

Building Works & Civil Engineering Specification



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Building & Civil Engineering Specification for Extension to Kilmacanogue
N.S., Kilmacanogue, Bray, Co. Wicklow, A98D602

Specification

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1 GENERAL

1.1 General Conditions of Contract

- 1.1.1 The General Conditions of Contract accompanying this Specification and all clauses therein shall be read together with and included in this specification.

1.2 Standard Specifications

- 1.2.1 Any Standard Specification quoted or referred to in the General Specification is thereby made part of the General Specification. Where reference is made to a Standard Specification, prepared either by the National Standards Association of Ireland, by the British Standards Institution or by the National Standards Institution of any other Member State of the European Union, the reference shall be deemed to apply to the issue of the specification with amendments or addenda, if any, current at the date of invitation to tender for the Works.
- 1.2.2 Where items certified by the National Standards Authority of Ireland as complying with an Irish Standard are called for, the provisions of the Department of the Environment, Heritage and Local government Circular Letter BM2/87 shall apply, i.e. the requirement shall be read as either certified by the National Standards Authority of Ireland as complying with the Irish Standard, or shall be certified as complying with a relevant international standard, or with the relevant national standard of another Member State of the European Union, which provides an equivalent guarantee of safety and suitability.
- 1.2.3 If an appropriate Standard Specification has not been published for an item or material, the item shall be to the satisfaction of the Engineer.
- 1.2.4 Nothing stated in this Specification is to be construed as discriminating against products and materials manufactured in any of the Member States of the European Union.

1.3 Safety

- 1.3.1 The Contractor shall comply in all respects with the following safety legislation and all subsequent amendments thereof. The Safety, Health and Welfare at Work Act 2013 Current Safety Health and Welfare at Work Regulations and associated Statutory Instruments.

2 MATERIALS – GENERAL

2.1 General

- 2.1.1 The whole of the materials shall be the best of their respective kinds, and shall in every case be subject to the approval of the Engineer whose decision in all matters appertaining to quality and suitability of materials and workmanship shall be final and binding. So far as is practicable, the origin of goods and materials used in the Works shall be Ireland, or one of the other member states of the European Union.
- 2.1.2 All materials shall be new and of the best quality and shall be transported, handled and stored in such a manner as to prevent deterioration, damage or contamination. As soon as possible after the contract is awarded, the Contractor shall inform the Engineer of the names of the suppliers from whom he proposes to obtain materials but he shall not place orders for such materials without the approval of the Engineer, which approval may be withheld until samples have been submitted and satisfactorily tested. Approval by the Engineer of any materials shall not relieve the Contractor of any of his obligations under the Contract.
- 2.1.3 Where proprietary products are specified similar products from other manufacturers may be accepted at the discretion of the Engineer provided they are at least equal in quality to those specified. Samples shall be taken in accordance with the appropriate Irish or British Standard where applicable. The materials subsequently supplied shall conform to the quality of samples, which have been approved by the Engineer. Names of additional suppliers and sources may be submitted by the Contractor during the execution of the Contract, but no source of supply shall be changed without the Engineer's approval.
- 2.1.4 The Engineer reserves the right to reject materials from a Supplier whose terms or conditions of supply purport to restrict Product Liability to the prime cost of such materials or restrict to such other degree as may in his view afford inadequate redress to the Employer in the event that such materials prove defective and have to be replaced.

2.2 Testing of Materials

- 2.2.1 Every item of material shall from time to time be subject to such tests as the Engineer may prescribe in accordance with the several clauses relating thereto in the General Conditions of Contract, and the materials tested shall conform in every detail with the requirements of the appropriate standard specification or with any other standard test which the Engineer may lay down in the course of this Specification.

2.3 Materials Licensing

- 2.3.1 Where applicable, construction materials shall be certified by the National Standards Association of Ireland (N.S.A.I.) under the Irish Standard Mark Licensing Scheme. Manufacturers or suppliers will be called upon by the Engineer to produce evidence from the N.S.A.I. that their products are so certified. Notwithstanding the furnishing of this certificate, nothing shall prejudice or override the inalienable right of the Engineer to have independent tests carried out. For the purpose of carrying out such tests the Engineer shall have full authority to have the samples taken, either at the manufacturer's factory or from consignments at the Works, and to submit the same to an approved Engineering Laboratory chosen by him for testing. Furthermore, the Engineer shall have the right to reject any material as a result of such tests, notwithstanding that the manufacturer's certificates may have shown the materials to be satisfactory.

2.4 Testing Apparatus

- 2.4.1 The Contractor shall provide such assistance, instruments, machines, labour and materials as are normally required on the site for examining, measuring and testing the Works, the quality, weight, or quantity of the materials used. He shall supply samples of materials before incorporation in the Works for testing as may be selected and required by the Employer.

2.5 Works Tests and Inspections

- 2.5.1 The Engineer shall be entitled at all reasonable times during the manufacture of materials to inspect, examine and test such materials. Such tests and inspections of pipeline materials in particular at Manufacturers' Works may be carried out initially while Tenders are being examined in order to approve of the manufacturer and subsequently at regular intervals throughout the Contract Period.

2.6 Storage of Materials

- 2.6.1 Materials and components shall be stored in such a manner as to preserve their quality and condition to the standards required by the Contract. The quantity of materials and components stored on the Site shall be consistent with that necessary for efficient working.

2.7 Handling and Use of Materials

- 2.7.1 Materials and components shall be handled in such a manner as to avoid any damage or contamination, and in accordance with all applicable recommendations of the manufacturers.
- 2.7.2 Unless otherwise described in the Contract, the use, installation, application or fixing of materials and components shall be in accordance with all applicable recommendations of the manufacturers. Where appropriate, the Contractor shall make use of any technical advisory services offered by manufacturers.

3 EARTHWORKS, EXCAVATION AND BACKFILL

3.1 Excavation – General

- 3.1.1 The Contractor shall first remove all trees, stumps, bushes, hedges, structures and loose objects, to a minimum depth to underside of topsoil over the site of all permanent structures, embankments or slopes and over any area which will be disturbed during the construction. Stumps of trees and roots shall be grubbed up or destroyed. Mature trees shall not be damaged or removed unless specifically required by the contract or instructed by the Engineer. All combustible materials from the clearance shall be disposed of by a licensed contractor.
- 3.1.2 The Contractor shall carry out the excavating operations in such a manner as to avoid damage to or deterioration of the Final Surfaces of excavations. The Contractor shall be responsible for the safe preservation of existing underground services, and if any damage is occasioned thereto, the Contractor shall at his own expense make good all such underground services to the satisfaction of the Engineer, and of the Authority concerned.
- 3.1.3 Unless specifically indicated to the contrary, the Contractor may select any method of excavation below the surface soil to the final formation level. The last 100mm depth of excavated material together with any additional local excavation required for foundations, drainage sumps or similar items shall be excavated in an approved careful manner and the entire formation shall be trimmed accurately. The last 100mm above formation level shall not be excavated until immediately before concrete or other formation material is to be placed upon it.
- 3.1.4 The excavation bottoms are to be carefully examined for the presence of hard objects such as stones, rock projections or tree roots, and these removed and the bottoms then prepared. Filling the bottom of excavations or trenches to the level of any hard objects found on the bed is forbidden.
- 3.1.5 All excavations shall be to the widths, depths and lengths shown on the Drawings or described in the Specifications, or to such alternative depths and dimensions as may be directed by the Engineer.
- 3.1.6 Excavated material to be used for backfilling shall be kept well clear of open trenches at least 600mm from the edge of the trench and shall not be placed or stored in a manner which might constitute an excessive load on the open trenches or otherwise endanger the stability of the excavations or which causes obstruction to any road or right of way, or which jeopardises the safety of any person in or about the Works. If excavated material is deemed by the Engineer to be unsuitable for refilling then following disposal of same, approved fill shall be imported to the site for this purpose.

3.2 Excavations for Foundations

- 3.2.1 The sides of all excavations shall be adequately supported at all times or battered to a safe angle where such battering is acceptable.
- 3.2.2 The bottom of all excavations shall be carefully levelled and accurately shaped to receive the structure to be placed upon them and all concrete shall be laid on an even and solid foundation.

3.3 Trenches for pipelines

- 3.3.1 Trench sides shall be adequately supported or safely battered back at all times. The bottoms of the trenches are to be carefully levelled to the correct gradient and rammed to thorough consolidation before the underbed is constructed. Supports are needed where, if not battered back, the depth of the trench exceeds 1.2m.

3.4 Trench Widths

- 3.4.1 From the bottom of the trench to a level of 300mm above the crown of the pipe, trench widths shall not be less than the minimum nor greater than the maximum figures shown in Table 3.1 below. The minimum width is that width between the faces of the soil required to ensure the correct placing and compaction of bedding materials equally on either side of the pipe. All sheeting and supports are to be outside this width. The maximum width is that width between the faces of the soil that has been used in the structural design of the pipeline, and it includes an allowance for sheeting and tolerance. The Contractor shall provide whatever additional pipe protection is necessary should the specified maximum width be exceeded due to his method of working.

Nominal Pipe Diameter (mm)	Minimum Trench Width (mm)	Maximum Trench Width (mm)
100	450	600
150	500	700
225	600	800
300	700	900
375	950	1150
450	1050	1250
450	1050	1250
525	1150	1350
600	1250	1450
675	1350	1550
750	1400	1600
900	1950	2150
1050	2100	2300
1200	2300	2500
1350	2450	2650
1500	2290	300
1800	2800	3400

Table 3.1 Trench Widths

3.5 Excavation in Rock

3.5.1 Excavation in rock shall mean excavation in natural rock formation, which can properly be removed only by means of blasting, ripping, barring, wedging or by some other recognised methods of quarrying. It shall include solid rock boulders exceeding one quarter cubic metre or more in volume in trenches or one cubic metre in general excavation, which can only be removed by one or other of the aforesaid methods. It shall include existing concrete, or bonded masonry laid in mortar, but shall not include shale formations, tree trunks or such like objects, despite their removal by methods similar to those normally adopted in solid rock excavation. In the event of disputes the Engineer shall decide what is to be classified for payment as solid rock and any such decision given by the Engineer in writing shall be binding on all parties to the Contract.

3.5.2 Where rock or boulders are encountered in trenches the bottom of the trench shall be excavated for an additional depth of 100mm before bedding is placed. No projection of rock closer than 200mm to the side of a pipe in trench shall be permitted. Blasting to remove rock in trenches shall be carried out in accordance with the Clauses entitled "Use of Explosives" below. The trench width for the purpose of measurement of Rock in trenches shall be deemed to be the maximum trench width defined on the Table in the Clause entitled "Trench Widths".

3.6 Use of Explosives

3.6.1 The Contractor shall not use explosives without the express permission of the Engineer in writing which permission will not be unreasonably withheld. The Contractor shall acquire, store and use the explosives in accordance with statutory requirements and shall hold and produce on the Site when required the licences necessary under these requirements. The storage and use of explosives on the site shall in every way comply with the detailed requirements of the Engineer and of the Gardai.

3.6.2 Before commencement of any blasting operation the Contractor shall obtain the Engineers approval of the pattern and nature of the blasting proposed and shall satisfy the Engineer that safe values of vibrational amplitude and peak particle velocity will not be exceeded.

3.6.3 The following parameters shall be enforced for blasting operations carried out within 6 metres of existing structures, electrical cables or services, unless otherwise stated in the Specification.

- Peak particle velocity shall not exceed 12mm per second
- Amplitude of vibration in any direction shall not exceed 0.04mm.

- 3.6.4 Where blasting is carried out at distances greater than 6 metres from existing structures, cables or services, blasting parameters shall be agreed with the Engineer before any blasting is carried out.
- 3.6.5 Where blasting is to be carried out adjacent to Buildings the Contractor shall provide a Vibrograph or other suitable instrument to measure and record with printout facilities the peak particle velocities for each blast together with personnel experienced in the operation of such equipment and in the interpretation of results.
- 3.6.6 Firing shall be by electric or non-electric delay detonation and shall only be carried out by an experienced shotfirer. Prior to the use of electric detonators the Contractor shall ensure;
- 3.6.6.1 that there is no leakage of static electricity in the vicinity which could lead to premature detonation;
- 3.6.6.2 that there is no usage of radio signals in the area and
- 3.6.6.3 that there is no electrical activity of any nature occurring which could lead to premature detonation.
- 3.6.7 Charges must be fired so as not to interfere with, damage or cause nuisance to persons, animals or property or to Works either completed or under construction. The Contractor must provide, at all times when firing is to take place, adequate blasting mats or other suitable blasting cover to prevent all possible flyrock.
- 3.6.8 The Contractor shall also give due warning of the times he proposes to fire charges to all persons liable to be affected. He shall employ watchmen provided with red flags and erect warning notices at sufficient distances and in such directions as may be required to warn persons and traffic that such operations are being carried out.
- 3.6.9 In the event of damage being caused or the Engineer considering it necessary for any other reason the Contractor will be required to reduce the charges and adjust his method of working. In the event of such steps not being successful the Engineer reserves the right to withdraw permission for the use of explosives.
- 3.6.10 Explosives shall be packed, conveyed and stored in accordance with the relevant statutory orders, instruments and by-laws. The Contractor shall comply with Part 8 of the "Safety, Health and Welfare at Work (Construction) Regulations 2006" and with all current regulations and requirements of the Gardai for the security and use of explosives. Explosives shall be handled by experienced and competent personnel and only with the direct authority of the Contractor. The Contractor shall ensure that there is no unauthorised issue or improper use of explosives on Site.
- 3.6.11 In each and every circumstance the Contractor will be entirely responsible for all damage and accidents arising out of or in relation to blasting operations and he shall hold the Employer indemnified against any claims for injury or damage arising there from.
- 3.6.12 In no circumstances will blasting be permitted in under or near buildings, railways, canals, bridges, or culverts. Where blasting is proposed close to residential property this will not be permitted during the night or on Sundays without the Engineer's permission which will not be unreasonably withheld. The Contractor shall allow for all the requirements of this Clause in the appropriate rates in the Bill of Quantities.

3.7 Unsuitable Ground

- 3.7.1 All unsuitable ground in the bottom of the excavations and trenches shall be excavated to such depths as may be directed and then filled in with approved material such as Clause 804 to the NRA Specification for Roadworks. The Contractor shall make good any unsound or weak areas and shall not commence any of the Permanent Works until the foundations have been approved in writing by the Engineer. If the bottom is damaged as a result of excavations or allowed to deteriorate the Engineer shall be promptly informed. The Contractor shall in any case carry out his operations in such a manner as to avoid such damage or deterioration of the final surface.

3.8 Excavation Below Final Surface

- 3.8.1 Any excavation carried out inadvertently by the Contractor below the final surface shall be filled and compacted with approved material such as Clause 804 material to NRA Specification for Roadworks, at the Contractor's expense.

3.9 Excavation in or adjacent to Paved Surfaces

- 3.9.1 The Contractor shall carry out excavation, disposal of spoil and construction of the works in such a manner that adjacent paved and trafficked surfaces are not unduly damaged and, unless specified elsewhere, any damage caused to such surfaces outside the payment widths for surface restoration shall be made good at the Contractors own expense. Furthermore, any spillage of materials or deposition of mud and clay on roads shall be cleaned up immediately.

- 3.9.2 All paving flags, kerbs etc., likely to be damaged during the construction of the works shall be carefully removed, stored in an appropriate secure location and replaced at a later date.
- 3.9.3 The surfaces of road excavations shall all have saw cut edges. Field turf shall be carefully cut into narrow widths and carefully rolled and stacked for later re-use. It shall be kept free of weeds.
- 3.9.4 Excavations in and adjacent to roads and footways shall be adequately protected by substantial barriers and illuminated.
- 3.9.5 If through the improper use of construction plant or through carelessness or for any other avoidable reason the Contractor excavates trenches to greater widths than are specified, or if in the remaining portions of roadways, pavement or footpath, damage is done to surfaces by construction plant the Contractor shall be entirely responsible for the complete restoration of the surfaces so damaged. He shall restore them to the condition in which they were before the Contractor commenced his operations, or shall pay to the owner or Local Authority the certified costs of such repairs.
- 3.9.6 In the event of failure of the Contractor to repair, or pay the cost of the above, the Engineer shall have power to deduct the costs from any monies due or which may become due to the Contractor.

3.10 Excavation in or Adjacent to Lawns & Gardens

- 3.10.1 Where excavation lies in private lawns or gardens, the turf shall be cut in squares and carefully removed for re-use during reinstatement.
- 3.10.2 The Contractor shall not, cut or break down any fence, hedge or trees in the line of the proposed works, without written permission of the Engineer. Lawns and gardens, on which excavated material is placed, or walls which support it must be protected.

3.11 Excavation in or Adjacent to Fields And Open Areas

- 3.11.1 The Contractor shall carefully strip the topsoil over those areas likely to be disturbed during construction for re-use during reinstatement.
- 3.11.2 The work shall be done in such a manner that the minimum area required to be stripped and all disturbed areas shall be fully reinstated when the works are completed.

3.12 Excavation Adjacent to Existing Buildings

- 3.12.1 The Contractor shall make all necessary provision for shoring, strutting, underpinning or supporting any walls, foundations or other built structures, the stability of which may possibly be endangered by the execution of the works.
- 3.12.2 The Contractors overall rates for excavation, and temporary restoration of surfaces shall be deemed to include for the restoration and making good of all boundary walling indirectly damaged or affected by the use of explosives or machinery during the course of construction.
- 3.12.3 In excavating near the foundations of existing buildings the Contractor may be required to underpin, so as to ensure the stability of such foundations. In such circumstances the excavations shall be carried out in short lengths not exceeding 1 metre and the underpinning shall be constructed in alternate sections. In excavating each length the foundations of the existing structure and all sides of the trench or heading shall be boxed with close boarding all around and properly strutted. The Contractor shall be responsible for the safety of such structures, and should any subsidence or any other damage occur due to the insufficiency of the underpinning or other supports provided, the damages shall be made good by the Contractor at his own expense.

3.13 Underground Services

- 3.13.1 The positions of gas mains, water mains, electricity mains, telephone cables, sewers, drains and other services, together with house and private services of any kind, where shown on drawings provided by Statutory Undertakers and property owners, or where shown on Contract Drawings, shall be regarded as approximate only. Further services to individual properties not shown on the drawings are also likely to exist.
- 3.13.2 The contractor shall make his own enquiries of statutory and public authorities and of property owners to satisfy himself as to the exact positions of apparatus and services, together with the depths, sizes and gradients thereof. Where the presence of underground services is suspected, hand excavated exploratory holes shall be dug to a minimum depth of 1m before excavation using mechanical plant commences.

3.14 Temporary Removal of Excavated Material

- 3.14.1 If all or any excavated material cannot be stored on the site in such a manner as to maintain adequate traffic flow it shall be removed from the works and temporarily stored. After the construction of the works as much of this material as is of satisfactory quality and necessary for the purpose shall be brought back and used for backfilling the excavation.
- 3.14.2 No excavated material suitable for re-use in the Works shall be removed from the Site except on the direction, or with the permission of the Engineer.

