for the purpose of design of the Works.

K1.1.1 Definitions – Boring, rig and hole

Boring shall mean advancing a hole using a machine driven auger, shell, chisel or clay cutter. The rig used shall be called a boring rig and the hole shall be called a borehole.

K1.1.2 Amount of investigation

The Contractor shall base his choice of design parameters for soils upon the results of soil investigation. The soil investigations shall comprise site investigation by boring, sampling and testing of samples. The soil investigation will include work previously undertaken by the Employer and additional work undertaken by the Contractor as necessary. As a guideline the contractor's plan for site investigation shall include for exploratory holes not less in number than;

- 1 per two thousand m^2 of area of foundations covered by buildings structures and earthworks excluding landscaping works,
- at least one hole within the perimeter of each separate foundation.

The soil investigation results shall be sufficient in total to satisfy the Engineer that the value of any soil parameter used in a design relates properly to the soil conditions for the part of the works to which the design relates.

Each borehole shall penetrate at least 10m below ground level or 2m below rock level whichever is less, or such greater depth that the Contractor shall deem necessary. Boreholes shall be sited at locations agreed with the Engineer.

Type of sample from borehole	Interval for sampling - m
Undisturbed sample	1.5
Large disturbed sample	3
Small disturbed sample	1
Moisture content (cohesive soils)	1

Type of test in borehole	Interval for testing - m
Standard penetration test	1.5

Testing of borehole samples other than strength and consolidation tests shall be carried out at least the following frequency:-

Test	Number of tests
Moisture content	1 per moisture content sample 1 per undisturbed sample 1 per large disturbed sample
Particle size distribution	1 per undisturbed sample 1 per large disturbed sample
Atterberg limits	1 per cohesive undisturbed sample
Chemicals tests: -pH -soil sulphates -soil chlorides	 1 per undisturbed sample and 1 per large disturbed cohesive sample
Dry density	1 per undisturbed sample

Drained and undrained tri-axial tests, consolidation tests and shear box tests shall be carried out as deemed necessary by the Contractor in respect of the soil types and degree of uniformity of soil.

K1.2 Reference Standards

(a) British Standards

The following British Standards and Codes of Practice are referred to in this section:-

CP 2001	Site investigations
BS 1377	Methods for testing soils for civil engineering purposes.
BS 4019	Core drilling equipment

(b) Indian Standard (BIS) comparable to above British Standards are acceptable

(c) Standard texts

The following standard texts are referred to in this specification:

(i) Earth Manual of the United States Bureau of Reclamation (2nd edition revised);

(ii) The preparation of maps and plans in terms of engineering geology: published in the Quarterly Journal of Engineering Geology, Volume 5, No.4 1972; Geological Society, London.

(iii) The measurement of soil properties in the tri-axial test: A.W. Bishop and D.J. Henkel (2nd edition 1962); Arnold, London

(iv) Laboratory testing in soil engineering: T.N.W. Ackroyd. 1969.

(v) Manual of soil laboratory testing: Head K.H., Pentech Press, London, 1980.

K1.3 Submissions by the Contractor

K1.3.1 Approval of personnel

Before the commencement of work, the Contractor shall provide for the Engineer's approval a list of the personnel who will be employed in site investigation works, both drillers and supervisory staff, together with a summary of their previous relevant experience. Only the highest standard of superintendence by the Contractor will be accepted and the Engineer shall be entitled to order the Contractor to remove from the works any member of his staff who in the Engineer's opinion is not fully competent or is lacking in qualifications or experience. The Contractor shall provide within one week a suitable replacement for any member of his staff so removed and he shall suspend the site investigation works or any part thereof if so ordered by the Engineer until such replacement is present on the works.

The Contractor's supervisory staff shall include full-time on the works a graduate engineer or engineering geologist and sufficient other staff trained and experienced in all aspects of the proposed investigations, able to carry out the tests as specified and to give accurate and reliable descriptions of soil and rock samples. Personnel shall be conversant with the Specification. An experienced technician shall be provided to supervise the field tests.

K1.3.2 Approval of plant and equipment

Before the commencement of work, the Contractor shall provide for the Engineer's approval a detailed list of all plant and equipment which the Contractor proposes to use and where required details of individual pieces of equipment. The Contractor shall ensure that the equipment is suitable for the terrain. The list shall include, but not necessarily be limited to:

- number and descriptions of boring rigs to be used;

- number and details of sampling equipment and containers;

- details of arrangement for carrying out field moisture content determination

No plant or equipment shall be used unless and until the Engineer has given his approval.

K1.3.3 Approval of laboratory and storage facilities

Before the commencement of work, the Contractor shall provide for the Engineer's approval full details of the laboratory at which samples are to be tested. If required, the Contractor shall arrange for the Engineer to inspect and visit the proposed laboratory before approval.

The Contractor shall submit for the Engineer's approval his proposed arrangements for storage of samples on Site, at the laboratory and at all other locations required in the Contract.

K1.3.4 Ownership of results and samples

The results of the investigation shall become the property of the Employer and shall not be divulged by the Contractor except to the Employer or the Engineer. All cores, samples and other materials recovered shall also become the property of the Employer and the Contractor shall not dispose of any such material and samples except as directed by the Engineer.

K1.3.5 Daily field records

Each day during the work on the Site, the Contractor shall hand to the Engineer two legible copies in English of the records of the previous day's work containing the following information in respect of each hole where work was in progress:

(a) Name of Contract;
(b) Location of work;
(c) Date and hours worked on the Site;
(d) Brief description of the weather;
(e) Make and type of machine in use;
(f) The water levels in boreholes;
(g) The approximate quantity of water poured into each borehole and the time(s) when it was done;
(h) Diameter of the hole and depths of any reduction in diameter;
(i) The length of hole for which casing was used and the diameter of such casing;
(j) A full geo-technical description of each stratum encountered;
(k) Depth below ground of each change of stratum;
(l) Reference number, depths and other details of all small and large disturbed samples, field moisture content samples and undisturbed samples (giving serial number and type of the sampler, length of sample recovered and number of blows used if driven);
(m) Data obtained during in-situ tests, together with the water level in the hole during the test;
(n) Details of any instrumentation installed;
(o) Details of backfilling and grouting;
(p) Details of delays and breakdowns;
(q) Any other relevant information.

K1.3.6 Water levels and measurements

Readings of water levels in all holes where the work is in progress shall be taken with an electrically operated sounder and recorded in the daily field records and logs at the following times:

(a) Before work commences in the morning;
(b) Before any break of more than 30 minutes duration;
(c) After any such break;
(d) After work has finished for the day, both before and after water (if any) is added to stabilise the hole;
(e) When a hole has been completed;
(f) Immediately prior to backfilling a hole;
(g) At the time of undisturbed sampling and standard penetration and other in-situ tests;
(h) When the Engineer requires.

The level of the bottom of the hole and the bottom of the casing, if any, shall be measured and recorded at the same time as each water level reading.

If, at any time, the level of the water in a hole fluctuates, a record shall be kept of the fluctuation. If the hole "makes" or "loses" water, the Engineer shall be informed immediately.

Any addition of water to assist the advance of a hole shall be recorded and any extraordinary smell or colour of the water and any other unusual circumstances shall be reported.

K1.3.7 Logs

Specimens will be provided by the Engineer: the logs shall include descriptions of all strata including details of the soil macro fabric (such as frequency, orientation and nature of fissures) and details of samples taken, and an account of all observations and field tests. All logs shall be subject the approval of the Engineer and two draft copies shall be submitted to the Engineer, not more than two weeks after the hole is backfilled. Soil and rock descriptions shall conform to the recommendations given in "The preparation of maps and plans in terms of engineering geology", published in the Quarterly Journal of Engineering Geology, Volume 5, No.4, 1972.

K1.3.8 Field test results

In addition to the field data supplied to the Engineer as daily field records, two preliminary copies of the results of each field rest shall be submitted to the Engineer within fourteen working days of completing the test.

K1.3.9 Reports

In addition to the records required during the course of the works, the Contractor shall supply to the Engineer reports of all the logs, results of field tests, drawings showing locations and levels of holes and laboratory test results. Reports shall be complete in respect of structures or groups of structures.

K1.4 Workmanship

K1.4.1 Boring

Boring rigs shall be capable of completing holes to at least 15m at a minimum diameter of 150mm. Boring may be carried out by percussion tools but not by water jets. Nothing except clean water shall be added during boring.

In cohesive materials, water shall only be added after specific approved by the Engineer.

In boring through permeable materials the Contractor shall avoid any unnecessary disturbance to the material and shall ensure that:-

(a) the water level in the hole shall be maintained slightly above the water table in the permeable stratum;

(b) the casing shall be left as near to the bottom of the hole as possible; and

(c) close-fitting tools shall be withdrawn slowly to avoid suction pressure.

The diameter of the holes shall allow for a sufficient number of reductions to complete the hole in a minimum diameter of 150mm and to permit the taking of all required types of samples and the removal of all other material in such a way that it can be accurately identified and the levels of each stratum accurately determined to the fully depth of the borehole.

A hole shall be cased in any stratum which is friable or not sufficiently strong to stand unsupported. When a borehole is being cased, the bottom of the casing shall always be maintained within 150mm of the bottom of the borehole. The casing shall never be in advance of the bottom of a borehole during undisturbed sampling or standard penetration tests.

The Contractor shall ensure that casings are of a suitable size and are inserted in such a manner as to render them recoverable. Casing shall not be removed nor any filling introduced into a hole until work in the hole is completed. Casings shall be gradually withdrawn and the filling shall be kept above the bottom of the casing during withdrawal. Holes shall be backfilled with well-compacted soil.

K1.4.2 Labelling of samples

The Contractor shall assign a reference number of each soil and water sample taken from holes. The number shall be unique for that hole and shall be in order of depth below ground level.

All disturbed and undisturbed soil samples and water samples taken from holes shall be clearly labelled. Each label shall include the following information:-

(a) Location of work and structure;
(b) Reference number of the hole;
(c) Reference number of sample;
(d) Date of sampling;
(e) Brief description of the sample, eg. stiff blue silty clay;
(f) Depth of the top and bottom of the sample below ground level;
(g) Location and geographical orientation of the sample in test pit ;
(h) Number of the sampler tube.

K1.4.3 Small disturbed samples

Small disturbed samples shall be truly representative of the composition of the in-situ soil. When the samples have been taken from the hole, they shall be placed without delay in airtight glass jars of not less than 0.4kg nominal size and each sample shall fill the jar as nearly as possible. If the material in the ground includes large pieces which it is impracticable to include in the glass jars, a large sample of the material shall be taken, sealed and labelled inside the bag and on the bag.

K1.4.4 Large disturbed samples

Large disturbed samples of granular materials shall weigh at least 10kg. At the same time small disturbed samples of the same material shall be taken.

All large samples shall be sealed into heavy duty plastic bags immediately they are taken. Each bag shall be labelled and a second waterproof label giving the same information shall be placed inside the bag.

K1.4.5 Field moisture content samples

Field moisture content samples shall be placed in airtight containers immediately after sampling and shall be weighed within two hours of sampling. The moisture content shall be determined from this weight using the method specified in BS 1377 Test 1(a). The oven and scales necessary for the tests shall be ready to receive samples before sampling starts.

K1.4.6 Open drive undisturbed samples

Undisturbed samples 100mm diameter shall be taken in cohesive soils in boreholes.

The Contractor shall make every effort to avoid disturbance of the material to be sampled. The debris in the bottom of the hole shall be cleaned out as much as possible before sampling by careful use of the clay-cutter or shell dropped through a short distance. The Contractor may be required to drive double or triple coupled sample tubes so as to improve the quality of the sample. The number of blows required to drive each 75mm of penetration shall be recorded.

Prior to sampling in excavation, the area overlying the soil to be sampled shall be cleared by the Contractor of all material which has altered from its natural conditions.

Before withdrawal, the sampler shall (if practicable) be rotated through one complete revolution to shear the soil horizontally at the bottom of the sampler. The sampler shall then be withdrawn smoothly so as to cause the minimum disturbance to the sample. The total length of the sample shall be measured and recorded and, if any of the soil has fallen out of the bottom of the tube, this fact shall also be recorded.

K1.4.7 Sealing, labelling and storing undisturbed samples

After removing the cutting shoe and the adaptor head with the disturbed material which they contain, the visible ends of the sample shall each be trimmed of any wet disturbed soil and then immediately coated with not less than four layers of just molten microcrystalline wax or other similar material approved by the Engineer. A metal foil disc 10mm greater diameter than the tube shall then be added and followed by more molten wax to give a total thickness of not less than 25mm. Any space remaining in the ends of the sample tube shall be solidly filled with damp sawdust or other material approved by the Engineer and the ends of the sample tube shall be covered with tight fitting screw caps.

The sample tube shall immediately be labelled. A second waterproof label given the same information shall be placed inside the sample tube at the top end.

The sample tube shall be protected from adverse effects of the weather and stored at a temperature between 7^0C and 18^0C in a humid atmosphere.

K1.4.8 Standard penetration tests

The Contractor shall carry out standard penetration tests in accordance with BS 1377 (1975), Test 19. All external and internal faces of the sampler shall be smooth and free from scars. A cone-ended adaptor with a 300 half-angle may replace the open-ended driving shoe for gravelly soils. Every precaution shall be taken to minimise disturbance of the soil to be tested. If the shell is used, it shall be worked gently up and down to avoid disturbance of the soil by surging, the distance through which the shell is dropped shall be small and the shell shall be removed slowly to minimise sanction. If possible the casing shall be turned down through the overlying 300mm of soil and it shall not penetrate the soil to be tested. The test shall be stopped if the total blow count, including the seating drive, reaches 75. A small disturbed sample and, for cohesive soils, a field moisture content sample shall be taken from each soil type in the sampler core. The water level in the hole at the time of the test shall also be recorded.

K1.4.9 Laboratory tests

The Contractor shall send to the Engineer two preliminary copies of the results of tests within three days of the completion of the test. Laboratory tests shall generally be carried out in accordance with the procedures described in "The measurement of soil properties in the tri-axial test" by A.W. Bishop and D.J. Henkel (2nd edition, 1962), in "Laboratory testing in soil engineering" by T.N.W. Akroyd and in BS 1377 "Methods of testing soils for civil engineering purposes" or "Manual of soil laboratory testing", Pentech Press, London.

The Engineer shall have right of access to the Contractor's laboratory while laboratory testing is being carried out in connection with the Contract.

The Contractor shall agree with the Engineer, at the end of the consolidation stage of a test, and/or before starting to shear a specimen, the rate of strain to be used.

When laboratory tests are carried out on part of a soil sample, the remainder of the soil in the sampler or container shall be resealed as soon as possible and retained.

All soil on which laboratory tests have been carried out, including that wasted during the preparation of test specimens, shall be retained in labelled air-tight containers until otherwise directed by the Engineer.

K2.0 EARTHWORKS AND FOUNDATION DESIGN

K2.1 Scope

This specification covers the design methods to be used by the Contractor for the design of earth embankments and foundations.

K2.2 Reference Standards

The following texts are referred to in this specification:

Janbu N 1973 "Slope stability computations. Embankment-dam engineering" Wiley, New York, 1973;
Terzaghi K and Peck R B. "Soil mechanics in engineering practice". 1967;
U.S. Bureau of Reclamation "Earth manual" (2nd Edition).

K2.3 Calculations

Calculations shall take into account the worst conditions that will occur during construction and the life of the Works, including highest and lowest water levels and water pressures, porewater pressure, seepage, construction methods and their effects on the specified parameters. Where not otherwise specified, calculations shall be made in accordance with the methods set out in Terzaghi and Peck 1967, or with any other accredited and recognised design method approved by the Engineer.

K2.4 Design parameters

Design parameters for geo-technical calculations shall be obtained from properties measured in the site investigation. Where necessary, the Contractor shall extend or check site investigations made by himself or others to satisfy himself and the Engineer that the appropriate parameters are being used.

Shear strength parameters shall be measured on undisturbed samples in tri-axial tests or, where appropriate, in shear boxes. Quick tri-axial tests, giving total stress parameters, may be used for design of foundations against shear failure, or for the design of slopes not more than 5m high. Effective stress parameters measured in drained tri-axial tests shall be used for the design of all cut slopes or embankments more than 5m high. Pore pressures for stability and other calculations shall be computed for each situation from the worst combination of circumstances which can occur during the life of the Works.

Settlement characteristic parameters shall be measured on undisturbed samples in consolidation tests or in the case of non-cohesive materials by suitable in-situ tests.

Permeabilities shall be measured by in-situ tests in accordance with the procedures set out in the USBR Earth Manual, Second Edition, or in falling head parameters.

Parameters, measured in tests as specified and approved by the Engineer, shall be the specified parameters.

K2.5 Anchorages and thrust blocks

Anchorages and thrust blocks shall design to IS5330 and to resist with the specified factors of safety, any pulls or thrusts to which they may be subjected. Where the factor of safety against sliding is not otherwise specified, it shall be taken as not less than 2, calculated on frictional resistance only on the base of the anchor block in the direction of incipient sliding. When it is necessary to take into account passive resistance of soil, the factor of safety against sliding shall not be less than 3, even if frictional resistance is included. Passive resistance shall not be taken into account where movement cannot be permitted.

Anchorages for retaining walls shall be positioned so as to be outside the zone influenced by deflection or lateral displacement of the retaining wall. Connections between such anchorages and retaining walls shall be designed to resist the tensile stresses and all lateral or vertical stresses to which they may be subjected by settlement, earth-moving during construction or other causes.

The Contractor shall ensure that, during tests on anchorages or thrust blocks, the factor of safety is sufficient to prevent movement where movement cannot be permitted, as for example, at rigid pipe joints.

Anchorages and thrust blocks on pipelines shall be designed to resist with at least the proposed factors of safety the pulls and thrust arising in the following conditions:

Test pressure	-	a factor of safety of 1.1 on friction on sides and base of structure or such factor that the Contractor deems necessary in view of his responsibility for the Works.
Closed valve pressure	-	a factor of safety of 1.4 with pumps running on friction on sides and base of structure or such factor that the Contractor deems necessary in view of his responsibility for the Works.

Should the Contractor feel justified in mobilising passive resistance by designing the thrust block and pipeline to accept movement, then the factors of safety on test and closed valve pressure conditions shall be increased depending upon the relative contributions from passive resistance and friction.

If, during testing of a pipeline or closed valve pressures, there is unacceptable movement at a thrust block or anchor, the Contractor shall redesign and rebuild the structure with such increased factors of safety as are necessary to provide adequate resistance.

K2.6 Retaining walls

Retaining walls which are not restrained above their bases shall be designed for not less than active earth pressure. Retaining walls which are restrained above their bases, or form part of a basement, shall be designed for at-rest earth pressure; the co-efficient of earth pressure at rest shall be taken as not less than 0.5 of the vertical pressure at the point being considered.

In addition to the specified earth pressures, retaining walls shall be designed for any surcharge which may be applicable and for appropriate water pressure.

Factors of safety against shear failure under vertical loads and against horizontal sliding shall be as specified or of sufficient magnitude to prevent settlements or movements from exceeding specified limits. Where no such factors of safety or no such limits are specified, the factor or safety against shear failure under vertical load shall not be less than 3, and the factor of safety against horizontal sliding shall not be less than 2.

Calculations shall be made in accordance with methods set out in Terzaghi and Peck, 1967.

K2.7 Earthworks

Earthworks shall be designed to be stable under all conditions that occur during construction or afterwards for the life of the Works. Where necessary, earthworks shall be designed and constructed to retain water safely.

Calculated settlements or heaves shall be compensated where necessary by appropriate allowances during construction.

K2.8 Embankments

Embankments shall be designed to be stable under all conditions to which they may be subjected, including external vertical loads, lateral loads, water pressure, seepage and drawdown and seismic effects, all where appropriate.

All embankments shall be designed to have side slopes no steeper than 1 in 3 and crest widths of minimum width 2m. If the Contractor considers that embankments with steeper side slopes or narrower crests are required in order to provide the Works in accordance with the Specification then he shall inform the Engineer giving his reasons. The Contractor shall in any case submit calculations in consideration of slope stability.

All embankments shall include a minimum freeboard allowance of 100mm to account for settlement during and after construction. The Contractor shall in any case submit calculations in consideration of settlement and shall increase the allowance for settlement as necessary to account for the results of those calculations.

The 'design level' on the embankments shall be deemed as that level on the finished surface of the placed, compacted material forming the impermeable core of the embankment and shall not include the depth of topsoil to be replaced on the surface of the embankments following construction.

Calculations shall be made using the method of Janbu (simplified) (1973) with the specified parameters to produce factors of safety not less than those specified. Where not otherwise specified, the factor of safety against shear failure, either in the embankment fill, or its foundations shall not be less than 1.5.

Calculations shall be made, using the specified parameters, of settlements expected as a result of compression of the fill and of the foundations. Where appropriate, estimates shall be made of the time to reach particular amounts of settlement.

For water retaining embankments, estimates of seepage and exit gradients shall be made using the specified parameters. Corrections shall be made for differences between vertical and horizontal permeabilities where necessary. Seepage quantities and exit gradients shall not exceed the specified quantities. Where no exit gradient is specified, it shall not exceed one eighth; that is to say, the head dissipated over the last section of soil considered immediately before the seepage emerges from the soil shall not exceed one eighth of the length of the seepage path over which it is dissipated. If not otherwise specified, the Contractor shall take such length of seepage path in soil to calculate the exit gradient as the Engineer shall direct. Where the geometry prevents compliance with this requirement, a weighted inverted filter shall be provided and designed in accordance with the rules of Terzaghi and Peck, 1967.

K2.9 Foundations

Foundations that are not piled shall be founded on suitable strata. Bearing capacity and settlement of foundations shall be investigated by the methods set out in Terzaghi and Peck, 1967.

The factor of safety against shear failure in the soil beneath foundations shall be as specified. Where not otherwise specified, the factor of safety against shear failure shall not be less than 3. Settlements of foundations shall not exceed values specified. Where not otherwise specified, the total settlement of any unit shall not exceed 25mm; differential settlements shall not cause a gradient between two points originally level of more than 1 in 300.

Buried concrete and metal shall be protected in the manner specified against chemical attack from corrosive materials in the ground. Where specified, buried concrete shall be made using sulphate resisting cement of the quality specified, and tanked using asphaltic membranes in the manner specified. Where protection is damaged by construction operations, it shall, before being covered up, be repaired to the satisfaction of the Engineer.

Water conditions including groundwater conditions shall be checked before placing foundations. Uplift, including uplift due to artesian conditions, shall, where necessary, be allowed for in foundation design.

K2.10 Erosion protection grassing and site drainage

Surfaces that are not paved surfaces or an integral part of a structure shall be finished as follows:-

- Sloping surfaces of gradient steeper than 1 in 2.5 shall be pitched with grouted stone pitching. Weepholes shall be installed on pitched surfaces at 2 m c/c spacing;

- Sloping surfaces of gradients between 1 in 2.5 and 1 in 20 shall be topsoiled and seeded as per the Specification and shall be protected with an erosion control blanket of coir pinned into the subsoil at 2m intervals in two directions using biodegradable pegs of length not less than 400mm;

- flat surfaces shall be grassed as specified here-in. Flat surfaces shall have slopes not greater than 1 vertical to 20 horizontal and not less than 1 vertical to 50 horizontal;

- surface drains shall be installed at the intersections of sloped and flat surfaces and shall be sufficient in capacity to remove surface runoff of 100 mm per hour to the site drainage system;

- the site drainage system shall be installed to have sufficient capacity to drain water from all roofed, paved and sloping areas at a surface runoff rate of 100 mm/hour;

- the site drainage systems shall discharge into the overflow lagoons or into the overflow drain;

- the Contractor shall install an automatic irrigation system to apply irrigation water to grassed areas.

K3.0 STRUCTURAL CONCRETE DESIGN

K3.1 Design principles and analysis

Calculations by the Contractor for the design of any structures shall be prefaced by a statement explaining the principles of design and the type of analysis adopted. The statement shall also indicate the codes of practice upon which the design is based and into which category the structure, (or part of a structure) is placed for design purposes, i.e. class 1, 2 or 3 as described later under 'classification of concrete structures'.

For a superstructure framework, a separate statement shall be included, explaining how the overall stability is to be achieved and whether reliance is to be made on infill walls, whether of brick, concrete or other material, to provide stability.

Any computer programs used in structural concrete design shall be fully described, and details of input and print-out shall be presented in a manner which can be readily understood. Program manuals and any instructions to program users shall be made available to the Engineer upon request.

Where any such program cannot be demonstrated by the Contractor to have been fully checked, or where the Engineer considers it necessary, the Contractor shall run such test examples as the Engineer may choose, in order to verify the completeness and accuracy of the program.

K3.2 Reinforced and prestressed concrete

Reinforced and prestressed concrete shall be designed in accordance with either of the following British or Indian Standard codes of Practice, whichever is relevant:

BS 8110	Structural use of concrete, Part 1
BS 8007	"The structural use of concrete for retaining aqueous liquids".
IS 456	Code of practice–plain and reinforced concrete
IS 3370	Code of practice for concrete structures for storage of liquids

Plain concrete (un-reinforced) shall be designed in accordance with BS 8110: Part 1.

The thickness of reinforced concrete walls and slabs designed to BS 8007 (Class 2 and 3 structures) shall not be less than that derived from the following constraints:

(a) All plane walls and slabs:

The thickness shall nowhere be less than the design internal or external water pressure (expressed as the height of water column) divided by 10.

(b) Vertical walls and slabs inclined at angles more than 15 degrees above the horizontal:

where walls and slabs are 'external', i.e. bounding the outside of a water containing space so that leakage, if it ever occurred, would pass through the wall to or from foundations, drainage collection systems or places intended to be dry and accessible, the thickness shall be not less than 350mm;

where walls and slabs, reinforced on both faces, are 'internal' ie. dividing the internal part of a structure so that leakage, if it ever occurred, would pass through the walls from one water containing space to another water containing space, the thickness shall not be less than 225mm.

(c) All walls and slabs:

The thickness shall nowhere be less than the structural thickness required by the design procedures for Class 2 and 3 structures specified in K3.4.

The Engineer will in any event reserve the right not to approval of the design of any structure, or individual structural member, if in the Engineer's opinion the design is either impractical or not in keeping with good design practice.

K3.3 Classification of concrete structures

This classification shall apply equally to parts of structures, where more than one case exists within the overall framework of a particular structure.

Structures are divided into three classes as follows:

Class 1 - those not normally subjected to hydrostatic pressure and not intended for the purpose of storage, retention, or transmission of liquids. Examples include: building superstructures, supporting elements to elevated tanks, foundations, shallow basements.

Class 2 - do not function to store liquids, but may be subjected to hydrostatic pressure and/or external soil pressure.

Examples include: culverts, spillways, water intakes, aqueducts, overflow channels, dry pumping station basement areas.

Class 3 - for storage or retainment of liquids. Examples include: liquid storage tanks of all types, service reservoirs, filters, clarifiers, pump sumps.

K3.4 Design methods

Class 1 structures shall be designed to BS 8110, using limit state design methods.

Class 2 structures shall be designed to BS 8007, using limit state design methods. A limiting design crack width of 0.2mm shall be used for the serviceability limit state of cracking.

Class 3 structures shall be designed to BS 8007 using limit state design methods. A limiting design crack width of 0.1mm for Class A exposure conditions and 0.2mm for Class B exposure conditions shall be used for the serviceability limit state of cracking.

Where a wall or slab is required to be designed to BS 8007 and is subject to either Class A or B exposure on one face only, the remote face shall be considered as Class C exposure, provided the member exceeds 225mm in thickness.

Where additional concrete beyond normal structural design needs is introduced for the purpose of gaining dead weight to counter the effects of buoyancy, any such additional concrete shall, so far as possible, be uniformly distributed among the sub-structure members.

K3.5 Reinforcement for control of temperature and moisture effects

(a) Class 1 superstructures

Where a slab or wall is exposed to 'severe' exposure conditions (BS 8110 classification), the reinforcement provided to exposed face shall be not less than that indicated below:

- sections up to 250mm thick, High Yield Steel Bars 12mmØ - 250mm c/c in each direction;
- sections 300mm to 450mm thick, High Yield Steel Bars 16mmØ - 200mm c/c in each direction;
- sections 500mm thick or greater, High Yield Steel Bars 16mmØ - 175mm c/c in each direction.

(b) Class 2 and 3 structures

Slabs and walls shall have reinforcement calculated in accordance with Appendix B to BS 8007, using the following data:

fct = 1.15 for grade 25 concrete, 1.30 for grade 30 concrete

fy = 250 N/mm^2 for plain round mild steel bars

fy = 410 N/mm^2 for deformed high yield (type 2) bars

fct = 1.0 for plain round mild steel bars
fb

fct = 0.667 for deformed high yield (type 2) bars
fb

α = 12 x 10-6 = coefficient of thermal expansion of concrete

T1 = fall in temperature from hydration peak to ambient.

This shall be calculated allowing for the following:

(i) Estimated temperature at time of placing

(ii) Cement content in the mix

(iii) Size of members

(iv) Formwork materials

T2 = fall in mean seasonal temperature.

K3.6 Design loadings

Structures shall be designed to withstand the loads exerted by the plant and components, including dynamic effects where these occur.

Other loadings shall be in accordance with those given in BS 6399: Loadings for building Part 1 and IS 1893-Earthquake loads. For ultimate limit state analysis, water and soil pressures shall be considered as 'imposed' loadings.

All loads used in design, including those of plant and components, shall be clearly indicated in the design calculations.

Wind pressures on structures shall be calculated in accordance with IS 875(part 3) "Wind loads", using a basic wind speed of not less than 39 m/s.

The effects of air temperature and fluctuations in air temperature shall be taken into account in the designs. Information on climatic condition is given in Part 2 of the Specification.

K3.7 Grades of concrete

These shall generally be in accordance with the following table:

Grade	Description
40	Prestressed concrete
30	Class 1 structure, where directly exposed to 'severe' exposure conditions (BS 8110)
30	Class 2 and 3 structures where member size is less than 300mm
25	Class 1 structure, where protected
25	Class 2 and 3 structures where member size is 300mm or greater
25	Blinding concrete throughout
20	'Hearting' concrete to massive sections
15	Plain (un-reinforced) concrete
15	Concrete fill

Grade 20 concrete shall not be used in reinforced concrete members, except as indicated above for 'hearting' concrete to massive sections.

K3.8 Reinforcement

Main reinforcement shall generally be high yield deformed (Type 2) steel bars. Links to beams and columns may be high yield deformed (Type 2) or plain round mild steel bars.

The following characteristic strengths shall be used in design calculations:

- plain round mild steel bars: 250 N/mm2
- high yield deformed steel bars: 410 N/mm2

K3.9 Cover

Cover to the outermost reinforcing bars (including links) shall be not less than 50mm where concrete is grade 25 and 40mm where concrete is grade 30, except for internal slabs and walls to building superstructures where less than 300mm thick and in 'mild' (BS8110) conditions of exposure which shall have not less than 25mm cover.

Where exposed aggregate finishes are used, the reinforcement covers specified above shall be increased by 10mm for concrete with a maximum aggregate size of 20mm, and 15mm for concrete with a maximum aggregate size of 40mm. It shall be made clear on the detailed structural drawings that the specified covers to exposed aggregate surfaces are related to the original as-cast surfaces.

Where ribbed finishes are used, the reinforcement covers shall be increased by the dimensions of the rib protection and the detailed structural drawings shall indicate that the specified covers are to be measured from the outermost surface of the ribs.

K3.10 Bond and lap length

The minimum 'anchorage bond length' and 'lap length' to develop the force in the bars shall be as given in the following table:

Grade of concrete	Anchorage and lap lengths in terms of bar diameter Ø			
	Tension		Compression	
	Mild steel	High yield steel	Mild steel	High yield steel
25	40	47	30	32
30	37	41	26	28

In no case shall the lap length be less than 25 times the bar diameter plus 150mm for bars in tension and 20 times the bar diameter plus 150mm for bars in compression. Where lapped bars are of two different diameters, the lap length shall be calculated using the diameter of the smaller bar.

K3.11 Water stops and sealants

Expansion and contraction joints in Class 2 and 3 structures shall incorporate water stops or surface sealers, or both, as specified in K3.12.

In expansion joints and complete contraction joints, internal waterstops shall be of a centre bulb type. Surface waterstops shall be of an expansion type.

In partial contraction joints, internal waterstops shall be of a 'dumbbell' type.

K3.12 Joints in concrete

Construction joints are introduced for convenience in construction. Reinforcement shall be carried through the joints and special measures taken to achieve full continuity in the concrete in accordance with the requirements of the specification for Concrete. The Contractor's proposed layout of construction joints shall also be in accordance with the requirements of the specification for Concrete. In addition, the joint positions shall, wherever possible, be located to avoid zones of high stress.

Contraction joints are permanent joints designed to prevent continuity in the concrete and are primarily intended to control the effects of early thermal contraction and shrinkage in the concrete.

Contraction joints shall be of two types:

(a) Complete contraction joints

In this type, concrete and reinforcement are completely discontinuous. Concrete faces shall be painted with two coats of bituminous paint, to prevent continuity. In Class 2 and 3 structures, the joint shall be sealed on one or both faces and a water stop provided.

A sealer shall always be provided on faces in contact with water.

Slabs and walls in contact with soil or where protected from contact with soil by a membrane tanking shall incorporate either a surface type waterstop or a centrally placed waterstop. Where shear forces may occur across a joint, a suitable joggle shall be provided to transfer the shear.

(b) Partial contraction joints

This type is similar to a complete contraction joint, except that the reinforcement is stopped-off at each side of the joint such that only 50% of the reinforcement crosses the joint. Transfer of shear forces across this type of joint will not be permitted.

Expansion joints are permanent joints provided with an initial gap between adjoining parts of a structure to accommodate expansion and contraction.

A compressible joint filler shall be used to form the joint. Exposed edges of the filler shall be protected by a sealer.

In Class 2 and 3 structures, a waterstop shall be provided and, at all faces in contact with water, a sealer shall be provided.

Slabs and walls in contact with soil, or protected from contact with soil by membrane tanking, shall incorporate either a surface expansion type waterstop on the soil side or a centrally placed dumbell type waterstop.

K3.13 Surface finishes

Finishes shall generally be provided as described below:

(a) Formed surfaces

(i) Class F.1

Surfaces against which further concrete is to be placed and surfaces to be permanently concealed by rendering, plastering, etc.

(ii)Class F.2

All surfaces permanently exposed to view, except where Class F.3 is required.

Surfaces either permanently in contact with stored, retained or flowing liquids. Surfaces against which a membrane tanking is to be applied.

(iii) Class F.3, 'ribbed' and 'exposed aggregate' finishes.

Surfaces prominently exposed to public view where good appearance is of special importance. Class F3 is also known as 'fairfaced' finish.

(b) Un-formed surfaces

(i) Class U.1

Surfaces of foundations, slabs and other structural members to be subsequently covered by further stages of concrete construction, bonded concrete toppings cement/sand screeds.

(ii)Class U.2

All surfaces permanently exposed to view, except where Class U3 finish is required.

Surfaces including those of blinding concrete, against which a membrane tanking is to be applied.

(iii) Class U.3

For hard smooth surfaces to slabs, walls, parapets and other structural members, where exposed to weathering.

K3.14 Drawings

Drawings shall be prepared such that the details are presented in a clear, concise and un-ambiguous manner. Written descriptions shall be as brief as possible, consistent with completeness. Lettering shall be legible and clear, but not too small.

Special requirements associated with the design, eg. details of chambers, sequence of construction, position and type of joints, shall be described on the detailed structural drawings.

Special consideration shall be given to the spacing of bars, to ensure that the concrete can be placed and consolidated without difficulty.

Wherever possible, distribution (secondary) reinforcement in walls and slabs shall have staggered laps.

The following scales shall be used:

General arrangement drawings	1 to 50
Walls and slabs* - plans and elevations	1 to 50 or 1 to 20
Walls and slabs - sections	1 to 20
Beams and columns - elevations	1 to 20
Beams and columns - sections	1 to 20 or 1 to 10

*Where concrete profiles and/or reinforcement details are complex and liable to result in a drawing which is difficult to read, the larger scale shall be adopted.

Detailing shall be as follows:

(a) Lines

Main reinforcement - to be 0.6mm thick

Concrete outline and links, etc - to be 0.4mm thick

Dimension lines, etc - to be 0.2mm thick

Note: When detailing reinforcement all bars shall be indicated by full lines. Where, for clarity, bars which are detailed elsewhere are shown extending into the part of the structure being details (eg. from an adjacent span of a beam, or from a support), they shall be indicated by broken lines.

(b) Reinforcing bar notation

The following method, complying with IS 2502–Code of practice for bending and fixing of bars for concrete reinforcement, shall be used.

(i) Elevations of walls and plans of slabs (example)

20 Y12 - 63 - 150 NF where:

20 indicates number of bars

Y indicates type of steel - see note (c) below

12 indicates diameter of bars in mm

63 indicates the bar mark

150 indicates spacing centre to centre bars in mm

NF indicates location of disposition of bars

Use one of the following abbreviations:-

EW	- each way	NF	- near face
EF	- each face	B	- bottom
FF	- far face	T	- top

(ii) Main reinforcement in beam and column elevations (example)

4Y25 - 39 where:

4 indicates number of bars

Y indicates type of steel - see (c) below

25 indicates diameter of bars in mm

39 indicates the bar mark

(iii) Type of steel

R = round mild steel bars in the metric round range of areas.
Y = high yield bars having a high bond strength, in the metric round range of areas.

Adequate information shall be given on the plan, elevations or sections for the bending dimensions of all reinforcing bars.

All reinforcing bars shall be positioned by dimension to concrete faces.

Basic structural dimensions shall be specified on the drawings, eg.

slab depth, wall thickness, beam length, width and depth, etc

(c) Slabs

Slab plans shall be drawn as viewed from above the slab and shall show any grid reference and the beam and wall numbers.

A 'run' of bar reinforcement on plan shall have the limits of the run shown by short lines and one intermediate bar only shown in full. The short lines at the limits shall be joined by a thin collecting line.

Provided congestion does result, the description of bar reinforcement on the plan shall be written on the collecting line; otherwise the description shall be written on an extension of the collecting line.

(d) Beams

Elevations shall give the full bar notation of main reinforcing bars and link reinforcement.

Cross sections shall show the individual position of each reinforcing bar, its bar mark, the concrete cover and the shape of the link reinforcement.

Slab reinforcement and reinforcement in adjacent beams shall only be shown on the beam details for their relationship with the reinforcing bars in the subject beam, and when shown shall be indicated by broken lines.

K4.0 STRUCTURAL STEEL DESIGN

K4.1 General

Calculations by the Contractor for the design of any structure shall be prefaced by a statement explaining the principles of design and the type of analysis adopted. The statement shall also indicate the codes of practice and specifications upon which the design is based.

Any computer programs used in the design process shall be fully described, and details of input and print-out shall be presented in an easily understandable form. Program manuals and any instructions to program users shall be available to the Engineer upon request. Where any such program cannot be demonstrated to have been fully checked or where the Engineer considers it necessary, the Contractor shall run such test examples as the Engineer may choose in order to verify the completeness and accuracy of the program.

K4.2 Codes and Standards

(a) Structural steelwork shall be designed in accordance with the following:

IS 800 Code of practice for general construction in steel

(b) Structures which are considered by the Engineer to be beyond the scope of the aforementioned standard shall be designed in accordance with:

BS 5400 "Steel, concrete and composite bridges"

or such other standards as may be approved by the Engineer.

(c) Runway beams and the longitudinal support beams of underslung cranes shall be designed in accordance with:

BS 2853 "Specification for the design and testing of steel overhead runway beams".

Where the Contractor requires the use of a standard or code of practice different to those specified, he shall first obtain the approval of the Engineer. After having obtained such approval, the Contractor shall use the standard in its entirety for the whole structure. The Contractor may use isolated parts of other standards that are considered relevant, but he shall obtain the Engineer's approval before doing so. The Engineer may exclude such a process on grounds of incompatibility with the main standard.

K4.3 General principles

Structures may be designed either by the working stress approach, using unfactored loads against a working stress (generally limited to 0.7 x yield stress) as specified in the relevant standard, or by the limit state method. Structures designed to the limit state methods shall be designed by considering the limit state at which they would become unfit for the use for which they are considered and applying appropriate safety factors to provide an adequate degree of safety and serviceability.

The overall design concept shall give due regard to the fact that the structure as a whole will be required to behave as one three dimensional entity. The layout of its constituent parts, including the steel members, the other structural elements, the foundations and the connections between each component, shall be such as to produce a strong and stable structure.

The structure shall be checked for the effects of all possible vertical and horizontal loads, acting both in conjunction and separately as appropriate, using factored loads when checking strength and stability to a limit state analysis and unfactored loads when checking deflections or strength and stability using a working stress approach.

The structures shall be designed to be capable of accepting without overstress a reasonable amount of extra loading due to any cause including extra services, heavier cladding, or other appurtenances that may reasonably be added during the life of the structure.

Structures shall be designed such that undue reliance is not placed on 'key' elements (a key element is one whose removal tends to prejudice the ability of the whole structure to survive). The removal or damage of such elements shall not entail collapse of more than a limited part of the structure. Structures will not be considered to be adequate if, in the event of abnormal loading, accident or misuse, the damage to the structure is out of proportion to the magnitude of the event.

The design shall take account of the need for stability of both the framework and the individual elements at all stages of erection. Where temporary bracing is required it shall be checked for the effects of all loadings that may arise during erection including those due to erection equipment and its operation. Such bracing shall be clearly indicated on the drawings together with clear instructions as to the appropriate stage of removal.

The design of crane beams shall take due account of all factors relevant to the provision of effective support to the crane under all conditions of loading including:

(a) Underslung cranes and monorail runway beams:

- (i) combined flange stresses resulting from overall bending and local flange bending due to wheel loads causing transverse stresses;
- (ii) lateral instability;
- (iii) torsional restraint;
- (iv) deflection limitations;
- (v) joints, particularly local force concentrations due to loads passing across joints.

(b) Overhead, overslung cranes and gantry girders;

- (i) lateral loading combined with vertical loads related to seismic effects;
- (ii) as above but related to coincident lifting, slewing, transversing actions of the crane.

All cranes supporting structures shall be designed for the greater of:

(a) the design loadings; or
(b) the provided capacity of the crane.

K4.4 Design loadings

Structures shall be designed to withstand the loads exerted by the plant and components including for dynamic effects where these occur. Other loadings shall be in accordance with BS 6399 "Design loads for buildings", and/or IS 1893– Earthquake loads.

All loads used in the design, including those of plant and components shall be clearly indicated in the design calculations.

Wind pressures on structures, plant and cladding shall be calculated in accordance with IS 875(part 3): "Wind loads" using a basic wind speed of not less than 39 m/s. The Contractor shall submit global and local wind pressure coefficients to the Engineer for his approval before commencing the actual design of clad structures.

The Contractor shall allow for temperature variations between components of structures as well as in the structure itself. Due account shall be taken of the effects of direct sunlight on structures which could cause high temperatures in exposed steelwork.

Information on climatic conditions is given in Volume 1 of the Specification.

Crane loads shall be generally in accordance with BS 449.

K4.5 Deflection limits

When checking the deflections of a structure, the most adverse realistic combination and arrangement of unfactored loads shall be assumed.

The deflection of a building or part of a building shall be limited so as not to impair the strength or efficiency of the building or of its contents, nor be unsightly or cause damage to the finish or inconvenience to the occupants.

Deflection of members listed in the table below shall not exceed the tabulated limits, unless the Contractor can demonstrate to the Engineer's satisfaction that greater values would not be detrimental to the performance of the structure.

(a) Beams	Deflection due to imposed loads
Cantilevers	Length/180
Lintel beams supporting brickwork	Span/360
Beams carrying plaster finish	Span/360
Roof beams not carrying plaster finish	Span/200
Purlins and sheeting rails	To suit the characteristics of the sheeting, roofing and ceiling materials.
(b) Columns	Horizontal deflection
Each storey, top of column, brick or plaster cladding	Height/300
Single storey portal framed structures, with metal cladding	Height/300
(c) Crane girder	Deflection at point of

	maximum span moment
Vertical deflection due to static wheel loads	Span/700
Horizontal deflection (calculated on properties of top or bottom flange along as applicable)	Span/500

The relative lateral deflection of adjacent frames (including the end frames) of sheeting clad structures shall be limited generally to frame centres/250 unless greater values can be shown to have no detrimental effect on the structural performance of the sheeting.

K5.0 PIPELINE DESIGN

K5.1 General

Where the Contract states that the Contractor shall be responsible for pipework/pipeline design his design shall include: hydraulic analysis, pipe material, pipe wall thickness, internal and external coatings, valves, thrust blocks, surge vessels, chambers, bedding/backfill material, supports, crossings.

The Contractor's design calculations shall be submitted to the Engineer for approval.

The Engineer will review the Contractor's pipe design and the Contractor's bedding, foundation and backfill design. The approval process is specified below. The Engineer may give provisional approval allowing the Contractor to proceed subject to field tests and trials. Approval of the Engineer shall not relieve the Contractor of his liabilities.

K5.2 Loads

Pipelines shall be designed for internal pressures as follows:

(a) the pressure class;
(b) the greater of (1) a surge pressure of the pressure class plus 10% (ii) the surge pressure set out in Reference Standards for the pipe material;
(c) sub atmospheric pressure of 3m water (0.3 bar).
and to external loads as follows:
(d) soil load, assuming the `wide trench' condition (unless the Contractor can demonstrate that other conditions will prevail);
(e) traffic load from 2 number 70kN wheel loads 900mm apart with an impact factor of 1.5 (representing two vehicles passing, parallel to the pipeline);
(f) ground water at ground at surface.

The sub-atmospheric pressure is a preselected figure. It links to the specification for the air valves which are required to admit air rapidly in the event of a burst.

Load combinations shall be as follows:

- pipe empty: (d) plus (e);
- pipe full: (a) plus (d) plus (e);
- pipe full: (a) plus (b) plus (d) plus (e).

Soil load shall be considered as dead load: surge and traffic shall be considered as transients.

Rerounding due to internal pressure shall not be taken into account except for the combination of pipe full, internal pressure plus surge. The effects of pipe weight and contents weight shall be taken into account.

The load combination for buckling shall be (d) plus (e) plus (f) plus (c).

K5.3 Standards and criteria

The Works shall be designed for a design life of at least 50 years.

Design shall be based on the following standards:

- steel: AWWA M11;
- ductile iron: AWWA/ANSI C150/A21.50-91;

In the absence of soil modulus data obtained from the Site, preliminary designs may be made based on published values of soil modulus.

If in design of ductile iron pipe the backfill soil moduli are used as given in AWWA C950-88 then a deflection lag factor shall be applied as given in AWWA C950-88.

Values more refined than those given in the above standards may be taken from internationally accepted references approved by the Engineer, subject to consistency with the method of analysis and calculation.

In determining calculated deflections the soil modulus used shall be such that there will be a probability of at least 95 per cent that the actual average deflection will be less than the calculated value. Procedures relating to probability value are described in AWWA C950-88 section A.3.4.2.6.

The Contractor shall carry out tests to determine soils modulus and other data for the materials he proposes to use. The value of soil modulus E' shall be determined by the method of Allgood referred to in Section 4.3.3 of CIRIA Report 78 with corrections as follows:

E' = 0.75.D.Ks.H for dry granular backfill;
E' = 1.5.D.Ks.H for saturated granular material;
E' = 0.75.D.Kc for clay.

In Allgood's method, the constrained modulus of the backfill is measured in an oedometer. The oedometer shall be a hydraulic cell type as designed by Rowe. Poisson's ratio is measured in drained tri-axial tests on the same compacted soil as described by Bishop and Henkel. The soil modulus E' is derived from the constrained modulus using a formula containing Poisson's ratio.

The laboratory test results shall be correlated with values (back calculated and laboratory) obtained from field trials and from monitoring pipe deflections and with published values and shall be submitted to the Engineer together with recommendations for values for design.

Before results are accepted at least three sets of laboratory tests shall have been performed, which shall have given substantially equal results in terms of E'. The same backfill design shall also have been shown to give uniform results in at least three field tests on each of three trial backfills.

The Contractor may propose an alternative design procedure but he shall satisfy the Engineer as to the suitability of the method.

Notwithstanding calculated values, the measured values for deflection and for stress and strain shall not exceed the limits set out in the Contract.

K6.0 PROTECTIVE COATING DESIGN

K6.1 Scope

This section specifies design methods for the protective coating to be applied to structural steel, metalwork and ironwork as corrosion protection systems. The systems designed as specified here shall be applied as specified under Protective Coatings. Protective coatings specified elsewhere for particular works such as pipes and cladding shall firstly be designed in accordance with particular requirements specified elsewhere and secondly in accordance with any requirements herein which are not over-ridden elsewhere.

K6.2 Reference Standards

This specification makes reference to the following standard:

BS 5493 " Code of practice for the protective coating of iron and steel against corrosion".

K6.3 Submissions by the Contractor

The Contractor shall design each protective coating system and shall submit details of each system to the Engineer for approval. Submissions shall where possible be in the format of which examples are given at the end of this section with such additional information and samples as the Contractor may provide or the Engineer may require to enable the system to be assessed.

K6.4 Design generally

Protective coatings shall be designed in accordance with BS 5493 to have a long life, generally of at least 15 years to first maintenance for metal surfaces and tank linings and 5 years of first maintenance for building works. Protection systems shall be chosen to be easily maintained in the future and to allow non-specialist on-site re-coating where necessary using single part paints.

K6.5 Environment

For the purpose of system design the general environment shall be as specified in BS 5493 Table 3 Part 2 'Exterior exposed polluted inland'. Bulkhead gates and stoplogs shall be assumed to be exposed to a Table 3 Part 8 'Non-saline water' environment unless otherwise approved by the Engineer.

Interior spaces shall be considered to be dry in administration areas open to continuous access and damp or immersed in other spaces. The protective coatings of components or structures which are continuously or infrequently immersed shall be designed for the more onerous of these two conditions relevant to the protection system used.

All exterior exposed items to be coated shall have a final coat of good appearance of a colour and type as approved by the Engineer.

K6.6 Systems

Protective coating systems shall generally fall into one of the following basic systems:

- galvanising;
- galvanising plus painting;
- multi-coat painting;
- bitumen enamel;
- others as proposed by the Contractor and approved by the Engineer.

The Contractor shall submit to the Engineer details of his proposals for the corrosion protection of each of the items requiring such protection, which will generally fall into the above categories as follows:

- trash screens, flooring, ladders, access covers and frames, step irons and other components which are inaccessible but subject to abrasion/damage;
- structural steelwork (including crane beams, monorails, crane structures and chassis), bulkhead gates, stoplogs, grappling beams, steel tanks and other large items readily accessible for maintenance;
- valves and other corrosion-susceptible items which may be buried and are not covered by the provisions of other specifications;

other components not covered by the above for which the Contractor may propose a system which he considers to be more suitable for the duty.

The Contractor shall submit his proposals in the form of a schedule that should follow the format of the following example:

EXAMPLE OF SCHEDULE

General	Component or area of the Works	Pumphouse main frame except as defined on schedule
	Material to be coated	
	Environment category (BS 5493 - Table 1)	Interior normally dry
	Type of coating (BS 5493 - Table 2)	Ref G : Silicone alkyd
	Typical time to first maintenance (BS 5493, Table 3)	Medium : 5 - 10 years
Surface preparation	Type of surface treatment	Blast cleaning
	Quality level (BS 7079)	Second quality
Metal coating	Type of metal coating	None
	Grade of zinc for spray coating	N/A
	Thickness of spray coating	N/A

Type of paint	Priming coat	Alkyd - zinc phosphate
	Stripe coat	Alkyd - zinc phosphate
	Undercoat	Chlorinated rubber with titanium dioxide
	Finish	Silicone dioxide
Number of coats and DFT	Priming coat	1 coat : 35 microns
	Stripe coat	1 coat : 35 microns
	Undercoat	2 coats : each 35 microns
	Finish	1 coat : 35 microns
Colour	Priming coat	Not specified
	Stripe coat	Not specified
	Undercoat	To be advised
	Finish	To be advised
All protective coating and painting shall be shop applied except		Second undercoat and finish coat

K7.0 BRICKWORK AND BLOCKWORK DESIGN

K7.1 Principles and analysis

Calculations by the Contractor for the design of any brickwork and blockwork shall prefaced by a statement explaining the principles of design and the type of analysis adopted. The statement shall also indicate the codes of practice (and other relevant publications) upon which the design is based.

For walls forming infill panels between superstructure framework, a separate statement shall be included, indicating whether reliance upon these panels is to be made for the overall stability of any building.

All loads and structural wall sizes, including positions and sizes of any chases and openings, shall be clearly indicated in the design calculations.

Any computer programme used in the brickwork and blockwork design shall be fully described and details of input and printout shall be presented in a manner which can be readily understood. Program manuals and any instructions to program users shall be made available to the Engineer upon request. Where any such program cannot be demonstrated by the Contractor to have been fully checked, or where the Engineer considers it necessary, the Contractor shall run such text examples as the Engineer may choose, in order to verify the completeness and accuracy of the program.

The Engineer will in any event reserve the right not to approve the design of any wall, if in the Engineer's opinion the design is either impractical or not in keeping with good design practice.

K7.2 Reference Standards

The following publications are referred to in this section;

SP 20(S and T)	Handbook on masonry design and construction
BS 5628	Code of Practice for use of masonry
BS 1449 Part 2	Stainless and heat resisting steel plate, sheet and strip
IS 875(part 3)	Windloads
IS 456	Code of practice–plain and reinforced concrete
IS 1893(part 1)	Earthquake loads
BS 8110	Structural use of concrete, Part 1.

K7.3 Design

The design of unreinforced brickwork and blockwork shall be in accordance with either of the following:

(a) SP 20(S and T) Handbook on masonry design and construction

(b) BS 5628 Part 1 : "Structural use of Unreinforced masonry", using limit state methods.

(c) BS 5628 Part 2 : "Structural use of reinforced and prestressed masonry", using elastic methods.

The limit state and elastic methods shall not be used together in the same design.

As a minimum requirement, all walls shall also comply with BS 5628 Part 3 "Materials and Components".

The layout of walls shall, if designed to interact with the superstructure framework, be such as to ensure a robust and stable design. Walls shall be designed to support loads caused by normal function, allowing for corrosive environments, but in the event of misuse or accident they must not collapse catastrophically or suffer damage disproportionate to the original cause. This requirement is also applicable during construction of any element of the works.

In addition, due to the nature of a particular occupancy or use of a building (eg. chemical house), consideration shall be given to the effects of a particular hazard and to ensure that, in the event of an accident, there is an acceptable probability of the walls remaining after that event, even if in a damaged condition.

The design of the walls must include for overturning, buckling and twisting caused by elastic or plastic instability, having due regard to the effects of sway when appropriate.

When damp-proof courses in vertically spanning walls are required to transmit compression, they must also combine adequate shear resistance with negligible deformation under horizontal and vertical loads. Consideration shall be given to the use of dpc bricks, slates and suitable metals.

Where walls act as infill panels between a structural framework, they shall, wherever possible, be supported along at least three sides by one of the following methods:

(a) angle and/or channel sections fixed (not shot fired) or cast into the main structure;

(b) dovetail-ended wall ties inserted into dovetail slots cast into the structural framework, where the latter is of concrete construction.

All fixings in (a) and (b) above shall be of stainless steel.

The design of the junction between infill wall panels and the structural frame, including the fixings, shall take account of thermal movement, shrinkage and any other movements associated with the walls and the structural frame. In addition, where an infill wall is used to provide stability to a structural framework, the details including fixings at the junction of the wall and the framework shall be sufficient to ensure that the design requirements regarding stability are fully met.

Where an infill wall panel is designed to span vertically, eg. as external wall cladding, special consideration shall be given to the design of the fixings to the top horizontal edge, where it joins the structure.

Wired butterfly and double triangle type wall ties will not be permitted in any wall. Wall ties shall be stainless steel strip, but of a twist type for the leaves of cavity walls.

K7.4 Loadings

Wind pressures on walls shall be calculated as for 'Class A - Units of Cladding' in accordance with IS 875(part 3) "Windloads", using a basic wind speed of not less than 39m/s.

Other loadings shall be in accordance with those given in BS 6399: Loadings for Buildings Part 1 and/or IS 1893 Earthquake loads. Where applicable, walls shall also be designed to withstand any loads exerted, including plant and components, dynamic effects, sway forces, having due regard to effects caused by air temperatures, creep, moisture and shrinkage.

Main reinforcement shall generally be high yield deformed steel bars. Links shall be plain round mild steel bars.

The characteristic strengths shall not be greater than the following:

- plain round mild steel bars: 250 N/mm^2
- high yield deformed steel bars: 410 N/mm^2

The design stresses shall be in accordance with the relevant references of this specification.

As a minimum requirement, the cover to reinforcement shall be in accordance with the relevant references of this specification. Due regard shall be given to corrosive environments, where appropriate.

Steel expanded metal or welded wire mesh strips shall not be considered as structural reinforcement for the design of wall structures. This type of reinforcement shall only be used in unreinforced brickwork and blockwork for the purpose of controlling thermal movement, shrinkage, creep and moisture cracking. The cover to the reinforcement shall be in accordance with the relevant references of this specification, having due regard to corrosive environments, where appropriate.

K7.5 Joints

Without affecting the aesthetics and structural stability of any building (or part of building), permanent joints shall be provided in brickwork and blockwork to allow for expansion and contraction caused by temperature changes, shrinkage and moisture movement.

Unless there are specific requirements (eg. stability of superstructure framework), compressible joint fillers shall be used to form the joints, together with, protective sealers.

K7.6 Drawings

Where applicable, the production of structural drawings shall be in accordance with the requirements for Concrete.

Particular attention shall be made regarding the correct positioning and sizes of any chases and openings for services. The methods and positions for supporting walls at their edges shall be clearly indicated.

K8.0 ROCK GROUTING

K8.1 Scope

The specifications cover the construction of the grout cut-off curtain in the rock out crop.

K8.2 Definitions

The following words, wherever used in this section, shall have the meaning here in assigned to them.

'Curtain Grouting'	means grouting in a narrow width of the rock on either side of a central line of fixed by Engineer – in – charge to deeper depths for providing a deep barrier to seepage.
'Consolidation Grouting'	means grouting the rock, to full width of the rock demarcated by the Engineer – in – charge of the work, for shallow depths with a view to consolidate and make the bed rock stronger and less pervious.
'Stage Grouting'	means the procedure of drilling a hole to a limited depth, grouting to that depth, cleaning the hole by washing or other suitable means before the grout has set sufficiently to require redrilling, letting the grout surrounding the hole to take initial set, drilling the hole to a deeper stage, setting a packer at the bottom of the previously grouted stage or elsewhere as directed by the Engineer – in charge, grouting the new stage and thus continuing in many stages of drilling and grouting as required.
'Packer Grouting'	means the procedure of drilling a hole to the full depth in one operation and grouting from the bottom of the hole upwards in one or more stages by means of packers set at predetermined depth.

K8.3 General Programme

The curtain wall in general be formed by grouting from a single row of holes, but in places where specified, double rows shall be provided.

K8.4 Grout Materials

K8.4.1 General

Grout shall normally be composed of Portland cement and water. It is possible that the addition of sand may also be required. The grout mixture shall be varied as required to suit the characteristics of each hole and for different stages of the hole as determined by rock conditions encountered.

K8.4.2 Basic Grout Materials

Water, Portland cement and sand used for the performance of work shall be known as basic grout materials and shall conform to the following requirements:

(a)	Water:	Water used for all drilling, testing and grout mixing shall be free from dirt and other suspended impurities;
(b)	Cement:	Cement used in grout mixture shall conform to the requirements of I.S. 269
(c)	Sand:	Sand used in grout mixture shall conform to the requirement of relevant BS for concrete sand, with limitation that sizes above No.120 British Standard Sieve, shall be excluded (Corresponding IS Code No.383).

K8.4.3 Admixture

It is anticipated that admixtures will not be required. However, calcium chloride/bentonite may be needed occasionally.

K8.4.4 Grout Mixtures

Grout to be used shall normally be a water cement mixture. The ratio of water to cement will be varied to cement will be varied to meet the characteristics of each hole as revealed by grouting operations. As a general rule, initially the grout shall be fairly thin, (in relation to thicker mixes, which may be used later) so that the characteristics of the rock could be estimated without chance of loosing the hole.

Grout mix used shall be tested at frequent intervals to ensure that the mix is uniform in quality. Grout shall be used within an hour and retampering shall not be permitted. Grout mix left unused for more than an hour, or at the end of day's work, shall be rejected.

K8.5 Grout Equipment

The equipment for mixing and grouting shall be capable of effectively mixing in correct and specified proportion, agitating the grout and pumping it into the holes in an uninterrupted flow at the designed pressure up to a maximum of 3.5Kg/cm2. There should be satisfactory arrangements for accurately measuring the quantity of water, cement and other ingredients to be used. The agitator shall have pedals of suitable design and shapes to keep the mix at the proper consistency, till it is pumped into the holes. The pump shall be air driven, double acting and reciprocating type.

The mixing and conveying system shall be laid out to provide sufficient capacity for heavy flow of grout. The mixture shall be in two compartments or parts, so that grout could be mixed in one while that from the other is being pumped. The compartments or parts shall be independently connected to the pump. In general uninterrupted flow of grout shall be maintained and the grout be conveyed from the pump to the hole through a pipe.

The mixer shall be placed as near to the hole as possible and long pipe lines avoided. A portable unit mounted on a truck or a trolley on pneumatic tyres of suitable design would be best. The flow of grout into the holes shall be controlled by pressure relief valve, by passing and returning to the mixture, all the grout not accepted by the hole, at the desired pressure.

Proper pressure gauges shall be provided to measure the pressure of the grout being pumped into the hole. They shall be provided with diaphragm to prevent grout from getting into the gauges and clogging them.

The circulating system shall be so provided that the grout shall be kept circulating continuously at sufficient velocity to prevent undue settlement of cement or clogging of pipe line and fittings. The pumps and the pipelines shall be flushed with clear water at frequent intervals to keep them clear. Deposits of grout in the pump, mixer, etc, not removed by flushing shall be removed by scraping, chipping etc.

A fine screen capable of being readily removed, cleaned and replaced, would be desirable between the mixer and the pump. Proper arrangements shall be provided with the equipment to stock adequate quantity of cement, sand, dust etc, likely to be required for the grouting.

K8.6 Casing Pipes

Black steel pipes for grout connections shall be set in the rock foundation, in the concrete or elsewhere, if required, as shown on the drawings or as directed by the Engineer – in – charge. Grout pipes shall not end less than 25 mm inside of the finished surface of the concrete and recess shall be provided in the concrete to be filled with dry pack after grouting is completed. The size of the grout pipe for each hole will be as determined by the Engineer – in – charge to meet the requirement of the drilling and grouting equipment used. The end of the pipe, farthest from the finished face, shall be cut at 45° to the centre line of the pipe to ensure that the outer end does not but against rock surface and thus hinder satisfactory grouting. The depth of hole for setting pipe for grouting shall be as directed by Engineer – in – charge. The spaces between grout pipes and the rock, into which they are inserted, shall be carefully sealed with oakum, grout or other suitable material to prevent entry of unwanted material prior to grouting. All pipes and fittings to be inserted shall be cleaned thoroughly of all dirt, grease, grout and mortar immediately before inserting. The pipes and fittings shall be carefully assembled, placed, and shall be firmly held in position and protected from any damage.

K8.7 Drilling

Holes shall be set out and drilled at locations and to depths as shown in the drawings, or as required by site conditions. For consolidation grouting of foundation rock and curtain grouting of natural rock out-crop, the grout holes may be drilled using either diamond or percussion drilling, at the convenience of site Engineers. When percussion drills are used, the holes shall be cleaned carefully. However, for areas like fault zones etc, the method of drilling shall be as directed by Engineer–in– Charge. The minimum diameter of each grout hole shall not be less than that produced by the commercial standard EX-size drill-bit, i.e. approximately 38 mm.

Holes shall be drilled vertically or at an inclination to the verticals as shown on drawings, or as required by site conditions. Exploratory holes shall not deviate from the required direction by more than one per cent of the length of the hole, as measured at the point of maximum penetration. All measurements relating to the depth of hole shall be made from the ground collar of the hole. Wherever diamond core drilling is carried out for grouting, core from such hole shall be recovered and logged properly.

On completion of drilling the holes shall be immediately capped or plugged with wooden plugs or steel caps and shall be protected from entry of dirt, muck, grout water or any kind of waste. Drilled holes or portion of holes shall not be left ungrouted for a long time.

All holes remaining open on completion of work shall be backfilled with grout.

K8.8 Cleaning of Holes

Before grouting and when a suitable small group of holes has been drilled, all but three holes (consecutive or as otherwise considered suitable for the purpose of cleaning and more or less than three holes as may be required) shall be closed temporarily at the surface. Water and air shall be pumped under pressure as determined by the Engineer – in – Charge into two holes and allowed to escape, from the third until all possible loose materials, and mud, etc, has been washed out of communicating seams or other passage ways, if any. Combination of three holes at a time shall thus be cleaned before applying any grout into the holes. Suitable valves shall be used to permit alternate or continuous injection of air and water and for quickly switching the flow from one hole to the other so as to produce the turbulent action necessary to dislodge the softer material, if any. Water will be connected to one hole and air to the other, which shall be an adjoining hole. The water and air connections shall be interchanged at frequent intervals to cause water to flow in every possible direction. The operation should be continued till reasonably clear water emerges out of the holes to the satisfaction of the Engineer – in – Charge. In general, the pressure of water and air shall be such as to maintain the maximum possible velocity but sufficiently low to prevent heaving and movement of rock. The normal maximum pressure should be about 2 Kg per square centimetre (28.5 psi) for cavities, galleries, tunnels and shaft and about 8 Kg (115 psi) per square centimetre for other works. Higher or lower pressures shall be used where so specifically directed by the Engineer – in – Charge. The connected holes shall be blown clear of any deleterious that might have settled in the seams therein. Washing shall be so timed as to immediately precede the grouting. Before the grouting of a hole is taken-up, the adjoining holes shall be kept clear so that they are ready for grouting, in case they are found connected to the hole under grouting. All this shall be done in the presence of the Engineer – in – charge or his representative and under his direction.

K8.9 Pressure Testing of Holes

During the drilling of holes or after drilling is completed or during or after grouting any or all of the holes, shall be water pressure tested.

When during drilling, abnormal gain or loss of drill water is observed or caving of the hole occurs or the bit and drill rod falls through an open crack or cavity or when unusually low recovery is obtained, drilling shall be discontinued and the hole shall be water tested.

Water testing in about 20 per cent of consolidation grouting holes shall be required to be done for entire test holes.

The procedure for water pressure testing shall be as specified herein. If a hole is drilled to full depth, the section of the hole to be tested shall be isolated by sealing it off with special double packers attached to a perforated steel pipe and lowered into the hole. If stage drilling method is used, a single packer shall be used to isolate the section to be tested. Water shall then be pumped into the test section under pressure and for periods specified herein.

A record of the time, pressures, and quantities of water used for testing a section of a hole shall be maintained.

The pressure testing apparatus shall be calibrated before use and shall be periodically tested for accuracy and satisfactory operation.

The existing water level in the hole to be tested shall be established and recorded before commencement of pressure testing.

The pressure test shall be performed in one continuous operation using the following steps of pressures and times.

Step No.	**Pressure (P)**	**Elapsed time in Minutes**
1	P1 = 1/3 P3	5
2	P2 = 2/3 P3	5
3	P3 = Prescribed grouting pressure	10
4	P4 = 2/3 P3	5
5	P5 = 1/3 P3	5

The pressure for step number three shall be equal to the grouting pressure for the stage.

In some cases after steps 4 and 5, the hole valve shall be closed and the pressure drop observed recorded for maximum period of 3 minutes in each instance.

K8.10 Pressure Grouting

The general requirements for grouting described herein shall be followed throughout all grouting work unless otherwise directed.

Drilling and grouting holes for curtain grouting shall be done using the split spacing method.

Stage and packer grouting shall be used and drilling and grouting shall be performed in successive operations. In stage grouting, the hole will be drilled to a limited depth, pressure tested and then grouted at that depth. After the hole has refused grouting (to the extent specified herein after) it shall be flushed out before the grout in the hole has set sufficiently to require re-drilling. After the grout surrounding the grouting hole has set, the hole shall be water pressure tested and may be regrouted, if considered necessary. Thereafter successively deeper stages shall be drilled, grouted and tested at increasing water pressure, until the required depth of the hole is completely drilled and grouted. Each stage shall during these operations be isolated from the previous stage, by a packer provided at the bottom of the previous stage.

The packers shall consist of pneumatic or hydraulic expansible tubes or of mechanically manufactured rings of rubber, leather, or other suitable material, attached to the ends of the grout supply pipes. The packer shall be designed so that they can be expanded to seal the holes at the specified elevations and when expanded, shall be capable of withstanding, without leakage for a period of 10 minutes, the water pressure equal to the maximum grout pressures to be used.

The depth of each stage may be 10 to 15 m but may vary as required by site conditions. The holes less than 12 m depth, be grouted in one operation and those more than 12 m, in two stages, the upper being 6 to 8 m and the rest of the length being the second stage.

The maximum grouting pressure will be based on 0.17 Kg/cm^2 per meter depth of packer or grouted zone, measured on the back pressure gauge located at the head. In no case the pressure be such as will cause upheaval of the bed rock. Sensitive upheaval indicators shall be installed at suitable locations as directed by Engineer – in – charge and shall be carefully watched for any indication or uplift during water pressure testing and grouting operations. Higher grout pressure may be used in final sealing.

Bottom of these installations shall extend 6 m or more below the deepest grouting and into case be less than 3 m deeper than the bedding plane to which the grout in its vicinity extends.

The pumping rate will normally be governed by the required pressure. If it is found impossible to reach this pressure, while pumping a certain type of grout mixture at the maximum speed of the pump, the speed of the pump shall be reduced, and if the desired pressure still cannot be reached, the grout mixture shall be changed or pumping discontinued.

Under no conditions shall be pressure or rate of pumping be increased suddenly, as it may produce an effect which would promote stoppage or opening of cracks or seams.

Grout mixes usually shall range between 10:1 and 0.5:1 by volume. No grout hole or grout connection shall be grouted except with the permission of the Engineer – in – Charge until all concrete required within a radius or 60 meters has been placed, set and properly cured. Grouting of all holes shall, however commence with relatively thin mix. The specified pressure shall be maintained for a minimum period of 5 minutes with this mixture, if such pressure is attainable. The length of time for which this water-cement ratio is used, after the initial 5 minutes period, shall be determined according to the characteristics of the hole. For instance, if the hole takes grout freely at this water cement ratio and the pressure specified cannot be built up or maintained or if the grout appears in other holes drilled in the area or in cracks in the bed-rock surface, it shall not be used longer than for a period of 10 to 15 minutes, after which the water cement ratio shall be gradually decreased.

If it is found that a hole will take grout at the rate of the maximum capacity of the grout pump and no decrease in the rate of grout intake is observed while pumping a mixture having water cement ratio of 0.5 or that no resistance can be built by reducing the pump speed, the grouting of the hole shall be continued for a maximum of 1 hour at minimum pump speed. If the rate of grout intake still does not decrease, the grouting of that hole shall be discontinued for a minimum of 2 hours to allow the grout to attain initial set. Thereafter the hole shall be cleaned and after a period of 6 hours, grouting shall be resumed. If it is found that certain holes cannot be effectively grouted with water-cement mixture due do very large cavities or extensive grout intake, sand grout mixture may be used, when directed.

The amount of sand used in the mix will be increased progressively until the maximum amount, which the equipment will handle successfully, has been reached. If the desired results are not obtained with the mix, grouting will be discontinued. In such event the hole shall be cleaned, the grout allowed to set, and additional drilling and grouting shall then be done in this hole or in the adjacent areas, as directed, until the desired pressure is built up.

If necessary, to relieve premature stoppage, periodic applications of water under pressure may be made. However, no prolonged application of water shall be allowed. If during the grouting of any hole, grout is found to flow from adjacent grout holes in sufficient quantity to interference seriously with the grouting operation or to cause appreciable loss of grout, such holes may be capped temporarily. Where such capping is not essential, ungrouted holes shall be left open to facilitate the escape of air and water as the grout is forced into adjacent holes. Before the grout has set, the grout pumps shall be connected to adjacent capped holes and to other holes from which grout flow was observed and grouting completed at a pressure specified in this section.