3.15 Supporting Excavations

- 3.15.1 The Contractor shall furnish, put in place and maintain such sheeting, bracing etc., as may be required to support the sides and roof of the excavation and to prevent any movement which can in any way injure the masonry, concrete or pipeline, diminish the necessary width of excavation, or otherwise injure or delay the work or endanger adjacent pavements, buildings or other structures. If the Engineer is of the opinion that at any points sufficient or proper supports have not been provided, he may order additional supports put in at the expense of the Contractor and the compliance with such orders shall not release the Contractor from his responsibility for the sufficiency of such supports. Care shall be taken to prevent voids outside the sheeting, but if voids are formed they shall be immediately filled and consolidated to the satisfaction of the Engineer.
- 3.15.2 All linings and framings shall be inserted as the excavation proceeds and shall be tightened up against the adjacent soil by wedging or jacking and secured by cleats or other suitable means. In deep excavations provision shall be made for bracing the framings vertically so as to prevent downward slipping of any of the framing units. In long excavations horizontal/diagonal bracings may be necessary. In so far as is possible all timber linings and framings to excavations shall be so arranged that they can be withdrawn as the pipelaying or building in of the foundation proceeds.

3.16 Supports Left in Trench

- 3.16.1 The Contractor shall leave in place to be embedded in the backfill of excavations or tunnels all sheeting, bracing etc., not so shown on the plans which the Engineer may direct in writing to be left in.
- 3.16.2 All other sheeting and bracing shall be removed in such a manner as not to endanger the constructed structure, pipeline or properties whether public or private. All voids left or caused by the withdrawal of sheeting shall be immediately refilled and compacted.
- 3.16.3 The right of the Engineer to order sheeting and bracing left in place shall not be construed as creating any obligation on his part to issue such orders and the non-exercise of this function shall not relieve the Contractor from liability for damages to persons or property, occurring from or upon the work, occasioned by negligence or otherwise, growing out of the failure on the part of the Contractor to leave in place in the excavations and trench sufficient sheeting and bracing to prevent any caving or moving of the ground adjacent to the banks of the excavations and trench.

3.17 Dealing with Water

- 3.17.1 Where required for the protection of road sub-grade or the subsoils beneath the foundations and pipelines the Contractor shall remove by pumping, or otherwise any water which may accumulate or be found in the excavations and trenches and other openings made under this contract and shall form all dams, flumes or other works necessary to keep them entirely clear of water while pipelines are being laid and backfilled and foundations, structures and roads are being constructed. The Contractor shall have at all times upon the works sufficient pumps ready for immediate use.
- 3.17.2 Water from the trenches and excavations shall be disposed of in such a manner as to avoid damage to roads, public or private property, silting of drains or blocking water courses and shall not cause unnecessary interference with the use of the roadworks or accessways by the public or become a public health hazard.
- 3.17.3 It shall be the Contractor's responsibility having visited and inspected the site and having made any additional enquiries on water levels directly himself, having studied the site investigation results, and having carried out any further trial excavations himself and bearing in mind the proximity of the Works to major watercourses, to deal with ingress of any water in such a manner as to protect all formations.
- 3.17.4 Any drainage sumps required shall, where practicable, be sited outside the area excavated for the Permanent Works, and shall be re-filled with blinding concrete to the level of the underside of the adjacent Permanent Works.

- 3.17.5 The Contractor shall take all necessary precautions to prevent any ground water from entering mains to be used for the conveyance of potable water.
- 3.17.6 The Contractor shall ensure that the levels of fines removed due to groundwater pumping does not cause damage to adjacent structures/services as a result of settlement. All groundwater is to be disposed of through settlement tanks to enable assessment of the volume of fines present.

3.18 Removal of Hazardous Material

- 3.18.1 All hazardous matter met with during the excavation of the works immediately it is encountered shall be treated prior to disposal to a suitable dump and shall not be deposited upon the surface of any street, or any place near a dwelling house or where it is likely to be a nuisance. Such disposal shall take place at frequent intervals to prevent any accumulation of spoil and rubbish. Disposal of any material off site shall comply with the Waste Management Act, 1996 and any amendments thereof.

3.19 Temporary Drains

- 3.19.1 Whenever so directed by the Engineer, the Contractor shall excavate a trench or lay a temporary pipeline from the excavations to a natural watercourse. No water shall be discharged into any watercourse without the Contractor having first obtained all necessary consents and the permission in writing of the Engineer. Such permission shall not be granted unless the Contractor has provided to the satisfaction of the Engineer's Representative an efficient settling basin or sand trap through which all such water shall pass before discharge into the said watercourse or sewer.
- 3.19.2 Where temporary drains are required, they shall be laid in a narrow trench formed below the bottom of the excavation in an approved position. The pipes shall be open-jointed and shall be surrounded with Type A bedding material (as defined elsewhere in this Specification).
- 3.19.3 Grouting pipes shall be inserted in the line of the temporary drains at intervals not exceeding 25m, and the drains shall be solidly filled with grout, Class G3 or G4, the grout pipes being cut off on completion.
- 3.19.4 When no longer required or where directed by the Resident Engineer, temporary drains shall be removed or sealed.

3.20 Backfilling (In Normal Ground)

- 3.20.1 Unless otherwise directed all excavations shall be backfilled as soon as the structures therein have acquired adequate strength or pipelines have been laid and tested. Once started backfilling shall be carried out expeditiously.
- 3.20.2 Excavations in roads or trafficked areas shall be backfilled with approved graded granular material. Details of material type, grading and compaction requirements are specified elsewhere in this Specification.
- 3.20.3 Elsewhere, excavated material shall be used for backfilling laid and compacted in 200mm layers. Compaction shall be by means of six passes of a vibrating-plate compactor or approved equivalent. If the Contractor allows material, which, on excavation, is suitable for re-use to become unsuitable for backfilling, he shall replace it with approved material at his own expense.
- 3.20.4 Backfilling around tanks and other structures shall be undertaken in such a manner as to avoid uneven loading and, where appropriate, as the permanent work is built.
- 3.20.5 Where the excavations have been supported and the supports are to be removed, these, where practicable, shall be withdrawn progressively as backfilling proceeds in such a manner as to minimise the danger of collapse, and all voids formed behind the supports shall be carefully filled and compacted.

3.21 Backfilling of Trenches

- 3.21.1 Backfilling of trenches shall be carried out as described elsewhere in this Specification or as detailed in the drawings.
- 3.21.2 Trenches shall be refilled to within such a distance of the final surface as is required to enable the Contractor properly to execute the operations of temporary restoration hereinafter specified. All large stones shall be retained until filling approaches the final surface, and even then shall be carefully placed by hand.

3.22 Backfilling of Headings

- 3.22.1 Headings shall be filled with the excavated material packed tightly in layers and the materials shall be carefully rammed by approved methods. In shallow headings or where special circumstances so require the headings shall be filled with:
- 3.22.2 concrete consisting of 1 part of cement to 12 parts of aggregate by volume, or
- 3.22.3 hand packed hardcore or broken rock kept to a stepped face as work proceeds. Such timber as can be removed with safety shall be taken out as filling proceeds.

3.23 Backfilling in Rock

- 3.23.1 Where the filling material contains broken rock and stones special precautions shall be taken to protect structures or pipelines within the excavations.
- 3.23.2 Granular surround (in accordance with NRA Specification for Road Works, Vol.1, Series 500, Table 5/3) to a minimum depth of 300mm shall be placed over pipelines to the full width of the trench before rock backfill commences. Backfill of the first 600mm layer of rock or stones shall be carried out carefully and no rock or large stones shall be allowed to protrude into the granular layer. The interstices of the rock backfilling shall be filled with smaller stones and clay and the whole compacted carefully.
- 3.23.3 Any damage caused to structures or pipelines during the backfilling operations shall be rectified at the Contractor's expense.

3.24 Deficiency of Material for Fill

- 3.24.1 Should there be a deficiency of suitable material for backfilling, the Contractor shall supply and place such additional materials as may be required.

3.25 Disposal of Surplus

- 3.25.1 As each excavation and trench is refilled the surplus excavated materials shall be at once removed, the surface having been properly restored to its original level. All roadways, pavements, paths, yards, gardens, fields and any other place disturbed during the execution of the work shall be left as they were found, neat and tidy and free from accumulation of excavated soil.

3.26 Obstruction of Road

- 3.26.1 The Contractor shall comply with any Traffic Management Requirements of this Specification, or of any Traffic Management Plan or other relevant document forming part of the Contract Documents.
- 3.26.2 In any case, restrictions to vehicular or pedestrian traffic shall only be allowed by agreement with the relevant local Traffic Authority and the Garda Síochána.

3.27 Use of Materials Excavated from Public Property

- 3.27.1 The earth, stone, gravel, clay, turf, sand, timber and all other materials and things excavated from the works on public property shall not become the property of the Contractor, but the Engineer will allow the Contractor to use the same for the purpose of this contract, provided no detriment to the works is occasioned thereby, and that such portions of the said materials are suitable and in accordance with the terms of the specification.

3.28 Material Excavated from Private Property

- 3.28.1 Surplus sand, gravel, or other materials taken from any excavations on private property shall belong to the owner of the property, and must be dealt with as the owner requires, but if such owner does not require the materials then the Contractor shall remove and dispose of surplus materials as described above.

3.29 Forming Embankments

- 3.29.1 The Contractor shall form any embankments to the lines, levels, slopes and profiles shown on the drawings.
- 3.29.2 The areas on which embankments or other areas of fill are to be constructed shall be stripped of topsoil unless otherwise directed. Embankments and other areas of fill shall be formed of suitable material. Should the quantity of suitable excavated material from the works be insufficient to make up the embankments, the deficiency shall be made good with imported suitable material from sources approved by the Engineer.

- 3.29.3 All earthworks material placed in or below embankments, below foundation levels or elsewhere in the Works other than on roofs of tanks and underground chambers shall be deposited and compacted as soon as practicable after excavation, in layers of thickness appropriate to the compaction plant used as permitted in Table 3.2 or a permitted departure therefrom. Embankments shall be built up evenly over the full width and shall be maintained at all times with a sufficient camber and a surface sufficiently even to enable surface water to drain readily from them. During the construction of embankments the Contractor shall control and direct construction traffic uniformly over their full width. Damage to compacted layers by construction traffic shall be made good by the Contractor.
- 3.29.4 Filling on roofs of tanks and underground chambers shall be placed in an approved progression by such plant as will avoid risk of damage to the structure through unbalanced or excessive loading. Compaction of such filling shall be effected as required by the Contract or as directed.
- 3.29.5 Compaction of embankment and other areas of fill shall be undertaken to the requirements of the next Clause of this Specification. If the material deposited as fill subsequently reaches a condition such that it cannot be compacted in accordance with the requirements of the Contract the Contractor shall either:
- 3.29.5.1 make good by removing the material off the embankment either to tip or elsewhere until it is in a suitable physical condition for re-use, and replacing it with suitable material; or
 - 3.29.5.2 make good the material by mechanical or chemical means to improve its stability; or
 - 3.29.5.3 cease work on the material until its physical condition is again such that it can be compacted as described in the Contract.
- 3.29.6 Rock used in rockfill embankments shall, except for any specified external cover to slopes or near formation level, be of such size that it can be deposited in horizontal layers each not exceeding 450mm loose depth and extending over the full width of the embankment. Material shall be spread and levelled, and compacted in accordance with the Clause which follows. Each layer shall consist of reasonably graded rock and all surface voids shall be filled with broken fragments before the next layer is placed. The top surface and side slopes of embankments so formed shall be thoroughly blinded with approved fine graded material to seal the surface.
- 3.29.7 Such material may on side slopes and verges be topsoil. Isolated boulders each within range 0.02 cubic metres to 0.10 cubic metre in size may be incorporated in embankments not of rockfill at the discretion of the Engineer provided that the specified compaction requirements are met.
- 3.29.8 Where special forms of compaction, adjacent to structures are required by the Contract, filling may proceed over widths less than the full width of the embankment or other fill area and in steps not exceeding the depth of one layer above the adjoining area of fill.
- 3.29.9 The embankment shall be allowed to stand until all settlement has ceased and after any subsidence has been made good a 225mm layer of topsoil shall be spread and sown with grass seed, in accordance with landscaping section of this specification.

3.30 Compaction of Embankments and Other Areas of Fill

- 3.30.1 All materials used in embankments and as filling elsewhere shall be compacted as soon as practicable after deposition. Compaction shall be undertaken to the requirements of this Clause and Table 3.2 by approved plant, unless a variation thereof is approved.
- 3.30.2 Variations from the methods given in Table 3.2 or the use of plant not included therein, will not be approved unless the Contractor demonstrates at site trials that a state of compaction equivalent to that obtained using the approved methods is achieved by the alternative method. The procedure to be adopted for these site trials shall be approved.
- 3.30.3 The Engineer may at any time carry out comparative field density tests determined in accordance with BS 1377-9:1990 on material, which he considers to be inadequately compacted. If the test results, when compared with the results of similar tests made on adjacent approved work in similar materials carried out in accordance with Table 3.2, show the state of compaction to be inadequate the Contractor shall carry out such further work as may be directed.

3.30.4 Each layer of rock used as rock fill in embankments shall be spread and levelled in accordance with the previous Clause and systematically be compacted by at least 12 passes of a towed vibratory roller with a static load per 100 mm width of roll of at least 1.75 kiloNewtons (kN) or other approved plant. Where, however, the rock contains sufficient soft material for satisfactory compaction to the requirements of Table 3.2 for well-graded granular soil the fill shall be compacted to such latter requirements. When materials of widely divergent characteristics are used in embankments and fill areas they shall be spread and compacted in separate clearly defined areas in such a manner as to comply with the requirements of Table 3.2. If more than one class of material is being used in such a way that it is not practicable to define the areas in which each class occurs, compaction plant shall be operated as if only the material which requires the greatest compactive effort is being compacted.

3.30.5 Definitions and Requirements Associated with Table 3.2:

- The depth of compacted layer is the height by which an embankment is raised by each successive compacted layer.
- Number of passes is the number of times that each point on the surface of the layer being compacted has been traversed by the item of compaction plant.
- The load (force) per 100mm width is the total weight (force) on the roll divided by the total roll width. Where a smooth wheeled roller has more than one axle the machine will be assessed on the basis of the axle giving the highest value of load (force) per 25mm width.
- Vibratory rollers or self-propelled or towed rollers having means of applying mechanical vibration to one or more rolls.
- The requirements for vibratory rollers are based on the use of the lowest gear on a self-propelled machine and a towing speed of 30-40 metres per minute for a towed machine. If higher gears or speeds are used an increased number of passes shall be provided in proportion to the increases in speed of travel.
- Vibratory rollers operating without their vibration mechanism in use will be classified as smooth-wheeled rollers.
- Vibratory rollers shall be operated with their mechanism operating only at the frequency of vibration recommended by the manufacturers. All such rollers shall be equipped with a device automatically indicating the frequency at which the mechanism is operating.
- Vibrating-plate compactors are machines having a base plate to which is attached a source of vibration consisting of one or two eccentrically-weighted shafts.
- The static pressure under the plate of a vibrating-plate compactor is calculated by dividing the total weight (mass (Kg) x 98.1) of the machine in working order by the area in square centimetres in contact with compacted soil.
- Vibrating-plate compactors shall be operated at the frequency of vibration recommended by the manufacturer. They shall normally be operated at travelling speeds of less than 15 metres per minute but if higher speeds are necessary the number of passes shall be increased in proportion to the increase in speed of travel.
- Vibro-tampers are machines in which an engine-driven reciprocating mechanism acts on a spring system, through which oscillations are set up in a baseplate.
- Power rammers are machines, actuated by explosions in an internal combustion cylinder, each explosion being controlled manually by the operator.
- In the case of power rammers one pass will be considered as made when the compacting shoe has made one strike on the area in question.
- For items marked * the rollers shall be towed by track-laying tractors. Self-propelled rollers are unsuitable.

		Cohesive Soil		Well graded granular and dry cohesive soils		Uniformly graded materials	
Type of compaction Plan	Category	Maximum Depth of compacted layer (mm)	Minimum No. of passes	Maximum depth of compacted layer (mm)	Minimum no. of passes	Maximum depth of compacted layer (mm)	Minimum no. of passes
Smooth Wheeled Roller	Force per m width						
	2,100 - 2,600kg	125	8	125	10	125	10
	2,601 - 5,200kg	125	6	125	8	125	8
	> 5,200kg	150	4	150	8	N/A	N/A
Vibratory Roller	Force per m width						
	250 - 450kg	N/A	N/A	75	16	150	16
	451 - 700kg	N/A	N/A	75	12	150	12
	701 - 1,250kg	100	12	125	12	150	6
	1,251 - 1,750kg	125	8	150	8	200	10*
Vibrating Plate Compactor	Static force under base plate						
	850 - 1,050kg/m ²	N/A	N/A	N/A	N/A	75	6
	1,051 - 1,200kg/m ²	N/A	N/A	75	10	100	6
	1,201 - 1,400kg/m ²	N/A	N/A	75	6	150	6
	1,401 - 1,800kg/m ²	100	6	125	6	150	4
	1,801 - 2,100kg/m ²	100	6	125	6	150	4
	2,100kg/m ²	200	6	150	5	200	4
Vibro Tamper	Mass (Kg)						
	50-65	100	3	100	3	150	3
	65-75	125	3	125	3	200	3
	More than 75	200	3	150	3	220	3
Power Rammer	Mass (Kg)						
	100	150	4	150	6	N/A	N/A
	More than 100	270	8	275	12	N/A	N/A

Table 3.2 – Compaction Requirements

3.31 Dewatering of Embankments and Other Areas of Fill

- 3.31.1 The Contractor shall arrange for the rapid dispersal of water, shed on to the embankments and other areas of fill or completed formation of access roads during construction, or which enters such works from any source, and when practicable the water shall be discharged into the permanent outfall for the pipe drainage system. Adequate means for trapping silt shall be provided on temporary systems discharging into permanent drainage systems. The Contractor shall provide where necessary temporary watercourses, ditches, drains, pumping or other means of maintaining the earthworks free from water. Such provision shall include carrying out the work in such a manner that their surfaces have at all times a sufficient minimum crossfall and, where practicable a sufficient longitudinal gradient to enable them to shed water and prevent ponding.

3.32 Excavation in Narrow Passages

- 3.32.1 Where pipelines have to be laid in narrow passages the Contractor may be required to excavate partly by hand.

3.33 Land Drains

- 3.33.1 The positions of all land drains intercepted or disturbed shall be prominently marked at every point of intersection with the work. The Contractor shall record these positions, depths, pipe diameters and the types of construction, and a copy of these records shall be given to the Engineer. Care shall be taken during the progress of the Works to prevent disturbance of markers.
- 3.33.2 Prior to the permanent reinstatement of land drainage the Contractor shall clear the ends of existing drains, where intercepted by excavations, and shall afford facilities to the Engineer and the landowner or occupier to inspect them and determine the extent of replacement that may be necessary. The affected land drains shall be cut back into firm ground until, in each case, a section is exposed which is unaffected by the Works.
- 3.33.3 The backfill of intercepting excavations shall be compacted in 200mm layers, to give a firm bearing immediately before replacement pipes are laid, and shall be brought up to the level of the underside of the land drains or of any support to be provided.
- 3.33.4 Replacement pipes or support beams shall bear on undisturbed ground for at least 500mm at each end. The replacement pipes shall be of the same internal diameter as the sections of drain which they replace, and shall be properly connected at each end.
- 3.33.5 Records shall be kept of all drainage system reinstatement work carried out and a copy shall be given to the Engineer.

3.34 Gabions

- 3.34.1 Gabion boxes and mattress units shall be formed from hexagonal double twist steel wire mesh, divided by partition panels (diaphragms) at 1m centres, as detailed on the drawings and Bill of Quantities.
- 3.34.2 All wire shall be in accordance with BS 1052:1980 heavily galvanised with a zinc coating to IS EN 10244-2:2001 prior to weaving the mesh. Mesh openings shall be hexagonal in shape, nominally 80 x 100mm (Type 8) for gabions and 60 x 80mm (Type 6) for Mattresses. Mesh joints shall be flexible and shall consist of one and a half turns of wire. (This mesh is often called double or triple twist). The mesh wire shall be not less than 2.7mm dia. for gabions and not less than 2.0mm for mattress units. All edges of the mesh shall be reinforced with a 'selvedge' wire, heavier than the mesh wire and not less than 3.4mm diameter for mesh type 8/2.7 and 2.40mm diameter for mesh type 6/2.0.
- 3.34.3 All wires shall be additionally coated with PVC sheathing grey in colour, of mean wall thickness 0.50mm, giving an average overall diameter 1.0mm greater than the zinc coated core wire. The PVC shall be capable of resisting the deleterious effects of exposure to ultra violet light, immersion in seawater, normally occurring pollutants and abrasion.
- 3.34.4 The assembly and erection of the units shall be generally in accordance with the manufacturer's instructions, using lacing wire 2.2mm in diameter, of the same specification as the mesh wire. All lacing must be continuous and horizontal bracing wires must be fixed on exposed faces of box gabions. Particular care shall be taken throughout construction to ensure tightness of mesh, well packed filling with minimum voids, and secure lacing. The exposed faces of completed work shall present a neat face and line, free from excessive bulges or depressions.

- 3.34.5 Filling shall be carried out either by hand or using mechanical equipment approved by the Engineer. Box gabions shall be filled whilst under tension and over-filled by 25mm to 50mm above their tops to allow for subsequent settlement; 100mm filling material may be used for this purpose. This shall be hard, durable quarried or rounded material such as granite, basalt, dolomitic limestone, flint rejects, cobbles etc. Soft friable material and soft bricks shall not be used. For box gabions the size shall be not less than 100mm and not normally greater than 200mm. For mattresses the size shall be 75 to 150mm but never more than two-thirds the thickness of the mattress. A tolerance of 5% of smaller material is acceptable.
- 3.34.6 All mattresses shall be stretched out on site and tensioned to remove any unnecessary creases prior to filling. All wiring of compartments and final wiring of the lids shall be done as a continuous lacing action and not with individual twists at intervals.
- 3.34.7 All assembly and lacing of gabions shall be carried out strictly in accordance with the manufacturer's instructions. Assembled units shall be carried to the final position and laid in place. Each unit shall be securely wired to the adjacent units along selvages in accordance with manufacturer's instructions.
- 3.34.8 On slopes the long dimension of the mattress pocket shall lie along the slope and the short dimension up and down the slope. On steep slopes (greater than 1 in 1.5) hardwood stakes 50mm x 50mm x 750mm long shall be driven through the filled mattress and into the ground at 2000mm centres.
- 3.34.9 Mattresses shall be filled by commencing at the bottom where a slope exists. Compartments shall be slightly overfilled to allow for settlement. On completion of filling, all lid panels shall be securely wired down to the tops of sides, ends and partitions.
- 3.34.10 To fit difficult curves mattress units may be cut diagonally to form triangular sections. The open side shall then be butt jointed to an intact side panel.
- 3.34.11 Bulges or depressions greater than 50mm per square metre of face shall not be permitted. An overall tolerance of plus or minus 75mm both horizontally and vertically from the setting outlines shall not be permitted.

3.35 Warning Signs

- 3.35.1 Warning signs shall be in compliance with any Traffic Management Requirements of this Specification, or of any Traffic Management Plan or other relevant documents forming part of the Contract Document. Such warnings signs shall be maintained in a clean and easily legible condition and shall be moved daily or as required as the work proceeds so as always to be properly positioned for the convenience of road users.
- 3.35.2 Notwithstanding compliance with statutory public notices in the press etc. where Roads are closed, the Contractor must provide Diversion Notices at all such locations as may be necessary so that no user of the road is obliged to retrace his steps upon discovery of the works and the obstruction to passage. The Contractor is to obtain the Engineers approval to the details of the wording and to the proposed size and location of the boards.

3.36 Watching and Lighting

- 3.36.1 The Contractor shall fence, light and otherwise protect all open trenches and all heaps of accumulated material whether it has been excavated from the trenches or not. For night time warning to drivers adequate warning lights shall be placed to indicate all obstructions in the highway. In all aspects, the contractor shall meet the requirement of any Traffic Management Plan forming part of the Contract Documents in planning his lighting system.
- 3.36.2 The Contractor shall be held responsible for accidents and damage arising from failure on his part properly to fence, guard and light as aforesaid and for any inconvenience or damage caused to the public or to property owners through his negligence in these matters.

4 CONCRETE WORKS

3.1 Concrete - General

3.1.1 The quality of materials and the standard of workmanship for reinforced concrete shall comply with the relevant clauses of the BS 8110, Part 1 : 1997 and Part 2 : 1985, IS EN 206-1:2002, BS 8007:1987 in regard to all requirements not otherwise described in this Specification.

3.1.2 The Contractor shall employ a competent person, fully experienced in reinforced concrete construction, to supervise all stages in the preparation, sampling, testing and placing of concrete.

3.1.3 Ordinary structural concrete shall contain only the following:

Normal Portland Cement – CEM1 complying with IS EN 197-1:2001.

Aggregates comprising Natural Sands or Gravels or Crushed Stone as specified by IS EN 12620:2002.

Water, which is clean and free from harmful matter to IS EN 1008:2002.

3.2 Samples and Testing

3.2.1 When directed by the Engineer, representative samples of any materials used in the concrete works shall be tested in accordance with the relevant Standards and Codes of Practice.

3.2.2 Tests which are not normally field tests, shall be carried out in a laboratory to be approved by the Engineer.

3.2.3 The Contractor shall maintain on site appropriate equipment for routine site testing of materials.

3.2.4 Materials from which samples have been found to fail any test shall immediately be removed from the site.

3.2.5 All materials delivered to site or manufactured on site shall be equal to or superior in quality to that of the tested and approved samples.

3.3 Cement

3.3.1 All cement used in the work shall comply with IS EN 197-1:2001 for normal Portland Cement – CEM 1. The contractor shall, on request, produce the delivery docket and invoices of the various consignments for the inspection of the Engineer.

3.3.2 Portland Cement CEM 1 used in concrete, concrete products and other cement based products shall be certified as complying with IS EN 197-1&2:2001. Manufacturers' or suppliers' certificates of compliance with IS EN 197-1&2:2001 shall be provided when requested by the Engineer.

3.3.3 Cement shall be protected from the weather in transit and shall be stored at the Works in weatherproof buildings and, if delivered in bags, on dry floors raised above ground level. If different brands of cement are in use, a separate store shall be used for each brand.

3.3.4 The Contractor shall obtain with the first delivery to the Site a manufacturer's certificate in accordance with IS EN 197-1&2:2001. The furnishing of these Certificates shall in no way prejudice or over-ride the rights of the Engineer to have independent tests carried out.

3.3.5 Cement damaged in storage or handling shall not be used and shall be removed off site.

3.4 Water

3.4.1 Water for use in concrete shall comply with IS EN 1008:2002. It shall be clean, free from turbidity and suspended matter and shall be certified by a reputable chemist as suitable for its intended purpose. It shall also be free from ice or snow at the time of use.

3.5 Aggregates

3.5.1 Aggregates for concrete shall be obtained from an approved source and shall conform with the requirements of IS 5 and IS EN 12620:2002. Aggregates for Concrete. For fine aggregates gradings shall be within the limits of Table 8 IS 5-1:1990. Coarse and All-In Aggregate shall comply with the grading limit stipulated in Tables 7 and 9 IS 5-1:1990 respectively. The use of "All in aggregates" as specified in section 6.3 of IS 5-1:1990 will not be permitted, except in the case of Grade 10 (C8/10 to IS EN 206-1:2002) concrete and with the express approval of the Engineer.

3.5.2 The Contractor shall submit to the Engineer full details of his proposed aggregate source including the following:

Location and supplier's production facilities.

Confirmation of quarry registration.

Petrology and possible variability.

Proposed aggregates, processed sizes and results of at least three sieve analyses.

Certification from the supplier that the output from the source of production consistently conforms to the requirements of the appropriate clauses of IS 5 and IS EN 12620:2002.

Details of typical physical and chemical properties of aggregates from the source, as listed in IS 5 and IS EN 12620:2002.

Samples of each size of aggregate taken in accordance with IS 5 and IS EN 12620:2002.

Any changes in the particulars of the aggregates, which occur during the course of the Contract, must be notified to the Engineer without delay.

- 3.5.3 Aggregate shall consist of natural sands and gravels, crushed stone, or other suitable material. They shall be clean, hard, strong, sound and durable, and shall be free from clay, silt, loam and other organic matter, shells, mica, shale, coal, slag, soluble sulphates, adherent coatings, and all other extraneous deleterious matter, liable to reduce the strength or durability of the concrete, or to attack the steel reinforcement.
- 3.5.4 The fine aggregate shall be a natural pit or river sand passing a 5mm (3/16") BS sieve and shall be thoroughly washed in a mechanical washing plant. It shall contain only so much coarse material as may be permitted for the various specified classes of concrete.
- 3.5.5 The coarse aggregate shall consist of the following sizes:
- Passing 40mm (1½") BS Sieve, retained on 20mm (¾") BS Sieve
- Passing 20mm (¾") BS Sieve, retained on 10mm (3/8") BS Sieve
- Passing 10mm (3/8") BS Sieve, retained on 5mm (3/16") BS Sieve.
- It shall be composed of clean washed gravel or crushed stone of approved quality free from laminated and flaky particles, dust and other impurities. It shall contain only so much fine material as may be permitted for the various classes of concrete specified.
- 3.5.6 The graded fine aggregate and each size of coarse aggregate shall be stock piled separately on clean impermeable concrete, macadam or other approved surface with adequate provision for drainage. Aggregate, which contains ice or frozen material, shall not be used. Aggregate shall be stored in sufficient quantity to ensure continuity of supply for the duration of the Contract.
- 3.5.7 Aggregates shall have a low drying shrinkage and an absorption measured in accordance with IS 5 and IS EN 12620:2002 generally not greater than 3%. Aggregates containing silicious material and in particular reactive silica such as opal chalcedony, tridymite, silicious limestone, andesite or rhyolite shall not be used.
- 3.5.8 The Contractor shall produce with the first consignment of each size of aggregate a sieve analysis carried out on a sample of the consignment. If any such or other sample does not conform with the Specification the aggregate it represents shall be promptly removed from the Site and the Contractor shall carry out such modifications to the storage arrangements as may be necessary to secure compliance with the Specification.
- 3.5.9 Periodic sampling and testing of aggregates during the progress of the Works shall be carried out in accordance with the requirements of IS 5 and IS EN 12620:2002 and for this purpose the Contractor shall deliver the appropriate quantities of the different aggregates sizes free of charge upon the Contract at a nominated Engineering Laboratory, which in general shall be that attached to the Engineering School of the Constituent College of the National University of Ireland or any other approved Engineering Laboratory which is most convenient to the place at which the Works are in progress.
- 3.5.10 The grading of the fine and coarse aggregates shall be suitable for making a dense concrete or appropriate workability and strength with the proportions of cement and water with which the aggregate is to be used. The proportion of fine aggregate to coarse shall be in accordance with Table 4.1 below. In the case of a designed mix the proportions shall be submitted to the Engineer for approval.

3.6 Aggregates for Granolithic Concrete

- 3.6.1 Aggregates for granolithic concrete shall comply with IS 5 and IS EN 12620:2002 and be 10mm nominal size, graded in accordance with Table 9 of IS 5-1:1990 aggregates for concrete.

3.7 Sands

- 3.7.1 Sands for mortar and grout shall comply with BS 1200 and IS EN 13139:2002 and be graded in accordance with Table 1 of that Standard. Sands for internal plastering with gypsum plasters shall comply with BS 1199 and IS EN 13139:2002 and be Type 1 and 3 for undercoats and finishing coats respectively. Sands for external renderings, internal plastering with lime and portland cement and for floor screeds shall comply with the relevant provisions of BS 1199 and IS EN 13139:2002. All sands required to comply with BS 1199 or BS 1200 shall be washed sands.

3.8 Concrete Mix Design

- 3.8.1 Concrete mixes shall be either designed, where the Contractor will be responsible for selecting the mix proportions to achieve the required strength and workability and the Engineer will specify the minimum cement content, or prescribed (nominal) where the approximate mix proportions and a minimum cement content are specified. Designed and prescribed mixes shall be in accordance with IS EN 206-1:2002.
- 3.8.2 The cement content in any mix shall not exceed 540kg/m of concrete. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted in the required location. In all cases the Contractor shall be responsible for producing concrete of the required strength. The water/cement ratio shall be the minimum value possible consistent with producing a dense concrete of the specified workability and complying with the relevant requirements of the Specification.
- 3.8.3 The water content shall be such that excess water does not appear on the top surface on completion of compaction of the concrete in the formwork and such that the maximum free water cement ratio shall not exceed that given in BS 8110:1997 and Table 4.3 (F.1 (IRL) IS EN 206-1:2002. The maximum free water cement ratio for water retaining concrete shall not exceed 0.55. In the measurement of water content, due allowance shall be made for the water content of the aggregates.
- 3.8.4 The contractor shall specify the slump class and the flow class of the mix in accordance with Table 4.1 and 4.2 respectively.

Class	Slump (mm)
S1	10 to 40
S2	50 to 90
S3	100 to 150
S4	160 to 210
S5	≥220

Table 4.1 – Slump Classes

- 3.8.5 Compressive strength classes for normal-weight and heavy-weight concrete must comply with Table 4.3.

Class	Flow Diameter (mm)
F1	≤ 340
F2	350 to 410
F3	420 to 480
F4	490 to 550
F5	560 to 620
F6	≥ 630

Table 4.2 – Flow Classes

Compressive Strength Class	Minimum Characteristic Cylinder Strength, $f_{ck,cyl}$ (N/mm ²)	Minimum Characteristic Cube Strength, $f_{ck,cube}$ (N/mm ²)
C8/10	8	10
C12/15	12	15
C16/20	16	20
C20/25	20	25
C25/30	25	30
C30/37	30	37
C35/45	35	45
C40/50	40	50
C45/55	45	55
C50/60	50	60
C55/67	55	67
C60/75	60	75
C70/85	70	85
C80/95	80	95
C90/105	90	105
C100/115	100	115

Table 4.3 – Compressive Strength Classes for Normal-Weight and Heavy Weight Concrete

- 3.8.6 Compressive strength classes for light weight concrete must comply with Table 4.4. Classification of light-weight concrete by density must comply with Table 4.5.

Compressive Strength Class	Minimum Characteristic Cylinder Strength, $f_{ck,cyl}$ (N/mm ²)	Minimum Characteristic Cube Strength, $f_{ck,cube}$ (N/mm ²)
LC8/9	8	9
LC12/13	12	13
LC16/18	16	18
LC20/22	20	22
C25/28	25	28
C30/33	30	33
C35/38	35	38
C40/44	40	44
C45/50	45	50
C50/55	50	55
C55/60	55	60
C60/66	60	66
C70/77	70	77
C80/88	80	88
Other values may be used if the relationship between these and the reference cylinder strength is established with sufficient accuracy and is documented.		

Table 4.4 – Compressive Strength Classes for Light-Weight Concrete

Density Class	D1,0	D1,2	D1,4	D1,6	D1,8	D2,0
Range of Density (kg/m ³)	≥ 800 and ≤ 1,000	> 1,000 and ≤ 1,200	> 1,200 and ≤ 1,400	> 1,400 and ≤ 1,600	> 1,600 and ≤ 1,800	> 1,800 and ≤ 2,000

Table 4.5 – Classification of Light-Weight Concrete by Density

- 3.8.7 All mix designs must not contradict Table 4.3. Recommended limiting values for composition and properties of concrete.

3.9 Grades of Concrete

- 3.9.1 The grades of concrete to be employed shall be indicated on the Drawings/Specifications or in the Bill of Quantities. In no case shall the grade of concrete be altered except by written instruction of the Engineer.
- 3.9.2 The grades that will generally be used are set out in Table 4.6 and 4.7 below along with their required proportions. The minimum compressive strength of 7 days after mixing shall be two-thirds of the 28-day strength for the particular grade.
- 3.9.3 Except where otherwise specified, the concrete grades to be used in the various sections of construction shall be as follows:
1. Grade C30/37 D20 – Foundations, reinforced concrete walls, slabs, columns and beams, water retaining structures and all other reinforced concrete members unless otherwise specified.
 2. Grade C25/30 D10 – Structure concrete screeds unless otherwise specified.
 3. Grade C20/30 D20 – To be used only where specifically directed by the Engineer.
 4. Grade C20/25 D20 – Plain concrete work, beds, manholes, gully chambers, sewer beds and haunching.
 5. Grade C12/15 D20 – Pipe anchors in plain concrete, blinding concrete.