The grouting of any hole shall be continued until the hole takes grout less than 30 litres of the grout mix in 20 minutes, at a pressure of 3.5 Kg/cm2 or less as being used, in 15 minutes if pressure between 3.5 Kg/ cm2 and 7 kg/ cm2 are being used, in 10 minutes if pressure between 7 kg/ cm2 and 14 kg/ cm2 are being used, and in 5 minutes if pressure in excess of 14 kg/ cm2 are being used. After grouting of any hole is finished, the pressure existing in the hole shall be maintained by means of a valve until the grout has set to the extent that it will be retained in the hole.

The following requirements shall also be met during grouting:

(a) Drilling, washing, pressure testing, grouting shall not be permitted within a distance of 12m or such other distance as may be considered suitable for the site conditions from a hole being pressure tested or grouted, unless at least one grout hole between those holes, has been completely grouted and a period of 6 hours has elapsed since the completion of such grouting.

(b) On steeply sloping ground, grouting shall invariably proceed from the lower elevation to the higher.

(c) The arrangement of the grouting equipment shall be such as to provide a continuous circulation of grout throughout the system and to permit accurate pressure control by operation of a valve on the grout return line, regardless of how small the grout in-take may be. Pressure gauges and adequate valves will be required at the pump and at each hole to ensure required control by-pass and shut-off. The equipment and lines shall be prevented from becoming fouled by constant circulation of grout and by the periodic flushing out of the system with water. Flushing shall be done with the grout intake valve closed, the water supply valve open, and the pump running at full speed.

K8.10.1 Regrouting

The grouting shall be done so as to achieve permeability values of 5.0 Lugeons or less in the rock or as directed by Engineer – in – Charge.

The effectiveness of the grouting work shall be checked as work progress, by tests performed in a series of vertical and/or inclined holes drilled along the grout curtain every 15 m or so. Pressure tests in these holes and core recovery, may indicate parts of the rock already grouted which require additional grouting. In such event additional holes shall be drilled and grouted as and when required.

K8.10.2 Protection of work and cleaning

During drilling, testing and grouting operations, the rock surface in the grouting area and the surrounding 10m wide strip, shall be kept free and clean of oil, grease, drill cutting muck, grout cement, excess water or any kind of waste.

The appearance of grout from any of the cracks, opening, cavities, or drilled holes of any type in the grouting area shall be carefully watched and shall be recorded and immediately reported.

At all times during the process of the work, all open drill holes, cleaned out. Faults, cavities, and larger cracks in the bed rock or rock surface shall be protected from becoming plugged or filled with oil grease, drill cutting muck, grout cement or any kind of waste.

K8.11 Technical Field Records

An accurate and up to date technical field records of all surface testing, grouting and control operations and observations, required to be performed in connection with this work, shall be maintained for each hole in a chronological order in the proforma given in below:

Example of Technical Field Record

Hole No:-
Coordinates:-

Elevation
Natural ground level:-
Top of Hole:-

Pressure Grouting Record
Grout Cap width:-

Casing pipe
Depth:-

Uplift Gauge
Bottom Elevation:-
Diameter:-

(Space for Sketch)

Hole Log particulars	Log	Type of Grouting	Stage of Grouting	Date	Time	WATER PRESSURE TEST			PRESSURE GROUTING			UPLIFT		LEAKAGE FROM NEARBY HOLES			
						Pressure	Intake gallons / minute	Grout mix by volume	Pressure	Intake gallons/ minute	Cement consumption	Obs Pt-I	Obs Pt-II	Extent of leakage from surface joints and fissures	Hole No	Extent	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

NOTES:

(a) Sketch on the top right hand corner shall show the location of the hole being grouted, together with the locations and condition of nearby holes. Holes that have been drilled will be indicated by 'D' suffixed with the number, showing the depth of the hole, such as 'D-25'. The hole that has been grouted, will be indicated by the letter 'G' in a similar manner. Position of upheaval indicators shall also be shown.
(b) Columns 1 and 2 will also show the ground water table level.
(c) Columns 5 and 6 will record the date and time of any significant event in the operation. The change of pressure and intake in the water pressure test, and each change in grout mix, pressure or intake rate in the grouting operation will be recorded.
(d) The rate of intake in column 11 shall re recorded at every 15 minutes interval.
(e) Cement consumption in column 12 shall be recorded for each pressure or grout mix change.
(f) Columns 13 and 14 will show readings of uplift observation points at the beginning of the operations and at every noticeable change.

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(g) "Remarks" in column 18 shall be recorded indicating change or incident affecting the grouting operation, such as "Tight Hole", "Leaks chaulked", "Hole No.______ capped" "grout pump down", "grouting suspended due to ____________ hole completed" and so forth.

K9.0 EARTHWORKS

K9.1 Scope

K9.1.1 General

This Section contains requirements which, where relevant to this Contract, shall apply to site clearance; general excavation; Trench Excavation; embankments; topsoiling and landscaping.

K9.1.2 Definitions

The following terms shall have the meanings hereby assigned to them:-

"Topsoil"	any surface material capable of supporting vegetation and suitable for use in soiling areas to be grassed or cultivated.
"Rock"	naturally-occurring material which in the opinion of the Engineer would normally have to be loosened either by blasting or by the use of pneumatic tools (other than clay spades) or by other rock quarrying methods or, if excavated by hand, by the use of wedges and sledge hammers. An isolated solid boulder or detached piece of rock shall qualify as Rock only if it exceeds 0.2m³ in volume.
"Bulk Excavation" after	excavation in open cut (excluding Trench Excavation) down to levels specified on the Drawings or otherwise as being the general levels completion of excavation other than Incidental Excavation.
"Trench Excavation"	excavation, to levels and limits specified on the Drawings or otherwise, of trenches into which pipes and the like are to be laid.
"Incidental Excavation"	excavation (generally in small quantities) below or outside the limits of Bulk Excavation and Trench Excavation, but excluding Excess Excavation.
"Excess Excavation"	excavation outside the limits specified for Bulk, Trench or Incidental Excavation.

K9.2 Reference Standards

Reference Standards are referred to in the text of the Specification in abbreviated form (e.g. BS 1377). The full titles of some which have relevance to this Part are given below for convenience:

BS EN 1097	Testing aggregates.
BS 1377	Methods of test for soils for civil engineering purposes.
BS 3506	uPVC pressure pipe for industrial uses.
BS 3882	Recommendations and classification for topsoil.
BS 5607	Safe use of explosives in the construction industry.
CIRIA Report 97	Trenching practice

K9.3 Submissions by the Contractor

Submissions which the Contractor is required to make in relation to earthworks include, where relevant, the following-

(a) Drawings, survey notes etc

- Contractor's record drawings of the ground level survey prior to the start of any earthwork;
- Information obtained from trial holes ordered by the Engineer;
- Contractor's record drawings of any other level surveys taken for the purposes of measurement of quantities of excavation or filling, e.g. Rock level surveys;
- (Survey record drawings as specified above shall be submitted within 7 days of the completion of the survey work recorded on them);
- Survey notes on depths of Trench Excavation;
- Survey notes on Rock levels;
- Copies of designs for Temporary Works for supported and unsupported excavations.

(b) Certificates

- Laboratory tests;
- Field tests.

(c) Details of proposed methods

- Proposed methods of excavation, transport of materials, filling and compaction;
- Proposed source of free-draining fill and methods of selective excavation or processing;
- Programme for quality control of earthworks and proposals for the use of off-Site laboratories;
- Proposed methods of blasting rock, safety measures, hole patterns, blasting patterns charges, permits, licences.

(d) Samples

Materials proposed for filling and for geotextiles, where specified or where specifically required by the Engineer.

K9.4 Materials

K9.4.1 Fill material - general

Excavated material (including material excavated from borrow pits) selected by the Contractor for use as backfilling to excavations, as filling around structures or as filling for embankments shall be free from clods and lumps and shall be subject to the approval of the Engineer.

Should the material selected as filling, while acceptable at the time of selection, become unacceptable to the Engineer for any reason including exposure to weather conditions, flooding, contamination by other materials or segregation during the progress of the Works, the Contractor shall at no extra cost to the Employer remove such damaged, softened or segregated material and replace it with fresh approved material.

K9.4.2 Free-draining fill

Free-draining fill material shall be formed of hard durable particles and shall be free from clay, silt and organic matter, and shall comply with any particular requirements specified hereafter.

Material for free-draining fill shall be provided by the Contractor from an approved source. The Contractor shall submit full details of the proposed source, certified test results and samples for the approval of the Engineer. The Contractor may use material emanating from excavations having first processed it so that it complies with the specified requirements for free-draining materials fill.

K9.4.3 Imported Topsoil

Imported topsoil shall be provided by the Contractor from an approved source. It shall comply with BS 3882, the texture being `light' or `medium' and the soil reaction `slightly alkaline' or `slightly acid to neutral'. The stone content shall not exceed 10% by dry weight and no stone shall exceed 50 mm in any dimension.

K9.5 Workmanship

K9.5.1 General

(a) Levels to be recorded

Before the surface of any part of the Site is disturbed or the Works thereon are begun the Contractor shall take and record levels and dimensions of any such part. The Contractor shall also take and record such other levels and dimensions as are necessary during the progress of excavation to allow accurate measurement of the different categories of excavation.

All levels and dimensions shall be taken in the presence of the Engineer and recorded in the manner specified or as agreed with the Engineer, and such levels when agreed with the Engineer shall, if applicable, form the basis for measurement.

(b) Notification of Rock

Any material in the excavations which the Contractor considers may be classified as Rock as defined herein shall be notified to the Engineer before excavation of the material is begun. The quantities of Rock or material alleged to be Rock excavated from within the nominal limits of excavation shall be recorded and the agreed record shall be signed by the Engineer and the Contractor each day or at such shorter intervals as the Engineer may require. Overbreak (that is excavation in Rock outside the nominal limits of excavation) shall be kept to a minimum and shall be held to be Excess Excavation.

(c) Explosives and blasting

The Engineer shall have power to regulate, restrict or prohibit blasting if in his opinion it is necessary to do so for the safety of persons or property or to safeguard the Works. No blasting shall be carried out in any part of the Works without the permission in writing of the Engineer. Such permission shall not absolve the Contractor from any of his obligations or liabilities under the Contract. The Contractor shall take all necessary precautions including the use of blasting nets to avoid damage, loss or injury to persons and to public or private property.

Any work involved in the use of explosives, including storage and handling shall be carried out in accordance with BS 5607.

The Contractor shall obtain the necessary licences for the storage, transport and handling of explosives and shall provide a store or stores suitable for explosives in accordance with local regulations.

The Contractor shall keep the Engineer fully informed at all times when blasting is proposed to be carried out and of any details the Engineer may require concerning strength of charges and their positions.

(d) Excess excavation (backfilling)

Excess excavation may normally be backfilled with material emanating there from, but where the Engineer has ordered such material to be removed from Site as being unsuitable the Contractor shall make good the excess excavation with such kind of fill material or in such class of concrete as may be reasonably required by the Engineer having regard to the circumstances.

(e) Trial holes

The Engineer may direct that trial holes shall be excavated in advance of other excavation to such dimensions and depths as he shall order to obtain information required by him.

Any further trial holes required by the Contractor to determine the position of underground services, sub-soil drains or for any other reason shall be excavated and reinstated at no extra cost to the Employer.

The Contractor shall arrange for the refilling and reinstatement of trial holes to be carried out immediately the required information is obtained. The reinstatement of the surfaces of trial holes shall be carried out to the satisfaction of the Engineer.

(f) Excavations - support and working space

The Contractor shall provide effective support for the sides and ends of all excavations to prevent any fall or run from any portion of the ground outside the excavation and to prevent settlement or damage to structures adjacent to the excavation.

If, for any reason, any portion of the bottoms, sides or ends of any excavations shall give way the Contractor shall immediately, at no extra cost to the Employer, take all necessary remedial measures including the excavation and removal of all the ground thereby disturbed both within and without the nominal limits of excavation and such extra excavations shall be held to be Excess Excavation.

Where the Contractor proposes to carry out excavations with sloping faces (other than sloping excavations shown on the Drawings or required as permanent features of the Works) and without shoring, excavated faces shall be to stable slopes and heights and the resulting extra excavation shall be held to be Excess Excavation. Full details of the Contractor's proposals shall be submitted to the Engineer for approval.

The Contractor shall be deemed to have made his own allowance for any working space or support required, and any excavation outside the specified or nominal payment limits which has not been ordered by the Engineer, whether it be excavated to suit the Contractor's method of working or unavoidable overbreak or due to his carelessness or error, shall be held to be Excess Excavation.

(g) Fossils etc found in excavations

No requirement of the Specification regarding the disposal of material arising from Site clearance or excavation shall override any provision in the Conditions of Contract as to the discovery, or ownership, of fossils, coins, articles of value or antiquity, or anything of geological or archaeological interest found on the Site.

(h) Inspection by the Engineer

When the specified levels or limits of any excavation are reached, the Engineer will inspect the ground exposed and if he considers that any part of the ground is by its nature unsuitable he may direct the Contractor to excavate further. Such further excavation shall be refilled to the specified levels or limits with concrete, selected excavated material or selected imported material as directed but shall not be held to be excess Excavation.

Should the material forming the bottom or side of any excavation, while acceptable to the Engineer at the time of inspection, subsequently become unacceptable due to exposure to weather conditions or due to flooding or have become puddled, soft or loose during the progress of the Works, the Contractor shall remove such damaged, softened or loosened material and excavate further to a sound surface. Such further excavation shall be held to be Excess Excavation and material emanating therefrom shall be removed from the Site.

K9.5.2 Site clearance

(a) Site clearance

All areas of the Site specified or marked on the Drawings for clearance or from which material is to be excavated or upon which filling is to be deposited shall be cleared to the extent required by the Engineer of all buildings, walls, gates, fences and other structures and obstructions and of all bushes, hedges, trees, stumps, roots and other vegetation except for trees marked for preservation. Material so cleared shall so far as suitable be reserved and stacked for the Employer's use but shall otherwise be burnt to ash or disposed of off the Site as directed by the Engineer.

(b) Trees

Where directed by the Engineer trees shall be uprooted or cut down as near to ground level as possible. No trees shall be felled except as authorised by the Engineer and clearance of vegetation of any sort shall generally be kept to the minimum necessary for the Works and Temporary Works. Permissions required for tree cutting shall be obtained by the Contractor and the Employer shall provide necessary letters as requested by the Contractor.

When trees are allowed to be felled, branches and foliage shall be removed and burnt to ash or disposed of off the Site. Useful timber shall, as between the Employer and the Contractor, be deemed to be the property of the Employer and shall be cut into suitable lengths and transported a distance not exceeding 5 km to a location provided by the Employer where it shall be off-loaded and stacked.

(c) Stumps

Stumps and roots whether existing or remaining after tree felling shall where directed by the Engineer be grubbed out and disposed of off the Site. The resulting hole shall be filled with approved material deposited and compacted in layers to the same dry density as the adjoining soil.

K9.5.3 Excavation (other than for pipe trenches)

(a) Excavation generally

For the purposes of this Sub-section the term 'Excavation' shall include excavation, whether Bulk or Incidental, required for structures and roadworks and from borrow areas. It shall not include excavation for pipe trenches and the like except for miscellaneous isolated lengths of trenches beneath or adjacent to structures, such trenches being deemed to be Incidental Excavation.

The ground shall be excavated by such methods and to such dimensions and depths as shall allow for the proper construction of the Works.

(b) Stripping top surface

Where ordered by the Engineer the top surface including Topsoil if any shall be stripped, to such depths and over such areas as he may direct, as a separate operation prior to any further excavation which may be required.

(c) Trimming excavations

When excavating to specified levels for the foundation of any structure or to specified limits for the face of any structures required to abut undisturbed ground the Contractor shall not finally complete the excavation until immediately before commencing the construction work, except where the Engineer shall permit otherwise.

Before commencement of any construction work, all shattered and loose material shall be removed from the excavations so as to ensure that the work rests on a sound and clean foundation or where appropriate abuts against undisturbed ground.

(d) Disposition of excavated material within the Site

Subject to any specific requirements of the Contract, the disposition of excavated material within the Site shall be at the Contractor's discretion but shall be so arranged as to suit the overall requirements for the construction of the Works.

The Contractor shall ensure that no excavated material which is suitable for and is required for reuse in the Works is disposed of outside the Site.

(e) Spoil tips on the Site

Only material which has received the approval of the Engineer shall be placed in the various spoil tips. No tree trunks stumps roots branches or rubbish of any kind shall be placed in spoil tips.

Temporary spoil tips may be used to store excavated material as required and shall be arranged by the Contractor subject to the Engineer's approval having regard to any particular requirements of the Contract. Temporary spoil tips shall be so shaped as to maintain stability and good drainage at all times. Where directed by the Engineer, Topsoil stripped from the Site shall be stored in separate spoil tips for use in reinstatement or landscaping.

The limits of permanent spoil tips shall be as shown on the Drawings or as may be ordered by the Engineer for landscaping purposes. Permanent spoil tips shall be finished to shapes as indicated on the Drawings or as directed by the Engineer.

(f) Disposal of excavated material off the Site

Excavated material which is not required for or is unsuitable for re-use in the Works shall be disposed of off the Site as directed either to locations to be found by the Contractor (Contractor's tip) or to locations designated by the Engineer (Engineer's tip).

Material ordered to be disposed of to Contractor's tip shall, as between the Employer and the Contractor, be deemed to be the property of the Contractor and he shall be entirely responsible for its removal from the Site and ultimate disposal.

Material ordered to be disposed of to Engineer's tip shall remain the property of the Employer and shall be transported off the Site and deposited at places designated by the Engineer. Material so deposited shall be shaped up or spread and levelled as directed by the Engineer. Any necessary work to provide access to Engineer's tips or other preliminary work in connection therewith shall be valued as additional work.

(g) Field drains

Should any existing sub-soil or field drains be uncovered during excavation the Contractor shall either carefully replace them when backfilling or, if this is impracticable, shall divert them to new drains or ditches or otherwise relay them as the Engineer may direct and all work in this connection shall be valued as additional work.

(h) Backfilling of excavations

For purposes of this Sub-section the term 'backfilling' means replacing material into any part of the excavations which the Contractor has needed for working space and which is therefore deemed to be Excess Excavation. Backfilling shall be carried out using material emanating from the excavations and complying with specified requirements. The backfilling shall be properly compacted and where necessary the Contractor shall adjust the moisture content of the material either by drying out or by adding water. After such drying out or adding of water the material shall be thoroughly mixed until the moisture content is uniform. Compaction requirements are specified in Section K9.7.3.

(i) Filling to structures

Filling to structures means filling around or over completed structures (whether within excavations or not) using such material as may be specified and to the limits shown on the Drawings. It does NOT include 'backfilling' as described in the preceding Clause.

Where the Contract requires the placing of different types of fill material in separate layers or wedges the Contractor shall carry out the work so as to avoid mixing the different types of material. Should there be any mixing of materials, such mixed materials shall be removed from the Site and replaced with separate materials, all at no extra cost to the Employer.

(j) Backfilling etc not to endanger structures

The Contractor shall arrange the timing and rate of placing of backfilling or of filling to structures in such a way that no part of the Works is overstressed, weakened, damaged or endangered. The layers of material shall be so placed as to maintain adequate drainage and to prevent accumulation of water. In particular, the placing of material around the walls of basements, reservoirs and tanks shall commence only after the walls and floor have been completed and have attained their full specified strength. Material behind walls fixed at the top to the roof shall not be placed until the roof has been completed and, if made of concrete, has attained its full specified strength and had the temporary supports removed. The material shall be placed uniformly around the walls of structures in such a manner as to avoid eccentric or differential loads.

K9.5.4 Trench Excavation

(a) Trench Excavation generally

Trench Excavation means excavation of trenches into which pipes are to be laid and the term `pipes' shall mean pipes of all kinds and for whatever purpose, and shall also include cables except where the context clearly renders this inapplicable.

The line and level of trenches shall be as shown on the Drawings or as may be directed by the Engineer. Before commencing Trench Excavation, the route of the trench shall be set out accurately and the natural ground levels shall be recorded and agreed with the Engineer. Strong sight rails shall then be fixed and maintained at each change of gradient and at as many intermediate points as may be necessary. On these rails shall be marked the centre line and the level to which the excavation is to be carried out, such rails being not more than 40 m apart.

Trench Excavation shall be carried out by such methods and to such lines dimensions and depths as shall allow for the proper construction of the Works. Except where otherwise specified or approved, the types of temporary support, their design and the procedures for installing and withdrawing them shall comply with the requirements and recommendations of CIRIA Report 97.

Any Rock in Trench Excavation shall be so excavated that the clearance between the pipe when laid and the Rock sides and bottom of the trench is kept to the minimum limits necessary to provide for the specified thickness of bedding, haunching and surround to the pipe. Any excavation outside these limits whether for working space or due to overbreak shall be held to be excess excavation.

The sides of Trench Excavation shall be vertical unless the Engineer permits otherwise.

Any widening or deepening of Trench Excavations necessary to accommodate curves, joints or bends in the pipe or to provide extra working space for the construction thereof shall be held to be Excess Excavation.

No length of Trench Excavation shall be started until the pipes to be laid in that length are available on the Site. In any case at any particular location no more than 100 metres of trench shall be opened in advance of pipelaying, unless otherwise approved by the Engineer.

(b) Trench Excavation in roads and tracks

All Trench Excavation and other work carried out within the limits of any track highway or private road shall be completed as rapidly as possible and with every care for the safety of the public.

Unless the Contractor has made specific arrangements with the appropriate authority or owner the roads shall be kept open for normal traffic by the provision of suitable temporary works. In roads where the width is sufficient to carry at least two lanes of traffic, not more than half the width of the carriageway shall be obstructed at one time.

The Contractor shall take special precautions, which shall include the continuous support of the side of the excavation, from the time when excavation is begun until the refilling of the trench is completed, to ensure that there is no disturbance of the adjacent road or road foundation.

Road drainage shall be maintained in operation without obstruction during the progress of the work.

Any places on which material has temporarily been deposited shall on completion of refilling be restored to their original condition.

(c) Trench Excavation in open land

The term 'open land' includes fields, wasteland, moorlands, roadside verges, and all other like land whether publicly or privately owned and whether or not open to the public. No length of Trench Excavation located in open land shall be commenced until suitable temporary fencing has been erected around that length unless the Engineer permits otherwise. Temporary fencing shall not be removed without permission, which will not normally be given until the Trench Excavation has been refilled and reinstated and, where relevant, until sown grass has become established.

The Contractor shall have regard to the safety of livestock on open land, or which may be introduced thereon, and shall ensure that all excavations, access routes and steep or loose slopes arising from the Contractor's operations are adequately fenced and protected.

After the erection of temporary fencing the Contractor shall first remove the top surface including Top Soil if any to such depth and over such areas as may be necessary to provide sufficient material to ensure adequate surface reinstatement of the working areas occupied by the Contractor.

(d) Trimming Trench Excavations

When excavating to specified levels for Trench Excavation or to specified limits for the face of any structure therein required to abut undisturbed ground, the Contractor shall not finally complete the excavation until immediately before commencing construction work except where the Engineer permits otherwise.

Where no bedding material is specified to be laid beneath the pipe the bottom of Trench Excavation shall be carefully boned in and trimmed true to grade with the aid of a straight-edge so as to ensure a continuous support for the pipes. The trench bottom shall then be pricked over with a fork and any stones or flints likely either to cause the pipe to bed unevenly, or to damage the pipe or its coating, shall be picked out of the pipe bed and any holes so formed shall be filled in with soft material and trimmed to the correct level.

Where bedding material is specified, all shattered and loose material shall be removed from the bottom of the Trench Excavation so that the bedding material rests on a sound and clean foundation.

(e) Disposition of material from Trench Excavation

Subject to any specific requirements of the Contract, the Contractor shall make his own arrangements for the temporary storage of any excavated material which is required for use in refilling Trench Excavations, including any protection from the elements and any necessary double handling. In this connection the Contractor shall have regard to the working areas available to him for the construction of the pipeline, particularly where this is located in roads or in other places to which the public has free access. Any temporary tips alongside the Trench Excavations shall be to stable slopes and heights.

Top surface material and Topsoil, if any, shall be stored separately from other excavated materials.

Where the nature of the excavated material is suitable, the Contractor's temporary storage as aforesaid shall include for the separate storage as the Engineer may direct of suitable material for the surface reinstatement of Trench Excavation.

Any excavated material not required for or not suitable for use as refilling as aforesaid or for use elsewhere in the Works shall, as between the Employer and the Contractor, be deemed to be the property of the Contractor and he shall be entirely responsible for its removal from the Site and for its ultimate disposal.

(f) Trenches not to be left open

Trench Excavation shall be carried out expeditiously and, subject to any specific requirements of the Contract, the refilling and surface reinstatement of Trench Excavations shall be commenced and completed as soon as reasonably practicable after the pipes have been laid and jointed.

Pipelaying shall follow closely upon the progress of Trench Excavation, and the Contractor shall not permit unreasonably long lengths of Trench Excavation to remain open while waiting testing of the pipeline. The Contractor shall take precautions to prevent flotation of pipes in locations where open Trench Excavations may become flooded, and these precautions may include the partial refilling of the trench leaving pipe joints exposed while awaiting tests of the joints.

If the Engineer considers that the Contractor is not complying with any of the foregoing requirements he may prohibit further Trench Excavation until he is satisfied with the progress of laying and testing of pipes and refilling of Trench Excavation.

(g) Refilling Trench Excavations

Subject to any particular requirements specified hereafter Trench Excavations shall be refilled using suitable materials selected from nearby excavations.

After any specified concrete or granular bed haunch or surround has been placed the refill material shall be deposited and properly compacted in layers, any coarse or hard material being placed in the upper layers. Particular care shall be taken to avoid damage to the pipe and any sheathing or surround.

Where necessary the Contractor shall adjust the moisture content of the refill material either by drying out or by adding water to assist the compaction of the material.

Where directed by the Engineer, Trench Excavations shall be refilled with concrete.

(h) Refill material - special measures

Where in the opinion of the Engineer sufficient supplies of material suitable for trench refilling cannot reasonably be obtained from nearby excavations without resorting to sieving or other special means then he may order the Contractor :-

(i) to carry out such work as may be necessary to sieve or otherwise render the material suitable, or

(ii) to transport suitable material from excavations elsewhere ('overhaul'), or

(iii) to excavate material from suitable borrow areas and transport it to the length of trench to be refilled, or

(iv) to import suitable material.

(i) Surface reinstatement in open land

After he has refilled Trench Excavations in open land in the manner and to the level specified the Contractor shall cultivate the surface of the affected area to a depth of at least 300 mm and shall replace all top surface material, including Topsoil if any, previously removed; such replaced material shall be evenly distributed and levelled over the full extent of the stripped area. Such of the working areas occupied by the Contractor as were originally down to grass shall be sown with grass seed of equivalent quality and maintained until the new grass is properly established.

Any agricultural land not originally down to grass shall be dressed with suitable fertilisers harrowed in so as to restore the original level of fertility.

(j) Surface reinstatement in roads and tracks

Temporary or permanent surface reinstatement of trenches in roads and tracks shall comply with any particular requirements of the authority responsible for the maintenance of such roads and tracks. The Contractor shall be deemed to be familiar with the general specifications and requirements of the relevant authority or authorities and shall be deemed to have taken this into account in the Cost for the Works.

In any case the Contractor shall comply with the instructions of the Engineer concerning the reinstatement works necessary. Where the Contractor is responsible for reinstatement of the entire surfacing he shall reinstate a similar surface to that found prior to the works commencing. This shall include all necessary features of the pavement, including any sub-base, base course, wearing course and other such layers as may be evident from adjacent excavated areas. This shall include all necessary compaction, and testing to demonstrate adequate compaction of material. Any surfaces requiring reinstatement that do not encompass the entire pavement area shall be formed such that the reinstated area abuts the original surface with a clean straight joint and a flush surface between the reinstated and original surface. The joint between the reinstated and original surfaces shall be sealed against water intrusion with pourable bitumen.

(k) Field drains in Trench Excavation

Where field drains, mole drains or other drains are severed by Trench Excavation they shall be kept in effective temporary operation during construction of the pipeline.

At the appropriate stage of refilling the Trench Excavation the drains shall be permanently restored as specified below.

The drain shall be cut back into firm ground for at least 300 mm on each side of the excavated trench and a suitable length and diameter of uPVC pipe complying with BS 3506 shall be jointed to the existing drain and laid resting at the ends on solid ground with clay or other stopping to prevent the subsequent run of water from the drain into the pipe trench. During trench re-filling, earth shall be carefully placed and thoroughly compacted under the uPVC pipes to give them adequate support.

(l) Existing services

Where Trench Excavation is carried out close to or across the line of sewers, pipes, cables and other services whether underground or overhead the Contractor shall where necessary provide temporary supports or slings and where such sewer, pipe, cable or other service is temporarily disturbed it shall be replaced.

Where in the opinion of the Engineer construction of the pipeline cannot reasonably be carried out unless the sewer, pipe, cable or other service is permanently severed or permanently diverted or permanently supported he may order such permanent measures as he considers necessary to be carried out by the Contractor or by others and in either case at the cost of the Employer.

Notwithstanding any relevant information furnished by or on behalf of the Employer or Engineer, the Contractor shall be responsible for ascertaining from his own inspection of the Site and from the respective supply companies and public bodies, and by using cable locators and excavating trial pits, the position of all mains, pipes and cables whether underground or overhead, within or near the Site.

In any area where there may be buried power cables, the Contractor shall use a cable locator:

(i) to survey the trench route before starting excavation and

(ii) to re-survey at the start of each day the length to be excavated during that day.

(m) Hedges, fences and walls

Where the Trench Excavation crosses barriers such as hedges, fences and walls the Contractor, as a temporary measure during construction, shall provide temporary fencing in place of any parts of such barriers which have to be removed.

After Trench Excavation has been reinstated, the Contractor shall carry out such work as the Engineer may order for permanent restoration of such barriers. In the case of a hedge the section removed shall be replaced by rooted cuttings of the appropriate variety and where ordered by the Engineer the rooted cuttings shall be protected from stock on one or both sides by an adequate post and barbed wire fence. During the Defects Notification Period all hedges replanted in the above manner shall be inspected and any dead cuttings replaced by the Contractor.

(n) Crossing watercourses

Where the line of Trench Excavation crosses streams, ditches, culverts and other watercourses the Contractor shall be deemed to have allowed for all the additional measures necessary for the proper construction of the Works at these crossings including maintaining the full flow of water.

(o) Geotextiles

Geotextiles shall be protected at all times against mechanical or chemical damage. Those geotextiles which are susceptible to damage by light shall be stored under cover.

(p) Laying of geotextiles

Geotextiles shall be laid and lapped in accordance with the manufacturer's recommendations. The layer of material on which the geotextile is to be placed shall not have protrusions or sharp projections which are likely to damage the geotextile during installation or in service. The method of installation shall ensure that the geotextile is in continuous contact with the surface on which it is to be placed and the geotextile shall not be stretched or bridged over hollows or humps. Operation of construction plant directly on the installed geotextile will not be permitted. Care shall be taken in placing fill material to avoid damage to the geotextile.

K9.5.5 Embankments

(a) Embankments generally

The term 'embankment' includes, for example, the construction of embankments for roadworks and for small lagoons. It does not include the construction of large earthfill dams or reservoirs.

The forming of spoil tips and filling around or over completed structures are dealt with under Excavation.

(b) Material for embankments

Material for embankments shall comply with the general requirements for fill material and with any special requirements relevant to its particular kind or type.

(c) Construction of embankments

All embankments shall be constructed in accordance with the Drawings with selected materials obtained from the excavations or from other sources approved by the Engineer.

The Contractor shall submit to the Engineer full details of the materials that he proposes to use for earthworks. Details shall include :-

- the bulk unit weight of the undisturbed material,
- the moisture content of the undisturbed material,
- its shear strength,
- the maximum dry density obtained as per the BS Compaction Test described in

BS 1377, Test 12,

- its optimum moisture content,
- the particle size distribution chart for the material,
- its liquid and plastic limits.

Subject to any particular requirements specified hereafter, the approved materials shall be placed in layers, and shall be compacted to a dry density not less than ninety-five per cent of the maximum dry density. During compaction the fill shall have a uniform moisture content within +/- 2% of the optimum moisture content, expressed as a percentage. Where necessary the Contractor shall adjust the moisture content of the fill either by drying out or by adding water. After such drying out or adding of water the fill shall be thoroughly mixed until the moisture content is uniform. The layers of fill material shall be so placed as to maintain adequate drainage and to prevent accumulation of water.

Where the Contract requires the placing of different types of fill material in separate layers the Contractor shall carry out the work so as to avoid mixing the different types of material. Should there be any mixing of materials, such mixed materials shall be removed from the Site and replaced with separate materials, all at no extra cost to the Employer.

K9.5.6 Topsoiling and grassing

(a) Topsoiling

Parts of the Site as may be ordered by the Engineer shall, as soon as practicable after the completion of other earthworks, be covered with Topsoil and sown with grass, all as specified hereunder.

So far as is practicable Topsoil shall be obtained from material emanating from excavations and separately stored in temporary spoil tips as specified. If in the Engineer's opinion the Contractor cannot reasonably obtain sufficient Topsoil in this way he may order the Contractor to provide extra material ('Imported Topsoil') from an approved source off the Site.

Topsoil shall be evenly spread and trimmed over embankments and other areas to the slopes and levels shown on the Drawings or ordered by the Engineer. The depth after spreading and trimming shall be 250 mm unless otherwise directed, measured perpendicularly to the surface. All clods and lumps shall be broken up and any rubbish, large stones, roots and weeds shall be removed.

(b) Grassing

Where directed by the Engineer areas which have been covered with Topsoil, or otherwise suitably prepared, shall be sown with grass seed using the mixture and application rate specified hereafter or, where not so specified, using a mixture and application rate proposed by the Contractor and approved by the Engineer.

The top surface of the previously laid Topsoil shall be brought to a fine tilth suitable for seeding, and sowing shall be carried out as soon as practicable after completion of topsoiling having regard to the season and to weather conditions. If ordered by the Engineer, ground lime and fertiliser shall be applied in accordance with his directions.

After the seed has been sown uniformly at the specified rate it shall be raked and lightly rolled into the surface. The young grass shall be kept free from weeds and any bare patches shall be re-seeded until an even close turf is established. The grass shall be watered mown and rolled as specified and maintained in good condition until the expiry of the Period of Maintenance.

(i) Initial Cutting

When the grass has established and is 60 mm in height, it shall be cut to a height of 40 mm. Cuttings shall be removed from site.

Following the first cut of grass areas, the grass should then be cut to a height of approximately 25-30 mm.

The Maintenance of Grass Areas shall be carried out as detailed below:

(ii) Cutting of grass.

All grass areas shall be cut regularly. Cuttings may be utilised as a mulch on shrub areas or removed from site.

Grass shall be maintained at a height suitable for the grass species, ensuring that the blades are not set too low which may result in unsightly brown patches :

Prior to cutting, all stones or other deleterious material on the surface shall be removed.

(iii) Topdressing

Topdressing of lawn areas shall be carried out if necessary to eliminate minor hollows.

(iv) Pest and Weed Control

Grass areas shall be kept weed free, and free of pests and diseases, by spraying or spot treatment or hand weeding as necessary, in strict accordance with the manufacturer's instructions.

(v) Edging

All grass areas shall be edged regularly according wherever the grass areas meet with buildings, manholes, paving or other artifacts, around trees or against shrub areas. Edges shall be carefully cut using an approved trimmer.

In the case of shrub beds, the Contractor shall ensure that the original shape of the beds is maintained, and that edges are kept true to line and level. the Contractor shall be expected to repair edging damaged due to careless trimming.

The Contractor shall operate the irrigation system in order to keep grassed areas watered sufficiently.

K9.6 Testing

K9.6.1 Testing by the Contractor

The Engineer will perform the following testing:

- Compaction tests on each kind of filling material being used for embankments or backfill.
-
- Field density tests on backfilling and embankments at the rate of one test per layer of embankment or backfill or one test per 250 m^2 of an extensive single layer.

The Contractor shall be responsible for carrying out all other field and laboratory tests required for the proper control of earthworks.

Laboratory tests shall be carried out at the Site or in an off-Site laboratory approved by the Engineer.

Field density tests shall be performed to ensure that the specified density is being obtained. Tests shall be in accordance with BS 1377. Test results and copies of calculations shall be submitted to the Engineer.

Tests on geotextiles shall be in accordance with BS 6906 and the Contractor shall be responsible for carrying out such tests as required by the Engineer.

K9.7 Particular requirements

K9.7.1 Free-draining fill

Material for free-draining fill shall comply with the general requirements of Clause K9.4.2. Where material of Type 1 or Type 2 is shown on the Drawings, the particle size distribution, when determined by the method described in BS EN 1097, shall lie within the limits given below:-

Sieve size mm	Percentage of dry material passing by weight Type 1 (fine)	Type 2 (coarse)
37.5		100%
20.0		40% - 100%
10.0	100%	25% - 80%
5.0	85% - 10%	5% - 50%
1.18	15% - 85%	0% - 20%
300	0% - 35%	0% - 10%
75	0% - 10%	0% - 5%

K9.7.2 Trench widths

Except by written permission of the Engineer the overall width of Trench Excavations (including any trench support) shall be no less than as shown on the Drawings. In the instance of no provision being made in the Drawings, the followings conditions shall apply.

Trenches shall not be less than 750 mm wide, provided that trenches for small diameter pressure pipelines and cables shall not be less than 500 mm wide subject to there being a minimum of 150 mm clear on each side of the pipe barrel or cable.

If the Engineer permits the excavation to be battered back or to be stepped - eg, to accommodate additional trench support - such enlargement of the trench shall not in any case extend below a line 500 mm above the crown of the pipe
.

K9.7.3 Compaction

Fill shall be compacted so as to achieve the following:

Pipe trenches: Refer to pipeline specification

Structural embankments: 95% Maximum dry density

Landscaped areas: 90% Maximum dry density.

K10.0 BEARING PILES

K10.1 Scope

K10.1.1 Coverage

This Part contains requirements which, where relevant to this Contract, shall apply to bearing piles of the following types:

— precast reinforced concrete;

— precast prestressed concrete;

— driven cast-in-place concrete;

— bored cast-in-place concrete;

— continuous flight augered cast-in-place concrete;

— steel piles of H-section or box section.

K10.1.2 Definitions

Bearing piles are piles supporting structures in the Permanent Works. They may be required to resist vertical loads in a downward or upward direction, or both. Some bearing piles may be raked to resist lateral loads.

K10.1.3 Design responsibility

The Contractor shall design the bearing piles which shall be installed at the positions and to the rakes shown in the Drawings. Where the type of piles is not shown in the Drawings, the Contractor may propose any of the types listed above for the approval of the Engineer.

K10.2 Reference Standards

Reference Standards are referred to in the Specification in abbreviated form (such as BS 4449). The full titles are given below for convenience:—

BS 449	The use of structural steel in buildings
BS 4360	Weldable structural steels
BS 4449	Carbon steel bars for the reinforcement of concrete
BS 4486	Hot-rolled and processed high tensile alloy steel bars for the prestressing of concrete
BS 5135	Process of arc welding of carbon and carbon manganese steels
BS 5896	High-tensile steel wire and strand for the prestressing of concrete
BS 8004	Foundations
BS 8110	Structural use of reinforced concrete in buildings

K10.3 Submissions By The Contractor

Submissions required from the Contractor in relation to the design, installation and testing of bearing piles include the following:

- — detailed design calculations;
- — name of proposed supplier, or proposed methods of manufacture, as relevant;
- — proposed methods of installation;
- — detailed records of installation as carried out;
- — reports of test results.

K10.4 Design And Materials

K10.4.1 General — piles of all types

Bearing piles shall be designed to carry safely the working loads shown in the Drawings. The ultimate bearing capacity, as determined by test in accordance with Clause 10.6.1, shall be at least twice the working load. The ultimate bearing capacity is defined as the load which, applied at the head of the pile, causes the head of the pile to settle a distance equal to one-tenth of the pile diameter. In the case of non-circular piles, 'diameter' shall be taken to mean the diameter of the circle having an area equal to the cross-sectional area of the pile or, in the case of steel H-piles, to the area bounded by the flanges and lines joining the edges of the flanges.

The approximate length of bearing piles shall be determined from any geological information included in the Specification or obtained by preliminary site investigation or shall be determined from load tests carried out on non-working piles.

The final length of driven piles shall be determined by driving to a 'final set', expressed as the penetration in millimetres per 10 blows, approved by the Engineer. The final set may be calculated using an established pile-driving formula but shall not exceed the average of final sets recorded when driving non-working piles which have achieved the required ultimate bearing capacity.

The final length of bored or augered piles shall be not less than the average length of non-working piles which have achieved the required ultimate bearing capacity.

Precast concrete piles and pile casings shall be designed to develop the strength necessary to withstand without damage the stresses arising during transportation, handling and driving. The design shall be such that the compressive stress in the concrete during handling and pitching and under the working load does not exceed 0.275 f_{cu} due to direct load or 0.366 f_{cu} due to bending, where f_{cu} is the 28-day works cube stress.

Where not otherwise specified herein, the design of all piles shall comply with the relevant recommendations of BS 8004 and/or IS2911.

K10.4.2 Precast reinforced concrete piles

Depending upon the nature of the ground through which the piles are to be driven, and the nature and concentrations of dissolved salts in the groundwater, concrete for use in piles shall be made with ordinary Portland cement, sulphate-resisting Portland cement or super-sulphated cement, following the guidelines given in

Section 10.4 of BS 8004. The maximum size of aggregate shall be 20mm and the minimum cement content 370kg/m³ of finished concrete. Except where otherwise specified, the maximum free water/cement ratio shall be 0.4. The minimum cube strength at 28 days shall be 25N/mm².

Concrete mixes shall be specified in accordance with the requirements of Part 16 of the Specification.

The cover to all reinforcement including binding wire shall be not less than 50mm. Hoops and links shall fit tightly against longitudinal bars and be bound to them by welding or soft iron wire with the free ends turned inwards. The longitudinal bars shall be held apart by spreader forks not more than 1.5m apart.

The main longitudinal bars shall be level at the top of the pile and fit tightly into the shoe if one is used. Joints in the main longitudinal bars shall be made by full-penetration butt welding in accordance with BS 5135.

Piles shall be provided with flat or pointed co-axial shoes of steel or cast iron if the concrete at the tip of the pile is liable to be damaged by driving.

Reinforcement shall comprise mild steel deformed bars to BS 4449 and shall meet the following minimum requirements:

(a) longitudinal reinforcement shall be at least 10% of the gross concrete area;

(b) lateral reinforcement shall be in the form of hoops or links having a diameter of at least 6mm;

(c) the volume of lateral reinforcement shall be at least 0.2% of the gross volume except near the top of the pile where, for a distance of three times the width/diameter of the pile measured from the top of the pile, the volume of lateral reinforcement shall be not less than 0.6% of the gross volume, and for an equal distance below this where there shall be a gradual transition in the lateral reinforcement from at least 0.6% of the gross volume to at least 0.2%.

Manufacture, curing, transport and storage shall be in accordance with the recommendations of Clause 7.4.2.4 of BS 8004.

K10.4.3 Precast prestressed concrete piles

Design shall be in accordance with the recommendations of Clause 7.4.3.3 of BS 8004 except that the cover to prestressing steel and reinforcement shall be not less than 50mm.

Concrete shall be as specified in Clause 10.4.2.

Prestressing steel shall be in accordance with BS 4486 or BS 5896. Ordinary reinforcement shall be in accordance with the recommendations of BS 8110.

Manufacture, curing and transfer of stress shall be in accordance with the recommendations of Clause 7.4.3.4 of BS 8004.

K10.4.4 Driven cast-in-place piles

Driven cast-in-place piles shall have a casing of steel or concrete which shall be driven to a set and filled with concrete. The casing may, and where specified shall, be left in place as part of the Permanent Works. The casing shall be suitable for the proposed method of installation and for the purpose of forming a pile.

Precast concrete casing shall be reinforced either with steel bar or mesh or with polypropylene fibres. Concrete for casing and for shoes shall be as specified in Clause 10.4.2. Concrete casings and shoes shall be marked with a reference number and the date at the time they are made. They shall not be used in the Works until they are at least 28 days old.

Concrete casing may be delivered to the Site in short lengths ready for jointing. The use of damaged or cracked lengths of concrete casing will not be permitted.

Steel casing shall be of mild steel to BS 4360 and shall be delivered to the Site in as long lengths as the Contractor can reasonably handle.

Concrete for filling the casing shall be as specified in Clause 10.4.2 except that the maximum free water/cement ratio shall be 0.45. It shall have adequate workability for the method of placing used to form the pile. The average compressive stress under working load shall not exceed 25% of the specified works cube strength at 28 days calculated on the total cross-sectional area of the pile.

Unless otherwise specified, the cast-in-place concrete shall be reinforced over the whole length with mild steel deformed bars to BS 4449. The Contractor shall provide such steel as is necessary to comply with the provisions of BS 8110 for resisting stresses with a minimum longitudinal reinforcement of 0.8% of the gross concrete area in the top 3m of the pile. The cover to all reinforcement, including binding wire, shall be not less than 50mm measured to the inside of the casing, suitable spacers being provided to ensure this. Joints in the main longitudinal bars shall be made by full-penetration butt welding in accordance with BS 5135.

K10.4.5 Bored cast-in-place piles

Bored cast-in-place piles shall have a casing of steel which shall be filled with concrete. The casing may, and where specified shall, be left in place as part of the Permanent Works. The casing shall be suitable for the method of installation and for the purpose of forming a pile.

Steel casing and concrete for filling it shall be as specified in Clause 10.4.4.

Unless otherwise specified, piles shall be reinforced over the whole of their length as specified in the last paragraph of Clause 10.4.4.

K10.4.6 Continuous-flight augered piles

Continuous-flight augered piles are piles formed by boring with a continuous-flight auger and pumping concrete or grout down the hollow stem of the auger during retraction.

Concrete shall be in accordance with Clause 10.4.2 except that the maximum free water/cement ratio may be increased as necessary to achieve the required workability. The mix shall be so designed that there is no segregation and only a minimum of bleeding.

Unless otherwise specified, the upper part of the piles shall be reinforced down to the depth specified or approved. Reinforcement shall be as specified in the last paragraph of Clause 10.4.4 and shall be made up into cages designed to be inserted through the already-placed concrete or grout.

K10.4.7 Steel bearing piles

Steel bearing piles shall be either of H-beam section or fabricated box piles.

Steel sections, whether plain or fabricated, shall comply with BS 4360, Grades 43A, 50B or such other grades as the Engineer may approve.

The cross-sectional area of the steel shall be sufficient to withstand the blows of the hammer during driving and to carry the working load on the pile. The stress in the steel at working load shall not exceed 30% of the yield stress. Where the finished pile projects above the ground level the working stresses shall be reduced by the appropriate buckling coefficient.

The working load shall be transmitted to the pile through a capping plate, dowel bars or cleats.

Unless otherwise specified, fabricated box piles shall be filled with concrete, made with sulphate-resisting cement and with aggregate of 20mm maximum size. The minimum cement control shall be 330 kg/m^3 and the maximum free water/cement ratio shall be 0.50. Minimum works cube strength at 28 days shall be 25N/mm^2.

The bottom end of box piles shall be closed with a welded flat plate or a shaped shoe of cast iron, cast steel or fabricated steel.

K10.5 Installation

K10.5.1 General — piles of all types

The Contractor's method of working shall be such that the installation of the piles shall not cause any damage to adjacent structures or foundations.

The Contractor shall select his method or times of working or both to limit the noise of driving to reasonable levels and to comply with environmental legislation.

The sequence of working shall be to the approval of the Engineer and shall be arranged so as to minimise the vertical and lateral displacement of completed piles. Levels of the tops of adjacent piles shall be measured at intervals while a pile is being driven. Piles which have risen shall be re-driven or forced down to the original resistance.

Piles shall be constructed within the following tolerances:

(a) in plan, at the working level of the piling rig, 75mm in any direction from the position shown in the Drawings;

(b) 1 in 75 from the vertical for a vertical pile;

(c) 1 in 25 from the specified rake for a raking pile.

Where not otherwise specified herein, installation of all piles shall comply with relevant recommendations of BS 8004.

K10.5.2 Precast reinforced concrete piles

Piles shall be driven by a hammer of such a type and weight and with such a stroke that no damage is caused to the pile.

When the 'final set' has been achieved, repeat sets shall be carried out only with the approval of the Engineer.

The driving conditions when taking the 'set' shall be the same as those used when the sets on the non-working piles, described in Section 10.6, are obtained.

The pile head shall be protected during the driving with packing of resilient material evenly spread and held securely in place. A helmet shall be placed over the packing and provided with a dolly of hardwood or other suitable material not thicker than the width of the pile.

Pile heads shall be stripped down carefully, so as not to damage the pile, to a level such that the remaining concrete will project 50mm into the pile cap. The reinforcement shall be exposed for a length of 40 times the diameter of the main longitudinal bars, to permit it to be bonded into the cap. Any cracked or defective concrete shall be cut away and replaced with new concrete properly bonded to the old.

Where a pile has to be lengthened the concrete at the top of the original pile shall be cut down to expose not less than 200mm of the longitudinal reinforcement. Additional reinforcement shall be joined by full-penetration butt welding in accordance with BS 5135. Alternatively, the joint may be made by lapping the reinforcement, in which case the reinforcement at the head of the pile shall be exposed for a distance of 40 times the diameter of the bars and the new bars overlapped over this distance.

K10.5.3 Prestressed concrete piles

Driving shall be in accordance with Clause 10.5.2 above and with the recommendations of Clause 7.4.3.5 of BS 8004.
The bonding of the pile into the pile cap shall be in accordance with the recommendations of Clause 7.4.3.6 of BS 8004.

Any lengthening of piles shall be in accordance with the recommendations of Clause 7.4.3.7 of BS 8004.

K10.5.4 Driven cast-in-place piles

Steel casing shall be bottom driven by an internal drop hammer.
Concrete casing shall be driven on the pile shoe using a mandrel.

If steel casing has to be lengthened joints shall be made by butt welding in accordance with BS 5135 so that the full strength of the original section is developed. The joints shall be designed to maintain the true alignment and position of the pile section.

Concrete casing shall be jointed by coating the meeting faces with a plastic jointing compound and covering the closed joint with a steel strap.

All joints in the casing and between the casing and shoes shall be watertight during driving and on completion. The casing shall be inspected from the top after installation to check that it is neither damaged nor deformed.

The casing shall be completely filled with concrete, every precaution being taken to prevent waisting or the formation of voids.

The bonding of the pile into the pile cap shall be in accordance with Clause 10.5.2 above.

K10.5.5 Bored cast-in-place piles

During boring, the inflow of soil and the formation of cavities in the surrounding ground shall be prevented by adopting one or more of the recommendations of the first paragraph of Clause 7.4.5.4.1 of BS 8004.

Shelling out shall be done with a tool at least 75mm smaller in diameter than the casing and at such a speed that piping of the soil at the bottom of the boring does not occur.

Where the hole is dry, concrete shall be poured through a funnel and tube so that the flow is directed and does not hit reinforcement bars or the side of the hole. Where the cut-off level is below the groundwater level, a pressure shall be maintained on the unset concrete equal to or greater than the groundwater pressure.

Concreting under water or drilling mud shall be in accordance with Clause 7.4.5.4.2 of BS 8004.

The bonding of the pile into the pile cap shall be in accordance with Clause 10.5.2 above.

K10.5.6 Continuous-flight augered piles

Boring shall be by a continuous-flight auger capable of penetrating the ground without drawing surrounding soils into the bore. The auger shall not be raised until the required depth has been reached and until concrete or grout is being pumped down the hollow stem of the auger.

The rate of withdrawal of the auger shall be so controlled that the concrete or grout forms a continuous monolithic pile having the specified or approved cross section at all levels.

The reinforcement cage shall be inserted into the concrete with the minimum of delay after completion of concreting or grouting and shall be supported in its correct position with the required projection above the cut-off level.

The bonding of the pile into the pile cap shall be in accordance with Clause 10.5.2 above.

K10.5.7 Steel bearing piles

Piles shall be driven by a hammer of such a type and weight and with such a stroke that no damage is caused to the pile.

When the 'final set' has been achieved, repeat sets shall be carried out only with the approval of the Engineer.

The driving conditions when taking the 'set' shall be the same as those used when the sets on the test piles, described below are obtained.

The pile head shall be protected during the driving with packing or resilient material evenly spread and held securely in place. A helmet shall be placed over the packing and provided with a dolly of hardwood or other suitable material not thicker than the width of the pile.

Piles that have to be lengthened shall be jointed by butt-welding in such a manner that the full strength of the original section is developed in accordance with or BS 5135 taken in conjunction with BS 449. The joints shall be designed and constructed to maintain the true alignment and position of the pile sections. The joints in box piles shall be watertight.

Where any part of the pile is exposed to the atmosphere or to backfill the thickness of the steel over that required by the design criteria shall be increased on each exposed face by 4mm.

K10.5.8 Recording of pile installation

The Contractor shall keep records of every pile as follows:

— pile type;

— pile number;

— original ground level related to Ordnance Datum Newlyn;

— nominal diameter or dimensions;

— date driven or bored;

- date concreted;
- depth from ground level to toe of pile;
- depth or height from ground level to cut-off level of pile;
- depth or height from ground level to top of the concrete;
- final set for driven piles, weight and drops of hammer;
- details of any obstructions observed.

The Contractor shall also take a full driving record for all non-working piles and up to 20% of all the driven piles as directed by the Engineer. This full record shall include the number of blows for each 250mm of driving until the target toe level is approached or until the driving resistance increases to the calculated set value, whichever occurs first; thereafter the number of blows for each 50mm of driving.

All records shall be accurately kept in duplicate as the work proceeds and one copy shall be handed to the Engineer as soon as practicable after driving and not later than the completion of each day's work.

K10.6 Testing

The Contractor shall carry out maintained load tests on piles as follows:—

(a) Non-working piles, constructed for test purposes at positions selected by the Engineer, shall be tested to the ultimate bearing capacity as defined in Clause 10.4.1. These test piles shall be constructed in the same manner and to the same set (where applicable) as the working piles.

(b) Working piles (meaning piles forming part of the Permanent Works) will be selected at random by the Engineer and tested to a load of one and a half times the working load.

Piles shall not be tested until crushing tests on control cubes from the same mix and cured in the same way as the piles, show strengths greater than the specified works cube strength at 28 days.

The test procedure shall be in accordance with the recommendations of Clause 7.5.5 of BS 8004.

If a non-working pile fails to achieve the specified ultimate bearing capacity, the Contractor shall submit for the approval of the Engineer his alternative proposals for piles to meet the Specification. If, in the opinion of the Engineer, a test on a working pile indicates that the pile does not have the specified ultimate bearing capacity, the Contractor shall submit for the approval of the Engineer his proposals for:

(a) further testing of working piles; and

(b) measures to ensure the integrity of the foundation.

K11.0 CONCRETE

K11.1 Scope

This Part contains requirements which, where relevant to this Contract, shall apply to the supply of materials for concrete; design of mixes; quality control; mixing, transporting and placing; and curing of concrete.

K11.2 Reference Standards

Unless otherwise specified, materials for concrete, concrete products and testing procedures shall comply with the following Reference Standards where relevant.

Standard	Subject
IS 269	Ordinary Portland cement.
IS 8041	Rapid-hardening Portland cement.
IS 455	Portland-blast furnace cement.
IS 2386	Methods of test for aggregate for concrete
BS EN 1097	Testing aggregates.
IS 383	Aggregates from natural sources for concrete.
BS EN 12878	Pigments for Portland cement and Portland cement products.
BS EN 12620	Air cooled blast furnace slag aggregate for use in construction.
BS EN 13139	Building sands from natural sources
IS 12600	Low heat Portland cement.
BS 1881	Testing concrete.
BS EN 1008	Methods of test for water for making concrete.
BS EN 3797	Methods for sampling and testing of lightweight aggregates for concrete.
BS EN 13055	Lightweight aggregates for concrete.
BS 3892	Pulverized-fuel ash.
IS 12330	Sulphate-resisting Portland cement.
BS 146	Low heat Portland-blast furnace cement.
IS 6909	Supersulphated cement.
BS 4550	Methods of testing cement.
IS 9103	Concrete admixtures
BS 5328	Concrete.
IS 9893	Precast concrete lintels and sills.
IS 5751	Precast concrete coping blocks.
IS 12440	Precast concrete masonry blocks.
BS EN 197	Portland pulverised-fuel ash cement.
IS:1489-part 1	Portland-pozzolana Cement- part 1 fly ash based
IS:3812:1981	Fly ash for use as pozzolana and Admixture
IS 12089	Granulated blast furnace slag for use with Portland cement.
IS 5758	Precast concrete kerbs, channels, edgings, quadrants and gutter aprons.
BS 8004	Foundations
BS 8007	Design of concrete structures for retaining aqueous liquids.
BS 8110	Structural use of concrete.

IS 4926	Ready mixed concrete code of practice
CP 102	Protection of buildings against water from the ground.
ASTM D 512	Tests for chloride ion in water and waste water.
ASTM D 516	Tests for sulphate ion in water and waste water.

K11.3 Submissions by the Contractor

K11.3.1 Submissions generally

Submissions by the Contractor in relation to concrete work are described in the relevant clauses of the Specification. These submissions are summarised hereunder, with cross-references to the relevant sub-clauses.

K11.3.2 Certificates

Manufacturers' and suppliers' certificates of compliance with relevant standards in respect of the following materials:

-	cement	K11.4.1
-	aggregates	K11.4.3
-	admixtures	K11.4.6
-	ready mixed concrete	K11.5.10

Calibration certificates furnished by an approved person for:

-	weighing devices	K11.5.8
-	dispensing devices	K11.5.8
-	batching plant	K11.5.8

The results certified by an approved person for tests carried out subsequently on:

-	aggregate	K11.6.1 and K11.5.3
-	moisture content of aggregate	K11.5.9
-	fresh concrete	K11.6.2
-	concrete test tubes	K11.6.2
-	hardened concrete	K11.6.3 and K11.6.5

K11.3.3 Samples

Samples of all the foregoing materials except concrete and water shall be submitted, and those approved shall be kept in suitable containers, properly labelled and stored on Site for reference.

K11.3.4 Concrete mixes

Details of designed mixes for all grades of concrete required for the Works, together with proposed methods of transportation, handling, placing and compaction.

K11.3.5 Other submissions

Proposals for the following, where relevant to the Works:

- details of design mixes K11.4.6, K11.5.1, K11.5.4 K11.5.5, K11.5.6, K11.5.29

- layout of construction jointing and lifts K11.5.13, K11.5.21

- construction details for the installation of water stops K3.11

- special measures for dealing with particular circumstances (e.g. concreting in hot, etc) K11.5.13, K11.5.14 K11.5.15, K11.5.17

- methods for precast work K11.5.25

- methods for prestressed work K11.5.28

- methods of curing K11.5.20

K11.3.6 Records of concreting

Daily returns in respect of all concrete placed during the previous day.

The returns shall detail:

(a) in respect of each grade of concrete -

- the number of batches mixed;
- the number of batches and the total volume of concrete placed;
- the number of batches wasted or rejected;
- the weight of cement used.

(b) in respect of each location in the Works -

- the position of the pour (e.g. bay or lift reference number);
- the grade of the concrete placed;
- the total volume of concrete placed and the number of batches used.

In addition, the Contractor shall maintain an accurate and up to date record showing dates, times, weather and temperature conditions when each part of the Works was concreted. The record shall be available for inspection by the Engineer at all times.

Results of all tests on concrete shall be recorded and identified with the parts of the Works to which they relate.

K11.4 Materials

K11.4.1 Cement

The cement used for any particular mix shall comply with whichever of the following Standards is relevant:-

Ordinary and rapid-hardening Portland cement IS 269
Portland-blast furnace cement IS 455
Low heat Portland cement IS 12600
Pulverised-fuel ash BS 3892
Sulphate-resisting Portland cement IS 12330
Low heat Portland-blast furnace cement BS 146
Supersulphated cement IS 6909
Methods of testing cement BS 4550
Portland pulverised fuel ash cement BS EN 197
Pozzolanic cement with pulverised-fuel ash as pozzolana IS 1489
Ground granulated blast furnace slag for use with Portland cement IS 12089

Cement used in the Works shall be ordinary Portland cement unless otherwise specified or agreed with the Engineer.

The Contractor shall provide from each consignment of cement delivered to the Site such samples as the Engineer may require for testing. Any cement which is, in the opinion of the Engineer, lumpy or partially set shall be rejected and the Contractor shall promptly remove such cement from the Site. Cement which has been stored on the Site for more than forty days and cement which in the opinion of the Engineer is of doubtful quality shall not be used in the Works unless it is retested and the test results show that it complies with the relevant Standard.

K11.4.2 Storage of cement

Immediately upon arrival at the Site, cement shall be stored in silos designed for the purpose or in dry weather-tight and properly ventilated structures with floors raised 500 mm above ground level with adequate provision to prevent absorption of moisture. All storage facilities shall be subject to the approval of the Engineer and shall be such as to permit easy access for inspection and identification. Each consignment of cement shall be kept separately and the Contractor shall use the consignments in the order in which they are received.

Cement of different types and from different sources shall be kept in clearly marked separate storage facilities. Cement delivered to the Site in drums or bags provided by the supplier or manufacturer shall be stored in the unopened drums or bags until used in the Works. Any cement in drums or bags which have been opened on the Site shall be used immediately or shall be removed from the Site.

K11.4.3 Aggregates

Aggregates for concrete shall be obtained from an approved source, shall conform to the grading and other requirements of the relevant British Standards, and shall be washed clean. The British Standards are:

Foamed or expanded blast furnace slag lightweight aggregate for concrete BS

3797
Aggregates from natural sources for concrete IS
383
Air cooled blast furnace slag aggregate for use in construction BS
EN 12620
Clinker and furnace bottom ash aggregates for concrete BS
3797
Lightweight aggregates for concrete BS
EN 13055

Water absorption of aggregates when tested in accordance with the standard procedure prescribed in Part 2 of BS EN 1097, shall not exceed 3%.

(a) Mine waste

Aggregates for concrete shall not be obtained from the wastes of metalliferous mining.

(b) Alkali-silica reaction

The fine and coarse aggregates shall each consist of at least 95% of one or more of the rock types tabulated below. Sources of aggregates shall not contain opaline silica or quantities of flint, chert or chalcedony that could cause damage from alkali-silica reaction.

Air cooled blast furnace slag	Expanded clay/ shale/slate	Microgranite
		Quartz
Andesite	Feldspar	Schist
Basalt	Gabbro	Sintered pfa
Diorite	Gneiss	Slate
Dolerite	Granite	Syenite
Dolomite	Limestone	TrachyteTuff
	Marble	

If the Contractor wishes to use aggregates other than those listed, he shall submit evidence to the satisfaction of the Engineer from the previous performance of the coarse and fine aggregates which he proposes to use that, when used with the proposed cementitious constituents of the concrete mix in the proportions proposed there will be no cracking or expansion due to alkali-silica reaction during the life of the structure.

If this requirement cannot be met the Contractor shall adopt constituents for his concrete such that either

(i) The cementitious material shall have a reactive alkali content not exceeding a maximum value of 0.6% by mass when defined and tested in accordance with the method prescribed,

or

(ii) the total mass of reactive alkali in the concrete mix shall not exceed 3 kg per m3 of concrete when defined, tested and calculated in accordance with the method prescribed.

The Contractor shall notify the Engineer of his proposals for complying with this requirement at the time of tendering.

The methods prescribed for complying with (i) and (ii) above shall be those set out in:

Alkali-Silica Reaction: Concrete Society Technical Report No 30, October 1987.

For requirement (i) Clauses 16 and 17
(ii) Clauses 16 and 18.

(c) Soluble chlorides

Chlorides content, expressed as chloride ion, shall be such that the concrete mix as a whole complies with the limit of total chlorides specified in K11.5.3. If necessary the tests described in BS EN 1097 shall be used to ensure compliance with this requirement.

(d) Soluble sulphates

Water-soluble sulphate contents of the aggregates shall be such that the concrete mix as a whole complies with the limit of total water soluble sulphates specified in Clauses K11.5.3. If necessary the tests described in BS EN 1097 for acid-soluble sulphates shall be used to ensure compliance with this requirement.

(e) Coarse and fine low-shrinkage aggregates

The coarse aggregates shall be capable of producing concrete having a drying shrinkage of not more than 0.065 per cent, when tested in accordance with the method given in BS EN 1097.

The Contractor shall produce test sheets from the supplier certifying compliance with the stipulated requirement. Where such test sheets are not available, tests shall be carried out by the Contractor to establish the suitability of the proposed source of supply.

Where a source of supply produces coarse aggregates which do not satisfy the stipulated shrinkage requirement, such a source shall not be used for the supply of fine aggregates.

K11.4.4 Storage of aggregates

The Contractor shall provide means of storing the aggregates at each point where concrete is made such that (i) each nominal size of coarse aggregate and the fine aggregate shall be kept separated at all times, (ii) contamination of the aggregates by the ground or other foreign matter shall be prevented at all times, and (iii) each heap of aggregate shall be capable of draining freely.

The Contractor shall ensure that graded coarse aggregates are tipped, stored and removed from store in a manner that does not cause segregation.

Wet fine aggregate shall not be used until in the opinion of the Engineer it has drained to a constant and uniform moisture content, unless the Contractor measures the moisture content of the fine aggregate continuously and adjusts the amounts of fine aggregate and added water in each batch of concrete mixed to allow for the water contained in the fine aggregate. If necessary to meet the requirements of this clause, the Contractor shall protect the heaps of fine aggregate against inclement weather.

K11.4.5 Water

Water for washing aggregates, for mixing concrete and for curing shall be clean and free from harmful matter and shall satisfy the recommendations in the Appendix to BS EN 1008; the concentration of sulphates and chlorides shall be such that the concrete mix as a whole complies with the specified limits of salts content.

K11.4.6 Admixtures

Admixtures shall mean material added to the concrete materials during mixing for the purpose of altering the properties of the concrete mix.

Admixtures containing calcium chloride shall not be used.

The chloride ion content of admixtures shall not exceed 2% by weight of the admixture or 0.03% by weight of the cement when used in:

(a) concrete containing pre stressing tendons, reinforcement or embedded metal and made with any type of cement; and

(b) concrete made with cement complying with IS 12330 and IS 6909.

Admixtures shall be used only if the Engineer has given his prior approval in writing, and with due regard to the manufacturers' instructions. Both the amount added and the method of use shall be to the approval of the Engineer who shall also be provided in good time with the following information:-

(i) The typical amount added and any detrimental effects due to adding greater or smaller amounts.

(ii) The chemical name(s) of the main active ingredient(s) in the admixture.

(iii) Whether or not the admixture leads to the entrainment of air when used at the proposed rates of dosage.

Any approved admixture shall conform with IS 9103.

When more than one admixture is used in a concrete mix the compatibility of the various admixtures shall be established to the satisfaction of the Engineer.

K11.5 Workmanship

K11.5.1 Grades and Classes of concrete

The Contractor shall design mixes for any or all of the grades of concrete in the Table below as required for the Works.

Grade	Typical Use	Minimum cement content(kg/m3)	max free water/cement ratio
Reinforced Concrete			
M35	General structural–major superstructures	380	0.4
M35	Pile cap and piles	400	0.4
M35	General structural–poured underwater	420	0.4
M25	Water retaining structures	360	0.4
M20	General structural–minor structures(chambers, small building works)	330	0.45
Mass Concrete			
M35	Caisson/well bottom plug	330	0.4
M25	Caisson/well steining	310	0.45
M15	Caisson/well top plug	nominal mix to IS 456	
M10	General blinding/non structural fill		

Concrete grade is that number which represents its characteristic strength at 28 days expressed in N/mm2, followed by the maximum size of aggregate in mm.

Characteristic strength is that value of cube crushing strength below which not more than 5 per cent of all test results fall. This condition shall be deemed to be satisfied when the results comply with the specified test requirements.

K11.5.2 Free water/cement ratio

In designing and establishing approved mixes of concrete for any part of the Works the Contractor shall keep within any limitations on free water/cement ratios which may be expressly stated in the Specification, or shown on the Drawings as applying to concrete for particular parts of the Works or (where not so stated or shown) as given in the Table of concrete grades.

K11.5.3 Limits of salts content of mix

No concrete shall contain more than the following total quantities of the substances expressed as percentages by weight of cement:

(a) For mixes containing ordinary Portland cement to IS 269,

or Portland-blast furnace cement to IS 455,
or low-heat Portland cement to IS 12600,
or low-heat Portland-blast furnace cement to BS 146,
or a combination of ggbfs and pfa,

The total chlorides expressed as chloride ions calculated whenever possible from the mix proportions and the measured chloride contents of each of the constituents: 0.4%

(b) For mixes containing cements complying with IS 12330 (Sulphate-resisting) or IS 6909 (Supersulphated) the total chlorides expressed as chloride ions calculated as above: 0.2%

(c) For mixes used for prestressed concrete or heat-cured concrete containing embedded metal (all types of cement), the total chlorides expressed as chloride ions calculated as above: 0.1%

(d) For all mixes except where supersulphated cement to IS 6909 is used, total water-soluble sulphates: 4.0% (as SO3 ions)

Tests shall be carried out in accordance with the following standards:

(a) Aggregates
- Chlorides BS EN 1097
- Sulphates BS EN 1097

(b) Mixing water

- Chlorides ASTM D512
- Sulphates ASTM D516

Calcium chloride or chloride-based admixtures shall not be added to mixes intended to contain reinforcement, pre-stressing tendons or other embedded metal.

Where it is required to verify the salt content of hardened concrete, tests shall be carried out in accordance with BS 1881: Part 6.

K11.5.4 Workability

The workability of the concrete mixes shall be defined by their compacting factors determined by the method described in BS 1881: Part 103.

The workability of each concrete mix shall be such that satisfactory compaction can be obtained when the concrete is placed and vibrated in the work and that there is no tendency to segregate when it is handled, transported and compacted by the methods which the Contractor proposes to use in the Works.

When, by trial mixes according to Clause K11.5.6 or otherwise, a mix has been verified as complying with these requirements its workability shall be measured and, within the limits given below, confirmed or amended as considered necessary by the Engineer.

For reinforced concrete and prestressed concrete, the compacting factor shall lie between 0.85 and 0.92. For unreinforced concrete the compacting factor shall lie between 0.75 and 0.80. For concrete which is to be pumped, the compacting factor may be increased to 0.95.

K11.5.5 Design of concrete mixes

Each mix design shall be such that:-

(a) The aggregate shall comprise both fine aggregate and coarse aggregate. The maximum size of coarse aggregate shall be either 20 mm or 40 mm as directed by the Engineer. A separate mix shall be designed for each maximum aggregate size for any grade of concrete.

(b) The maximum free water/cement ratio shall be the maximum water/cement ratio when the aggregate is saturated but surface dry.

(c) The mixes shall be designed to produce a target mean concrete cube strength at 28 days after manufacture greater than the characteristic strength at 28 days by a margin of at least 10 N/mm^2 for grade 15 and a margin of at least 15 N/mm^2 for grades 20, 25, 30 and 40.

(d) Where sufficient data demonstrate that a different margin is acceptable or necessary, in order to maintain the standard of acceptance for characteristic strength, the mix shall be redesigned to have such different margin. Sufficient data shall mean cube test results from at least 40 separate batches of concrete produced over a period exceeding 5 days but not exceeding 6 months by the same plant under similar supervision. The different margin shall be 1.64 times the standard deviation of the test results considered, but not less than 5 N/mm2 for grade 15 or 7.5 N/mm2 for grades 20, 25, 30 and 40.

(e) Where a Class as well as a Grade (e.g. "Grade C25/Class 4") is shown on the Drawings (or elsewhere in the Specification), the mix shall be designed so as to meet the requirements of Table 7 of BS 5328: Part 1 in addition to those of (a) to (d) above.

For any concrete containing admixtures, the strengths shall be not less than those specified in the Table of concrete grades but the mixes shall be separately designed to take account of the effects of the admixtures, and shall have separate trial mixes made and tested.