Concrete Grade	Nominal Max Size of Aggregate (mm)	40		20		10	
	Workability	Medium	High	Medium	High	Medium	High
C25/30	Cement kg/m ³ Total Agg. Kg/m ³ % fines	370 1750 30-50	390 1700 30-40	400 1700 30-40	430 1650 35-45	460 1650 40-50	510 1550 45-55
C20/25	Cement kg/m ³ Total Agg. Kg/m ³ % fines	340 1800 30-35	360 1750 30-40	360 1750 30-40	390 1700 35-40	400 1700 40-50	450 1600 45-55
C16/20	Cement kg/m ³ Total Agg. Kg/m ³ % fines	300 1850 30-35	320 1750 30-40	320 1800 30-40	350 1750 35-45	360 1750 40-50	410 1650 45-55
C12/15	Cement kg/m ³ Total Agg. Kg/m ³ % fines	250 1850 30-45	270 1800 30-45	280 1800 35-50	310 1750 35-50		
C8/10	Cement kg/m ³ Total Agg. Kg/m ³ % fines	210 1900 30-40	230 1900 30-40	240 1850 35-50	260 1800 35-50		

Table 4.6 - Prescribed (nominal) mixes

Concrete Grade	Minimum Cement Content (kg/m ³)	Minimum Compressive Strength after 28 days	
		Preliminary Test (N/mm ²)	Works Test (N/mm ²)
C50/60	375	75	60
C40/50	375	65	50
C32/40	375	55	40
C30/37	375	52	37
C28/35	375	50	35
C25/30	375	45	30
C20/25	300	40	25
C16/20	250	35	20
C12/15	200	25	15
C8/10	160	17	10

Table 4.7 – Designed mixes

Exposure Class																					
	No risk of corrosion or attack	Carbonation-induced corrosion				Chloride-induced corrosion						Freeze/thaw Attack				Aggressive Chemical Environments					
						Sea Water		Chloride other than sea water													
	XD	XC1	XC2	XC3	XC4	XS1	XS2	XS3	XD1	XD2	XD3	XF1	XF2	XF3	XF4	XA1	XA2		XA3		
Max w/c Ratio	-	0.65	0.6	0.55	0.55	0.55	0.5	0.45	0.55	0.5	0.45	0.6	0.55	0.55	0.45	0.55	0.5		0.45		
Min Strength class	C12/15	C25/30	C28/35	C30/37	C35/45	C45/50	C30/37	C40/50	C30/37	C35/40	C40/50	C28/35	C30/37	C30/37	C40/50	C30/37		C35/45		C40/50	
Min Cement content (kg/m³)	-	280	300	320	320	360	400	320	360	400	300	320	320	320	400	320	280	360	320	400	360
Min Air content (%)												If less than C40/50 use: 5.5% (10 Agg.) 4.5% (14 Agg.) 3.5% (20 Agg.) 3.0% (40 Agg.)				(1) CEM1 (2) Sulphate resisting cement (3) Use sulphate resisting cement if SO42 > 1400mg/l					

Table 4.8 Recommended limiting values for Composition and Properties of Concrete

3.10 General Quality of Concrete

- 3.10.1 Concrete to be used in the works shall be of such consistency that it can be readily worked into all parts of the formwork and to unformed surfaces and around reinforced and built-in parts without segregation or voids and without the use of an excessive water content. It shall present finished surfaces which are free from honeycombing, dusting, marks caused by bleeding of free water, marks caused by air bubbles, cracking, discolouration caused by mould oil, or other blemishes.
- 3.10.2 The Contractor shall provide adequate supervision and control of concrete production at the works to ensure that materials and workmanship are to the required standard and consistency to produce concrete complying with all of the relevant requirements of the Specification. Only competent concrete operatives shall be used, supervised by a qualified foreman.

3.11 Workability

- 3.11.1 The workability of the concrete shall be controlled by maintaining a water / cement ratio that is found to be sufficient, but not more than sufficient, to produce a dense concrete of adequate workability and strength for its purpose, which shall surround and properly grip all the reinforcement and fill all formwork completely, without segregation or bleeding, to the required finish. The workability of the concrete shall be frequently checked in accordance with BS 1881 and IS EN 206-1:2002.

3.12 Batching and Mixing

- 3.12.1 Batching and mixing of concrete shall be carried out in accordance with the requirements of BS 8110 and IS EN 206-1:2005. All batching and mixing plant shall be maintained in clean, serviceable and accurate condition. The quantities of cement, fine aggregate and coarse aggregate shall be measured by weight. A separate weighing device shall be provided exclusively for weighing the cement. In the case of bagged cement, the cement may be measured by using a whole number of bags in each batch and by adjusting the batch quantities to maintain design proportions. The amount of water shall be measured by volume or by weight.
- 3.12.2 The accuracy of measuring equipment shall be such that the actual quantities of cement, fine aggregate and water in the concrete mix shall be within plus/minus 3% of the design quantities. The water content of aggregates shall be continuously monitored and due allowance shall be made in the batching of the aggregate and water, to ensure that the design quantities of dry aggregate and water are contained in the concrete mix. All batching equipment shall be used strictly in accordance with Manufacturer's Instructions.
- 3.12.3 The concrete mixer shall comply with the requirements of BS 1305, tested in accordance with BS 3963. The concrete shall be mixed to a uniform consistency and colour. The minimum mixing time and maximum batch shall be in accordance with the Manufacturer's Instructions, unless otherwise directed. The mixer shall be used strictly in accordance with the Manufacturer's Instructions.
- 3.12.4 Each concrete batch shall be completely discharged before recharging the mixer. Where the mixer has not been in use for more than 30 minutes, the mixer shall be thoroughly cleaned out before any fresh concrete is made.

3.13 Trial Mixes

- 3.13.1 Where the Contractor designs the mix, he shall before the commencement of concreting in the work, arrange for trial mixes to be carried out in an approved laboratory to achieve the target mean strength for each grade of concrete and satisfying minimum cement content, workability and maximum size of aggregate requirements.
- 3.13.2 The trial mixes shall contain identical constituent materials proposed for use at the works throughout the duration of the contract. Satisfactory trial mixes shall be carried out and tested in sufficient time to avoid delaying the commencement of concreting at the works. The Engineer may accept, as an alternative, evidence of previous concrete production by the Contractor, including test results, where identical constituent materials were incorporated.
- 3.13.3 Sampling and testing of concrete from trial mixes shall be carried out in accordance with BS 1881, I.S. EN 12350 and I.S. EN 12390, at an approved independent laboratory. From each of the three batches produced, three cubes shall be made for testing at 7 days and three for testing at 28 days. The workability of each trial batch shall be determined. The trial mix proportions shall be approved if, having satisfied the other provisions of the Specification, the average strength of the nine cubes tested at 28 days (7 days guideline only) exceeds the relevant value in Table 4.9 below:-

- 3.13.4 The Contractor shall not commence concreting until the above requirements have been met to the satisfaction of the Engineer. The Contractor shall provide and deliver, free of charge, sample specimens to an approved laboratory. Testing shall be carried out in accordance with BS 1881, I.S. EN 12350 and I.S. EN 12390. The cost shall be charged against the provisional sum included in the Bill of Quantities.
- 3.13.5 Adjustments in proportions may be approved by the Engineer, following sufficient evidence of cube test results, to approach more closely the target mean strength provided the other relevant requirements in relation to minimum cement content and maximum water cement ratio are complied with. Such adjustments, if approved by the Engineer, may be implemented without trial mixes.
- 3.13.6 Where ready mixed concrete is proposed, the Contractor shall obtain test certificates from the ready mixed supplier of cube tests on trial mixes carried out in an approved independent laboratory using identical materials proposed for use in the works. Sampling and testing shall be carried out in accordance with BS 1881 and IS EN 206-1:2002.

3.14 Works Tests

- 3.14.1 The sampling and testing of concrete for strength, workability, analysis of freshly mixed concrete and unit weight shall be carried out in accordance with BS 1881, I.S. EN 12350 and I.S. EN 12390. Such tests as are not normally field tests shall be carried out in a laboratory to be approved by the Engineer. The Contractor shall provide everything for the proper storage and transport of samples for testing. Three cubes shall be made per 20m³ of concrete placed per day or as directed by the Engineer. The samples of concrete for the test cubes shall be obtained at the place of deposition when the concrete is being placed in position. The test cubes shall be marked clearly in an approved manner. Attention is drawn to the detailed recommendations for sampling fresh concrete in field, given in BS 1881, I.S. EN 12350, I.S. EN12390 and IS EN 206-1:2002.
- 3.14.2 For each sample one cube shall be tested at 7 days and two cubes shall be tested at 28 days, unless otherwise directed by the Engineer. The Contractor shall arrange for copies of test results to be forwarded directly from the approved independent laboratory to the Engineer, not exceeding 48 hours after the tests have been carried out.
- 3.14.3 The results of the cube tests at 7 days shall comply with both of the following conditions:-
- The average strength determined from any group of four consecutive cube tests shall exceed the value indicated in the Table 4.10 below:-
 - The strength determined from any cube test shall not be less than the value indicated in Table 4.11 below:-
- 3.14.4 The values given in the above tables apply to ordinary structural concrete produced using normal Portland Cement - CEM1 and free from admixtures and cured under normal conditions. In the event of non-compliance with either Conditions (a) or (b), the Contractor shall immediately adjust the concrete mix design to increase its characteristic strength to the satisfaction of the Engineer. In addition, the Contractor shall be required to carry out remedial measures to the concrete, represented by the cube test or group of tests, as directed by the Engineer.
- 3.14.5 Compliance with the characteristic strength shall be assumed if both conditions (a) and (b) below are met by test results based on 28-day tests.
- (a) The average strength determined from any group of four consecutive test results shall exceed the value indicated in Table 4.12 below:
 - (b) The strength determined from any test result shall not be less than the value of the minimum strength indicated in the Table 4.13 below:-

Grade	Trial Mix	
	7 Day (N/mm ²)	28 Day (N/mm ²)
C12/15	-	26.5
C20/25	24.3	36.5
C25/30	27.7	41.5
C28/35	31.0	46.5

Table 3.9 – Average trial mix cube strength

Grade	Average Strength (N/mm ²) 7 Day Test (Four Consecutive Results)
C20/25	22
C25/30	25
C28/35	29

Table 3.10 – Average 7-Day works test cube strength

Grade	Average Strength (N/mm ²) 7 Day Test (Four Consecutive Results)
C20/25	17
C25/30	20
C28/35	24

Table 3.11 – Minimum 7-day works test cube strength

Grade	Average Strength (N/mm ²) 28 Day Test (Four Consecutive Results)
C12/15	17
C20/25	28
C25/30	33
C28/35	38

Table 3.12 – Average 28-day works test cube strength

Grade	Average Strength (N/mm ²) 7 Day Test (Four Consecutive Results)
C12/15	13
C20/25	22
C25/30	27
C28/35	32

Table 3.13 – Minimum 28-day works test cube strength

- 3.14.6 In the event of non-compliance with condition (a) above, then all of the concrete in all batches represented by the Group of the four consecutive test results shall be deemed not to comply with the strength requirements. This shall include the batches of concrete from which the first and last samples, of the group of four, were taken and all intervening batches.
- 3.14.7 In the event of non-compliance with condition (b) only, then only the particular batch from which the sample was taken shall be deemed not to comply with the strength requirements. If more than one test result in a group of four fails to comply with condition (b) then all of the concrete in all batches represented by the group of the four consecutive results shall be deemed not to comply with the strength requirements.
- 3.14.8 In the event of concrete being deemed not to comply with the strength requirements, the Contractor may be required to remove the concrete and shall take whatever remedial measures, as directed by the Engineer, to sections of the structure affected by the non-complying concrete. The Engineer may, alternatively, in less severe cases, direct that the Contractor retain the concrete carrying out remedial works as directed by the Engineer. Any work to be carried out by the Contractor as a result of non-compliance, shall be done at the Contractor's own expense.
- 3.14.9 The Contractor shall arrange to carry out Quality Control procedures in accordance with BS 1881 and IS EN 206-1:2002.
- 3.14.10 The Contractor shall install a maximum/minimum thermometer in an approved position on site to record air shade temperatures, as follows:-
- The maximum and minimum overnight air temperature each night,
- The air shade temperature at three approved times each day.
- 3.14.11 From each sample of fresh concrete, one specimen shall be tested for workability. The permissible deviation for slump for design mixes shall be $\pm 25\text{mm}$ or plus/minus one third of the specified value, whichever is the greater.
- 3.14.12 Where concrete pavements are machine-laid, the Compacting Factor Test shall be used. The permissible deviation for the compacting factor shall be within plus/minus 0.03 of the specified value.
- 3.14.13 The air content of air-entrained concrete in pavements shall be determined at least 6 times per day. If the air content determined in any test falls outside the limits of 4.5 plus/minus 1.5 per cent, a further test shall be carried out immediately and the average and range of the two results shall be calculated. If the average value falls outside the limit of 4.5 plus/minus 1.5 per cent or if the range exceeds 2 per cent, no further concreting shall take place until the Contractor take steps to adjust the air content of the concrete to the satisfaction of the Engineer.
- 3.14.14 The accuracy of air entrainment agent dispensing equipment shall be checked each day before concrete mixing commences. Where air entrainment is incorporated in concrete, strict control of water content shall be enforced by taking fresh concrete samples from which specimens will be tested for water content. In addition, compacting factor tests shall be carried out on specimens from the same samples.
- 3.14.15 As soon as the Engineer is satisfied with the consistency of test results and a correlation is established between the water content and the compacting factor, the frequency of water content tests may be reduced as directed by the Engineer. The cement content of each batch of concrete shall not be less than the specified minimum value minus 5% of the value, nor more than specified maximum value plus 5% of that value.
- 3.14.16 No traffic whatsoever shall be allowed over any part of the finished concrete or other work until it has set and been properly protected to the satisfaction of the Engineer.

3.15 Records

- 3.15.1 Records shall be kept by the Contractor of the location in the works of each day's output of concrete and of the test cubes, cores, and other specimens taken from it. Copies of these records shall be supplied to the Engineer.

3.16 Admixtures

- 3.16.1 The use of admixtures for damp proofing, waterproofing, hardening, frost proofing, or as workability aids shall only be used where and as directed by the Engineer and then subject to his express permission, and at the Contractor's expense. Where admixtures are allowed by the Engineer, they shall be used strictly in accordance with I.S. EN 480 and I.S. EN 934. The Engineer may request comparative trial mixes, with and without a proposed admixture, to determine the effects of the admixture on concrete properties. The cost of these trial mixes shall be borne by the Contractor.
- 3.16.2 Calcium chloride shall not be added to the concrete directly or in combination with other materials without the consent of the Engineer. The Contractor may at his own expense and, subject to approval by the Engineer, use a plasticiser with whose use he is familiar. It is to be used strictly in accordance with the manufacturer's recommendations.

3.17 Ready-Mix Concrete

- 3.17.1 All ready mix concrete shall be supplied in accordance with I.S. EN 206-1:2002.
- 3.17.2 The Contractor shall submit for approval by the Engineer, the name of the Ready-Mixed Company and details of the proposed supply, prior to the delivery of any concrete to the site.
- 3.17.3 The Contractor shall also ensure that the Ready-Mixed Company can deliver an uninterrupted supply of consistent concrete in order to maintain continuity of concrete placement between approved construction joints.
- 3.17.4 The supplier shall furnish results of previous tests such as will enable the Engineer to be satisfied as to the adequacy of quality control at the concrete supply plant. Complete records of delivery including the suppliers' original docket receipts shall be kept by the Contractor. The cement content of each delivery shall be shown on the docket. The delivery docket should contain (according to IS EN 206-1:2002):-
- 1) Reference of the production plant
 - 2) Serial number of ticket
 - 3) Date and time of loading, i.e., time when all materials enter the mixer/truck
 - 4) Truck number
 - 5) Name of purchasers, if relevant
 - 6) Name and location of site
 - 7) Specified standardized prescribed concrete
 - 8) Specified consistence class
 - 9) Chloride class, if specified
 - 10) Maximum nominal upper aggregate size
 - 11) Any additional specified requirements
 - 12) Declaration of conformity with reference to the specification and to IS EN 206-1:2002
 - 13) Name or mark of the certification body, if relevant.
 - 14) Note: Space should be provided for any additional items.
- 3.17.5 Sampling and testing of the concrete shall be carried out, by the Contractor, at the point of discharge in accordance with the provisions of the specification.
- 3.17.6 The concrete shall be carried in purpose-made agitators, operating continuously, or truck mixers. The concrete shall be compacted and in its final position within two hours of the introduction of cement to the aggregates, unless a longer time is agreed by the Engineer. The time of such introduction shall be recorded on the delivery note together with the weight of the constituents of each mix.
- 3.17.7 Where concrete is transported in non-agitating equipment, discharge shall be completed within one hour after the introduction of cement to the mix. When truck-mixed concrete is used, water shall be added under supervision, either at the site or at the central batching plant, as agreed by the Engineer but in no circumstances shall water be added in transit. Prior to the placement of any concrete on site, the Contractor shall ensure that the concrete mix to be delivered shall comply with the specified mix properties, without the addition of water or any other materials, on delivery to the site.
- 3.17.8 Unless otherwise agreed by the Engineer, truck mixer units and their mixing and discharge performance shall comply with the requirements of BS 1305 and IS EN 206-1:2002 (section 9). The Contractor shall obtain a certificate from the ready-mixed concrete manufacturer to show that all truck mixers have been tested in accordance with BS 3963 and EN 12609:1996 or, in the absence of the manufacturer's instructions, mixing shall continue for not less than 100 revolutions at a rate of not less than 7 revolutions per minute.

3.18 Transport and Placing

- 3.18.1 The method of transporting and placing concrete shall be to the approval of the Engineer. Concrete shall be so transported and placed that contamination, segregation or loss of the constituent materials does not occur.
- 3.18.2 Concrete shall not be placed in any part of the structure until formwork, reinforcement, inserts and water bars, means of mixing, transporting, placing and compaction have all been inspected and approved by the Engineer. Such approval shall be obtained within 24 hours of concreting and sufficient time shall be allowed for the Engineer to make such inspection and order if he considers that alterations should be made. If concreting is not started within 24 hours of approval being given, approval shall again be obtained from the Engineer.
- 3.18.3 No water shall be added to the mix after it has left the mixer. The concrete shall be placed in the positions and sequence indicated on the drawings, in the specification or as directed by the Engineer. It shall be placed so as to avoid segregation of concrete, or displacement of formwork, reinforcement, inserts or water bars. Concrete placement and compaction shall proceed continuously between approved construction joints. Concrete which has partially hardened, has been adversely affected by delay or weather, has become contaminated or segregated, or has fallen outside the section of formwork being filled shall not be used.
- 3.18.4 Fresh concrete shall not be placed against in-situ concrete, which has been in position for more than 30 minutes, unless a construction joint is formed.

- 3.18.5 Suitable precautions shall be taken to ensure that the temperature of the concrete after placing does not fall below 5° C until it has thoroughly hardened. The method of heating the concrete or formwork shall not be such as to cause drying of the concrete. Before placing concrete, all contact surfaces including formwork, reinforcement, adjacent concrete, and the ground shall be free of ice, snow and frost damage.
- 3.18.6 No concreting shall be carried out during cold weather until the shade temperature reaches 1° C on a rising thermometer nor shall concreting be continued on a falling thermometer below shade temperature of 4° C. Special care shall be taken to prevent the temperature of fresh concrete falling below 5° C, when placing against previously cast concrete which is at a lower temperature. A suitable maximum/minimum thermometer shall be installed on site in an appropriate location for this purpose. The concrete temperature shall be measured at the most unfavourable position for the limit in question.
- 3.18.7 Mixing water shall not be heated above 60° C. If it is desired to use water which is heated above 50° C the water shall first be mixed with the aggregate prior to adding the cement.
- 3.18.8 In addition to the above requirements, the concrete shall be protected from frost by covering with suitable insulating material for a period of at least 72 hours where normal Portland Cement - CEM1 is used, or 36 hours where rapid hardening Portland Cement - CEM1 is used. The placing of concrete may be prohibited at any time if in the opinion of the Engineer conditions are unsuitable or the proper precautions are not being taken, and notwithstanding any permission which the Engineer may give, all concrete damaged by frost shall be removed by the Contractor at his own expense, and replaced by sound materials to the satisfaction of the Engineer.
- 3.18.9 In hot weather suitable means shall be provided to shield the aggregate stockpiles from the direct rays of the sun or to cool the aggregates by spraying with water and to insulate the mixing water tank and pipelines to ensure that the temperature of the concrete when deposited shall not exceed 30° C.
- 3.18.10 Except where otherwise agreed by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth not exceeding 450mm, where internal vibrators are used or 300mm in all other cases.
- 3.18.11 Unless otherwise agreed by the Engineer, concrete shall not be dropped into place from a height exceeding 2 metres. When trunking or chutes are used they shall be kept clean and used in such a way as to avoid segregation.

3.19 Compaction of Concrete

- 3.19.1 Concrete shall be thoroughly compacted by vibration, or other means approved by the Engineer, and thoroughly worked around reinforcement, inserts, water bars and corners of formwork to ensure a solid mass free of voids throughout and to achieve the required surface finish. Where vibrators are used for compaction vibration shall be applied continuously during concrete placement and until the expulsion of air has practically ceased and in a manner which avoids segregation. Spare equipment in working order shall always be available on site in the event of breakdowns.
- 3.19.2 Vibration shall not be applied by way of the reinforcement. Where vibrators of the immersion type are used, contact with reinforcement and all inserts shall be avoided, so far as is practicable. Concrete shall not be subjected to vibration after it has been placed 4 hours.
- 3.19.3 Concrete shall be compacted in its final position within 30 minutes of discharge from the mixer unless carried in purpose-made agitators, operating continuously, when the time shall be within 2 hours of the introduction of cement to the mix and within 30 minutes discharge from the agitator.

3.20 Depositing Concrete under Water

- 3.20.1 No concrete shall be deposited under water unless the specific directions of the Engineer have been obtained in writing that the work shall be so undertaken. The cement content of such concrete shall be increased by an amount not less than 25% of the minimum quantities previously specified for the respective grades of concrete. The greatest care shall be taken in depositing the concrete to prevent the separation of the ingredients, and an approved drop bucket or tremie pipe shall be used for this purpose. Concrete shall be deposited continuously once the operation has begun, and the top surface shall be kept as nearly level as possible until the required height has been reached. When concreting is finished, the work shall be carefully covered up and the water shall be prevented from disturbing the concrete until it has been completely hardened.

3.21 Construction Joints

- 3.21.1 The position and detail of any construction joints not described in the contract shall be subject to the approval of the Engineer and shall be so arranged as to minimise the possibility of the occurrence of shrinkage cracks. All vertical construction joints shall be formed with well-braced timber stop ends. The vertical joints shall be in approved positions and such joints shall not be located at or adjacent to corners.
- 3.21.2 In the event of unavoidable stoppage in positions not predetermined, the concrete should be terminated on horizontal places and against vertical surfaces to the Engineer's approval.

- 3.21.3 Concrete placement shall be carried out continuously up to construction joints, the position and arrangement of which shall be as indicated on the drawings or approved by the Engineer. Immediately prior to re-commencement of concreting at a joint, the joint surface shall be cleaned of all loose matter, and then wetted and coated with a layer of cement grout. Care shall be taken to ensure that the concrete adjacent to joints is adequately compacted.

- 3.21.4 Before concreting against any temporarily stopped work or construction joints the procedure shall be as follows:-

(a) Bonding to Concrete 30 Minutes – 4 Hour Old

The surface of the hardening concrete shall be wetted with a fine soft spray. At the same time the surface shall be gently brushed with a soft brush to remove the cement film from the coarse aggregate without disturbing the hardening concrete. The prepared surface shall be lightly coated with a neat cement grout immediately before any subsequent concrete is cast. The first two batches out of a clean mixer shall not be used against existing work. Alternatively the surface layer shall be struck off and lightly coated with neat cement grout immediately before the fresh concrete is poured.

(b) Bonding to Concrete – Over 4 Hours Old

The surface shall be roughened by brushing or chipping to remove laitance and expose the aggregate. The roughened surface shall be washed with clean water to remove loose particles.

- 3.21.5 In structural concrete for retaining aqueous liquids, waterbars shall be incorporated at construction joints, unless otherwise approved by the Engineer. In walls approved heavy-duty waterbars 230mm in depth shall be centrally placed. For floors and roofs all construction joints in water retaining structures shall incorporate an approved externally placed water bar again of heavy duty and 240mm in depth. Precautions shall be taken to prevent rust staining during construction, caused by reinforcement projecting through construction joints.

3.22 Sealants for Joints in Concrete

- 3.22.1 Proprietary materials shall be used for making joints in concrete and are to be obtained from an approved manufacturer.
- 3.22.2 Hot applied sealing compounds shall comply with BS 2499 and I.S. EN 14188. Polysulphide type sealing compounds shall comply with IS EN 11600:2004.
- 3.22.3 All jointing materials shall be used strictly in accordance with the manufacturer's instructions. Junctions in water stops shall be factory-made where possible.

3.23 Curing of Concrete

- 3.23.1 Immediately after compaction and for 7 days thereafter, concrete shall be protected from the harmful effects of weather, water shock or any other agents which could cause distortion, efflorescence, cracking or deleteriously affect the strength and durability of the concrete. The methods of protection required shall be applied as soon as possible after placement and shall be of such duration as shall be specified, or directed by the Engineer in order that the concrete shall have attained the necessary properties to resist damage before removal of the protection system. Care shall be taken to ensure that components intended to have a similar exposed surface finish are cured under the same conditions.
- 3.23.2 Concrete shall be kept damp for a minimum period of 7 days during which the temperature of the concrete shall be maintained at not less than 5 °C. To maintain the concrete at the required temperature, adequate insulating material and windbreaks shall be provided. Alternatively when elevated-temperature curing is used, 4 hours must elapse from the completion of the placing of the concrete before its temperature is raised. The rise in temperature within any period of 30 minutes shall not exceed 10 °C and the maximum temperature attained shall not exceed 70°C. The rate of subsequent cooling shall not exceed the rate of heating.
- 3.23.3 The method of curing shall minimise the loss of moisture from the concrete. To keep the concrete damp an impermeable membrane, such as polythene to be approved by the Engineer, may be used to cover concrete. Care shall be taken to avoid cold water being applied to curing concrete surfaces, particularly in the case of thick concrete sections. Particular care shall be taken to prevent rapid drying out of concrete in thick sections. On concrete surfaces, which are to be waterproofed, curing membranes shall not be used. Details of all curing methods to be used shall be subject to the approval of the Engineer. Concrete shall not be subject to any traffic within 7 days of placement, unless otherwise approved. Members shall not be loaded before 28 days after casting, unless otherwise approved by the Engineer.

3.24 Early Loading

- 3.24.1 Concrete shall at no time be subjected to loading, including its own mass, which will induce a compressive strength in it exceeding 0.33 of its compressive strength at the time of loading or of the specified 28 day strength. For the purposes of this clause the assessment of the strength of the concrete and the stresses produced by the loads shall be subject to the approval of the Engineer.

3.25 Temporary Supports During Construction

- 3.25.1 The Contractor shall be responsible for ensuring the temporary stability of all work, including both in-situ and precast, during construction. Temporary supports shall take account of all construction loads, including wind, likely to occur between erection and the achievement of the final structural form. The arrangement of temporary supports shall be submitted for approval by the Engineer but such approval, if given, shall in no way remove responsibility for the temporary works from the Contractor. No temporary support shall be removed until requisite strength of the member and its connection has been achieved.
- 3.25.2 Work in existing buildings or near adjacent buildings or pavements and in particular excavations for foundations adjacent to existing buildings or pavements shall be carried out in such manner as will not endanger these existing buildings or pavements.
- 3.25.3 The Contractor's attention is drawn to the fact that he should comply with all relevant safety regulations in relation to temporary works, scaffold etc.

3.26 Formwork – General

- 3.26.1 Rough finish shuttering shall consist of boards sawn from good sound timber free from defects, sheet metal or any other suitable material, which will prevent the loss of grout when the concrete is vibrated.
- 3.26.2 Fair finish formwork shall be faced with wrought or thickened boards with square edges arranged in a uniform pattern. Plywood or metal panels may be used provided they are free from defects likely to detract from the general appearance of the finished surface and provided the plywood is resin bonded. Joints between boards and panels shall be horizontal and vertical unless otherwise directed.

3.27 Formwork – Construction

- 3.27.1 Formwork shall include all temporary or permanent forms required for forming the concrete, together with all temporary construction required for their support. Formwork shall be designed and constructed so that concrete can be properly placed and thoroughly compacted, to ensure that all concrete elements shall be constructed within the limits of Table 1 and Table 2, of BS 5606:1990, Code of Practice for accuracy in buildings.
- 3.27.2 Formwork shall be firmly supported and adequately strutted, braced or tied. It shall be capable of adjustment to the lines and dimensions of the finished concrete, and it shall be sufficiently strong to resist, without excessive distortion, the pressure of concrete during its placing and compaction, and other loads to which it may be subjected. It shall not be liable to suffer distortion under the influence of the weather. After hardening the concrete shall be in the position and of the shape, dimensions and surface finished described by the contract.
- 3.27.3 Where internal metal ties are permitted, they or their removable parts shall be extracted without damage to the concrete and the remaining holes filled with mortar. No permanently embedded metal part shall have less than 40mm cover to the finished concrete surface or the specified cover to the reinforcement whichever is the greater. The material and position of any ties passing through the concrete shall be to the Engineer's approval. Unless otherwise approved, it shall be possible to remove a tie so that no part of it remaining embedded in the concrete shall be nearer to the finished surface of the concrete than the specified thickness of the cover to the reinforcement. Any holes left after the removal of ties shall be filled with concrete or mortar of approved composition and neatly trowelled to give the desired fair finish.
- 3.27.4 The Contractor shall make allowances for any settlement or deflection of the formwork that is likely to arise during construction so that the hardened concrete conforms accurately to the specified line and level. The Contractor shall also make allowance in the formwork for any camber specified by the Engineer.
- 3.27.5 Formwork shall be constructed so that it can be removed from the sides of the members without disturbing the soffit formwork or its supports. Props and supports shall be designed to allow the formwork to be adjusted accurately to line and level and to be erected and removed in an approved sequence without injury to the concrete. Re-propping shall not be permitted.
- 3.27.6 All joints in formwork shall be closefitting to prevent leakage of grout from the concrete. At construction joints formwork shall be tightly secured against previously cast or hardened concrete to prevent the formation of stepping or ridges in the concrete.
- 3.27.7 Formwork shall be constructed to provide straight and true angles, arises or edges. Where chamfers are shown on the drawings, the fillets shall be accurately cut to size to provide a smooth and continuous chamfer.
- 3.27.8 Formwork panels shall have true edges to permit accurate alignment at sides and provide a clean line at construction joints in the concrete. Formwork panels shall be fixed with their joints either vertical or horizontal, unless otherwise specified.

3.28 Formed Surfaces – Classes of Finish

- 3.28.1 The requirements extra to the above to provide the finish described in the contract shall be:

Class F1	This finish is to be used for surfaces which backfill will be placed. Formwork shall consist of sawn boards, sheet metal or any other material, which will prevent the loss of material from the concrete when it is vibrated.
Class F2	This finish is to be used for exposed surfaces, but where appearance is not critical. Formwork shall consist of high quality fair finish formwork. This finish shall be such as to require no general filling or surface pitting, but fins, surface discolouration and other minor defects shall be remedied by methods approved by the Engineer.
Class F3	This finish is to be used for surfaces prominently exposed to view where good appearance and alignment are of special importance. Formwork shall be high quality formwork faced with resin-bonded plywood or metal panels, free from defects, in large sheets. Joints between sheets shall be arranged to coincide with architectural features wherever possible, and shall be vertical and horizontal unless otherwise directed by the Engineer. After removal of the formwork the Contractor shall make good any imperfections in the finish as required by the Engineer. Internal ties and embedded metal parts will not be allowed. The decision of the Engineer as to what constitutes finish to Class F3 is final and without appeal and any concrete failing to produce fair finish will be rejected.
Class F4	The requirements for Class F4 are for Class F3 except that internal ties and embedded metal parts will be permitted. The ties shall be positioned only in rebates or in other positions as described in the contract or as agreed by the Engineer.
Permanently exposed concrete surfaces to Class F4, F3 and F2 finish shall be protected from rust marks and stains of all kinds.	

- 3.28.2 Unless otherwise described in the contract, all formwork joints for exposed surfaces of concrete to Class F2, F3 and F4 finish shall form a regular pattern with horizontal and vertical lines continuous throughout each structure and all construction joints shall coincide with these horizontal or vertical lines.

3.29 Preparation of Formwork

- 3.29.1 The inside surface of forms shall, except for permanent formwork or unless otherwise agreed by the Engineer, be coated with a release agent approved by the Engineer. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not come into contact with the reinforcement or pre-stressing tendons and anchorages. Different release agents shall not be used in formwork to concrete, which will be visible in the finished works.
- 3.29.2 Immediately before concreting, all forms shall be thoroughly cleaned out. All rubbish, chippings, shavings, sawdust and dirt shall be removed from the interior of the formwork, before concrete is placed. The formwork to be in contact with the concrete shall be cleaned and either thoroughly wetted or treated with a suitable mould oil or approved composition. Care shall be taken that oil or composition is kept from contact with the reinforcement or with concrete at any construction joints. Retarding Agents shall not be used except with the permission of the Engineer expressly given in writing. Formwork shall be thoroughly cleaned after each use. Damaged or distorted formwork shall not be used.

3.30 Removal of Formwork

- 3.30.1 The Engineer shall be informed in advance when the Contractor intends to strike any formwork. All formwork shall be removed without shock or vibration that might damage the concrete. Before the soffit and props are removed, the surface of the concrete shall be exposed where necessary, in order to ensure that the concrete has hardened sufficiently. In no circumstances shall the formwork be struck until the concrete reaches a cube strength of at least twice the stress to which the concrete may be subject at the time of striking.
- 3.30.2 The time at which the formwork is struck shall be the Contractor's responsibility. In general, unless otherwise specified by the Engineer, the minimum period for retaining formwork in position, shall be as listed in Table 4.14 following:-

Formwork Element	Temperature	
	Above 7°C	Above 16°C
Vertical formwork to columns, walls and beams	18 Hours	12 Hours
Soffit forms to slabs	6 Days	4 Days
Props to slabs	15 Days	10 Days
Soffit forms to beams	15 Days	10 Days
Props to beams	21 Days	14 Days

Table 4.14 – Formwork retention times

- 3.30.3 For the purpose of the above table, the temperature shall be the surface temperature of the concrete. Days during which the concrete surface temperature falls below 3 °C shall not be taken into account in the above table. For each day, during which the concrete surface temperature is generally between 3 °C and 7°C a half of a day shall be added to the period listed in the above table. Where lintels or other precast concrete members, depending on composite action, are incorporated, props shall be used and kept in position, until the construction above has reached adequate strength as approved by the Engineer. Should the Contractor wish to strike the shutters earlier than the times mentioned in the above table, he will be required to confirm by means of 3 Cube Tests, that the concrete has attained a minimum strength agreed with the Engineer.
- 3.30.4 Formwork shall be constructed so that the side forms of members can be removed without disturbing the soffit forms and, if props are to be left in place when the soffit forms are removed, these props shall not be disturbed during the striking.
- 3.30.5 The Contractor shall be responsible for any injury to the concrete work and for damage caused by, or arising from the removal and striking of the forms and supports. Any advice, permission or approval given by the Engineer, relative to the removal and striking of forms and supports, shall not relieve the Contractor from responsibility.

3.31 Unformed Surfaces – Classes of Finish

- 3.31.1 Unformed surfaces shall be of the following form;

Class U1	This is a screeded finish for surfaces of roads or of foundations, bed, slabs and structural members to be covered by backfill, subsequent stages of construction, bonded concrete topping or cement mortar beds to receive pavings, and on exposed surfaces of paving where a superior finish is not required. The finishing operations shall consist of levelling and screeding the concrete to produce a uniform, plain or ridged surface, surplus concrete being struck off by a straight edge immediately after compaction. No further work shall be applied to the surface unless it is used as the first stage of a Clause U2 or Clause U3 finish.
Class U2	This is a floated finish for surfaces of beds and slabs to receive mastic pavings or block or tile pavings bedded in mastic, and for exposed surfaces of pavings bedded in mastic, and for exposed surfaces of pavings where a hard smooth steel-trowelled surface is not required. Floating shall be done only after the concrete has hardened sufficiently, and may be by hand or machine. Care shall be taken that the concrete is worked no more than is necessary to produce a uniform surface free from screed marks.
Class U3	This is a hard, smooth steel-trowelled finish for surfaces of concrete paving, tops of walls, copings and other members exposed to weathering, surfaces of beds and slabs to receive thin flexible sheet, tile pavings bedded in adhesive, and seatings for bearing plates and the like where the metal is in direct contact with the concrete. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked to the surface. The surfaces shall be trowelled under firm pressure and left free from trowel marks.

- 3.31.2 In addition, surface finish, which is to receive deck waterproofing, shall be to an accuracy such that when tested with a 3m straightedge, the maximum depression shall not exceed 10mm.
- 3.31.3 Any remedial treatment to surfaces shall be agreed with the Engineer following inspection immediately after removing the formwork and shall be carried out without delay.
- 3.31.4 Any concrete, the surface of which has been treated before being inspected by the Engineer, shall be liable to rejection.

3.32 Remedial Treatment of Surfaces

- 3.32.1 Where, in the opinion of the Engineer, the Contractor has failed to achieve the specified standard of finish, the concrete shall be removed, or such surface treatment as the Engineer considers necessary shall be carried out immediately. Plastering will not be allowed.
- 3.32.2 'Rubbing-up' of minor imperfections on surfaces shall be done using an approved mixture of neat White/Normal Portland Cement - CEM1.

3.33 Steel Reinforcement

- 3.33.1 Rolled steel bars, cold twisted bars, hard drawn steel wire and high tensile fabric reinforcement shall comply with the requirements of BS 4449:2005, BS 4482:2005 and BS 4483:2005 respectively. The Contractor shall on request supply a signed certificate from the manufacturer that each consignment of steel complies with relevant specification. The Contractor shall deliver free of charge, samples of the various reinforcements, for testing as directed. Any consignment of reinforcement failing to comply with the tests shall be removed from the site.
- 3.33.2 All steel shall be free from oil, grease, dirt and paint and all loose rust and mill scale shall be carefully removed before use. It shall be stored clear of the ground on a clean site with adequate protection to prevent deterioration.
- 3.33.3 The sizes and other dimensions of the reinforcement shall be checked against the drawings and site dimensions before the material is ordered. No alternative or substitution shall be made in the lengths, sizes or arrangement of the reinforcement, without the prior written approval of the Engineer. The reinforcement shall be cut cold, bent to the dimensions shown on the drawings and schedules, or to such other dimensions as may be directed, all in accordance with BS 8666:2005 and I.S. EN ISO 3766:2004.
- 3.33.4 Steel fabric reinforcement shall be welded at the intersections and unless otherwise required by the Contract, shall be delivered to the site in flat sheets.

3.34 Bending of Reinforcement

- 3.34.1 Reinforcement shall be bent to the dimensions given in the Bar Schedules. All reinforcement shall be bent at temperatures in the range of 5°C to 100°C. Heating of reinforcement will not be permitted without the Engineer's approval.
- 3.34.2 If the Contractor wishes and intends to bend reinforcement off site, this will be permitted provided he keeps and maintains a small stock of various sizes of steel bars and the necessary bending machines on site to carry out any minor alterations or additions to the reinforcement which may be required at a later stage.
- 3.34.3 Cold worked bars and hot rolled high yield bars shall not be straightened or bent again once having been bent. Where it is necessary to bend mild steel reinforcement projecting from the concrete, the internal radius of bend shall be not less than twice the diameter of the bar.