K11.5.6 Trial mixes

(a) Laboratory trials:

As soon as the Engineer has agreed the trial mix proportions for each grade of concrete, the Contractor shall produce in the concrete-testing laboratory on Site two batches from a trial mix for each grade (except grade 10) using cement and surface dry aggregates known to be typical of the proposed source of supply. Each batch shall contain the correct amount of cement and have a free water cement ratio at or below the maximum value given in the Table of concrete grades, and the workability of each batch shall be determined. Provided that the compacting factors so obtained fall within the specified limits and the requirements regarding cement content and free water cement ratio have been met, the Contractor may proceed to carry out Site trials.

As an alternative to producing trial mixes in a laboratory as described above, the Contractor may submit recent existing laboratory test reports from elsewhere. Such reports shall be acceptable only if the Engineer is satisfied with the laboratory's test procedures and that the materials used were typical of the proposed source of supply.

(b) Site trials:

Trial mixes shall be made at the site of the proposed concreting under full scale production conditions. The proportions of materials used, including the mixing water, shall agree with the mix proportions determined by the laboratory trial mixes. Three batches of concrete for each grade shall be produced, using the same plant and mixing time proposed by the Contractor for use in the Works.

For each grade of concrete the following shall be carried out:-

(i) The workability of each of the three batches shall be determined immediately after mixing by the compacting factor method described in BS 1881: Part 103.

(ii) Three 150 mm test cubes from each of the three batches shall be made by the Contractor in the presence of the Engineer. The cubes shall be made, cured, stored and tested at 28 days after manufacture in accordance with the method described in BS 1881: Parts 108, 111 and 116.

A Site trial mix for a particular grade of concrete shall be considered satisfactory provided that:

(iii) the compacting factors as under (i) above fall within the specified limits; and

(iv) the average value of the compressive strength of the nine cubes taken from the trial mix is greater than the target mean strength used in the mix design.

If the requirements under (iii) and (iv) above are not met for any mix the Contractor shall re-design that mix and he shall make further Site trials as above.

Where re-design of any concrete mix becomes necessary, the making and testing of the trial mix shall be repeated until the trial mix satisfies both requirements (iii) and (iv) above. Final approval will not be given to any trial mix which does not comply with the specified requirements appropriate to that grade of concrete.

K11.5.7 Mixes not approved

Approval of a mix may be withheld or withdrawn if (inter alia):

- the grading of the aggregate changes such that the fraction of aggregate retained on any sieve differs from the corresponding fraction of aggregate in the approved mix by more than 2% of the total quantity of fine and coarse aggregate; or

- the source of supply of aggregate or cement is changed.

If approval of a mix for any grade of concrete is withdrawn for any reason the Contractor shall carry out such further trials as are necessary to achieve a satisfactory mix for that grade of concrete.

K11.5.8 Batching of materials

Cement used in the production of concrete shall be measured by weight either with an approved weighing machine or by making the size of each batch of concrete such as to require an integral number of complete bags or drums of cement.

For concrete of grades 20, 25, 30 and 40 the fine aggregate and the several nominal sizes of coarse aggregate shall be measured singly or cumulatively by weight using weigh-batching machines.

For concrete of grades 10 and 15 the fine and coarse aggregate shall be measured separately either by weight using weigh-batching machines or by volume in gauge boxes.

Weigh-batching machines shall provide facilities for the accurate control and measurement of the aggregates either singly or cumulatively and shall be capable of immediate adjustment by semi-skilled operators in order to permit variations to be made to the mix. All weigh dials shall be easily visible from the place at which filling and emptying of the hoppers is controlled.

Every concrete mixing machine shall be fitted with a device to measure added water by weight or volume and shall be so constructed that the water inlet and outlet valves are interlocked so that neither one of them can be opened unless the other is fully closed. The water-measuring device shall be provided with an overflow with a cross-sectional area at least four times that of the inlet pipe and with its discharge point clear of the mixing plant. The entire water system shall be maintained free of leaks at all times and the measuring device shall be fitted with a drain pipe which allows the full quantity of water being measured to be drained off for checking the measurement. The outlet arrangement of the measuring device shall be such that between five and ten percent of the water enters the mixer before the other materials and a further five to ten percent of the water enters the mixer after the other materials. The remainder of the water shall be added at a uniform rate with the other materials. The water measuring device shall be readily adjustable so that the quantity of water added to the mixer can, if necessary, be varied for each batch.

Gauge boxes for use in volume batching shall be soundly constructed of timber or steel, with closed bottoms. Each box shall be sized to contain exactly the volume of aggregate required for one batch of any particular mix. In sizing up gauge boxes for fine aggregates, the Contractor shall make an allowance for bulking due to moisture contained in the aggregate stockpiles on Site. Each box shall be suitably identified by reference to the aggregate and the mix for which it has been made.

Any admixtures which may be used shall be measured separately in calibrated dispensers.

All mixing and batching plants shall be maintained free of set concrete or cement and shall be clean before commencing mixing. The accuracy of calibration of any weighing plant, water measuring device and admixture dispenser shall be checked before carrying out trial mixes, before the first mixing of concrete for inclusion in the Works, after each service or adjustment to the mixing plant, and in any case at least once per week.

K11.5.9 Mixing concrete

Concrete shall be mixed in batches in plant capable of combining the aggregates, cement and water (including admixtures if any) into a mixture uniform in colour and consistency, and of discharging the mixture without segregation.

On commencing work with a clean mixer the first batch shall contain only half the normal quantity of coarse aggregate to compensate for the adhesion of the other materials to the drum.

The moisture contents of the aggregates shall be determined before the commencement of each day's concreting and at such intervals during each day as may be necessary. The Contractor shall make due allowance for water contained in the aggregates when determining the quantity of water to be added to each mix, and shall adjust the amount of water added to each mix to maintain the approved free water/cement ratio of the mixed concrete.

K11.5.10 Ready-mixed concrete

Any concrete which is not prepared under the direct control of the Contractor and by plant situated on or reasonably adjacent to the Site shall be classed as ready-mixed concrete.

Ready-mixed concrete shall not be used in any part of the Works without the written approval of the Engineer, which approval may be withdrawn at any time.

The Contractor shall satisfy the Engineer that ready-mixed concrete complies with the Specification for concrete, and that the manufacturing and delivery resources of the proposed supplier are adequate to ensure proper and timely completion of each concreting operation. The proposed supply depot shall be open to inspection by the Engineer at all times.

The specified requirements as to the sampling, trial-mixing, testing and quality of concrete of various grades shall apply equally to ready-mixed concrete which shall furthermore be made and delivered in accordance with IS 4926.

The Contractor shall provide every additional facility which the Engineer may require for the supervision and inspection of the batching, mixing and transporting of ready-mixed concrete.

K11.5.11 Preparing for concreting

Before placing concrete the Contractor shall remove from the surface of the foundations or previously placed concrete all oil, loose fragments of rock, earth, mud, timber or other debris and (except as provided for in Clause K11.5.17) any standing water.

Where specified, and elsewhere as ordered by the Engineer, excavated surfaces on which concrete is to be placed shall be covered with either blinding concrete not less than 75 mm thick, or waterproof building paper, or polythene sheeting 0.1 mm in thickness immediately after completion of the final trimming of the excavation.

K11.5.12 Transporting concrete

Concrete shall be conveyed from the mixer to its place in the Works as rapidly as possible by methods which will prevent segregation or drying out and ensure that the concrete is of the required workability at the time of placing. If segregation has nevertheless occurred in any instance the materials shall be remixed or rejected.

K11.5.13 Placing concrete

Before placing concrete in any part of the Works the Contractor shall satisfy himself by inspection that that part is in all respects ready for the reception of concrete. He shall also notify the Engineer so as to enable him to inspect the location if so required. Failure by the Engineer to inspect prior to the scheduled time for pouring shall not constitute a reason for the Contractor to postpone the pour.

The temperature of concrete at placing shall not exceed 25°C, except where requirements of Clauses K11.5.14 and K11.5.15 (as appropriate) are met.

Concrete shall be placed and compacted before initial set has occurred and, in any event, not later than forty-five minutes from the time of mixing.

Concrete shall be carefully placed in horizontal layers which shall be kept at an even height throughout the work. Concrete shall not be allowed to slide or flow down sloping surfaces into its final position but shall be placed directly in its final position from skip, truck, barrow, down pipe or other placing machine or device or, if this is impossible, it shall be shovelled into position with care being taken to avoid segregation. Concrete placed in horizontal slabs from barrows or other tipping vehicles shall be tipped into the face of the previously placed concrete.

Concrete dropped into place in the work shall be dropped vertically. It shall not strike the formwork between the point of its discharge and its final place and shall not drop freely through a height greater than 1½ metres. Chutes and conveyor belts shall be designed so that there is no segregation or loss of mortar and shall be provided with a vertical pipe, or other device, which ensures that concrete is discharged vertically into place.

Where a lift of concrete is built up in layers, each layer shall be properly merged into the preceding layer before initial set takes place. If necessary the area of the pour will be restricted to ensure that this is achieved.

When pneumatic placers are used, if the end of the placer pipe is not equipped with an energy absorbing device it shall be kept as close to the work as practicable. Mortar or water used at the beginning or end of a run shall be discharged outside the formwork.

When pumps are used the end of the supply pipe shall be kept immersed in the concrete during placing to assist compaction. Mortar or water used at the beginning or end of a run shall be discharged outside the formwork.

Where concrete abuts against earth or other materials liable to become loose or to slip, the Contractor shall take steps to prevent any such loose material falling on to the surface of the concrete. Subject to the approval of the Engineer such steps may include leaving timbering in place or cutting away and removing timbering in small lengths or depths at a time.

K11.5.14 Concreting in hot weather

Hot weather is defined as any combination of high air temperature, low relative humidity, and wind velocity tending to impair the quality of fresh or hardened concrete or otherwise resulting in abnormal properties.

When the temperature of the concrete at placing exceeds 25°C the Contractor shall use admixtures to reduce the water demand and retard the initial setting of the concrete.

When the temperature of the concrete at placing exceeds 40°C and the relative humidity is less than 80 percent, the Contractor shall in addition cool the mixing water and/or replace part of the water by chipped ice. The ice shall be completely melted by the time mixing is completed.
The Contractor shall at all times:

(a) Provide sun shades over stockpiles of aggregates, cement silos, mixing water tanks and pipelines.

(b) Spray clean cool water over the aggregate stockpiles. The Contractor shall carry out regular tests on the aggregates to ensure that concentrations of sulphates or chlorides do not rise to unacceptable levels, and to ensure that moisture content determinations allow for such spraying.

(c) Shade or wet the outside of the formwork.

The Contractor shall also do the following if directed by the Engineer.

(d) Apply a fine moisture (fog) spray of clean cool water in order to cool and moisten the surrounding air and the sub-surface, to cool the formwork and reinforcement, and to lessen rapid evaporation from unformed concrete surfaces.

(e) Pour concrete at night.

The Contractor shall provide the Engineer with details of the precautions he proposes to take to comply with the above. No concreting in hot weather shall be put in hand until the proposed measures have received the approval of the Engineer.

K11.5.15 Concrete in large pours

A large pour is defined as a pour where the least dimension is greater than 1.5 metres.

Subject to the requirements for construction and movement joint locations and the requirements for the test blocks detailed in the following clause, the Contractor will not be limited as to the size of a large pour, provided that adequate measures are taken to control temperature differentials. Such measures will be evaluated with reference to the following:

(a) Temperatures

(i) The temperature of the concrete at the time of placing shall not exceed 15°C and the peak hydration temperature shall not exceed 60°C, except under hot conditions, when the requirements of Clauses K11.5.14 shall apply.

(ii) The difference in temperature between thermometers in the concrete near any concrete face and the interior of the concrete at a distance of 1 m from that face shall not exceed 20°C at any stage after placing.

(b) Monitoring of temperature changes

Sets of thermometers for recording concrete temperatures shall be placed at positions in the concrete near to each exposed face at spacings not exceeding 5 m. Further sets shall be placed at corresponding positions within the concrete at a distance of 1 m from each face. The concrete temperatures shall be recorded at intervals not exceeding 6 hours, or such other intervals as may be required by the Engineer, for a period of at least 7 days.

Where the minimum dimension of a pour is between 1.5 m and 2.0 m the internal temperatures shall be recorded by thermometers placed at mid depth of the least thickness.

(c) Insulation and protection of concrete surfaces

(i) Formwork shall be plywood 19 mm thick, or such other combination of materials having an equivalent insulation value. The formwork shall remain in position for a sufficient time to ensure that the temperature control requirement in (a)(ii) above can be maintained after its removal.

(ii) Unformed surfaces shall be protected, as soon as practicable after the initial set has taken place, by either of the following means:

- by ponding the surface with at least 100 mm depth of water;
- by covering the surface with a layer of polythene sheet upon which shall be placed a layer of sand of at least 50 mm thickness.

When the latter method of protection is adopted, the Contractor shall take appropriate steps to ensure that no loss of sand is suffered through the action of wind; the thickness of the sand layers shall be maintained at the specified minimum of 50 mm at all times.

Whichever method of protection is adopted, the protection itself shall be kept shaded from direct sunlight.

The Contractor shall provide the Engineer with details of the precautions he proposes to take to protect the concrete from the effects of temperature build-up and with details of the methods he proposes to use to assess the correct timing at which such protection may be removed. No concreting in large pours shall be put in hand until the proposed measures have received the approval of the Engineer.

K11.5.16 Test blocks

Before commencing any large pour (as defined in the preceding clause) for a particular mix of concrete, the Contractor shall construct three test blocks 2.0 m cube in size. The temperature of the concrete at the time of casting the blocks shall not exceed 15°C except under hot conditions, when the requirements of Clause K11.5.14 will apply. The materials used in making concrete for the test blocks, together with the reinforcement, formwork and materials used for protecting the top surfaces, shall be of the same type and from the same source as those intended for the large pour.

Two of the blocks shall be reinforced on two opposing sides and on the top face by 32 mm diameter high yield reinforcing bars at 250 mm spacing in each direction. The cover to the outer bars shall be 60 mm.

The Contractor shall ascertain the thermal characteristics of the cement and aggregates to be used, from which he shall calculate the likely maximum rise in temperature of the concrete. The data used shall be clearly indicated in the calculations which the Contractor shall give to the Engineer before casting the blocks.

Thermometers shall be installed in the concrete near to the surface at the centre of each face, with one placed centrally in the block. Temperatures shall be recorded at 6 hourly intervals for a period of at least 7 days for each of the blocks.

Six 150 mm test cubes shall be taken during placement of concrete for each block, two for testing at 7 days and four for testing at 28 days.

The test blocks shall be examined at regular intervals for cracks and a careful note shall be made of any found during the first 28 days.

The test blocks shall be considered satisfactory if, for each of the blocks, all the following conditions are met:

(a) The average strength of the four 28 day test cubes exceeds the specified 28 day characteristic strength by at least 7.5 N/mm^2;

(b) The rise in temperature during hydration does not exceed 45°C and the difference in temperature between any face and the centre of the block does not at any stage exceed 20°C;

(c) The nature of any cracks appearing is such that, in the opinion of the Engineer, the cracks would not constitute a potential source of harm if they were to occur in the Permanent Works.

If condition (a) above is not fulfilled the Contractor shall redesign the concrete mix, construct further test blocks, and repeat the testing as specified.

If condition (b) is not fulfilled or if under (c) the Engineer is of the opinion that the cracks as noted are potentially harmful, the Contractor may proceed with the casting of a large pour only if he incorporates one or more of the following procedures in the concreting operation:

- cool the mixing water/aggregate as set out in Clause K11.5.14;
- replace the 19 mm thick plywood formwork to formed faces with material having better insulating properties;
- increase the surface protection to unformed faces.

If the Engineer so requires, the Contractor shall construct further test blocks to demonstrate the efficacy of the measures which are being incorporated in the casting of the large pour.

K11.5.17 Concrete placed in water

Where any concrete is to be placed in water, the Contractor shall submit detailed proposals to the Engineer and shall obtain his approval before commencing the work.

The quantity of cement in any concrete placed in water shall if necessary be increased so that the free water/cement ratio of the mix is not more than 0.47.

Concrete shall not be placed in running water or be allowed to fall through water.

Concrete shall be placed in water only by means of a bottom-opening watertight box or a tremie of a type approved by the Engineer. Bottom-opening boxes shall not be opened until they are resting on the work, and the lower ends of tremies shall always be kept below the surface of freshly placed concrete.

K11.5.18 Compaction

Except as otherwise approved by the Engineer, concrete placed in situ shall be compacted with power driven internal type vibrators supplemented by hand spading and tamping, and shall be thoroughly worked around the reinforcement, tendons, duct formers and embedded items, and into the corners of the formwork, so as to form a solid mass free of voids. The vibrators shall at all times be adequate in number, amplitude and power to compact the concrete properly and quickly throughout the whole of the volume being compacted. Spare vibrators shall be readily on hand in case of breakdown.

Vibrators shall be inserted into the uncompacted concrete vertically and at regular intervals. Where the uncompacted concrete is in a layer above freshly compacted concrete the vibrator shall be allowed to penetrate vertically for about 100 mm into the previous layer. In no circumstances shall vibrators be allowed to come into contact with the reinforcement or formwork nor shall they be withdrawn quickly from the mass of concrete but shall be drawn back slowly so as to leave no voids. Internal type vibrators shall not be placed in the concrete in a random or haphazard manner nor shall concrete be moved from one part of the work to another by means of the vibrators.

The duration of vibration shall be limited to that required to produce satisfactory compaction without causing segregation. Vibration shall on no account be continued after water or excess grout has appeared on the surface.

K11.5.19 Attendance of steel fixer and carpenter

The Contractor shall take adequate steps to ensure that reinforcement, ducts or duct forming devices to house prestressing tendons, formwork and all embedded items are kept in their correct position as concreting proceeds.

The Contractor's arrangements for concreting shall include for a competent steel fixer and a carpenter to be in attendance on the concreting gang as and when required.

K11.5.20 Curing of concrete

Concrete shall be cured by being kept continuously moist throughout the curing period and by protecting the newly cast surface from the effects of sunshine, drying winds, frost, rain, running water or mechanical damage.

The curing shall be maintained for a continuous period of at least

- 7 days when the cement used in the concrete is ordinary Portland cement;

- 3 days when the cement used in the concrete is rapid hardening cement.

If, during the specified minimum period of curing, the average temperature of the concrete falls below 10°C, the period of curing shall be extended to allow for the concrete to reach sufficient maturity. The period of extension shall be as directed by the Engineer.

The protection shall be applied as soon as practicable after completion of placing and shall include one or more of the following methods as may best suit the circumstances:-

(a) by water sprays in continuous operation;

(b) by covering with hessian or similar absorbent material, or sand, kept constantly wet;

(c) after thorough wetting, by covering with a layer of waterproof fabric kept in contact with the concrete surface;

(d) by the application of an approved coloured non-staining liquid curing membrane which is either self removing or easily removed following the curing period and which has a 75% moisture retention standard. The liquid shall be applied to formed surfaces immediately after stripping the formwork.

Liquid curing membranes shall not be used on Class U 1 surfaces, or where laitance is to be removed and aggregate exposed to provide a satisfactory bond for placing further concrete or mortar screeds, or where in the opinion of the Engineer the use of a such a membrane is likely to spoil the finished appearance of an exposed surface.

The Engineer may also prohibit the use of liquid curing membranes where their effect on any retained liquid would make them unsuitable as curing agents.

Any concrete which, due to the Contractor's failure to comply with requirements for curing, is in the opinion of the Engineer likely to have been impaired shall forthwith be removed from the Site and replaced.

K11.5.21 Construction joints

A construction joint is defined as a joint in the concrete introduced for convenience in construction at which special measures are taken to achieve subsequent continuity without provision for relative movement.

Construction joints shall be located so as not to impair the strength of the concrete. Rebates, keys, or notches shall be formed and waterstops inserted as the Engineer may require.

Where possible the line of any construction joint shall coincide with the line of a formwork joint and that in any case all construction joint lines and formwork joint lines shall appear as a regular and uniform series.

For all exposed horizontal joints and purposely inclined joints, a uniform joint shall be formed with a batten of approved dimensions to give a straight and neat joint line.

Concrete placed to form the face of a construction joint shall have all laitance removed and the large aggregate exposed prior to the placing of fresh concrete. The laitance shall wherever practicable be removed when the concrete has set but not hardened, by spraying the concrete surface with water under pressure or brushing with a wire brush sufficient to remove the outer mortar skin and expose the large aggregate without disturbing it. Where the laitance cannot be removed due to hardening of the concrete, the whole of the concrete surface forming the joint shall be treated by high pressure water jet, sand blasting, use of a needle gun or a scaling hammer to remove the surface laitance. All loose matter on the existing concrete surface shall be removed and the surface slightly wetted before concreting is resumed

Concrete shall not be allowed to run to a feather-edge and any vertical joints shall be formed against a stop-end. If a kicker or stub-end is used it shall be at least 70 mm high.

No concreting shall be started until the Engineer has approved the positions and form of the construction joints.

K11.5.22 Dimensions and surfaces of finished concrete

Workmanship in formwork and concreting shall be such that no making good is required to achieve fair surface finishes. Concrete surfaces for the various classes of unformed and formed finishes shall in any event never exceed the maximum permitted tolerances stated in the Specification or Drawings, or, where not so stated, shown in the Table below.

In the Table `line and level' and `dimension' shall mean the lines, levels and cross-sectional dimensions shown on the Drawings.

Surface irregularities shall be classified as `abrupt' or `gradual'. Abrupt irregularities include, but shall not be limited to, offsets and fins caused by displaced or misplaced formwork, loose knots and other defects in formwork materials, and shall be tested by direct measurement. Gradual irregularities shall be tested by means of a straight template for plane surfaces or its suitable equivalent for curved surfaces, the template being 3.0 m long for unformed surfaces and 1.5 m long for formed surfaces.

Maximum tolerance (mm) in:-

Class of finish	Line and level	Abrupt irregularity	Gradual irregularity	Dimension
U1	± 12	6	± 6	-
U2	± 6	3	± 3	-
U3	± 6	3	± 3	-
F1	± 12	6	± 6	+ 12, - 6
F2	± 6	6	± 6	+ 12, - 6
F3	± 3	3	± 3	± 6

K11.5.23 Unformed surfaces - class of finish

Finishes to unformed surfaces of concrete shall be classified as U1, U2, U3, `spaded' or `bonded concrete' or such other special finish as may be particularly specified. Where the class of finish is not specified the concrete shall be finished to Class U1.

Class U1 finish is the first stage for Class U2 and U3 finishes and for a bonded concrete surface. Class U1 finish shall be a levelled and screeded, uniform plain or ridged finish, which (unless it is being converted to Class U2, U3 or bonded concrete) shall not be disturbed in any way after the initial set and during the period of curing, surplus concrete being struck off immediately after compaction.

Where a bonded concrete surface is specified, the laitance shall be removed from the Class U1 finish surface and the aggregate exposed while the concrete is still green.

A spaded finish shall be a surface free from voids and brought to a reasonably uniform appearance by the use of shovels as it is placed in the Works.

Class U2 finish shall be produced by manual or mechanical floating of the concrete surface after the initial set has taken place and the surface has hardened sufficiently. The concrete shall be worked no more than is necessary to produce a uniform `sandpaper' finish free from screedmarks.

Class U3 finish shall be a hard smooth steel-trowelled finish. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked into the surface. The surface shall be trowelled under firm pressure and left free from trowel marks.

Cement, mortar or water shall not be added during any of the above operations.

K11.5.24 Building in pipes and other items

Pipes and other items passing through concrete structures shall, wherever practicable, be built into the structure as work proceeds, having already been connected to the remainder of the system to ensure proper fit.

Where this procedure cannot be adopted, holes shall be formed to allow such items to be built in later. Such holes shall be of size and shape sufficient to permit proper placing and compaction of concrete or grout. The surfaces of the holes shall be treated so as to bond with the later concrete.

All items to be built in shall be securely supported in their correct position to prevent movement or damage during building-in. No pipe with flanged joints shall be concreted in until its accurate fit with other pipework has been checked and it has been secured in position.

Concrete used for building in shall be of the same grade as the surrounding concrete, except that the mix shall incorporate an approved expanding agent used in accordance with the manufacturer's instructions. Cement/sand mortar or cement grout used for building-in shall also incorporate an expanding additive. Concrete, mortar and grout shall be placed and compacted by methods which will avoid moving or damaging built-in items.

K11.5.25 Structural precast concrete

Structural units of precast concrete shall be manufactured in the grade of concrete and to the sizes and details shown on the Drawings. The concrete shall comply with the provisions of the Specification whether such units are manufactured on the Site or obtained from manufacturers approved by the Engineer.

Where the installation of precast concrete units in any structure is such that the faces of the units are to be left exposed either internally or externally, the exposed surfaces of the units as finished shall be uniform in colour and in texture. All cement, aggregates and other materials used in the manufacture of the units shall be obtained from the same approved sources throughout the period of manufacture.

Formwork and unformed surfaces for precast concrete units shall comply with the requirements for F3 formed surfaces and U3 unformed surfaces respectively.

The Contractor shall submit full details of his proposed method of carrying out all operations connected with the manufacture and assembly of precast concrete structural members, including:-

- a description of the types of casting bed, mould and formwork for the various types of members;
- the procedure for concrete casting and the method of curing the concrete;
- the procedure for transporting, handling, hoisting and placing of each type of precast structural member;
- particulars of the temporary supports deemed necessary to ensure adequate stability during erection and fully proof against the effects of construction loads, wind load and other transient loads.

K11.5.26 Dimensional tolerances

Dimensions and shapes of precast concrete structural members shall comply with tolerances given on the Drawings or, when not so given, with those stated hereunder:

(a) Length

not exceeding 3m	± 6 mm
exc. 3m not exc. 4.5m	± 9 mm
exc. 4.5 m not exc. 6 m	± 12 mm
additional for every subsequent 6 m	± 6 mm

(b) Cross section

(each direction) not exceeding 500 mm	± 6 mm
exc. 500 mm not exc. 750 mm	± 9 mm
additional for every subsequent 250 mm	± 3 mm

(c) Straightness or bow (deviation from intended line)

not exceeding 3 m	6 mm
exc. 3 m not exc. 6 m	9 mm
exc. 6 m not exc. 12 m	12 mm
additional for every subsequent 6 m	6 mm

(d) Squareness

When considering the squareness of a corner the longer of the two adjacent sides being checked shall be taken as the baseline, and a line perpendicular to the baseline shall be taken as the checkline. The shorter side shall not vary in its distance from the checkline so that the difference between the greatest and the shortest such distance exceeds:

length of shorter side - not exceeding 1.2	6 mm
exc. 1.2 m not exc. 1.8 m	9 mm
exceeding 1.8 m	12 mm

For the purpose of this requirement, any error due to lack of straightness shall be ignored; squareness shall be measured with respect to the straight lines which are most nearly parallel with the features being checked. When the nominal angle is other than 90° the included angle between the baseline and the checkline shall be varied accordingly.

(e) Twist

No corner of a nominally plane surface shall deviate from the plane containing the other three corners by more than:

surface dimensions- not exc. 600 mm wide and not exc. 6 m long	6 mm
exceeding 600 mm wide and for any length	12 mm

(f) Flatness

The deviation from a 1.5 m straight edge placed in any position on a nominally plane surface shall not exceed 6 mm.

K11.5.27 Installation of precast concrete structural members

At all stages and until completion of the Works, precast members shall be adequately protected to preserve all permanently exposed surfaces, arrises and architectural features. The protection shall not mark or otherwise disfigure the concrete.

All units shall be laid, bedded, jointed and fixed in accordance with the lines, levels and other details shown on the Drawings.

Dry-pack mortar jointing for packing shall consist of one part by volume of ordinary Portland cement and two parts by volume of fine aggregate passing a 1 mm sieve. The mortar shall be mixed with only sufficient water to make the materials stick together when being moulded in the hands. The mortar shall be placed and packed in stages, where possible from both sides of the space being filled, using a hardwood stick hammered until the mortar is thoroughly compacted.

Any precast concrete structural member which is found to be cracked, damaged or otherwise inferior in quality, either before or after erection, shall be rejected and replaced by the Contractor.

The Contractor shall submit for approval his proposals for the following:-

(a) Minimum ages for handling and transportation;
(b) Position and design of lifting point;
(c) Method of lifting;
(d) Lifting equipment;
(e) Methods of supporting and stacking;
(f) Methods of assembly and erection;
(g) Accuracy of assembly and erection;
(h) Temporary support;
(i) Final structural connections;
(j) Method of protecting units from damage;
(k) Marking for identification;
(l) Protection from frost;
(m) Preparation of contact surfaces;
(n) Removal of locating devices after erection.

K11.5.28 Prestressed concrete

Prestressed concrete work, whether precast or cast in situ, shall be as detailed on the Drawings and the Contractor shall provide full details of his proposals for carrying out all operations connected with prestressing including:-

(a) Design of concrete mix;

(b) Description of concrete casting and curing operations;

(c) Procedure for prestressing and method of checking and recording the prestress, wire extension and anchorage slip;

(d) Procedure for handling, hoisting and placing of any precast units;

(e) Grouting of ducts.

All tendons, duct forming devices, anchorages and other components shall be kept clean, dry and free of oil (except for water soluble oil applied for protection). They shall be placed with a tolerance of ±3 mm in concrete dimensions of 300 mm or less or ± 5 mm in concrete dimensions over 300 mm.

The bearing surfaces between anchorages and concrete shall be perpendicular to and concentric with the tendons and the line of action of the prestressing force.

No grouting of ducts shall take place when the surface temperature of the member is below 5°C, or is likely to fall below 5°C during the 48 hours following placement.

K11.5.29 No-fines concrete

No-fines concrete shall be made using a coarse aggregate conforming with IS 383 and cement to IS 269. No fine aggregate shall be used. The grading of the coarse aggregate shall be:-

- not less than 95% by weight passing a 20mm I.S. sieve; and

- not more than 5% by weight passing a 10mm I.S. sieve.

The proportion of aggregate, cement and water shall be determined in trial mixes by the Contractor starting with a cement: aggregate ratio of 1:8 by volume. The trial mix shall be considered suitable when all the aggregate particles are coated with a film of cement grout. The water content shall be just adequate to ensure that the cement paste completely coats the aggregate. The concrete when placed shall contain no layers of laitance.

No-fines concrete shall not be mixed by hand.

Vibration shall not be used to compact the concrete. Three test cubes of no-fines concrete shall be made of each trial mix. The minimum crushing strength of the chosen mix shall be 3N/mm2 at 28 days.

K11.5.30 Precast concrete products

Precast concrete products shall where appropriate be manufactured in accordance with British Standards as follows.

Type of unit	Standard
Kerbs etc.	IS 5758
Window sills	IS 9893
Masonry units	IS 12440

Units shall be hydraulically pressed wherever possible.

The concrete shall comply with the Specification whether such products are manufactured on Site or obtained from manufacturers approved by the Engineer.

K11.5.31 Installation of precast concrete products

Mortar for bedding and jointing units shall consist of one part by volume of ordinary Portland cement and two parts by volume of natural sand.

The provisions of Clause K11.5.27 shall otherwise apply to all precast concrete products.

K11.6 Testing

K11.6.1 Sampling and testing of aggregates

The Contractor shall take samples of all aggregates and test them for grading, by the methods described in IS 2386, at least once in each week when concreting is in progress and additionally as the Engineer may require.

Whenever the source of aggregate is changed and in any case at least once per month the Contractor shall carry out tests on aggregates relating to water absorption, potential alkali reaction, chloride content, sulphate content and shrinkage characteristics, all as specified.

K11.6.2 Sampling and testing of concrete

The Contractor shall provide the necessary equipment and shall determine the compacting factor of the freshly mixed concrete by the method described in

BS 1881: Part 103 on each occasion that a set of test cubes is made and at such other times as the Engineer may direct.

For each grade of concrete (except grade 10) works test cubes shall be made whenever required by the Engineer but not less frequently than as follows unless otherwise particularly specified:-

for concrete of grade 40	) :	one set of cubes per 10 m^3, or part thereof, concreted per day.
for concrete of grades 25, 30 or 35	) :	one set of cubes per 25 m^3, or part thereof, concreted per day.
for concrete of grades 15 or 20	) :	one set of cubes per 50 m^3, or part thereof, concreted per day.

Each set of cubes (three cubes per set) shall be made from a single sample taken from a randomly selected batch of concrete. One cube shall be tested 7 days after manufacture and two cubes 28 days after manufacture. The average of the two 28 day results shall be taken as the test result.

Where concrete of a particular grade is likely to be placed infrequently, and the above rates of sampling might not produce sufficient representative test cubes to enable the concrete quality to be monitored properly, the Contractor shall increase the number of standard samples taken during each day when concrete of that grade is being placed so as to ensure that enough representative test cubes are obtained.

K11.6.3 Compliance with specified requirements

The concrete shall be deemed satisfactory if the conditions given in both (a) and (b) are met:-

(a) The average 28 day strength determined from any group of four consecutive test cubes exceeds the specified characteristic strength by not less than 2 N/mm^2 for grade 15 concrete and 3 N/mm2 for grades 20 and above;

(b) The strength determined from any test result does not fall short of the specified characteristic strength by more than 2 N/mm2 for grade 15 concrete or 3 N/mm2 for grades 20 and above.

If only one cube result fails to meet the second requirement, that result may be considered to represent only the particular batch of concrete from which the cube was taken, provided that the average strength of the group satisfies the first requirement.

If more than one cube in a group fails to meet the second requirement, or if the average strength of any group of four consecutive test cubes fails to meet the first requirement, then all the concrete in all the batches represented by such cubes shall be deemed not to meet the strength requirements.

K11.6.4 Action in the event of failure to meet requirements

When concrete of a particular design of mix does not meet the strength requirements set out in clause K11.6.3 no further concrete from that mix shall be placed in the work and the Contractor shall establish the cause of the failure and apply such remedies as are necessary. The Contractor shall revise the mix accordingly and demonstrate by trial mixes and test cube results that the revised mix meets the specified requirements.

The Contractor shall within 24 hours of the date of test make proposals for approval by the Engineer for action to be taken in respect of any concrete represented by test cubes which fail to meet the foregoing requirements. These proposals may include, but shall not be limited to, cutting and testing cores. In the absence of such approved proposals the Engineer will instruct the Contractor regarding the action to be taken.

K11.6.5 Cutting and testing of core samples

For the examination and testing of hardened concrete, cylindrical core specimens of 150 mm nominal diameter shall be cut from it as and where directed by the Engineer. They shall be cut perpendicular to the face. The preferred ratio of length to diameter shall be 2. The procedure for drilling, examination, measurement and testing for compressive strength shall be in accordance with BS 1881: Part 120. Before preparation for testing, the specimen shall be made available for examination by the Engineer. If the estimated in-situ cube strength of the specimen determined in accordance with clause 7.2 of BS 1881: Part 120 is less than the specified characteristic strength at 28 days, or if in the opinion of the Engineer the concrete fails to meet the Specifications in other respects, the concrete in that part of the Works of which it is a sample shall be deemed not to comply with the Specification.

K11.6.6 Action in the event of concrete not complying

Concrete which is found not to comply with the Specification shall be rejected and shall be broken out and replaced or otherwise dealt with as directed by the Engineer.

K11.6.7 Contractor responsible for testing

In addition to any specific obligations for sampling and testing the Contractor shall be responsible for routine inspection sampling and testing of concrete, materials, measuring devices and plant, in order to control the quality of work and to ensure compliance with the Specification including conformity with approved samples.

If the Contract provides for a laboratory and testing equipment for the use of the Engineer's staff, the Contractor shall be allowed reasonable opportunity to use them for quality control. In the absence of such provision the Contractor shall himself provide all necessary test equipment.

K11.7 Particular Requirements

K11.7.1 Testing of concrete structures designed to retain aqueous liquid

After cleaning, and as far as practicable and as far as design requirements permit, before any earth or other filling is placed against the outside wall faces, concrete structures designed to retain an aqueous liquid shall be filled with water at a uniform rate of not greater than 2m in 24 hours. A period of 21 days shall be allowed by the Contractor for stabilisation, after which the water level shall be recorded by approved means at 24 hour intervals for a test period of 7 days. During the test period the total permissible drop, after allowing for evaporation and rainfall, shall not exceed 1/500 of the average water depth of the full tank or 10mm, whichever is the less.

Notwithstanding the satisfactory completion of the above test, any leakage visible on the outside faces of the structure shall be stopped. Any caulking or making good of cracks in the wall section shall, where practicable, be carried out from the inside face.

K12.0 CONCRETE JOINTING AND PROTECTION

K12.1 Scope

This Section includes requirements for joints in concrete and surface protection of concrete by membranes against groundwater and the salts which may be dissolved therein.

K12.2 Definitions

The following terms shall have the meaning hereby assigned to them:-

Construction joint	A joint in the concrete introduced for convenience in construction at which special measures are taken to achieve subsequent continuity without provision for further relative movement;
Movement joint	A joint in the concrete intended to accommodate relative movement between adjoining parts of a structure;
Expansion joint	A movement joint intended to accommodate expansion and contraction of the concrete without restraint;
Contraction joint	A movement joint intended to accommodate contraction of the concrete without constraint, in the case of a complete contraction joint, or with some constraint, in the case of a partial contraction joint;
Induced contraction joint	A contraction joint formed not by using a temporary stop end but by reducing the depth of the concrete section by at least 25%.

K12.3 Reference Standards

Unless otherwise specified, concrete jointing and protection shall comply with the following Reference Standards, where relevant, and the recommendations therein:

Reference Number	Standard
BS 747	*Roofing felts*
IS 1346	Waterproofing roofs with bitumen felts
BS 2499	*Hot applied joint sealants for concrete pavements*
IS 1834	Hot applied sealing compounds for joints in concrete
BS 3416	Bitumen-based coatings for cold application, suitable for use in contact with potable water
BS 4254	*Two-part polysulphide-based sealants*
IS 12118 parts1&2	Two-part polysulphide-based sealants
BS 5215	*One-part gun grade polysulphide-based sealants*
IS 11433 parts1&2	One-part gun grade polysulphide-based sealants
IS 10959	Glossary of terms for sealants for building purposes
BS 6213	Selection of construction sealants

BS 6949	Bitumen-based coatings for cold application, excluding use in contact with potable water
BS 8102	Protection of structures against water from the ground
ASTM D 1751	Preformed expansion joint filler for concrete paving and structural construction (non-extruding and resilient bituminous types)
ASTM D 1752	Preformed sponge rubber and cork expansion joint fillers for concrete paving and structural construction.

Other Reference Standards referred to in this Part include the following:

Reference Number	Standard
BS 8007	Design of concrete structures for retaining aqueous liquids
ASTM D 545	Testing preformed expansion joint fillers for concrete construction (non-extruding and resilient types).

K12.4 Submissions by the Contractor

Submissions which the Contractor is required to make in relation to concrete jointing and protection include, where relevant, the following:-

(a) Data

- Types of material and their properties.
- Manufacturers' catalogues.
- Manufacturers' proposals for choice and application of products with details of the joint geometry where applicable and the allowable movement accommodation factor.
- Manufacturers' recommendations for storage handling, and installation of products, including where relevant:
    - extent of allowable movements of joints;
    - design life; and
    - method of fixing during installation.

When required by the Engineer, details of previous successful applications of the material offered.

Submissions shall be in accordance with the Specification but, where the Contractor considers that a departure from the Specification will benefit the work, he shall make an additional submission, drawing attention to the points of departure. Such departures require the express approval of the Engineer.

(b) Drawings

Full-scale dimensioned drawings of waterstop cross sections.

(c) Samples

Where required by the Engineer, samples of materials for inspection or independent testing or both.

(d) Certificates

Manufacturers' and suppliers' certificates of compliance with relevant standards. Such certificates shall state the results of tests carried out.

K12.5 Materials

K12.5.1 Materials generally

Materials for concrete jointing and protection shall be obtained from manufacturers approved by the Engineer. Unless otherwise approved, all materials for concrete jointing and protection which are in contact with each other or jointed together to form a jointing and/or protective system shall be obtained from a single manufacturer.

All materials for concrete jointing and protection which may come into contact with one another shall be compatible with each other. They shall not cause any change in properties of the materials with which they are in contact which may make them unsuitable for use in concrete jointing or protection, or which may reduce the working life of joints or protection.

The Contractor shall supply manufacturers' test sheets to certify compliance of all jointing and protection materials with relevant quality standards. Where there is no relevant quality standard, the Contractor shall prove by demonstration, tests or otherwise the suitability, adequacy and performance of the material under Site conditions. Only such materials as have been approved by the Engineer shall be used in the Works.

K12.5.2 Materials in contact with sewage

Materials which may come into contact with sewage shall not be susceptible to chemical or biological attack, and shall retain their specified properties.

K12.5.3 Waterstop

Waterstop shall be of the following types, as shown on the Drawings or specified elsewhere:

- rubber or PVC waterstop for use within the thickness of the concrete member;
- PVC waterstop for use on the outer face of the concrete member.

Waterstop shall be dense, homogeneous and free of holes or other imperfections. The cross section shall be uniform along the length and symmetrical transversely so that the thickness at any given distance from either edge will be uniform. Where not otherwise shown on the Drawings:

- the width of the waterstop shall be not less than 80% of the thickness of the concrete section and not less than 250 mm;

- the web thickness shall be not less than 9mm in the case of waterstop for use within the concrete thickness or 5mm in the case of waterstop for use on the outer face;

- all waterstop shall incorporate a solid bulb or major rib at or near each edge;

- waterstop wider than 180mm which is for use on the outer face shall incorporate a total of at least two major ribs each side of the centreline;

- waterstop at movement joints shall incorporate a central hollow bulb;

- waterstop for use at induced contraction joints shall incorporate a crack inducer;

Rubber waterstop shall be of natural rubber, suitable synthetic rubber, or a blend of the two. PVC waterstop shall be of an elastomeric plastic compound; no reground material shall be used.

Waterstop shall have the following properties when tested at 25°C:

Property	Rubber	PVC
Minimum tensile strength (N/mm2)	20	13.75
Minimum elongation at break (%)	450	280
Hardness (Shore `A')	60-70	70-80
Softness (BS 2571)	-	42°-52°
Specific gravity	1.05-1.15	-

All intersections and junctions in waterstop shall be factory-produced by the manufacturer of the waterstop, normally as moulded special pieces; so that the only joints remaining to be made at Site shall be straight butt joints between straight lengths of waterstop of the same section and material

K12.5.4 Joint filler and capping strip

Joint fillers shall be preformed, compressible and resilient and shall comply with all relevant requirements of this clause, except where alternative requirements are specified, shown on the Drawings or specifically approved by the Engineer.

Bitumen impregnated joint fillers of fibre or cork shall comply with ASTM D 1751.

Resin bonded cork or self expanding cork joint filler shall comply with ASTM D 1752. Sponge rubber joint fillers shall also comply with ASTM D 1752 except that the load required to compress the test specimen to 50% of its initial thickness shall not exceed 0.5 N/mm².

Joint fillers of closed-cell polyethylene or polyvinyl foam shall, when tested in accordance with ASTM D 545, have the following properties:

- the load required to compress the test specimen to 50% of its thickness before test shall be no less than 0.13 N/mm² nor greater than 0.3 N/mm²

- 10 minutes after release of the compressive load (or 1 hour if the retest provision applies) the test specimen shall have recovered not less than 80% of its initial thickness.

Joint filler for use in joints which may be submerged shall be of closed-cell polyethylene or self expanding cork.

Joint filler for use in joints across which little load needs to be transferred shall be of sponge rubber, closed-cell polyethylene or polyvinyl foam.

Capping strip to joint filler shall be of grey plasticised PVC complying with Clause K12.5.3, formed to shape and sized for use with the appropriate thickness of joint filler.

K12.5.5 Joint sealant

Joint sealant shall be one of the following types as shown on the Drawings or specified elsewhere:

- polysulphide-based sealant complying with IS 12118, having a movement accommodation factor of at least 25% and a minimum service life expectancy of 15 years;

- synthetic rubber based on polysulphide to IS 12118 or IS 11433, having a movement accommodation factor of at least 10% and a minimum service life expectancy of 15 years;

- approved proprietary product formulated from chemically resistant elastomeric polymers, having a movement accommodation factor of at least 20% and a minimum life expectancy of 15 years;

- rubber-bitumen compound complying with IS 1834 (equivalent to a type F1 as per BS 2499) , having a movement accommodation factor of at least 10% and a minimum service life expectancy of 10 years;

- approved bituminous putty proprietary product, having a movement accommodation factor of at least 10% and a minimum life expectancy of 10 years.

Where not otherwise specified herein or shown on the Drawings, sealant shall be selected in accordance with BS 6213. Definitions included in BS 6213 shall apply to this Specification.

Sealant shall be non-degradable under the prevailing conditions. Where sealant will be in contact with sewage, the Contractor shall submit for the Engineer's approval evidence that the proposed product will resist aerobic and anaerobic attack.

K12.5.6 Back-up material, bond breaker and primer

Back-up material inserted in a joint to limit the depth of sealant (where joint filler does not serve this purpose) shall comprise closed-cell low-density compressible joint filler preformed for the purpose or such other material as is recommended for this use by the sealant manufacturer and approved by the Engineer.

Bond breaker installed behind joint sealant shall be thin self-adhesive polyethylene tape. Where the sealant manufacturer recommends the use of primer before the application of sealant, it shall be provided by the sealant manufacturer for the purpose.

K12.5.7 Slip membrane

Slip membrane for use in a two-layer separating membrane at sliding joints shall consist of plastic sheet not less than 1.5 mm thick which shall have a coefficient of friction not exceeding 0.2 between rubbing surfaces when used in accordance with the manufacturer's instructions and subjected to a load of 0.27 N/m^2.

K12.5.8 Bituminous paint

Bond breaking paint for use on concrete or steel reinforcement shall be bituminous paint complying with the relevant provisions of BS 3416 or BS 6949, as appropriate.

K12.5.9 Dowel caps

Where dowels of steel reinforcement are used for bridge expansion joints, the dowel to one side of the joint shall be painted with 2 coats of bituminous paint and the end of the dowel shall be fitted with a dowel cap. The cap shall comprise a cardboard or plastic tube which is a free fit on the dowel and which is filled with joint filler for a part of its length not less than the thickness of the joint filler in the joint.

K12.5.10 Protective membrane systems

Membrane for the protection of concrete from salts present in groundwater shall be flexible self-adhesive impervious composite sheeting of total thickness not less than 1.5mm consisting of either:

- a sheet not less than 0.25mm thick of cross-laminated polyethylene or PVC, and a rubber-bitumen compound; or

- a bituminous sheet and a polyester surface film.

Membrane for the exclusion of groundwater or the retaining of an aqueous liquid shall comply with the recommendations of BS 8102 and shall be flexible self-adhesive impervious composite sheeting of total thickness not less than 1.5mm consisting of either:

- a sheet not less than 0.30mm thick of cross-laminated polyethylene or PVC, and a rubber-bitumen compound; or

- a polyester-reinforced bituminous felt to IS 1346(equivalent to type 5B in BS 747).

Primer for membrane and other sundry materials for forming fillets, upstands and chamfers shall be fully compatible with the membrane material.

K12.6 Workmanship

K12.6.1 Storage of materials

All materials for concrete jointing and protection shall be stored under weatherproof cover. Any storage conditions recommended by the manufacturer of any materials for concrete jointing and protection shall be observed.

Materials shall be used in order of delivery from the manufacturer and shall not be used after the expiry of any storage life recommended by the manufacturer.

K12.6.2 Waterstop

Each waterstop system shall be made up of straight lengths of waterstop and factory-produced intersections and junctions, jointed together so as to form a continuous impermeable barrier.

No joints shall be made at Site except straight butt joints between lengths of waterstop of identical section and material, made by heat fusion or hot vulcanising in accordance with the waterstop manufacturer's instructions and using jigs, tools and equipment provided by him.

Waterstop shall not be stretched or kinked during handling or installation. It shall be fixed using only such methods as are approved by the Engineer for the section being fixed. It shall be positioned in accordance with the Drawings and shall not be in contact with reinforcement or built-in items. The concrete shall be properly compacted around it so that no voids or porous areas remain.

Unless otherwise approved, waterstop shall not be bent more sharply than:

- a radius equal to its width, viewed `on edge': or

- a 15 m radius in the plane of the waterstop.

K12.6.3 Joint filler and capping strip

Joint fillers employed to form and fill expansion joints shall have the same nominal thickness as the joint width specified or shown on the Drawings and shall extend through the full thickness of the joint not occupied by other jointing materials.

The joint filler shall be fixed by dabs of adhesive to the surface of the first placed concrete forming one side of the joint. Alternatively the joint filler shall be placed against the formwork on the concrete side of the first pour. The latter method shall be used when the joint filler edge is to be finished with capping strip. In that case, joints between lengths of capping strip shall be made by heat fusion and the capping strip pushed firmly over the edge of the joint filler which shall be accurately pre-cut.

Where sealant is required, the recess or caulking groove to receive it may be formed by the use of removable forms or where appropriate by cutting back the filler to the required depth, the filler being incised upon installation to facilitate this.

K12.6.4 Joint sealing

The caulking groove to accept sealant shall be formed to the dimensions shown on the Drawings or recommended by the sealant manufacturer and approved by the Engineer. After the concrete has cured and dried out, the bonding faces of the caulking groove shall be first grit blasted or wire brushed and then vacuum cleaned to remove all dirt, surface laitance and dust. The adjacent areas shall also be thoroughly vacuumed to reduce the risk of cleaned caulking grooves becoming contaminated.

Any wet or damp areas shall be allowed to dry out, or where necessary shall be dried out, before joint sealing materials are applied.

Where back-up material is required it shall be at least 20% wider than the joint and shall be placed accurately in position to define the required depth of sealant.

The back of the caulking groove, whether of concrete or joint filler shall be covered by bond breaker tape except where the joint sealant is to be applied hot, or where the caulking groove forms part of a structural hinge joint.

The sides of the caulking groove shall be primed where appropriate in accordance with the joint sealant manufacturer's instructions.

On permanently exposed areas of structures, joint sealing is to be carried out with the aid of masking tape to form neatly defined surface limits to the seal.

Should sealant suffer any of the types of failure described in BS 6213, it shall be replaced after the possible causes of failure have been investigated and the appropriate remedial action has been taken.

K12.6.5 Slip membrane

Surfaces to receive slip membrane shall be smooth, plane and clean. Concrete surfaces shall be Class U3 finish.

Two layers of slip membrane shall be cut to size and fastened together along all edges using masking tape. The complete assembly shall then be placed and fixed in position in accordance with the manufacturer's instructions.

K12.6.6 Bituminous painting

Where specified or shown on the Drawings, concrete surfaces or reinforcement shall be painted with two coats of bituminous paint. Concrete surfaces to be painted shall be of Class F2 finish, smooth, plane, clean and dry. New concrete shall not be placed against the painted surface until the paint is dry.

K12.6.7 Protective membrane

All concrete to which protective membrane is to be applied shall be of Class U2 or F2 finish, free from sharp protrusions and hollows. External angles shall be chamfered. All surfaces shall be clean and dry. Except for horizontal blinding concrete, all concrete to receive membrane shall be primed in accordance with the membrane manufacturer's instructions.

One complete layer of protective membrane shall be applied in accordance with the manufacturer's instructions with laps of not less than 150 mm at all joints. All corners shall receive two layers of membrane either by use of an additional reinforcing strip of membrane not less than 300 mm wide or by carrying each overlapping membrane at least 150 mm beyond the corner to provide an overlap not less than 300 mm wide. Internal angles shall have approved fillets installed to facilitate proper dressing of the protective membrane with the corner.

Chamfers and fillets shall be not smaller than 25 x 25 mm.

K13.0 FORMWORK AND REINFORCEMENT FOR CONCRETE

K13.1 Scope

This Section contains requirements which, where relevant to this Contract, shall apply to formwork and reinforcement for concrete.

K13.2 Reference Standards

Unless otherwise specified, formwork and reinforcement shall comply with the following Reference Standards.

IS 432	Mild steel and medium tensile steel bars and hard drawn wire for concrete reinforcement.
IS 1786	High strength deformed steel bars and wires for concrete reinforcement
IS 2502	Code of practice for bending and fixing of bars for concrete reinforcement
BS 4482	Cold reduced steelwire for the reinforcement of concrete
IS 1566	Hard-drawn steel wire fabric for concrete reinforcement
IS 2090	High tensile steel bars used in prestressed concrete
BS 4871	Approval testing of welders working to approved welding procedures
BS EN 1011	Arc welding of carbon and carbon manganese steels
BS 5896	High tensile steel wire and strand for the prestressing of concrete
BS 5975	Falsework
IS 456	Plain and reinforced concrete-code of practice
BS 8007	Design of concrete structures for retaining aqueous liquids
CP 110	The structural use of concrete

K13.3 Submissions by the Contractor

Submissions required from the Contractor in relation to formwork and reinforcement shall include the following where relevant:

- calculations for, and design and layout of, formwork
- manufacturers' data on accessories and mechanical couplings
- manufacturers' test certificates for each delivery of steel reinforcement and prestressing steel tendons as required by the relevant quality standard
- details of proposed welding procedures and welders' qualifications
- test certificates for mechanical couplings
- samples of steel reinforcement for testing

K13.4 Formwork

K13.4.1 Materials for formwork

Formwork shall be constructed of timber, sheet metal or other approved material.

Ties shall be of the rod and cone or other approved proprietary type.

Ties for use in water-retaining structures 300 mm thick or less shall incorporate a diaphragm not less than 50 mm dia. welded to the mid point of the tie, designed to prevent water passing along the tie.

K13.4.2 Design and layout of formwork

The design and construction of formwork shall take account of safety and of the surface finish required. The formwork shall be sufficiently rigid and tight to prevent loss of grout or mortar from the fresh concrete or the formation of fins or other blemishes on the concrete. The Contractor shall appoint a Falsework Coordinator to carry out on behalf of the Contractor the following duties:

(a) coordinate all falsework activities;
(b) ensure that the various responsibilities have been allocated and accepted;
(c) ensure that a design brief has been established with full consultation, is adequate, and is in accord with the actual situation on site;
(d) ensure that a satisfactory falsework design is carried out;
(e) ensure that the design is independently checked for:
    i) concept;
    ii) structural adequacy;
    iii) compliance with the brief;
(f) where appropriate, ensure that the design is made available to other interested parties, e.g. the structural designer;
(g) register or record the drawings, calculations and other relevant documents relating to the final design;
(h) ensure that those responsible for on-site supervision receive full details of the design, including any limitations associated with it;
(i) ensure that checks are made at appropriate stages covering the more critical factors
(j) ensure that any proposed changes in materials or construction are checked against the original design and appropriate action taken;
(k) ensure that any agreed changes, or corrections of faults, are correctly carried out on site;
(l) ensure that during use all appropriate maintenance is carried out;
(m) after a final check, issue formal permission to load if this check proves satisfactory;
(n) when it has been confirmed that the permanent structure has attained adequate strength, issue formal permission to dismantle the falsework.

Formwork and its supports shall maintain their correct shape and profile so that the final concrete structure is within the limits of the specified dimensional tolerances. They shall be designed to withstand the worst combination of self-weight, reinforcement weight, wet concrete weight, concrete pressure, construction and weather loads, together with all incidental dynamic effects caused by placing, vibrating and compacting the concrete. Formwork shall not be tied to or supported by the reinforcement.

On formwork to external faces which will be permanently exposed, all horizontal and vertical formwork joints shall be so arranged that joint lines will form a uniform pattern on the face of the concrete. Where the Contractor proposes to make up the formwork from standard sized manufactured formwork panels, the size of such panels shall be subjected to the approval of the Engineer before they are used in the construction of the Works. The finished appearance of the entire elevation of the structure and adjoining structures shall be considered when planning the pattern of joint lines caused by formwork and by construction joints to ensure continuity of horizontal and vertical lines.

K13.4.3 Erection of formwork

Faces of formwork in contact with concrete shall be free from all foreign matter such as water, dirt, projecting nails and the like, splits or other defects.

Except where the surface is subsequently to be rendered, formwork in contact with the concrete shall be treated with a suitable non-staining release agent before the steel is fixed or the concrete placed. Care shall be taken to prevent the release agent from touching the reinforcement or concrete at construction joints. Surface retarding agents shall not be used unless specified.

All exposed exterior angles on the finished concrete of 90° or less shall be given 20 mm by 20 mm chamfers unless otherwise specified.

Formwork shall be provided for the top surfaces of sloping work where the slope exceeds fifteen degrees from the horizontal unless otherwise specified, and shall be anchored so that the concrete can be properly compacted and to prevent flotation. Care shall be taken to prevent air being trapped.

Where ties are built into the concrete for the purpose of supporting formwork, part of any such supports shall be capable of removal so that no part remaining embedded in the concrete shall be within 50 mm of the surface in the case of reinforced concrete or 150 mm in the case of unreinforced concrete. Holes left after removal of such supports shall be neatly filled with epoxy or well rammed dry-pack mortar.

Openings for inspection of the inside of the formwork, for the removal of water used for washing down and for placing concrete shall be provided and so formed as to be easily closed before or during placing concrete. Before placing concrete all bolts, pipes or conduits or any other fixtures which are to be built in shall be fixed in their correct positions, and cores and other devices for forming holes shall be held fast by fixing to the formwork or otherwise. Holes shall not be cut in any concrete without prior approval of the Engineer.

K13.4.4 Removal of formwork

Formwork shall be designed to permit easy removal without resorting to hammering or levering against the surface of the concrete.

The periods of time elapsing between the placing of the concrete and the striking of the formwork shall have regard to the following factors:

(a) concrete strength;

(b) stresses in the concrete during construction including for precast units any disturbance and handling stresses;

(c) curing;

(d) subsequent surface treatment requirements;

(e) the presence of re-entrant angles requiring early removal of formwork to avoid thermal cracking.

The time shall be as approved by the Engineer after consideration of the loads likely to be imposed on the concrete and shall in any case be not less than the periods shown in the following table:

Minimum period before striking formwork (concrete made with ordinary or sulphate-resisting Portland cement)		
Type of formwork	Minimum period before striking	
	Surface temperature of concrete (t°C)	
	Between 0°C and 15°C	15°C and above
Vertical formwork to columns, walls and large beams	$\frac{300}{t+10}$ hours	12 hours
Soffit formwork to slabs	$\frac{100}{t+10}$ days	4 days
Soffit formwork to beams and props to slabs	$\frac{250}{t+10}$ days	10 days
Props to beams	$\frac{350}{t+10}$ days	14 days

Any time during which the temperature remains below freezing point shall be added to the above times.

Notwithstanding the foregoing the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

K13.4.5 Formed surfaces - class of finish

Finishes to formed surfaces of concrete shall be classified as F1, F2 or F3, or such special finish as may be specified. Where the class of finish is not specified the concrete shall be finished to class F1.

Formwork for Class F3 finish shall be lined with panels of non-staining material with a smooth unblemished surface such as sanded plywood or hard compressed fibre board. The panels shall be as large as possible and shall be arranged in a uniform approved pattern and fixed to back formwork by oval nails. Unfaced wrought boarding or standard steel panels will not be permitted.

Formwork for Class F2 finish shall be faced with wrought tongued and grooved boards or plywood or metal panels arranged in a uniform approved pattern and free from defects likely to detract from the appearance of the surface.

Formwork for Class F1 finish shall be constructed of timber, sheet metal or any suitable materials which will prevent loss of grout when the concrete is vibrated. Surfaces subsequently to be rendered plastered or tiled shall be adequately scabbled or roughened as soon as the formwork is removed to reduce any irregularities to not more than half the thickness of such rendering, plastering or bedding for tiles and to provide a satisfactory key.

K13.4.6 Defects in formed surfaces

Workmanship in formwork and concreting shall be such that concrete shall normally require no making good, surfaces being perfectly compacted and smooth.

Any minor surface blemishes shall be repaired to the satisfaction of the Engineer immediately after removal of formwork. Remedial measures may include, but shall not be limited to, the following:

- holes left by formwork supports shall be thoroughly cleaned out to remove all loose material and the sides shall be roughened, if necessary, to ensure a satisfactory bond. They shall then be filled with epoxy or dry-pack mortar.

- fins, pinhole bubbles, surface discolouration and minor defects may be rubbed down with sacking and cement immediately the formwork is removed.

- abrupt and gradual irregularities may be rubbed down with carborundum and water after the concrete has been fully cured.

- small defects and minor honeycombing shall be chipped out perpendicular to the face of the concrete to a depth of at least 25 mm and filled with epoxy or dry-pack mortar.

Where deeper or more extensive defects occur, the Contractor shall obtain the approval of the Engineer to the methods of repair proposed which may include, but shall not be limited to, cutting out to a depth of at least 25 mm with a diamond saw to give a regular edge to the repair and further chipping to form a hole with undercut edges to sound concrete or to a total depth of 75 mm whichever is the greater. If reinforcing steel is exposed the concrete shall be removed to a depth of 25 mm beyond the back side of the reinforcement. Steel mesh reinforcement shall then be sprung into the hole, which shall be refilled with concrete or suitable epoxy resin mortar.

The Contractor shall thoroughly clean any hole or defective area that is to be filled and break out any loose, broken or cracked concrete or aggregate.

Where the remedial work is to be carried out using dry-pack mortar or concrete, the concrete surrounding the hole shall be thoroughly soaked after which the surface shall be dried so as to leave a small amount of free water on the surface. The surface shall then be dusted lightly with cement by means of a small dry brush until the whole surface that will come into contact with the dry-pack mortar has been covered and darkened by absorption of the free water by the cement. Any dry cement in the hole shall be removed.

Where concrete is to be used, the mix shall be subject to the approval of the Engineer.

Where the remedial work is to be carried out using epoxy resin mortar or other special material, the surface of the cleaned hole shall be prepared and primed and the repair material placed, compacted and finished in accordance with the manufacturer's instructions.

Where, in the opinion of the Engineer the defect is too extensive to permit satisfactory repair, either from the point of view of structural integrity or appearance, the concrete containing the defect shall be broken out and replaced.

K13.4.7 Dry-pack mortar

Dry-pack mortar for filling holes and repairing surface blemishes shall be made from one part by weight of cement and three parts fine aggregate passing a 1 mm sieve. The colour of the mortar shall match that of the surrounding concrete. The mortar shall be mixed with just sufficient water to make the materials stick together when being moulded in the hands.

The dry-pack material shall be placed and packed in layers having a thickness not greater than 15 mm. The compaction shall be carried out by use of hardwood stick and hammer and shall extend over the full area of the layer, particular care being taken to compact the dry-pack against the sides of the hole. After compaction the surface of each layer shall be scratched before further loose material is added. Holes shall not be over filled and the surface shall be finished by laying a hardwood block against the dry-pack fill and striking the block several times. Steel finishing tools shall not be used and water shall not be added to facilitate finishing.

K13.5 Reinforcement

K13.5.1 Steel reinforcement

Steel for reinforcement shall be of the following kinds as may be specified

Type R - hot rolled plain round mild steel bars conforming to IS 432.

Type T - either hot rolled deformed high yield steel bars conforming to IS 1786. Such bars shall be of weldable quality with a cast analysis giving a carbon equivalent not exceeding 0.51 per cent.
- or cold worked deformed high yield steel bars conforming to IS 1786.

Fabric - welded hard drawn steel wire and other cold worked high bond bar fabric conforming with IS 1566.

K13.5.2 Prestressing tendons

Prestressing steel wire or bar shall be of the following kinds as specified

(a) Cold drawn wire or cold drawn and stress relieved wire conforming with BS 5896

(b) Stress relieved seven-wire strand conforming to BS 5896

(c) Hot rolled and hot rolled and processed high tensile alloy steel bars conforming to IS 2090.

K13.5.3 Accessories

Spacer blocks for maintaining concrete cover to reinforcement shall be of concrete of the same strength, durability, porosity and appearance as the in-situ concrete. They shall be cast in the form of a truncated cone or pyramid with the smaller face having a minimum dimension of 50 mm.

Chairs and other accessories for maintaining reinforcement and prestressing tendons in position shall be of steel.

Binding wire shall be No 16 gauge (1.60 mm) soft iron wire.

K13.5.4 Cutting and bending of reinforcement

Bars shall be bent in accordance with the provisions of IS 2502 and IS 456. Bending shall be carried out slowly, at a steady even pressure, without jerk or impact. The temperature of the steel at the time of bending shall be not less than 5°C. If necessary, reinforcement may be warmed to a temperature not exceeding 100°C. to facilitate bending, after which it shall be allowed to cool slowly in air. Hot bars shall not be cooled by quenching with water. Bent bars shall not be re-bent unless permitted by the Engineer.

K13.5.5 Storage of reinforcing bars and steel fabric

The Contractor shall stack separately and label different types of reinforcement for positive identification.

Reinforcement shall not be subjected to mechanical damage or shock loading prior to embedment.

Steel reinforcing bars shall be kept clean and shall be free from pitting, loose rust, mill scale, oil, grease, earth, paint, or any other material which may impair the bond between the concrete and the reinforcement.

All materials shall be stored under cover on wooden or concrete supports at least 150 mm clear of the ground.

K13.5.6 Storage of prestressing wire and bars

In addition to complying with the above storage requirements, the Contractor shall ensure that prestressing wire and bars are protected from mechanical damage by storing them on timber supports above a concrete slab; he shall also ensure that during storage the wire and bars are kept properly coated with water soluble oil inside protective wrapping.

K13.5.7 Fixing of reinforcement

All reinforcement shall be securely and accurately fixed in positions shown on the Drawings using approved plastic spacers, spacer blocks or chairs. These shall be not more than 1 m apart and at closer intervals if necessary. All intersections of bars shall be secured with soft iron wire, the ends being turned into the body of the concrete. The Contractor shall ensure that all reinforcement is maintained in correct position at all times, particular care being taken during placing of the concrete.

Concrete cover to reinforcement shall be as detailed on the Drawings and shall be maintained in accordance with the tolerances specified in BS 8110.

Top reinforcement in slabs shall be maintained in position by chairs, sized and spaced to provide adequate support and fixity for the reinforcement.

No part of the reinforcement shall be used to support formwork, access ways, working platforms or placing equipment, or for the conducting of an electric current other than as part of an earthing system during the site welding of reinforcement.

K13.5.8 Welding of reinforcement

The Contractor shall not weld any reinforcement on site except where this has been specified in the Contract or is approved by the Engineer in writing.

Reinforcement which is to be welded shall be welded in accordance with the requirements of BS EN 1011 and BS 8110, and with the recommendations of the manufacturer. The Contractor shall demonstrate by bend and tensile tests on specimen welds that the strength of the parent metal is not reduced and that the weld possesses a strength not less than that specified for the parent metal. The welding procedure established by successful test welds shall be maintained and no departure from this procedure shall be permitted.

Following the establishment of a satisfactory welding procedure, each welder to be employed on the Works shall carry out welder performance qualification tests on reinforcing bars of the same metal and size as those on the Works. The requirements of BS 4871 shall be observed.

Details of welding procedure and welder qualification tests shall be submitted for the approval of the Engineer before welding of reinforcement commences.

Tack welds or other welds in positions other than those shown on the Drawings shall not be permitted, unless specifically approved by the Engineer.

K13.5.9 Mechanical couplings

Mechanical couplings shall be used where shown on the Drawings or as approved by the Engineer, and shall be obtained from an approved manufacturer.

The Contractor shall demonstrate by tensile tests on sample joints of all sizes required for use in the Works that:

(a) the use of the couplings does not reduce the strength of the parent bars,

(b) completed couplings possess the strength required by BS 4449 and

(c) there is no significant permanent set in the couplings as the bars are loaded.

Equipment used for making the couplings shall be supplied by the coupling manufacturer and shall be operated in accordance with the manufacturer's instructions.

K13.5.10 Prestressing operations

All operations regarding the placing of ducts, anchorages and tendons and the stressing and grouting of tendons shall be carried out in full compliance with the requirements of BS 8110.

K13.5.11 Testing of samples of reinforcement

The Engineer/Employer/Third Party Inspection Agency may require to witness routine testing of steel reinforcement at the manufacturer's works.

When required by the Engineer the Contractor shall take samples from reinforcement delivered to site and shall arrange for the samples to be tested by an approved testing agency. Test certificates from that agency shall be submitted to the Engineer.

K13.5.12 Bar schedules

Any bar schedules issued by the Engineer are for the assistance of the Contractor, who shall nevertheless be entirely responsible for checking the correctness of such schedules before arranging for the supply cutting and bending of steel reinforcement. In the event of any information being apparently missing or incorrect the Contractor shall promptly refer to the Engineer.

K14.0 STRUCTURAL STEELWORK

K14.1 Scope

This specification covers structural steelwork generally for buildings and other structures, except portal cranes and road and rail bridges.

The specification does not cover roof and side cladding which shall comply with Bs 5950-6, or ladders, catwalks, handrails, and light trusses which shall comply with BS 4211 and BS 5973 respectively.

K14.2 Reference Standards

Unless otherwise specified, structural steelwork shall comply with the relevant Reference Standards listed below:

BS 4	Structural steel sections.
IS 808	Dimensions of hot rolled steel beam, column, channel and angle sections
IS 800	Code of practice for general construction in steel
IS 814	Covered electrodes for manual metal-arc welding.
BS 2853	The design and testing of steel overhead runway beams.
BS 4190	ISO metric black hexagon bolts, screws and nuts.
BS 4320	Metal washers for general engineering purposes.
BS 4360	Weldable structural steels.
BS 4395	High-strength friction grip bolts.
BS 4604	The use of high-strength friction-grip bolts in structural steelwork.
BS 4848	Hot-rolled structural steel sections.
BS 4870	Approval testing of welding procedures.
BS 4871	Approval testing of welders working to approved welding procedures.
IS 816	Code of practice for metal arc welding
BS 5500	Unfired fusion-welded pressure vessels.
BS 5531	Code of Practice for safety in erecting structural frames.
BS 5950	Structural use of steelwork in building.
BS EN 288: Part 3	Specification and approval of welding procedures for metallic materials.

K14.3 Submissions by the Contractor

The following submissions are required by this Part of the Specification:-

(a) Drawings:
- general arrangements;
- general assembly, detailed shop and erection drawings;
- detailed manufacturing drawings.

(b) Data:
- calculations for connection details, where requested by the Engineer;
- welding procedure sheets.

(c) Certificates:
- material tests;
- Inspection certificates;
- qualification certificates.

K14.4 Materials

K14.4.1 Structural steelwork generally

Rolled structural steel sections shall be of Grade 43A mild steel conforming to BS 4360 and subject to the additional requirements of IS 800 and BS 5950. The dimensions, tolerances and properties of the structural sections shall conform to BS 4 or BS 4848 or IS 808.

Where the use of proprietary designs of prefabricated building frames is proposed, the standards to which they are manufactured shall be no less rigorous than those stated above.

K14.4.2 Bolts and nuts

Steel bolts and nuts shall be high-strength friction-grip bolts conforming to BS 4395 or black bolts conforming to BS 4190 as detailed in the Drawings. Washers shall conform to BS 4320.

High-strength friction-grip bolts shall be used in conjunction with approved proprietary load-indicating washers.

K14.4.3 Welding consumables

All welding consumables (electrodes, wire, filler rods, flux, shielding gas and the like) shall comply with the requirements of IS 816.

In addition, weld electrodes for metal-arc welding shall conform with IS 814 and to the requirements of the appropriate weld procedure.

K14.5 Workmanship

K14.5.1 Detailing

The detailing and fabrication of structural steelwork shall be such as to minimise the need for site welding. Structures and components such as trusses, combined columns and beams shall be shop fabricated so as to form sub-assemblies of the largest practical size suitable for transportation, handling and erection. Connections between members at the erection stage shall generally be bolted.

Structural steelwork shall be so detailed and fabricated as to minimise the formation of pockets to hold condensation, water or dirt. Where such pockets are unavoidable, suitable drainage shall be provided.

Detailing shall be in accordance with IS 800 or BS 5950.

K14.5.2 Detail drawings and welding procedure sheets

The Contractor shall prepare detailed shop and erection drawings and welding procedure sheets for all structural steelwork and these shall be submitted to the Engineer for approval before fabrication commences. The sequence of submissions shall match the order of fabrication and erection.

Shop drawings for fabrication shall show full details of the type of steel, member sizes and dimensions, weld details, welding sequences and any requirements for weld stress relieving.

Welding procedure sheets shall show all details of the welds including:

- welding method;
- current type, voltage and amperage;
- welding positions;
- preparation angles and methods;
- number of runs and their welding positions;
- type, size and class of electrode;
- shielding gas type and flow rate (where applicable);
- non-destructive testing methods and extent of coverage;
- pre-heat, post-heat and stress-relief methods, temperatures and the like.