3.35 Placing Reinforcement

- 3.35.1 The number, size, form and position of all reinforcement shall be in accordance with the contract. It shall be secured in an approved manner so as to withstand, without displacement, the placing and compaction of the concrete. Where reinforcing bars project from the concrete, precautions shall be taken to prevent the bars from being struck or jarred in such a way as to impair the bond between the steel and concrete.
- 3.35.2 Unless otherwise permitted by the Engineer, all bar intersections shall be tied together and ends of the tying wire shall be turned into the main body of the concrete. 1.2mm diameter stainless steel wire shall be used for in-situ members having exposed soffits. 1.6mm diameter soft annealed iron wire shall be used elsewhere. No splices shall be made in the reinforcement except where described in the concrete or where approved by the Engineer. Support chairs for top mat reinforcement shall be designed by the Contractor and approved by the Engineer.
- 3.35.3 Cover blocks and spacers shall be designed to maintain the correct clear cover of concrete over steel reinforcement, shall be as small as possible consistent with their purpose, and of a shape acceptable to the Engineer. Concrete cover blocks shall be manufacturer with a 10mm maximum aggregate size and otherwise produced to the same specification as the surrounding concrete. Wire cast in the block for the purpose of tying it to the reinforcement shall comply with BS 4482:2005. Spacers shall be of rustproof material and shall not produce staining, or otherwise be detrimental to the concrete or steel.

3.35.4 Concrete shall not be placed until reinforcement has been checked and approved by the Engineer. Such approval shall not, however, absolve the Contractor from his liability if bars are found subsequently to be placed otherwise than as shown on the drawings.

3.35.5 No alterations or substitution shall be made in the lengths, sizes or arrangement of the reinforcement without the prior written approval of the Engineer.

3.36 Welding of Reinforcement

3.36.1 Reinforcement in structures shall not be welded except where permitted in the contract. All welding procedures shall be subject to the prior approval of the Engineer in writing.

3.37 Precast Concrete

3.37.1 All precast concrete units shall be manufactured to comply with BS 8110-1:1997 and shall be cast in strong, rigid moulds, clean, wetted before concreting and with fillets fixed to the angles to give chamfered arises as necessary. Moulds shall not be removed until the concrete is sufficiently hard to permit this being done without detriment. The concrete shall be as specified for the particular section. The concrete shall be kept wet for seven days by means of sacking covers or other approved means. No cracked, spalled, crooked or otherwise defective units shall be used.

3.38 Waterproof Paper

3.38.1 Waterproof paper shall be Grade B1F complying with the relevant provisions of BS 1521:1997.

3.39 Grouting

3.39.1 Grouting up supports to mechanical equipment or in any other position as necessary shall be carried out with 3:1 mortar, or as otherwise directed to the satisfaction of the Engineer. The grout shall be worked well into all recesses and corners and all air forced out and, when directed, the surface of the concrete shall be first hacked over and cleaned.

3.40 Non-Structural Concrete Screeds

3.40.1 Unless otherwise noted in this specification, screeds shall comply with BS 8204. Concrete screeds shall be laid flat or to the falls indicated on the drawings.

3.40.2 Separate bonded screeds shall be a minimum of 40mm thick laid on a roughened, cleaned, damped and grouted surface. Separate unbonded screeds shall be a minimum of 65mm thick and shall incorporate mesh wire netting of mesh size 31 to 50mm in accordance with I.S. EN 10223-2, zinc coated hexagonal steel wire netting.

3.40.3 Screed mixes shall comprise 1 part cement, 1.50 parts sand to 3 parts coarse aggregate (max size 10mm). Screeds shall be placed semi-dry with only sufficient water to permit thorough compaction. Where the thickness of screed exceeds 40mm it shall be laid in two courses, each at least 20mm thick but with the first course thicker than the second course. The second course shall be placed immediately after compaction of the first course.

3.40.4 Screeds shall be cured using polythene sheeting for at least 1 week and thereafter shall be protected from traffic by covering with planks etc., until ready to lay the floor finish.

3.41 Sample Panels

3.41.1 The Contractor shall be required before construction of Reinforced Concrete Structures commences, to construct sample panels of walling to the size of the concrete pours proposed by him and no permanent construction shall begin until the Engineer has given his approval to such samples of work.

3.42 Tolerances

3.42.1 The setting out and dimensions of the finished work, unless otherwise shown on the drawing or specified, shall be within the permissible tolerances given hereafter and the Contractor will be held responsible for the cost of all corrective measures required by the Engineer to rectify work which is not constructed within these specified tolerances.

3.42.2 Except where specially noted, dimensions, levels, sizes, positions and covers are to be exactly dimensioned or specified with the following tolerances:

- (a) Concrete cover around reinforcement +/- 5mm, except for slabs where the tolerances shall be +/- 3mm.
- (b) For sizes of beams, columns and slab or wall thickness not less than dimensioned and not more than 10mm greater.
- (c) For setting out positions or dimensions, horizontal or vertical +/- 6mm.
- (d) Levels of floors, ceiling, beams, lintels etc., (top and bottom) +/-6mm overall, but no surface line intended to be horizontal must slope more than +/- 3mm under a 3 metre straight edge.
- (e) Errors of plumb, not more than +/- 6mm overall and no surface intended to be vertical shall slope more than 6mm in 3 metres.

3.43 Fixing Blocks Etc

- 3.43.1 The Contractor shall be responsible for co-ordinating with sub-contractors for incorporating any electrical conduit, fixing blocks, chases or holes require in concrete members and he shall ensure that these requirements have been approved by the Engineer before work commences. Structural concrete shall not be cut without the Engineers approval.

3.44 Testing Water Retaining Structures

- 3.44.1 Not less than 28 days after all concrete shall have been placed, water-retaining structures shall be filled with water in a manner to be approved by the Engineer. After allowing a period of three days or such other period as the Engineer may decide, for absorption, the water level shall be recorded by a hook gauge with vernier attachment or by other approved means, and the water shall be allowed to stand for a period of seven days, during which 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 less. Any leak showing or occurring in the tanks shall be sealed to the satisfaction of the Engineer, at the Contractor's expense. The tests shall be made before any earth banking is placed to the outside of the walls.
- 3.44.2 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 cracks in the wall section shall, where practicable, be carried out from the inside face.

3.45 Cleaning of Water Retaining Structures

- 3.45.1 On completion of construction and before any sterilisation, internal surfaces of structures designed to retain an aqueous liquid shall be cleaned thoroughly in such a way as to remove all oil, grit and other deleterious matter.

3.46 Testing of Roofs

- 3.46.1 Roofs shall be watertight and shall, where practicable, be tested on completion by lagooning with water to a minimum depth of 25mm for a period of 24 hours.
- 3.46.2 Where it is impracticable, because of roof falls or otherwise, to contain 25mm depth of water, the roof shall be thoroughly wetted by continuous hosing for a period of not less than six hours.
- 3.46.3 In either case, the roof shall be regarded as satisfactory if no leaks or damp patches show in the soffit.
- 3.46.4 The roof covering shall be completed as soon as possible after testing.

3.47 Sterilisation of Structures for Potable Water

- 3.47.1 Immediately before acceptance of any structure for potable water, hypochlorite solution shall be distributed over the floor so as to give a uniform concentration of not less than 20 mg/l of free chlorine in 300mm depth of water. This solution shall then be used to spray the roof soffit, walls and columns, ensuring that the whole of the expose area is covered. The solution shall then be run to waste and the structure flushed with potable water.

5 STRUCTURAL STEELWORK SPECIFICATION

5.1 Materials

- 5.1.1 Structural steelwork shall comply in all respects with BS 5950 and implicitly with all standards called up therein except as modified by this Specification.
- 5.1.2 The recommendations and guidance stipulated in BS 5531:1988 Code of Practice for safety in erecting Structural Frames, shall be complied with at all stages of design, fabrication and erection.

5.2 Mild Steel

- 5.2.1 Mild Steel shall comply with IS EN 10025 Grade 43A for plates, sections, flats up to 10mm thick and Grade 43C for plates and sections over 10mm thick and for tubes 0 and hollow sections. All steel shall have a Charpy impact value at 0C of not less than 27 J.

5.3 High Tensile Steel

- 5.3.1 High tensile steel shall comply with IS EN 10025 Grade 50B for plates, sections, flats and tubes up to 10mm thick and Grade 50C for plates and sections over 10mm thick. All steel shall have a Charpy impact value at 0C of not less than 27 oJ.

5.4 Cold Rolled Steel

- 5.4.1 Cold rolled steel sections shall comply with IS EN 10162:2003 formed from materials conforming to IS EN 10132-1/-4:2000, IS EN 10151:2002.

5.5 Dimensions, Weights and Tolerances

- 5.5.1 The dimensions, form, weight and tolerances of hot rolled beams, columns, joists, channels and tee bars shall comply with BS 4 Part 1, equal and unequal angles with BS EN 10056-1:1999 and hollow sections with BS EN 10210-2:2006.

5.6 Marking of Steel Grade

- 5.6.1 In addition to ring mark, steels of Grade 50B and 50C shall be marked with a continuous pale blue paint line in accordance with IS EN 10025-1 /-2.

5.7 Bolts, Screws and Nuts

- 5.7.1 Unless otherwise shown on the drawings, all materials shall be as specified under Section 2 of this Specification.

5.8 Screwed and Bolted Fastenings

- 5.8.1 Screw threads - screw threads on all bolts, nuts and similar screwed pieces shall be ISO metric threads in compliance with BS 3643.
- 5.8.2 Blackbolts - the selection of black bolts, screws and nuts from 5 to 68mm diameter shall be based on BS 4190.
- 5.8.3 Precision bolts and nuts shall comply with the requirements of BS 3692.
- 5.8.4 Machine screws - machine screws and nuts from 1 to 20mm diameter shall comply with BS 4183, IS EN ISO 1580 and IS EN ISO 7045.
- 5.8.5 Pipe threads - steel tubes shall be screwed BSP to accord with IS EN ISO 228-1&2 (or BS 21A & IS EN 10226-1 for "pressure tight" screwed joints).
- 5.8.6 HSFG Bolting - the use of high strength friction grip bolts shall be limited to the load indicating type. The bolts, nuts and washers shall be in compliance with BS 4395:Part 1 and BS EN 14399 Parts 1 to 6, general grade (metric sizes). They shall be used in accordance with the manufacturer's instructions/recommendations. N.B. If for any reason a nut or bolt is slackened off after full tightening, the bolt, nut and washer(s) shall be discarded and never used again.
- 5.8.7 Bolt length - the protrusion of the screwed end of a bolt through the nut shall not be excessive. The shortest possible standard bolt shall be selected for each bolt position consistent with a length which allows not less than one full thread to protrude through the nut. This principle shall also apply to similar screwed pieces such as studs, tubes etc. (excluding tension screws).

- 5.8.8 Rag bolts and nuts shall conform to BS 1494.
- 5.8.9 Bolt Holes, etc. - bolt and rivet holes in all steelwork shall be drilled, none shall be flame cut. Non-structural platework may be punched.
- 5.8.10 Washers - plain tapered washers other than for use with HSFG bolts, shall comply with the requirements for BS 5950 and BS 4320.
- 5.8.11 Countersunk bolts - where countersunk bolts are required, the socket head type shall be employed.
- 5.8.12 Black bolts, screws, nuts and washers shall be galvanised to IS EN ISO 1461 Part 1, where they are to be used in galvanised metalwork.
- 5.8.13 Holding down bolts - holding down bolts shall conform BS 4190 strength Grade 4.6, coarse pitch series.
- 5.8.14 Locks nuts shall be thin nuts to BS 4190 Grade 4.
- 5.8.15 Bolts for movement joints shall be purpose made shoulder bolts to BS 3692, Grade 8.8 and sized to suit the movement and fitted with spring and round washers.

5.9 Surface Defects

- 5.9.1 Surface defects shall be assessed as per the relevant specification: BS 7668:2004, IS EN 10210-1&2, IS EN 10029:1991, Parts 1-3 of IS EN 10113, IS EN 10025-1&5&6.

5.10 Shop Details

- 5.10.1 Two copies of all shop details shall be submitted to the Engineer for approval. No fabrication shall commence until all shop details have been approved by the Engineer. Shop details shall conform to the general arrangement drawings and this Specification.
- 5.10.2 The Engineer will verify the correct interpretation of his requirements, but will not verify dimensions and the Contractor shall be entirely responsible for the accuracy of the drawings, the correctness of details of all members, connections and joints. Approval of the drawings shall in no way relieve the Contractor of his responsibilities for the work under the Contract.

5.11 Design

- 5.11.1 The design of all steelwork details shall comply with the requirements of BS 5950: 1990 and BS EN 1993-1-3/-1-5:2006,

5.12 Fabrication

- 5.12.1 All fabrication shall comply with BS 5950-2:2001.
- 5.12.2 As much as possible of the work shall be fabricated in the Contractor's works.
- 5.12.3 The steelwork shall be fabricated so that the dimensions required on completion of erection are obtained.

5.13 Shop Preparation

- 5.13.1 Rolled material before being worked, shall be straight. If straightening is necessary, it shall be done by methods approved by the Engineer. Sharp kinks and bends may be cause for rejection of the material. Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture.
- 5.13.2 Cuts shall be neatly sawn, sheared, cropped or gas cut by machine. Undercut gusset plates will not be accepted. Shearer plates shall be flattened.
- 5.13.3 Holes through more than one thickness of material for members such as compound stanchion and girder flanges shall, where possible, be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, provided the holes are punched 3mm less in diameter than the required size and reamed after assembly to the full diameter. The thickness of material punched shall not be greater than 16mm. When holes are drilled in one operation through two or more separable parts, these parts, when so specified by the Engineer, shall be separated after drilling and the burrs removed.
- 5.13.4 Holes in connecting angles and plates, other than splices in roof members and light framing, may be punched full size through material not over 13mm thick, except where required for close tolerance of barrel bolts. All matching holes for rivets and black bolts shall register with each other so that a gauge 1.5mm less in diameter than the diameter of hole will pass freely through the assembled members in a direction at right angles to such members. Finished holes shall not be more than 1.5mm in diameter larger than the diameter of the rivet or black bolt passing through them, unless otherwise specified. Gas blown holes are prohibited.

5.14 Shearing, Milling and Ending

- 5.14.1 The ends of stanchion bases shall be machined to a flat uniform surface and shall be connected to base plate by fillet welds designed to transmit the whole load in the stanchion.
- 5.14.2 Where indicated on the drawings the ends of stanchions and compression members, shall be machined to a uniformly flat surface at right angles to the axis or such other angle as might be indicated. This machining shall be carried out with the angle cleats and gusset on the end of the shaft fixed in their permanent position.
- 5.14.3 Where a load is transmitted by a direct bearing, column base plates, cap plates and splice division plates shall be machined to a uniformly flat surface so that the permitted stress in bearing is not exceeded nor eccentricity of loading created.
- 5.14.4 The edge of slab bases and the underside when bearing on concrete need not be machined, if such face is true and parallel to the upper face.
- 5.14.5 Except where otherwise indicated on the drawings web stiffener angles and other stiffener angles intended as supports for concentrated loads shall be milled, ground or welded to secure an even bearing against the flange angles.
- 5.14.6 To facilitate grouting, holes shall be provided where necessary to column bases for the escape of air.

5.15 Welding General

- 5.15.1 All welding of steel to BS 7668:2004, BS EN 10029:1991, BS EN 10025-1:2004, BS EN 10025-3:2004, BS EN 10025-4:2004, BS EN 10210-1:2006 shall comply with BS 5950 and IS EN 12334 unless specified otherwise.

5.16 Welding Procedures

- 5.16.1 The temperature of steels welded in accordance with IS EN 1011-1&2 shall not be 0 less than 5 C when welding is commenced.
- 5.16.2 Electrodes and fluxes shall be used strictly in accordance with the manufacturer's instructions, and shall be so chosen that the properties of the deposited metal are not inferior to those of the parent metal.
- 5.16.3 Procedure for welding including programme for shop welds, particulars of the preparation of fusion faces, the method of pre-heating where required, the method of making the welds, the type of electrodes to be used and the workforce to be employed, shall be submitted to the Engineer for his approval 14 days before the work is put in hand. No departure from the agreed welding procedure or from the details shown on the Drawings shall be made without the permission of the Engineer.
- 5.16.4 Particular consideration shall be given to the size and type of electrode used for welds made under restraint.
- 5.16.5 The welding sequence and procedure shall be so arranged that distortion is reduced to a minimum. Due allowance shall be made for contraction in the lengths of members. The welding sequence shall be such that welds are made under the least possible restraint with the necessity to reduce or prevent distortion.
- 5.16.6 Special care shall be taken to remove slag from weld and weld spatter from surrounding surfaces.
- 5.16.7 Weld reinforcement of all joints shall present a neat and even convex surface and comply with IS EN 970.

5.17 Butt Welds

- 5.17.1 Run on and run off plates shall be used for all butt welds to ensure full throat thickness at ends of welds. The materials and preparation of the plates shall be identical to the material being welded. After welding the plates shall be removed and the surface of the joined parts where the plates were attached ground smooth. The plates shall be retained and identified for inspection.

5.18 Welding and Flame Cutting Procedure Trials

- 5.18.1 Where directed by the Engineer and before fabrication is commenced, welding and flame cutting procedure trials shall be carried out using representative samples of material to be used in the Works.

5.19 Qualification and Testing of Welders

- 5.19.1 Evidence shall be supplied of the welder's competence to undertake the specified work. Welders shall have been tested to BS 4872 Part 1 using the same electrodes and welding positions which will be used in the work. The Engineer may require any welder to perform test welds under conditions specified by the Engineer before approving his employment as a welder.

5.20 Supervision of Welding

- 5.20.1 Welding shall be carried out only under the direction of a qualified, experienced and competent Supervisor. A record shall be kept to enable major butt welds to be identified with the welders responsible for the work. Finished work shall not be marked by hard stamping for this purpose.

5.21 Welding Plant

- 5.21.1 The welding plant shall be capable of maintaining at the weld the voltage and current recommended by the manufacturer of the electrodes. When required by the Engineer the Contractor shall provide instruments to verify the characteristics of the welding equipment.

5.22 Bolting

- 5.22.1 Bolting shall comply with BS 5950 and BS EN 1993-1-3/-1-5:2006 unless otherwise specified. Holes shall be drilled to the correct clearance sizes and not distorted or enlarged to obtain a fit.
- 5.22.2 Bolted connections shall include washers under the nuts of such thickness that the thread is clear of the parent hole. The bolt shall project beyond the nut at least 3mm. Tapered washers shall be used to give a true bearing on all sloping surfaces.
- 5.22.3 The holes for turned bolts shall be reamed and the holes shall be finished to provide a driving fit.
- 5.22.4 Where a tubular member is drilled to take bolts or studs, provision shall be made to prevent the access of moisture to the interior of the tube. Either a transverse sleeve where a bolt passes through a tube or grommets shall be used under the heads and nuts.
- 5.22.5 Where holes are mis-aligned, these may be reamed for a larger size bolt only on the express permission of the Engineer.
- 5.22.6 Washers of the correct size flat or tapered as required shall be placed under all nuts and under the heads of bolts connecting metal sections.
- 5.22.7 Hand wrenches shall have a length not greater than 18 times diameter of bolt to be fixed. Power tools shall be carefully regulated to ensure that bolts and nuts are not overstressed.
- 5.22.8 The threaded portion of each bolt shall project through the nut at least one thread and not more than five.
- 5.22.9 Close tolerance or turned bolts shall be of sufficient length to avoid any threaded portion being within the thickness of the connected parts.