Where substitution of alternative structural steel sections or modifications to the design or details is proposed, the Contractor shall prepare revised drawings, and supporting calculations if required, for consideration by the Engineer. Any such proposals by the Contractor shall not be put into effect unless the Engineer has given his approval.

Erection drawings shall detail all connections, showing bolt types and sizes and site weld details as applicable.

Shop and erection drawings shall show all marks necessary to facilitate erection and the marks shown in the drawings shall be identical with those shown on the fabrications.

K14.5.3 Welding

All welding carried out during fabrication or erection shall be in accordance with the requirements of IS 816 and as shown in the approved detail drawings. Details of the proposed weld procedures shall be submitted to the Engineer for approval at the same time as the detail drawings. All connections shall be welded in such a manner as to make the finished connections neat and smooth in appearance and suitable for painting. All slag shall be removed and any sharp projections shall be ground smooth.

Before welding is commenced either in the fabrication shop or on Site, weld procedure tests shall be carried out in accordance with BS 4870 where directed by the Engineer.

All welders employed either in the fabrication shop or on Site shall pass qualification tests relevant to the weld procedures in use in accordance with BS 4871. Welders shall have satisfactory evidence of having been engaged in welding for at least 9 months in the preceding 12-month period. If the work of any welders employed on the Contract is unsatisfactory, the Contractor shall carry out such further welder qualification tests as are necessary to demonstrate that the welders are proficient.

Welds shall be subjected to non-destructive testing by processes which may include but shall not necessarily be limited to radiographic, ultrasonic, magnetic-particle or dye-penetrant methods, depending on the type of weld and its position in the structure. The standards of acceptance shall be as defined in BS 5500: Table 5.7, unless otherwise agreed with the Engineer.

If any work shows defects or fails to comply with the requirements of the Drawings or Specification for any reason it shall be repaired or rejected, even though it may have been carried out by qualified welders using approved procedures.

K14.5.4 Fabrication tolerances

The general tolerance on all dimensions shall be !2mm. Holes shall be aligned such that fasteners can be freely inserted through the members at right angles to the contact face. Where holes in members cannot be aligned without damaging or distorting the structure or (unless the Engineer shall permit) reaming the holes, the member or members shall be rejected.

A structural member shall not deviate from straightness (or from the specified shape) by more than:

- 1/1000 of the length between lateral restraints in the case of compression members and beams, or
- 1/500 of the overall length (maximum 25m) in the case of other members.

A structural member shall not deviate from its intended length by more than:

- +/- 1mm in the case of compression members faced at both ends for bearing, or
- + 0mm to – 4mm in the case of other members.

Lengths of components shall be such that cumulative variations do not prejudice the accurate alignment of the completed structure.

Where two steel surfaces are required to be in contact to effect a bearing or frictional contact, the surfaces shall be prepared so that at least 90% of the area is touching before any clamping force is applied.

K14.5.5 Dissimilar metals

Where metals dissimilar to those specified in Section 14.4 are used in close proximity to structural steel members or their connections, contact between such metals and the steel shall be avoided unless the Contractor can demonstrate to the satisfaction of the Engineer that contact between the dissimilar metals will not lead to galvanic corrosion.

Contact between aluminium or aluminium alloy and galvanised mild steel will be permitted. For fixing aluminium to steel structures, bolts, nuts, washers and screws shall be galvanised.

Where galvanised parts might otherwise become sacrificial anodes to the main structure, or where the electrolytic potential difference exceeds 250mV, the parts shall be separated by an insulating medium of adequate strength.

K14.5.6 Identification of members

All members of assemblies shall be marked at the factory with distinguishing numbers, letters or marks corresponding to those on approved drawings or parts lists. Such marks, if impressed before painting, shall be clearly readable afterwards.

Any temporary bolts for field erection shall be clearly marked as such to distinguish them from high-strength bolts for permanent connections.

K14.5.7 Marking of overhead runway beams

The Contractor shall ensure that the safe working load, identification number and any limiting operating conditions are plainly and permanently marked on overhead runway beams so as to be clearly visible to the operator.

K14.5.8 Storage

All structural elements and other materials shall be stored (whether at the place of fabrication or on Site) clear of the ground and shall be protected against deterioration from any cause. The Contractor shall agree the storage areas on the Site with the Engineer before any structural steelwork is delivered.

K14.5.9 Erection

All erection processes shall be carried out in accordance with the recommendations of BS 5531. The plant used for handling and erection shall be suitable and safe. The Contractor shall supply, maintain and afterwards remove temporary protection to workmen and materials below any structural steel under erection and shall provide walkways and ladders so that inspection of any part of the completed structure may be safely carried out.

Anchor bolts shall be properly located by the use of templates or other approved method. After building in the anchor bolts, a sufficient time shall be allowed for concrete strength to develop before finally pulling down to shims and grouting.

Every part of the structural steelwork shall be positioned accurately in accordance with the dimensions on the approved drawings with a maximum tolerance of !5mm except where the steelwork supports metal flooring, when the finished tolerances shall be such that differences in level between adjacent flooring sections or between flooring sections and adjacent building floors do not exceed 3mm. Gaps between flooring sections shall not exceed 3mm.

Where structural steelwork is to be grouted on or against a concrete or other similar surface and the design requires a uniform contact area under the base plate, or where directed by the Engineer, the Contractor shall remove all steel shims or wedges and replace these with grout of the same constituents and consistency as the main grout. Such steel shims shall be initially positioned so as to aid removal. In the case of baseplates with large overhangs or with heavy bearing loads the positions of shims shall be agreed with the Engineer before the structure is erected on them.

During erection, the work shall be securely bolted or otherwise fastened, and if necessary temporarily braced, so as to make adequate provision for all erection stresses and conditions, including those due to erection plant and its operation. No permanent bolting shall be done until proper alignment has been achieved.

The Contractor shall immediately report to the Engineer any errors in shop fabrication, and any deformations resulting from handling or transportation, which prevent proper assembly and fitting of parts. Methods to be used to correct such errors or deformations shall be agreed with the Engineer prior to beginning of any corrections.

The Contractor may use drift pins to bring several parts together but shall not use them in such a way as to cause distortion or damage.

K14.5.10 Bolted connections

When assembled, all joint surfaces, including those adjacent to bolt heads, nuts and washers, shall be free from burrs, dirt or other deleterious matter or defects preventing proper seating of the parts.

The Contractor shall make bolted connections in accordance with the details shown in the shop or erection drawings and with IS 800. The bolts used shall be either high-strength friction-grip bolts in accordance with BS 4395 or mild steel black bolts in accordance with BS 4190, as detailed in the Drawings. Where necessary, washers shall be tapered or otherwise suitably shaped to give the nuts and heads of bolts a satisfactory bearing. The bolt length shall be such that each bolt shall project through the nut not less than one thread and not more than five threads when fully tightened; the length of the threaded portion shall be such that there shall be at least two threads under the nut after tightening.

The Contractor shall ensure that the faying surfaces (meaning those surfaces required to transmit friction in conjunction with high-strength friction-grip bolts) are kept free of contamination by grease, rust, moisture, dust and the like. If the surfaces are primed after fabrication, the primer shall be suitable for use in such connections and shall be protected from damage during transit or erection. If contamination should occur, it shall be remedied by appropriate means, such as:

- on coated surfaces, with a degreasing agent followed by washing and drying;
- on uncoated surfaces, as above or by blast cleaning or wire brushing to clean steel.

These remedial measures shall be taken immediately before the surfaces are bolted together.

High-strength friction-grip bolts shall be used in accordance with BS 4604, using approved load-indicating washers to check bolt tension. They shall be tightened in accordance with the manufacturers' recommendations and the tension shall be re-checked not less than three hours after first tightening. The bolts shall then be retightened to the initial load, all to the approval of the Engineer.

K14.6 Inspection and testing

The Engineer/Employer/Third Party Inspection Agency may inspect structural steelwork during fabrication and witness testing at the fabrication works. The Contractor shall give the Engineer adequate notice of such operations in order that the necessary arrangements may be made.

The Contractor shall arrange for the Engineer and his authorised representatives to have access to the fabrication works at all reasonable times and to be provided with all the necessary facilities and test equipment to carry out such inspections.

Before any steel overhead runway beam is taken into use for the first time, the Contractor shall submit to the Engineer a signed certificate from the manufacturer in accordance with Clause 10 of BS 2853.

K15.0 METALWORK

K15.1 Scope

This part covers the supply and installation of engineering metalwork.

K15.2 Reference Standards

The following standards are referred to in this Part of the Specification.

Standard Reference No.	Subject
BS EN 124:	Manhole and road gully tops
IS 1726	Cast iron manhole covers and frames
BS l247	*Manhole step irons.*
IS 5455	Cast iron steps for manholes
IS 736	Wrought aluminium and aluminium alloys - plate.
IS 737	Wrought aluminium and aluminium alloys - sheet and strip.
IS 738	Wrought aluminium and aluminium alloys - drawn tube
IS 733	Wrought aluminium and aluminium alloys - bars, rods and section.
IS 3822	Eye hooks for use with chains.
IS 3815	Point hook with shank for general engineering purposes.
IS 1363	Black hexagon bolts, nuts and lock nuts and black hexagon screws.
BS 42ll	Steel ladders for permanent access.
BS EN 10113	*Weldable structural steels.*
IS 2063	Weldable structural steel
BS 4592: Part 1	Industrial type metal flooring, walkways and stair treads.
: Part 2	Short link chain for lifting purposes: grade M (4) non-calibrated chain.
IS 9595	Metal arc welding of carbon and carbon manganese steels.
BS 5834: Part 2	*Surface boxes, guards and underground chambers for gas and waterworks purposes: small surface boxes.*
IS 3950	Specification for surface boxes for sluice valves
IS 13415	Protective barriers in and around buildings-code of safety

K15.3 Submissions by the Contractor

The following submissions are required by this Section of the Specification.

(a) Drawings

- General arrangement
- Detailed manufacturing

(b) Certificates

- Material tests

(c) Data

- Manufacturers' catalogues (where alternatives are offered for approval)
- Manufacturer's catalogues and test data for proprietary fixing bolts.

K15.4 Materials

K15.4.1 General

The Contractor shall supply and install the items of metalwork shown on the Drawings or specified herein, together with all fixings, mounting brackets, locking screws, lifting keys and other accessories normally required for erection, permanent fixing and operation.

No orders for engineering metalwork shall be placed by the Contractor until he has submitted his detailed drawings, and where applicable supporting design calculations, to the Engineer and received the Engineer’s approval.

Where the Contractor proposes to use dissimilar metals either in contact or close enough for the gap between them to be bridged by an electrolyte, he shall satisfy the Engineer that adequate anti-corrosion provision is included in the design.

K15.4.2 Steel items - general

Steel items for which there is no relevant standard shall be fabricated as shown on the Drawings from steel which is in accordance with BS EN 10113, Grade 43A, by welding using procedures in accordance with IS 9595.

Unless otherwise specified or detailed on the Drawings, all steel items shall be galvanised in accordance with BS 729. Galvanised items shall not be painted except where so specified or shown on the Drawings. No galvanised metal shall be painted until the Engineer has inspected the coating.

K15.4.3 Aluminium items - general

Items of aluminium and aluminium alloy shall comply with the relevant provisions of IS 733, 736, 737, and 738.

K15.4.4 Steel ladders

Unless otherwise specified or shown on the Drawings, steel ladders shall be generally in accordance with BS 4211 for Class A ladders with solid steel stringers (stiles) but shall have the following dimensions:

- minimum thickness of stringer   l2 mm
- diameter of rungs   20 mm
- rung spacing   250 mm
- rung length between stringers   400 mm
- minimum clearance to wall or other obstruction   220 mm
- maximum distance between stringer supports   2.0 m

Wherever possible, stringers shall extend 1.0 m above the level of the floor or platform at the top of the ladder and the clear width between stringers shall be increased to 600 mm for this length.

Where such an extension to the ladder is not possible, handholds shall be provided in the upper surface of the floor or platform as shown on the Drawings or subject to the approval of the Engineer.

The stringers shall be sized to suit the height of ladder and the intervals of the stringer supports. Stringers shall be drilled to receive the rungs which shall be welded to the stringers on each side of each stringer. Unless otherwise detailed on the Drawings, the bottom ends of the stringers shall not be designed for floor fixing, but shall terminate at wall fixing supports at least l50 mm above the floor. All edges of stringers, brackets, splice plates and other components shall be ground smooth to remove burrs and sharp edges.

Ladders exceeding 3m high shall be provided with safety hoops at intervals not exceeding 900 mm, with the lowest hoop 2.5 m above the ladder foot unless otherwise specified or shown on the Drawings. Unless provided otherwise, landings of open mesh flooring and handrails as specified shall be provided at intervals not greater than 9 m. When detailed on the Drawings, anchorage points shall be provided for attaching safety harnesses instead of the above safety hoops.

K15.4.5 Steel stairways

Stairways shall be designed for a loading of 5.0 kN/m² of plan area of the stairway. Steel stairways shall be provided with tubular handrailing and stringers of cross section suitable for the span and loading. Treads shall be of open bar gratings, expanded metal grating panels or cold formed planks as shown on the Drawings and in accordance with Part 1, 2 or 3 respectively of BS 4592: PART 1. Except where so shown on the Drawings, treads of pressed bar construction shall not be used.

The angle of rise of stairways shall be between 30° and 42°. The rise between treads shall be uniform and between 155 mm and 190 mm. Stairways in the same area of the Works and in similar locations shall have the same angle of rise and the same rise between treads.

The width of the treads shall be between 250 mm and 300 mm. The width of the stairways shall be as shown on the Drawings.

The stringers shall be mounted by means of angle brackets with slotted holes for adjustment of line and level.

K15.4.6 Manhole steps

Except where otherwise specified or shown on the Drawings, manhole step shall be of malleable cast iron in accordance with IS 5455. *The shape and dimensions shall be to the figure of that BS shown in the following table:*

Position	*Figure*
In brickwork or in-situ concrete	*1*

In precast concrete manholes 2

Where the thickness of the structure permits, the larger tail dimensions in Figures 1 and 2 shall be used.

Manufacturers' certificates shall be provided for all manhole steps. Witness of manufacturers' inspection tests is not required.

K15.4.7 Access covers, road gully gratings and frames

Except where otherwise detailed on the Drawings, access covers and frames shall be of ductile iron and shall comply with IS 1726. Lockable units shall be provided for the locations specified or detailed on the Drawings.

Covers and frames detailed as sealed shall incorporate suitable neoprene or other approved synthetic rubber sealing rings, or shall seal by another approved sealing method.

Road gully gratings shall be of ductile iron and comply with BS EN 124.

K15.4.8 Surface boxes

Surface boxes for key operation of valves and sluice gates shall be of grey or ductile iron and shall comply with the relevant requirements of IS 3950: Part 2. Except where otherwise specified or shown on the Drawings, they shall be Grade A and coated.

K15.4.9 Metal flooring and walkways

Metal flooring and walkways shall comply with BS 4592: Part 1, Part 1, 2 or 3 as appropriate. Subject to anything specified under Particular Requirements or shown on the Drawings, metal flooring and walkways:

(a) may be of steel or aluminium;

(b) shall be Heavy Duty; and

(c) may be of open bar gratings, expanded metal grating panels or cold formed planks but pressed bar construction shall not be used in places exposed to the weather or in situations where condensation is likely.

Except where otherwise specified, flooring panels shall be removable and the maximum weight of each panel shall not exceed 25 kg. Removable sections of flooring shall be provided with holes for lifting keys, and keys to suit.

Flooring shall be detailed and fabricated so that no cutting is required on site. Supporting steelwork shall comply with the requirements of Part 3I of the Specification (Structural steelwork). Bolt holes in brackets and mountings shall be slotted to allow for adjustment of line and level. Cut-outs shall be trimmed with straight or curved bars as appropriate. Angle kerbing for seating the flooring in concrete shall be provided as shown on the Drawings. Kerbing and other supporting structures for building into concrete shall have lugs welded on at maximum spacing of 600 mm.

Except where otherwise specified or shown on the Drawings, the width of any access walkway shall be not less than 750 mm.

All members of assemblies shall be marked at the factory with distinguishing numbers, letters or marks corresponding to those shown on approved drawings or parts lists.

K15.4.10 Chequer plate

Except where otherwise specified or shown on the Drawings, chequer plate flooring shall have a raised pattern without enclosed recesses and shall have a minimum base thickness of 4.5 mm in the case of steel plats or 8 mm in the case of aluminium. Panels shall be secured to supports with countersunk screws at maximum spacings of 1.0 m along supports.

K15.4.11 Handrailing

Metal handrailing shall be aluminium alloy throughout and shall comply with the relevant provisions of IS 13415. Except where otherwise specified or shown on the Drawings, metal handrailing shall consist of standards at regular intervals not exceeding l.5 m, and two rails. The upper rail shall be 1.1 m above the adjacent finished floor level, and 0.9 m above the nosing line on stairways. The lower rail shall be midway between floor or nosing line and the upper rail. Rails shall be fabricated from 32 mm bore mild steel tube and standards from 38 mm dia solid mild steel bar.

Handrailing shall be ball-jointed. Handrailing terminating against a wall shall either have a suitable wall fixing flange or shall terminate at a standard or a loop with a gap between the standard or loop and the wall not exceeding 75 mm. Where the shape of the floor or platform structure does not incorporate an upstand at the edge of walkways, toe plates not less than 4 mm thick and not less than 100 mm high shall be fixed to the handrail standards. The bottom edge of such toe plates shall be about 15 mm above the surface of the walkway.

The handrail standards for stairways and for landings and walkways of width less than l.2 m shall have palm fittings for bolting to the sides of the structures. Elsewhere the standards shall be designed for fixing 100 mm (minimum) inside the edge of concrete structures, or at the supporting edge girder of steel flooring, or have palm fittings as detailed on the Drawings. Standards either side of openings shall be equipped with eyes for attaching safety chains at top and middle rail level.

Safety chains shall be of mild steel of l0 mm nominal size, short link, smooth welded chain. Each length of chain shall be fitted with a shackle at one end and a snap fastening at the other.

K15.4.12 Servicing hooks

Servicing hooks shall comply with those provisions of IS 3822 and 3815 which relate to the appropriate Type. Each hook, together with any beams and other supporting members, shall be designed (with an appropriate allowance for dynamic loading) to carry safely the heaviest item of plant required to be lifted.

The safe working load shall be clearly and permanently displayed alongside each hook so as to be legible from the normal working level.

K15.4.13 Fixings for metalwork

Bolts for fixing metalwork to concrete, brickwork or blockwork shall be of the following types:-

(a) For fixing in drilled holes in horizontal, vertical or inclined surfaces, approved proprietary epoxy resin fixed bolts shall be used. The epoxy resin shall be a quick setting formulation, supplied in suitable pre-measured sachets to separate the components until punctured in the hole and mixed by rotation of the fixing bolt. The resin and bolts shall be used in accordance with the manufacturers' instructions. When fixed, the resin shall completely fill the space between the bolt and the hole to the surface of the concrete, brickwork or blockwork.

(b) As an alternative to (a), approved mechanical expansion type bolts may be used for fixing to concrete surfaces inside buildings above ground level where the application proposed by the Contractor is approval of the Engineer. Expansion bolts shall not be used inside liquid retaining structures, in chambers, basements and similar locations below ground level, in exterior locations, nor in any brickwork or blockwork.

(c) For fixing to horizontal top surfaces of concrete by grouting with cement based grout or mortar, foundation bolts may be used in preformed, drilled or cut pockets,

(d) Where approved by the Engineer, screws and approved fixing plugs.

The Contractor shall submit details of his proposed fixings for the approval of the Engineer. Where required by the Engineer, the Contractor shall demonstrate the effectiveness of the fixings by suitable tests.

Other bolts and nuts used in fabrication or erection shall be in accordance with IS 1363.

Bolts, nuts, screws, washers and other fixings shall be stainless galvanised, sherardised or electro-plated steel in accordance with the provisions of Section 0 of the Specification (Paints and protective coatings).

K15.4.14 Opening tools

Lifting keys and devices for unfastening locking screws shall be of galvanised mild steel. They shall be supplied at the rate of one set for each five similar covers, with a minimum of two sets of each particular type.

K15.5 Workmanship

K15.5.1 Tolerances

Metalwork shall be constructed and installed within the following tolerances:

Metalwork at floor level (e.g. joints between flooring sections and between steel flooring and adjacent concrete):

difference in level at joints	3 mm
joint gap	3 mm
Dimensions shown on Drawings	± 5 mm
Levels shown on Drawings	± 5 mm

K15.5.2 Installation

Where metalwork is to be founded on and/or fastened to concrete the Contractor shall use one of the following methods:-

Method	Description
1.	Bolting or screwing the metalwork to plates or angle section having anchors cast into the concrete structure or set into pockets left in the concrete structure.
2.	Setting the metalwork into pockets left in the concrete structure.
3.	Bolting the metalwork to anchor bolts (studs) cast into the concrete structure or set into pockets left in the concrete structure.
4.	Bolting the metalwork to anchor bolts (studs) as specified, in holes drilled into concrete structure.
5.	Bedding the metalwork on cement mortar placed on the concrete surface.

Cement mortar of 3 parts of sand to l part of cement shall be used for bedding access covers and the like and for filling around metalwork or bolts set into pockets smaller than 100 mm square or equivalent. For larger holes, concrete of the same grade as the structure shall be used instead of mortar. The installation methods permitted for various types of metalwork are specified below:

Metalwork items	Permissible methods of installation
Stairs, ladders, flooring	1, 3 and 4
Step irons, sockets for removable items	2

Handrailing	2, 3 and 4
Access covers, surface boxes and gully gratings	2 and 5

During installation each item of metalwork shall be temporarily braced as necessary to resist all forces which are likely to be applied to it during installation, fixing and building in. Any bolted connections required as part of the installation operation shall be fitted and tightened before fixing bolts are tightened or pockets are grouted. The nuts of grouted or resin fixed bolts shall not be tightened until the grout or resin has fully cured.

Where approved by the Engineer, small or lightly loaded items may be fixed using screws and plugs set in drilled holes.

K15.6 Particular requirements

K15.6.1 Aluminium ladders in chambers

Aluminium ladders in chambers shall be designed to provide the same carrying capacity as steel ladders. Aluminium ladders shall provide the same clearances and spacings as those specified for steel ladders. Aluminium ladders shall have a retractable top section which can be lifted up from the chamber to 750mm above roof level to ease transfer to and from the ladder.

K16.0 SLUICE GATES AND FLAP VALVES

K16.1 Scope

This Section contains requirements which, where relevant to this Contract, shall apply to the supply and installation of cast iron and lightweight plastics sluice gates and flap valves.

K16.2 Definition

Operating head:	The head of water measured above gate invert level which tends to drive the gate on or off its seatings. Operating heads shall be taken to operate in an on-seating direction except where they are stated as off-seating heads or where off-seating heads are shown on the Drawings. Operating heads may be differential heads where applicable

K16.3 Reference Standards

The following standards are referred to in this Section of the Specification.

BS 729	Hot dip galvanized coatings on iron and steel articles.
BS EN 1982	Copper alloy ingots and copper alloy and high conductivity copper castings.
BS EN 1561	Flake graphite cast iron.
BS EN 12163	Copper and copper alloy rods and sections.
BS 3416	Bitumen-based coatings for cold application, suitable for use in contact with potable water.
BS 4147	Bitumen-based hot-applied coating materials for protecting iron and steel, including suitable primers where required.
BS 6949	Bitumen-based coatings for all cold application excluding use in contact with potable water.
AWWA C501	Cast-iron sluice gates.

K16.4 Submissions by the Contractor

The following submissions are required by this Section of the Specification:-

(a) Drawings

- General arrangement drawings of standard items
- Detail drawings of special items
- Foundation and fixing arrangements

These details must be provided sufficiently early to allow the structural design and position of reinforcement to be adjusted to suit the design and fixing details of the items before the structures are constructed.

(b) Data

- Manufacturers' catalogues and data sheets
- Operation and maintenance manuals.

(c) Certificates

- Materials certificates

K16.5 Materials

K16.5.1 General

Sluice gates, flap valves and stop logs shall be manufactured to the requirements specified hereunder and shall be provided by the Contractor except as specified otherwise. They shall be suitable for use with water at the temperatures and operating heads specified or detailed on the Drawings.

All sluice gates and flap valves shall be suitable for frequent operation and for infrequent operation after long periods in the open or closed condition.

Rubber used shall be ethylene propylene rubber (EPDM or EPM) or styrene butadiene rubber (SBR). It shall be suitable for making a long term flexible seal and resistant to mechanical, chemical or bacteriological attack leading to deterioration of the flexible seal.

The types, sizes, locations and operating and design conditions shall be as shown on the Drawings or as specified. All parts shall be of adequate section and ribbed where necessary to withstand the hydraulic and operating forces. All metal surfaces forming joints or bearings shall be machined.

When closed under all differential pressures up to the maximum specified, the leakage per metre of peripheral seating face shall not exceed 1 litre/minute when the head is on-seating or (in the case of sluice gates) 3 litre/minute when the head is off-seating.

Gaps between seating faces shall nowhere exceed 0.10 mm.

Screw operated sluice gates shall have rising spindles unless otherwise specified or detailed on the Drawings.

All sluice gates, flap valves or stop logs of similar type shall be obtained from the same manufacturer.

K16.5.2 Cast iron sluice gates

Cast iron sluice gates shall have adjustable wedges to ensure tight closing of the gates in the frames. The frame guides shall support not less than half the vertical height of the gate when it is in the open position.

Seating faces shall be mounted on accurately machined surfaces on the frame and gate by methods which will avoid a build-up of corrosion products which might distort the seating faces within the life of the gate. Alternatively, where resilient sealed sluice gates are specified, the seal on one face shall be of synthetic rubber. The resilient seal shall seat on rigid thermoplastic bonded and pinned to the frame, the gate location being accurately controlled throughout its travel by bronze guide bars. Alternatively the resilient seal shall seat against a machined cast iron face, sliding wear on the rubber seals being minimised by the gate being held away from the guides throughout most of its travel; bronze swivelling cams being used instead of wedge blocks to cause the seals to seat during the last part of gate travel.

Gate frames for metal seated sluice gates shall incorporate spigots partially or wholly extending into the water passage in the structure to which the gate is to be fixed:

- where the gate aperture is not encompassed by a 1 m square;
- where the gate aperture is not encompassed by a 600 mm square and an off-seating head of 3 m or more may occur;
- where recommended by the manufacturer of the sluice gate;
- where specified or shown on the Drawings.

The spigot shall be integral with the gate frame. Alternatively gates with separate wall thimbles in accordance with AWWA C501 but otherwise in accordance with this Specification, may be used.

All other gate frames shall be flat backed.

Sluice gates for channel mounting shall have flush inverts and resilient seals unless otherwise specified.

The hand lifted types shall be provided with a means for locking the gate in any position from fully open to fully closed.

The materials for the various component parts for cast iron sluice gates shall be as specified in table below:

<table>
<tr><th rowspan="2">Type of sluice gate</th><th colspan="4">Components and materials</th></tr>
<tr><th>Frames and gates</th><th>Seating faces</th><th>Spindles and lifting rods</th><th>Thrust nut and wedge faces</th></tr>
<tr><td>Resilient sealed type with screw spindle operation</td><td rowspan="4">Cast iron to BS EN 1561 Grade 220 for all types</td><td>Rubber seal against machined frame seating</td><td rowspan="2">Manganese bronze, or aluminium bronze to BS EN 12163</td><td rowspan="2">Gunmetal to BS EN 1982 Grade LG2</td></tr>
<tr><td>Metal seated type with screw spindle operation</td><td rowspan="3">Gunmetal to BS EN 1982 Grade LG2 or LG4</td></tr>
<tr><td>Vertical, hand lifted</td><td rowspan="2">Galvanised steel</td><td rowspan="2">Not applicable</td></tr>
<tr><td>Pivoted disc, hand lifted</td></tr>
</table>

K16.5.3 Cast iron flap valves

Cast iron flap valves shall have frames and doors of cast iron to BS EN 1561 grade 220, seating faces of gunmetal to BS EN 1982 grade LG2 or LG4 and hinge pins and links of gunmetal, aluminium bronze or phosphor bronze to BS EN 1982 or the appropriate grade of stainless steel.

K16.5.4 Stainless steel sluice gates

Details of any proposed stainless steel sluice gates shall be submitted to the Engineer for approval.

Unless otherwise specified or detailed in the Drawings, the frames for lightweight sluice gates, flap valves and stop logs shall be fabricated from mild steel, blast cleaned, flame zinc sprayed and finished with an etch primer and epoxy paint system at the manufacturer's works. Details of the protection system shall be submitted to the Engineer for approval.

K16.5.5 Operating gear, headstocks and actuators

Sluice gates shall be provided with manual operating gear, including headstocks and crank handles or handwheels, except where electrically operated actuators or tee key operation are specified or shown on the Drawings.

Manual operating gear and any manually operated standby arrangements shall where necessary incorporate suitable gearing and bearings to enable the sluice gate to be opened and closed in a reasonable time under the maximum operating differential pressure specified for the sluice gate by one person only. Under this condition the force required to open the valve from the closed position shall not exceed 125N at each of two diametrically opposite points on the rim of the handwheel or at each end of the tee key (ie the `push-pull' effort needed shall not exceed 250N).

Manually operated devices such as tee keys, handwheels or crank handles shall close the sluice gates when turned in a clockwise direction.

Handwheels shall be shaped to give a safe grip without sharp projections, clearly marked with the direction of closing and be fitted with integral locking devices; a padlock and chain will not be an acceptable device. Handwheels operating through gearing or requiring more than 50 revolutions for full travel of the gate shall be provided with a rim mounted roller handle comprising a non-corroding freely rotating hand grip otherwise secured upon its spindle. Alternatively crank type handles with similar freely rotating roller handles may be provided.

Headstock columns, handwheels and winding handles shall be of cast iron, stems shall be of mild steel and bearings shall be gunmetal-bushed. The centres of handwheels, whether horizontal or vertically mounted, and crank handles shall be approximately 750mm above the level of the operating platform. Headstock bases shall be drilled for fixing to structural steel members or to concrete as shown on the Drawings.

Headstocks for sluice gates with rising spindles shall have robust, clear plastic protection tubes incorporating graduated position indicators. Headstocks for sluice gates with non-rising spindles shall have index pointers working over graduated position indicators fixed to the side of the pillars. The indicators shall have robust clear plastic protection plates to exclude dust water and other foreign matter from the mechanism. Where the equipment incorporates a gearbox mounted on the headstock pillar, the position indicator may be an integral part of the gearbox.

Gearboxes shall be totally enclosed, oil bath lubricated. Thrust bearings shall be provided in such a way that the gearcase may be opened for inspection or be dismantled without releasing the stemthrust or taking the sluice gate out of service. Oil and grease lubricated gearings, bearings and glands shall be protected against the ingress of dust and moisture.

Key operated sluice gates shall be provided with detachable cast iron spindle caps to take a standard size of key. One key of each size shall be supplied for every five sluice gates installed, with a minimum requirement of two keys in any one range.

Guide brackets for spindles shall be the split-bearing type and the maximum spacing between spindle supports shall be not greater than 100 times the spindle diameter.

Electrically operated actuators shall comply with the requirements for electrically operated actuators for valves except that actuators for sluice gates shall be rated at not less than 50% in excess of the power required to operate the sluice gate under maximum working conditions.

K16.5.6 Protection of cast iron items

Except for parts which are to be built into concrete or where decorative painting is specifically required (for example for headstocks and actuators within pumping stations), cast iron sluice gates, headstocks and actuators shall be provided at the manufacturer's works with a bitumen-based coating complying with BS 3416, BS 4147 or BS 6949, as appropriate. The minimum dry film thickness of this coating shall be 200 microns.

K16.6 Workmanship

K16.6.1 Handling

The Contractor shall supply handling equipment as necessary to handle and install sluice gates, flap valves, stoplogs and associated equipment without damaging the items or their exterior or interior coatings. The equipment shall include lifting beams, reinforced canvas slings, protective padding, cradles and the like. Wire rope or chain slings shall not be used for handling these items.

Temporary packing, coverings or crates provided for protection in transit shall not be removed (except for inspection purposes after which they shall be replaced) until immediately before installation.

K16.6.2 Delivery and storage

All items shall be checked against packing lists immediately on delivery to the Site and shall be inspected for damage and checked for shortages. Damages and shortages shall be remedied with the minimum of delay.

The Contractor shall take into temporary protective storage all items not required for immediate installation in the Works.

Until required for installation they shall be stored carefully under cover, and particular care shall be taken for the protection of associated electrical or mechanical equipment, so that at the time of installation they shall have suffered no damage or deterioration from any circumstance including exposure to the weather. If, in the opinion of the Engineer, any damage or deterioration does occur it shall be made good by the Contractor at no additional cost the Employer.

K16.6.3 Installation - general

Sluice gates, flap valves and stop log frames shall be installed in accordance with the manufacturer's instructions and kept in the closed position. Particular care shall be taken to prevent distortion of any parts during storage, handling, fixing and grouting to the structure. Guide brackets for spindles shall be accurately installed to hold the spindle in alignment without binding.

Bolts, nuts and washers for fixing sluice gates and flap valves to concrete shall be stainless steel. For stop log frames they shall be either stainless steel or mild steel hot-dip galvanised in accordance with BS 729.

The following method of fixing shall be used:-

(a) For fixing into a drilled hole in horizontal, vertical or inclined surface, proprietary epoxy resin fixed bolts shall be used. The epoxy resin shall be a quick setting formulation, supplied in suitable pre-measured sachets to separate the components until punctured in the hole and mixed by rotation of the fixing bolt. The resin and bolts shall be used in accordance with the manufacturer's instructions. When fixed, the resin shall completely fill the space between the bolt and the hole to the surface of the concrete.

(b) As an alternative, but only for horizontal upward facing surfaces in concrete, rag or indented foundation bolts may be grouted into preformed, drilled or cut pockets using cement based grout or mortar.

Anchor bolts for face mounted sluice gates and flap valves shall be located by the use of templates or other approved method and after building in a sufficient time shall be allowed for the concrete, grout, mortar or resin strength to develop before final tightening onto shims and grouting.

Sluice gate and flap valve frames shall be grouted and pointed with cement mortar of 2½ parts of sand to 1 part of cement, incorporating an approved additive to prevent shrinkage.

K16.6.4 Cleaning and final protection

After installation all parts shall be thoroughly cleaned. All cast iron surfaces shall then be given coats of bitumen-based coating complying with BS 3416, BS 4147 or BS 6949, as appropriate, to a total dry film thickness of 200 microns in addition to the manufacturer's coating.

All bearing surfaces shall be lightly greased.

Any damage to the epoxy finish on the steel parts of lightweight items shall be made good in accordance with the manufacturer's instructions.

K16.6.5 Inspection and testing

After installation, the Contractor shall demonstrate to the satisfaction of the Engineer the operation of all sluice gates and flap valves and the placing and removal of all stop logs.

Before water is admitted to the area of the Works where any sluice gate is installed, free movement of that gate in each direction over the whole operating range shall be demonstrated.

Once any sluice gate, flap valve or stop log is installed and submerged, that item shall be tested for water tightness under the specified differential pressure. Sluice gates shall then be opened and closed under the maximum operating conditions. If either the leakage or the force required to operate the item is in excess of the maximum specified, the Contractor shall take all necessary steps to correct the defects. On completion, the item shall be further demonstrated to the Engineer. No additional payment will be made for remedial work or retesting.

Where the full specified differential pressure or maximum operating conditions cannot be simulated within a reasonable time in the opinion of the Engineer, and such failure does not result from any cause for which he Contractor is responsible, then the testing may proceed at such lower head as is accepted by the Engineer or, if no leakage test is practicable, the item shall be operated and the clearance between metal seating faces checked with feeler gauges.

K16.7 Particular requirements

K16.7.1 Dezincification of copper alloys

Notwithstanding any specifications elsewhere to the contrary, all copper alloys which may come into contact with the raw or treated water shall contain not more than 4% zinc and preferably less than 2% zinc.

K17.0 PIPELINES FOR WATER SUPPLY

K17.1 Scope

This Part contains requirements which, where relevant to this Contract, shall apply to the supply, handling, installation and testing of pipelines for the conveyance of raw and treated water including pipes, fittings and appurtenances where required to be laid in, on or above ground or to be fixed on or built into other parts of the Works. It covers washout pipelines but does not apply to pipework for sewers, drains or building services.

Except as specified otherwise (including in Parts for Valves and Flowmeters) this Part, including requirements for protection, installation, subsequent pressure testing and measurement, shall apply to valves, flowmeters and the like.

Excavation and refilling of pipe trenches shall be carried out as specified for Earthworks subject to further requirements as specified in this part.

K17.2 Definitions

The following terms shall have the meanings hereby assigned to them :-

'Pipes'	straight pipes, whether whole or cut, and their joints.
'Fittings'	all components fitted to a pipe for jointing, connecting or changing the direction or bore of a pipe (including bends, tees, tapers, collars and couplings).
'Pipeline appurtenances'	all items additional to pipes and fittings required to complete a pipeline including but not limited to internal and external protection systems, supports and anchorages, chambers, washouts, marker posts and any apparatus or construction required for testing, cleaning, disinfecting or operating the pipeline.
'Pipeline'	the whole pipeline inclusive of pipes, fittings, pipeline appurtenances and, except where the context requires otherwise, valves, flowmeters and the like.

K17.3 Reference Standards

K17.3.1 Introduction

Unless otherwise specified, pipelines shall comply with the relevant Reference Standards listed below or relevant Indian Standards. Where a Reference Standard, or a further standard referred to in a Reference Standard, states that a requirement should be met, it shall be met unless otherwise specified. Where a Reference Standard allows a choice between other standards, preference shall be given to the standard or standards listed as Reference Standards or Indian Standards, if any. Where pipelines or any parts thereof are outside the range of sizes covered by the Reference Standards, the requirements of the Reference Standards shall still apply where relevant, unless otherwise specified.

K17.3.2 General

Reference Standards applicable to various types of pipelines include the following standards:-

BS 812: Part 103.1	Method for determination of particle-size distribution: sieve tests.
BS 1377	Methods of test for soil for civil engineering purposes.
BS EN 681-1&2	Elastomeric seals for joints in pipework and pipelines.
BS 3251	Indicator plates for fire hydrants and emergency water supplies.
BS 3927	Rigid phenolic foam (PF) for thermal insulation in the form of slabs and profiled sections.
BS 4190	ISO metric black hexagon bolts screws and nuts.
BS 4320	Metal washers for general engineering purposes. Metric series.
BS EN 1092	Circular flanges for pipes, valves and fittings (PN-designated): steel, cast iron and copper alloy flanges.
BS EN ISO 10216	Corrosion-resistant stainless steel fasteners.
BS 6076	Polymeric film for use as protective sleeving for buried iron pipes and fittings.(for site and factory application)
BS 6956: Part 5	Jointing materials and compounds: Jointing compounds for use with water, low pressure saturated steam, 1st family gases (excluding coal gas) and 2nd family gases.
BS 7079: Parts O & A1	Preparation of steel substrates before application of paints and related produces: Introduction and visual assessment of surface cleanliness.
BS 8010: Part 1	Pipelines on land: general.
BS EN 681–1	Vulcanized rubber
BS EN 1514–1	Dimensions of non-metallic flat gaskets
BS EN 22063	Metallic and other inorganic coatings. Thermal spraying. Zinc, aluminium and their alloys.
AWWA C651	Standard for disinfecting water mains.
AWWA M12	Simplified procedures for water examination.
AWWA C210	Liquid epoxy coatings
AWWA C216	Polyethylene heat shrink sleeving
WIS 4–52–01	Polymeric anti-corrosion (barrier) coatings.
SIS 05–5900	Pictorial surface preparation standards for painting steel surfaces.

K17.3.3 Ductile iron pipelines

Reference Standards for ductile iron pipelines include the following standards:-

BS 3416	Bitumen-based coatings for cold application suitable for use in contact with potable water
IS 12330	Sulphate-resisting Portland cement.
BS 8010: Section 2.1	Pipelines on land: design, construction and installation: Ductile iron.
BS EN 545	Ductile iron pipes and fittings, accessories and their joints

	for water pipelines. Requirements and test methods.
BS EN 1563	Founding. Spheroidal graphite cast iron
BS EN 1564	Founding. Austempered ductile cast irons
BS EN 22063	Metallic and other coatings. Thermal spraying. Zinc, aluminium and their alloys.
ISO 2531	Ductile iron pipes, fittings and accessories for pressure pipelines.
IS 8329 : 2000	Centrifugally cast (spun) Ductile Iron Pressure pipes for water
IS 9523 : 1980	Ductile Iron fittings for pressure pipes for water
IS 13382 : 1992	Cast iron specials for mechanical and push on flexible joints for pressure pipelines for water
IS 5382 : 1985	Rubber sealing ring for gas mains water mains and sewer
IS 12258	Code of practice for use and laying of Ductile Iron Pipes

K17.3.4 Steel pipelines

Further Reference Standards for steel pipelines include the following standards:-

BS EN 10224	Non-alloy steel tubes and fittings for the conveyance of aqueous liquids including water for human consumption.
IS 3589	Steel pipes for water and sewage.
BS 2633	Class I arc-welding of ferritic steel pipework for carrying fluids.
BS 2971	Class II arc-welding of carbon steel pipework for carrying fluids.
BS EN 10217-1:2002	Welded steel tubes for pressure purposes. Non-alloy steel tubes with specified room temperature properties.
IS 12330	Sulphate-resisting Portland cement.
BS 4129	Welding primers and welding through sealants, adhesives and waxes for resistance welding of sheet steel.
BS 4147	Bitumen-based hot-applied coating materials for protecting iron and steel, including suitable primers where required.
BS 4515	Welding of steel pipelines on land and offshore.
PD 5500	Unfired fusion-welded pressure vessels.
BS 6200: Part 3	Sampling of iron, steel and other ferrous metals.
CP 2010: Part 2	Design and construction of steel pipeline on land.
BS EN 22063	Metallic and other coatings. Thermal spraying. Zinc, aluminium and their alloys.
ASTM A751	Standard test methods, practices and terminology for chemical analysis of steel products.
API 5L	Line pipe.
API 1104	Welding of pipelines and related facilities.
AWWA C213	Fusion-bonded epoxy coating for interior and exterior of steel water pipelines.
AWWA M11	Steel pipe design and installation.
GBE/CW6: Part 1 (British Gas)	Requirements for coating materials and methods of test.
DIN 30670	Polyethylene coatings for steel pipes and fittings.
IS 5822: 1994	Code of practice for laying of electrically welded steel pipes for water supply
IS 814: 1991	Covered electrodes for manual metal arc welding of carbon and carbon manganese steel

IS 3600: Part 1	Welding jointing testing
IS 4853: 1982	Recommended practice for radiographic Inspection of fusion and welded butt joints
IS 4620: 1986	Recommended practice for ultrasonic method test
IS 2720: Part 7 1980	Method of test of soils (Compaction test for backfilling, consolidations)
IS 4081: 1986	Safety code for blasting and related drilling operation-laying welded steel pipelines
IS 10221 : 1982	External lining of MS pipelines with coal tar asphaltic enamel reinforced with filter glass with expansion joints
IS 5330 : 1984	Criteria for design of anchor blocks for penstock with expansion joints
IS 4711 : 1974	Method of sampling of steel pipes
IS 4736 : 1986	Hot dip zinc coating in mild steel tubes
IS 1916 : 1982	Cement lining of steel pipes

K17.3.5 High density polyethylene (HDPE) pipelines

Reference Standards for HDPE pipelines include the following standards:—

BS 5114	Performance requirements for joints and compression fittings for use with polyethylene pipe.
BS 6572	Blue polyethylene pipes up to nominal size 63 for below-ground use for potable water.
CP 312: Part 1	Plastics pipework (thermoplastic material): General principles and choice of material.
CP 312: Part 3	Plastics pipework (thermoplastic material): Polyethylene pipes for the conveyance of liquid under pressure.
WIS* 4–32–03	Blue polyethylene pressure pipe (nominal sizes 90 – 1000 for underground and protected use).
WIS* 4–32–08	Site fusion jointing of HDPE pipe and fittings.
WIS* 4–32–14	PE80 and PE100 electrofusion fittings for nominal sizes up to and including 630.
WIS* 4–32–15	PE80 and PE100 spigot fittings, and drawn bends for nominal sizes up to and including 1000.
IS 4984	Specification for High Density Poly ethylene Pipes
IS 7328	Specification for material of manufacturing
IS 7634	Guidance on proper methods for laying and jointing of polyethylene pipe work system

(* WRC Water Industry Specifications, previously called Information and Guidance Notes)

K17.4 Submissions by the Contractor

K17.4.1 Drawings and data

Submissions which the Contractor is required to make in relation to pipelines shall include, where relevant, the following:

- typical drawings of standard items;
- detail drawings of special items;

- pipe, fittings and joint details including manufacturer, pressure/temperature ratings, material properties and thickness and lubricants;
- design details of flanges outside the range of Reference Standards;
- external and internal protection and lining system details;
- method of boxing out and building pipes into structure walls;
- method for control of line and level of pipeline during installation;
- welding procedure details including plant, method, weld materials, air testing of joints and names of welders;
- thermal fusion-jointing details including method, tools and equipment, procedure, testing programme and jointers' names, training and experience;
- manufacturers' calculations, catalogues and data sheets;
- constituents and properties of materials used in non-homogeneous pipe wall construction;
- Contractor's calculations for pipe and fitting design;
- methods for pipe handling, installation and backfill;
- details of pipeline insulation system;
- evidence of compliance with requirements for materials, substances and products in contact with water which is to be supplied for drinking, washing or cooking or for food production.

After award of the Contract, the Contractor shall submit for the Engineer's approval, a schedule of substances and products he proposes to use in the Works giving the following information as applicable:

- item of plant;
- substance/product in contact with water;
- manufacturer of plant/substance/product;
- point of use in the Works;
- name of the regulatory body which has approved the substance/product;
- date of approval (for use on water quality and on health grounds);
- approval (with respect to water quality and health) reference number;
- any condition attached to the approval.

For all other products and substances to be used in the Works in such situations, the Contractor shall at his own expense obtain the necessary approval and follow the procedure set out above and obtain the Engineer's approval before use.

K17.4.2 Records to be kept

The Contractor shall keep detailed and up-to-date records in a form to be approved by the Engineer of all pipes, fittings and pipeline appurtenances, the quantities of each type, size and class which have been:

(a) ordered during the course of the Works;
(b) delivered during the course of the Works;
(c) declared on delivery to be faulty, damaged or deficient;
(d) broken, damaged or lost during the course of the Works;
(e) repaired;
(f) laid or installed.

Each week the Contractor shall provide the Engineer with an up-to-date copy of the above records.

The Contractor shall also keep detailed and up-to-date records in a form to be approved by the Engineer of the following:

- deviations from the pipeline line and level shown in the Drawings;
- services encountered in pipelaying;
- details and locations of fittings, valves, joints and the like where installed in a way not shown in the Drawings;
- classification of soil against which thrust blocks and structures constructed, together with depth to water table at each;
- details and locations of pipe fittings installed for the purposes of pipeline testing, swabbing and disinfection;
- details of fittings used for connection to existing pipes;
- locations of marker posts as installed;
- details of cleaning, swabbing and disinfection as executed;
- locations of cable pass holes;
- details and locations of pipe bedding and surround where executed in a way not shown in the Drawings.

Records shall be submitted to the Engineer at intervals as directed by the Engineer.

K17.4.3 Certificates of tests

The Contractor shall forward to the Engineer the following certificates, where relevant:

(a) works tests on pipes and fittings;
(b) material tests;
(c) inspection;
(d) welder-qualification tests;
(e) non-destructive tests on completed welds.

K17.4.4 Method and programme of pipeline testing and cleaning

The Contractor shall submit for the approval of the Engineer details of his proposed methods and programme for pipeline testing, swabbing, disinfection and cleaning (including details of test and cleaning equipment).

K17.5 Materials

K17.5.1 General

K17.5.1.1 Materials, substances and products

Materials for pipelines shall be manufactured to the requirements specified hereunder and shall be provided by the Contractor except as specified otherwise. All items shall be of the diameter detailed in the Drawings or in the Schedules and be suitable for the test pressure and working pressure specified or detailed in the Drawings. Pipe class or pressure rating shall not be less than the values set out in the Contract.

K17.5.1.2 Connections between different pipe materials

Where different types or classes of pipe material are jointed together, the

Contractor shall supply special fittings or stepped couplings designed and manufactured to suit the ends of pipes to be jointed. Stepped couplings shall comply with the requirements for detachable flexible couplings and flange adaptors where applicable.

K17.5.1.3 Joint sealing rings

Joint sealing rings shall be obtained from the manufacturer of the pipe or joint.

Joint sealing rings shall comply with the relevant requirements of BS 2494 Type W, shall be of a material suitable for making a long-term flexible seal between the pipes and shall be resistant to mechanical, chemical or bacteriological attack leading to deterioration of the flexible seal. Rubber for sealing rings shall be ethylene propylene rubber (EPDM or EPM), acrylonitrile butadiene rubber (nitrile) or styrene butadiene rubber (SBR) which complies with the above requirements.

Lubricants used during jointing shall have no deleterious effects on either the sealing ring, pipes or pipe coating, and be unaffected by the liquid to be conveyed.

K17.5.1.4 Flanged joints

Except where otherwise specified or detailed in the Drawings, flanges and bolting shall be PN16 to BS EN 1092 and BS EN 1515. Flanges to other standards shall be used only if approved by the Engineer and provided that any differences do not effect mating dimensions. Back faces of flanges shall be machined.

For steel pipes, flanges shall be type 12 B hubbed slip-on, raised face flanges to BS EN 1092-1, welded to the pipe by the electric arc process or other approved method. Flanges shall be square to the longitudinal axis of the pipe and truly faced over their whole width. The bolt holes, which shall be drilled off-centre, shall be truly in line end-to-end with the longitudinal axis of the pipe.

Gaskets shall be inside bolt circle type to BS EN 1514–1. Gaskets shall be of such physical properties as to be capable of forming permanent watertight joints against pressures up to the maximum test pressure. The use of jointing paste, adhesive tape or grease on gaskets will not be permitted.

Except where otherwise specified or shown in the Drawings, bolts and nuts shall be to BS 4190 and washers to BS 4320. Stainless steel nuts, bolts and washers shall be in accordance with BS 6105: Grade A4, manufactured from Grade 316S31 steel complying with BS 970: Part 1 or BS 1449: Part 2. Zinc-coated bolts and nuts shall be plated to BS 3382: Part 2 or to BS 1706 designation Zn12 or sheradised to BS 4921: Class 2. There shall be two washers per bolt, one below the bolt head and one below the nut. Each bolt shall be of sufficient length to show two threads past the nut when installed.

The Contractor shall be responsible for checking and ensuring that mating flanges are compatible in all cases, including where connections are to be made to existing pipe flanges.

K17.5.1.5 Detachable flexible couplings and flange adaptors

Where detachable flexible couplings or flange adaptors are used these shall be of the Viking-Johnson type except where otherwise specified or approved by the Engineer.

Detachable flexible couplings shall be suitable for the angular deflections specified below without leakage. Flange adaptors shall be suitable for half the angular deflection stated.

Nominal pipe diameter (mm)	Angular deflection (degrees)
Up to 600	5
601 to 750	4
751 to 900	3
901 to 1200	3
1201 to 1800	2
1801 upwards	1

Flexible couplings for each size of pipe shall also be capable of withstanding the shear force applied by the weight of a 4m length of pipe of that diameter full of water suspended between two couplings.

Detachable flexible couplings shall be provided with central registers or location plugs only where specified or detailed in the Drawings.

Flange adaptors shall have flanges as specified for flanged joints.

Bolts, nuts and washers shall comply with the requirements for bolts, nuts and washers for flanges.

The metal components of detachable flexible couplings and flange adaptors shall be protected by thermoplastic polyamide or fusion-bonded epoxy coatings unless otherwise specified or detailed in the Drawings.

K17.5.1.6 Fusion-bonded epoxy coating

Fusion-bonded epoxy coatings described in this clause are intended for application to ductile iron, cast iron, steel, and aluminium-based materials used in the manufacture of pipes, fittings and their components, where they will be in contact with potable water, domestic effluent, any soil conditions or above-ground applications. The coating shall consist of a polymeric anti-corrosion barrier applied at a factory approved by the Engineer.

The coating system requirements, performance testing and factory applied coating requirements and practice shall be in accordance with the Water Industry Specification (WIS) 4–52–01.

The method of surface preparation and cleaning shall be in accordance with the Contractor’s specification which shall be no less than the minimum requirements specified by the coating material manufacturer and the following requirements:

(i) the pre-coating surface shall be blast-cleaned to a minimum standard of Grade B Sa 2½ in accordance with BS 7079: Part A1;
(ii) the surface shall be tested for soluble salts and re-blasted if soluble salts are found to be present;
(iii) all oil, grease and other contaminants shall be removed;
(iv) all slivers and scabs made visible by blast cleaning and detrimental to the coating process shall be removed;
(v) welds shall be fettled smooth;
(vi) edges and corners shall be smoothed to a 3.0mm minimum radius;
(vii) any pre-treatment prior to coating shall not be permitted without the written approval of the Engineer.

The shot-blasted surface shall have a roughness RZ between 40μm and 80μm inclusive.

The minimum and maximum thickness for pipes and fittings shall be as in the table below:-

Location	Minimum	Maximum
Pipe walls	300 microns	1. 6 mm
Fittings including flanges	300 microns	2.0 mm
Inside bolt holes	300 microns	2.0 mm

All thickness-critical surfaces shall be coated to the thickness specified and within the tolerances identified. Raised flange faces shall be dressed after coating to remove coating runs.

Unless otherwise specified, each item shall be checked for holidays over all of the coated surfaces. A fitting with two or more holidays per 3m² of surface area or a pipe with 30 or more holidays per pipe length shall be rejected for subsequent stripping and re-coating. All holidays detected shall be repaired and on completion the item shall be re-examined for holidays. After repair the coating shall be holiday free to Class A.

Coatings on pipes and fittings to be installed exposed in open air or in chambers, pumphouses and the like shall be treated with a UV-inhibitor to prevent chalking or loss of colour.

Repairs shall be carried out in accordance with the manufacturer's instructions, in the absence of which the procedures for spray applied epoxy shall be followed.

External protection to pipes to be surrounded in concrete over part of their length shall extend at least 150mm within the concrete.

Materials and instructions shall be supplied for repair of coatings damaged in transit and on site. Repair materials shall be compatible with the coating in colour and adhesion and shall be suitable for site application.

K17.5.1.7 Wrapping material

Wrapping material for external protection of buried pipelines and for site wrapping of completed joints or fittings shall be heavy-duty, self-adhesive, rubber-bitumen compound with PVC carrier strip together with primer and moulding putty except where otherwise specified or shown in the Drawings.

All materials shall be supplied by the same manufacturer.

The primer shall be a fast-drying bitumen solution type compatible with the wrapping material and the pipeline materials including coatings to which it is to be applied.

The moulding putty shall be compatible with the wrapping materials and the primer and shall be capable of being moulded cold by hand.

The wrapping material shall possess the following minimum physical characteristics:

- thickness:
- compound: 0.85mm
- PVC: 0.75mm
- total: 1.60mm
- tensile strength: 12 N/mm
- elongation: 230%
- tear resistance: 45N
- impact resistance: 7 joules
- adhesion (180E peel): 2 N/mm
- di-electric strength: 20 000 volts minimum
- insulation resistance: 1 000 000 ohms/cm²

Wrapping for pipes shall be machine applied in controlled conditions. Tensile modulus of the PVC shall suit the method of application.

The material shall be suitable for application in the environmental conditions at the Site. It shall be supplied in rolls with an interleaved release paper extending 10mm beyond each side of the wrapping material.

K17.5.1.8 Polyethylene and heat-shrink sleeving

Polyethylene sleeving for the wrapping of pipes and for the protection of fittings, valves and the like shall be in accordance with BS6076 except as otherwise specified. Suitable adhesive PVC tape shall also be provided to fix the sleeving in position and to make joints between the adjacent sections. Sleeving for potable water pipelines shall be blue unless indicated otherwise.

Heat-shrink sleeve for use at pipe joints to complete coatings shall be a Type I or II in accordance with AWWA C216, manufactured from heavy-duty radiation cross-linked polyethylene sheet material, coated on one side with high shear strength hot-melt adhesive.

K17.5.1.9 Marker tape for buried services

The marker tape laid above buried services shall be 150mm wide and 0.1mm nominal thickness coloured polythene or similar approved system boldly printed with the word 'CAUTION' and words to identify the particular service, throughout its entire length, in accordance with the following codings:-

Types of service	Colour tape	Service identification wording
Water supply pipes	Blue	WATER MAIN BELOW
Pipes carrying waste water, effluent & sludge of all types	Green	WASTE PIPE BELOW
Fuel oil or gas pipes	Orange	FUEL MAIN BELOW
Electricity & earthing cables	Yellow	ELECTRIC CABLE BELOW
Instrumentation, telephone & telemetry cables	Red	CONTROL CABLE BELOW

K17.5.1.10 Marker posts and indicator plates

Route marker posts shall be of reinforced concrete, 500mm high, 75mm thick, 230mm wide with a recess for an indicator plate.

Indicator plates shall be of cast aluminium alloy with raised black characters and be generally similar to single class A hydrant indicator plates to BS 3521 with apertures for the insertion of character plates indicating the pipe diameter in millimetres and the distance in metres from the plate to the object identified. Plates for marking the location of pipeline equipment shall be of the following types:-

<table>
<tr><th>Object identified</th><th>Identification characters</th><th>Plate colour</th></tr>
<tr><td>Air valve</td><td>AV</td><td>Blue</td></tr>
<tr><td>Stop valve</td><td>SV</td><td>Blue</td></tr>
<tr><td>Washout valve</td><td>WO</td><td>Blue</td></tr>
<tr><td rowspan="2">Hydrant</td><td>H</td><td>Yellow</td></tr>
<tr><td colspan="2">(as BS 3251 single class A plate)</td></tr>
</table>

K17.5.1.11 Marking and packing

Each pipe and fitting shall be indelibly marked over any factory-applied coating with the following:

Manufacturer’s distinguishing mark have BIS / any other international specification certification as per reference standards.

Diameter (in mm)- outside or nominal dependant on material

The Letters “JICA-TWAD”

Length of the pipe/angle of the bend (mm. degrees)

Works test pressure

Approximate weight of the pipe or special (Tons)

Sequential manufacturing number – to be consistent with works manufacturing records

Pressure Rating/Grade-(not steel pipe)

Plate Thickness (mm) – steel pipe

Steel grade –steel pipe

Initial stiffness – GRP pipe

Marking shall be in triplicate on the outside of the pipe or special. The three sets of markings shall be painted on the item at 120 degrees to each other, such that at least one set can always be seen.

Where there is insufficient smooth surface area to accommodate the above information the marking shall be put on rust-proofed metal tags secured to the item with galvanised wire.

The letters JICA-TWAD shall be painted on only after the pipes or specials have been found to satisfy any tests and/or other requirements of the Specification. The sequential manufacturing number shall be painted on the pipe and stamped indelibly onto the inside of the socket. Clearly identifiable coloured bands, as approved by the Engineer shall be used to differentiate between sized and unsized pipes.

The flanges of pipes and fittings shall be protected by wooden discs attached by means of service bolts or by other approved means. Service bolts shall not be incorporated in the Works.

All other pipe ends shall be protected against impact damage and entry of foreign matter.

Small items, such as bolts, nuts, gaskets and other joint components shall be crated for delivery. Each crate shall contain a detailed packing list in a waterproof envelope. The outside of the crate shall bear a general description of the contents and an identification mark relating it to the detailed packing list.

K17.5.1.12 Water for testing and cleaning

The Contractor shall provide all water required for testing and cleaning pipelines at his own cost. For this purpose the Employer will wherever possible and if required by the Contractor make available metered supplies of water from existing mains at the points shown in the Drawings. The Employer or the Engineer cannot guarantee the quantities, the flow rates or the pressures of these metered supplies.

K17.5.1.13 Pipeline insulation

Insulation of pipelines shall consist of close-fitting profiled sections of rigid foam to BS 3927, enclosed in aluminum casing fastened by aluminium straps. Joints in the enclosure shall be sealed to prevent water ingress. Insulation thermal resistance shall be as specified or shown in the Drawings.

The Contractor shall submit proposals for pipeline insulation to the Engineer for approval.

K17.5.2 Steel pipelines

K17.5.2.1 Certificate of quality of pipes and specials

With every consignment of pipes and specials delivered under this contract the Contractor shall furnish a certificate worded as follows:-

- "This is to certify that the quality of pipes and specials delivered in this consignment is not inferior to the quality laid down in the Specification".
- No payment shall be made in respect of any consignment of pipes and specials that is not accompanied by such a certificate.

The Contractor shall operate a Quality Assurance System, including:-

- Records of Tests performed by suppliers on materials brought in;
- Testing of materials for this Contract at various stages of manufacture as herein specified, and preservation of the results of such testing;
- Sequential numbering of pipes and fittings.

The Quality Assurance System records shall be open to inspection by the Engineer, and shall be maintained in such a way that any pipe or fitting is identified by a unique sequential production number and can be uniquely related to each stage of its manufacture including material origin and quality, date and time of each operation, operator(s) involved and results of relevant quality control tests.

On completion of the Contract, the Contractor shall pass a complete set of the Quality Assurance records to the Engineer.

K17.5.2.2 Supervision of manufacture

The Contractor shall keep hourly records, during periods of operation, of the temperature, relative humidity, dew point and any other such data as may be required that directly relates to the manufacture of coated and lined pipe. This information shall be made available to the Engineer as he requires and all equipment used shall be new at the time of commencing the work and shall be regularly checked and replaced as necessary. The provision of this data shall be included within the rates for manufacturing the pipe.

K17.5.2.3 Grade of steel

The pipes and specials shall be made by submerged-arc welding from carbon steel with an ultimate tensile stress of not less than 430 N/sq. mm. and a lower yield stress of not less than 275 N/sq. mm. Material shall be in accordance with IS3589 and IS10748.

K17.5.2.4 Process of manufacture

The pipes shall be made by either:-

Longitudinally butt welding internally and externally preformed carbon steel plate or strip, by an automated submerged metal-arc welding process and circumferentially butt welding these shells internally and externally by the same process into standard length pipes with a maximum of four circumferential welds or,

Rolling a strip, sheet or plate so that a helical seam is formed around the circumference of the pipe. The helical seam shall be butt welded internally and externally by an automated submerged arc welding process.

The weld metal shall have a smooth finish with no abrupt edges and shall not stand more than 1.5 mm proud of the pipe shell internally or externally.

Mismatches of adjacent surfaces at sectional welds shall not exceed 2 mm, and shall be faired out on the outside of the pipe or fitting only.

Welding procedures, welder specification, weld testing and other manufacturing requirements shall be as required for Class II welding of BS 2971.

K17.5.2.5 Thickness and diameter

The thickness of the steel plates and diameter of the pipes shall be as shown below, except as otherwise specified

Outside Diameter (mm)	Thickness of Steel plate (mm)
1829	14.2
1626	14.2
1422	12.5
1219	10
1118	8.8
1067	8.8
1016	8.8
914	8
813	8
711	6.3

K17.5.2.6 Effective length

The Effective Length is defined as 'the actual length that a pipe contributes when assembled in a run of piping'. The Effective Length of each pipe shall be as the Contractor chooses provided that it is not less than 8 metres or greater than 13.5

metres and that all full-length pipes are of the same Effective Length. The variation of pipe length from the agreed Effective Length shall not exceed 50 mm.

Where details on the Drawings are based on an assumed Effective Length for the purposes of illustrating the Works, the Contractor shall be responsible for designing and constructing, at his own cost and to the Engineer's approval, any additional or revised supports, restraints or other details necessitated by the Contractor's choice of Effective Length.

K17.5.2.7 Specials

Specials shall conform to the appropriate dimensions given in BS EN 10224.

K17.5.2.8 Sized pipes

Where stated in the Bills of Quantities sized pipes shall be supplied for cutting to provide closing lengths. They shall be truly circular throughout their length and sized throughout their length to the same dimensions as the spigot ends.

K17.5.2.9 Pipe ends

The ends shall be cut nominally square or angular with the axis of the pipe and shall be free from excessive burrs.

The lining and external coating of pipes and specials to be joined by welding shall be stopped at least 150mm from the ends.

The external coating of pipes and specials to be jointed by mechanical couplings or flange adaptors shall be stopped at least 150mm from the end.

Care shall be taken to ensure that butterfly valve discs will not touch the linings of adjacent pipework.

K17.5.2.10 Butt joints

Bevelled ends shall be beveled to angle of 30^{O} +5/-0 degrees measured from a line drawn perpendicular to the axis of the pipe. The root face shall be 1.6+/- 0.8 mm

K17.5.2.11 Special joints

At joints between cement mortar lined steel pipe (or specials) and valves, the internal diameter of the steel pipe or special shall be finished to match the bore of the valve by gradually decreasing or increasing the thickness of the lining in the pipe or special, although the lining shall be no where less than 6 mm thick. Any increase or decrease in the thickness of the lining shall be gradual and smooth and the Contract Rates shall be deemed to include for all costs incurred in providing such a lining.

K17.5.2.12 Welding collars

Welding collars shall be to BS EN 10224, Annex C.

K17.5.2.13 Control tests

Control tests as defined in BS EN 10217-1:2002 shall be carried out as follows before pipes are lined or coated:-

Tensile Test	once every 50 pipes
Submerged-arc weld test	once every 50 pipes
Hydraulic Test	Every pipe
Radiography of Welds	3% of welds in every pipe & 100% for specials

All pipes which pass the hydraulic test shall be stamped with the Contractor's test stamp.

The minimum length of weld to be radiographed at any location shall be 300 mm each end. The execution and interpretation of weld radiography shall be to API 5L.

K17.5.2.14 Defects and rejection

Materials with defects at the place of manufacture or at Site, or which prove to be defective when properly applied in service shall be completely repaired or shall otherwise be replaced at no cost to the Employer.

Defects shall include cracks, leaks, laminations, lack of complete penetration, lack of complete fusion, dents exceeding one eighth of the specified wall thickness and under cutting or reduction in the pipe wall thickness adjacent to a weld exceeding 0.8 mm in depth.

Slag inclusions and gas pockets or voids shall be considered to be minor imperfections and may be affected if the maximum size and distribution does not exceed the limits shown in Table 9.3 and 9.4 and Figures 9.2 and 9.3 of A.P.I. Standard 5L – 1991.

Any pipe or special which fails to pass the Hydraulic Pressure Test shall be rejected.

Any pipe or special which has been rejected shall be marked in a distinctive manner to preclude any possibility of its use in the Works. Such pipes and specials may be submitted for re-test following the correction of any defects, where such correction is permitted by the Engineer.

K17.5.2.15 Cleaning

After hydraulic testing of each pipe has been completed satisfactorily, pipes and specials shall be thoroughly descaled by acid picking or grit blasting in order to remove all mill scale, rust, paint, grease and loose dirt. After cleaning, the pipes and specials shall be protected from and maintained free of all oil, grease and dirt until they have been external coated and internally lined.

K17.5.2.16 Cement mortar lining

Cement mortar lining shall be applied at place of manufacture with centrifugally applied cement mortar made from Ordinary Portland Cement and specially graded washed silica sand. The cement mortar shall have a minimum cement content of 100 kg / m3 and water cement ratio of between 0.3 to 0.45. The materials, application method and curing of the finished lining and the manufacture and testing of test cubes shall comply with B.S.534: 1990 and shall be carried out to the approval of the Engineer.

(a) Methods:

The cement mortar lining shall be applied by centrifugal spinning process for pipes and by manual application for fittings.

The lining shall be applied in a single operation by high speed centrifugal process. The consistency of the mortar mix and the speed and duration of the spinning shall be such that the segregation of the aggregates from the cement is minimized. The spinning of the pipe shall continue until the surplus water has been dispersed and the greatest possible density of lining is obtained. Any damage caused to the end rings shall immediately be made good by hand before the lining is set. No more than one hour shall elapse between the removal of lined pipe from the lining machine and commencement of the approved curing procedure.

Surface crazing of the lining will be acceptable unless cracks are so severe that they can be penetrated to a depth of 2mm by a 250-micron feeler gauge at 10 points or more over a length of 300mm when measured with the lining in a saturated condition. Such cracks shall be cut back to full depth and sealed with an approved epoxy resin filler.

Where the lining is stopped short of the pipe ends the edge of the lining shall be angled back at 75° to the pipe axis. The lining shall be omitted over an area 25mm around cable pass holes and provide a positive key for in-situ protection after the cable pass hole has been permanently closed.

Lining thickness shall be as shown below with tolerance on minimum values of +3 mm. and -0 mm

Diameter	Lining Thickness(mm, nominal)	Lining Thickness(mm, min)
Above DN1200	14	12
DN901-DN1200	10	8
DN700-DN900	8	6

Hand finishing at the ends of the pipe for not more than 100 mm shall be permitted to rectify the thinning of linings. Where possible, fittings and specials shall be lined using the centrifugal process, or if their shape precludes this, they shall be hand finished and cured so as to achieve comparable results. Tests shall comply with the requirements for continuously applied cement mortar linings

(b) Curing of factory-applied concrete lining

Lined pipes and fittings shall be marked with the date of lining and moist cured at atmospheric pressure in sealed chambers. Curing shall be continuous and the lining shall not be subjected to rapid changes of temperature either during or at the end of curing.

Within one hour of completion of lining, the lined pipes shall be sealed into the curing chambers in which air shall be maintained in a saturated state while the temperature is raised at a rate not exceeding 16°C per hour to 43°C. The lining shall then be cured for at least 24 hours during which time the temperature shall be maintained between 43°C and 65°C. The lining shall then be kept moist by continuous water spraying for a period of at least 3 days. This procedure may be varied in the light of experience with the approval of the Engineer.

On completion of water curing, pipes shall be protected from sunlight and the linings shall be kept moist for a further period of one week.

(c) Tests on cement mortar lining

Test blocks of the same material as used for pipe lining shall be made in 100 mm moulds and subjected to cube crushing tests. Each block shall be removed from its mould as soon as practicable and cured under conditions of temperature and humidity identical with in which lining of the pipe is cured.

The cube strength of the test cube shall not be less than 31 N /mm^2 after 28 days of curing or 17 N/mm^2 after 7 days of curing. The density of the test cube shall not be less than 2100 kg/m^3.

K17.5.2.17 External coating for underground pipes

The Contractor shall perform the work in accordance with NAPCA Pipe Coating Specification Bulletin No.3-67 unless stated otherwise in the specification. The Engineer will inspect the result of the work and determine acceptability. The Contractor shall provide the Engineer with access to all phases of the work.

(a) Material and equipment:

Primer shall be a Type B or C material as per AWWA C203-02 section 4.3. and shall be a material recommended by the enamel manufacturer as compatible with the enamel coating.

Coal tar enamel shall be a Type I material as per AWWA C203-02.

Glass fibre reinforcement material shall be reinforced in the longitudinal direction, shall have minimum thickness of 0.5 mm (0.020inches) and shall conform to AWWA C 203-02 Section 4.3.

The outer wrap material shall be a coal tar impregnated, 15 lb/100ft^2 perforated fibreglass conforming to the requirements of AWWA C203-02 section 4.3.

The Contractor shall demonstrate that the coal tar enamel proposed will form a firm bond to the primer and shall receive approval from the Engineer prior to the start to priming operations.

The Contractor shall submit samples of proposed glass fibre reinforcement and fibreglass with coal tar enamel outer wrap to the Engineer and receive approval prior to the start of coating operations.

All equipment, tools and supplies furnished by Contractor must be of good quality, adequate design, must be maintained in good condition during use and shall be subject to the approval of the Engineer.

Coating materials shall be properly handled and stored by Contractor to prevent deterioration. Any coating or wrapping materials, which are damaged or condemned by the Engineer because of Contractor's negligence, shall be replaced at Contractor's expense.

All cleaning and priming machines, coating machines and combination cleaning and coating machines shall be equipped with rubber or hard fibre crawler wheels. Knurled steel or other type crawler wheels, capable of marking of indenting the pipe shall not be permitted. The Contractor shall employ only competent, skilled and careful workmen experienced in the operation of cleaning, priming, coating and wrapping machines.

The Contractor shall furnish suitable kettles for heating the enamel. Kettles shall be equipped with the following:-

Continuous mechanical agitation devices.

Dial type indicating thermometers of a suitable range (60 to 200 degrees C) mounted 100 mm from the bottom of the kettle with the dial plainly visible.

1.6 mm (1 /16 – inch) mesh strainer boxes that can be easily cleaned.

All kettles shall be clean and may not contain any coating residues, dirty water or other foreign matter before starting work. Kettles shall be cleaned periodically during the work and at the Engineer's request. If kettles or other equipment have previously been used with a coating material that is not compatible with the material to be used in these specifications, the Engineer may require the Contractor to burn out the kettles and other equipment or remove all traces of the old material.

(b) Coating Application

(i) Surface Preparation:

The outside surface of the pipe shall be thoroughly cleaned with approved sand or steel shot blast cleaning to Swedish Standards SIS 2-1/2 and the procedure to be used shall be approved in advance by the Engineer.

Before cleaning, oil and grease shall be removed from surface by wiping with clean rags saturated in a suitable solvent approved by the Engineer.

The compressed air for blasting shall be free of water and oil. Adequate separators and traps shall be provided.

Blast cleaning operations shall not be conducted on surfaces that will be subject to becoming wet after blasting and before coating; when the pipe surfaces are less than 2.5°C above dew point; or when the relative humidity of the air is greater than 85 per cent, unless preheating of the pipe is employed. Blast cleaning under these conditions can be conducted provided the pipe can be warmed to a temperature sufficient to perform the blasting operations without visual appearance of moisture on the pipe surface. Preheat pipe temperature shall not exceed 65°C.

After cleaning, the pipe surfaces shall be bare metal free of all mill scale, lacquer, old coatings, oil, grease, moisture, rust, mud, dust, welding residue other foreign or deleterious matter.

(ii) Priming:

Primer shall be kept off Site and only the daily requirements shall be brought to the Site. Primer shall be thoroughly agitated in its container before use. Only the amount of primer required for immediate use shall be emptied from the drums into open container. After obtaining the quantity required, bungs shall be immediately replaced to prevent the loss of solvents by evaporation. Primer which has become contaminated with foreign matter or has thickened because of evaporation of solvents shall not be used. The primer shall be applied to a clean, dry surface, immediately after the cleaning operation.

The primer shall be applied as received from the manufacturer unless, in the opinion of the Engineer, a thinner should be used to speed up the drying time. Thinner shall be mixed with the primer in the manner and proportions recommended by the manufacturer of the primer.

Primer shall be machine applied at a rate recommended by the manufacturer in a uniformly thin film free from runs, bubbles, sags, dust, grass or other foreign matter. Primer shall completely cover the circumference of the pipe and all surfaces to be enamel coated. Missed spots or areas covered with insufficient primer shall be touched up immediately by hand brushing. Primer which has been applied too heavily, such as at the base of welds, shall be brushed out before the primer sets. Any dried runs or sags shall be scraped off and the area reprimed. Hand brushing of primer where required shall be neatly using only good quality paint brushes. Care shall be taken to prevent damage to the primer film prior to enamel application.

If the enamel is not applied within any maximum permissible time specified by the manufacturer or, if in the opinion of the Engineer the Contractor has failed to comply with any of the manufacturer's specifications, then the Contractor shall reprime the pipe at his own cost. Only two applications of primer are permitted, if pipe requires further repriming it shall be cleaned to bare metal by a cleaning machine or solvents and reprimed.

Used primer shall not be re-used either by recycling or otherwise. Removal of primer from the primed pipe due to abrasion from any metallic contact will be reprimed properly and allowed adequate curing time before flood coating.

The primer coat shall be exposed for curing as per the time limits recommended by the manufacturer and protected from dust impingement while curing.

(iii) Coating and Wrapping

After the primer has been properly applied and cured, the pipe shall be coated with successive layers of coal tar enamel, glass fibre reinforcement innerwrap, coal tar enamel, glass fibre reinforcement innerwrap and coal tar enamel impregnated fibreglass outer wrap.

The coating and wrapping shall terminate 150 mm from the ends of each length of pipe. The finished thickness of the coating and wrapping shall be a minimum of 4.75 mm throughout.

Except as otherwise stated in this section, the coating and wrapping operations shall be as per AWWA Standard C-203-02 sections:

- 4.4.4 Equipment for enamel preparation.
- 4.4.5 Enamel preparation and supply.
- 4.4.6 Condition of the liquid adhesive coated pipe prior to enameling.
- 4.4.9 Application of enamel, innerwrap and outerwrap systems to exterior pipe surfaces.
- 4.4.10 Holdback of lining and coating at ends of pipe sections.

The enamel shall be furnished in expendable sheet metal or paper drums. The enamel will be chopped or cut on a suitable platform to prevent the enamel from coming into contact with dirt, weeds, cinders, grass and other contaminants. The chopped or cut pieces of enamel may not weigh more than 10 kg. The pieces of enamel shall be covered when they are in danger of contamination because of atmospheric conditions.

Care shall be taken to prevent contaminants from mixing with the enamel at any time. The enamel shall be slowly heated to the temperature recommended by the manufacturer in a clean kettle.

In case of an interruption or short shutdown due to weather conditions or other unavoidable circumstances, the temperature of the enamel charge shall be reduced approximately to 55°C lower than the application temperature until coating operations resume.

The enamel shall be applied with an approved combination coating and wrapping machine. Machine operators shall be required to make all necessary adjustments to assure a continuous film of enamel without undue loss of temperature at point of application. Defects, such as bubbling or foaming, shall be cause for shutting down operations until any air pockets have been removed from pumps and supply lines, and required coating shoe adjustments have been completed.

Coating shoes shall be kept evenly centered on the pipe and shall not be allowed to drag or thin the enamel below specified thickness at any point due to improper bridling. Shoes which are not round or are damaged shall be immediately replaced. One or more auxiliary spray rings shall be used if necessary. Thickness of the coating applied shall be frequently tested with an approved pit gauge. The coating punctured by the pit gauge shall be repaired.

The minimum thickness of the first enamel coating shall be 2.4 mm.

Glassfibre reinforcement inner wrap shall be applied using an approved continuous end feed machine.

The minimum composite thickness of two layers of enamel and reinforcement shall be 4.75 mm.

The coal tar impregnated fibreglass reinforcement outerwrap shall be applied using an approved continuous end feed machine. No wrinkling in the wrapping will be allowed and the outer wrapping shall be completely bonded to the enamel.

Where coating is stopped short at pipe ends, the edge of the wrapping shall be chamfered at 25 degrees to the axis of the pipe.

All foreign substance, dirt, steel short and other debris shall be removed from inside pipe before stockpiling or shipping. All primer and enamel inside the pipe shall be removed with solvents and wiped clean. The coated pipe shall be placed in such a manner that the enamel can set, cool and harden without damage. After the wrapping has been tested, it shall be given one coat of a non-stick light- and heat-reflecting paint.

K17.5.2.18 Inspection, Testing and Repairs

All records of inspection and testing of material received by Contractor and all manufacturers' material certificates shall be made available to the Engineer.

All materials shall be certified by means of the manufacturer's certificate of analysis for each batch of material supplied. Representative samples of material may be tested by the Engineer. The cost of testing shall be borne by the Contractor.

Any supervision of the Contractor's manufacturing work by the Engineer shall not relieve the Contractor of his obligations under the specification.

The 'Shop or Field Peel Test Procedure', Section 5.8 of AWWA C 203-02 shall be applied to each pipe in the initial production, until such time as the Engineer is satisfied that the bond is satisfactory, when he may relax the test to one pipe in ten, chosen at random. He will also from time to time cut out 25 cm^2 samples from the coating for determination of thickness. The Contractor shall repair such any defects arising from the Engineer's tests at his own cost.

Contractor shall furnish high voltage electronic holiday detectors of a type acceptable to the Engineer and shall test all coating applications immediately after coating and wrapping. Testing for coating flaws shall be in accordance with AWWA 230-02 section 5.2. The crest voltage of the holiday detector shall be set as high as practicable. The Contractor shall provide necessary devices for calibrating the holiday detector.

All coated pipe under test shall be positively grounded by a means satisfactory to the Engineer. The detector electrode shall be periodically cleaned to continuously provide full contact with the surface of the coating. The holiday detector shall be passed over the coated and wrapped pipe as coating progresses. The detector shall be passed at a sufficient distance behind the coating and wrapping machine to permit the enamel to set. The initial inspection is made to provide prompt warning of coating machine maladjustments or other conditions preventing a proper coating application as specified, in order that immediate corrective adjustments may be made.

Any defective part of the coating shall be clearly marked by Contractor immediately after it is detected.

All pin holes, voids, holidays, air bubbles, cracks, and other breaks shall be carefully marked. Repairs shall be made, reinspected and approved prior to storing or shipping. Repairs to enamel coating shall be made by removing the wrap over the damaged coating in a manner that will not disband the adjacent coating. The repair area shall be primed and hot enamel shall then be poured or "ragged" over the area, with the felt wrap embedded and bonded to the enamel. All coating repairs shall be made with the wrap smoothly applied and without wrinkles or buckles.

Pipe joints shall be rejected if three (3) or more holidays are detected in its length. Similarly, a pipe joint shall be rejected and no repair allowed to it if any one holiday is bigger than 0.1 square metre in size.

The Contractor shall repair all coating damage and defects his own cost.

After testing and inspection the outside surface of the outerwrap is to be given a finish coat of water resistant whitewash. Prior to final stacking of pipe, the uncoated ends shall be cleaned by wire brushing and coated as per the recommendation of the primer manufacturer. Such temporary protective coating should not require removal while marking field-joints and applying corrosion protective coating later while laying the line. The type and film thickness is to be agreed by the Engineer.

K17.5.2.19 Sprayed epoxy and polyurethane coatings

(a) General

Where exposed in chambers or in other areas where bitumen enamel wrapping is not to be applied, pipes and fittings shall be supplied with a polyurethane or epoxy coating, as specified.

Unless otherwise indicated the following clauses shall be applicable to internal and external sprayed epoxy coatings and polyurethane coatings.

(b) Materials

Internal epoxy coating shall be a two component solvent free, spray applied epoxy coating to provide a high build inert lining system.

External sprayed epoxy coating shall be a two part, solvent free, to provide a high build epoxy coating system. The material shall have resistance to abrasion and mechanical damage.

External polyurethane coating shall be a two component, solvent free, polyurethane applied in a single coat. The material shall have resistance to abrasion and mechanical damage.

All materials that comprise the coating shall be supplied by a single manufacturer and shall together comprise a recognised coating system that has been proven on other projects.

(c) Steel surface preparation

All surfaces should be free from oil, grease and other contamination prior to abrasive blasting.

Surfaces should be blast cleaned to a minimum Sa2½ in accordance with BS7079 Part A1 1989 or equivalent. Prior to blast cleaning, any sharp protuberances, surface laminations, weld spatter, etc. shall be removed by thorough cleaning and grinding. The abrasive used should be capable of producing a minimum profile of 50-75 microns corresponding to 'medium' in accordance with BS7079 Part C4. Throughout the blast cleaning process the humidity should be checked and maintained at less than 85%. The pipe surface should be at least 5°C above the dew point prior to abrasive blasting.

Immediately after blast cleaning, all dust, residues and debris left on the surface must be removed.

After blast cleaning, ends of pipes which will subsequently be welded should be masked off for 150mm back from end of pipe.

(d) Concrete and Cement Mortar Surfaces for Internal Coating

All surfaces should be dry and, if required, be lightly scarified to remove weak and loosely adherent deposits. All debris from the surface preparation process should be swept or blown from the surface.

(e) Concrete Surfaces for External Coating

All surfaces to be coated should be prepared by either lightly abrasive blast cleaning using wet abrasive or dry techniques or high pressure water jetting. All dust and abrasive material should be removed from the surface.

K17.5.2.20 Application of epoxy and polyurethane coating

(a) General

The application of the coating shall comply with the provisions of AWWA C210, section 4.4, except as otherwise stated.

Prepared surfaces must be completely clean of dust, dirt and grease and thoroughly dry.

No coating shall be applied in the following atmospheric conditions:

i) Relative humidity exceeding 85%,

ii) When the surface to be coated is less than 3°C above the dew point,

iii) The surface temperature is less than 7°C or greater than 50°C.

Coating shall be curtailed 150mm from both ends of the pipe to permit site welding of joints.

(b) Coating thickness

Internal epoxy coating shall be applied as a single coat with final thickness of 500 microns.

External epoxy and polyurethane coating shall have a final thickness of 1.5mm or 1.2mm if used in conjunction with cathodic protection measures.

(c) Touch up and repair procedures

The finished coating shall be inspected for damage or reduced thickness. Any such areas shall be repaired by thoroughly degreasing the surface and abrading using 180 grade abrasive paper, the abraded area should extend from the edge of the damage for 50-75 mm onto surrounding sound coating. The prepared surface can then be re-coated.

The coating shall be 'hard dry' before the surface is abraded. No surface shall be abraded within the times given in the following table:

Temperature(deg C)	7	10	15	20	25	30
Time to Elapse Between Application and Abrasion for Repair(hours)	36	32	24	16	12	8

(d) Final cure times

The lined pipes shall be stored for curing in accordance with the durations given in the following table:

Ambient Temperature(deg C)	45	40	35	30	25	20	15	10	7*
Minimum Number of Days Storage	1	1	2	4	5	7	11	17	22

*minimum possible cure temperature

(e) Coating of joints after welding

All weld areas shall be thoroughly cleaned to remove welding spatter and debris, including damaged coating, using angle grinders, needle guns or rotary grinders ensuring that a coarse profile is achieved on metal surfaces and surfaces are not polished.

The abraded area should extend from the edge of the weld area for 50-70 mm onto surrounding sound coating ensuring the surface of the coating is thoroughly flatted off to remove all gloss and is then uniformly profiled. This requirement is absolutely essential to ensure a sound finish and shall be strictly followed at all times.

All loose dust and abrasive residue shall be removed from the surface by brush or airline.

Surfaces shall be degreased with detergent solution to ensure no oil or grease resulting from the abrading process is present.

The coating shall be mixed in accordance with the manufacturer's product data sheet then applied to the prepared area to achieve the same thickness as the pre-coated pipe.

(f) Tests and Inspection

The Contractor shall carry out the following tests:-

(i) Surface Preparation Stage

Comparison with Appropriate Standards for surface preparation

Comparison with Appropriate Standards for blast profile

Cleanliness of surface prior to coating

Humidity dew point and surface temperature during blast cleaning.

(ii) Application Stage

Wet film thickness

Visual Assessment

Humidity, dew point and surface temperature

(iii) Minimum 24 hours after Application

Dry coating thickness

(iv) After 48 hours Curing

Test for porosity using holiday detector

(g) Trial Application

Once the Contractor has established his equipment and working method he shall do a trial lining of a coated section of pipe. The length of the initial sample pipe shall be no less than 2m. If, in the opinion of the Engineer, the finished lining does not comply with the specification, then the Contractor shall modify the equipment or method so as to achieve a satisfactory result. The trial shall be repeated until a satisfactory finish is achieved. Once the trial lining has been approved on the sample length, the Contractor shall line and cure a section of pipe of normal length to the satisfaction of the Engineer. If, after curing, the coating demonstrates any residual surface tack then the Contractor shall wet the surface of the lining to demonstrate whether or not this causes it to disappear. If the surface remains tacky then the Contractor shall consult the manufacturer. Residual surface tack may be due to the temperature and humidity at the location of application and if it disappears under the application of water is not a cause for concern.

K17.5.3 Ductile iron pipelines

K17.5.3.1 Pipes, fittings and joints

Ductile iron pipes and fittings shall comply with BS EN 545 or ISO 2531. Unless otherwise specified pipes shall be Class K9 and fittings shall be to Clause 9 of BS EN 545.

All pipes shall be manufactured by the centrifugal casting process.

Except where flanged or other types of joints are specified or detailed in the Drawings, pipes and fittings shall have push-in socket and spigot joints. The joints shall permit pipes to be deflected angularly by up to 2° axially for diameters up to 900mm and by up to 1.5° axially for diameters over 900mm. Self-anchored couplings and flange adapters shall not be used for transmission of axial loads.

Except where specified otherwise in the Drawings, all detachable flexible couplings on buried ductile iron pipelines shall be of the sleeve type with a ductile iron collar and two bolted-gland joints.

Bolts for use with bolted gland joints shall be spheroidal graphite in accordance with BS EN 1563.

K17.5.3.2 Protection

Pipes and fittings shall be coated externally with metallic zinc in accordance with Clause 4.4.2 of BS EN 545.

Except where otherwise specified, pipes and fittings shall be further protected externally with an approved bitumen-based coating in accordance with Clause 4.5.2 of BS EN 545.

Except where otherwise specified, pipes and fittings shall be lined with Type B cement mortar i.e. sulphate resistant, in accordance with Clause 3.2 of BS EN 545.

K17.5.4 HDPE Pipelines

K17.5.4.1 Pipes, fittings and joints

High-density polyethylene pipes and fittings for pressure pipelines shall be in accordance with IS 4984-1995 and specifications issued by U.K. Water Industry Engineering and Operations Committee – WRC as Water Industry Specifications (WIS) 4–32–13, 4–32–14 and 4–32–15 and any other relevant BS. The manufacturer shall be responsible for all testing and quality assurance procedures and be covered by a third-party certificate scheme all in accordance with these standards. Pipes exceeding 90mm nominal diameter shall not be supplied in coils.

All HDPE pipe and fittings for thermal fusion jointing to form an individual pipeline or pipeline system shall be supplied by one manufacturer unless the Engineer approves otherwise. Electrofusion couplings are excepted from the requirement but must be of a type approved by the Engineer and incorporate pins which pop up to confirm that optimum melt pressure has been achieved.

Mechanical joints shall be of the Viking Johnson 'Quicklock' type and shall be complete with liners.

K17.5.4.2 Thermal fusion-jointing equipment

All tooling and equipment used for thermal fusion jointing shall be of types approved by the Engineer and shall include all equipment necessary to cut, plane and clean, clamp, heat and align pipe and indicate or control temperatures and heating and cooling periods to an acceptable international such as the Water Industry Specification (WIS) 4–32–08.

Fusion tools and heating plates shall be electrically heated and thermostatically controlled with any handles or brackets made of material having electrical insulating properties conforming to BS 2559: Part 3 for use with 110V ac or, if made of wood, they shall conform to BS 3823: Part 1. The tool or plate shall be earthed through the generator.

A thermometer shall be fitted and shall have a green zone indicating the correct fusion temperature range for HDPE marked with the appropriate code. Thermometers shall be suitably protected from mechanical damage, shall be replaceable and shall be accurate to !3°C within the fusion temperature range. If an alternative temperature-indicating system is used, the plate shall have provision for inserting a suitable conventional thermometer.

The wattage of the heater elements shall be such that the required surface temperature range is reached within 15 minutes in still air and at ambient temperatures of 20°C 15°C.

The input leads shall conform to BS 6500 or other agreed standards.

The temperature control system (thermostat) shall be flameproof in accordance with BS EN 50018.

Hydraulic rams used to align pipe ends and bring them together shall each have independent pressure gauges. Each gauge shall have a performance certificate indicating any deviations in true to actual readings issued by an independent tester not less than one month prior to its use. The certificates shall be made available to the Engineer, together with data relating the hydraulic pressure of the machine to the total force applied to the pipe.

K17.6 Workmanship

K17.6.1 General

K17.6.1.1 Handling

The Contractor shall supply handling equipment as necessary for installation of pipelines without damaging pipeline materials including exterior and interior coatings. The equipment shall include lifting beams, reinforced canvas slings, protective padding, struts, cradles, pipe trailers and the like. Wire-rope or chain slings shall not be used for handling pipeline materials.

Throughout the installation of the pipeline the Contractor shall not use methods, plant or equipment which may cause damage to the pipeline materials.

Pipes for butt welding shall be provided with mechanical protection for the bevelled pipe ends.

Temporary packing, coverings or crates provided for the protection of pipeline materials in transit shall not be removed (except for purposes of inspection after which they shall be replaced) until immediately before installation and shall then be disposed of by the Contractor.

The Contractor shall ensure that the above requirements are also observed whenever pipes are handled, whether during shipment or otherwise, and that all necessary precautions are taken, including the provision of adequate temporary protection, to ensure that pipes will not be damaged in any way whilst being handled, transported and stored.

K17.6.1.2 Delivery

The Contractor shall take delivery of pipeline materials at times and locations or storage areas on or about the Site to be arranged with the suppliers. Any such location or storage area which is not part of the Site shall be arranged for by the Contractor at his own risk and without extra cost to the Employer.

All items shall be inspected for damage and checked for shortages against packing lists immediately on delivery. Damage and shortages shall be remedied with the minimum of delay.

In the event of a fusion-bonded epoxy coating being damaged after leaving the factory, the item shall be returned to the factory for repair or, with the consent of the Engineer, be repaired at Site. Repairs shall be effected in accordance with the manufacturer’s recommendations. Notwithstanding such recommendations, the repair shall meet the following minimum requirements:

(a) repair materials shall be compatible with the original factory-applied coating materials;

(b) the edges of the original factory-applied coating shall be ground off to a taper or feather edge;

(c) exposed metal shall be cleaned and prepared as specified;

(d) the relative humidity of the atmosphere in which the repair is to be effected shall be maintained (if necessary, by the use of hot-air blowers and tenting) at less than 85%, a wet/dry thermometer being provided during repairs to demonstrate humidity;

(e) the surface temperature of the exposed metal shall be raised to at least 3°C above dew point and the coating shall then be applied in stages, as recommended by the manufacturer, so as to achieve a total thickness in accordance with the Specification.

All repairs shall be checked with a holiday detector and any holidays shall be repaired, after which the repairs shall rechecked.

K17.6.1.3 Storage

The Contractor shall take into temporary protective storage all pipeline materials not required for immediate installation in the Works or, in the case of pipes, be responsible for stringing them out along the pipeline route.

Prior to the delivery of any pipes the Contractor shall prepare firm, well drained, level areas to stockpile the pipes and shall provide adequate areas for vehicle access, manoeuvring and egress. The Contractor shall provide supervisory staff to register the arrival of deliveries, supervise off loading and to maintain security at the storage area.

Pipes and fittings at all times prior to installation shall be laid on wedged timber bearers so as to be at least 150mm clear of the ground; subject to the manufacturer's recommendations, pipes may be stacked up to three pipes high if suitable protective packing is placed between the layers. All pipes and fittings shall be suitably cushioned at all points of support so as to prevent damage to the pipe wrapping or coating. Covered areas shall be provided as necessary to protect any materials such as joint rings etc that will be damaged by exposure to weather.

The period between taking delivery of a pipe and the completion of its installation shall be kept to a minimum. Pipes may be strung out along the pipeline route prior to installation providing that any necessary temporary fencing has first been erected. Jointing and wrapping parts and materials shall be stored under cover. Pipes and fittings liable to be affected by exposure to ultra-violet radiation shall be kept under cover except when being handled during delivery or installation.

K17.6.1.4 Installation

Trench Excavation and backfill shall be carried out in accordance with the Specification.

Trench Excavation and backfill shall be co-ordinated with the construction of the pipeline as a whole so as to ensure expeditious completion of the whole operation.

Where Trench Excavation is to be carried out in areas where buried pipes or cables are likely to be encountered, the location of such pipes or cables shall, whenever practicable, be determined ahead of Trench Excavation. Methods used for detecting the location of pipes and cables shall include the use of electronic detection equipment. Details of the type and manufacturer of the equipment to be used shall be provided to the Engineer and subject to his approval.

The pipeline shall be accurately installed to the lines, levels, grade and positions as set out by the Contractor and agreed with the Engineer following the initial alignment survey.

The Contractor shall submit full details of the methods he proposes to use for control of the accuracy of pipe laying. The invert level of any pipe shall be within 16mm of the specified level unless specified otherwise.

Pipes shall be laid in dry trenches. The Contractor shall make appropriate arrangements for dewatering, which shall be subject to the approval of the Engineer.

Pipes shall be lowered carefully into the trench using appropriate mechanical lifting equipment with ropes or slings, no hooks shall be used. No pipe shall be rolled and dropped into the trench or allowed to assume an inclination of more than 5 degrees to the horizontal whilst on slings.

Pipes shall be laid to even grades for as long a length as possible, with a minimum grade in the direction of flow of 1 in 300 (0.33%) on declined pipe and 1 in 500 (0.2%) on inclined pipe. Changes in direction or in grade of the pipeline shall be carried out by making use of any permissible deflection of joints between straight pipes or by the introduction of bends where shown in the Drawings. The barrel of the pipe shall be continuously supported throughout its length by the bottom of the trench or by bedding material as specified.

Flexibly-jointed socket and spigot pipes shall normally be laid with sockets leading. Where the gradient exceeds 5%, installation shall proceed on an ascending grade with sockets leading. Except as otherwise specified, pipes shall generally be installed singly and shall not be jointed until after they have been laid. After laying and jointing, the invert level of each pipe shall be checked before the next pipe is laid.

Joint holes shall be excavated to provide adequate clearance to enable joints to be made satisfactorily and any specified wrapping to be completed and to provide a clearance of at least 50mm from the trench bottom below the joints.

The Contractor shall keep the interior of pipes clean and free from water, dirt, stones and other foreign matter as installation proceeds. At the end of the day's work or at other times when installation work is not proceeding, the open ends of pipes shall be sealed by a suitable stopper. The Contractor shall take such precautions as are necessary to prevent pipes from floating.

Wherever pipes, cables, ducts and similar services are buried in the ground a marker tape shall be laid 300mm above each and every service in the trench.

At each location where pipe is being laid, the Contractor shall have the equipment available to carry out the necessary in-situ tests and obtain samples for laboratory tests.

The Contractor's Site Traffic shall not cross backfilled trenches without auxiliary support except where the backfilling and reinstatement have been carried out to the point at which public traffic is permitted to cross the line. At other crossing points for Site Traffic, the Contractor shall install a temporary bridge of adequate strength from undisturbed ground on one side of the pipe trench to undisturbed ground on the other.

In no circumstances shall the Contractor's Site Traffic cross above an elevated section of pipeline.

K17.6.1.5 Jointing

Before making any joint, the Contractor shall ensure that the interior of each pipe or fitting is clean. The Contractor shall clean the end of each pipe to be jointed and shall prepare the ends for jointing as necessary. All mechanical joints shall have their coating made good before assembly in accordance with the coating manufacturer's recommendations.

The Contractor shall use only the proper jointing parts as specified and obtained from the suppliers of pipes or fittings. All joints shall be assembled and tightened and shall be made only on pipes which comply dimensionally and have been prepared in accordance with the joint manufacturer's instructions. All joints shall be capable of passing tests for individual joints and for the completed pipeline as specified.

Where shown in the Drawings, longitudinal movement of pipes joined by mechanical couplings shall be restricted by a steelwork harness approved by the Engineer. After installation the harness shall be cleaned and painted with two coats of bituminous paint before wrapping.

Where a change of direction is to be achieved by the deflection of a flexible joint of any kind, the deflection shall not exceed 50% of the maximum value for the size and type of joint as specified by the manufacturer, unless otherwise specified or detailed in the Drawings.

Bolts for flanged and other mechanical joints shall show two threads clear of the nut after tightening.

Stainless steel nuts and bolts shall be lubricated before assembly with an anti-galling lubricant. Nuts shall be tightened to the torques recommended by the joint manufacturer. Torques shall not exceed values at which there is risk of galling.

After completing the joint, any protective or other coating shall be made good and any lining and joint protection completed as specified or detailed in the Drawings without delay.

K17.6.1.6 Flanged joints

When assembling flanged joints, the joint ring may be fastened to the bolts with cotton thread. The use of jointing paste, adhesive tape or grease will not be permitted. The bores of abutting pipes or fittings and the joint gasket shall be concentric; no joint material is to be left protruding into the bore. All nuts shall first be tightened by hand and nuts on opposite sides of the joint circumference shall then be alternately and progressively tightened with a spanner so as to ensure even pressure all round the joint. The bolts shall be tightened to the torque recommended by the manufacturer.

K17.6.1.7 Work inside pipelines

The Contractor shall provide, operate and maintain adequate systems of access, lighting and ventilation to any part of a pipeline where work is in progress inside the pipes.

K17.6.1.8 Sleeving of pipelines

Where the application of polyethylene sleeving is specified or detailed in the Drawings, the following procedure shall be followed.

Immediately before lowering the pipes into the trench pipe shall be cleaned of all soil and foreign matter and any damage to factory-applied coatings made good. The sleeving as specified shall be slipped over the pipes and secured in place using adhesive PVC tape. The sleeving shall be pulled tight against the lower part of the pipe and the excess girth shall be gathered into a fold situated in the upper part of the pipe as laid. This fold shall be directed downwards from the crown of the pipe. The sleeving at the ends of the pipes shall be left loose until after jointing and wrapping has been completed. The loose sleeving shall then be carefully pulled over the joints so that it is continuous, and joints at the overlaps shall be secured with PVC tape. Bends, tees and similar fittings shall be protected similarly. Any sharp edges such as at bolted gland or flanged joints shall be padded with four thicknesses of sleeving material before the sleeving is placed over them.

Where pipes are supplied with the barrels already wrapped in polyethylene sheet, a loose sleeve of polyethylene sheet shall be fitted over one pipe end at each joint position prior to jointing. After jointing operations have been satisfactorily completed, this sleeve shall be pulled over the joint and secured with PVC tape to the pipes on either side so that, in conjunction with the factory-fitted sleeving, a continuous wrapping of the pipeline will be achieved. The method of fastening the joint sleeve shall be similar to that described above for loose sleeving.

Where the pipe is laid below the water table the polyethylene wrap shall be secured around the pipe with PVC tape at intervals of 600mm or less.

Care shall be exercised during handling, installing and backfilling to prevent damage to the sleeving. Any minor damage to the sleeving shall be repaired by wrapping a sheet of material cut from the sleeving material right round the pipe and so that it provides an overlap of at least 200mm past each side of the puncture; all edges being taped to the sleeving.

Polyethylene sleeving shall be omitted from the sections of pipes and fittings which are embedded in concrete and where there is a need to ensure a watertight seal between the pipe barrel and the concrete (such as where pipes pass through chamber walls) or where there will be an axial transfer of thrust between the pipe and the concrete (such as at valve and taper thrust blocks). The sleeving shall also be omitted from pipes which are embedded in a continuous concrete surround. The sleeving should be retained around fittings (such as bends and tees) where they are built into concrete thrust blocks which will only receive transverse thrusts from the pipeline.

Where the sleeving is to terminate where a pipe enters a concrete structure, the end of the sleeving shall not be embedded in the concrete. Before placing the concrete, the end of the sleeving shall be folded back clear of the concreting operations and a run of adhesive PVC tape not less than 50mm wide shall be affixed around the pipe barrel so that the centre of the tape is aligned with the eventual position of the concrete face. After concreting is completed, the sleeving shall be reinstated around the pipe up to the concrete face, any surplus being neatly folded back and secured to the pipe barrel with PVC tape. This shall be done in a way such that the end of the sleeving overlaps the tape previously placed around the pipe and such that no part of the pipe remains exposed. The termination of the sleeving shall be completed by placing a further run of adhesive PVC tape around the pipe, spanning between the end of the sleeving and the face of the concrete.

K17.6.1.9 Cutting of pipes

Pipes which are to be cut to enable fittings to be accurately positioned or to form closing pieces in any portion of the pipeline or to terminate in manholes or other parts of the work shall not be cut until after adjacent pipes have been laid and jointed and accurate measurement of the length required can be made. The Contractor shall determine the length of each cut pipe and the required angle and shape of the cut. The cut shall be neatly performed by an experienced skilled man using tools or machinery appropriate for the type and diameter of pipe to be cut. The cut ends of the pipes shall be shaped up and trimmed so as to ensure an accurate joint or termination as the case may be. Any damage to wrapping, coating or lining shall be made good.

The unused part of any cut pipe shall be disposed of off the Site unless, with the Engineer's approval, it can be used elsewhere in the Works or it is required to be returned to the Employer for use in future maintenance works.

K17.6.1.10 Closing lengths

The Contractor shall avoid using closing lengths wherever possible by laying pipelines in a continuous length.

Pipes for closing lengths or for inserting into pipelines already laid shall be cut to allow a gap of at least 20mm between adjacent pipe ends. Otherwise, the gap shall be as recommended by the manufacturer of the coupling. The closing joints in pressure pipelines shall be made with detachable flexible couplings with locating plugs except where otherwise specified or shown in the Drawings.

Where, in the opinion of the Engineer, completion of the internal lining would be impracticable or undesirable, the pipe ends (including the inside and outside of the pipe walls) shall be protected with an approved site-applied coating, applied in accordance with the manufacturer's instructions.

K17.6.1.11 External wrapping of joints and fittings

Unless otherwise specified or detailed in the Drawings, joints and fittings in pipelines to be buried shall be wrapped with material as specified.

After the jointing operation is complete, the pipe joint or fitting shall be thoroughly cleaned and dried and given one coat of primer supplied by the manufacturer of the wrapping material. The joint or fitting profile shall then be modified by the application of moulding putty supplied by the manufacturer of the wrapping material to provide a suitable profile for wrapping. Wrapping shall then be continued over the joint and shall lap with the works applied external protection on the pipes each side of the joint or to the extent specified elsewhere or shown in the Drawings. The wrapping shall be applied under tension to achieve conformability and intimate adhesion without trapped air pockets. Longitudinal overlap between adjacent strips shall be 25mm minimum. End overlaps where a new roll joins a completed one shall be 150mm minimum.

Field joints of fusion-bonded epoxy coated pipes shall be protected by heat-shrink sleeves. The sleeve shall be pre-cut to size and wrapped around the epoxy before it has cured. The completed sleeve shall conform to the pipeline shape, show no blisters or sign of air entrainment and the hot-melt adhesive shall be visible as a flow from all edges.

K17.6.1.12 Concrete bed and surround

Where specified or indicated in the Drawings, pipes shall be bedded and haunched or surrounded in concrete in accordance with the typical details shown in the Drawings. If not shown otherwise then the minimum extent of surround to any part of the pipe barrel shall be 150mm. Unless otherwise shown, concrete shall be unreinforced class M20. Any formwork required shall be of Class F1.

Each pipe shall be supported on at least two purpose-made precast concrete blocks, which shall be left in place. Concrete, other than the precast blocks, shall not be placed until the joints at each end of the pipe have been completed. The full width and depth of bedding concrete shall be placed and carefully worked and compacted beneath the pipe, followed at once by the addition of any haunching and surround concrete. Unformed surfaces shall be of spade finish. The pipe shall be prevented from floating or otherwise moving during concreting.

The continuity of concrete bed, haunch or surround to pipes with flexible socket and spigot joints shall be broken at each flexible joint by 25mm thick fibreboard, placed against the face of the socket. The concrete bed, haunch or surround shall be discontinued at detachable flexible couplings, leaving a clearance of 75mm each side of the coupling.

Where two or more pipelines are laid in the same trench, the joints shall coincide at the joints in the largest diameter pipeline where the continuity of the concrete bed, haunch or surround shall be broken. Any intermediate joints in the smaller diameter pipelines shall be surrounded in concrete.

K17.6.1.13 Anchor and thrust blocks

Concrete anchor and thrust blocks in accordance with the details shown in the Drawings shall be constructed at all tees, bends, tapers, valves and hydrants for the anchorage of the pipeline as appropriate. Concrete shall be of the class shown in the Drawings.

Unless otherwise detailed in the Drawings, thrust blocks shall be constructed with the bottom and thrust side surfaces bearing against undisturbed ground.

If blinding concrete is required or allowed to be placed beneath any horizontal thrust block, shear keys shall be formed on its upper surface as shown in the Drawings or directed by the Engineer.

K17.6.1.14 Chambers and manholes

Valve chambers, air valve chambers, flowmeter chambers, manholes and similar structures shall be built into the pipeline where shown in the Drawings or directed by the Engineer and shall be constructed in accordance with the Drawings and Specification.

Valve chambers in which pipes are anchored shall be treated as specified for anchor and thrust blocks.

If undisturbed ground has not been maintained next to a thrust-bearing surface, the gap shall be backfilled with mass concrete.

All pipework and fittings within the chamber shall be set to exact line and level prior to the construction of the chamber walls. Pipes, fittings and valves in chambers shall be protected from damage and soiling of coatings during construction. After construction all chambers and manholes shall be cleaned of any accumulation of silt, mortar, debris or any other foreign matter and shall be free of any such accumulation at the time of final inspection.

K17.6.1.15 Pipelines built into structures

Any pipeline, except continuous welded steel, which is built into a chamber, manhole or other structure, including a thrust block, shall be provided with two flexible joints outside each face of the structure. Unless otherwise detailed in the Drawings, the first joint shall be not more than one pipe diameter or 500mm, whichever is the smaller, from the outside face, and the length of pipe between the flexible joints shall be equal to two pipe diameters or 1000mm, whichever is the greater.

The flexible joints shall be either flexible spigot and socket joints or detachable flexible couplings.

Pressure pipes passing through the walls of valve chambers or other structures shall be ductile iron or steel provided, where detailed in the Drawings, with anchorage flanges designed to transmit the full end thrust with closed valve under test into the structure's wall. Boxouts, if used, shall be designed to fulfil the above requirements. Drawings showing the method of construction using boxouts shall be submitted for review by the Engineer.

Where no anchorage flanges are detailed for pipes passing through the walls of structures the pipe shall be provided with a puddle flange integral with the pipe wall or bolted on to resist movement of water along the pipe to concrete interface. Such puddle flanges shall protrude at least 50mm from the pipe barrel.

Where the pipeline is above ground level the short length of pipe providing flexibility shall be self-supporting.

Where pipes pass through non-water retaining masonry or brickwork, the masonry/brickwork shall be arched over the pipe barrel such that there is at least 50mm clearance to the pipe and the gap plugged with compressible filler as approved by the Engineer.

K17.6.1.16 Pipelines in the same trench

Where two or more pipelines are detailed as being laid in the same trench, the pipes shall be laid so that there is a minimum distance of 300mm between the barrels of the pipes, measured in plan at mid-barrel height, unless a greater distance is shown in the Drawings or is required to enable jointing to be properly completed. The invert levels of the pipelines shall be the same at any cross section, unless otherwise required.

The larger of the pipelines shall be laid in straight lines between bends as shown in the Drawings. Where it is necessary to increase the distance between the pipelines from that specified above to allow the construction of air valve or washout chambers or for any other reason, the deviation of a pipe from the line of the preceding pipe shall be made by deflecting as many flexible joints as necessary to limit the amount of deflection at each joint to not more than half that available.

K17.6.1.17 Installation of pipelines other than buried pipelines

The Contractor shall take due care to support adequately the pipework during installation until permanent supports and anchorages as detailed in the Drawings have been completed. The Contractor shall ensure that no excessive loads or stresses are imposed upon the plant, pipework or structure during installation.

Pipework systems shall be complete and checked for correct position and alignment with adjacent plant and structures immediately before and after being embedded in concrete.

Exposed pipework on pipe supports shall be provided with straps unless otherwise indicated on the drawings. Straps shall be mild steel to BS EN 10139, nuts and bolts shall be to BS 4190. Straps shall be formed and placed such that they conform accurately to the circumference of the pipe when securely bolted down. Straps and appurtenances shall be primed and then coated with zinc paint as approved by the Engineer, and shall be applied as per the manufacturer's instructions.

Where pipes are to have free axial movement the pipe straps shall not be tightened in such a way that axial movement is prevented, and the clearance between the pipe and strap is not more than 3mm around the upper arc. Free axial movement shall be provided by means of roller bearings mounted on the pipe support. The Contractor shall supply his design for the roller bearing, which shall have a sliding coefficient less than 0.1 and include appropriate provision for lubrication. The design shall be subject to approval by the Engineer.

Pipes between supports shall be straight and at constant gradient, changes of gradient shall only occur at fittings as shown on the drawings.

K17.6.1.18 Existing pipelines and buried cables

Where pipelines cross or run in close proximity to existing pipelines or buried cables, the crossings shall be constructed as shown in the Drawings, particular care being taken to avoid damage to the existing pipelines or cables. The Contractor shall give one month's advance notice of the work to the owners of the existing pipelines or cables, and shall comply with any special requirements of the owners for safety or security during progress of the work.

K17.6.1.19 Connecting to existing pipelines

Where the Drawings indicate that a connection of any kind is to be made into an existing pipeline or whenever the Contractor is directed by the Engineer to make such a connection, the Contractor shall verify before starting work on the connection, if necessary by excavating trial pits, that the materials to be furnished under the Contract will be suitable for making the connection.

Before making a connection into an existing pressure pipeline, the Contractor shall liaise with the authority responsible for the operation of that pipeline and shall locate the valves that will allow the isolation of the relevant section of the existing pipeline. The Contractor shall prepare a detailed programme for the completion of the connection, clearly indicating the period for which it will be necessary for the existing pipeline to be taken out of service and any measures that will be taken to prevent contamination of the existing pipeline. The programme shall also indicate the method and plant proposed and standby plant to be made available. The period of planned shut-down shall be kept to the minimum practicable in the circumstances. The Contractor's programme shall be subject to the approval of the Engineer and of the operating authority.

Work on the connection shall be undertaken in accordance with the approved programme. Unless otherwise agreed in writing, the operation of valves necessary to isolate the section of the existing pipeline and subsequently to restore it to service shall only be undertaken by staff of the operating authority. If so instructed by the Engineer, the Contractor shall assist the authority in carrying out any activities necessary to facilitate the efficient completion of work on the connection.
The new pipeline and, where practicable, the existing pipeline at the connection shall be tested for leakage. Any existing pipe, fitting or joint leaking due to damage occurring during the connection operation shall be removed and replaced by the Contractor at no extra cost to the Employer. The test shall be repeated until a satisfactory test is obtained. Additional cleaning and disinfection procedures required in respect of the connection shall be performed by the Contractor.

K17.6.1.20 Plugging of dead ends

The dead ends of pipes and fittings shall be plugged and concrete anchors shall be provided as shown in the Drawings.

K17.6.1.21 Cables sharing pipeline trenches

Where cables are detailed in the Drawings to be laid in pipe trenches the pipes shall be installed and fine backfill shall be placed to 150mm above the crown of the pipe. The cable shall then be laid as shown in the Drawings before the remainder of the trench is backfilled.

Where ducts are detailed as being laid in large radius curves in either the horizontal or vertical planes these shall normally be not less than 50m radius, unless a smaller radius is specifically detailed. In no case shall a curve of less than 25m radius be installed. Ducts shall be laid in regular curves of the required radius by bending the pipe during installation. Curves shall not be formed with angular deviations at flexible joints.

The Contractor shall provide the cable duct and draw cord as specified and shall lay and joint the duct, complete with draw cord, in the pipe trench to the line and levels ordered by the Engineer within the nominal dimensions of Trench Excavation.

Joints in the draw cord shall be kept to a minimum; they shall be at least as strong as the cord and shall be so made as not to cause any jamming in use.

In refilling Trench Excavation, the Contractor shall ensure that the duct is not displaced or distorted and that, whatever its position in the pipe trench, it is surrounded by at least 150mm of well-compacted soft material (free from stones greater than 20mm in size). Where directed by the Engineer the cable duct shall pass through sleeves cast into anchor and thrust blocks and the walls of junction boxes and the like, but it shall not be buried in concrete surround to pipes.

K17.6.1.22 Marker posts

In order to leave permanent indication of the route of the pipeline and the location of valves and hydrants, the Contractor shall provide and set up marker posts with indicator plates in accordance with the details specified and shown in the Drawings. Route marker posts shall be installed at every field and property boundary, at every change of horizontal direction and elsewhere as ordered by the Engineer. The Contractor shall insert a peg at the proposed location of each marker post. Marker posts shall be installed only after their location has been approved by the Engineer.

The marker posts shall be set up as soon as practicable after Trench Excavations have been refilled but the Contractor shall provide any temporary marking required and shall be responsible for correct information being given on the indicator plates. Indicator plates shall be fixed to their marker posts in accordance with BS 3251 Appendix A.

K17.6.1.23 Cleaning pipelines

Before commencing pressure testing, the Contractor shall clean out the part of the pipeline to be tested to the satisfaction of the Engineer. All materials and equipment necessary for cleaning shall be provided by the Contractor unless otherwise specified. Full records shall be kept of the cleaning and shall be submitted to the Engineer soon after the cleaning operations.

After the whole pipeline has been successfully pressure tested (whether as a whole or in sections) and the Contractor has removed all temporary works and has reconnected any parts temporarily removed from the pipeline, the Contractor shall finally clean out the whole pipeline and flush it through with clean water.

Flushing water shall be discharged only on sites or into conduits that are suitable. Discharges which cause damage, create a nuisance or health hazard, or interfere with the work of others will not be permitted. The Contractor shall obtain the consent of any local regulatory authority before discharging any water to a watercourse.

The Contractor shall be liable to the Employer for any damage caused to the pipeline or to pumps and other equipment of the Employer as a result of foreign matter of any kind not having been cleared out of the pipeline before it is handed over to the Employer.

K17.6.1.24 Swabbing of pipelines

Temporary swab insertion and retrieval points shall be incorporated into pipelines by the Contractor to suit the method proposed for swabbing where these points are not provided as part of the permanent works.

Swabbing of mains shall be carried out after pressure testing by passing a foam swab through the main. The swab shall be non-abrasive but shall fit compressed into the pipeline. Swab stiffness shall be selected to suit the pipe and lining material. The swab shall be driven at a velocity of between 0.3m/s and 1.0m/s by admission of treated water unless specified otherwise. Sufficient passes of the swab shall be made to produce clear water.

Swabs and debris from the pipe shall be disposed of to suitable locations by the Contractor. Flushing water shall be disposed of as specified in Clause K17.6.1.23.

All materials and equipment, including swab insertion and retrieval points shall be provided by the Contractor unless specified otherwise. Records shall be kept of the swabbing and shall be submitted to the Engineer soon after the swabbing operations.

K17.6.1.25 Disinfection of pipelines

Disinfecting pipelines shall be carried out in accordance with AWWA C651 except as otherwise specified. All materials and equipment necessary for disinfection shall be provided by the Contractor unless otherwise specified. Full records shall be kept of the disinfection and submitted to the Engineer soon after the disinfection operations.

Liquid chlorine, calcium hypochlorite or sodium hypochlorite may be used for disinfecting. If liquid chlorine is to be used it shall be used only in conjunction with proper equipment and under the supervision of qualified personnel who are familiar with the physiological, chemical and physical properties of this element and who are properly trained and equipped to handle any emergency that may arise.

Potable water pipelines shall be disinfected by the continuous feed method. Water entering the pipeline shall be maintained at a minimum of 20 mg/l available chlorine or such level as may be necessary to ensure that at the end of 24 hours the treated disinfecting water shall contain not less than 2 mg/l of chlorine at all points in the pipeline being disinfected. The chlorine concentration shall be measured at regular intervals in accordance with AWWA M12 to assure that the required concentration is maintained.

After the required retention period, the heavily-chlorinated water shall be flushed from the main using potable water until the chlorine concentration in the water leaving the main is no higher than that generally prevailing in the systems and not exceeding 0.1 mg/l. Chlorine-residual determinations shall be made to ascertain that the heavily chlorinated water has been removed from the main. Discharges shall be in accordance with the specification. De-chlorination shall be carried out if necessary in order to achieve acceptably low levels of residual chlorine in the discharge to satisfy the local drainage, sewer or river authority.

After final flushing and before a potable water pipeline is put into service, a sample, or samples, shall be collected from the end of the main which is remote from the source of supply and tested for bacteriological quality. Such samples shall show the absence of coliform organisms. Samples shall be collected in sterile bottles treated with sodium thiosulphate. No hose or fire hydrant shall be used in the collection of the samples. The Contractor shall install in the main, at no extra cost to the Employer, a sampling cock with a copper tube gooseneck. The sampling cock shall remain in place upon completion of the test.

If the initial disinfection fails to produce satisfactory samples, disinfection shall be repeated until satisfactory samples have been obtained.

K17.6.1.26 Painting of pipes, fittings and valves

Factory-applied coatings on pipes, fittings and valves in chambers and other exposed areas shall be made good on completion of construction of those chambers as necessary to return the items to the appearance on leaving the factory.

Where specified, exposed pipes, fittings and valves and their joints shall be over-painted to a colour to be agreed with the Engineer. Paint systems for over-painting shall be compatible with any factory coatings including coatings made good on site.

Bitumen coated items shall be primed with two coats of aluminium sealer to a total dry-film thickness not less than 30 microns. Top coats of approved colour of alkyd chlorinated rubber finish shall be applied sufficient to give a total over-paint dry-film thickness of 80 microns.

FBE or epoxy-coated items shall be lightly rubbed down with emery to provide a key and painted with 2 coats of alkyd or epoxy finish coats of approved colour.

K17.6.2 Steel pipelines

K17.6.2.1 General

Workmanship shall generally be in accordance with Sub-section K17.6.1 of the Specification with the following amendments and additional requirements. Installation shall be in accordance with the recommendations of CP 2010: Part 2 except where otherwise specified.

K17.6.2.2 Handling and storage

The Contractor shall develop the method of stock piling on his transport vehicles and shall furnish special loading spacers, bolsters and the like, approved by the Company's engineer, to protect the pipe during transport.

Coated pipe shall be handled at all times with wide non abrasive or leather belts or other equipment designed to prevent damage to the coating. All such equipment shall be kept in repair so as to prevent injury to the coating. The use of tongs, bare pinch bars, chain slings, protruding rivets, pipe hooks, or any other handling equipment that may be injurious to the coating shall not be permitted. The coated pipes will be padded while being transported and the Contractor shall take due account of the likely road condition throughout the year.

The bolster of the rail car, trailer, or barge shall have a bearing surface not less than 30 mm to give necessary support to the padding which protects the coating. Sacks partly filled with sand or sawdust should be placed on the bolster and between the outside bottom pipes and the bolster stakes

The maximum piling heights for various types of coated pipe shall be limited to such heights as will prevent damage to pipe nested with regular coated pipe.

Pipes shall be provided with 4-6 legged spider stiffeners so designed as not to damage the lining. The stiffeners shall not be removed until a joint is about to be made.

K17.6.2.3 Damaged Pipes, Specials, Valves, etc.

All pipes, specials, valves, etc., shall be carefully examined for damage prior to fixing or laying and prior concreting or backfilling.

If any pipe, special, valve, etc., is found to be damaged in any way, the Contractor shall notify the Engineer. The damaged item shall be clearly marked and set aside for repair, cutting to a shorter length or removal from site as the Engineer may direct. All expenses involved in repairing, cutting and or replacement of defective or damaged pipes, specials, valves, etc. shall be borne by the Contractor. The Contractor shall be responsible for any delays caused thereby. Only pipes which on inspection are found to be sound in every respect shall be fixed or laid.

Before steel pipes and specials are laid, all damaged covering and lining shall be cut out and replaced with new materials compatible with the sheathing material as directed by the Engineer. Cracks up to 0.8 mm. wide may be caulked with an approved material, provided the cracks are not fully circumferential and that no detached areas on lining can be detected in the internal mortar lining of steel pipes and specials.

All pipes, valves and specials shall be examined for rust and loss of paint prior to installing in position. The exposed surfaces of valves affected by rust shall be wire brushed and painted with repair coats of approved material compatible with the manufacture.

K17.6.2.4 Adequate separation from other pipelines

Where the pipeline runs parallel to existing pipes and cables, the distance of separation shall be 2(D+d), where D is the diameter of the larger pipeline and d the diameter of the small pipeline.

Where pipelines cross, the minimum distance shall be 500mm. If this cannot be achieved, both the pipelines at the crossing should be rigorously tested for holiday detection and Pearson detection. Furthermore, the trench for the new pipe shall be lined with polyethylene sheeting for a length agreed with the Engineer. This provision is to ensure electrical separation of the pipes/cables.

If high voltage cables are to be crossed, they shall be shielded by placing PVC split ducts around them for a length agreed with the Engineer.

K17.6.2.5 Installation

Unless specified otherwise or as permitted below, pipes shall be installed singly and shall not be jointed until after they have been laid.

Jointing of pipes outside the trench and installation as a string of pipes will be permitted only in straight trench where all parts of the string are lowered into the trench simultaneously. Such pre-jointed lengths shall not exceed 20m without the Engineer's written permission. Snaking into the trench of a pre-jointed string of pipes will not be permitted. Changes in direction or in grade of the pipeline shall be achieved whenever possible by the use of normal or shorter length pipes with the average deflection per joint not exceeding 2°.

Pipes manufactured with longitudinal or spiral welds shall be aligned before jointing so that these welds are at least 15° apart around the joint circumference.

Bedding and backfill material shall be placed and compacted in accordance with the procedure approved in the Trial, in layers not exceeding 150 mm thick. Bedding material shall be laid to a depth such that, with at least 300 mm of bedding below the pipe barrel, the base of the pipe is embraced over an arc as specified on the Drawings.

A dished recess to conform to the shape of the pipe shall be excavated in the bedding so that when the pipe is positioned to correct line and level it is substantially uniformly supported by the bedding. Part of the bedding shall be omitted at each joint to provide space to complete the joint.

The vertical and horizontal diameters at the ends and mid-point of placed pipe shall be measured and recorded. The pipe shall then be finally aligned, the joint made, air-tested and protected, and placing of the remaining bedding and backfilling shall be continued using methods and control as approved during the Trial. Surround material shall be compacted at near optimum moisture content by approved hand, mechanical or pneumatic tampers to the specified density. Care shall be taken to ensure that the material under the haunches of the pipe is thoroughly compacted. Stones that are likely to damage the pipe or its coating shall be excluded from the bedding and surround material and heavy mechanical compactors shall not be used within 300mm of the pipe crown.

Once the backfill has reached 300 mm above the crown of the pipe, the internal vertical deflection at the welded joint and mid-point shall be checked by an approved means. If deflection at this stage is such that subsequent backfilling is unlikely to restore the specified deflection, the backfill shall be carefully excavated and recompacted, or replaced if needed by better material.

Above 300 mm from the crown the remainder of the trench shall be backfilled with the appropriate material compacted in horizontal layers not exceeding 300 mm thickness under agricultural land or estate roads and 150 mm thickness under or alongside main roads.

The Contractor shall gradually withdraw any trench sheets as backfill is raised.

Concrete diaphragms or clay stanks shall be formed where shown on the Drawings or instructed on the Site to prevent the pipe trench forming a land drain.

When backfilling is completed the vertical and horizontal diameters at each joint and mid-point shall be measured again. The measured deflection shall be less than 2%.

No reinstatement shall be done until the Engineer has approved the backfill.

The Contractor shall record details of the successive procedures of Trench Excavation, placing bedding, pipe laying, jointing, air-testing, protection, backfilling hydraulic testing and reinstatement on a proforma, the layout of which shall be agreed with the Engineer at the commencement of the Contract. One copy of the pro-forma shall record all the activities related to each pipe length, and shall identify the pipe by both its manufacturing number and its potion in the line. Cut pipes shall be identified by the original manufacturing number of the whole pipe.

Concerning hydraulic testing, the pro-forma shall only note the result and the test pressure applied. Full details of the hydraulic testing shall be recorded elsewhere.

K17.6.2.6 Site welding of joints

Welding of joints in trench for steel pipes shall be carried out manually by the metal-arc process complying generally with the requirements of BS 4515.

Before starting the welding of pipe joints on Site, the Contractor shall submit for the Engineer's approval details of the plant, methods and materials he proposes to use, including make and size of electrodes, number of runs, current strength, and arrangements for air testing of individual joints.

The Contractor shall make test specimens on bare steel shells or pipes of the same size and thickness as the pipelines to be welded. The joints shall be tested in the presence of the Engineer for each procedure in accordance with requirements of A.P.I Standard 1104.

Welded joints in trench shall generally be of the parallel short-sleeve, spherical-spigot and socket type with a circumferential full-strength fillet weld both internally and externally. Welding gap tolerances shall be as specified. Full-strength fillet welds shall have a throat thickness not less than 0.7 times the thickness of the pipe to be welded.

Where pre-jointing of straight runs of pipe outside the trench is adopted, full-penetration butt welds executed by manual or automatic procedures to the approval of the Engineer may be used. Butt welds shall have a throat thickness not less than the thickness of the pipe wall. During welding, the pipe ends shall be securely held by an approved method ensuring a correct and uniform root gap.

At closing lengths where two plain-ended pipes are to be joined by a welded collar joint, the gap between the two pipe ends shall not exceed 75mm and the collar shall be placed centrally over the two ends to be jointed. The end of each pipe shall be welded to the sleeve collar using circumferential full-strength fillet welds both internally and externally. Where a split collar is used, the two halves shall be drawn together by tie bolts until the gap between them is less than 3mm. The four circumferential welds shall then be made, after which the tie bolts shall be removed and the longitudinal seam between the collar pieces welded. The tie bolt lugs shall then be cut off and the attachment points smoothed before the welds are tested.

Welding gap tolerances for collar joints shall be as specified.

All parts to be welded shall have scale, slag, loose rust, paint and other foreign matter removed by means of a mechanical brush and shall be left clean and dry immediately before welding. All scale and slag shall be removed from each weld run when it is completed and prior to air testing.

After completion of welding at each joint, magnetic crack detection tests shall be carried out on all fillet welds made and 100% radiographic examination carried out on all butt welds made. All such tests shall be carried out by the Contractor in the presence of the Engineer. Where butt joints are being welded mechanically, the Engineer may permit the proportion of weld radiographically examined to be reduced to 20% if and when and for as long as he is satisfied with the results being obtained. The standard of acceptability of welds shall be in accordance with API 1104 Section 6. Where necessary, welds shall be repaired in accordance with Section 10 of API 5L. Weld repairs shall not be made more than once at any position on the joint.

K17.6.2.7 Welders and welder performance tests

Welding shall be carried out only by welders approved by the Engineer and each welder shall identify his own work by means of a stencilled mark.

The Contractor shall submit for the Engineer's approval the names of persons whom he proposes to employ as welders and they shall carry out on Site the qualifying tests prescribed in BS 4515.

The Contractor shall maintain an up-to-date list of welders approved by the Engineer and, if ordered by the Engineer, he shall remove from the approved list any welder whose workmanship, as demonstrated by the results of air pressure and/or other tests and visual inspection of individual welded joints, is in the Engineer's opinion below a reasonable standard of quality or consistency.

K17.6.2.8 Site applied coating of joints

(a) Internal cement mortar protection at joints

The lining at joints and cable pass holes in factory cement mortar lined pipe steel pipe shall be completed using in situ hand applied cement mortar. It shall be completed within 24 hours of backfilling that length of pipe.

The Contractor shall not commence hand-placed lining at joints until the two pipes concerned have both been jointed and laid to the correct line and level in the trench and backfilled to the specified standard to at least 300mm above the top of the pipe.

Areas to which hand-applied mortar is to be applied shall be thoroughly cleaned of all protective coatings, loose material and grease, wire brushed and shall be moistened with water just prior to the application of the mortar. The adjacent lining shall be wetted with thick cement slurry but no accumulations of water in the gap shall be allowed. Hand mortaring shall not commence until the Contractor has received written confirmation from the Engineer that the surface preparation is acceptable.

Hand-placed in-situ mortar shall be as specified under 'Building Works' and shall consist of 1 part of cement to 1.5 parts of sand by volume, or other approved mix, and shall be of suitable water content and consistency for adhesion and trowelling to a smooth finish. The thickness of hand-applied mortar shall be the same as the adjacent factory-applied lining.

During operations within the pipe the Contractor shall maintain adequate ventilation for his personnel. Hand-placed mortar shall be finished with a steel trowel and shall have a smooth surface of uniform appearance with even transitions to adjacent machine-placed lining.

Curing of the lining shall commence immediately after completion of the lining operation at each joint or area of defect. The sections of the pipe to be cured shall be isolated and a moist atmosphere shall be maintained at the place to be cured to keep the mortar lining damp. Curing shall continue for two weeks.

Curing compounds shall not be used without the approval of the Engineer and, if approved, shall be used in accordance with the manufacturer's recommendations or otherwise as determined by the Engineer.

(b) Completion of coating & wrapping at joints

After the Engineer has advised the Contractor in writing that a joint to be buried has complied with the Specification, the external coating & wrapping shall be completed to ensure continuity of protection along the pipeline.

The Contractor shall ensure that personnel are not endangered by toxic fumes arising from the process of coating & wrapping at joints. The Contractor shall use operatives to do this work that have previous experience of similar operations.

Once the joint has passed the tests in the specification, the uncoated surface shall be machine cleaned and immediately primed as per the specifications and manufacturer's instructions. The cleaned joint shall be kept free of surface moisture and dust until the coating is completed.

Where the joint is to be completed with coal tar enamel, hot coal tar enamel will be poured and spread over the joint area after the primer is cured and fibre glass cloth immediately wound around ensuring adequate impregnation. A Second coat of enamel shall be applied and outer wrap wrapped around the joint area. A minimum 50mm overlap shall be made between the parent coating and the field joint.

Where the joint is to be completed with heat shrink sleeving, it shall be applied as per the Specification, and in accordance with the manufacturer's instructions.

The coating shall be tested in the presence of the Engineer using a Holiday detector.

K17.6.2.9 Access to interior of pipelines

Pipes provided with cable pass holes shall be laid so as to provide a pass holes positioned on the top of the pipeline at intervals of approximately 60m. When a pass hole is no longer required, the screw plug shall be replaced and welded to the pipe externally and the internal lining and external wrapping of the pipe shall be made good over the plug and holiday tested.

The Contractor shall record the location of all cable pass holes and that they have been sealed.

K17.6.2.10 Pipe cutting

Where it is necessary to cut pipes to provide closing lengths or for laying pipe specials or in the repair of damaged or chipped pipes, the cutting shall be neatly and accurately performed so as to have the end of the pipe truly normal to the axis of the pipe.

Where it is necessary to cut steel pipes to provide closing lengths the damaged concrete lining near the cut shall be repaired and shaped for jointing and the external coal tar enamel shall be stripped over a sufficient distance from the end to accommodate the collar joint or flexible mechanical coupling.

K17.6.2.11 Building Pipes through Structures

The plain end of a pipe built through a wall or structure shall protrude from the concrete by a maximum of 300 mm or that distance required to properly make the joint to the next pipe.

Any over excavation adjacent to a structure and beneath the formation level of a pipe trench to be excavated by the Contractor shall be backfilled to the formation level of the pipe trench with concrete Class M10. This concrete shall extend to the limit of the over-excavation along the line of the pipe trench and across the full width of the pipe trench shown on the Drawing or to the limit of the excavation whichever is the lesser.

Where the pipeline beyond structure is above ground and is to be coated in an aluminium Paint System, a rectangular chase 25 mm. deep and 25 mm wide shall be formed in the concrete as it is cast. The chase shall extend around the full perimeter of the pipe. After removing the former and allowed the concrete to cure, The Contractor shall clean and fill the chase completely with an approved thixotropic sealant to prevent ingress of moisture between the pipe and the concrete. The sealant shall be compatible with the aluminium Paint primer and system and shall achieve its final set within 24 hours, the aluminium paint then being applied across the face of the sealant up to the concrete.

K17.6.2.12 Making Joints with Mechanical Flexible Coupling and Flange Adaptors

Joints made with mechanical flexible couplings and flange adaptors shall only be made between pipe spigots which are of the correct external diameter and in strict accordance with the instructions given by the manufacturer, mechanical joints shall not be included on lengths of pipe in concrete surround.

The pipe ends at a flexible coupling shall be separated by an amount sufficient to accommodate expansion of the pipes due to a rise in temperature from ambient to 40 degrees C. The ends of each pipe shall be wire brushed before jointing to remove any protective material, rust, or other matter adhering to the coating. The pipe ends at the inside surface of the sleeve of the coupling or adaptor shall then be painted with two coats of approved bituminous paint.

The coupling or adaptor shall be slipped loosely over the fixed pipe, if possible, or otherwise over the loose pipe to be attached. The loose pipe shall then be supported in the correct position, axially aligned with the fixed pipe (or flange) and at the recommended distance from it. If at this stage it is apparent that one or both pipes, if this is practical, or to substitute a new pipe or pipes with squared end. The Contractor shall himself bear the cost of re-trimming or replacing pipes when he is responsible for a skew end.

The coupling shall then be aligned centrally over the gap between pipes and the bolts tightened systematically so that the sealing rings are uniformly and steadily compressed. If the coupling is not square to the pipe on completion the bolts shall be slackened for and then retightened when the coupling has been correctly positioned.

On completion of the joint, the Contractor shall sheath the joint by one of the Methods specified for sheathing joints.

K17.6.2.13 Painting of Exposed Steel Pipelines

Exposed portions of steel pipelines shall be protected by a paint system of which the primer coat shall have been applied in the manufacture's works.

Damaged primed surfaces shall be repaired in the field by cleaning and further priming with the same primer to at least the thickness of the works-applied primer coat.

After the completion of pipe assembly in the field, damaged areas of the primed surface shall be fully repaired and the whole surface shall be cleaned of foreign matter. The finishing paint coat shall then be applied.

The finishing coat shall be aluminium heat-resisting finish applied in sufficient layers (at least 2) to give a minimum dry film thickness of 50 micron.

The primer and finishing coats shall be mutually compatible and shall be from the same approved manufacturer.

The approval of the Engineer shall be obtained to all details of paint system application, including surface preparation, works environment, application techniques, intermediate drying times and repair of coatings.

Paint shall not be applied to wet surfaces or during rain. The Contractor shall be deemed to have made full allowance in his Tender for the effects of weather.

K17.6.2.14 Record of Materials and Articles buried by Backfilling

Before any excavation is backfilled, the Contractor or Articles and his representative and the Engineer or his representative shall make a joint inspection and compile a record of the number of buried pipes, specials, fittings, valves, joints etc. All such records shall be signed by both parties and shall be binding.

K17.6.2.15 Sampling Points

Where shown on the Drawings or directed by the Engineer, the Contractor shall fix 2-inch BSP tappings and blanking plugs into pipe work in chambers for the purpose of sampling and meeting.

K17.6.3 Ductile iron pipelines

Workmanship shall generally be in accordance with Sub-section K17.6.1 of the Specification with the following additional requirements.

Where specified pipes, joints and fittings shall be tape-wrapped or polyethylene-sleeved. Tape wrapping to pipes shall be factory applied, but wrapping for joints may be applied on site using materials in accordance with Clause K17.5.1.7

K17.6.4 High-density polyethylene (HDPE) pipelines

Workmanship shall generally be in accordance with Sub-section K17.6.1 of the Specification with the following amendments and additional requirements.

Installation shall be in accordance with the recommendations of CP 312: Parts 1 and 3 and of the manufacturers of pipes, fittings, tooling and equipment. Should any of these requirements conflict, the Contractor shall inform the Engineer of the conflict and propose the procedure to be adopted in sufficient time to allow the Engineer to approve or modify the Contractor's proposals.

HDPE pipe shall be handled and laid in such a way as to prevent damage by sharp objects. Any pipes with cuts, holes, deep scrapes or dents shall not be incorporated in the Works.

Thermal-fusion jointing, whether by socket-fusion, butt-fusion or the use of electrofusion couplings, shall be carried out only by workmen who have been trained in such work by a manufacturer of HDPE pipe meeting this specification. Thermal fusion jointing procedures shall be in accordance with specifications issued by WRc as Water Industry Specification WIS 4–32–08. The Contractor shall submit the names of thermal-fusion jointers to the Engineer for approval together with full details and evidence of the relevant training and experience each has received. Only approved jointers shall be allowed to make each type of joint.

Where not otherwise specified, pipes shall be joined using electrofusion couplings or socket or butt thermal fusion. However, socket or butt thermal fusion shall be used only where the Contractor has made proposals for its use and for routine testing of a proportion of joints which are acceptable to the Engineer. Should the Engineer become dissatisfied with the standard of socket or butt thermal-fusion jointing he may withdraw approval for its use, in which case electrofusion couplings shall be used.

Gradual changes in direction or grade of the pipeline may be made by bending the pipe provided that the pipe centre-line radius shall not be less than 40 times the pipe nominal diameter. Flexible joints are not required for use with HDPE pipe.

HDPE pipe or fittings to be built into concrete shall first be wrapped in not less than 3 layers of heavy-gauge polyethylene sheet.

K17.7 Inspection and testing

K17.7.1 Specialist inspection and testing

The Employer, under a separate contract, may employ a specialist firm to give the Engineer such assistance as he may require in any matter connected with pipelines, including the inspection of materials and workmanship and the witnessing of tests at any stage (including manufacture) during the execution and maintenance of the Works.

The Engineer may require the specialist firm to supervise welding procedure tests and welder performance tests and to carry out various independent tests such as holiday tests, Pearson tests, magnetic crack detection and radiographic examination of welded joints. Such independent tests may be carried out at any stage during the execution and maintenance of the Works but they shall not relieve the Contractor of any of his own obligations under the Contract.

To the extent ordered by the Engineer, the Contractor shall provide labour plant and materials for direct assistance to the specialist firm in their inspection and independent testing and for any further work of investigation and repair which the Engineer considers necessary as a result of such inspection or testing. Except where such provision is otherwise covered by the Contract, the cost of providing such labour, plant and materials shall be paid for by the Employer except in cases where, in the Engineer's opinion, the inspection, test or further investigation shows that materials and workmanship provided by the Contractor do not comply with the specified requirements, in which case the cost shall be borne by the Contractor.

K17.7.2 Inspection at time of installation

In addition to any inspection and tests made when delivery is taken, pipeline materials, including any coating, lining or other protection, shall be inspected by the Contractor immediately before and after installation and any damage shall be repaired by the Contractor as directed by the Engineer before the pipe or fitting is installed or jointed as the case may be. Any special material required for the repair of pipe lining, coating or protection shall be obtained from the pipe supplier and shall be used in accordance with his recommendations.

The Engineer may himself, and without thereby relieving the Contractor of any of his obligations, inspect and test the pipeline materials by any means he considers appropriate and any damage discovered by such inspection shall be repaired by the Contractor.

The Contractor shall remove from the Site and shall provide a replacement for any pipe or fitting which in the opinion of the Engineer is so badly damaged as to be unfit for repair on the Site.

K17.7.3 Testing pipelines — general

The Contractor shall subject all parts of the completed pipeline system to a final test. For the purposes of this final test, the pipeline system shall be divided into suitable sections as agreed with the Engineer. Each section shall be tested as soon as is reasonably practicable. All testing shall be witnessed and approved by the Engineer.

Where directed by the Engineer, a section of pipeline in a particularly difficult location shall be subjected to a hydrostatic test immediately the section has been completed using the final test pressure.

Notwithstanding the foregoing, the Contractor may at any stage of construction carry out such preliminary tests as he considers desirable to check materials and workmanship on the pipeline but this shall not relieve the Contractor of his obligations to achieve approved test results on completion.

The Contractor shall during testing demonstrate satisfactory operation under working pressure of each valve and hydrant installed under the Contract.

The Contractor shall supply all pressure gauges, meters, hoses, pumps, stop ends and other temporary supports and equipment necessary for carrying out tests.

The Contractor shall remain responsible for the care of the Works during testing and cleaning of the pipeline and in particular he shall take all precautions to prevent frost damage to any exposed parts of the pipeline.

K17.7.4 Procedure for site pressure testing

Steel pipelines shall be tested in accordance with ANSI B315 or DIN standard.

Before filling for pressure testing is started, the Contractor shall re-check pipes and valves for cleanliness and shall re-check the operation of all valves. The 'open' ends of the pipeline (or sections thereof) shall normally be stopped off by blank flanges or cap ends additionally secured where necessary by temporary struts, wedges or thrust blocks. All thrust blocks and valve chambers shall have been completed with backfill placed around them and the concrete shall have attained its specified 28-day strength, all pipe straps and other devices intended to prevent the movement of pipes shall have been securely fastened and backfilling of the trench between pipe joints shall have been placed to the extent necessary to prevent movement of the pipeline. Where the Contractor has not previously demonstrated to the Engineer's satisfaction that joints do not leak when subject to air tests, mechanical joints shall be left exposed for inspection during field pressure testing.

The section of pipeline to be tested shall be filled with water and all air shall be removed. Before the test proceeds further, the pipeline shall stand full of water for at least 24 hours at the working pressure. The pressure shall then be raised by pumping in water until the specified test pressure is reached and shall be maintained at this pressure by further pumping for a period of not less than 1 hour during which time the pipeline shall be inspected for points of concentrated leakage. In the case of pipelines of absorbent materials, this period shall be extended as necessary until the absorption has ceased. Pumping shall then cease and the time (T) for the observed pressure head to fall by 10m shall be recorded. Pumping shall then be resumed and the quantity of water (Q) pumped into the pipeline from calibrated container(s) in order to restore the test pressure shall be recorded. Provided that if the observed pressure head has not fallen by 10m before an expired period of three hours, then pumping shall be resumed at once and the time (T) shall be recorded as being three hours. The rate of loss shall be calculated as being the quantity (Q) into the pipeline from calibrated container(s) divided by the time (T).