5.23 Nuts

- 5.23.1 Nuts shall be used in combination with the correct strength grade bolts as recommended in the relevant British Standards.

5.24 Bolt and Nut Protective Coatings

- 5.24.1 Where any bolts, screws, nuts and washers are used to connect any galvanised metalwork, they shall have adequate clearance on the threads and they shall be spun galvanised to IS EN ISO 1461 with a minimum average coating weight of 305 g/m². All stages of galvanising of fasteners are to be controlled by the manufacturer of the components. All bolts Grade 8.8 HSFG bolts and accessories shall be stress relieved before galvanising. Nuts will be retapped after galvanising to give the correct clearance without detriment to the fit of nuts on bolts. The threads of the nuts shall be oiled after tapping and cleaning. Where any such bolts, screws, nuts, washers etc. are to be subsequently painted, they shall be treated with a phosphate passivator prior to painting.

5.25 High Strength Friction Grip (HSFG) Bolts, Nuts and Washers

- 5.25.1 HSFG bolts, nuts and washers shall conform to the requirements of Clause 9.8 of this Specification.
- 5.25.2 Torque spanners or part turn methods shall not be used.
- 5.25.3 HSFG bolt connections shall be designed using a slip factor of 0.45 on the faying surface. The Contractor shall provide proof that a slip factor of 0.45 can be achieved using bolts as proposed in accordance with BS 4604 Part 1, Appendix A.

5.26 Preparation of HSFG Joints

- 5.26.1 Holes shall be drilled to the required tolerances and the burrs removed. All holes in the separate plies of a joint shall be correctly aligned so that the bolts may be freely placed in position. Bolts must not be driven out, and shall be clean so that nuts run freely on the bolt threads.

- 5.26.2 Where necessary, bolt threads shall be lubricated using a high pressure lubricant applied only to the outstanding threads after the bolts have been inserted through the steelwork. Surplus lubricant shall be removed.

5.27 Part and Final Tightening of HSFG Joints

- 5.27.1 Before any bolt of a group is finally tightened all bolts of a group shall be part tightened to approved sequenced and bedding torque. After the bedding torque has been applied to each bolt the final tightening to the approved pattern shall proceed.
- 5.27.2 If for any reason a bolt is removed after full tightening, it shall be discarded.

5.28 Rag Bolts

- 5.28.1 Rag bolts shall conform to BS 1494.

5.29 Flattened Ends of Tubes

- 5.29.1 For welded or bolted connections, the ends of tubes may be flattened or otherwise formed provided the methods adopted are such as not to injure or deface the material. The change in section shall be gradual.

5.30 Shop Assembly

- 5.30.1 The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged, and shall be so prepared that the specified cambers, if any, are provided. All tubular members shall be sealed so as to prevent the access of moisture to the inside of members.
- 5.30.2 All surfaces in contact and all surfaces inaccessible after assembly shall be thoroughly cleaned by shot blasting and given one coat of "Blast Primer" (as described later in this Specification) before being brought together.
- 5.30.3 Members shall then be assembled with sufficient tack bolts and drifts to register all holes and bring the surfaces closely in contact. Any drifting done during assembly shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal.

5.31 Inspection

- 5.31.1 The Contractor shall notify the Engineer when steelwork is ready for inspection, and the Engineer shall have free access at all times to any section of the workshop or site where work is being done under this Specification. No fabricated steelwork shall be delivered to the site unless inspected and passed by the Engineer or instructions to the contrary are issued by the Engineer.
- 5.31.2 The acceptance of any materials or finished members by the Engineer shall not be a bar to their subsequent rejection, if found defective. Rejected material and workmanship shall be replaced promptly or made good by the Contractor at his own expense.

5.32 Site Erection

- 5.32.1 The Contractor shall provide the falsework and all tools and appliances, including drift pin and fitting up bolts, necessary for the expeditious handling and erection of the steelwork. Equipment not suitable to produce the quality of work required will not be permitted on the site.
- 5.32.2 Material to be stored shall be placed above the ground upon platforms, skids or other supports. It shall be kept free from dirt, grease and other foreign matter and properly drained and protected as far as practicable from corrosion. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection.
- 5.32.3 Before starting the work, the Contractor shall inform the Engineer fully as to the method of erection he proposes to use. Both the method of erection and equipment shall be subject to the approval of the Engineer. The approval of the Engineer shall not however relieve the Contractor of the responsibility for the safety of his method or equipment or from carrying out the work in full accordance with the plans and this Specification.
- 5.32.4 During the progress of the work the Contractor shall have a competent foreman in personal charge of the work. All work shall be done by skilled, competent workmen.
- 5.32.5 All those employed on welding at the site shall be competent and suitably qualified in accordance with BS 4871-3, IS EN 287-1, IS EN ISO 9606 and BS 4872.

5.33 Trial Erection

- 5.33.1 Where required by the Engineer, a trial erection of steelwork shall be carried out in the contractor's fabrication shop to the satisfaction of the Engineer prior to delivery to the site.

5.33.2 All work shall conform to BS 5950 and BS EN 1993-1-3/-1-5:2006 unless otherwise specified, and the requirements of BS 5531 and guidance of HMSO Health and Safety Document GS238 Parts 1 and 2.

5.33.3 Prior to any erection a method statement shall be forwarded to the Engineer for approval. This shall outline the sequence and method of working, the plant to be used and details of any temporary works.

5.34 Stability

5.34.1 The methods of erection shall not depart from the Method Statement submitted by the Contractor without the written authority of the Engineer and shall ensure the stability of the structure of all stages of construction. The acceptance, approval or lack of approval by the Engineer of any drawings, details or proposals shall not relieve the Contractor of his obligation under Clause 1.33.2.

5.35 Erection Stresses

5.35.1 Steelwork shall be erected in a manner which does not distort any members of the structure or cladding, or exceed the safe loading capacity of the partly or fully erected structure.

5.36 Erection Tolerances

5.36.1 Unless shown otherwise on the drawings, steelwork shall be fixed to the following plus or minus tolerances:

Location	Tolerance
Location of first erection column	5mm
Linear Dimensions up to 8m	10mm
8m – 15m	15mm
15m – 25m	20mm
Over 25m	25mm
Plumb of columns in any storey	5mm
In any height of structure	10mm
Level of Bases	5mm
Level of Beams (AOD)	5mm
Level of Beams in any one floor	5mm
Level of Tops or soffits of beams meeting at Columns	5mm
Difference in End Levels of Beams	5mm

5.37 Encased Steel Work

- 5.37.1 Steelwork encased in concrete shall be free from loose scale, rust, dirt or grease. The protective treatment shall terminate 75mm inside the concrete surface and the steel painted with a rich portland cement (CEMI to IS EN 197-1&2&4) slurry before encasement.

5.38 Erection of Stanchions

- 5.38.1 Before commencement of steelwork erection, the Contractor shall inspect all adjoining structures, steel, concrete, brickwork etc. including a position, line and level of all connecting or seating points including holding down bolts and pockets etc. Should any discrepancies be found, they shall be brought to the attention of the Engineer in sufficient time for them to be considered and decisions taken so as to prevent any delays to the Works. The Contractor shall ensure pockets are clean and free from rubbish or water.
- 5.38.2 Any remedial work found necessary shall not be carried out without the express permission of the Engineer.
- 5.38.3 Bolts shall be free to move in their sleeves and have the correct projection.
- 5.38.4 Stanchions shall be plumbed with appropriate steel wedges and packs arranged to evenly and securely support the base plate and not to cause any distortion of the structure.
- 5.38.5 Final tightening of the holding down bolts will be carried out after grouting has been completed.

5.39 Grouting to Holding Down Bolts and Stanchion Bases

- 5.39.1 After final levelling and alignment of steelwork, grouting shall be carried out. The grout shall completely fill the holding downbolt holes prior to grouting under the stanchion base. Temporary shuttering shall be used to ensure that the space under the stanchion base is completely filled with grout.

5.40 Site Bolting

- 5.40.1 For normal bolted connections, the work in all respects shall be carried out as described in Clause 9.22 above. Black bolt connections may be used where directed by the Engineer provided the stresses are limited in accordance with BS 5950 and BS EN 1993-1-3/-1-5:2006.
- 5.40.2 High tensile friction grip bolts shall be used where directed by the Engineer. Torque shall be applied in an approved manner and to the degree called for on the drawings.

5.41 Site Welding

- 5.41.1 Site welding shall not generally be allowed. Where it is desired to use site welding, prior written permission must be obtained from the Engineer.
- 5.41.2 All site welding, including preparation, shall comply in all respects with the British Standards quoted and with Clause 9.15 Welding. Proper working platforms shall be provided to enable the operator to work with easy access to the work. All faces shall be wire brushed immediately before welding and heavy scale, moisture, paint, oil or similar deleterious substances shall be removed. Welding shall not be permitted on wet surfaces or during rain, snow or high winds unless the operator works under cover. Site welding shall not be permitted on any surface at or below 0°C (32°F).

5.42 Site Assembly

- 5.42.1 The various parts shall be accurately assembled as shown on the drawings. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged. Hammering which will injure or distort the member shall be prohibited.
- 5.42.2 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 equipment and its operation. Neither permanent bolting or welding shall be done until proper alignment has been obtained.

5.43 Setting Out

- 5.43.1 The positioning and levelling of all steelwork, the plumbing of columns and the accurate placing of every part of the structure in accordance with the drawings, shall be Contractor's responsibility. The steelwork shall be erected under the supervision of a competent foreman.
- 5.43.2 The Contractor will be responsible for the cost of all corrections required by the Engineer to rectify work which is not erected within the tolerances.

5.44 Bearings and Anchorages

- 5.44.1 During the construction of concrete, masonry or brickwork to support the steelwork, anchor bolts shall be placed as shown on the drawings. The bearing plates shall be set level and supported by steel wedges and the space under the steel shall be thoroughly cleaned before grouting.
- 5.44.2 Fluid Portland cement (CEMI to IS EN 197-1&2&4) mortar with a non-shrink additive, to a thickness of 25mm shall be used. The mortar shall not be leaner than 1:2 cement to sand and shall be mixed as thickly as possible consistent with fluidity. The non-shrink additive shall be thoroughly mixed in, in accordance with the manufacturer's instructions. It shall be poured under a suitable head and tamped until the space has been completely filled.
- 5.44.3 The location of anchor bolts in relation to slotted holes in expansion shoes shall correspond with the temperature at the time of erection.
- 5.44.4 Surface of steel bearing plates intended for sliding contact in expansion bearings shall be set carefully so that the direction of movement will be parallel to the centreline of the beam, girder, or other member under consideration, unless otherwise shown on the drawings.

5.45 Site Drilling

- 5.45.1 All site holes shall be drilled and the burrs removed. Gas blown holes are prohibited.

5.46 Testing and Inspection

- 5.46.1 All materials shall be able to be identified as to their primary source. The Contractor shall provide fully detailed certificates and signed documentation identifying each and every source of the various materials, their chemical composition and physical properties.

5.47 Inspection

- 5.47.1 The Contractor shall provide all facilities to allow the Engineer to carry out inspections at all stages of fabrication and erection.
- 5.47.2 The Contractor shall, at his own expense, arrange and provide all necessary inspection to ensure that steel containing lamination and other defects is not incorporated in the work. Any inspection carried out by the Engineer or on the Engineer's behalf shall not relieve the Contractor of the duty to provide such inspection.
- 5.47.3 Any steel subsequently found to be defective shall be discarded and replaced at the contractor's expense, notwithstanding any acceptance of the material, previously given or implied by the Engineer.
- 5.47.4 Visual inspection of welded joints shall be carried out in accordance with IS EN 970.

5.48 Samples

- 5.48.1 Samples of various materials, including welds, shall be provided by the contractor for testing as the Engineer may direct. The provision of samples shall include cutting of plate and sections, machining to provide test pieces and the supply of bolts, including holding down bolts.

Test	Sample Rate
Bend Tests	One sample per 20 tonnes (minimum 3 tests)
Tensile Tests	One sample per 20 tonnes (minimum 3 tests)
Impact Test	One Sample per 20 tonnes (minimum 3 tests)
Weld Test	One Sample per 10 tonnes of parent material (minimum 6 tests)

5.49 Testing General

- 5.49.1 Testing shall be as required by the Engineer to ensure compliance with the relevant Specifications. Testing shall be carried out by an independent testing authority nominated by the Contractor and subject to the approval of the Engineer. The Contractor shall instruct the testing authority to send four copies of each test certificate immediately and directly to the Engineer.

5.50 Testing of Structural Steel

- 5.50.1 All testing of structural steel shall be carried out in accordance with IS EN 10025.

5.51 Testing of Welds

- 5.51.1 Welds shall be tested in accordance with IS EN 1043-1&2, IS EN 1320, IS EN 1321, IS EN 875, IS EN 876, IS EN 895, IS EN 910.

5.52 Non Destructive Testing

- 5.52.1 Non-destructive testing of welds shall be carried out in accordance with:
- 5.52.1.1 IS EN 1435:1997 Non-destructive examination of welds. Radiographic examination of welded joints.
 - 5.52.1.2 IS EN 1714:1998 Non destructive testing of welded joints. Ultrasonic testing of welded joints.
 - 5.52.1.3 IS EN 12668-3:2000 Non-destructive testing. Characterization and verification of ultrasonic examination equipment. Combined equipment
 - 5.52.1.4 IS EN ISO 9934-1: Methods for Magnetic Particle Flaw Detection.
 - 5.52.1.5 IS EN 571-1: Methods for Penetrant Flaw Detection.
- 5.52.2 Approximately 10% of all fillet welds, 100% of butt welded tee junctions and 20% of all other butt welds will be tested and tests will be carried out on all butt welds where the combined thickness of the jointed plates exceeds 45mm. All these tests to be by radiographic testing.
- 5.52.3 Those portions requiring testing will be identified at random by the Engineer. No payment will be made in respect of time lost whilst tests are being carried out.
- 5.52.4 Acceptance levels for welds will be as Quality Category B, Tables 18 and 19 of IS EN 1011-1, IS EN 1011-2.

5.53 Rejected Material or Workmanship

- 5.53.1 Any material or work that is found to be defective or in the opinion of the Engineer is not in accordance with the Drawings or Specification shall be rejected. Any delay caused by such rejection shall not in any way relieve the Contractor of his obligation with regard to the provisions of the Contract. Any rejected material or work and any re-testing of same when it has been replaced and/or cut out and re-done shall be at the Contractor's expense. The Engineer's approval shall be obtained before any defects are repaired.
- 5.53.2 In the event of the Engineer deciding that welding or material must be re-examined or extra examination is required, over and above that required by the Specification as a result of welds and/or materials failing to comply with the Specification, the Contractor shall be responsible for all delays and/or additional costs associated with the re-examination or extra examination.

5.54 Costs of Inspection and Testing

- 5.54.1 The costs of cutting, machining, packing, transport and testing of all materials shall be borne by the Contractor.

5.55 Markings, Packing and Shipment

- 5.55.1 All steelwork shall carry a clear identification consisting of the drawing number and part mark. The marks shall be made in a clear legible manner by an approved method which will not be obliterated by blast cleaning or over painting.
- 5.55.2 Steelwork shall be assembled and bundled into suitable sizes for shipment within the normal permitted transport gauge for road or rail. Sufficient wire banding shall be used and tightened to allow for handling by crane or forklift truck, loose shims, end plates, cleats etc shall be securely wired to the parent piece for shipment.
- 5.55.3 All bolts shall be graded and bagged then placed into crates. Each crate shall contain a shipping document, listing its contents, within a sealed waterproof envelope. All crates shall be externally marked with the contract number etc on the top and two opposite faces together with any other instructions.

- 5.55.4 Any equipment, steelwork, bolts etc. short shipped, lost or damaged due to inadequate shipping instructions, documentation or packaging etc. shall be replaced by the contractor at his own cost.

5.56 Preparation and Painting

- 5.56.1 Shop preparation and priming shall be carried out in accordance with the requirements of BS 5950. All steelwork is to undergo the following preparation and painting process, unless noted otherwise:
- Shot Blast to Swedish Standard 2.5 or BS 7079, IS EN ISO 8501-1, BS 7079-a1, C1 to C4, IS EN 8503-1 to 4 - "Surface Finish of Blast-Cleaned Steel for Painting" - Second Quality.
 - Remove all traces of loose rust, grit etc. by compressed air hose or careful brushing with a clean dry brush. Inspect for laminations and remove by careful grinding leaving a smooth surface.
 - The steelwork shall then be dusted off and the "Blast Primer" applied by airless spray within two hours. "Blast Primer" to be one coat of an approved two-pack epoxy zinc rich primer (e.g. Interzinc 52) to BS 4652 - metallic Zinc-Rich Priming Paint, to a DFT of 25 microns.
 - Allow steelwork to dry and fabricate as necessary.
 - After fabrication all weld flux, splatter and rough edges shall be carefully removed by scraping, chipping and grinding to a smooth surface. All unsound, scorched primer around weld areas, dust, dirt, grease etc, shall be removed. Wash with white spirit where necessary. Spot prime all bare metal with "Blast Primer" and allow to dry overnight.
 - Apply by airless spray to the clean dry surface one coat of an approved 2 pack high build zinc phosphate primer (e.g. Interzinc 200 HS) to BS 4652 to a DFT of 75 microns.
- 5.56.2 Steelwork that is to be encased in concrete is to remain unpainted.
- 5.56.3 All paints used shall be supplied by an approved manufacturer and shall be new in sealed tins and their storage, use, quality and application shall be strictly in accordance with the manufacturers recommendations.

5.57 Shear Connectors

- 5.57.1 Shear connectors shall be in accordance with BS 5950 Part 3.

5.58 Composite Flooring

- 5.58.1 Composite flooring shall be as specified on the drawings or similar approved.
- 5.58.2 The composite flooring shall be manufactured from zinc coated steel to IS EN 10326 Fe E 280G Z 275. Minimum yield stress of the steel shall be 280N/mm² Minimum zinc coating mass is 275g/m total including both sides.
- 5.58.3 The installation of composite flooring including connections to supports and side laps shall be in strict accordance with the manufacturer's instructions.

6 BUILDING WORKS

6.1 Walls - Brickwork & Blockwork - General

- 6.1.1 Blockwork and Brickwork shall comply with the relevant provisions of BS 5628 "Code of Practice for the use of Masonry".
- 6.1.2 The moisture content of the bricks and blocks shall be adjusted so that excessive suction is not exerted on the mortar.
- 6.1.3 Sand shall be used in such proportions as may be determined by the Engineer. All sand shall pass a 5mm test sieve and not more than 10% of sand used shall pass a No. 100 sieve.
- 6.1.4 Blocks shall contain not more than 240 kg/m³ of cement to combined fine and coarse aggregate and mixing shall be carried out in the manner hereinbefore specified for concreting generally.
- 6.1.5 Blocks for incorporation in the works may be made on site in accordance with the directions herein contained or with such other directions as may be issued by the Engineer when results of tests on samples of aggregate intended for use in blockmaking have been furnished from an independent laboratory. Blocks when made shall be laid out on timber or steel pallets, and shall not be stacked until at least fourteen days have elapsed calculated from the date of manufacture of each batch.