K17.7.5 Test standard for pressure pipelines

If the rate of loss as calculated above does not exceed the figure given below, the pipeline (or section thereof) shall be deemed to have passed the pressure test, provided that there is no evidence of concentrated leakage.

Type of pipeline	Allowable rate of loss (litres per 24 hours per 10mm of nominal internal pipe diameter per kilometre of pipe for each 30m head of pressure applied)
Steel pipelines with butt-welded or internally and externally welded sleeve and spigot joints, and less than 10% flexible joints	0.25
All other pipelines	1.0

K17.7.6 Action following test failures

If the pipeline (or a section thereof) fails to pass the pressure test the Contractor shall locate the faults and shall uncover, repair, retest and reinstate the pipeline as may be necessary until all parts of the pipeline shall have passed the pressure test.

K17.8 Particular requirements

K17.8.1 Working pressure and site test pressure

Works and site test pressures and definitions of design pressures/pressure ratings for different materials are as follows:

Materia l	Source	Design / Rating pressure (DP)	Works test pressure (WTP)	Site test pressure (STP)
Steel	BS 3601 BS 10224	Design pressure as STP	Pipe: according to steel grade Fittings: 1.5 × MSOP	1.5 × MSOP
Ductile iron	BS 8010: Sect 2.1	Class suitable for MSOP (K9, 12, 14 etc)	According to Class	MSOP + 5 bar
HDPE	IS 4984: 1995 & WIS 4-32-13	Class suitable for MSOP	According to SDR	1.5 × MSOP

MSOP = Maximum sustained operating pressure
SDR = Standard dimension ratio (OD/thickness)

The value of the maximum sustained operating pressure (MSOP) at a given point shall be calculated as the difference between the level of total energy head and pipe invert at that point, including any allowances for surge.

K17.8.2 Bedding, surround and backfill to pipes

The type of bedding, surround and backfill to be used at any location is referred to in the drawings as either Class A or Class B.

The bedding, surround and backfill is divided into three zones, as shown on the drawings. The zones are defined as Zone I, II and III. The material to be used in each zone, for each class of bedding is shown in the table below:

Class A

Zone	Material	Source	Compacted Density
I	Granular, graded material up to 10mm or Sand	Imported or selected excavated material	85%

II	Granular graded material up to 20mm- For HDPE or bitumen enamel wrapped steel material shall be up to 10mm	Imported or selected excavated material	85%
III	General	Excavated material	85%

Class B

Zone	Material	Source	Compacted Density
I	Mass concrete	-	
II	Granular graded material up to 20mm For HDPE or bitumen enamel wrapped steel material shall be up to 10mm	Imported or selected excavated material	85%
III	General	Excavated material	85%

Compaction shall mean with respect to maximum dry density as determined in test 13 of BS1377.

Granular graded material shall be as follows:

Size	Specification
up to 10mm	Free from silt, clay, dust and organic impurities. 100% by weight shall pass a BS 10 mm sieve and not more than 10% by weight shall pass a BS No.100 sieve.
up to 20mm	100% shall pass a BS 20 mm sieve and not more than 10% by weight shall pass a BS No.200 sieve.

Zone III shall generally be excavated material but in certain circumstances the Engineer may determine that the material is inappropriate and instruct the Contractor to dispose of such material and use imported material instead, which may be from other excavations on Site.

Pipes shall not be supported on timber wedges, pre-cast concrete blocks, or other hard materials.

The material shall be tested in accordance with BS 812: Part 111, and shall have a 10% fines value greater than 50kN. Material retained on a 7mm sieve shall have an index of flakiness less than 25% and an index of elongation less than 45%.

K17.8.3 Pipeline trials

Prior to proceeding with laying pipelines the Contractor shall do a trial to test the Contractor's proposed method of working and provide a basis for systematic control throughout the Contract. The Contractor shall submit a method statement to the Engineer for approval three days before undertaking the trial. The trial shall not commence until the Engineer has approved the statement and the Contractor has provided in the site laboratory all staff and equipment necessary for the trial.

The trial shall conform to the approved method statement and shall take place at a point on the pipe route so that if it is successful the work can form part of the permanent works.

In the trial, the Contractor shall excavate the trench, prepare the pipe bedding, lay and join the pipes, air-test the joints, apply protection and place and compact the backfill up to 300 mm above the crown of the pipe over a total pipeline length of 30 metres. All these procedures shall be carried out in conformity with the Specification using methods, plant and personnel that the Contractor proposes to use on the remainder of the Contract.

During the trial the Contractor shall measure soil properties and other parameters as and where required by the Engineer. The list of measurements required will include but not be limited to the following:-

(a) JKR probes in undisturbed ground after stripping top soil;
(b) Proctor Needle tests on trench base;
(c) Pocket penetrometer tests on trench sides;
(d) Atterberg limits of bedding material;
(e) Moisture content/dry density relationship for bedding material;
(f) Particle size distribution of bedding material;
(g) Measurement of bedding material layer thickness (Before and after measured number of passes of compaction plant);
(h) In-situ density of bedding;
(i) Proctor Needle tests of bedding;
(j) Moisture content of bedding materials, before the placing;
(k) Tests on backfill material as for bedding material;
(l) Determination of backfill placing sequence and optimum trench width to allow passage past pipe of plant used to compact backfill below and alongside waist to pipe;
(m) Measurement of pipe internal deflections on delivery, after placing, after welding and during and after backfilling.

After the trial the Contractor shall confirm in writing his method of working and testing subject to the approval of the Engineer. The Contractor shall follow these procedures unless the Engineer orders that a new Trial shall be carried out. Reasons may be when there is a significant change in conditions or when the Contractor proposes a different method of working.

All laboratory tests related to the Trial and to subsequent control of pipe laying shall be carried out in the Contractor's site laboratory. In-situ density shall be measured by sand replacement.

K17.8.4 Tests on granular bedding, pipe surround and trench backfill

The Contractor shall be responsible for carrying out all field and laboratory tests to ensure that all fill material placed complies with the grading limits specified and plasticity index (where specified), that the material is compacted to within the specified limits of dry density and at moisture contents within the limits specified. Testing shall be to BS 1377 unless otherwise approved.

Particle-size distribution (grading) shall be determined by the appropriate test from Clause 9 of BS 1377: Part 2. The tests described in 9.2 and 9.5 shall be used unless otherwise agreed by the Engineer.

Bedding and fill density shall be determined by the sand-replacement method generally in accordance with the test described in Clause 2.2 of BS 1377: Part 9 or a similar approved test.

Samples for laboratory testing of maximum dry densities and optimum moisture contents shall be on samples taken adjacent to and including in-situ density test locations.

Maximum dry densities and optimum moisture contents for compaction control by relative compaction shall be derived using the test described in Clause 3.3 of BS 1377: Part 4 and maximum and minimum dry densities for compaction control by relative density shall be derived using the test described in Section 4 of BS 1377: Part 4.

The location of each field test or sampling point shall be to the approval of the Engineer.

Test results and copies of calculations shall be submitted to the Engineer promptly upon completion.

K17.8.5 Deflection of pipes

Where deflection of any section of any pipe exceeds the maximum allowable values stated below at any time including during handling storage or installation before or after backfilling, the pipe shall be removed from the works and disposed of by the Contractor who shall provide a replacement pipe.

Pipe material	Maximum allowable deflection as proportion of true circular diameter
Steel pipes (with mortar or concrete lining)	2%
Steel pipes (without mortar or concrete lining)	5%
HDPE pipes	5%

K17.8.6 Cover

Except as otherwise indicated in the drawings, the minimum cover shall be as follows:

Land Type	Minimum cover(m)
Open land	0.9
Panchayat Roads	1.0
National Highway	1.2

K17.8.7 Commissioning of Transmission Main

Commissioning shall mean the progressive disinfection of sections of the main, bringing the main into service and operating it for the period designated in the Specification. The Contractor shall submit a programme to the Engineer one month in advance of the date of commencement of commissioning and the programme shall be subject to the approval of the Engineer.

As part of the commissioning the Contractor shall demonstrate that all valves are operable, functioning, and the mains behaves safely when static pressure is fully developed such that no movement occurs at thrust blocks / anchor blocks, valve chambers, pipe supports on piers of bridges, etc.

At the time of handing over the work to the employer the contractor shall furnish a detailed manual describing operation and maintenance of all pipe components, the modes of charging the pipe and emptying the pipe etc. He shall train the employer's staff in operation and maintenance during the commissioning period.

K18.0 PIPELINES FOR WASTE WATER

K18.1 Scope

This Section contains requirements which, where relevant to this Contract, shall apply to the supply, handling, installation, jointing, testing and cleaning, of pressure pipelines, sewers and other gravity pipelines, including valves, sluice gates and fittings of all kinds (except as may be noted hereunder), whether required to be laid in, on or above ground or to be fixed on or built into other parts of the Works. It also applies to uPVC cable ducts but does not apply to drainage for roads, or to pipelines for water supply or building services.

Excavation and refilling of pipe trenches shall be carried out as specified for Earthworks.

K18.2 Definitions

The following terms shall have the meanings hereby assigned to them except where the context clearly renders these meanings inapplicable:-

"Pipes" pipes, bends, junctions and other specials and includes jointing parts (except material required for the completion of run-lead, leadwool, yarn and mortar, and welded joints).

"Valves" valves, sluice gates (generally described as penstocks in the UK), air valves, hydrants, metering devices and the like and includes jointing parts, operating gear, and associated fittings.

"Manholes" manholes and inspection chambers on gravity pipelines; chambers for air valves and washouts on pressure pipelines; including precast concrete manhole sections, access covers, ladders and other fittings.

"Installation" handling placing and fixing in position ready for jointing pipes and valves, whether in trench or elsewhere in the Works.

"Pipeline appurtenances" all items additional to pipes, valves and manholes required to complete a pipeline including, where relevant, but not limited to internal and external protection systems, supports and anchorages, washouts, vent columns and marker posts.

"Pressure pipelines" pipelines for the conveyance under pressure (normally by pumping) of raw or treated water, stormwater, sewage, industrial waste, effluent, washwater or sludge, inclusive of pipes, valves, manholes and pipeline appurtenances.

"Gravity pipelines" pipelines which do not normally run full, used for drainage and for the conveyance of liquids, including but not limited to stormwater, sewage, industrial wastes, partially treated wastes, effluents and washwater, inclusive of pipes, manholes and pipeline appurtenances.

K18.3 Reference Standards

Unless otherwise specified, pipelines for waste water shall comply with the relevant Reference Standards listed below.

Standard	Subject
BS 65	Vitrified clay pipes, fittings and ducts, also flexible mechanical joints for use solely with surface water pipes and fittings.
BS EN 295: Part 1	Vitrified clay pipes and fittings and pipe joints for drains and sewers; requirements
BS 437	Cast iron spigot and socket drain pipes and fittings.
BS EN 512	Asbestos cement pressure pipes and joints.
BS EN 124	Manhole covers, road gully gratings and frames of cast iron and cast steel.
BS EN 10224	Steel pipes, joints and specials for water and sewage.
BS EN 1097: Part 111	Testing aggregates: Methods for determination of TFV.
BS 1196	Clayware field drain pipes and junctions.
BS EN 13139	Building sands from natural sources.
IS 5455	Manhole steps.
BS 1377	Methods of test for soil for civil engineering purposes.
BS EN 1982	Copper alloy ingots and copper alloy and high conductivity copper castings.
BS EN 1561	Flake graphite cast iron.
BS EN 681 & BS EN 682	Elastomeric seals for joints in pipework and pipelines.
BS EN 12163	Copper and copper alloy rods and sections.
BS 3284	Polythene pipe (Type 50) for cold water services.
BS 3416	Bitumen-based coatings for cold application.
BS 3506	uPVC pipe for industrial uses
BS EN 588	Asbestos cement pipes, joints and fittings for sewerage and drainage.
BS 4190	ISO metric black hexagon bolts, screws and nuts.
BS 4320	Metal washers for general engineering purposes, metric series.
BS EN10113	Weldable structural steels.
BS EN 1092 & BS EN 1515	Circular flanges for pipes, valves and fittings: Steel, cast iron and copper alloy.
BS EN 545	Ductile iron pipes and fittings.
BS EN 1514	Dimensions of gaskets for pipe flanges to BS 4504.
BS 4999	General requirements for rotating electrical machines.
BS EN 1171	Cast iron gate valves.
BS EN 12334	Cast iron check valves for general purposes.
BS 5292	Jointing materials and compounds.
BS EN 102245: Part 1	Code of Practice for selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres : General

	recommendations.
BS 5395:Part 3	Code of Practice for the design of industrial type stairs, permanent ladders and walkways.
BS ISO 11922 & BS ISO 4065	General requirements for dimensions and pressure ratings for pipe of thermoplastics materials.
BS 5886	Methods for field pressure testing of asbestos cement pipelines.
BS 5911	Precast concrete pipes, fittings and ancillary products.
BS 6076	Tubular polyethylene film for use as protective sleeving for buried iron pipes and fittings.
BS 7079: Parts O & A	Preparation of steel substrates before application of paints and related produtes: Introduction and visual assessment of surface cleanliness.
BS EN 14161	Code of Practice for pipelines: Pipelines on land, general.
CP 312	Code of Practice for plastics pipework (thermoplastics material).

K18.4 Submissions by the Contractor

Submissions which the Contractor is required to make in relation to pipelines for waste water include, where relevant, the following:-

K18.4.1 Drawings

- Typical drawings of standard items;
- Detail drawings of special items.

K18.4.2 Data

- Manufacturer's calculations, catalogues and data sheets including pressure/temperature ratings for pipes, fittings and joints;
- Method of boxing out for and building pipes into structure walls;
- Methods of control of line and level of pipeline during installation.

K18.4.3 Records to be kept

The Contractor shall keep detailed and up-to-date records in a form to be approved by the Engineer of all pipes and valves, showing the quantities of each type, size and class which have been

(a) ordered during the course of the Works;

(b) delivered during the course of the Works;

(c) declared on delivery to be faulty damaged or deficient;

(d) broken damaged or lost during the course of the Works.

Each week the Contractor shall provide the Engineer with an up-to-date copy of the above records.

K18.4.4 Certificates of tests

The Contractor shall forward to the Engineer before dispatch, certificates from the manufacturers to show that pipes and valves have been tested and comply with the appropriate British Standard.

K18.4.5 Method and programme of pipeline testing and cleaning

The Contractor shall submit for the approval of the Engineer details of his proposed methods and programme for pipeline testing and cleaning (including details of test and cleaning equipment).

K18.5 Materials and equipment

K18.5.1 General

Materials for pipelines shall be manufactured to the specification given hereunder and shall be provided by the Contractor except as specified otherwise.

K18.5.2 Vitrified clay pipes

Clayware pipes shall be in accordance with BS EN 295 but shall not be Class L (`Lower strength'). Alternatively clayware pipes may be `Extra strength' pipes in accordance with BS 65, provided that the application is consistent with Clause 1 (Scope) of that specification.

The Contractor will be at liberty to use pipe lengths up to the maximum normally manufactured. Some shorter pipes with flexible joints may be required to permit the required levels, positions and lengths to be accurately obtained.

K18.5.3 Clayware field drain pipes

Clayware field drain pipes shall comply with BS 1196. The Contractor will be permitted to use seconds quality stoneware open jointed spigot and socket pipes in their place at no additional cost to the Employer.

K18.5.4 Concrete pipes

All concrete pipes and fittings for gravity pipelines shall be in accordance with BS 5911 and shall be spigot and socket pipes with Stanton Cornelius flexible joints or similar approved.

The pipes shall be made with an approved aggregate and sulphate resisting Portland cement, shall be centrifugally spun and shall be obtained from an approved manufacturer. The pipes shall generally be in the manufacturer's full lengths.

The Contractor will be at liberty to introduce half length and quarter length concrete sewer pipes at no extra cost to the Employer if he finds it expedient to do so.

K18.5.5 Ductile iron pipes

All ductile iron pipes and fittings shall comply with BS EN 545 and shall be obtained from an approved manufacturer.

Except where indicated otherwise, all socket and spigot pipes and fittings and flanged pipes and fittings shall be to the standard class designation (K9, K12 and K14). Socket and spigot pipes and fittings shall be suitable for Tyton or Stantyte type joints or, where required, for Viking-Johnson type couplings. Flanges shall be PN16.

K18.5.6 Cast iron drainage pipes and fittings

Cast iron drainage pipes and fittings shall conform to BS 437.

Joints shall be caulked with tarred hemp and sealed with mastic.

K18.5.7 High density polyethylene (HDPE) pipes

All high density polyethylene pipes for sewerage purposes shall comply with BS 3284 and BS ISO 11922 AND BS ISO 4065, and shall have a minimum sustained pressure rating of 12 bar.

K18.5.8 Connections between different pipe materials

Where different types or classes of pipe material are jointed together, the Contractor shall supply special fittings or stepped couplings designed and manufactured to suit the ends of pipes to be jointed. Stepped couplings shall comply where applicable with the requirements for flexible couplings and flange adapters as specified hereafter.

K18.5.9 Gaskets for flexible joints

Gaskets for joints shall be obtained from the manufacturer of the pipe or joint.

Joint gaskets shall comply with the relevant requirements of BS EN 681 AND BS EN 682, shall be of a material suitable for making a long term flexible seal between the pipes and shall be resistant to mechanical, chemical or bacteriological attack leading to deterioration of the flexible seal.

Lubricants used during jointing shall have no deleterious effects on the joint rings, pipes or pipe coating.

K18.5.10 Flanged Joints

Flanges and bolting shall be to BS EN 1092 and BS EN 1515, PN16, except where otherwise detailed on the Drawings or specified. Gaskets shall be inside bolt circle type to BS EN 1514. Gasket material shall be single ply fabric reinforced rubber, 3.2 mm thick, in accordance with BS 5292. Gaskets shall be of such physical properties as to be capable of forming permanent watertight joints against pressures up to the maximum test pressure. The use of jointing paste or grease will not be permitted. Bolts and nuts shall be to BS 4190 and washers to BS 4320. There shall be two washers per bolt. Each bolt shall be of sufficient length to show two threads past the nut when installed.

The Contractor shall be responsible for checking and ensuring that mating flanges are compatible in all cases, including where connections are to be made to existing pipe flanges.

K18.5.11 Flexible couplings and flange adaptors

Where detachable flexible couplings or flange adaptors are for use with pipes these shall be of the Viking-Johnson type.

Flexible couplings for each size of pipe shall be capable of withstanding the shear force applied by the weight of a 4 m length of pipe of that diameter full of water suspended between two couplings.

Flexible couplings shall be provided with central register ribs or location plugs where specified or detailed on the Drawings.

Flange adaptors shall have flanges as specified for flanged joints. The metal components of detachable flexible couplings and flange adaptors shall be protected as specified.

K18.5.12 Sluice valves

All sluice valves shall be obtained from a single approved manufacturer to the following requirements.

Sluice valves shall be in accordance with BS EN 1171 Class PN 10 with flanges to BS EN 1092 and BS EN 1515, PN 16.

The face to face dimensions of sluice valves have been taken to be in accordance with the above when determining the lengths of flanged pipework given in the Bill of Quantities. If valves with a different face to face dimension are supplied, the lengths of straight pipes shall be adjusted accordingly.

Each sluice valve shall be fitted with a handwheel on a non-rising spindle and arranged to close in a clockwise direction.

Extension spindles of aluminium bronze to BS EN 12163 shall be provided where shown on the drawings.

K18.5.13 Non-return valves

Non-return valves shall be in accordance with BS EN 12334, swing type Class PN 10. They shall have gunmetal faces with the internal parts easily removable and with external hand operating levers. The flanges shall be the same as those for sluice valves.

K18.5.14 Air valves

Where shown on the Drawings or described in the Bill of Quantities air valves for sewage pumping mains shall be `Epex' dual orifice air valves manufactured by Glenfield & Kennedy Ltd. of Kilmarnock, Scotland, or similar.

K18.5.15 Sluice gates

All parts shall be of adequate section and ribbed where necessary to withstand the hydraulic and operating forces. Sluice gates for channel mounting shall have flush inverts.

Screw operating sluice gates shall have rising spindles unless otherwise specified or detailed on the Drawings. Rising spindles shall have robust clear protection tubes with gate position indicators.

A headstock, handwheel or operating key shall be supplied with each sluice gate.

K18.5.16 Cast iron sluice gates

The materials for the various component parts for cast iron sluice gates shall be as specified in Table below:

<table>
<tr><th rowspan="2">Type of Sluice Gate</th><th colspan="4">Component materials</th></tr>
<tr><th>Frames and gates</th><th>Sealing faces</th><th>Spindles and lifting rods</th><th>Thrust nut</th></tr>
<tr><td>Vertical screw spindle - flush invert, channel mounted</td><td rowspan="4">Cast iron to BS EN 1561

Grade 220 for all types or LH4</td><td>Rubber</td><td rowspan="2">Aluminium bronze to BS EN 12163</td><td rowspan="2">Gunmetal to BS EN 1982 Grade LG2 or LG4</td></tr>
<tr><td>Vertical screw spindle - face mounted</td><td>Gunmetal to BS EN 1982

Grade LG2 Galvanised</td></tr>
<tr><td>Vertical - hand lifted</td><td></td><td>Galvanised steel</td><td></td></tr>
<tr><td>Pivoted disc - hand lifted</td><td></td><td>Steel</td><td>-</td></tr>
</table>

Cast iron sluice gates shall have adjustable wedges to ensure tight closing of the gates in the frames.

The hand lifted types shall be provided with a means for locking the gate in any position from full open to closed.

The pivoted disc flushing sluice gates shall be of the sliding sealing face type with lever action lifting handles and rods.

K18.5.17 Fusion bonded epoxy coating

Fusion bonded epoxy coatings shall be as described in the section 'Pipelines for water supply'.

K18.5.18 Wrapping material

Wrapping material shall be as described in the section 'Pipelines for water supply'.

K18.5.19 Polyethylene sleeving

Polyethylene sleeving for loose pipe wrap shall conform to BS 6076. Suitable adhesive PVC tape shall also be provided to fix the sleeving in position and to make joints between the adjacent sections.

K18.5.20 Marker tape for buried services

The marker tape shall be as described in the section 'Pipelines for water supply'.

K18.5.21 Precast concrete manholes

Precast concrete circular manhole sections and cover slabs shall conform in all respects to BS 5911: Part 200 and shall be obtained from Stanton & Staveley Ltd or other approved manufacturer. They shall be made with an approved limestone aggregate and the chamber and shaft rings shall be spun. The chambers shall be 1 200 mm internal diameter, and the shafts 675 mm internal diameter, the tapers connecting them being of the straight back type. All precast cover slabs shall be heavy duty and shall be provided with 600 mm (minimum) tapered opening over which the cast iron manhole cover will be set. The slabs shall be provided with built-in lifting rings.

K18.5.22 Manhole covers and fittings

The covers and frames for manholes shall be to BS EN 124 Table 3 with a clear opening of 600 mm diameter. They shall be carefully set to the slope of the ground or road surface.

Manhole covers on all foul sewers shall be embossed with the word `Foul'.

K18.5.23 Handrailing

Handrailing shall consist of tubular standards with 35 mm outside diameter handrailing and shall be heavily galvanised.

K18.5.24 Safety chains

Safety chains shall be made from 38 mm links and permanently attached at one end and hooked at the other. The safety chains, including the hooks and rings, shall be heavily galvanised. Alternatively the safety chains may be of black nylon of an approved type.

K18.5.25 Manhole steps

Manhole steps shall be galvanised malleable iron step irons to IS 5455 of approved pattern.

Alternatively, where indicated, round iron step irons 300 mm wide, and projecting 150 mm from the finished face of the work, shall be provided as detailed on the Drawings and shall be heavily galvanised. Manhole steps irons shall not be painted.

K18.5.26 Ladders

Fixed ladders shall be in accordance with BS 5395: Part 3 and shall be mild steel hot dip galvanised.

K18.5.27 Nuts and bolts

All bolts, nuts and washers are to be in accordance with BS EN 10113 as regards material and with IS 1363 as regards dimensions. Two washers shall be supplied and fitted with each bolt. All bolts and nuts shall be zinc or cadmium electroplated.

K18.5.28 Bricks

Where engineering brickwork is specified the bricks shall be Class B engineering bricks.

All bricks shall be well shaped, hard, sound, uniform in size and free from cracks and flaking.

K18.6 Workmanship

K18.6.1 Handling

Throughout the construction of the pipeline including the operations of off-loading, delivery, handling, storing and transporting pipes, valves and precast manhole sections on or about the Site, the Contractor shall use such methods, plant and equipment as will prevent damage to the pipes, valves, precast manhole sections and to any sheathing, lining or paintwork, and such methods shall include the use in appropriate cases of pipehooks, lifting beams, reinforced canvas slings, protective padding, struts, cradles and pipe trailers.

Temporary packing, coverings or crates provided by the suppliers for the protection of pipes and valves in transit shall not be removed (except for purposes of inspection after which they shall be replaced) until immediately before the pipe or valve is installed, and shall then be disposed of by the Contractor.

No pipe shall be moved by rolling, save over suitable timber planking so arranged as not to damage the pipe or its sheathing.

K18.6.2 Delivery

The Contractor shall take delivery of and off-load pipes, valves, and precast manhole sections which he is required to provide at times and at locations or storage-areas on or about the Site to be arranged by him with his suppliers. Any such location or storage area which does not form part of the Site shall be arranged for by the Contractor at his own risk and expense.

After pipes, valves and precast manhole sections have been delivered to and off-loaded at delivery locations as aforesaid the Contractor shall make all arrangements for subsequent transport and handling on or about the Site to the point of installation, including where necessary any movement into and out of temporary storage.

The Contractor shall inspect all pipes, valves and precast manhole sections upon delivery from the manufacturer and shall note all damaged, broken or otherwise unsatisfactory items and shall take immediate steps to rectify or replace such broken or damaged or unsatisfactory items. Items with damaged fusion bonded epoxy coatings shall be treated in accordance with Clause K18.6.43.

K18.6.3 Storage

The Contractor shall take into temporary protective storage all pipes, valves and precast manhole sections not required for immediate installation in the Works or, in the case of pipes and precast manhole sections, for stringing out along the pipeline route.

Valves shall be stored under cover until they are required for installation and particular care shall be taken for the protection of any associated electrical or mechanical equipment.

Pipes in storage shall be laid on wedged timber bearers so as to be at least 100 mm clear of the ground; pipes may be stacked up to three pipes high if suitable protective packing is placed between the layers. To prevent damage to the sheathing of pipes which are sheathed with bitumen the bearers shall be positioned at the unsheathed ends of the pipes.

The period between taking delivery of a pipe and the completion of its installation shall be kept to a minimum and in the case of steel pipes this period shall not exceed six months. Any period during which the pipes are strung out along the pipeline route or placed alongside the Works awaiting installation shall also be kept to a minimum and if this period exceeds one month pipes shall be raised at least 100 mm from the ground on timber bearers. Jointing parts and materials shall in any case be stored under cover as for valves.

Subject to the foregoing and to any restrictions of the duration of temporary occupation of parts of the Site, pipes may be strung out along the pipeline route prior to installation providing that any necessary temporary fencing has first been erected.

K18.6.4 Installation of pipelines - general

Trench Excavation and backfilling shall be co-ordinated with the construction of the pipeline as a whole so as to ensure expeditious completion of the whole operation.

Trench Excavation and backfill shall be carried out in accordance with the requirements for Earthworks in this Specification and, where not otherwise specified, in accordance with Section 4 of BS EN 14161. The minimum depth of cover above pipelines shall normally be 1200mm in roads, and 900mm in fields and open lands, the depth of cover being measured from original ground level to the top of the barrel of the pipe. Any pipeline with less than normal cover shall be surrounded with at least 150 mm of concrete.

The Contractor shall submit full details of the methods he proposes to use for control of the accuracy of pipelaying. Where sight rails are used, they shall be fixed and maintained at each change of gradient, and at as many intermediate points as may be necessary, but not more than 35 m apart. Sight-rails shall be clearly painted in contrasting colours and be not less than 1 metre long and 150 mm deep, straight and level, rigidly supported by stout wooden posts at each end. Any pipes placed on end for affixing the base of the posts shall be not less than 225 mm in diameter and shall be filled and rammed solid with earth or sand. Posts shall otherwise have their bases concreted in, with the approval of the Engineer. Boning rods or travellers for use with sight rails shall be of robust construction, clearly painted and accurately made to the various lengths required, the lower ends being provided with shoes with sufficient projection to rest on the pipe inverts.

Unless specified otherwise pipes shall be installed singly and shall not be jointed until after they have been laid. The Contractor shall keep the interior of pipes clean and free from water, dirt, stones and other foreign matter as installation proceeds, and at the end of the day's work or other times when installation work is not proceeding the open ends of the pipes shall be sealed off by a suitable stopper. The Contractor shall take such precautions as are necessary to prevent pipes from floating.

Wherever pipes, cables, ducts and similar services are buried in the ground a marker tape shall be laid 300 mm above each and every service in the trench.

K18.6.5 Installation of pressure pipelines

The lines and levels of the pipeline and the positions of the bends, junctions and other fittings which are shown on the Drawings may be adjusted by the Engineer as necessary before construction of a particular section commences. The pipeline shall be accurately installed to the lines, levels, grade and positions required.

Pipes shall be laid to even grades for as long a length as possible, with a minimum grade of 0.2%, irrespective of local changes of elevation of the ground surface. Changes in direction or in grade of the pipeline shall be carried out by making use of any permissible deflection of joints between straight pipes or by the introduction of bends.

Socket and spigot pipes shall normally be laid with sockets leading. Where the gradient exceeds 5%, installation shall proceed on an ascending grade with sockets leading. After laying and jointing, the invert level of each pipe shall be checked before the next pipe is installed.

Joint holes shall be excavated to provide adequate clearance to enable joints to be made satisfactorily and any specified wrapping to be completed and to provide a clearance of at least 50 mm from the trench bottom below the joints.

K18.6.6 Installation of gravity pipelines

Each length of pipe shall be laid in a straight line, both in the horizontal and vertical planes, the levels and gradients shown upon the Drawings being rigidly adhered to unless otherwise ordered in writing by the Engineer.

Site rails shall be used to control the accuracy of pipelaying unless the Engineer directs otherwise. Strong site rails shall be placed at each end of the length of pipeline to be laid and not more than 35 metres apart. A third sight-rail shall be used wherever possible for ease of checking against accidental displacement.

Where pipelines are to be bedded on concrete, precast concrete bedding blocks shall be set to a level allowing for the thickness of the pipe barrel, and side string lines shall be used for checking alignment.

K18.6.7 Installation of valves

Valves shall be installed in the Works as shown on the Drawings or directed by the Engineer. Installation of valves shall include installation and fixing of any operating gear and associated fittings. Before installing valves the Contractor shall tighten all loose nuts and bolts on the valves and associated equipment and shall ensure that they are watertight and in proper working order.

Valves shall be fixed in manholes before the benchings are constructed. They shall be coated with grease and the Contractor shall take precautions against damaging and fouling them during concreting operations.

Where a valve is built into the benching it shall be surrounded by a 75 mm casing of lime mortar to facilitate subsequent removal. The lime mortar shall be rendered with cement mortar 20 mm thick.

After installation valves shall be cleaned inside and out, and shall be left in the closed position.

The spindles of all valves without actuators shall extend to the positions indicated on the Drawings; they shall be for ease of operation and bracketed 150 mm below tops of walls and at intervals not exceeding 2 400 mm.

The provision for fixing sluice gates to walls shall be subject to the approval of the Engineer and all sluice gates shall be watertight on completion. Sluice gates shall be bedded on and pointed up with cement mortar. Sluice gates shall be maintained in the closed position during installation.

All bolts, nuts and washers on the sluice gates and the foundation bolts, nuts and washers shall be of bronze.

Working drawings for all sluice gates shall be submitted to the Engineer for approval prior to manufacture.

K18.6.8 Bedding to pipes

Clayware and concrete pipes for gravity pipelines and clayware lateral pipes shall be laid on concrete bedding. For pressure and gravity pipelines of steel, grey iron and ductile iron pipes, the bottom of the trench shall be finished smooth and free from irregularities, so that the pipes bear uniformly and are supported throughout their entire length. The holes required at each joint shall be made as small as possible.

Where ordered by the Engineer pressure and gravity pipelines of steel, grey iron and ductile iron pipes, shall be bedded on soft material from nearby Trench Excavations. The bedding material shall be placed and compacted using a vibrating plate or similar type of compacting machine, and shaped to provide continuous support to the bottom of each pipe along its full length.

Where the base of the Trench Excavation is in rock, a further 150mm of rock shall be excavated below the intended bedding line for the pipe barrel and this excavation shall be refilled with soft material, or with sand free from stones greater than 19mm size, or with concrete.

K18.6.9 Concrete bedding and surround

Where specified or indicated on the Drawings or ordered by the Engineer, pipes shall be bedded haunched or surrounded in concrete in accordance with the typical details shown on the Drawings. Concrete shall be un-reinforced of the grade shown on the Drawings or itemised in the Bill of Quantities. Any formwork required shall be of Class F1.

All gravity pipelines and laterals, except those which are surrounded with concrete or are of steel, grey iron or ductile iron, shall be laid on a concrete bed with a minimum thickness under the pipe as shown on the Drawings. Such concrete shall not be placed until the joints at each end of the pipe have been completed. The full width and depth of bedding concrete shall be placed and carefully punned beneath the pipe, followed at once by the addition of any haunching and surround concrete. Unformed surfaces shall be of spade finish. The pipe shall be prevented from floating or other movement during concreting.

Wherever pipes are provided with concrete protection they shall be supported temporarily on precast concrete blocks cast to the shape of the bedding and where they have a concrete surround the depth of the precast concrete block shall be increased to suit. For the pipes the precast concrete blocks shall be positioned behind each socket. The width of the precast concrete blocks shall be half the diameter of the supported pipe subject to a minimum and maximum of 115 mm and 300 mm respectively. The blocks shall be left in and paid for as in-situ concrete.

To ensure flexibility of the pipeline a 12 mm thick board of softwood, `Flexcell' or other approved material cut to shape shall be placed at each pipe joint to break the continuity of the concrete protection completely. In the case of clayware pipes the board shall be placed against the face of the socket.

Where two or more pipelines are laid in the same trench the joints shall coincide at the points where the continuity of the concrete surround is broken, ie at the joints in the pipeline with the longest pipes. Any intermediate joints in the other pipelines with shorter pipes shall be surrounded in concrete.

K18.6.10 Granular bedding and surround

Where indicated on the Drawings or ordered by the Engineer, pipes shall be bedded with granular material up to the half pipe diameter and for the full width of the trench. uPVC and other `flexible' pipes shall be surrounded with granular material across the full width of the trench and to a level at least 100 mm above the top of the pipe.

Granular bedding shall be well compacted to the correct levels so that pipes are given full support along the entire barrel length. Recesses shall be formed in the granular bedding to accommodate sockets, collars or other pipe joints. Pipes shall not be supported on timber wedges, pre-cast concrete blocks or other point supports.
After pipes have been correctly laid and tested further granular material for haunching or surround shall be placed and carefully compacted so no disturbance of the pipe occurs.

Material for granular bedding and surround shall be coarse sand.

The material shall be tested in accordance with BS EN 1097: Part 111, using specimens in the soaked condition, and shall have a 10% fines value greater than 50 kN.

Whenever the Engineer directs, a test for compaction shall be carried out on the material for granular bedding in accordance with CP 312: Part 1 Appendix A.2.

K18.6.11 Jointing - general

This clause shall be read in conjunction with the particular requirements specified for each type of joint.

Before making any joint the Contractor shall ensure that the interior of each pipe or fitting is clean and that it remains clean. Immediately before starting a joint the Contractor shall clean the end of each pipe to be jointed and shall prepare the ends for jointing as necessary. All mechanical joints shall be cleaned and have their coating made good before assembly.

The Contractor shall use only the proper jointing parts as specified and obtained from the suppliers of pipes or fittings. All joints shall be assembled and tightened in accordance with the manufacturer's instructions and shall be capable of passing the test for individual joints and for the completed pipeline as specified.

Detachable flexible couplings shall be installed where detailed on the Drawings. The joints shall be assembled and tightened in accordance with the manufacturer's instructions.

Where the Drawings show, or the Engineer requires, a change of direction to be achieved by the deflection of a flexible joint of any kind, the deflection shall not exceed 50% of the design value for the size and type of joint as recommended by the manufacturer.

After each joint has been completed, any protective or other coating shall be made good and any lining shall be completed as specified or detailed on the Drawings without delay. Any metal joint which is not already coated shall be cleaned and painted with two coats of bituminous paint to BS 3416 (excluding Clause 10).

K18.6.12 Joints for clay ware pipes

Clayware pipes shall be jointed with due regard to the manufacturer's instructions.

K18.6.13 Joints for concrete pipes

In making joints for concrete pipes the Contractor shall take account of the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular the Contractor shall ensure that rubber rings are correctly positioned and free from twists. The rubber rings and any recommended lubricants shall be obtained only through the pipe supplier.

K18.6.14 Joints for iron pipes

In jointing iron spigot and socket pipes and specials the Contractor shall take account of the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular the Contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, that the rubber ring is correctly positioned in the socket and that the two pipes are accurately in line, before the joint is made. After the joint has been made the Contractor shall ensure by the use of a suitable feeler gauge that the rubber ring is evenly seated in its correct final position. The rubber rings and any recommended lubricant shall be obtained only through the pipe supplier.

K18.6.15 Viking Johnson type couplings for iron or steel pipes

In jointing iron plain ended pipes with Viking Johnson or similar couplings the Contractor shall take account of the manufacturer's recommendations as to the methods and equipment to be used in assembling the joint. In particular the Contractor shall render the end of each pipe perfectly smooth so as to allow the joint sleeve to slide freely and where necessary shall re-coat the pipe ends with two coats of quick drying bituminous solution.

K18.6.16 Flanged joints for iron or steel pipelines

When assembling flanged joints the rubber joint ring may be fastened to the bolts with cotton thread. The use of jointing paste or grease will not be permitted. The bores of abutting pipes or fittings shall be concentric with the joint gasket positioned centrally; no joint material is to be left protruding into the bore. All nuts shall first be tightened by hand and nuts on opposite sides of the joint circumference shall then be alternately and progressively tightened with a spanner so as to ensure even pressure all round the joint.

K18.6.17 Joints for plastic pipes

The joints for uPVC, polythene and HDP pipes shall be of the mechanical type, and solvent welding or thermofusion techniques shall not be used without the approval of the Engineer. The pipes shall be laid and jointed strictly in accordance with the manufacturer's instructions and shall conform to CP 312.

K18.6.18 Closing lengths

Pipes which are required to be cut to form closing pieces in any portion of the pipeline or to terminate in manholes or other parts of the Works shall not be cut until after all adjacent pipes have been installed and jointed. Pipes for closing lengths shall be cut to allow a 20 mm gap between adjacent pipe ends.

The Contractor shall determine the length of each closing piece and the end of the pipe shaped up and trimmed so as to ensure an accurate joint or termination as the case may be. Any damage to sheathing coating or lining shall be made good.

Pipes terminating in manholes and the like shall except where otherwise specified be cut so that the end of the pipe is flush with the face of the structure into which it is build.

The closing joints in pressure pipelines shall be made with detachable flexible couplings with locating plugs.

The Contractor may arrange at his own risk for cuts to be performed by the pipe supplier.

K18.6.19 Work inside pipelines

The Contractor shall provide, operate and maintain adequate systems of access, lighting and ventilation to any part of a pipeline where work is in progress inside the pipes.

K18.6.20 Protection of iron pipes and valves

Except where decorative painting is specifically detailed (for example within pumping stations) pipes and valves installed above ground or in chambers and tanks shall be provided with a bituminous coating at the manufacturer's works. After installation, the items shall be thoroughly cleaned and given two further coats of bituminous paint to BS 3416 (excluding Clause 10).

All buried iron pipes and valves, including Viking Johnson couplings, shall be protected from corrosion with wrapping material as specified below.

K18.6.21 External wrapping

Where specified or detailed on the Drawings, pipes, fittings and valves which are to be buried in the ground shall be protected with wrapping material. All items not wrapped before installation shall be clean and dry and shall be given one coat of primer supplied by the manufacturer of the wrapping material. Joint and fitting profiles shall then be modified by the application of moulding putty supplied by the manufacturer of the wrapping material to provide a suitable profile for wrapping. Wrapping shall then be carried out and shall lap with the works-applied protection on the pipes on each side of the joint. The wrapping shall be applied under tension to achieve conformability and intimate adhesion without trapped air pockets. Wrapping shall be carried out with a 55% overlap of adjacent strips. End overlaps where a new roll joins a completed one shall be 150 mm minimum.

K18.6.22 Sleeving of pipelines

All ductile iron pipes shall be provided with polythene sleeving as specified. After the application of wrapping material, where specified, and immediately before lowering the pipe into the trench the sleeving shall be slipped over the pipe and secured in place using adhesive PVC tape. The sleeving shall be pulled tight against the lower part of the pipe and the excess girth shall be gathered into a fold situated in the upper part of the pipe as laid. This fold shall be directed downwards from the crown of the pipe. The sleeving at the ends of the pipes shall be left loose until after jointing (and wrapping if specified) has been completed. The loose sleeving shall then be made continuous over the joints with an overlap of at least 300 mm and secured with PVC tape.

K18.6.23 Pipelines in the same trench

Where two or more pipelines are detailed as being laid in the same trench the pipes shall be laid so that there is a minimum distance of 150 mm between the barrels of the pipes, measured in plan at mid-barrel height, unless a greater distance is shown on the Drawings or is required to enable jointing to be properly completed. The invert levels of the pipelines shall be the same at any cross section, unless otherwise required.

The larger of the pipelines shall be laid in a straight line as shown on the Drawings. Where it is necessary to increase the distance between the pipelines from that specified above to allow the construction of air valve or washout chambers or for any other reason, the deviation of a pipe from the line of the preceding pipe shall be made by deflecting the flexible joints.

K18.6.24 Anchor and thrust blocks

Concrete thrust and anchor blocks shall be constructed at all tees, bends, tapers, valves and hydrants necessary for the anchorage of the pipeline. Concrete shall be grade M20.

Unless otherwise detailed on the Drawings thrust blocks shall be constructed with the bottom and thrust side surfaces bearing against undisturbed ground and shear keys shall be formed on the upper surface of concrete blinding for horizontal thrust blocks.

K18.6.25 Pipelines built into structures

Any pipeline which is built into a chamber, manhole or other structure, including a thrust block, shall be provided with two flexible joints outside the face of the structure. Unless otherwise detailed on the Drawings the first joint shall be not more than one pipe diameter or 500 mm, whichever is the greater, from the outside face, and the length of the short pipe between the flexible joints shall be equal to two pipe diameters or 1000mm, whichever is the greater.

The flexible joints shall be either flexible spigot and socket joints or detachable flexible couplings.

Pressure pipes passing through the walls of the valve chambers or other structures shall be ductile iron or steel provided with anchorage flanges designed to transmit full end thrust with closed valve under test into the structures wall. Boxouts, if used, shall be designed to fulfil the above requirements. Drawings showing the method of construction using boxouts shall be submitted for approved by the Engineer.

Where no anchorage flanges are detailed for pipes passing through the walls of structures the pipe shall be provided with a puddle flange integral with the pipe wall or bolted on to resist movement of water along the pipe to concrete interface. Such puddle flanges shall protrude at least 50 mm from the pipe barrel.

In the case of clayware gravity pipelines the short length of pipe built into the wall shall be of the same material and shall be surrounded in concrete. Where uPVC pipes are built into walls or surrounded with concrete they shall be protected with wrapping material, with a 55% lap, to a point 50 mm outside the face of the wall or concrete surround.

Where the pipeline is above ground level the short length of pipe providing flexibility shall be self supporting.

K18.6.26 Installation of pipelines other than buried pipelines

The Contractor shall take due care to support adequately the pipework during installation until permanent supports and anchorages have been completed. The Contractor shall ensure that no excessive loads or stresses are imposed upon the plant, pipework or structure during installation.

Pipework systems shall be complete and checked for correct position and alignment with adjacent plant and structures immediately before and after being embedded in concrete. Brackets and fixings shall be painted with two coats of bituminous paint to BS 3416 (excluding Clause 10).

K18.6.27 Connecting to existing pipelines

Where a connection of any kind is to be made into an existing pipeline, the Contractor shall verify before starting work on the connection, if necessary by excavating trial pits, that the materials to be furnished under the Contract will be suitable for making the connection.

Before connecting into an existing pressure pipeline, the Contractor shall locate the valves governing the flow to the section of pipeline in question and shut these valves after obtaining the approval of the Engineer. These valves shall be re-opened only after obtaining the approval of the Engineer.

The Contractor shall take into account that the period of interruptions of the service in the existing pipeline shall be minimised.

The existing pipeline to which the connection has been made, as well as the new, shall then be tested for leakage. Any existing pipe failing to pass the test due to damage occurring during the connection operation shall be removed and replaced by the Contractor at no extra cost to the Employer. The test shall be repeated until a satisfactory test is obtained. Any additional cleaning and disinfection procedures required in respect of the connection shall be performed by the Contractor at no extra cost to the Employer.

K18.6.28 Plugging of dead ends

The dead ends of pipes and fittings shall be plugged as indicated on the Drawings or as directed by the Engineer. Concrete anchors shall be provided.

K18.6.29 Cables sharing pipeline trenches

Where cables are detailed on the Drawings to be laid in pipeline trenches, the pipes shall be installed and fine backfill shall be placed to 150 mm above the crown of the pipe. The cable shall then be laid as shown on the Drawings before the remainder of the trench is backfilled.

K18.6.30 Route marker posts

In order to leave permanent indication of the routes and depths of pressure pipelines and cables where they are below ground the Contractor shall provide and set up marker posts with aluminium indicator plates.

The marker posts shall be set up as soon as practicable after Trench Excavations have been refilled but the Contractor shall provide any temporary marking required and shall be responsible for correct information being given on the indicator plates.

Marker posts shall be provided at changes in direction of the main or cable and at field boundaries and elsewhere as may be ordered by the Engineer indicating the diameter and depth of the main cable below giving ground level.

K18.6.31 Chambers and manholes

The requirements for anchors and thrust blocks in respect of excavation, backfilling and forming shear keys in the concrete blinding for horizontal thrust blocks shall also apply to valve chambers in which pipes are anchored.

If undisturbed ground has not been maintained next to a thrust bearing surface the gap shall be backfilled with mass concrete.

All chambers and manholes shall be cleaned of any accumulation of silt, mortar, debris or any other foreign matter and shall be free of any accumulation at the time of final inspection.

K18.6.32 Manholes on gravity pipelines - general

A manhole shall be constructed at each alteration of gradient or direction, at each intersection with other sewers and at such other points, not exceeding 80 metres apart.

The excavation for the manholes shall be carried to such depths as may be determined from the sewer sections or as are directed by the Engineer.

Backfilling around manholes shall be carried out as construction proceeds. On no account shall the concrete work be built up so far ahead of backfilling as to impede proper consolidation of the backfill material.

When constructing manholes provision shall be made for future connections thereto from future sewers by laying one length of pipe sealed by a cap as ordered.

All manholes shall be watertight on completion.

K18.6.33 Precast concrete circular manholes

Except for the base, precast manholes shall be formed using precast concrete circular manhole sections and cover slabs.

All joints in precast manhole sections shall be made with cement mortar except in the case of manholes protected in accordance with the clause `Protection of manholes' hereafter.

The bases shall be cast in situ in concrete 150 mm thick and shall be poured upon a blinding layer of concrete not less than 80 mm in thickness.

The clayware channel inverts including all necessary bends, tapers, junctions and double junctions shall be accurately laid to fall, the bends being as `slow' as possible by siting manholes `off centre' at changes in direction. The sewer pipe shall be built into the vertical upstands which shall vary in height above the crown level of the sewer pipe to obtain the required manhole depth with standard precast rings.

The manholes shall be surrounded with grade 20 concrete 150 mm thick as shown on the Drawings and the concrete shall be shuttered with Class F1 formwork.

Manhole floors shall be constructed of grade 20 concrete benching and grade 25 precast concrete bullnosed sections, formed to the required shapes. The top of the in-situ benching shall be sloped back at 1 in 12 and rendered with cement mortar 20 mm thick.

Galvanised malleable iron step irons at vertical intervals of 300 mm and 300 mm centres horizontally shall be fixed in the precast circular manholes.

K18.6.34 Cast-in-situ manholes

Cast-in-situ manholes shall be rectangular and the walls, bases and cover slabs shall be cast-in-situ reinforced concrete grade 25.

The channel shall be formed using RCC on straight-through manholes, or 20 mm layer of sulphate resisting cement mortar on internal-bend manholes. The manhole floors shall be constructed of grade 20 concrete benching formed to the required shape and the top of the in-situ benching shall be sloped back at 1 in 12.

Junction manholes shall be arranged so that the branch sewer enters the manhole on the opposite side to the access platform unless directed otherwise by the Engineer.

All bends on sewers up to and including 600 mm dia. shall be sited inside the manholes. All bends on sewers over 600 mm dia shall be sited outside and immediately downstream of the manholes.

Galvanised mild steel ladders, handrailing standards and safety chains shall be fixed in the rectangular manholes as shown on the Drawings. The safety chains at access openings shall be permanently fixed at one end and hooked at the other and the safety chains across sewer openings shall be fixed at both ends.

K18.6.35 Flushing manholes

Flushing manholes, as shown on the Drawings, shall be placed at the head of each sewer.

K18.6.36 Fixing and positioning manhole covers

Cast iron covers shall be built with their frames bedded on the concrete cover slabs except where the Engineer directs that a course of engineering brickwork shall be introduced. On no account will more than one course be allowed.

The covers shall be carefully set to the slope of the ground or road surface. After setting in position the lifting and prising holes provided in the cover shall be cleaned out and refilled with tarred hemp.

K18.6.37 Cover keys

Two pairs of keys for use with each type of cover shall be handed over by the Contractor at the completion of the Contract.

K18.6.38 Protection of manholes

The internal surfaces of manholes located on sewers at and within 2 000 metres downstream of a pumping main discharge connection shall be provided with an anti-corrosive coating.

Joints between clayware channel inverts and concrete benching, shall be made with sand epoxy mortar as approved by the Engineer.

On completion of the construction of the manholes and the testing for watertightness, all internal faces including precast concrete sections and cover slabs, benching, precast concrete bullnosed sections and concrete in manhole bases shall be painted with an approved protective coating system. The materials shall be used strictly in accordance with the manufacturer's instructions, with particular attention to the provision of fresh air (by means of a power fan) when painting.

K18.6.39 Brickwork

All brickwork shall be uniformly bedded, bricks always being laid frog upwards, and each brick `floated', `rubbed in' or `hammered down' upon such a sufficient quantity of mortar that the mortar may be squeezed up into the joints and each joint not already full shall be `flushed up' with the mortar of the next succeeding bed. The whole of the beds and joints shall be completely filled and compressed so as to ensure the greatest possible density. Horizontal weathered jointing shall be provided to all external faces. Bricks with a very high suction may be wetted, but not saturated, immediately before laying. Engineering brickwork shall not be laid in wet weather. Should any joints to external faces become damaged by frost or otherwise they shall be cut out to a depth of 20 mm and caulked with mortar and finished as above without extra charge.

All engineering brickwork shall be built in cement mortar as specified.

K18.6.40 Cement mortar

All cement mortar shall be composed of fine aggregate and cement in such proportions as may be specified or as directed by the Engineer.

The ingredients shall be thoroughly mixed while dry by machine or hand until the cement colour can no longer be distinguished from the fine aggregate in any part of the mass and then shall be uniformly wetted by means of a rose while undergoing further thorough mixing.

The mortar shall be prepared and used at such places and times and in such quantities that a longer time than thirty minutes shall not elapse between the first wetting and its completed use upon the Works. If mixed by hand no single mixing shall exceed a quarter of a cubic metre.

The fine aggregate for cement mortar shall comply with BS EN 13139, the grading being in accordance with Table 1.

K18.6.41 Ventilating columns

Aluminium ventilating columns as specified shall be provided at all pumping main discharge manholes, and at other manholes as shown in the Drawings.

The side tube which is supplied loose shall be suitably aligned and sealed with 'Denso chrome' or similar approved tape at its connection to the shaft as shown in the Drawings.

The shaft, which is supplied with a heavy-duty bitumastic coating on both internal and external surfaces from its butt end to 75mm above ground level, shall be erected so that the full planting depth, that is from the butt end to ground level, is set in concrete grade 20 made with sulphate resisting cement. The concrete shall be finished as closely as possible round the shaft in order to avoid creating a crevice.

The columns shall be positioned and connected to the manhole as directed by the Engineer.

K18.6.42 Cleaning pipelines

The pipelines shall be kept thoroughly cleaned and ready for inspection by the Engineer at any time and an adequate supply of expanding rubber plugs shall at be available all times to ensure that all pipe-ends are stoppered off. Except when cleaning or water testing, water shall not be allowed to flow through the pipes.

Gravity pipelines and ducts shall be proved by passing through them a train consisting of an approved badger and a circular rubber squeegee followed by a wooden ball. The wooden ball shall not be smaller than 25 mm less in diameter than the pipes under inspection. The Contractor shall remove any obstruction found during these operations.

Before commencing pressure testing the Contractor shall clean out the part of the pipeline to be tested to the satisfaction of the Engineer. The method of cleaning shall be decided by the Contractor and may include flushing through with water.

After the whole pipeline has been successfully pressure tested (whether as a whole or in sections) and the Contractor has removed all temporary works and has reconnected any parts temporarily removed from the pipeline the Contractor shall finally clean out the whole pipeline and flush it through with clean water.

K18.6.43 Repair of fusion bonded epoxy coatings

In the event of a fusion bonded epoxy coating being damaged after leaving the factory, the item shall be returned to the factory for repair or, with the approval of the Engineer, be repaired at Site. Repairs shall be effected in accordance with the following requirements:

(a) repair materials shall be compatible with the original factory-applied coating materials;

(b) the edges of the original factory-applied coating shall be ground off to a taper or feather edge;

(c) exposed metal shall be treated as specified in Clause K20.4.18;

(d) the relative humidity of the atmosphere in which the repair is to be effected shall be maintained (if necessary, by the use of hot air blowers and tenting) at less than 85%;

(e) the surface temperature of the exposed metal shall be raised to at least 3°C above dew point and the coating shall then be applied in stages, as recommended by the manufacturer, so as to achieve a total thickness in accordance with Clause K20.4.18.

All repairs shall be checked with a holiday detector and any holidays shall be repaired, after which the repairs shall be re-checked.

K18.7 Inspection and testing
K18.7.1 Specialist inspection and testing

The Employer may, under a separate contract, employ a specialist firm to give the Engineer such assistance as he may require in any matter connected with pipeline materials, including the inspection of materials and workmanship and the witnessing of tests at any stage (including manufacture) during the execution and maintenance of the Works.

Such independent inspection and witnessing of tests may be carried out at any stage during the execution and maintenance of the Works but they shall not relieve the Contractor of any of his obligations under the contract.

To the extent ordered by the Engineer, the Contractor shall provide labour plant and materials (but not special testing equipment) for direct assistance to the specialist firm in their inspection and independent testing and for any further work of investigation and repair which the Engineer considers necessary as a result of such inspection or testing. The cost of providing such labour, plant and materials shall be paid for by the Employer except in cases where in the Engineer's opinion the inspection, test or further investigation shows that materials and workmanship provided by the Contractor do not comply with the specified requirements, when the cost shall be borne by the Contractor.

K18.7.2 Inspection at time of installation

In addition to any inspection and tests made when delivery is taken, pipeline materials, including any sheathing, lining or protective paintwork, shall be inspected by the Contractor immediately before and after installation and any damage shall be repaired by the Contractor as directed by the Engineer before the pipe or fitting is installed or jointed as the case may be. Any special material required for the repair of pipe sheathing or lining shall be obtained from the pipe supplier and shall be used in accordance with his recommendations.

The Engineer may himself, and without thereby relieving the Contractor of any of his obligations, inspect and test the pipeline materials by any means he considers appropriate and any damage discovered by such inspection shall be repaired by the Contractor.

The Contractor shall remove from the Site and shall provide a replacement for any pipe or fitting which in the opinion of the Engineer is so badly damaged as to be unfit for repair on the Site.

K18.7.3 Testing pipelines - general

The Contractor shall subject all parts of the completed pipeline system to a final test. For the purposes of this final test, the pipeline system shall if necessary be divided into suitable sections as agreed with the Engineer. All testing shall be witnessed and approved by the Engineer.

Where directed by the Engineer a section of pipeline in a particularly difficult location shall be subjected to a hydrostatic test immediately the section has been completed, using a pressure not less than that to be applied for the final test.

Notwithstanding the foregoing the Contractor may at any stage of construction carry out such preliminary tests as he considers desirable to check materials and workmanship on the pipeline but this shall not relieve the Contractor of his obligations to achieve approved test results on completion.

The Contractor shall during testing demonstrate satisfactory operation under working pressure of each valve installed under the Contract.

The Contractor shall provide for the supply of water, and shall supply all pressure gauges, meters, hoses, pumps, stop ends and other temporary supports and equipment needed for carrying out tests.

The Contractor shall remain responsible for the care of the Works during testing and cleaning of the pipeline and in particular he shall take all precautions to prevent frost damage to any exposed parts of the pipeline.

K18.7.4 Procedure for pressure testing

Before filling for pressure testing is started the Contractor shall re-check pipes and valves for cleanliness and shall re-check the operation of all valves. The `open' ends of the pipeline (or sections thereof) shall normally be stopped off by blank flanges or cap ends additionally secured where necessary by temporary struts and wedges. All thrust blocks and valve chambers shall have been completed with backfill placed around them and the concrete shall have attained its specified 28 day strength. All pipe straps and other devices intended to prevent the movement of pipes shall have been securely fastened and backfilling of trench between pipe joints shall have been placed to the extent necessary to prevent movement of the pipeline.

Pressure pipelines shall be tested as follows.

The pipeline or section of pipeline to be tested shall be filled with water and all air shall be removed. Before the test proceeds further, the pipeline shall be allowed to stand full of water for at least 24 hours. The pressure shall then be raised by pumping in water until the specified test pressure (P) is reached and shall be maintained at this pressure by further pumping for a period of at least 24 hours during which time the pipeline shall be inspected for points of concentrated leakage. In the case of pipelines of absorbent materials, this period shall be extended as necessary until the absorption has ceased. Pumping shall then cease and the time (T) for the observed pressure head to fall by 10 m shall be recorded. Pumping shall then be resumed and the quantity of water (Q) pumped into the pipeline from calibrated container(s) in order to restore the test pressure (P), shall be recorded. Provided that if the observed pressure head has not fallen by 10 m before an expired period of three hours then pumping shall be resumed at once and the time (T) shall be recorded as being three hours. The rate of loss shall be calculated as being the quantity (Q) divided by the time (T).

K18.7.5 Test standard for pressure pipelines

The test pressure (P) refers to measurements at the same level as the pumping main adjacent to the pumping station. Where test pressures are measured along the pumping main at levels significantly above or below the level of the pumping main adjacent to the pumping station the test pressures shall be decreased or increased accordingly.

Unless otherwise directed by the Engineer the test pressure (P) shall be such that a water column connected to the pipeline would reach a height of 60metres.

A pipeline shall be deemed to have passed the pressure test if the rate of loss as calculated above does not exceed the equivalent of 0.025 litres per 24 hours per millimetre of nominal internal pipe diameter per 100 m of pipe.

If any pumping main fails to pass the pressure test the Contractor shall locate the faults and shall uncover repair retest and reinstate that pumping main as may be necessary until all pumping mains shall have passed the pressure test.

K18.7.6 Testing gravity pipelines

Each length of gravity pipeline shall be carefully air tested before concrete bedding is placed and before the trench is backfilled. The air pressure shall give 100 mm head of water on a manometer tube, and the loss shall not exceed 25 mm over a period of five minutes. The pipeline shall be tested in convenient lengths and all necessary tester junctions, expanding rubber plugs, testing equipment etc. shall be provided by the Contractor. The Contractor shall immediately remedy any defect which may become apparent and re-test to the satisfaction of the Engineer.

With the approval of the Engineer the concrete bedding may then be placed and the trench backfilled in the manner specified, and the pipeline shall again be tested as before unless the water table is above the level of the pipeline and the Engineer prefers to test for infiltration. Where an infiltration test is carried out the water entering the pipeline by this means shall not exceed 0.40 litres per 24 hours per millimetre of nominal internal pipe diameter per 100 metres of pipe.

If it appears that any pipe has been broken or any joint has been disturbed during backfilling then the Contractor shall re-open the trench and repair the defect or defects until the pipeline has been retested to the satisfaction of the Engineer.

The Contractor shall ensure that a complete set of testing equipment and all necessary expanding rubber plugs are available at all times at all parts of the Works where pipelaying is in progress in order that the Engineer may carry out a test at any time.

Water testing, as an alternative to air testing will be allowed at the discretion of the

Engineer in which case the pipeline shall be tested under at least 1 500 millimetres head of water and the loss shall not exceed 0.40 litres per 24 hours per millimetre of nominal internal pipe diameter per 100 metres of pipe.

Unless the Engineer shall direct otherwise the Contractor shall be at liberty to retain the water in the pipes after the first test and during the process of backfilling so that the pipe lengths need only to be water filled once for testing purposes.

K18.7.7 Testing building laterals and drains

Each building lateral is to be provided with a junction for the insertion of an expanding test plug. This junction shall be located next to the junction on the pipeline or the connecting bends if used. When testing the pipeline the plug will be placed on the pipeline side of the junction so that the watertightness of the lateral as far as the plug will also be proved. When testing the lateral the plug will be inserted on the other side of the junction. Upon the satisfactory completion of the latter test the plug will be removed and the function sealed by a clayware stopper with a flexible joint.

If any building lateral or drain fails to stand the test, as described for gravity pipelines the defect or defects shall be discovered and made good by the Contractor and the lateral or drain retested.

K18.8 Particular requirements

The requirements of sub-section Clause K17.8 shall apply.

K19.0 VALVES

K19.1 Scope

This Section contains requirements for the supply, installation and testing of valves for use with raw, treated and potable water on pipelines. The specification for valves within pumping stations and other such installations is given in the mechanical standard Specification.

Further requirements concerning installation and testing are included in the Section for pipelines. All relevant requirements of that Section shall apply to valves except where otherwise specified in this Section.

The valves specified in this Section are:

(a) Stop valves, comprising-
- gate valves (sluice valves), and
- butterfly valves

(b) Air valves;

(c) Fire hydrants;

(d) Check valves (non return valves);

(e) Control valves (pressure and flow);

(f) Ball float valves.

K19.2 Reference Standards

Unless otherwise specified, valves shall comply with the relevant Reference Standards listed below. Where valves are outside the range of sizes covered by the Reference Standards the requirements of the Reference Standards where relevant shall still apply, unless otherwise specified.

BS 750	Underground fire hydrants and surface box frames and covers.
BS 970	Wrought steels for mechanical and allied engineering purposes: Part 1. General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and valve steels.
BS 1041	Temperature measurement.
BS 1042	Measurement of fluid flow in closed conduits.
BS EN 1982	Copper alloy ingots and copper alloy and high conductivity copper castings.
BS EN 1561	Flake graphite cast iron.
BS EN 837	Bourdon tube pressure and vacuum gauges.
BS EN 1563	Spheroidal graphite or nodular graphite cast iron.
BS EN 12163	Copper and copper alloys rods and sections.
BS 3416	Bitumen-based coatings for cold application, suitable for use in contact with potable water.
BS 4147	Bitumen-based hot-applied coating materials for protecting iron and steel, including suitable primers where required.

BS 4504	Circular flanges for pipes, valves and fittings.
BS EN 545	Ductile iron pipes and fittings.
BS 4999	General requirements for rotating electrical machines.
BS EN 1171	Cast iron gate valves.
BS EN 12334	Cast iron check valves for general purposes.
BS EN 593	Butterfly valves.
BS 5163	Predominantly key-operated cast iron gate valves for waterworks purposes.

K19.3 Submissions by the Contractor

Submissions which the Contractor is required to make in relation to valves include, where relevant, the following:-

K19.3.1 Drawings

- Typical drawings of standard items
- Detail drawings of special items
- Foundation requirements

K19.3.2 Data

- Manufacturers' catalogues and data sheets
- Pressure ratings
- Materials of manufacture
- Flange details
- Sealing materials and seating designs
- Performance data of air valves, hydrants, check valves and control valves
- Evidence of satisfactory performance
- Operation and maintenance manuals

K19.3.3 Records to be kept

The Contractor shall keep detailed and up-to-date records in a form which shall be subject to the approval of the Engineer of all valves, showing the quantities of each type, size and class which have been:-

(a) ordered during the course of the Works

(b) delivered during the course of the Works

(c) declared on delivery to be faulty, damaged or deficient

(d) broken, damaged or lost during the course of the Works,

and of all tests made during or after installation and on commissioning the valves.

Each week the Contractor shall provide the Engineer with an up-to-date copy of the above records.

K19.3.4 Test certificates

The Contractor shall forward to the Engineer the following certificates:-

Works tests
Materials tests

Each test certificate shall record all the test measurements taken and shall quote the reference number(s) of the valve(s) tested.

K19.4 Materials

K19.4.1 General

Valves shall be manufactured to the requirements specified hereunder. All valves shall be suitable for use with water at the temperatures and pressures specified or detailed on the Drawings.

Unless otherwise detailed or specified, valves shall have integral PN16 flanges to BS 4504 (Section 3.2) or BS EN 545, where applicable. Flanges to other standards shall be used only if approved by the Engineer and provided that any differences do not affect mating dimensions. Back faces of flanges shall be machined.

Where the Contractor proposes to use dissimilar metals either in contact or close enough for the gap between them to be bridged by an electrolyte the Contractor's design shall include provisions to prevent corrosion.

Gate valves (sluice valves) and butterfly valves shall be suitable for flow in either direction.

All standard valves shall be suitable for frequent and infrequent operation after long periods in the open or closed condition.

Rubber used in valves shall be ethylene propylene rubber (EPDM or EPM) or styrene butadiene rubber (SBR). It shall comply with the requirements of Appendix B of BS EN 593, be suitable for making a long term flexible seal and be resistant to mechanical, chemical or bacteriological attack leading to deterioration of the flexible seal.

Where valve bodies or other parts are specified to be of cast iron to BS EN 1561, valves incorporating bodies or other parts of speroidal graphite iron (ductile iron) to BS EN 1563 shall be supplied if available, provided that they otherwise comply with the specification.

Unless otherwise specified elsewhere (including in Reference Standards), or expressly permitted by the Engineer, valve components shall be of materials not inferior in strength or resistance to corrosion to those listed below.

Bodies, covers, cowls and plungers: cast iron	spheroidal graphite iron to BS EN 1563 grade 500/7 or to BS EN 1561 grade 220.
Pistons, sleeves, liners, guides, bushes, seats, seat	bronze to BS EN 1982 grade PB1 or gunmetal to BS EN 1982 grade LG2.

rings and seal holders:

Hinge bushes and pins:	bronze to BS EN 12163 grade PB 102
Valve stems, spindles other than extension spindles, and pins:	stainless steel to BS 970: Part 1, grade 410 S21.
Extension spindles (plain ends):	mild steel to BS 790: Part 1, grade 220 MO7

Except where otherwise specified, joints, gaskets, wrapping material and polyethylene sleeving shall be as specified for pipelines.

K19.4.2 Gate valves (sluice valves)

Standard gate valves up to and including 1000mm nominal diameter shall conform to the requirements of BS EN 1171 for copper alloy faced or resilient seated valves with solid or split wedge, save that gate valves up to and including 600 mm nominal diameter may alternatively conform to BS 5163.

Gate valves larger than 1000mm nominal diameter shall comply with the materials and other relevant provisions of BS EN 1171.

Gate valves up to 300mm in diameter shall be of the `resilient seated' type. Gate valves of 350mm in diameter and over shall be of the `gunmetal faced seal' type.

Valve spindles shall be of the internal non-rising type. The valve seal shall be replaceable with the valve full open and the main under pressure.

Unless otherwise detailed on the Drawings, gate valves in chambers and other similar locations shall be provided with extension spindles with supports where necessary and handwheels. Valves which are to be buried in the ground shall be provided with extension spindles, spindle caps, spindle supports, protection tubes and surface boxes as specified.

K19.4.3 Butterfly valves

(a) General

Butterfly valves shall comply with BS EN 593 except as specified herein. Valves shall be suitable for mounting in any position.

The Contractor shall provide details of the materials of manufacture and the design of butterfly valves, including the access route to repair or replace seals, and shall provide evidence to show that the proposed materials and seating designs for the sealing and seating arrangements have given satisfactory performance in similar conditions to those applying under the Contract.

Flanges and hubs for shaft bearing housing shall be integrally cast with the valve body except where otherwise specified or shown on the Drawings. All bearings shall be of a type which is independent of external lubrication.

Hollow discs, and any other castings with voids, shall be fitted with threaded plugs.

Discs shall be capable of maintaining their fully open and fully closed positions with the gearbox removed. Limit stops shall be capable of absorbing full operating torque with a minimum design safety factor of 5.

The shaft shall be fabricated of stainless steel if it is exposed to pipeline fluid. The shaft and disc fixing shall be capable of absorbing the full operating torque with a minimum design safety factor of 5. Shaft seals, when used, shall be of the resilient 0-ring type. Packing shall be either of the resilient 0-ring or self-adjusting chevron type.

(b) Resilient seated valves

Resilient seated valves shall have tight shut-off.

The valve seal shall be resilient, durable, replaceable and formed of approved material. The valve seal shall be securely clamped either into a machined groove in the valve body or to the edge of the disc by seal retention members or other equivalent retention device, in such a manner as to prevent leakage of water under the seal and to hold the seal securely in position during opening and closing of the valve disc. The seal retention members shall be of stainless steel and shall be securely fastened to the body or disc with stainless steel fasteners.

The seal and its retention members shall be adjustable to ensure watertightness and to minimise the seating and unseating friction forces. When all the seal retention members are in place, the finished edges of the seal shall fit closely and the surface shall be smooth with all fastenings set flush in the water passage so as to offer the least resistance possible to the flow of water through the valve.

Valve seats which extend over the face of the flanges to secure the seat in place, or which require surface grinding and/or hand fitting of the disc, or designs which require the adjoining pipe flange to retain the seat in place and resist line pressure, are not acceptable.

(c) Metal seated valves

Metal seated butterfly valves shall have metal to metal seating, and shall be of the low leakage or regulating type or both, as particularly specified.

Regulating valves shall be designed for long-period operation in the partly closed, throttled position.

K19.4.4 Air valves

(a) Definition

These are defined as valves, the function of which is to admit air to, or release air from a pipeline. Valves which are classified as air valves shall comply with the following clauses as appropriate.

(b) General

Each air valve shall be provided with an isolating valve. Air valves with a connection not exceeding 25mm diameter to the main pipeline shall each have an integral lever-operated ball isolating valve. All other air valves shall have a separate resilient-seated, double-flanged gate valve or double-flanged or wafer butterfly valve with lever operation as specified or shown in the Drawings. Wafer valves shall be provided with a means of firmly securing them to the pipeline tees so that the air valves may be removed while the pipeline is in service.

Balls or floats shall be of ABS plastic, vulcanite, rubber-covered metal or stainless steel. Balls and seats shall be designed so as to minimise the risk of adhesion of the ball to the seat. They shall be of a type proved by experience to be suitable for the specified duties. Floats of air valves shall seat against its orifice or cause the orifice to close without leakage of water at all pressures measured at the valve between 0.1 bar and the maximum working pressure. Orifices shall be nylon, bronze or stainless steel.

(c) Single small-orifice air valves (SAVs)

SAVs shall automatically open and exhaust accumulated air from a pipeline and shall automatically close when all air has been exhausted from the pipeline. The valve shall function properly at all pressures up to maximum working pressure.

Each valve shall be fitted with a test cock in the valve body to permit easy verification that the valve is operating properly and that its orifice is not blocked.

Valves shall be capable of discharging not less that 0.5m^3/min of free air when the pressure in the pipeline is at the maximum working pressure for which the valve is designed.

(d) Single large-orifice air valves (LAVs)

LAVs shall automatically open to allow air into a pipeline as it is drained of water or ventilate air out from a pipeline as it is filled with water. LAVs shall close automatically when all air has been exhausted from the pipeline on filling. Valve shall be constructed so that the air flow actively holds the valve open during air flows in both directions up to the design discharge.

Except where otherwise specified, LAVs shall, when coupled to their respective isolating valves, be capable of admitting and exhausting from the pipeline the quantities of air shown in the following table without the pressure differential across the combined air valve and isolating valve exceeding 0.25 bar;

Pipeline nominal size (mm)	**LAV minimum branch size** (mm)	**LAV minimum discharge of free air** (m^3/min)
80 to 250	50	10
300 to 400	80	25
500	80	35
600	80	50
700	100	70
800	100	90
900	100	115

1000	100	145
>1000	125	175

(e) Double orifice air valves (DAVs)

DAVs shall, within a single valve unit, fulfil all the functions of both SAVs and LAVs and shall comply with the requirements for both those valves as specified above.

K19.4.5 Ball float valves

Ball float valves shall be designed for installation on the inlet pipe to a storage tank and shall automatically shut off when the water reaches a predetermined level. They shall be of the single beat type with balancing piston, resilient seatings and direct float and lever operation.

Ball float valves shall be suitable for long term operation in a part-open state.

K19.4.6 Spindles (stems) and caps

Operating and extension spindles for valves operated by tee key shall be capped.

Extension spindles shall be circular in section. For valves installed in chambers, extension spindles shall be provided with split bearings rigidly held on brackets spaced no more than 1500 mm apart. For buried valves the spindle shall be supported inside a protecting tube held on a purpose-made support fixed to the top of the valve and provided with a spindle guide.

Bearings and spindles shall be suitably protected against corrosion.

Extension spindle couplings shall be provided with split pins to prevent pullout.

K19.4.7 Painting and protection

Except where decorative painting is specified and subject to the second paragraph of clause K19.4.1, valves and associated equipment shall be protected with a bituminous coating at the manufacturer's works as specified in the relevant quality standard, or in accordance with BS 3416 or BS 4147 where no coating material is otherwise specified.

Wrapping material and polyethylene sleeving for the additional protection of buried valves shall be as specified for Pipelines.

K19.4.8 Manual operating gear

Manual closure of stop valves shall be achieved by clockwise rotation of the tee key or other rotating device.

Handwheels shall be shaped to give a safe grip without sharp projections, clearly marked with the direction of closing and be fitted with integral locking devices (not padlock and chain). Tee key operated valves shall be provided with detachable cast iron spindle caps to take the key. One key shall be supplied for every five valves installed, with a minimum requirement of two keys in any one size.

All manually-operated valves shall be capable of being opened and closed by one person only, when the specified maximum unbalanced pressure is applied to the valve in use. Under this condition the force required to open the valve from the closed position shall not exceed 125N at each of two diametrically opposite points on the rim of the handwheel or at each end of the tee key. (ie the `push-pull' effort needed shall not exceed 250 N).

Gearboxes shall be totally enclosed oil bath lubricated. Thrust bearings shall be provided in such a way that the gearcase may be opened for inspection or be dismantled without releasing the stemthrust or taking the valve or sluice gate out of service. Oil and grease lubricated gearing, bearings and glands shall be protected against the ingress of dust and moisture.

Operating gear shall be of the outdoor waterproof type that is watertight under an external head of 5 m of water. Where practicable, operating gear shall be fitted with mechanical position indicators clearly visible from the operating position.

K19.4.9 Headstocks

Except where otherwise specified or shown on the Drawings, separate headstocks shall comply with the following requirements.

Columns and handwheels shall be of cast iron, stems shall be of mild steel and bearings shall be gunmetal-bushed. Bases shall be drilled for holding-down bolts.

Stems shall be non-rising. Where the operational conditions so dictate, handwheels shall be mounted vertically, operation being through bevel gears; vertical handwheels shall have crank handles. The centres of handwheels, whether horizontally or vertically mounted, shall be approximately 750 mm above the level of the operating platform.

Where headstocks are structurally mounted above a valve chamber, or otherwise distant above valves, then operating spindle extensions shall be provided between the valve and headstock. These shall be suitable for length adjustment during assembly on Site and shall be fitted with universal couplings adjacent to the valve and to the headstock. The two coupling shall be so orientated as to give a linear transmission of rotational movement between headstock and valve stem.

Handwheels shall be shaped to give a safe grip without sharp projections. The valve or penstock shall be closed by turning the handwheel clockwise and this shall be clearly marked on the handwheel. The maximum force required for operating the headstock shall be as specified for integral handwheels in the preceding clause.

Headstocks shall be provided with integral locking devices (not padlock and chain) and with open-to-closed position indicators consisting of index pointers working over polished and engraved scales protected by robust clear plastic covers to exclude dust.

K19.4.10 Electrically operated actuators

Electrical actuators shall operate valves at opening rates that will not impose unacceptable surge pressure on the pipework. Electric actuators shall be rated at not less than 20% in excess of the power required to operate the valve under maximum working conditions.

Actuator enclosures shall have a minimum protection IPW 67 to BS EN 60529.

Actuator electric motors shall comply with BS 4999. For non-modulating type actuators, the motor short-time rating (STR) shall permit the successive full travel operation from open to closed and vice versa but shall be not less than 15 minutes. For modulating type actuators, the motor shall have a duty-type rating (DTR) to meet varying cyclic load requirements of the valve.

Electric motors shall be provided with built-in thermal protection complying with BS 4999: Part 111.

Actuator shall be complete with:—

(a) An alternative system for manual handwheel operation which shall be lockable.

(b) An interlock, to prevent engagement of the handwheel whilst the actuator is being power driven and to positively disengage the manual drive when the power drive is started.

(c) Reversing-type motor starter, complete with isolating switch.

(d) Local and remote control selector switch when specified which shall be lockable.

(e) 4mA to 20mA generator for remote valve-position indication when remote control is specified.

(f) Torque switches for mechanical disengagement of the drive at the extremes of valve operation in the event of excess torque.

(g) Supply failure and remote control-available monitoring relay(s). The supply failure relay shall operate under single-phasing and phase-reversal conditions.

(h) Voltage-free changeover type contacts for the remote indicate of:
— motor tripped on overload;
— valve fully open;
— valve fully closed;
— supply failed;
— remote control available.
The rating of voltage-free contacts shall be not less than 15A at 240V ac and 2A at 50V dc unless otherwise specified. The contact shall be suitable for inductive load switching.

(j) Anti-condensation heater.
Separate or segregated terminal boxes shall be provided for the connection motor, heater and control cables.

K19.4.11 Marking and packing

Each valve shall be indelibly marked with the diameter and pressure rating and shall in addition carry a unique reference number to enable each item to be clearly identified with works fabrication records, works test certificates, delivery notes and the like. Wherever possible the identification marks shall be painted on the outside of the item but where there is insufficient smooth surface area to accommodate the identification marks they shall be put on rust-proofed metal tags secured to the item with galvanised wire (not through flange holes).

Flanges shall be protected with wooden discs attached by service bolts or other approved means. Service bolts shall not be incorporated in the Works.

All items shall be properly prepared and packed for delivery and storage. In particular small items such as small valves, parts of operating gear, bolts, nuts, gaskets and other joint components shall be crated for delivery. Each crate shall contain a detailed packing list in a waterproof envelope. The outside of the crate shall bear a general description of the contents and an identification mark relating it to the detailed packing list.

Valves shall be packed in the `closed' position except that uncrated resilient seat gate valves for transport to tropical areas shall be in the `open' position.

K19.5 Workmanship

K19.5.1 Handling

The Contractor shall supply handling equipment as necessary to handle and install valves and associated equipment without damaging the items or their exterior or interior coatings. The equipment shall include lifting beams, reinforced canvas slings, protective padding, cradles and the like. Wire rope or chain slings shall not be used for handling these items.

Temporary packing, coverings or crates provided for protection in transit shall not be removed (except for inspection purposes after which they shall be replaced) until immediately before installation.

K19.5.2 Delivery and storage

All items shall be checked against packing lists immediately on delivery to the Site and shall be inspected for damage and checked for shortages. Damages and shortages shall be remedied with the minimum of delay.

The Contractor shall take into temporary protective storage all valves and associated equipment not required for immediate installation in the Works.

Until required for installation they shall be stored carefully under cover, and particular care shall be taken for the protection of associated electrical or mechanical equipment, so that at the time of installation they shall have suffered no damage or deterioration from any circumstance including exposure to the weather. If, in the opinion of the Engineer, any damage or deterioration does occur it shall be made good by the Contractor at no additional cost to the Employer.

K19.5.3 Installation of valves

Valves shall be installed and commissioned in accordance with the manufacturer's instructions. After installation valves shall be cleaned. Gates, discs, seats and other moving parts shall be closely inspected and all foreign matter removed and the valve shall be checked for ease of operation. Moving parts shall be lightly greased or otherwise treated as the manufacturer instructs to bring them into a good operating condition.

Except when otherwise specified or directed by the Engineer, butterfly valves shall be enclosed in chambers and fixed with the disc spindle horizontal and supported as detailed on the Drawings, and installed so that when the valve is opening the lower portion of the disc moves in the direction of the main or normal flow.

Except where shown otherwise on the Drawings, gate valves shall be fixed with their spindles vertical.

Gate valves without external gearing, not exceeding DN200 and not otherwise required to be in a chamber, may be buried. The buried part of the valve shall be protected as specified. Except where shown otherwise on the Drawings the valve shall be backfilled to just below the top of the valve or spindle shroud, and a surface box shall be provided.

Jointing, sleeving, external wrapping, anchor and thrust blocks, valve chambers, valve marker posts and the cleaning and disinfection of valves shall be executed as specified for Pipelines.

K19.5.4 Painting and protection

After installation, valves protected with a bituminous coating which remain exposed or within chambers shall be thoroughly cleaned and given two further coats of the bituminous coating.

Valves and associated equipment which are to be buried shall be wrapped with either polyethylene sleeving or self adhesive wrapping material. The wrapping material or sleeving shall be lapped over and taped to the sleeving or other protection of the adjacent pipeline.

K19.6 Inspection and testing

K19.6.1 General

Factory tests on valves and associated equipment shall be carried out as specified hereafter and in the relevant Reference Standards.

Each item shall be inspected by the Contractor immediately before and after installation and any damage shall be repaired by the Contractor as directed by the Engineer.

The Contractor shall carry out a final test and inspection of valves and associated equipment immediately before the pressure testing of the pipeline.

K19.6.2 Specialist inspection and testing

The Employer may, under a separate contract, employ a specialist firm to give the Engineer such assistance as he may require in any matter connected with valves and associated equipment, including the inspection of materials and workmanship and the witnessing of tests at any stage including manufacture during the execution and maintenance of the Works.

The carrying out of tests by a specialist shall not relieve the Contractor of any of his own obligations under the Contract.

To the extent ordered by the Engineer the Contractor shall provide labour, plant and materials (but not special testing equipment) for direct assistance to the specialist firm in its inspection and independent testing and for any further work of investigation and repair which the Engineer considers necessary as a result of such inspection or testing. The cost of providing such labour, plant and materials shall be paid for by the Employer except in cases where in the Engineer's opinion the inspection, test or further investigation shows that materials and workmanship provided by the Contractor do not comply with the Specification, in which case the cost shall be borne by the Contractor.

K19.6.3 Gate valves (sluice valves)

Each gate valve shall be tested at the manufacturer's works in accordance with the requirements of BS EN 1171 or BS 5163 as relevant. In either case, valve seat tests shall be made under open-end conditions, the test pressure being applied to each face of the valve in turn.

K19.6.4 Butterfly valves

Each butterfly valve shall be tested at the manufacturer's works in accordance with BS EN 593. The seat test shall be for tight shut-off and low leakage valves under maximum unbalanced water test pressure in either direction.

K19.6.5 Air valves

Air valves shall be water tested at the manufacturer's works for drop-tightness at all pressures from 0.2 bar in steps of 2 bar up to the specified pressure. The valve body shall be water tested for mechanical strength of 1.5 times the specified pressure, at which pressure no damage or permanent deformation of the valve body, ball or seat shall occur.

Two valves of each type and size incorporating large orifices shall be tested for exhaust of air at a differential pressure up to 1 bar in steps of 0.1 bar and for inflow of air at a differential pressure up to 0.5 bar in steps of 0.1 bar. During the tests the air flow rates shall be measured by orifice plates in accordance with BS 1042. Pressures (positive or vacuum) shall be measured by Bourdon tube gauges in accordance with BS EN 837, or by means of mercury-in-glass manometers. The temperature of the flowing air shall be measured in accordance with BS 1041: Part 1 and Part 2. The barometric pressure shall also be measured.

If the manufacturer provides results of independently witnessed air flow tests similar to those specified and these are accepted by the Engineer, then the specified airflow tests shall be deemed to be completed.

K19.6.6 Fire hydrants

Each hydrant shall be water tested at the manufacturer's works and shall be drop-tight at the pressures specified or detailed on the Drawings.

K19.6.7 Check valves

Each check valve shall be tested at the manufacturer's works in accordance with the requirements of BS EN 12334.

K19.6.8 Pressure and flow control valves

Each pressure and flow control valve shall be tested at the manufacturer's works as follows:-

- body strength: closed-end test, valve open, test pressure 1.5 times working pressure.
- valve element strength: open-end test, valve closed, test pressure applied to inlet end of 1.5 times working pressure.
- leak tightness: open-end test, valve closed, test pressure of the working pressure applied to inlet end, no visible leakage permitted.

K19.6.9 Ball float valve

Each ball float valve shall be tested at the manufacturer's works for the strength of the body and valve element with valve closed and a pressure of 1.5 times the working pressure applied to the inlet end.

Each valve shall be tested to be drop tight at the working pressure.

K19.7 Particular requirements

K19.7.1 Dezincification of copper alloys

All copper alloys which may come into contact with raw, treated or potable water shall contain not more than 4% zinc and preferably less than 2% zinc.

K20.0 PAINTING AND PROTECTIVE COATINGS

K20.1 Reference Standards

Unless otherwise specified or approved by the Engineer, painting and protective coatings, including surface preparation, shall comply with the relevant Reference Standards listed below:

BS 245	Mineral solvents for paints and other purposes.
BS 729	Hot dip galvanised coatings on iron and steel articles.
BS EN 12540	Electroplated coatings of nickel and chromium.
BS 1336	Knotting.
BS 1387	Screwed and socketed steel tubes
BS 7079	Chilled iron shot and grit.
BS 2569	Sprayed metal coatings.
BS EN 10143	Continuously hot-dip zinc coated and iron-zinc alloy coated steel strip, sheet and plate.
BS 3416	Bitumen-based coatings for cold application, suitable for use in contact with potable water.
BS 3698	Calcium plumbate priming paints.
BS 4129	Welding primers and weld-through sealants, adhesives and waxes for resistance welding of sheet steel.
BS 4147	Bitumen-based hot-applied coating materials for protecting iron and steel.
BS 4652	Metallic zinc rich priming paint (organic media).
BS 4756	Ready mixed aluminium priming paints for woodwork.
BS 4764	Powder cement paints.
BS 4800	Paint colours for building purposes.
BS 4921	Sherardised coatings on iron and steel.
BS 5252	Colour co-ordination for building purposes.
BS 7956	Solvent-borne priming paints for woodwork.
BS 5493	Code of Practice for protective coating of iron and steel structures against corrosion.
BS EN1436 & BS EN1871	Pavement marking paints.
BS 6150	Code of Practice for painting of buildings.
BS 6900	Raw, refined and boiled linseed oils for paints and varnishes.
BS 6949	Bitumen-based coatings for cold application, excluding use in contact with potable water.
BS 7079	Preparation of steel substrates before application of paints and related products.
CP 3012	Code of Practice for cleaning and preparation of metal surfaces.

K20.2 Submissions by the Contractor

Submissions which the Contractor is required to make in relation to painting and protective coatings shall include, where relevant, those listed below.

K20.2.1 Schedule of paint systems and protective coatings

The Contractor shall prepare a detailed schedule for the complete Works which shall contain the following information:-

1. System reference
2. Type of surface
3. Component or section of the Works
4. Environment of item
5. Surface preparation
6. Paint system or protective coating to be applied
7. Name of coating manufacturer
8. Brand name and reference number for each coat to be used
9. Colour of finishing coat stating the Munsell system colour notation
10. Proposals concerning place of application and detailed method of application of each coat, including information on equipment to be used
11. Wet film minimum and target thickness for each coat
12. Dry film minimum and target thickness for each coat
13. Density of paint for each coat and coverage of paint per unit volume.

The schedule shall be accompanied by manufacturers' data sheets for each coat, including technical description of paint, and the British Standard (BS 4800) shade.

The work detailed on the schedule shall meet the requirements specified or otherwise required by the Contract.

Where practicable, the schedule shall be in the format of the specimen schedule of paint systems and protective coatings included at the end of this Section.

The schedule shall be subject to the approval of the Engineer.

K20.2.2 Record sheets for steelwork

For each section of steelwork, the Contractor shall provide a numbered record sheet and continuation pages in duplicate on which the progress of each operation will be recorded from the initial state of the steel before cleaning through to final inspection.

All relevant data shall be recorded including:

- reference to identify the steelwork precisely;
- date;
- weather conditions (or ambient conditions in a workshop);
- preparation, coating or repair being undertaken;
- area coated and quantity and type of materials used;
- details of tests and measurements taken;
- delays and causes, faults observed and corrections made.

There shall also be space for comments or confirmation by the Engineer who shall receive one copy not more than 24 hours after the work is completed.

<table>
<tr><th colspan="2">Type of surface</th></tr>
<tr><td rowspan="4">General</td><td>Component or section of the Works</td></tr>
<tr><td>Environment category
(BS 5493 - Table 1)
(BS 6150 - Table 9)</td></tr>
<tr><td>Type of coating system
(BS 5493 - Table 2)
(BS 6150 - Tables 5 to 8)</td></tr>
<tr><td>Typical time to first maintenance
(BS 5493 - Table 3)
(BS 6150 - Tables 10 to 15)</td></tr>
<tr><td rowspan="2">Surface preparation prior to painting</td><td>Type of surface treatment</td></tr>
<tr><td>Quality level</td></tr>
<tr><td rowspan="2">Metal coating</td><td>Type of metal coating</td></tr>
<tr><td>Thickness of coating</td></tr>
<tr><td rowspan="2">Surface preparation prior to metal coating</td><td>Type of surface treatment</td></tr>
<tr><td>Quality level</td></tr>
<tr><td rowspan="4">Type of paint</td><td>Priming coat</td></tr>
<tr><td>Stripe coat</td></tr>
<tr><td>Undercoat</td></tr>
<tr><td>Finish</td></tr>
<tr><td rowspan="4">Number of coats and DFT</td><td>Priming coat</td></tr>
<tr><td>Stripe coat</td></tr>
<tr><td>Undercoat</td></tr>
<tr><td>Finish</td></tr>
<tr><td rowspan="4">Colour</td><td>Priming coat</td></tr>
<tr><td>Stripe coat</td></tr>
<tr><td>Undercoat</td></tr>
<tr><td>Finish</td></tr>
</table>

SPECIMEN SCHEDULE OF PAINT SYSTEMS AND PROTECTIVE COATINGS

K20.3 Materials

K20.3.1 Paints - general

Paints shall be supplied only by a manufacturer who has received the approval of the Engineer.

Paints shall be supplied only by a manufacturer who has received the approval of the Engineer. Unless otherwise approved by the Engineer, all paints to be applied to a particular surface as part of a paint system shall be obtained from a single manufacturer.

Where priming of surfaces is executed before delivery to Site, the Contractor shall ensure (and obtain written confirmation from the appropriate supplier) that the primers used in these instances are obtained from the same manufacturer as that approved by the Engineer for the finishing coats.

Where appropriate the Contractor shall certify to the Engineer that paints supplied for use on the Works are compatible with any timber preservation or fire proofing treatment which may be specified.

All paint shall be supplied in sealed containers bearing the following information in addition to any statutory requirements:-

(a) Manufacturer's name, initials or trade mark.

(b) Type of paint.

(c) Whether priming, undercoat or finishing coat.

(d) Whether for interior or exterior use.

(e) The colour and its reference number.

(f) The method of application (ie. brush, spray or roller).

(g) The batch number and date of manufacture or re-test.

(h) Storage instructions and shelf life.

(i) Appropriate safety instructions.

Containers for protective materials other than paints shall bear as much of the above information as appropriate.

Paint containers shall not exceed 5 litres capacity with the exception of containers for emulsion, spraying paints, bituminous paints, stone, cement and road marking paints which may be of larger capacity.

K20.3.2 Paint colours

All paint colours shall comply with BS 4800. Final coats shall be in accordance with colour schedules to be issued by the Engineer. Each coat shall differ noticeably in tint from the previous coat.

K20.3.3 Thinners and solvents

The type and quality of thinners to be added to paint shall be that recommended by the manufacturer for the particular type of paint.

White spirit shall comply with BS 245 Type `A'.

Separate supplies of solvents shall be kept on site for brush or other cleaning purposes. Solvents for these purposes shall be tinted a different colour to thinners used for thinning paint.

K20.3.4 Knotting and stopping

Knotting shall comply with BS 1336.

Stopping for concrete or sand/cement plastering shall be of similar material to the background and shall have a similar surface finish.

Stopping for woodwork, hardboard and plywood shall be a proprietary spirit-based wood filler tinted to match the undercoat colour.

Stopping for natural finished woodwork shall be a proprietary spirit-based wood filler tinted to match the woodwork.

K20.3.5 Bitumen coatings

Bitumen coatings shall be formed of the appropriate grades of materials complying with BS 3416 or BS 6949 for cold application, or with BS 4147 for hot application.

K20.3.6 Primers and linseed oil for wood

Priming paint for wood shall be aluminium wood primer to BS 4756 except where the Engineer approves low lead priming paint to BS 7956 or, if narrow strips of galvanised steel and timber abut, calcium plumbate priming paint Type A to BS 3698, or a quicker drying equivalent.

Linseed oil shall be refined linseed oil and shall comply with BS 6900.

K20.3.7 Cement paints and pavement marking paints

Cement paints shall comply with BS 4764.

Pavement marking paints shall comply with BS EN 1436 AND BS EN 1871.

K20.3.8 Welding primers and priming paints for steel

Welding (prefabrication) primers shall comply with BS 4129; they shall be suitable for continuous spray application, dry rapidly, and harden sufficiently within 10 minutes to permit handling of the steel without damage to the prefabrication primer.

Prefabrication primers shall be non-toxic and shall not give rise to objectionable fumes during flame-cutting and welding. The prefabrication primers, when applied to the steelwork in the thickness of coating necessary to protect the steel effectively during the period before application of the main protective system, shall not affect the strength or quality of welds made through the coating.

Prefabrication primers and priming paints for steel shall contain corrosion-inhibiting pigments, adhere firmly to the substrate and form suitable bases for the succeeding coats in the protective paint system.

Where specified to be included in the steelwork paint systems:

(a) zinc inorganic silicate prefabrication primers and priming paints shall contain a minimum 90% by weight metallic zinc in the dry film;

(b) zinc phosphate prefabrication primers and priming paints shall contain 40% minimum by weight of zinc phosphate as a percentage of the dry pigment.

K20.3.9 Epoxy paints

Containers of epoxy paint shall be of a pack-size suitable for complete usage by one operator within the pot life of the material at the highest likely ambient temperature. The Engineer may approval to the supply and use of larger packs but only where the proportioning of the various parts, their mixing, and issue of paint shall be under the direct control of a skilled and experienced operator. A mechanically operated mixer shall be used and shall be of a design which does not entrain air in the paint.

Except where otherwise specified epoxy resin paints shall be so formulated that the epoxy resin content, together with its curing agent, shall be not less than 40% by weight of the solid binder.

The pot-life of epoxy primers and paints when mixed shall be not less than one hour at the temperature at the place of application at the time of mixing. When approved by the Engineer will have regard to the ambient temperatures likely to obtain for field application and may restrict paint application to those times when the temperature is sufficiently low for the specified pot-life to be ensured.

Thinners shall not be mixed with epoxy materials. Strict control shall be exercised in the issue of thinners for cleaning brushes and equipment.

K20.4 Workmanship

K20.4.1 Painting - general

Paint shall be supplied from the Contractor's paint store to the painters ready for application. Any addition of thinners shall be made in the store under supervision and up to the limit detailed on the appropriate manufacturer's paint data sheet, for the particular method and conditions of application concerned. Paint shall be thoroughly stirred before and during use, and shall be strained as and when necessary.

Paint shall be applied only when the ambient temperature is above 5°C, and when the relative humidity is below 90%. Surfaces to which the paint is applied shall be dry and shall remain free from moisture until the coating has dried or cured sufficiently to avoid effects harmful to the subsequent appearance or satisfactory protective behaviour of the paint.

Application of paint shall be by one of the following methods, the choice being the Contractor's unless one particular method is specified or is recommended in the manufacturer's instructions for use of the paint:-

- brush;
- air pressure spraying;
- airless spraying.

Paints with suitable flow-out properties may be applied to large flat areas by mohair sleeved rollers. Rollers shall not be used under other circumstances or for the application of paints containing micaceous iron oxide pigments.

Each coat shall be allowed to dry, be rubbed down and be cleaned as necessary before application of any subsequent coat of paint.

Brushes, tools and equipment shall be kept in a clean condition and surfaces shall be clean and free from dust during painting. Painting shall not be carried out in the vicinity of other operations which might cause dust. The final coat shall be uniform in colour and free from brush marks, runs or other defects.

The Contractor shall not dispose of solid or liquid wastes from painting work down any permanent sanitary fittings, sinks or drains and a non-inflammable portable container shall be provided and used for this purpose.

The Contractor shall take every precaution to protect newly painted surfaces from damage by any cause including wind blown dust. Precautions shall include warning signs, barriers and covers.

K20.4.2 Storage of paint

Paint shall be stored in sealed containers in a lock-up store maintained at a temperature of not less than 4°C and not more than 27°C. Any special storage conditions for the paint recommended by the manufacturer shall be observed.

Containers of any one paint shall be used in strict order of delivery from the manufacturer.

No paint shall be used more than 12 months after the date of its manufacture nor shall any paint be used after the expiry of the shelf life specified on the paint containers.

At the end of each working period during which paint application has been carried out, all two-pack primers and similar chemically-cured paints with a limited pot life which have been mixed but not used, shall be discarded. Other types of paint from painters' kettles shall be returned to the store and kept in sealed containers with not more than 10% ullage.

A separate store shall be provided for cleaning solvents used for brush or other cleaning purposes. Cleaning solvents shall not be stored where paint or paint thinners are stored or where paint is prepared for application.

K20.4.3 Protection of surfaces

All necessary precautions shall be taken by the Contractor before the commencement of any painting activities to ensure that no damage or disfigurement of any kind is caused thereby to any part of the Works. If in the opinion of the Engineer the precautions taken are inadequate the Contractor shall make all such improvements as the Engineer directs.

The Contractor shall exercise particular care not to apply paint to any surfaces not intended to be painted and shall promptly and thoroughly remove any paint applied to such surfaces. All floors and surfaces liable to damage or spillage shall be protected with dust sheets.

The Contractor shall remove all ironmongery and door furniture before painting work commences and refix all items on completion of the painting.

K20.4.4 Safety precautions for painting

The implementation of manufacturers' recommendations concerning health and safety aspects of all paints used on the Works shall be mandatory under this Contract.

K20.4.5 Preparation of surfaces for painting

The Contractor shall regard the preparation of surfaces to be painted as work of fundamental importance, the object being to ensure the production of sound, clean, smooth and dry surfaces. The preparation shall have no detrimental effect on the substrate to be painted nor shall it be prejudicial to subsequent painting operations.

K20.4.6 Preparation of wood surfaces

The preparation of wood surfaces shall include stopping, filling, rubbing down and bringing to a smooth surface free of dust.

Surfaces which are to be painted shall be rubbed down to remove all contaminating substances and imperfections which would be visible in the finished paint film. The surfaces of knots and resinous streaks shall then be painted with two coats of shellac knotting to BS 1336, the first being allowed to dry before the second is applied.

The surfaces of timber treated with a water-borne preservative by an impregnation process shall be rubbed down and dry-brushed to remove all traces of efflorescence before the primer is applied.

Where surfaces are suspected of being infected with mould, they shall be thoroughly treated with a fungicide.

Wood surfaces shall not be painted when the moisture content of the timber measured with an electric conductivity moisture meter exceeds 12 percent for interior surfaces or 17 percent for exterior surfaces.

The backs of timber members in contact with walling shall be painted with two coats of aluminium wood priming paint prior to fixing.

K20.4.7 Preparation of plaster, brickwork and concrete surfaces for painting

Efflorescence present on the surfaces of plaster, brickwork and concrete shall be removed by scraping, brushing and wiping with a dry coarse cloth followed by a damp cloth. When efflorescence has been removed surfaces shall be left for at least three days and shall be approved by the Engineer before painting. Painting shall be deferred where further salt deposits form on the surface during this period.

Plaster surfaces to be painted shall be cleaned down, filled and smoothed as necessary.

Brickwork, blockwork and concrete surfaces shall be cleaned of all contaminating matter before being painted. Subject to the approval of the Engineer large holes which would cause a break in the paint film shall be filled with mortar the surface being rubbed down to match the surrounding areas.

K20.4.8 Preparation of concrete and rendered surfaces for epoxy coatings

Concrete and rendered surfaces shall be thoroughly cured before the application of an epoxy filler primer or paint is begun.

All surfaces to be protected with an epoxy paint system shall be prepared as described below, maintaining the sequence of operations indicated.

Areas of concrete contaminated with machine oil or grease shall be cut out as necessary to remove all traces of such substances and shall be made good with an approved epoxy mortar. Areas contaminated with release agent shall be scrubbed with suitable emulsion cleaners and any mould growth shall be treated with water-soluble fungicide. All surfaces so treated and any other water-solubles on the surfaces (e.g salt) shall be rinsed off with sweet water until they are clean.

All concrete and rendered surfaces to be coated shall be lightly blast cleaned to remove the cement-rich surface layer, taking care not to roughen the surface unduly. Grit and detritus shall be removed by vacuum cleaning immediately prior to priming.

Blow-holes and honeycombed areas in the concrete which in the opinion of the Engineer are not capable of being satisfactorily levelled at the primer stage shall be filled with an epoxy mortar supplied by the coating manufacturer for the purpose. Such mortar shall be knifed into the surface to level the area and to leave no excess.

K20.4.9 Preparation of metalwork and associated fixtures and fittings for building works

The main priming paint coat shall be applied to steelwork as soon as practicable after fabrication and, where possible, shall be of the same general formulation as that used for the prefabrication primer, if one has been used.

The preparation of ferrous metal surfaces primed at works shall include the removal of any rust and touching up with primer within seven days of delivery to Site.

The preparation of ferrous metal surfaces delivered to Site unprimed shall include removing all mill scale and thoroughly wire brushing before painting.

Steel which is to be totally embedded in concrete shall not be primed.

K20.4.10 Blast cleaning steel

Where steelwork is to be blast cleaned, the period and conditions under which steel stocks are held and the speed, conditions and methods of fabrication shall be such that immediately before blast cleaning no significant part shall have rusted more extensively than is shown for rust grade B in BS 7079: Part A1.

Surfaces to be blast cleaned shall be prepared by thoroughly removing all dirt, oil, grease and other contaminants by one of the methods recommended by CP 3012, using an approved emulsion cleaner which shall be changed regularly.

Blast cleaning shall be carried out only when the ambient temperature is above 5°C and the relative humidity is below 85%. Blast cleaning shall be carried out in conditions under which no protective coatings can fall onto or condense on the surfaces during or immediately after cleaning. Special attention shall be paid to the cleaning of any ends, re-entrant corners and edges which will not be cut off or welded after blasting.

After blast cleaning, dust and blasting grit particles shall be removed from the surfaces, where possible by vacuum cleaning. Any lamination or other defects in the surfaces exposed by blast cleaning, which could form a corrosion centre under subsequent protective treatment cover (but which is not otherwise a cause for rejection of the item), shall be marked clearly for later remedial work.

Blast cleaning shall be followed within four hours by the application of a blast-primer or the priming coat of the protective coating system.

The Contractor shall supply and operate such dehumidification equipment as may be necessary to preserve blast-cleaned surfaces in a pristine condition until they can be coated and/or to provide the curing conditions necessary for such coats.

Steelwork fabricated under factory conditions shall not be blast cleaned until all machining and fabrication has been completed, with such fabrication comprising continuous welded runs with all exposed surfaces accessible for subsequent treatment. All slag and spatter shall be removed from the area of welds by chipping hammer prior to blast cleaning.

Surfaces shall be blast cleaned to BS 7079: Part A1, Grade Sa1, Sa2, Sa2½ or Sa3, as specified, or otherwise as required or recommended by the Reference Standards and as proposed by the Contractor and approved by the Engineer. Where not otherwise required (e.g. to give a rougher surface to receive sprayed metal coatings), the abrasive used shall be chilled iron grit to BS 7079, (or a steel grit of similar hardness), preferably all passing a No. 30 (0.5 mm aperture) mesh and all retained on a No. 36 (0.42 mm aperture) mesh but a finer grit to BS 7079 Table 2 Grade G07 would be an acceptable alternative. The abrasive shall not be re-used without satisfactory cleaning.

Where surface defects revealed or present during blast cleaning are subsequently ground out or otherwise made good, the resulting dressed surfaces shall be blast cleaned so that the preparation grade characteristics of the entire surface are uniform.

K20.4.11 Galvanising and other metal coatings

Where steel or wrought iron is to be galvanised, the galvanising shall be executed after all fabrication has been completed. Surfaces shall be prepared by removing all weld slag and spatter, paint, oil and grease. The articles shall then be pickled by either Method F.1 or Method F.2 of CP 3012 and thoroughly washed and dried.

Galvanising shall be carried out in accordance with BS 729 so that the whole of the metal is evenly covered, with clean edges and bright surfaces being presented. The minimum average coating weight shall be not less than 610 grammes per square metre of galvanised surface except for tubes to BS 1387 and sheet, plate or strip to BS EN 10143, which shall be galvanised as specified in those standards. On steel of under 5 mm thickness, lower coating weights in conformity with Table 1 of BS 729 will be accepted only where they and any overcoating to be applied will provide the required life to first maintenance, as shown in Table 3 of BS 5493.

Zinc or cadmium coatings applied by electroplating or Sherardising shall be used only on small components where galvanising would be impracticable. Electroplated coatings on threaded components shall comply with BS EN 12540 for service condition number 4. Sheradised coatings shall be Class 1 to BS 4921.

Sprayed metal coatings shall comply with BS EN 22063.

K20.4.12 Cleaning galvanised surfaces

Dirt and other adherent contaminating matter shall be removed from galvanised surfaces by brushing with wire or stiff bristle brushes or by other methods approved by the Engineer. Cleaning shall be such as not to damage the galvanising. Oil or grease shall be removed from galvanised surfaces by the application of an emulsion cleaner. Any zinc corrosion products remaining shall be removed by washing with sweet water and scrubbing with hard bristle brushes.

After being cleaned and degreased all galvanised surfaces shall be etched with T-wash as described in BS 5493. If any surface fails to turn black, the cleaning, degreasing and etching processes shall be repeated.

K20.4.13 Application of paint generally

All paints shall be prepared and applied in accordance with the manufacturer's instructions. Copies of appropriate data sheets and of the relevant parts of this Specification shall be issued to all the supervisors and foremen concerned with surface preparation and coating. Where a manufacturer's instructions conflict with this Specification, a ruling shall be sought from the Engineer.

No thinners or cleaners shall be employed other than those recommended by the paint manufacturer.

Except where otherwise specified or approved by the Engineer all priming paints shall be applied by brush.

Exposure of intermediate coats of paint for periods in excess of a few days shall not be permitted except in the case of work delivered to Site in a primed condition.

The dried films of the specified paints shall be free from bloom, sinkage, sheeriness, wrinkling, sagging, curtaining, discolouration and extraneous matter.

No exterior or exposed paintwork shall be carried out under adverse weather conditions.

Painting shall insofar as is practicable be shaded from direct sunlight to prevent wrinkling and blistering. Whenever possible, exterior painting during the day shall be so programmed as to be carried out in shadow.

Painting of surfaces shall not be carried out when the relative humidity of the atmosphere is such that condensation is present on such surfaces or the application and/or drying of the paints is likely in the opinion of the Engineer to be affected.

K20.4.14 Painting building surfaces

Painting work shall comply with the recommendations of BS 6150 and the instructions of the paint manufacturer, except where otherwise approved by the Engineer.

Except where otherwise specified or approved, at least 24 hours shall be allowed between the application of successive coats of paint. Each coat shall be dry before the next coat of paint is applied and each coat of paint shall be rubbed down with fine glass paper before the next coat is applied.

All wall and ceiling surfaces scheduled to be painted with emulsion paint, shall receive at least three coats. On absorbent surfaces the first coat of emulsion may be thinned with the prior approval of the Engineer. At least 4 hours shall be allowed between the application of successive coats of emulsion.

The Contractor shall satisfy the Engineer as to the covering capacity of paints and emulsion according to the absorption of varying surfaces. The method and application of paints and emulsions shall be sufficient to give solid cover in the number of coats specified.

The Contractor shall prepare sample panels of painting on internal walls and ceilings and sample areas of painting to metal surfaces and timber surfaces for the Engineer's approval.

The Contractor shall clean off all paint stains from joinery, metalwork and floors on completion of the painting work.

K20.4.15 Priming steel and iron

The main priming paint coat shall be applied to the steel as soon as practicable after fabrication and where possible shall be of the same general formulation as that used for the prefabrication primer, if one has been used.

After prefabrication-priming of any steel plate or section, edges, corners, crevices or holes still present after fabrication, and not part of a welded joint or interior surface of a hermetically sealed void, shall be given an additional stripe coat of the appropriate main primer by brush to ensure continuity of protection of the steel across such edges and the like.

With reference to Clause K20.4.10, the inside surfaces of members and similar non-fabricated sections where blast cleaning is impracticable shall be cleaned to preparation grade St 2 as shown in BS 7079: Part A1. The priming coat shall be compatible with this preparation grade.

K20.4.16 Painting bolted connections

Joint areas for bolted connections shall be masked to maintain the surfaces free from any paint applied prior to making the connection. Masking shall be removed before erection.

After installation and after all bolts have been tightened, the areas of the connection shall be cleaned to remove all dirt, dust, oil or other contaminant. Particular care shall be taken to ensure that all traces of oil and grease are removed from bolts, nuts and washers.

Any surrounding areas of paintwork which have been damaged shall be repaired as specified in clause K20.4.18.

Bolts, nuts and washers and any areas exposed at bolted connections shall also be primed as specified, particular care being taken to ensure that any crevices are fully sealed.

The remaining coats of the paint system shall then be applied.

K20.4.17 Painting welds

After the completion and grinding of exposed welds, weld spatter, weld residues and all alkaline deposits and contaminants shall be removed from the surface of the steel-work, and welds and any other areas affected or damaged by the welding process shall be blast cleaned. Primer shall be applied to the blast cleaned areas as specified and the remainder of the paint system applied as necessary to complete the protection across the welded seam and damaged areas to the same state as that existing generally on the faces of the parent metal. Each coat applied shall overlap the corresponding existing paint coat by 50 mm both sides of the weld on each exposed face of the parent metal.

K20.4.18 Repairing damaged coats

Damaged areas of zinc coatings not individually exceeding 40 mm2 in area shall be made good by the application of a metallic zinc-rich priming paint complying with BS 4652. Sufficient material shall be applied to provide a zinc coating at least equal in thickness to the original coating.

Factory prepared surfaces, other than zinc coated surfaces, damaged during site fabrication and/or handling shall be treated as described in the following paragraphs.

All slag and spatter shall be removed from areas of welds by chipping hammer and such areas together with all other areas of damaged priming or other coat shall be thoroughly mechanically wire brushed and given one coat. The priming coat shall be applied by brush, taking care to cover uneven surfaces completely, particularly those of welds. Further approved coats shall be applied where necessary to build up the thickness of the repaired coating to at least that of the original coating.

Areas of paint on steelwork which have been damaged shall be cleaned to sound material and the edges of the undamaged paint shall be smoothed with sandpaper to a gentle bevel. The specified paint system shall then be applied to bring the damaged area up to the same state of protection as the surrounding paintwork, with each coat of new paint overlapping the corresponding existing coat of paint by at least 50 mm.

Where the steel is exposed, it shall be cleaned to remove all corrosion, by blast cleaning if ordered by the Engineer.

Where epoxy coatings are damaged, suitable repair material supplied by the manufacturer of the original coating shall be applied.

K20.4.19 Epoxy coating work generally

In addition to the general requirements of this specification the following conditions shall apply wherever epoxy coating work is being carried out:-

(a) The work shall be illuminated to the satisfaction of the Engineer.

(b) Forced drought ventilation to the approval of the Engineer shall be used wherever required for the needs of personnel or for drying out surfaces.

(c) Operatives shall work in pairs.

The Contractor shall demonstrate all his methods, equipment and materials before any work commences. Sample areas of substrate shall be prepared and coated as required by the Engineer and for his approval.

There shall be strict control of surface cleanliness between primer and epoxy coating and between coats of the same. Vacuum removal of dust and sand shall be employed and contamination shall be removed as specified in appropriate preparation clauses herein. Where dirt or dust has become trapped in the epoxy coating surface it shall be removed with suitable abrasive paper. The surface being coated shall be free of visible moisture throughout these operations.

Epoxy coating shall be applied only to clean dry primed or previously coated surfaces. Any thick runs or collections of paint shall be removed before they harden.

No fewer than two coats shall be applied over the primer by airless spray; no fewer than three by brush.

Each coat shall be distinctly different in colour from the primer or previous coat. The colour of the final coat shall be as required by the Engineer.

Each coat shall be seen to have completely covered the preceding coat without `misses' or pinholes or any areas visibly low in thickness. A high voltage pinhole detector shall also be used to determine the integrity of the coats.

The manufacturer of the coating shall stipulate primer and epoxy re-coating intervals for all curing temperatures likely to be encountered and these shall be adopted with a maximum tolerance of +4 hours. Where this is exceeded, the surfaces to be re-coated shall first be suitably abraded or treated with solvent to remove gloss and give key.

Wet thickness gauges shall be used continually by the coating operators to check that sufficient coating is being applied to achieve the desired dry film thickness.

K20.4.20 Epoxy coating concrete and rendered surfaces

No priming shall commence until the moisture content of the cementitious surface is less than 5% measured by "Wet Check" moisture meter or other instrument approved by the Engineer.

Similarly moisture measurements over the primer or any epoxy intercoat shall not exceed 1% on the concrete scale of the instrument when the probe tips are held against such painted surfaces just prior to re-coating.

The primer shall be a low viscosity two or three pack epoxy supplied by the manufacturer of the approved epoxy coating material. It shall have complete compatibility and inter-coat adhesion with the first coat of high build epoxy paint.

The primer shall be applied by suitable nylon bristle brush or spray over the whole area to be coated at such thickness that it may then be squeegeed into the pores of the concrete. Any excess shall be effectively removed before application of the high build epoxy.

The Engineer may approve an alternative application method where the Contractor can demonstrate a suitable technique.

The protective coats shall be of an approved high build epoxy, 2 or 3 pack, completely resistant to the corrosion conditions to be encountered. Certain types of coal-tar epoxy may be approved for this purpose where the Contractor has stated at the time of tendering the type of curing agent and coal-tar, with the percentage content of the latter.

The total dry film thickness of the paint layer shall have a minimum value of 0.75 millimetres.

Wherever the paint inspection gauge has been used, and wherever the coating has been otherwise damaged, the surface shall be abraded for 50 millimetres around such damage and the area shall be touched in with not less than two thick applications to restore the coating integrity and thickness.

Adhesion tests shall be carried out on the cured coating surface using the test equipment supplied under the Contract. The resulting test specimens shall show no indication of poor adhesion to the substrate, residual laitance or intercoat adhesion weakness.

K20.5 Inspection

The following tests shall be carried out:-

(a) Checking wet film thickness

Wet film thickness gauges of an approved type shall be provided for each painter to check the rate of paint application.

(b) Checking dry film thickness

The thickness of the built-up dry film after each paint coat applied to steel or other magnetic surfaces shall be measured systematically, with a dry film thickness gauge.

(c) Holiday detection on steel and iron surfaces

The Contractor shall use a suitable method of detecting pinholes in the coating system after trials on test plates. The sweep voltage on high voltage dc equipment shall not exceed half the voltage required to spark through the complete paint system specified.

K20.6 Particular requirements

K20.6.1 Design generally

Paint systems and protective coatings shall be designed to have a long life, generally of at least 15 years to first maintenance for metal surfaces and tank linings, and for at least 5 years to first maintenance for building works. Where practicable, they shall be chosen to be easily maintained in the future and to allow non-specialist on-site re-coating where necessary, using single part paints.

For the purpose of system design in accordance with BS 5493, the general environment shall be `Exterior exposed, non-polluted inland' as defined in Table 1. Stoplogs shall be assumed to be exposed to a `Non-saline water' environment unless otherwise approved or directed by the Engineer. Interior spaces shall be considered to be `normally dry' in administration areas open to continuous access and `Frequently damp and wet' in other spaces. The protective coatings of components of structures which are immersed continuously or for part of the time shall be designed for the more onerous of these two conditions relevant to the protection system used.

For the purposes of system design in accordance with BS 6150, the severity of exposure of the exterior shall be `Mild' as defined in Table 9. Interiors shall also be considered to have a `Mild' exposure in administration areas open to continuous access and a `Severe' exposure elsewhere.

All items to be coated which will normally be exposed to view, shall have a final coat of good appearance of a colour and type to the approval of the Engineer.

K20.6.2 Systems

Protective coating systems shall generally fall into one of the following basic systems:

(a) galvanising;
(b) galvanising plus painting;
(c) multi-coat painting;
(d) bitumen enamel;
(e) epoxy;
(f) others as proposed by the Contractor and approved by the Engineer.

The Contractor shall submit to the Engineer details of his proposals for the corrosion protection of each of the items requiring such protection, which will generally fall into the above categories as follows:

(i) trash screens, floorings, ladders, access covers and frames, step irons and other components which are inaccessible but subject to abrasion/damage;
(ii) structural steelwork (including crane beams, monorails, crane structures and chassis), stoplogs, grappling beams, steel tanks and other large items readily accessible for maintenance;
(iii) valves and other corrosion-susceptible items which may be buried and are

not covered by the provisions of other specifications;

(iv) other components not covered by the above for which the Contractor may propose a system which he considers to be more suitable for the duty.

Examples of protective coating and paint systems for various surfaces and working environments are detailed in Systems 1 to 9 on the following pages.

Alternative proposals for protective coatings and paint systems submitted by the Contractor shall be at least equal in standard to the given examples.

SYSTEM 1	
System Reference	Chlorinated rubber
Type of surface	Ferrous metal
Working environments	Atmospheric - interior and exterior
Surface preparation	Blast clean to BS 7079: Part A1, Grade Sa2½
Description of system	Solvent-borne self-curing zinc silicate - 75 µm DFT High-build chlorinated or acrylated rubber - 80 µm DFT Chlorinated or acrylated rubber enamel - 35 µm DFT
SYSTEM 2	
System Reference	Chlorinated rubber
Type of surface	Ferrous metal - galvanised, sheradised or zinc sprayed
Working environment	Atmospheric - interior and exterior
Surface preparation	Wash and scrub to remove oxide
Description of system	Two-component etch primer containing phosporic acid and rust-preventing pigments - 10 µm DFT High-build chlorinated or acrylated rubber - 80 µm DFT Chlorinated or acrylated rubber enamel - 35 µm DFT
SYSTEM 3	
System Reference	Chlorinated rubber
Type of surface	Aluminium
Working environment	Atmospheric - interior and exterior
Surface preparation	Wash to remove oxide and lightly abrade to produce a key
Description of system	Two-component etch primer containing phosphoric acid and rust-preventing pigments - 10 µm DFT

	High-build chlorinated or acrylated rubber - 100 μm DFT Chlorinated or acrylated rubber enamel - 35 μm DFT
SYSTEM 4	
System Reference	Epoxy
Type of surface	Ferrous metal
Working environment	Submerged
Surface preparation	Blast clean to BS 7079: Part A1, Grade Sa 2½
Description of system	Shop-primer (if epoxy coating cannot follow immediately) Catalyst cured straight epoxy: 3 coats to 240 μm total DFT
SYSTEM 5	
System Reference	Factory applied stoved paintwork for enclosures for electrical equipment
Type of surface	Metal
Working environment	Atmospheric - indoor
Surface preparation	According to material to be coated:- Steel: blast clean to BA 7079: Part A1, Grade Sa 2½
Description of system	Galvanised: etch prime 5 coat stove-enamel system - total DFT 200 μm gloss or semi-gloss
SYSTEM 6	
System Reference	Gloss paint
Type of surface	Softwood joinery - decorative finish
Working environment	Atmospheric - interior and exterior
Surface preparation	Rub down with sandpaper and dust with soft brush
Description of system	One coat of wood primer. Two coats of alkyd undercoat - 40 μm DFT per coat One coat of alkyd enamel to 30 μm DFT
SYSTEM 7	
System Reference	Wood varnish
Type of surface	Hardwood and softwood - clear finish
Working environment	Atmospheric - interior

Surface preparation	Rub down with sandpaper and dust with soft brush
Description of system	Three coats of marine varnish - 20 µm DFT per coat
SYSTEM 8	
System Reference	Wood protection
Type of surface	Softwood joinery - clear finish
Working environment	Atmospheric - exterior
Surface preparation	Rub down with sandpaper and dust with soft brush
Description of system	Two coats of Wood preservative basecoat Two coats of decorative wood preservative
SYSTEM 9	
System Reference	Emulsion paint
Type of surface	Concrete, plaster and blockwork
Working environment	Atmospheric
Surface preparation	Wash down with 3% solution of phosphoric, hydrochloric or acetic acid, followed by fresh water
Description of system	One priming coat of vinyl copolymer emulsion thinned with 10-20% fresh water Two coats of vinyl copolymer emulsion to 60 µm total

K20.6.3 Interior decorating trial

Before interior decoration is started generally, a designated area shall be completely decorated as a sample of the work to be carried out. The area shall include complete samples of all woodwork, walls, ceilings and metalwork. The area shall be offered for review by the Engineer, and shall then be preserved as a reference standard for the work.

K20.6.4 Application of epoxy coatings by a specialist

All epoxy coating work shall be carried out by a specialist firm or sub-contractor approved by the Engineer. When applying for such approval, the Contractor shall submit a letter of guarantee from the specialist sub-contractor backed by the paint manufacturer that the product he proposes to supply, when applied in accordance with this Specification and any additional specifications which shall be quoted by the sub-contractor, will withstand the environmental service conditions to be encountered. The letter shall quote the guarantee period in years from time of application of the coating.

K20.6.5 Colour coding

Pipework, tanks and ducting shall be colour coded either by banding with the appropriate code colour over the decorative paint, or by totally painting with on appropriate code colour.

The Contractor shall submit a schedule of colours for coding purposes, drawn up in accordance with BS 5252, to the Engineer for his approval and prior to the commencement of painting. The schedule shall cover but not necessarily be limited to:-

(a) pipelines for raw, filtered and treated water;

(b) pipelines for fuels and air;

(c) pipelines for each chemical and gas;

(d) pipelines for service water, potable water supply and fire fighting water;

(e) pipelines for waste water;

(f) chemical storage tanks;

(g) crane beams and the like.

All pipes and tanks shall also bear painted labels to indicate the contents. Lettering shall be in English. Labels on pipework shall incorporate arrows showing the direction of flow within the pipework. When pipes are colour coded with coloured bands, the label shall be located on the colour band. Black lettering shall be used on orange, yellow, and green, and white lettering shall be used on red and blue. Sufficient labels shall be used to ensure adequate identification throughout the length of the pipe runs. These shall be located at least adjacent to each flange or disconnecting joint, where pipework passes through walls or floors, crosses doorways and other access ways and at intervals in long runs of pipework.

K21.0 ROADWORKS

K21.1 Scope

This specification covers the furnishing of all materials, plant, labour, equipment, tools and services for the complete and proper construction of access roads from water-bound macadam with bituminous surfacing treatments and cross drainage works.

K21.2 Reference Standards

Unless otherwise specified, roadworks and footpaths shall comply with the relevant Reference Standards listed below.

K21.3 Submissions by the Contractor

The Contractor shall submit the following items to the Engineer for his approval in advance of constructing the Works.

(a) Proposals/samples for:

- sub-base material;
- road base material;
- bituminous emulsions;
- coated macadam;
- flexible surfacing;
- road marking paint;
- precast concrete paving blocks;
- vitrified clay pipes and ducts;
- precast concrete pipes;
- precast concrete channels kerbs and edgings;
- precast concrete flags.

(b) Certificates:

- suppliers' certificates of compliance with specified requirements for the above.

K21.4 Materials

K21.4.1 General

All materials shall be obtained from local sources and shall be subject to approval by the Engineer prior to use.

Substitution of material shall be on an "Approved equal" basis as determined by the Engineer and shall result in finished roads as designated in this Specification and at no additional cost to the Employer.

Mineral aggregates shall consist of natural or crushed stone, gravel or sand, shall be of reasonably uniform quality throughout, and shall be clean and free from soft or decomposed particles, excess clay, foreign, organic, or other deleterious matter.

K21.4.2 Coarse aggregate for sub-base, base and semigrout

Coarse aggregate shall be crushed or broken stone and shall conform to the physical requirement given below.

Physica1 Requirements of Crushed Stone for Road Work:

Sr. No.	Test	Limiting Value	
		For aggregates to be used for Road base and surfacing	For aggregate to be used for sub-grade
1.	Specific Gravity	Not less than 2.6	Not less than 2.0
2.	Water Absorption	Not more than 2%	Not more than 5%
3.	Flakiness Index	Maximum 25%	--
4.	Elongation Index	Maximum 40%	--
5.	Aggregate Impact Value or Aggregate Crushing Value	Not more than 30%	Not more than 40%
6.	Los Angeles Abrasion Value	Not more than 30%	Not more than 50%
7.	Stripping Test	Maximum 15%	--

The crushed or broken stone shall be hard, durable and free from excess of flat, elongated, soft and disintegrated particles, dirt and other objectionable matter.

Crushed or broken stone shall conform to the grading given below.

Grading Requirements of Coarse Aggregates:

Grading No.	Size Range	I.S. Sieve Designations	Percent by Weight passing the sieve
1.	90 mm to 40 mm	100 mm 80 mm 63 mm 40 mm 20 mm	100 65 - 85 25 - 60 0 - 15 0 - 5
2.	63 mm to 40 mm	80 mm 63 mm 50 mm 40 mm 20 mm	100 90 - 100 35 - 70 0 - 15 0 - 5
3.	50 mm to 20 mm	63 mm 50 mm 40 mm 20 mm 10 mm	100 95 - 100 35 - 70 0 - 10 0 - 5

K21.4.3 Screenings

Screenings shall consist of predominantly non-plastic materials such as sandy gravel or gravel (other than rounded river borne material) with Liquid Limit and Plasticity Index below 20 and 6 respectively and fraction passing 75 micron sieve not exceeding 10%. The material shall be sound and hard, free from all impurities and shall be screened at the quarry. Gravel shall comprise large, coarse, siliceous grains, sharp and gritty to the touch, thoroughly free from dirt and impurities.

Screenings shall conform to the grading indicated below.

Grading for Screenings:

Grading Classification	Size of Screenings	I.S. Sieve Designation	Percent by Weight passing the Sieve
A	12.5 mm	12.5 mm 10.0 mm 4.75 mm 150 microns	100 90 - 100 10 - 30 0 - 8
B	10.0 mm	10.0 mm 4.75 mm 150 microns 75 microns	100 85 - 100 10 - 30 0 - 10

K21.4.4 Blinding material

Any non-plastic material such as gravel/grit/dust/sand/brick powder may be used to act as blinding to fill in the voids in the coarse aggregates. The plasticity index of the material shall not exceed six.

K21.4.5 Bituminous macadam

The grading, composition and characteristics of bituminous macadam shall be as follows:

Aggregate Grading, 50mm graded:

IS Sieve Designation	Percentage Passing
50mm	100
40mm	60-100
25mm	30-70
20mm	20-70
6.3mm	10-20
2.36mm	0-5
Bitumen(Grade S65)	**3.7 to 4.3% by weight of total mix**

Aggregate Grading, 25mm graded:

IS Sieve Designation	**Percentage Passing**
25mm	100
6.3mm	10-40
2.36mm	0-5

Bitumen(Grade S65) **3.7 to 4.3% by weight of total mix**

Aggregate Grading, 12mm graded:

IS Sieve Designation	**Percentage Passing**
12mm	100
6.3mm	10-40
2.36mm	0-5

Bitumen(Grade S65) **3.7 to 4.3% by weight of total mix**

K21.4.6 Seal coat

The grading, composition and characteristics of 6mm seal coat shall be as follows:

Aggregate grading

I.S. Sieve Designation	Percentage passing
6.3 mm	100
2.36 mm	70 - 100
600 micron	25 - 50
300 micron	0 - 10

Bitumen (Grade S65) Content: 7% to 8% by weight of total mix.

K21.4.7 Binder

Binder shall be straight run Bitumen of grade S35 or S65 and shall conform to the requirements for Bitumen Binder specified below.

Sr. No.	Characteristic	Requirement for Grade		Method of Test Reference to
		S 35	S 65	
1.	Specific gravity at 27°C, Min.	0.99	0.99	IS : 1202
2.	Water percent by weight, Max	0.2	0.2	IS : 1211
3.	Flash point, Pensky Martens closed type °C, Min.	175	175	IS : 1209 (Method A)
4.	Softening point, °C	50-65	40-55	IS : 1205
5.	Penetration, at 25°C, 100 g, 5 sec in 1/100 cm	30-40	60-70	IS : 1203
6.	Ductility at 20°C in cm, Min.	50	75	IS : 1208
7(a)	Loss on beating, percent by weight, Max.	1	1	IS : 1212

(b)	Penetration of residue (expressed as percentage of item 5), Min	60	60	IS : 1203
8.	Matter soluble in carbon disulphide, percent by weight, Min.	99	99	IS : 1216

K21.4.8 Slab culverts

Concrete for Cast in-situ culverts shall be of reinforced M20 concrete unless otherwise shown. Masonry and brickwork shall comply with the section of this Specification concerning Building Works. Pre-cast concrete culverts shall be to the approval of the Engineer.

K21.4.9 Pipe drains

Pipes for road drainage shall be precast concrete pipes Class NP2/NP3, and shall conform to IS:458.

Each consignment of cement concrete pipes shall be inspected, tested if necessary, and approved by the Engineer at the place of manufacture or at Site before their incorporation in the Works.

K21.5 Workmanship

K21.5.1 Setting out

The Contractor shall provide all labour and materials such as line, strings, pegs, nails, bamboos, stones, mortar, concrete, etc., required for setting out, establishing bench marks and giving profiles. The Contractor shall maintain any established setting out items such as bench marks, profiles and other stakes and marks as long as they are required for the work in the opinion of the Engineer.

K21.5.2 Earthwork

Earthworks shall comply with the provisions of the section of the Specification for Earthworks.

K21.5.3 Preparation Of sub-grade

Sub-grade shall be cleaned of all foreign substances, vegetation, etc immediately prior to laying sub-base. Any ruts or soft spots shall be corrected and the sub-grade dressed off parallel to the finished profile. The sub-grade camber shall conform in shape to that of the finished road surface. Camber boards shall be used to get the required section.

The prepared sub-grade shall be lightly sprinkled with water as necessary, and rolled with a powered roller of 10-12 tonnes. The roller shall make a minimum of five passes. Any undulations in the surface that develop due to rolling shall be made good with approved earth and sub-grade re-rolled.

K21.5.4 Depth of coursing

Each course shall be constructed to the final minimum compacted thickness shown in the table below, based on the type of road indicated. In the case of National, State, District, City and Municipal roads, the details shall be agreed with the relevant Authority and may vary accordingly.

Type of Road		Sub-base	Base Course	Wearing Course
National Highway	Material	Grade 2	Grade 3	25mm graded + seal coat
	Thickness	150	75	40
State Highway	Material	Grade 2	Grade 3	25mm graded + seal coat
	Thickness	75	75	40
District Road	Material	Grade 2	Grade 3	12mm graded + seal coat
	Thickness	75	75	20
City/Municipal Road	Material	Grade 2	Grade 3	25mm graded + seal coat
	Thickness	75	75	40
Village Road	Material	Grade 2	Grade 3	12mm graded + seal coat
	Thickness	75	75	20
Service Roads	Material	Grade 2	Grade 3	25mm graded + seal coat
	Thickness	75	75	40

K21.5.5 Sub-base

K21.5.5.1 General

Sub-base shall not be constructed on wet sub-grade. The sub-base course shall be 150 mm wider on either side than the wearing course.

K21.5.5.2 Spreading and rolling

Spreading shall be uniform and even upon the prepared sub-grade. The spreading shall be done from stock piles along the side of the roadway. In no case shall the aggregates be dumped in heaps directly on the prepared sub-grade nor shall hauling over an uncompacted or partially compacted base be permitted. The surface of the aggregate shall be carefully checked with templates and all high or low .spots remedied by adding or removing aggregate. No segregation of large or fine particles shall be allowed.

The material shall be rolled immediately following spreading and shall be done with three wheeled, powered rollers of 10 to 12 tonnes capacity or tandem or vibratory rollers of a type approved by the Engineer. Rolling shall begin from the edges gradually progressing towards the centre, with the roller moving parallel to the centerline of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall be continued until the material has been thoroughly keyed and forward movement of stones ahead of the roller is no longer visible. Slight sprinkling of water may be done if necessary.

K21.5.5.3 Application of blinding

Blinding shall be applied by spreading approved dry screened material uniformly and brushing it into the voids and shall continue until the voids are filled. Once the voids are filled with dry material the surface shall be wetted thoroughly and additional blinding added if necessary to top up any voids. The final surface shall be well bound and void free. This procedure shall be applied to both layers.

K21.5.6 Water bound macadam course

K21.5.6.1 Preparation of base

The sub-base shall be .prepared to the specified grade and camber and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm.

K21.5.6.2 Spreading coarse aggregate

Coarse aggregates shall be spread uniformly upon the prepared base and compacted to 80 mm.

Spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. In no case shall the aggregate be dumped in heaps directly on the surface prepared to receive the aggregate nor shall hauling over uncompacted or partially compacted base be permitted.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate.. No segregation of large or fine particles shall be allowed.

Coarse aggregate shall not be spread more than 3 days in advance of the subsequent operations.

K21.5.6.3 Rolling

The material shall be rolled immediately following spreading and shall be done with three wheeled, powered rollers of 10 to 12 tonnes capacity or tandem or vibratory rollers of a type approved by the Engineer.

On super elevated portions rolling shall proceed from inner to outer edge. Otherwise rolling shall begin from the edges gradually progressing towards the centre, with the roller moving parallel to the centerline of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space to permit application of blinding. During rolling slight sprinkling of water may be done if necessary. Rolling shall not be done when the sub-grade or sub-base is soft or yielding or when it causes a wave-like motion in the sub-grade or base course.

The rolled surface shall be checked transversely and longitudinally with templates and any irregularities corrected by loosening the surface, adding or removing necessary amounts of aggregate and re-rolling until the entire surface conforms to the desired camber and grade. In no case shall blinding be permitted to make up depressions.

K21.5.6.4 Application of blinding

Blinding shall be applied by spreading approved dry screened material uniformly and brushing it into the voids and shall continue until the voids are filled. Once the voids are filled with dry material the surface shall be wetted thoroughly and additional blinding added if necessary to top up any voids. The final surface shall be well bound and void free. This procedure shall be applied to both layers.

Blinding material shall be spread and finished in the same day.

K21.5.6.5 Setting and drying

After the final compaction of water bound macadam course, the road shall be allowed to dry overnight. The next morning the surface shall be inspected and any voids blinded, and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer shall have the discretion to stop hauling traffic from using the completed surface if in his opinion it would cause excessive damage.

K21.5.7 Tack coat

K21.5.7.1 Preparation of base

The base course surface shall be prepared, shaped and conditioned to the specific lines, grade and cross section by repairing all potholes, patches and ruts. Potholes shall be drained of water and cut to regular shape with vertical sides. All loose and disintegrated material shall be removed. Potholes shall be repaired by painting the sides and bottom of the hole with bitumen and either:

Filling with coarse aggregate and screenings, compacted with heavy hand rammers or approved mechanical tempers; or

Filling with premixed chippings with binder (bitumen grade S 35/ S 65) content of 3 percent by weight of total mix, after painting the sides and bottom of the holes with a thin application of bitumen,

K21.5.7.2 Application

The surface shall be cleared of dust and loose matter. The binder used for tack coat shall be bitumen of suitable penetration grade within S35 to S65 conforming to IS:73. Binder shall be heated to the temperature appropriate to its grade and as approved by the Engineer. The binder shall be sprayed on the prepared base at the rate of 1.0 kg/sq.m. The binder shall be applied uniformly with the aid of either self propelled or towed bitumen pressure sprayer with self heating arrangement and spraying nozzle arrangement to provide a uniform spread. The tack coat shall be applied just ahead of laying asphalt macadam.

K21.5.8 Bituminous macadam

K21.5.8.1 Application

The bituminous macadam shall be laid by mechanical compactor and finisher, the final consolidation being by means of power roller weighing not less than 10 tonnes. The finished surface shall not vary by more than 12.5 mm above or below the designed level and the average thickness shall not be less than 65 mm after consolidation.

The bituminous macadam may be prepared in a hot mix plant or the bitumen may be cut back with a suitable solvent so that the heated cut back bitumen may be mixed with the aggregate. In either case mixing shall be carried out in a power driven pugmill mixer and shall be continued until all the aggregate is coated.

K21.5.8.2 Protection of pavement

During the period between initial compaction of the coarse aggregate and completion of the seal coat, the surface shall be protected from all traffic other than absolutely essential to its construction.

K21.5.8.3 Premixed seal coat

After the aggregate has been rolled, the interstices shall be completely filled with pre-coated grit of the following composition:

The premixed seal may be prepared in a hot mix plant or the bitumen may be cut back with a suitable solvent so that the heated cut back bitumen may be mixed with the aggregate. In either case, mixing shall be carried out in a power driven pugmill mixer and shall be continued until all the aggregate is coated.

The premixed seal must be brushed to fill in the interstices, additional material being applied during rolling if found necessary. The quantity of premixed seal required for this purpose shall be 1.22 cu.m. per 100 sq.m.

K21.5.9 Quality control

K21.5.9.1 General

All works performed shall conform to the lines, grades, cross sections and dimensions as specified or as directed by the Engineer subject to the permitted tolerances described hereinafter.

K21.5.9.2 Horizontal alignments

These shall be reckoned with respect to the centreline of the carriageway as specified. The edges of the carriageway as constructed and all other parallel alignments shall be corrected within a tolerance of ± 20 mm.

K21.5.9.3 Longitudinal profile

The level of any point on the various surfaces after compaction shall comply with the following :

Surface	Tolerance from specified level
Sub-grade	± 25 mm
Sub-base	± 20 mm
Base course	± 15 mm
Wearing course	± 10 mm

However, the negative tolerance for wearing course, shall not be permitted in conjunction with the positive tolerance for the base course, if the thickness of the wearing course is thereby reduced by more than 6 mm.

K21.5.10 Slab culverts

K21.5.10.1 Graded gravel free draining backfill

Free draining backfill 200mm thick shall be provided on each side of uncoursed rubble walls supporting slabs. The material for this backfill shall be granular, consisting of sound, tough, durable particles of crushed or uncrushed gravel, crushed stone or brickbats which will not become powdery under loads and in contact with water. The material shall be free from soft, thin, elongated or laminated pieces and organic matter. It shall be graded to the approval of the Engineer.

K21.5.10.2 Weep holes

Weep holes shall be provided in masonry. Weep holes shall be of uPVC pipes with M-10 concrete surround, 75 mm thick. They shall extend through the full width of the masonry at a spacing of 1.5 mm c/c and with slope of about 1 vertical to 20 horizontal towards the draining face.

K21.5.11 Pipe drains

Surface water drainage for roads shall consist of open ditches or of piped drainage. Where practicable, drainage work under the roadway shall be completed before roadworks are commenced.

Open ditches shall be excavated to the appropriate cross-section with the sides dressed fair throughout and the bottoms accurately graded to regular falls.

French drains shall be excavated and backfilled to the appropriate cross-section and filled with free-draining granular material and shall incorporate porous or perforated pipes as necessary.

Trenches for piped drainage shall be excavated to the minimum dimensions necessary for the proper construction of the Works, and after pipes have been laid, tested and surrounded with gravel or concrete, the trenches shall be back-filled with selected excavated material and compacted to a dry density equal to that of the adjacent ground. Surplus excavated material shall be disposed of to the Contractor's tip. Trenches shall be kept free from standing water.

Pipes shall be laid with a permitted tolerance of 20mm in line and level. Where directed by the Engineer pipes shall be haunched or surrounded with concrete. The pipes shall be fitted and matched so that when laid they form a drain with a smooth uniform invert. All joints shall be made with care so that their interior surface is smooth and consistent with the interior surface of the pipes. The ends of the pipes shall be so shaped as to form a self-centering joint with jointing space 13 mm wide. The jointing space shall be filled with cement mortar (1 cement to 2 sand) mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed. After finishing, the joints shall be kept covered and damp for at least four days.

The pipe strength and surround for crossings under the roadway shall be designed to take account of final vehicle loading. The Contractor shall at no extra cost to the Employer take all necessary precautions to avoid damage occurring to the pipes as a result of construction traffic. Should any damage occur to the pipes as a result of construction traffic, the Contractor shall at no extra cost to the Employer replace the damaged pipes to the satisfaction of the Engineer.
Porous or perforated pipes shall be laid dry-jointed and shall be surrounded with gravel.
Where the Contractor is required to lay ducts for Statutory Undertakers then these shall be laid in the appropriate positions, draw ropes laid inside the duct and the Contractor shall adequately record or mark the position of the ducts as instructed by the Engineer.

Precast concrete manholes and gullies shall be constructed complete with cast iron covers or gully gratings. No cover or grating shall be set at such a level relative to final pavement level that, in the opinion of the Engineer, it constitutes a danger to pedestrians or traffic.

K21.5.12 Inspection and testing

The longitudinal profile shall be checked with a 3.0 m long straight edge, along the centreline of the road. The transverse profile shall be checked with a camber board at intervals of 30 m. Permitted tolerances are specified below :

Permitted tolerances of Surface Regularity for Pavement Courses

No.	Type of Construction	Longitudinal Profile (Maximum permissible undulation when measured with a 3 m straight edge) (mm)	Cross Profile (Maximum permissible variation from specified profile when measured with a camber template) (mm)
1	Sub-grade	18	12
2	Sub-base	18	12
3	Base-Course Asphalt	12	10
4	Macadam	10	8

K21.5.13 Repairing defects

Where the surface irregularity of sub-grade and the .various pavement courses falls outside the specified tolerances, the Contractor shall rectify these in the manner described below and to the satisfaction of the Engineer.

(a) Sub-grade

Where the surface is high it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected by adding fresh material.

(b) Stabilised sub-base

Where the surface is high, the same shall be suitably trimmed while taking care that the material below is not disturbed due to this operation. However, where the surface is low, the same shall be corrected as described below :

When the time elapsed between detection of irregularity and the time of mixing is less than 2 hours, the surface shall be scarified to a depth of 50 mm, supplemented with freshly mixed material as necessary and recompacted to the relevant specification. When this time is more than 2 hours, the full depth of the layer shall be removed from the pavement and replaced with fresh material to specification. In either case the area treated shall not be less than 5 m long by 2 m wide.

Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and recompacted. The area treated at a place shall not be less than 5 m long and 2 m wide.

(c) Bituminous construction

For bituminous construction other than wearing course where the surface is low, the deficiency shall be corrected by adding fresh material and compacting to the Specification. Where the surface is high, the full depth of the layer shall be removed and replaced with fresh material and compacted to the Specification.

For wearing course where surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to the specification. In all cases where removal and replacement of bituminous layer is involved, the area treated shall not be less than 5 m long and 2 m wide.

K21.5.14 Quality control test during construction

The Contractor shall do the quality control tests described below. The testing frequencies given are the desirable minimum and the Engineer shall have the authority to order tests as frequently as he may deem necessary.

(a) Earthworks for embankment construction:

Sl. No.	Test	Frequency
1.	Plasticity	As directed by the Engineer
2.	Density	Each soil type to be tested. 1-2 tests per 8000 cubic metres of soil
3.	Deleterious Content	As directed by the Engineer
4.	Moisture content	1 test for every 250 cubic metres of soil
5.	CBR test	As required by the Engineer

(b) Construction testing:

Sl. No.	Type of Construction	Test		Frequency
1.	Sub-base	i)	Gradation	1 test per 2000 m2
		ii)	Plasticity	As required
		iii)	Deleterious Constituents	As required
		iv)	CBR test	As required
		v)	Moisture content prior to compaction	1 test per 250 m2
		vi)	Dry density	1 test per 500 m2
2.	Water Bound Macadam	i)	Gradation	1 test per 1000 m2
		ii)	Flakiness index	1 test per 2000 m2
		iii)	Plasticity of binding material	1 test per 1000 m2
3.	Bitumen Macadam	i)	Quality of binder	As required
		ii)	Aggregate impact value	1 test per 50-100 m2 of aggregate
		iii)	Flakiness index	1 test per 50-100 m2 of aggregate
		iv)	Grading of aggregates	2 tests per day per plant, both on the individual constituents and mixed aggregates from the dryer (one at plant and one at Municipal Lab)

Sl. No.	Type of Construction	Test		Frequency
		v)	Binder content	Periodic subject to 2 tests per day per plant
		vi)	Control of temp. of binder and aggregate for mixing and of the mix at the time of laying and rolling	At regular close intervals
		vii)	Rate of spread of mixed material	Regular control through checks on layer thickness
4.	Seal Coat	i)	Quality of binder	As required
		ii)	Aggregate Impact Value	1 test per 2000 m2
		iii)	Flakiness Index	1 test per 2000 m2
		iv)	Aggregate grading	2 tests per day
		v)	Temp. of application	At regular close intervals
		vi)	Rate of spread of materials	2 tests per day

Where a specific procedure is not indicated for quality control tests in these specifications, it shall be carried out as per the relevant Indian Standard code of practice.

K21.5.15 Compaction control

Density shall be measured once per 500 square metres of compacted area. The determination of density shall be in accordance with IS:2720 (Part 28). Test locations shall be chosen only through random sampling techniques. Assessment shall be based on the mean value of a set of 5-10 density determinations. The number of tests in one set of measurements shall be 5, as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance of work shall be subject to the condition that the mean dry density equals or exceeds the specified density and the standard deviation for any set of results is below 0.08 g./cm3.

However, for earth work in shoulders and in the top 500 mm portion of the embankment below the sub-grade, at least one density measurement shall be taken for every 500 square metres of the compacted area provided further that the number of tests in each set of measurements shall be at least 10.

K22.0 BUILDING WORKS

K22.1 Materials and Workmanship

K22.1.1 Finishes in general

If in the opinion of the Engineer, the Contractor consistently fails to achieve the required standard of finish for any of the works detailed in this section, the Engineer may order the Contractor to employ a specialist firm of subcontractors approved by the Engineer to carry out all or part of this work at no extra cost to the Employer.

K22.1.2 Cement/lime mortar

Mortar for brickwork, brickwork and stonework shall be prepared, in accordance with I.S. 2250. Cement mortar shall consist of Portland cement and sand, in proportions specified elsewhere. Lime mortar for laying of tiles shall consist of one part of cement, 2 parts of lime and 6 parts of sand.

Mortar shall be mixed on clean, hard, dry platforms protected from sun and rain. The constituents shall be measured using properly made gauge boxes and shall be thoroughly mixed dry before water is added. Any mortar not used 30 minutes after the water is added shall be discarded.

For lime mortar, lime from burnt stone shall be used. It shall be free from ash and impurities and be in the form of lumps and not powder when brought to Site. Lime which is damaged due to rain, soaking, moisture or air slaking shall not be used.

Portland cement for mortar shall comply with I.S. 269.

Sand for mortar shall comply with I.S. 2116 and shall be of the following grading :

I.S. Sieve	Percentage passing by weight
4.75 mm	98 - 100
2.36 mm	80 - 100
1.18 mm	60 - 80
600 microns	40 - 65
300 microns	10 - 40
150 microns	0 - 10

Sand for mortar shall be from an approved source and shall consist of hard, coarse siliceous grains free from deleterious matter. It shall be stored separately from other sand or fine aggregate and shall be kept covered. The Contractor shall submit samples of sand for mortar for the Engineer’s approval if ordered.

Water for mortar shall comply with the specification for water for concrete.

K22.1.3 Bricks

Bricks for common brickwork shall be whole, sound, well burnt clay bricks free from cracks and shall comply with the requirements of I.S. 1077. Samples of bricks to be supplied shall be submitted to the Engineer for his approval. Clay engineering bricks shall comply with the requirements of I.S. 2180.

Bricks shall not be tipped on the Site but shall be carefully stacked by hand in separate stacks. Broken or damaged bricks shall not be used in brickwork.

Crushing Strength = 50 kg/cm2
Water Absorption = not >25% for partition walls
Size = Tolerance Allowed = 3.3% positively

K22.1.4 Brickwork

Brickwork shall be built in accordance with the requirements of I.S. 2212. Every brick shall be wetted and laid on a full and close joint of mortar on its bed, side and end in one operation, joints being, fully flushed up as the work proceeds. No previous course shall be wetted if it has dried and the walls shall be brought up evenly with no portion racked up (and not toothed) more than one metre higher than another. All brickwork shall be properly bonded together. Joints shall not exceed 10 mm in thickness and shall be raked out to a depth of 7.5 mm as a key for rendering or plastering. All courses shall be truly horizontal and all perpends shall be strictly plumb and square.

In the cavity walls the two leaves of brickwork shall be bonded with galvanised wall ties 150 mm to 250 mm long as required. The ties shall be built into the horizontal joints as the work proceeds and the space between successive ties shall not exceed 750 mm horizontally nor 250 mm vertically. Ties shall be staggered and shall be laid sloping down towards the outer leaf of the cavity. Cavities shall be kept free from mortar droppings by the use of suspended battens and temporary openings at the bottom of the wall. Every fourth vertical joint in the external face in the course immediately above the horizontal damp proof courses shall be raked out and left open to form a weephole. Completed brickwork shall be kept wet for a minimum period of 14 days.

K22.1.5 Concrete blocks

Concrete blocks whether made on or off Site shall be manufactured to the shapes, sizes and finishes as specified or directed by the Engineer and shall comply with the requirements of IS: 2185. The Contractor shall submit full details of his proposed manufacturing arrangements to the Engineer for his approval before making any blocks for use in the Works and shall submit such samples as may be needed to demonstrate the quality of the finished product. Production of blocks shall be of equal standard to the approved sample blocks.

Concrete for blocks shall be made such that the combined aggregate shall have a fineness modulus lying between 3.6 and 4 and shall conform with the following grading

I.S. Sieve	Percentage passing By weight
12.5 mm	100
10 mm	> 85
4.75 mm	> 60

300 microns > 10

Concrete for blocks shall be minimum Class M-20. Hand mixing shall not be permitted. When ordered by the Engineer, sample block from any batch shall be tested as specified in I.S. 2185.

Finished blocks shall be neatly stacked for storage on firm dry support and shall be covered to protect them from dirt, sun and rain. Damaged blocks shall not be used in the Works.

K22.1.6 Blockwork

Concrete blockwork shall be laid generally as specified for brickwork above except where specified otherwise or as directed by the Engineer. The construction of hollow block masonry shall be generally in accordance with I.S. 2572. Blockwork for partition walls shall be laid in stretcher bond. Fair face blockwork which is not to be plastered shall be neatly pointed as specified.

K22.1.7 Uncoursed stone masonry

Uncoursed stone masonry shall be built in layers not exceeding 450 mm in height. No stone shall be less in breadth than 14 times its height and less in length than twice its height. Every stone whether large or small, shall be laid in its natural bed and set flush in mortar, and the small stones used for wedging or filling being carefully selected to fit the interstices between the large stones. Care shall be taken to see that no dry work or hollow space is left in the masonry. The stones shall be so arranged as to break joints at least every 80 mm and long vertical joints of joints shall be avoided. The joints at the face shall be finished off neatly, being struck and smoothed with a trowel while the mortar is fresh. The upper surface of the work shall be brought to a uniform level at the height of each course. The faces of masonry walls shall be kept in perfect plumb and where batter has to be given it shall be uniform. The stones at all comers and junctions of walls shall be of large sizes and hammer dressed to the correct angle.

Each stone shall be thoroughly wetted before being used in the work. The masonry shall be kept thoroughly wet during the progress of the work, (care being taken to water it even on Sundays and Holidays, special labour being employed if so required for this purpose) until it has set. As far as practicable, the whole of the masonry shall be raised in one uniform level and no part of the masonry shall be allowed to rise more than 1 metre above the rest to avoid unequal settlement. If raising one part of wall before the other becomes unavoidable the end of the raised portion shall be racked back in steps to prevent cracks developing at the junction of the old and new work. Care shall be taken to see that the sides of the wall are not built separately from the hearting, the faces and internal filling being done simultaneously. .The stones shall overlap and cross each other as much as possible. No course shall be laid unless the previous course is perfectly set.

At least one header or through stone per square metre of wall face shall be built into the work. The headers or through stones shall be at least 0.05 m2 in area at face and shall have at least 0.025 m2 area at the back face. Where the thickness of the wall is more than 600 mm a series of through stones shall be laid through the work so as to form a tie from front to back, breaking joints or overlapping each other for at least 150 mm. No stone whose length is less than 600 mm shall be used in such work as a header.

All the through stones shall be marked inside and outside and the marks shall be retained until ordered by the Engineer to be removed. Sufficient number of headers shall be collected on site before commencing any masonry work. Where adequate sized through stones are not available in required quantities, the use of pre-cast plain concrete headers in M-20 mix may be permitted at the discretion of the Engineer. No extra payment will be made for the provision of substitute headers in concrete

Quoins shall be 150 mm high and formed of header stones at least 300 mm long. They shall be laid lengthwise alternately along each face and square on their beds, which shall be dressed to a depth of at least 80 mm.

Weep holes 80 mm wide and 150 mm in height shall be provided in retaining walls at the rate of one per square metre as specified or directed. They shall be pointed with 1:2 cement sand mortar after raking the joints to a minimum depth of 25 mm.

Completed masonry shall be kept wet for a minimum period of 14 days. In wet weather newly laid masonry shall be protected from the effects of heavy rainfall by tarpaulins or other approved material.

K22.1.8 Pointing of uncoursed masonry

Joints in exposed masonry faces shall be formed while the mortar is still green and shall be finished as flush joints, weathered joints, round-recessed joints or square-recessed joints as directed by the Engineer. Masonry which is to be rendered or plastered shall have the joints raked out to a depth of 15 mm to form a key.

K22.1.9 Stone pitching

Stone for pitching shall be obtained from an approved source and shall be hard, sound, durable, clean and generally as specified. The minimum dimension of any stone shall be at east equal to the specified thickness of the pitching.
After excavation and trimming, slopes to be pitched shall be spread with a 75 mm thick layer of crusher run rock or graded coarse aggregate ranging from 75 mm particle size to fines. The slope shall then be hand packed with hard broken rock to a total thickness of 150 mm, each stone being individually placed and rammed home, with smaller stones edged into the cracks. 50 mm dia weep-holes shall be provided at intervals not exceeding two metres in both directions. Joints in stone pitching shall be flushed up with sand/cement mortar on completion.

K22.1.10 Rubble packing

Rubble used for packing under floors, foundations, etc. shall be hard and durable rock, free from veins, flaws and other defects. The quality and size of the rubble shall be subject to the approval of the Engineer.
Rubble shall be laid closely in position on the sub-grade. All interstices between the stones shall be wedged in with smaller stones of suitable size well driven to ensure tight packing and complete filling of interstices. Such filling shall be carried out simultaneously with the packing in position of rubble stones and shall not lag behind.

Small interstices shall be filled with hard clean sand and well watered and rammed.

K22.1.11 Floor screeds

Where required or specified, dense concrete floor screeds shall be placed over the structural concrete floor. Before the structural concrete is fully hardened, the surface shall be roughened by wire brushing in order to expose the aggregate. Immediately before laying the screed, the concrete shall be cleaned with stiff brushes and then thoroughly dampened. Before the screed is laid and after the excess water has been removed, a thin layer of stiff cement grout shall be well brushed into the roughened surface.

Where directed by the Engineer an approved water proofing admixture shall be added to screed concrete in accordance with the manufacturer's recommendations.

Heavy duty screeds shall be in M20 concrete. The coarse aggregate shall be well graded to a maximum size of 12 mm. Light duty screeds shall consist of 1 part Portland cement by weight to 4 parts sand. Water content shall be kept to the minimum consistent with providing adequate compaction. Unless otherwise specified, screeding shall be finished to a U2 quality.

Screeds shall be laid to the falls shown in the specification drawings subject to a minimum fall of 1 in 120. The minimum thickness of screed shall be 60 mm for heavy duty and 40 mm for light duty. Screeds shall be cured in accordance with the Specification for concrete.

K22.1.12 Indian patent stone flooring

The Indian Patent Stone Flooring shall be 50 mm in thickness and shall consist of cement concrete mixed in the proportion of 1:2:3 (with 12.5 mm chips only) with an admixture of approved water-proofing compound. The water cement ratio of approximately 0.5 should be used.

Neat cement slurry shall be applied to the surface and the flooring laid, in bays of suitable sizes but not exceeding 6 sq.m. each, to the required slope in a chess board panel fashion and neatly finished smooth in red colour where directed with lines drawn as directed. The concrete shall be cast against teakwood stop-off boards, which shall be removed only after the concrete is set.

No dry cement shall be allowed to be used for finishing the surface. Mechanical mixing may be resorted to.

The surface shall be kept well watered after it is dry, for period of 8 days.

Construction joints shall be formed in between the sequential panels cast, with straight edges, 20 mm deep and 12 mm wide in groove form. These joints on completion of work, shall be cleaned and washed free of dust with the help of brush and shall be treated with hot bitumen poured in the gap, over which fine sand shall be spread to arrest the flow of bitumen.

K22.1.13 Shahabad/Tandur/Kota stone flooring

Stones, shall be of approved quality, hard, sound, durable and of uniform thickness. Edges shall be chisel dressed and the top surface shall be machine polished with joints running true and parallel from, side to side. Stones shall be laid on a bed of lime mortar of proportion 1:2 or cement mortar of proportion 1:4. Thickness of mortar bedding shall not be less than 12 mm and not more than 25 mm. Before laying, the stone slabs shall be thoroughly wetted with clean water. Thick cement slurry shall be spread over the mortar bed over as much area as cou1d be covered with the stone slabs within half an hour. The slabs shall then be laid and gently tapped with mallet till they are firmly and properly bedded. There shall be no hollows left. The joints shall not be more than 2 mm wide and shall be struck smooth. The floor shall be kept covered with damp sand or water for a week. Slabs shall be of standard sizes and shapes and shall meet all the required properties and test requirements as stipulated in I.S. 1124.

Stones in skirting shall be laid against a bedding of cement mortar l:4 20 mm thick to the full height of skirting, to a true plane, level and plumb. The workmanship shall be similar to flooring. The skirting shall be laid projected beyond the finished plastered surfaces. The continuous horizontal grooves at the top of skirting shall be provided if required. The skirting surfaces shall be repolished with hand to the satisfaction of the Engineer. The skirting shall be cure for 7 days. Top of exposed skirting shall be machine cut and polished. Tile used at projecting corners shall be suitably levelled to present a neat corner.

K22.1.14 Marble mosaic flooring

The type, quality, size, thickness, colour etc. of the tiles for flooring and skirting work shall be of best quality from samples approved by the Engineer.

Before the tiling work is commenced, the sub-surface shall be thoroughly cleaned and washed of all loose materials, dirt, and scum or laitance and then well wetted without forming water pools on the surface.

The tiles shall be laid on lime concrete mortar bedding of 30 mm thick. The proportion of mortar shall be one part of cement, 2 parts of lime and 6 parts of sand. The mortar shall be evenly spread on the sub-floor. Over this mortar bed, 5 kg. of cement per sq.m. of floor area shall be spread. The tiles shall be fixed on this bed one after another, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be perfectly straight and uniform in thickness. The tiles shall be laid perfectly in level unless otherwise specified or required or desired by the Engineer. After laying the tiles the joints shall be finished with white cement or cement of approved colour.

For lime mortar, lime from burnt stone shall be used. It shall be free from ash and impurities and be in the form of lumps and not powder when brought to site. Lime which is damaged due to rain, soaking, moisture or air slaking will be rejected.

Floor tiles laid adjoining the wall shall project 12 mm under the plaster, skirting or dado as may be required by the Engineer. Half tiles and pieces shall be avoided, as far as possible. After laying, the flooring shall be allowed to cure undisturbed or seven days. Design traffic shall not be allowed on the floor for at least 14 days after laying the tiles.

About a week after laying the tiles, each and every tile shall be lightly tapped with a small wooden mallet to find out if it gives a hollow sound if it does such tiles along with any other cracked or broken tiles shall be removed and replaced with a new tile to proper line and level. The same procedure shall be followed again after the tiles are finally polished. For the purpose of, ensuring that such replaced tiles match with those earlier laid, it is necessary that the Contractor order enough extra tiles from the factory to meet this contingency. The tiles shall finally be cleaned and polished by using dilute oxalic acid or any other method recommended by the manufacturer and approved by the Engineer.

K22.1.15 Glazed tile flooring and dado

Glazed tiles including ang1es, corners, borders and specials shall be of an approved make and quality, Johnson or equivalent.

Before laying the tiles shall be soaked in water for at least 2 hours and shall be set in lime concrete mortar of one part of cement, two parts of lime and six parts of sand or cement mortar 1:4 for floors and cement mortar 1:4 for dado to walls. Tiles which are fixed in the floor adjoining the wall shall be so arranged that the surface of the round edge tiles shall correspond to the skirting or dado. Neat cement grout of honey like consistency shall be spread over the bedding mortar just to cover so much area as can be tiled within half an hour. The edges of the tiles shall be smeared with neat white cement slurry and fixed in this grout one after the other, each tile being well pressed and gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. There shall be no hollows in bed or joints. The joints shall be kept as close as possible and in straight lines. The joints between the tiles shall not exceed 1.5 mm in width.

K22.1.16 Acid and/or alkali resistant tile flooring and dado

The acid and / or alkali resistant tiles shall have true and straight edges, shall be non-absorbing, without stains, non-fading, shall conform to IS: 4457 and approved manufacturers.

The Contractor shall submit for the Engineer’s approval the characteristics of the tiles and shall enclose the manufacturer’s literature for the same confirming their serviceability for both acids and alkalis. The Contractor shall submit samples of tiles for approval to the Engineer and the bulk supply will only be accepted if it conforms in all respects to the approved samples kept with the Engineer.

The surface over which tiles are to be laid shall be plain and plumb and without uneven depressions. It shall be chemically etched with 15% commercial hydrochloric acid and then washed with alkaline solution. Subsequently, the surface shall be washed with sufficient water until it is fully neutralised.

After the underbed is thoroughly dried, it shall be cleaned thoroughly with wire brushes to remove all loose particles and brushed properly to obtain a completely dust free surface. A heavy grade bituminous corrosion resisting protective coating shall be applied on to this dust free surface either by brushing or by other means in accordance with manufacturer’s specifications so as to provide an isolating layer between the Portland cement concrete and the acid-alkali resistant treatment as well as to provide a proper bonding between the same.

This bituminous material shall be resistant to the splashes and fumes of both inorganic acids and alkalis and should form an elastic film not subject to flaking. Prodorlac SPL as marketed by Coromandal Prodorite Pvt. Ltd. or equivalent may be used for this bituminous lining and the number of coats provided as per manufacturer’s recommendation. If a multiple coat is used, sufficient drying period shall be allowed between completion of one coat and application of the next as recommended by the manufacturer, and depending on the prevalent temperature. On top of the bituminous undercoat specified above, a special mastic of 12 mm minimum thickness or as recommended by the manufacturer shall be applied to provide an impervious underlay membrane to the tiling. This special mastic shall consist of a primer and a mortar. Both these shall be thermoplastic compounds of selected fillers and blended bitumens which are solid at ordinary temperatures.

The primer shall be broken up into small pieces and put into cauldron and heated. The material shall be kept in motion during heating. When the primer is hot enough to flow it shall be poured over the undercoat surface and promptly spread to uniform thickness.

Care shall be taken to avoid moisture entrapment on the surface and to eliminate bubbles. Two layers of primer are normally suitable, but manufacturer’s recommendation in this regard shall prevail.

The mortar is to be heated as required to make a stiff paste similarly breaking up into fairly small pieces and melted in the cauldron. When it reaches a butter like consistency, it is to be applied on to the primer applied surface in single or multiple layers as to form a total thickness of the special mastic membrane of at least 12 mm or as required by the manufacturer’s specification. The mortar shall be applied hot either by trowelling or by means of a standard wooden float and thoroughly worked in until it forms an even coating. The covering shall be done piece by piece and care taken to keep the correct temperature, so that a perfect weld is made. The special mastic material may be the product of Coromandel Prodorite Pvt. Ltd. or equivalent. Over this underlay the acid/alkali resistant tiles shall be bedded in special cement mortar and jointed in acid/alkali resistant resin based cement mortar. The bedding mortar shall have a bed thickness not less than 6 mm. The material shall be self-hardening, chemically setting silicate type and chemical resistant comprising an intimate mixture of a solid filler, a setting agent usually contained in the filler and a liquid binder.

The material may be supplied in two components, powder and solution. When the filler powder and the liquid binder are mixed at ordinary temperature, a trowelable mortar shall be formed which should subsequently harden by the chemical reaction between the setting agent and the silicate binder forming an insoluble silica gel. The liquid binder may be a neutral solution of sodium silicate and/or potassium silicate and the fillers may be silica, quartz or other material insoluble in common mineral acids.

The jointing of the tiles shall be done with a self-hardening cement mortar specially designed to resist both acidic and alkaline as well as mixed acidic and alkaline conditions. For this purpose a resin-type chemical resistant mortar conforming to

IS:4832 Part II shall be used comprising an intimate mixture of liquid resinous material and a powder composed of properly selected filler material and usually containing the setting agent. The material may be supplied in two components which when mixed at ordinary temperature shall form a trowelable mortar that subsequently hardens. The liquid resin may be either one of or a combination of the types like phenolic resin, furane resin, epoxy resin and polyester resin. The filler materials, which are usually of a carbonaceous or siliceous nature shall be selected to have resistance particularly to Hydrochloric acid and caustic soda. The catalyst material may be incorporated in the fillers in such a manner that it becomes effective when mixed with resin .For phenolic and furane resin mortars the resin and the filler may be supplied in two packs. The resin shall have a viscosity that will permit it to be readily mixed with the powder by manual methods. The filler materials shall have properly graded particles that will permit the preparation of a minimum joint thickness of 1.5 mm.

The mortar is to be prepared and applied strictly in accordance with the manufacturer's instructions. If the material is supplied in two separate parts, an inert powder and a resin based syrup, they must be mixed in the proportions given by the manufacturer's data table.

The jointing shall be done for the full depth of the tile and the joint width shall be 3 mm. The joints shall be finished smooth and flush printed.

Mixing shall be carried out very thoroughly and carefully in a clean enamelled dish or bowl. Any lumps in the powder shall be broken down by careful mixing. Mixing shall be carried out by adding powder to the syrup. The mixing shall be so arranged that the mixed mortar is used up quickly and does not remain in bulk longer than the time specified by the manufacturer. At a temperature of 200°C or above, the mixing pan and contents shall be kept cool by immersion in water. All necessary measures should be taken so that the bulk masses of this resin based mortar, which generates heat in setting, are not allowed to remain under fairly warm conditions which may lead to a flash set. To avoid this, it is essential that the mixed mortar is spread in a thin layer on a flat tray and not left in a mass. After jointing the tiles, the flooring should not be placed under service in normal conditions before eight days or as recommended by the manufacturer and depending on atmospheric temperature. During setting and hardening, no water, steam or acid should come in contact with this jointing mortar.

If the flooring has to be sloped the same shall be provided in the concrete slab or an additional graded underbed shall be provided if required, with cement sand mortar (1:3) by volume as specified or as directed by the Engineer.

The Contractor shall furnish full details regarding the materials for the different treatments described above pertaining to this flooring work as per manufacturer IS specifications, and shall lay underlayer, special mastic, setting mortar etc. and set the tiles properly in full conformation with the manufacturer's instructions. The entire work shall be done in workmanlike manner to the complete satisfaction of the Engineer.

K22.1.17 Heavy duty abrasion resistant flooring

The type, quality, size, thickness, colour, etc. of the tile for flooring and skirting work shall be of the best quality approved by the Engineer. For this purpose, the

Contractor shall provide the Engineer with necessary samples for his selection. Tiles shall be hardwearing, resistant to impact, resistant to abrasion, free from slipperiness and also resistant to attack by water, oils and greases. The tiles shall be laid on lime concrete mortar bedding of about 30 mm thick to give an overall thickness of 50 mm.

K22.1.18 Integral cement finish on concrete floor

In all cases where integral cement finish on a concrete floor has been specified, the top layer of concrete shall be screeded off to proper level and tamped with tamper having conical projections so that the aggregate shall be forced below the surface. The surface shall be finished with a wooden float and a trowel with pressure. The finish shall be continued till the concrete reaches its initial set. No cement or cement mortar finish shall be provided on the surface.

K22.1.19 Brick bat coba china mosaic type water proofing

The proportion of brick bat shall be 2 parts of brick bat to one part of lime mortar (one part of lime to 2 parts of sand). The brick bats shall be hard, well burnt and of size varying from 12 mm to 25 mm. Lime shall be of best quality of hydraulic lime double ground. While preparing brick bat concrete, jaggery in portion indicated by the Engineer shall be added. The brick bat coba shall then be laid to slopes, providing necessary wattas, and beated at least for 48 hours after laying. Over the brick bat coba a bedding of 1:2 lime mortar 20 mm to 25 mm thick, shall be provided. A layer of neat cement grout, about 10 mm thick shall then be laid. Immediately on application of cement grout, assorted pieces of coloured china, previously soaked in water shall be set closely on the fresh surface and properly tamped to the required grade, The cement grout freshly laid shall work its v lay to the top surface. The surface after completion .of work shall be finally cleaned with saw dust, and waste and if so directed by the Engineer with dilute acid. China mosaic shal1 be cured for at least 10 days. If so directed by the Engineer, a border of colour or white mosaic shall be provided.

Brick bat coba and china mosaic shall be taken up the parapet walls to a height of 125 mm to 150 mm. Necessary wattas shall be provided towards drain pipes as shown on drawings or as directed by the Engineer.

On prior approval from the Engineer, cement based proprietary type of waterproofing may be allowed to be done by a Specialist Contractor.

The Contractor shall give a guarantee of waterproofing for a minimum period of 10 years against bad or faulty material faulty material and construction and shall rectify the work at his own cost during the guarantee period.

K22.1.20 Nerru plaster

Cement and sand shall conform to IS: 269 and IS: 383 respectively.

Neat lime shall be made of the best description of lime, slaked with fresh water and sifted. The lime shall be reduced to fine powder by grinding it on a stone or in a hand mill as directed by the Engineer. The neat lime thus prepared shall be kept moist until used and the quantity to be prepared at one time shall be such that it can be consumed within eight days.

All stone or brick masonry surface shall be thoroughly wetted for at least 6 hours and the joints raked out to a depth of at least 12 mm and walls washed before any plastering is done. The surface shall then be rendered with 1:4 cement sand plaster with specified roughness. The surface shall then be floated or set with a thin coat, 3 mm thick, of cement and polished well with a trowel or flat board. The cement mortar shall be used within 30 minutes after it leaves the mixing board or mill. Before any plaster work is started patches of plaster 150 mm x 150 mm shall be put on at every 3 metres as gauges so as to ensure an even thickness throughout the work. Cement plaster shall be done in even squares or strips. Care shall be taken to keep the whole surface thoroughly wetted for at least a week. The finishing surface shall be as specified and directed. Neat lime finish shall be applied to the prepared and partially set but somewhat plastic surface with steel trowel to a thickness slightly exceeding 1.5 mm, (1/16") and rubbed down to 1.5 mm (1/16") thickness and polished to a perfectly smooth and even finish working from top to bottom. The total thickness of the plaster shall be at least 12 mm.

The junction between beams and brickwork shall be plastered after fixing the expanded metal wire mesh of 300 mm width. 10 mm deep and 15 mm wide groves shall be provided between concrete & brick surfaces.

K22.1.21 Sand faced cement plaster

Cement and sand shall conform to IS: 269 and IS: 383 respectively. The sand faced cement plaster, where specified, shall be applied in two coats. All stone or brick masonry surface to be plastered shall be thoroughly wetted for at least 6 hours and the joints raked to a depth of at least 12 mm and walls washed before any plastering is done.

The first coat of cement plaster in 1:3 cement sand mortar shall be applied uniformly all over the surface to be plastered to a thickness of 14 mm with a trowel and in exact plumb. This coat shall be allowed to set for not less than half an hour. Indentation shall then be made in the form of waves by raking a wire broom over the surface to form' a key for the second coat. Water proofing compound such as CICO, Impermo etc. shall be added in the 1st coat of cement plaster at the rate of 1.50 kg. per bag of cement or at the rate specified by the manufacturer for its effective results. The plastered surface shall be allowed to cure for at least four days.

The second coat shall be applied in 1:3 cement sand mortar using clean sand screened through a mesh of not less than 1.5 mm and not more than 3.00 mm size to a uniform thickness of 6 mm by trowel and flat board in exact plumb. The surface shall then be tapped with a cork, piece to give a desirable uniform granular appearance. Care shall be taken for keeping the whole surface thoroughly wetted for at least one week.

K22.1.22 Epoxy linings

The Contractor shall employ specialist firms, approved by the Engineer, for the supply and laying of epoxy linings.

K22.1.23 Acoustic tiles

Acoustic tiles shall be of a design and manufacture approved by the Engineer and shall be bonded to ceilings in accordance with the manufacturer's details. They shall have glass wool backing resin bonded to grade RB2 and be fixed on timber or aluminium scantlings.

K22.1.24 Inserts, bolts, etc.

Fabricated pipe, moulded, cast or fabricated frame inserts, bolts, plates, etc. shall be provided in masonry and concrete works as required. It is imperative that all inserts, bolts, fixtures and fittings shall be provided in their position very accurately. Such inserts and bolts shall be fixed by use of templates. If as a consequence of negligence on the part of the Contractor, the inserts, bolts, fixtures, fittings, etc. are out of alignment, the Contractor shall make arrangements to have the inserts and bolts removed and refixed in their proper position as directed by the Engineer.

K22.1.25 Woodwork in doors, windows, partitions, louvers, railings, etc.

Wood used for all work shall be of approved quality of teak wood and properly seasoned by at least 6 months air drying, suitable for joiner's work, should be of natural growth, uniform in texture, straight grained, free from sapwood, dead knots, open shakes, boreholes, rot, decay and all other defects and blemishes.

The thicknesses specified for joiner's wrought timbers are, unless otherwise specified, prior to planning and 3 mm will be allowed from the thickness stated for each wrought faces.

All joining shall be wrought on all faces and finished off by hand with sand paper, with slightly rounded arises.

The joints shall be pinned with hard wood pins and put together with white lead. Jointing shall be by means of mortice and tennon or dovetailed joints, as approved by the Engineer.

Any joiner's work which shall split, fracture, shrink, or show flaws or other defects due to unsoundness, inadequate seasoning or bad workmanship, shall be removed and replaced with sound material at the Contractor's expense.
Doors, windows and ventilator frames shall be rebated. All dimensions shall be as approved. The top framing member of doors and top and bottom framing of windows and ventilators shall project about 150 mm in brickwork. The verticals of door frames shall project about 50 mm below finished floor. Surface coming in contact with brick work shall be painted with bitumen as directed by the Engineer. Each of the door and window frames shall be provided with 3 Nos. M.S. 225 mm x 25 mm x 6 mm flat split hold-fasts on each side. These hold-fasts shall be embedded in masonry or concrete work. The work shall conform to I.S. 4021.

Panelled doors shall comprise a 250 mm wide bottom rail, 150 mm wide middle rail and all other rails middle, top and vertical 100 mm wide. All rails shall be 40 mm thick. Panels shall be 20 mm thick. The panelled doors shall have minimum of 3 panels.

The workmanship of all door shutters shall conform to the requirements of I.S. 1003 (Parts I & 11) and I.S. 2202 (Part I). If required, flush door panels shall be tested as per I.S. 4020. Flush doors Shall be of 35 mm thick solid Core.

All doors shall have 15 mm thick, 40 mm wide teak wood architraves on both sides. Railing and architraves shall conform to the shape as approved and fixed by means of screws (counter-sunk or otherwise) or bolts.

Woodwork shall not be painted, oiled or otherwise treated before it has been approved by the Engineer.

The whole of the woodwork shall first be treated with two coats of anti-termite wood preservative chemicals of an approved make. All the wood shall thereafter be applied with primary coat of paint. The application of primer shall not be done within 24 hours of the application of the second coat of anti-termite treatment.

The doors shall have following fixtures,

(a) Single leaf doors

(i) Heavy duty railway type butt hinges of oxidised brass, 150 mm long -3 Nos.
(ii) Godrej 6 lever mortice lock with lever handles on both sides -1 No. (chromium plated brass)
(iii) Tower bolt 300 mm long -1 No. (chromium plated brass)
(iv) Door stop -1 No. (CP brass with rubber stopper)
(v) Door closer -1 No. (heavy duty hydraulic type)

(b) Double leaf doors

All material shall be same as for single leaf doors.

(i) Heavy duty railway type hinges 150 mm long - 6 Nos.
(ii) Aldrop - 1 No. (300 long)
(iii) Tower bolts 300 mm long - 2 Nos.
(iv) Pull handles - 4 Nos. (CP brass 150 long)
(v) Door stops - 2 Nos.
(vi) Door closer - 1 No.

Where the single leaf doors are 1200 mm wide the number of hinges used shall be four. Similarly, if the height of the door exceeds 2200 mm, the number of hinges shall be suitably increased. The doors shall be provided with parliamentary type hinges, wherever required.

Door closures shall be of heavy duty hydraulic type.

K22.1.26 Glazing for doors, windows and ventilators

(a) Glass in general

Glass shall conform to the requirements of relevant IS codes and shall be free from bubble, smoke wanes, air holes, scratches and other defects and shall be cut to fit the rebates with due allowance for expansion. Glass which does not have uniform refractive index or which is wavy shall not be used.

(b) Sheet glass

Sheet glass shall be flat, transparent and clear as judged by the unaided eye. It shall be free from cracks. Sheet glass shall be of B quality or ordinary quality and the thickness shall be as specified. Sheet glass used for glazing in building shall conform to I.S. 1761.

(c) Wired glass

All wired glass shall be 6 mm thick, polished Georgian or equivalent, with both faces ground and polished. The glass shall conform to I.S. 5437.

(d) Glazing

Putty for glazing to wood shall be prepared in accordance with I.S. l635. Glazing work in buildings shall conform to IS:3548.

Compound for glazing to metal is to be an approved special compound manufactured for the purpose.

K22.1.27 Metal doors and windows

(a) Aluminium doors, windows and screens

All extruded sections used in work of aluminium doors, windows etc. shall be minimum 3 mm thick of Jindal or Hindal make or equivalent. All sections shall be aluminium anodised in matt or polished finish as directed. Aluminium doors, windows etc. of only approved manufacturers shall be used. The aluminium doors and windows shall conform to I.S. 1948. Fixing of all aluminium doors and windows shall be carried out through the Agency of Manufacturers as per their specifications. Aluminium doors and windows shall be completely water tight.

The aluminium windows shall have either side projected or top projected shutters as specified to facilitate the cleaning of glasses. In case of side hung windows friction hinges shall be used, with stainless steel pins. Centre hung ventilators shall be hung on two pairs of cup-pivots of aluminium alloy or brass or bronze pivots chromium or cadmium plated. Glass panes shall be free from flaws, speck or bubbles and shall be with properly squared corners and straight edges.

Following fixtures and fittings shall be provided :

(i) For Doors

- Two floor springs of suitable make such as Everite, Prabhat, etc. or equivalent having double action spring.
- Each door leaf shall be fitted with two Nos. of suitable size of aluminium anodised handles from extruded tube of 100 mm x 50 mm minimum.
- One leaf out of two shall be fitted with tower bolt at top or bottom of 230 mm size of chromium plated brass.
- 6 lever brass lock concealed in section tube and openable from both sides with two keys.
- 1 door closer of heavy duty hydraulic type for each door leaf.

(ii) For Windows

- One opener, one handle and 15 cm. long tower bolt of brass, chromium plated.

(b) Steel windows, Ventilators and doors

Steel windows, ventilators and doors, including folding doors, shall be supplied complete with frames and fitted with standard fixtures such as hinges, locks, bolts, stoppers, handles as necessary.

Steel used in fabrication of windows and doors shall have a minimum thickness of 3 mm. There shall be no distortion in the frames.

The whole frame with the exception of lugs and external faces of channels shall be painted after manufacture as per specifications.

(c) Vehicular doors

Vehicular doors shall be of mild steel construction not less than 1.25 mm thick and shall be of the roller shutter or concertina type as specified. The doors shall be supplied by a reputable manufacturer to the approval of the Engineer and shall include a wicket door where specified. Doors shall be delivered to site painted with one coat of approved primer. After installation any damage to the paintwork shall be touched up and final painting will be carried out when approved by the Engineer. Doors shall be smooth operating, capable of opening and closing by one man and shall be fully weatherproof when closed. They shall be supplied complete with secure locks including locks to the wicket doors where appropriate.

Slats for the rolling shutters shall be in one piece and be made of heavy gauge steel sheets minimum 1.25 sq.in thickness. A cylindrical hood shall be provided on the top to enclose the shutter when it is open.

K22.1.28 Gravel in under drains

The gravel / metal shall be sound, durable, tough, clean, chemically stable of 20 mm single sized which will not become powdery under loads and in contact with water. The gravel shall be free from soft, thin, elongated, or laminated pieces and vegetable or other delicious substances. The gravel shall be spread and thoroughly compacted in layers of 150 mm taking care that it does not get crushed.

K22.1.29 Water supply and sanitary works - general

All plumbing works shall be carried out through a licensed Plumber and the pipes and fittings shall be as per the requirements of the Municipal water bye-laws. The Contractor shall get the pipes and fittings work done to the entire satisfaction of the Engineer. The Contractor shall submit the name of the licensed Plumber to whom the work is to be entrusted for approval of the Engineer.

(a) Sheet lead for flashing

The lead shall be new lead in accordance with I.S. 405. Unless otherwise specified all lead shall weigh 200 N/m^2.

When laying lead care shall be taken to ensure that there is provision for expansion and contraction. No solder shall be used except where it is unavoidable.

(b) Copper tubing

Copper tubing shall be light gauge solid drawn seamless copper in accordance with I.S. 5493. Brass or gunmetal fittings of the non manipulative compression joint type or capillary fittings shall be subject to the approval of the Engineer. Copper tubing shall be fixed at not greater than 1.5 m centres with cast brass pipe brackets or other approved fasteners.

(c) Galvanised steel tubing

Galvanised mild steel tubing and fittings shall be supplied by an approved manufacturer with screw and socket joints, tested hydraulically to a pressure of 48 bar. Pipes shall be secured to structures at not more than 1.5 m centres, with galvanised malleable cast iron brackets.

(d) Fixtures and valves

All fixtures and valves shall be of types approved by the Engineer and in accordance with I.S. 6157. Stop valves which are generally concealed shall be made of brass or gunmetal. Stop cocks which are exposed and bib and pillar cocks attached to sanitary fittings shall be brass or gunmetal bodies chromium plated and marked "hot" or "cold" as required. Ball valves shall be brass in accordance with IS: 1703.

K22.1.30 Laying of drains

Before laying the drains the centre of each manhole shall be marked by a peg, or otherwise, as determined by the Engineer. The Contractor shall then dig holes for setting up two posts (about 100 mm x 100 mm and 1.8 m long) at each manhole at nearly equal distance from the peg and at sufficient distance therefrom to be well clear of all intended excavation. A sight rail shall then be fixed level against the posts and perpendicular to the line of excavation. The posts shall be erected in such a manner that they remain clear of all the other excavation trenches if any, converging on the manhole. The sight rails shall not be in any case more than 30 metres apart and intermediate rails may be erected if necessary.

Boning rods shall be prepared from timber section 75 mm x 50 mm in various lengths, each length being a multiple of half a metre and with a fixed tee head about 300 mm long. The boning rod shall be marked on both sides to indicate its length. According to the circumstances of each case, a suitable length of boning rod shall first be determined and thereafter markings shall be done on both posts or walls or fences to which the sight rails are fixed. These markings shall be at the level obtained by adding the invert level of the drain at the position of the sight rail and the selected level of the boning rod.

The sight-rail (about 100 mm x 25 mm) shall then be Screwed with the top edge against the level marks. The centre line of the drain .hall be marked on the rail, and this mark will denote a1so the meeting point of the centre lines of any converging drains. A line drawn from the top edge of one rail to the top edge of the next rail will be vertically parallel with the invert of the drain, and the depth of the invert of any intermediate joint may be easily determined by letting down the selected boning rod until the tee head comes in the line of Bight from rail to rail.

The posts and rails shall in no case be removed until the trench is excavated, the drains constructed, and permission given to proceed with the filling-in.

K22.1.31 Supply of stoneware pipes

The pipes used in the Works shall be of the approved make. All pipes shall be perfectly straight and truly cylindrical, glazed inside and outside, free from cracks and flaws, and perfectly burnt. Those not conforming to above requirements shall be rejected.

K22.1.32 Formation for drain pipes

The bottom of every trench shall have a true grade throughout and shall be made in perfect straight lines. In case any loose, soft or bad ground is met with, it shall be excavated to a solid foundation and be filled up to the invert level of the drain sewer with concrete or otherwise as directed by the Engineer.

The floor of every drain trench pit shall be formed for receiving the socket of the pipes and a mass of clay shall be placed all around every joint of the drain.

In excavating any trench, the materials forming the surface of any road, foot-path, garden or field, shall be kept separate and preserved for re-use at the surface when the trench is filled up. Before any road metalling is re-used it shall be carefully shifted.

K22.1.33 Laying of drain pipes

In laying the drains, care shall be taken that they are laid perfectly true to the grade and as far as possible, straight from point to point of the manholes, vents or lamp holes, and that all pipes are carefully and solidly packed underneath so as to guard against subsidence or fracture of the pipes.

The drainage line shall be in stoneware pipes of approved make. The line shall be laid true to gradient in the underground portion. Where the pipeline is above ground, cast iron pipes shall be used. The pipes, bends and other specials in the superstructure work shall be laid vertical and fixed properly, to the satisfaction of the Engineer. The vent pipes shall be raised to about 200 cm above the terrace floor level.

All pipes in trenches less than 1.5 m and over 4.5 m deep and those in loose grounds and under-roads shall be protected and encased with concrete of grade M-15 all round.

K22.1.34 Jointing of pipes

Stoneware pipes shall be jointed by forcing two strands of tarred gaskets into the joints. The strands shall be sufficiently thick to fit tightly into the annular space between the sockets and spigots. The annular space shall then be solidly filled with neat Portland cement, which shall be forced into the socket, so as to fill it and a fillet of cement shall then be worked round the outside of the joint. This fillet shall be kept in position by a band of coarse cloth, which shall be kept moist until the cement has set. Every joint of the stone-ware pipes, which is not concreted, shall be further protected by clay placed in the outer sides of the joint of cement (well tampered and tenacious) so as to completely surround the joint.

The joints of cast iron shall be done in the manner described below:

Before treating the joint with cement-sand mortar, it shall be cleaned and moistened with water. The joint shall then be filled with a mixture of 1 part of cement and three parts of clean fine sand, with just sufficient water to have a consistency of semi dry condition. The mortar is forced into the joints and well rammed with caulking tool until the whole space round the spigot and the socket is filled, and the joints shall then be finished off with a splayed fillet sloping at 45 degrees to the sides of the pipe. The shaft of the pipes entering or leaving the manhole shall have a splayed fillet of neat cement laid around the same, extending outside the plastering of the manhole by 75 mm. Care shall be taken after the joints are made to see that the pipes are not moved or shaken before the cement has thoroughly set, and that they are watertight.

After the joints have thoroughly set, the Engineer may inspect the joints, and if he has any doubt as to their soundness, he may require, the Contractor to cut open and clear away the cement of any joint that he may select, and to make good the same at his expense. Normally he may not be required to open more than one joint in 20 metres of pipe laid. If however defects are found on such opening, the Engineer may direct him to open as many joints as he may deem necessary. The joints, made on anyone day will not as a rule be inspected until the following day so that the cement may have sufficient time to set, well before being covered up.

K22.1.35 Refilling of the trenches

After the foundations of any buildings or other works have been completed or the sewer or drain pipes have been laid and jointed or the inspection chamber manholes and vents completed and as soon as the joints have been inspected and passed by the Engineer, the trenches shall be re-filled with the materials taken therefrom or as directed by the Engineer. In re-filling the trenches, utmost care shall be exercised so as no to disturb, break or damage the jointed pipes.

Immediately the finest selected material shall be put round the pipe or be thrown into the trenches until the same is completely protected by the finer material filling referred to above. The back filling shall be done in suitable layers and shall be rammed properly until it is thoroughly consolidated and watered in addition, if considered necessary by the Engineer. Care shall be exercised so that the trenches are filled in solidly with selected material without voids under the pipes and that no damage is done to the pipe during the process of filling and consolidation.

K22.1.36 Testing the joints for water tightness

The joints of stoneware pipes laid under ground shall be tested for 600 mm head of water over the crown of the highest pipe between two inspection chambers.

The lowest end shall be plugged water tight. The water shall then be filled in the inspection chamber at the upper end of the line with 600 mm depth of water over the crown. Any defective joint shall be remade or embedded into M-15 cement concrete to make it leakproof.

K22.1.37 Manholes

Manholes shall be constructed at places of every change of alignment of pipeline. The junction manholes shall be constructed at places where two or more pipelines converge at a point. Manholes, shall be sufficiently spacious to accommodate a man to clean the same.

The manhole shall be circular and shall be constructed in brick work in cement mortar (1:4) and shall be plastered on both sides in 20 mm thick cement mortar (1:4). The walls shall be brought up within 180 mm of the road surface and shall be covered with a heavy duty cast iron frame and cover.

The floors shall be cast unless otherwise specified, in M-15 cement concrete. Salt glazed or concrete half channel pipes of required size and curve shall be laid and embedded in cement on the concrete base to the same line and gradient as drain pipes, unless otherwise directed. Both sides of the channel pipes shall be benched up in concrete and rendered in cement mortar 20 mm thick and formed to a slope not less than 1 in 12 to the channel.

Where a pipe enters and leaves a manhole, bricks on edge must be cut to proper form and laid around the upper half of pipe so as to form an arch. All around the pipe, there shall be 13mm thick joint of cement mortar between the pipes and the bricks. The ends of all pipes shall be properly built in and neatly finished off with cement mortar.

Where the depth of invert exceeds 1 metre below the surface of the ground, cast iron steps of approved pattern shall be built in the brick work at every four courses with additional hand irons.

Cast iron frames shall be bedded in cement mortar (1:3) on the brick works with splayed fillet all round and in such position that the top shall be about 13mm above the original surface of the road. The covers shall then be placed in position and the whole work shall be left neat and dry.

Covers and frames shall be of cast iron and circular in pattern conforming to IS: 1726. They shall be coated with Dr Angus Smith's composition. They shall be coated with Dr. Angus Smith's composition. They shall be air tight, heavy pattern only, weighing about 150 kg to 180 kg.

K22.1.38 Inspection chambers

Rectangular Inspection Chambers shall be constructed wherever the depth of the invert is less than 1.5 metres. They shall be constructed in brick masonry in cement mortar (1:2), and shall be plastered on both sides in 20 mm thick cement mortar (1:2). It shall be brought up to about 180 mm above the grounds level and shall be covered with heavy duty cast iron frame and cover. Floor shall be cast with haunches and channel etc. in M-15 cement concrete. Cast iron steps of approved quality shall be provided.

Covers and frames shall be of cast iron conforming to I.S. 1726. They shall be coated with Dr. Angus Smith's composition. They shall be air tight heavy pattern only, weighing about 150 Kg to 180 Kg.

K22.1.39 Septic tanks and soak away pits

The sewage from toilets shall be led to septic tanks prior to final disposal. The design and construction of septic tanks shall conform to IS:2470 (Part I). The floor shall be of cement concrete grade M20 and shall have a minimum slope of 1:10 towards the sludge outlet. The thickness of the floor at the lower most point shall be 150 mm. The walls shall be of such thickness as to provide adequate strength and water tightness. Walls built out of bricks shall be minimum 230 mm thick and shall be plastered with 20 mm thick 1:3 cement mortar of both inside and outside. Stone masonry walls shall be minimum 370 mm thick. A storage volume of sludge of 1 weir shall be considered in the design. The effluent septic tank shall be taken to soak away pits which shall conform to IS:2470 (Part 2).

K22.1.40 C.I. Nahani trap

The Contractor shall supply 8 cm (3") size C.I. Nahani traps, bends and pipes with 12.5 cm (5") C.I. grating of the best quality, conforming to I.S. 3989.

The Contractor shall fix the traps in position in M-10 cement concrete as directed by the Engineer. The joints shall be sealed in cement mortar (1:1).

K22.1.41 C.I. Rain water pipes

The Contractor shall use good quality iron pipes and fittings of approved make and coated with an approved protection system. The tolerance limits for various diameters for Cast Iron rain water pipes shall be as set out in I.S. 1230.

The size of the grating shall be slightly bigger than the external diameter of the pipe. The cavity between brick masonry and the pipes etc. shall be made good in cement mortar, neatly, after the fixing of the pipe.

In case of terraced roof, the cast iron grating shall be fixed at the inlet end of the pipes, properly secured in the wall to receive the rain water. The cast iron grating shall be recessed at a slightly lower level than the adjacent terrace floor level.

The pipes shall be fixed with nails driven through the holder battens fixed in the walls with the sockets facing up. Pipes and fittings shall be kept 12 mm from the walls to facilitate cleaning, paintings etc. The joints shall be sealed with a few turns of spun yarn soaked in bitumen or tar, which shall be pressed home with a caulking tool for 1/3rd the depth of joints. More spun yarn shall then be wound round the joint with cement mortar (1:3). At the ground level, they shall be supported on M-10 concrete blocks 300 mm x 300 mm of sufficient height. The pipes shall be painted with one coat of red lead oil paint and two coats of anticorrosive oil paint of approved shade.

Pipes, fittings and joints shall be tested for leaks as specified and defects, if any, shall be rectified.

K22.1.42 Cast iron soil/vent/waste pipes with necessary fixtures and fittings etc.

The contractor shall supply good quality pipes of approved make, including all fixtures viz. tees, bends, etc. as required, free from cracks, flaws etc., The tolerance limits for various diameters for Cast Iron Soil, Waste and Ventilating pipes shall be as set out in I.S. 1729.

Care shall be taken to see that in case of soil or waste pipes the sockets shall be at the inlet end. In case of vent pipes, the sockets shall face up. The Cast Iron pipes shall be fixed with nails driven through the holder battens fixed in the walls. Pipes and fittings shall be kept 12 mm from the walls to facilitate cleaning, painting etc. The joints shall be sealed with a few turns of spun yarn, soaked in bitumen or tar, which shall be pressed home with a caulking tool for 1/3 the depth of joints. More spun yarn shall then be wound round the joint with cement mortar (1:1).

The cast iron pipes shall be painted with one coat or red lead oil paint and two coats of anti corrosive oil paint, of approved make and shade.

Pipe fittings and joints shall be tested for leaks as specified in K17.7 and defects if any, shall be rectified.

K22.1.43 Testing of joints of drainage pipes and fittings

The joints of drainage of pipes and fittings shall be tested by the Contractor as described below:

All soil pipes, waste pipes and vent pipes and all other pipes when above ground shall be tested for gas tightness by smoke test under a pressure of 25mm of water and maintained for 15 minutes after all trap seals have been filled with water. The smoke shall be produced by burning oily waste or tar paper in smoke machine. Chemical smokes are not satisfactory. If leaks are found during testing, the joints shall be made good and the test repeated.

K22.1.44 Stoneware gully traps

The Contractor shall supply and fix salt glazed stoneware gully trap outside the building and construct the brick masonry chamber including C.I. frame and cover around it as specified below. Stoneware pipes shall conform to I.S. 651.

The gully trap shall be set in M-10 cement concrete extending 30 cm beyond trap on three sides over which the brick masonry chamber shall be constructed in cement mortar (1:4). The building wall will be on the fourth side. Brick masonry shall have internal and external plaster 20 m thick in cement mortar (1:4). The C.I. cover including its frame shall be fixed in M-10 cement concrete 10 cm thick. The trap in the chamber shall be provided with gratings.

K22.1.45 Intercepting sewer trap

The Contractor shall provide the intercepting trap and the half glazed stoneware pipes of the approved make.

The foundation concrete shall be in M-10 and shall be laid to a thickness of 250 mm. The intercepting sewer trap shall be fixed into the extended portion of the foundation concrete on the main sewer side of the chamber. Brick masonry chamber of one brick thickness shall be constructed in cement mortar (1:4) with inside dimension of 90 cm x 90 cm and depth corresponding to the depth o the trap of the drain. During the construction, the rodding pipe of the trap shall be embedded in brick masonry. Channel in M-10 cement concrete shall be formed to lead away the sewage. Alternatively half round stoneware pipes can also be provided to form channels. The floor of the chamber shall be sloping towards the channels. The brick masonry chamber shall be plastered on both sides in 20,m thick cement mortar (1:4). The C.I. cover and frame shall be fixed in M-10 cement concrete, 10 cm thick.

K22.1.46 Bitumen layer to water closet slab

A bitumen layer shall be provided over the water closet slab for making it water proof. Bitumen shall have a penetration limited to 40 when tested in accordance with I.S. 1203.

The exposed slab surface shall be thoroughly cleaned of all dirt, dust and loose material. The surface of concrete shall be dry. Bitumen shall then be applied at the rate of 2Kg/sq. metre at a temperature of not less than 121^0C (250^0F) evenly throughout and allowed to dry before laying brick bat coba etc.

K22.1.47 Coloured glazed earthenware water closet pan

The Contractor shall provide English type white glazed earthenware water closet pan conforming to I.S.2556 of the specified dimensions with cast iron high level flushing cistern and other flushing accessories and necessary pipe connections up to the soil and vent pipes fixed on the outside of wall. All the materials shall be of approved make. The Contractor shall obtain the prior approval of the Engineer before fixing the pan and its accessories into place.

The pan shall be placed into position with the trap jointed in cement mortar (1:1) and the connecting pipes duly connected including the 32 mm diameter lead or galvanised iron pipe from the flushing cistern.

Brickbat cement concrete 1:2:4 shall be cast as specified by the specialist waterproofing agency in the full water closet area and pressed all around the embedded surface of the pan and fittings and pipes to get solid embedding without any hollows. The pan shall be fixed at a slightly lower level than level of the general flooring which shall slope on al sides towards the pan. If the pan is damaged while handling or fixing, it shall be replaced by the Contractor at his own cost. The flushing cistern shall be fixed on two cast iron or mild steel cantilever brackets fixed in the wall at the height specified or as directed by the Engineer.

The lead or galvanised iron flushing pipe shall be bent leaving a straight length of about 30 cm at the top and the lower portion after the bend shall be lowered into a recess left out in the wall and shall be concealed in the plaster. The whole installation shall be tested for leak-proof joints and satisfactory functioning.

The cistern, brackets and all the exposed pipes shall be painted with a base coat of zinc rich primer and two coats of enamel paint of approved make and shade.

K22.1.48 Coloured glazed earthenware urinal

The Contractor shall provide white coloured earthenware flat back urinals of approved make conforming to IS: 2556 including high level automatic flushing cistern of capacity as per IS: 2326, and a 'P' trap with vent extension. The urinal shall be securely fixed to the wall with the top of bowl 65 cm from the floor or such distance as may be directed by the Engineer. All the pipe connections such as water connection from the cistern to the urinal with 20mm diameter main and 15mm diameter branch C.I. pipes and 32 mm diameter lead waste pipe upto C.I. waste shaft on the outside wall shall be carried out as required. Holes made in wall shall be made good in cement mortar (1:4).

K22.1.49 Coloured glazed earthenware wash basin

Coloured Glazed earthenware wash basin conforming to I.S. 2556 including all necessary fixtures and pipe connections upto the outside face of the wall, all of approved make and quality, shall be provided and fixed at the location and level specified or as directed by the Engineer. The wash basin shall be supported on a pair of rolled steel or cast iron cantilever brackets embedded in the wall or fixed to the wall with wooden cleats and screws. The height of the top of the basin from the floor shall be 75 cm unless otherwise directed by the Engineer.

The waste pipe shall be of 32 mm diameter galvanised iron and shall be provided as required up to a length of one metre with lead or nickel plated G.I 'P' trap with rubber plug. The wash basin shall be G.I. supply pipe of 15 mm diameter, stop cock No.1 and 15mm swan nickel plated tap. If holes are not left in the wall initially, they shall be cut and the cavity surrounding the drain or water pipes made good after fixing of the pipes.

K22.1.50 White wash

Walls shall be thoroughly cleaned of all dirt and loose particles etc. before white wash is applied. Inequalities and holes shall be filled up with gypsum which should be allowed to set hard. White wash shall be of ordinary fat lime and of good quality. It shall be slaked with an excess of water to the consistency of a cream and allowed to remain under water for 2 days. It shall then be strained through a cloth and 2 Kg of clean gum added for every cubic metre of lime ready for white washing.

Each coat is to be applied with a brush spray. It shall be laid with a stroke of the brush from the top downwards, another from bottom upwards over the first stroke and similarly, one stoke from the right and another from the left over the first brush before it dries. Three such coats shall be applied.

K22.1.51 Breaking of concrete, brickwork, blockwork and stone masonry

The waste material from breaking shall be at once removed from the location and dumped at a suitable location or transported and disposed off as directed by the Engineer. The Contractor shall observe all precaution by way of necessary propping, strutting, etc. to the satisfaction of the Engineer, to ensure that the adjacent framework is not damaged.

Any damage to any adjacent framework, brickwork or blockwork resulting from any negligence or the Contractor thereof shall be made good at the Contractor's cost, to the satisfaction of the Engineer.

K22.1.52 Locks

All the doors and gates shall be provided with locks of approved quality available locally and in accordance with I.S. 2209 or I.S. 275 as appropriate. The locks shall be provided with keys in duplicate.

K23.0 CATHODIC PROTECTION FOR STEEL PIPELINES

K23.1 Scope

K23.1.1 Coverage

This Part contains requirements which, where relevant to this Contract, shall apply to the supply, installation and testing of the cathodic protection of steel pipelines for the conveyance of raw and treated water including pipes and fittings where required to be laid in, on or above ground or to be fixed on or built into other parts of the Works.

K23.1.2 Definitions

The following terms shall have the meanings hereby assigned to them:—

'Pipelines':	The steel pipeline between to be laid by the Contractor under the Works for which CP is required as identified in the Particular Specification.
'System':	The equipment and materials making up the cathodic protection for the pipeline.
'Foreign pipelines':	Pipelines other than that for which the cathodic protection is primarily intended.

K23.2 Reference Standards

K23.2.1 Introduction

Unless otherwise specified, pipelines shall comply with the relevant Reference Standards listed below. Where a Reference Standard, or a further standard referred to in a Reference Standard, states that a requirement should be met, it shall be met unless otherwise specified. Where a Reference Standard allows a choice between other standards, preference shall be given to the standard or standards listed as Reference Standards, if any.

K23.2.2 General

Reference Standards applicable include the following standards:

BS 5467	Specification for cables with thermo-setting insulation for electricity supply.
BS 6004	Specification for PVC-insulated cables (non-armoured) for electric power and lighting.
BS 6346	Specification for PVC-insulated cables for electricity supply.
BS 7361: Part 1	Cathodic protection: Code of Practice for land and marine applications.

K23.3 Submissions By The Contractor

K23.3.1 Drawings and data

The Contractor shall prepare a detailed Design Specification for the proposed final design which will be the basis for installation, commissioning and future maintenance of the cathodic protection system. 3 copies shall be submitted to the Engineer.

The Design Specification shall include all of the design requirements listed below:

— the calculations on the basis of which cathodic protection (CP), current requirement, CP station location and CP station capacity have been made;
— typical drawings of standard items;
— detail drawings of special items;
— positions and construction of the cathodic protection transformer/rectifier stations proposed, including fencing details;
— the location, extent and method of installation of groundbeds with details of size, type and configuration of anodes;
— provision of details of the physical size and electrical rating for the cathodic protection current source, anodes and cables, with circuit diagrams, and manufacturer's technical literature, and the like;
— plot plans sufficient for legal acquisition on behalf of the Employer of any land required outside plant, stations or pipeline easement limits for groundbeds, cable runs and cathodic protection power sources including demarcated areas;
— construction drawings showing details of the cathodic protection station and pipeline monitoring and surge voltage protective installations proposed;
— design proposals for the cathodic protection of station/plant pipework;
— designs for the stray current protection of foreign pipelines or other facilities as necessary, including design and layout of bonding systems;
— design proposals for pipeline crossings;
— design and location of pipeline isolation blocks;
— proposals for the protection of the pipeline from induced current pick-up from power lines during construction and operation;
— size, shape and weight of anodes and length of anode strings and anode size required.

K23.3.2 Records to be kept

The Contractor shall keep detailed and up-to-date records in a form to be approved by the Engineer, that include schedules, tables, drawings and the like which shall detail all of the following:

— the exact location of all magnesium or zinc anodes fitted, together with the position of all cables and groundbeds;
— the location of all crossings of other buried metallic services, detailing the nature of the other service, the owner of the service concerned and an indication of whether connected to the system;
— the exact location of every potential/marker post bond box or current

measurement post.

Each month the Contractor shall provide the Engineer with an up-to-date copy of the above records.

K23.3.3 Certificates of tests

The Contractor shall forward to the Engineer the following certificates where relevant:

(a) works tests on anodes and transformer/rectifier;

(b) material tests;

(c) insulation tests at isolating flanges;

(d) potential and current measurement tests;

(e) interaction tests;

(f) system commissioning tests.

K23.3.4 Method and programme of work

The Contractor shall submit for the approval of the Engineer details of his proposed procedure and programme for commissioning the pipeline cathodic protection system. The procedure shall include:

— methods of measuring pipe to soil potentials and current outputs;

— methods for demonstrating that stray current and induced current risks on the pipeline and on foreign pipelines can be checked and controlled within defined limits.

After completion of commissioning the Contractor shall prepare a commissioning report for submission to the Engineer, which shall include all test and commissioning results.

K23.4 Materials

K23.4.1 General

The Contractor shall provide all materials necessary for the works.

All power supply stations shall be accessible by 4-wheel-drive vehicles at all times of the year. The stations shall also be securely fenced.

All materials and equipment shall be suitable for continuous use under the climatic conditions in all the sites of the Project.

K23.4.2 Transformer-rectifiers

All transformer-rectifier units shall be oil-cooled and designed and constructed to operate outdoors in all conditions. The transformer-rectifiers shall be mounted on concrete plinths and securely fenced.

All units shall be for the same manufacturer and shall be interchangeable on their plinth mountings.

Transformer-rectifier units shall consist of a transformer and rectifier circuit with manual output regulation. All shall be installed in a welded steel weatherproof tank which shall be oil-filled such that all components of the transformer, rectifier and regulation equipment are below oil level. The transformer and rectifier shall be continuously-rated and the transformer suitable for connection to a 400/230 volt, three-phase 50Hz AC supply. An earthed shield shall be placed between primary and secondary windings of the transformer.

Fuse protection shall be provided on both AC and DC sides of the rectifier.

The rectifier circuit shall provide full wave rectification and the assembly shall be continuously rated for the maximum output current. Easily-accessible output-regulation controls shall be provided to allow for continuous on-load variation, by auto-transformer, of the output uniformly over the whole voltage range.

A suitably-rated single-pole neutral-linked AC switch-fuse capable of being locked in either the 'ON' or 'OFF' position shall be located in an accessible position.

A single-phase time-switch shall be capable of switching the unit at full output on a '50-seconds on, 10-seconds off' cycle. A double-pole changeover switch shall be provided to enable a selection to be made of either continuous operation or time-controlled operation of the unit.

A surge diverter rated at 200 to 300 volts shall be mounted directly across the main DC-output terminals of the unit on the output side of the DC fuse.

Each unit shall have:

— an oil-level sight gauge;

— an oil drain with a valve;

— an oil tank breather provided with silica gel cartridge and breather oil seal, complete with a spare desiccant cartridge;

— an earthing terminal.

K23.4.3 Alternative CP power sources

Where AC supplies are not available, solar power panels with storage batteries shall be installed.

The design of any solar-powered cathodic protection station shall be on the assumption that no power supply is available from the outside sources.

K23.4.4 Cables

AC power cables shall be 3-core copper, PVC steel wire-armoured PVC 600/1000 volt grade.

DC cables shall be single-core multi-strand copper, double-insulated and sheathed for protection against the aggressive soil environment. Minimum cable size shall be $10mm^2$. Bonding cables and main DC current-carrying cables shall generally be

50mm².

All cables shall be sized so that cable voltage drops will not reduce the capacity of the system.

K23.4.5 Anodes

The Contractor shall provide anodes appropriate to the local soil and groundwater conditions. These may be platinized titanium, metal-oxide coated titanium (LIDA) anodes or silicon iron.

Silicon iron anodes shall be of the silicon iron, chromium type for resistance to aggressive chloride-containing soils. A low-resistivity backfill shall be used if the soil resistivity in groundbed location is expected to exceed 100 ohm-cm at any time of the year.

Proprietary long-life deep groundbed anodes may be proposed for the approval of the Engineer.

K23.5 Workmanship

K23.5.1 Groundbeds

Groundbeds shall be constructed using inert anodes in carbonaceous backfill or saline water and designed for a life on full CP station output of not less than 25 years.

Groundbed markers shall be installed.

K23.5.2 Connections

Pipe to cable connections shall be made by pin brazing and shall be coated with corrosion protective epoxy or similar approved material.

Cable joins or splices should be limited to the minimum and, where necessary, they shall be made above ground.

Lugs approved by the Engineer shall be used on all other connections and, wherever possible, connections shall be made above ground in weathertight boxes.

K23.5.3 Cable laying and pipeline connections

All cables shall be identified where they terminate in transformer-rectifiers or bond or anode boxes and potential marker posts.

All cables shall be laid in trenches with a minimum cover of 750mm and with a surround of sand or selected fine backfill.

Cables and connections shall be identified to the requirements of the Employer.

Where necessary anode cables shall be insulated against chloride attack.

K23.5.4 Cable joints

Epoxy-filled splicing kits are to be used at all anode/ring-main cable connections and
all other cable connections underground.

K23.5.5 Power source

The Contractor shall be required to liaise with the Employer and such other utility and land owners as necessary for the installation of power supplies and cables.

K23.5.6 Surge diverters and earths

Surge diverters shall be installed at all isolation joints.

Zinc earths or equivalent protective systems shall be included at above ground sections if considered necessary to control surge or induced current problems.

K23.5.7 Current-measurement locations

Current-measurement facilities shall be installed at cathodic protection stations. Permanent reference electrodes and current drain test coupons shall be installed at high corrosion risk areas. They shall consist of two cables attached to the pipeline exactly 30m from the negative cable connection and a further cable attached to the negative cable/pipe connection point. Cables shall terminate in a single marker post and be labelled.

Provision shall be made for measuring rectifier output, recording on data loggers and for future connection to a telemetry outstation.

K23.5.8 Isolating spools

Pipelines shall be electrically isolated from other plant, foreign structures or pipelines and electrical earthing systems.
Monoblock isolating joints shall be used where possible.

K23.5.9 Valve boxes

Above-ground valve and control facilities shall be carried on insulated supports or be isolated by isolation joints. In the latter case attention shall be given to bonding the CP across the joint and the provision of surge diverters.

Consideration must also be given to the risk to personnel of induced current pick-up from nearby power sources. Pick-up voltages in excess of 9 volts are considered hazardous and provision of zinc earth terminals may be required if the above ground pipe sections are not fitted with isolation blocks.

K23.5.10 Foreign service crossings

At all locations where the pipeline crosses other metallic services, one cable shall be

attached to the pipeline and one to the foreign service. It shall be the Contractor's responsibility to arrange for the owners of services to be notified so that the test lead may be attached to his service while the trench is open. The Contractor must establish whether the service owner wishes to make the connection himself or have his representative present during the work.

The cables shall be terminated in a potential/marker post.

K23.5.11 Temporary cathodic protection

The Contractor shall identify any particular risk areas due to construction practice, and submit proposals to the Engineer for approval for their protection as necessary.

K23.5.12 Pipeline casing

Where the pipeline is protected by a steel casing, such as at road crossings, the casing shall be insulated from the pipeline and provided with potential test facilities.

K23.5.13 Test posts

Test posts and distribution boxes shall be installed above ground and shall be of rugged construction and protected from external and internal corrosion. Test points shall be provided at intervals not exceeding 1km and at each insulation device along the pipeline.

Compartments shall be weatherproof and lockable.

The compartments shall have adequate space for the termination of all test cables, pipeline bonding and provision of resistors or other facilities as determined by the design.

K23.5.14 Parallelism with overhead high tension power lines

In order to prevent voltage peaks due to induction from parallel overhead high-tension power line on the pipeline, zinc anodes shall be connected to the pipe or power line crossings with the pipeline and at the ends of parallelisms. During laying, sections of continuously-welded pipe above ground shall not be permitted to exceed 400 metres within 100 metres of overhead high-voltage power lines and shall be earthed.

K23.6 Testing And Commissioning

K23.6.1 Pre-commissioning, testing and inspection

The Contractor shall carry out all pre-commissioning tests in the presence of the Engineer to confirm satisfactory installation and operation of all equipment. Such tests shall include trial operation of power sources to their maximum capacity and measurement of cathodic protection circuits to confirm satisfactory connections.

K23.6.2 Commissioning

The Contractor shall carry out commissioning as follows:

— all pipe to soil potentials shall be measured with reference to a copper/copper sulphate half-cell using a high-resistance voltmeter / potentiometer and recorded as volts negative;

— the results of the commissioning tests shall be recorded and included in a commissioning report to be submitted to the Engineer.

K23.6.3 Interaction testing

The Contractor shall carry out interaction testing. He shall be responsible for contacting all the service owners concerned and arranging for their presence at the tests if they so desire.

The Contractor shall be responsible for confirming the results of interaction testing with the service owners concerned and obtaining written confirmation from them that results are acceptable to them and they have no objections to the operation of the cathodic protection system.

K23.7 Particular Requirements — Design

K23.7.1 General

The general requirements of the design are as follows:

— cathodic protection shall be provided within one month of the laying of the pipe until the permanent system is commissioned;

— to obtain adequate corrosion protection for all sections of the pipeline;

— protection is to be established by designing and commissioning a suitable system(s) that will ensure that the entire lengths of the pipelines are protected at an electrical potential of between −950mV and −1500mV with reference to a $Cu/CuSO_4$ electrode;

— to ensure that the Protective Current is adequate to supply a current density of at least 10mA per square metre to all bare areas predicted to form during the life of the pipelines;

— to ensure that pipelines and services owned by the Employer, foreign pipelines, utilities and power transmission towers in, or near, the pipeline corridor do not have their existing corrosion protection and cathodic protection de-rated or adversely affected in any way during, or subsequent to, the CP installation;

— to provide all of the above requirements by use of an impressed current system;

— to achieve a design life of 25 years.

The above requirements are to be achieved while maintaining safe working practice and ensuring that the final design is safe, in particular with reference to stray current or induced current pick-up from foreign buried or overhead power lines.

K23.7.2 Groundbeds

Groundbeds may be shallow, horizontal systems, deep groundbeds or a mixture of the two, depending on the soil resistivity and the complexity of foreign lines particularly in urban areas. If necessary, sacrificial anodes may be used to boost protection locally.