6.2 Walls - Concrete Blocks

- 6.2.1 All concrete masonry shall comply with the following Standards:-
- Solid concrete blocks I.S.20
 - Hollow Concrete Blocks I.S.20
 - Forticrete Dense Concrete Masonry or Equivalent I.S.20
 - Aggregate used in the manufacture of blocks shall consist of naturally occurring sand, gravel or stone or a combination thereof. They shall be hard, strong, durable, clean and free from adherent coatings and shall not contain excessive quantities of flat or elongated particles. Coarse aggregate shall all pass a 20mm test sieve.
- 6.2.2 The concrete blocks used in the works shall conform to the type specified in Tables 5.1 and 5.2 below.
- 6.2.3 Block types are defined as follows:-
- (i) Type A Block: Dense aggregate solid or hollow concrete blocks of density not less than 1500kg/m³. They are suitable for general use in building below the ground level damp-proof course.
 - (ii) Type B Block: Dense aggregate hollow concrete blocks or light aggregate solid or hollow concrete blocks of density less than 1500kg/m³. Dense aggregate blocks of this type are suitable for general use in building including the use below the ground level damp-proof course. Light aggregate blocks of this type are suitable for general use in building except below the ground level damp-proof course.
 - (iii) Type C Block: Light aggregate solid or hollow concrete blocks of density less than 1500kg/m³ for use in internal non-loadbearing walls and partitions (including panels in framed construction).
- 6.2.4 Block definitions are as follows:-
- (i) Solid Block: A block shall be deemed to be solid if the solid material is not less than 75% of the total volume of the block calculated from the overall dimensions.
 - (ii) Hollow Block: A block shall be deemed to be hollow if it has one or more large holes or cavities which pass through the block and the solid material is between 50% and 75% of the total volume of the block calculated from the overall dimensions.
 - (iii) Cellular Block: A block shall be deemed to be cellular if it has one or more moulded holes or cavities which do not effectively pass through the block and the solid material is between 50% and 75% of the total volume of the block calculated from the overall dimensions.
 - (iv) Block Density: The density is calculated by dividing the weight of a block by the overall volume including holes and cavities.
 - (v) Co-ordinating Size: The size of the space allocated for the block including allowances for joints and tolerances.
 - (vi) Work Size: The size of block specified for manufacture to which the actual size should conform to specified tolerances.

Block Reference Number		Type	Work Size		Compressive Strength (N/mm ²)
			Length x Height (mm)	Thickness (mm)	
1	A	Solid	440 x 215	140	5
2	A	Solid	440 x 215	140	10.5
3	A	Solid	440 x 215	140	21
4	A	Solid	440 x 215	140	28
5	A	Solid	440 x 215	100	5
6	A	Solid	440 x 215	100	10.5
7	A	Solid	440 x 215	100	21
8	A	Solid	440 x 215	100	28
9	A	Solid	440 x 215	65	5
10	A	Solid	440 x 215	65	10.5
11	A	Solid	440 x 215	65	21
12	A	Solid	440 x 215	65	28
13	A	Solid	440 x 290	100	5
14	A	Solid	440 x 190	100	10.5
15	A	Solid	440 x 140	100	5
16	A	Solid	440 x 140	100	10.5
17	A	Solid	440 x 100	100	5
18	A	Solid	440 x 140	100	10.5
19	A	Solid	440 x 65	100	10.5
20	A	Solid	340 x 215	100	5
21	A	Solid	215 x 215	100	5
22	A	Solid	440 x 215	100	5
23	A	Hollow	440 x 215	215	10.5
24	A	Hollow	440 x 215	140	10.5
25	A	Hollow	440 x 215	100	10.5
26	A	Hollow	440 x 215	100	10.5
27	A	Hollow	440 x 215	215	10.5
28	A	Hollow	440 x 215	100	10.5
29	B	Hollow	440 x 215	215	3
30	B	Hollow	440 x 215	215	5
31	B	Hollow	440 x 215	140	3
32	B	Hollow	440 x 215	140	5
33	B	Hollow	440 x 215	100	3
34	B	Hollow	440 x 215	100	5
35	B	Hollow	440 x 215	215	3
36	B	Hollow	215 x 215	215	5

Table 6.1 – Block index (Imperial sizes)

6.3 Walls - Brickwork & Blockwork - Handling and Storage of Materials

- 6.3.1 Cement shall be stored in a manner to ensure that it is not affected by damp and shall be used in the order of delivery.
- 6.3.2 Sands shall be stored separately according to type in such a manner that they will not be contaminated.
- 6.3.3 Reinforcement and ties shall be protected from becoming contaminated, and reinforcement shall be free from loose mill scale and rust.
- 6.3.4 Facing bricks and blocks shall be carefully unloaded so as to avoid damage to the units. All blocks shall be stacked on prepared level areas to ensure that the stack is stable. Blocks used for fairfaced work shall be covered to prevent saturation and shall be protected to prevent the exposed faces from becoming stained or marked. All blocks shall be delivered to site, and transported on site banded on pallets.
- 6.3.5 Blocks may not be incorporated in the structure until at least 28 days have elapsed calculated from the date of manufacture, and satisfactory compliance with the requirements of IS 20 in regard to weight, absorption and moisture content is a condition precedent in their incorporation.

6.4 Walls – Brickwork & Blockwork - Testing

- 6.4.1 For the purpose of testing of blocks, the Contractor shall supply free of charge 10 blocks, from every consignment of 1000 blocks, and shall arrange their carriage to and delivery at an approved Engineering Laboratory, likewise free of charge to the Employers. Three of the blocks shall be tested for absorption and moisture content and the arithmetical mean of the absorption and moisture content of the three blocks shall be deemed to be the absorption and moisture content of the consignment. The absorption of the blocks tested in accordance with IS 20 shall not be more than 15 lbs. per cubic foot (240 kg/m³) and the moisture content of the blocks shall not exceed 40% of the absorption.
- 6.4.2 Five whole blocks taken at random from the samples supplied shall be tested in accordance with the method of determination of compressive strength set out in Appendix 8 of IS 20 and the arithmetic mean of the compressive strength of the blocks. The compressive strength of mature blocks when so tested after 28 days shall not be less than 5 N/mm².

6.5 Walls – Brickwork & Blockwork - Laying

- 6.5.1 Blocklaying shall be carried out only by experienced masons, skilled in their trade, and the work shall be set out and built to the respective dimensions, thicknesses and heights shown on the Drawings. Blocks shall be buttered with mortar before being laid, all joints shall be thoroughly flushed up as the work proceeds.
- 6.5.2 Brickwork and blockwork shall rise uniformly; corners and other advanced work shall be raked back and not raised above the general level more than 1 metre. Brickwork and blockwork shall be laid out in a uniform manner with adequate bond and plumb. Bricks or blocks may be bedded directly on foundations, or other rigid supporting structures. Bricks and blocks shall be laid in mortar properly bedded and jointed and all joints filled with mortar at every course. Bricks and Blocks in each course shall break joint correctly with the bricks underneath. The courses shall be laid parallel with the joints of uniform thickness and shall be kept straight or regularly curved as required. No bats or broken bricks or blocks shall be incorporated in the work unless essential for bond. Where the surfaces of walling does not provide an adequate key, the joints on faces of walls to be plastered shall be raked out 12mm deep.
- 6.5.3 The setting out and dimensions of the finished work, unless otherwise shown on the drawings or specified, shall be within the tolerances set out hereafter and the Contractor will be held responsible for the cost of all corrective measures required by the Engineer to rectify work which is not constructed within the specified tolerances. All walls shall be kept strictly in horizontal and vertical alignment, and the whole shall be properly bonded together and levelled around the top at the completion of blockwork. On dimensions of 3m and over a tolerance of plus or minus 5mm and on dimensions of less than 3m a tolerance of plus or minus 2mm will be allowed. Walls shall not be more than 5mm out of plumb in their storey height.
- 6.5.4 All perpend, quoins, joints etc., shall be kept strictly true and square, other angles shall be plumbed and the whole properly bonded or tied together and the bed joints levelled as the work proceeds.
- 6.5.5 The brickwork and blockwork shall be built to the bond indicated on the drawings. Where no bond is indicated, the units shall be laid in stretcher bond. Where possible the coursing shall be arranged to allow a full brick or block to be positioned directly beneath a lintel bearing.
- 6.5.6 The positions and sizes of chasings shall be as indicated on the drawings and shall be carried out neatly using a chasing tool, and shall be carried out under constant supervision. Under no circumstances, even where the strength and stability of the wall are not critical, should the depth of any horizontal chase exceed one-sixth of the thickness of the single-leaf at any point. Under no circumstances should the depth of vertical and diagonal chases exceed one third of the thickness of the single-leaf at any point. The cutting of holes in the unit locally to accommodate items of equipment up to 300mm square may be permitted provided permission has been given by the Engineer.

- 6.5.7 Where building regulations allow, services may be taken through cavities in the units, but care should be taken that units are not unduly damaged at the point of entry or exit. Lightweight fittings may be fixed directly to lightweight or cavity units by nails or screws. For fixing heavier fittings to lightweight units or cavity units an appropriate fixing device approved by the Engineer shall be used. For fixing fittings to brickwork and dense aggregate concrete blocks, the units shall be drilled and plugged for screws unless special approved fixing devices at the direction of the Engineer are approved.
- 6.5.8 Where brickwork is required to be bonded to concrete, dovetail slot ties shall be evenly placed at three per square metre and brickwork shall be brought up subsequent to the concrete.
- 6.5.9 The course upon which the damp course is laid should be carefully finished up with mortar and trowelled to form a level even bed. The damp-proof course should project slightly beyond the face of the mortar immediately below and above it on both sides of the wall except that it may be finished with the inner face of a cavity wall where it is stepped up from the outer leaf to the inner leaf and is intended for diverting water moving downwards.
- 6.5.10 In cavity walls, mortar droppings should be prevented from falling down the cavity by the use of laths, which should be drawn up the cavity as the work proceeds. Any mortar which may unavoidably fall on the wall ties should be removed daily and temporary openings (clean-outs) should be provided to permit the daily clearance of mortar droppings from the bottom of the cavity. Generally both leaves of a cavity wall should be raised at the same time; one leaf should never be more than 450mm higher than the other in cases where strip ties are used, and 1.35m higher where wire ties are used. Maximum height of brickwork or blockwork to be carried out in one day is 1.2m.
- 6.5.11 Near the sides of door and window openings ties shall be placed at each 225mm of height to increase stability. Wall ties shall be set to a minimum depth of 50mm in each leaf. All ties shall be kept free of mortar and debris
- 6.5.12 Finished surfaces of fair faced blockwork shall be protected at all times from scaffold splash, mortar droppings, grout leakage from suspended slabs and the harmful effects of weather. Blockwork shall be allowed to set thoroughly hard before cutting or chasing out is performed.

6.6 Walls – Brickwork & Blockwork - Weather

- 6.6.1 No brick or block laying shall be carried out when the temperature is at or below 3°C unless precautions are taken to ensure a minimum temperature of 4°C in the work when laid and thereafter to maintain the temperature above freezing point until the mortar has hardened. Should any brick or block wall be damaged by frost it shall be pulled down and laid thereafter to maintain the temperature above freezing point until the mortar has hardened. This shall be made good at the Contractor's expense. Walls shall, where necessary, be adequately braced during construction to prevent damage by winds or other causes.
- 6.6.2 Blocks separated from stacks before use shall be adequately protected.
- 6.6.3 Mortar shall be protected at all times from frost damage.
- 6.6.4 The top of blockwork shall be covered at the end of each day, to prevent damage or deterioration.
- 6.6.5 The Contractor shall ensure that any additive used in the mortar does not cause a variation in the colour of the joints.

6.7 Walls - Materials for Mortars

- 6.7.1 The cement used shall be in accordance with IS EN 197-1 Portland Cement CEM1.
- 6.7.2 Limes used in mortars shall be non-hydraulic (calcium) limes or semi-hydraulic (calcium) and magnesium limes to conform with the requirements of IS EN 459-1. Hydrated Lime shall comply with IS 8.
- 6.7.3 The sand shall be free from deleterious materials and substances and shall comply with the requirement for quality and grading of sand for mortar given in BS 1199, BS 1200 and IS EN 13139:2002 COR2004.
- 6.7.4 Water shall be potable and free from impurities harmful to the mortar. Where the quality of supply is doubtful it shall be tested in accordance with IS EN 1008.
- 6.7.5 Pigments should comply with the requirements of IS EN 12878 and should not exceed 10% by mass in the mortar. Care should be taken to ensure that the strength of the mortar remains adequate. Carbon black should be limited to 3% by mass of the cement.
- 6.7.6 Plasticisers should comply with the requirements of IS EN 934-3:2004 and should be used only with the WRITTEN permission of the Engineer. The Contractor shall provide the Engineer with the appropriate manufacturer's recommendations and then submit:-
- (i) Evidence of satisfactory performance of the admixture when correctly used;
 - (ii) details of his arrangements for the use of the admixtures;
 - (iii) an undertaking to conform with the manufacturer's specification.

6.8 Walls - Preparation of Mortars

6.8.1 Mortar used in the works shall comply with Table 6.2 below:-

Type of Mortar				Mean Compressive Strength at 28 Days	
Class	Cement : Lime : Sand	Masonry : Cement : Sand	Cement : Sand with Plasticiser	Preliminary (Lab) Tests (N/mm ²)	Site Tests (N/mm ²)
M1	1 : 0 to ¼ : 3	-	-	16	11
M2	1 : ½ : 4 to 4 ½	1 : 2 ½ to 4 ½	1 : 3 to 4	6.5	4.5
M3	1 : 1 : 5 to 6	1 : 4 to 5	1 : 5 to 6	3.6	2.5
M4	1 : 2 : 8 to 9	1 : 5 ½ to 6 ½	1 : 7 to 8	1.5	1.0

Table 6.2 – Requirements for mortar

- 6.8.2 Ready mixed lime-sand for mortar should comply with the requirements of IS EN 998. The appropriate addition of cement should be gauged on site. Wet ready mixed retarded cement:lime:sand mixes should only be used with the WRITTEN permission of the Engineer.
- 6.8.3 The materials for the mortar shall be measured accurately to conform with the specified mix proportions either by weight batching or by the use of gauge boxes, but not by shovels.
- 6.8.4 Mortar shall be mixed only as and when required in the relevant proportions indicated in the above table, until its colour and consistency are uniform. The constituent materials shall be accurately gauged, allowance being made for bulking of sand. The mortar shall be mixed by machine. The machine should be cleaned out before use, to avoid contamination, and before changing mixes. Hand mixing may only be used for small quantities and should be carried out on a clean, watertight platform. Mortars containing cements should be used within 2 hours of the mixing of the cement and water and any mortar not then used should be discarded and not retamped.

6.9 Walls – Brickwork & Blockwork - Mortar Joints

- 6.9.1 All bricks and blocks shall be laid on a full mortar bed. Vertical joints shall be filled. All joints are to be nominally 10mm thick. Each brick or block shall be laid and adjusted to its final position while the mortar is still plastic.
- 6.9.2 Joints for all locations shall be as specified by the Engineer. The tooling of joints shall be carried out to the specified profiles while the mortar is thumb-print hard.
- 6.9.3 Joints shall be struck or raked as specified by the Engineer for plastering, rendering etc. Advice as to whether the wall needs to be struck or raked shall be obtained from the manufacturer of the blocks.
- 6.9.4 Any mortar which extrudes from the joint of fairfaced units shall be cut away and on no account is mortar to be smeared onto the face of the blocks.

6.10 Walls - Reinforced Walls

- 6.10.1 The cores shall be kept clear and clean of mortar droppings and any extruding mortar shall be removed while soft.

6.11 Walls - Control Joints

- 6.11.1 Control joints shall be constructed as indicated on the drawings. Expansion joints shall be cleaned out to ensure that mortar does not bridge the joint.

6.12 Walls - Double Leaf Cavity Walls

- 6.12.1 Where cavity walling is specified the outer and inner leaves shall be separated by the width shown on the drawings and tied together with stainless steel ties embedded in the mortar at least 65mm. Xtratherm full fill PIR Cavity wall or equivalent insulation shall be incorporated by fixing the Insulation Panels. Unless otherwise detailed the ties shall be staggered in alternate courses and spaced in accordance with the following Table 5.4 below.

Least Leaf Thickness (mm)	Cavity Width	Spacing of Ties		No. of Ties per m ²
		Horizontally (mm)	Vertically (mm)	
75	50 – 75	450	450	4.9
90 or more	50 – 75	900	450	2.5
90 or more	75 – 100	750	450	3.0
90 or more	100-150	450	450	4.9

Table 6.4 - Wall tie spacing

- 6.12.2 The cavity and ties shall be kept clear and clean of mortar droppings or other materials during construction and any extruding mortar shall be struck off flush. No cavity shall be sealed off until inspected and approved by the Engineer or his representative.
- 6.12.3 Weepholes 10mm wide by 75mm high, spaced at centres not exceeding 900mm and extending through the vertical mortar joints of the outer leaf, shall be provided at ground level and at positions where the cavity is bridged or at locations indicated on the drawings.
- 6.12.4 Vent holes shall be of the dimensions as for weepholes and shall be positioned at locations indicated on the drawings.
- 6.12.5 The cavity shall be closed at the jambs of doors and windows by a vertical damp proof course formed of slates. The slate damp proof course shall consist of two courses of sound, whole slates not less than 225mm in length, laid breaking joint and bedded solidly in cement mortar and neatly pointed on exposed edges. The top of the cavity shall be sealed with slates in the manner hereinbefore specified and shall finish in a continuous concrete band of eaves.

6.13 Walls - Metal Ties

- 6.13.1 Metal ties for cavity wall construction shall comply with the relevant provisions of IS EN 845. Ties shall be type 2 heavy duty ties as specified on the drawings. The minimum embedment length in block work shall be 2/3 of the leaf thickness.

6.14 Walls - Lintels and Cills

- 6.14.1 Prefabricated concrete and steel lintels shall be in accordance with BS 5977-1 and IS EN 845-2.
- 6.14.2 Cills and non-metallic copings shall be in accordance with BS 5642.

6.15 Walls - Damp-Proof Courses

- 6.15.1 Damp-proof courses (d.p.c's) shall comply with the requirements of CP 102, BS 8102, BS 8215 and BS 5628: Part 3.
- 6.15.2 Horizontal damp-proof courses shall be provided at positions shown on the drawings and be positioned so as to fully cover the leaf thickness. All horizontal damp-proof courses shall be laid on an even bed of fresh mortar and eventually covered by mortar so as to maintain regular coursing and joint thickness and while exposed shall be protected from damage while the building is proceeding. Stepped damp-proof courses at openings shall extend beyond the end of the lintel by at least 100mm. All horizontal damp-proof courses shall protrude 10mm from the external face of the wall and be turned downwards. Vertical damp-proof courses shall be of adequate width and be fixed so as to separate the inner and outer leaves of the wall. The material for damp-proof courses shall comply with BS 5628 Part 3. Particular care is to be taken in detailing and positioning of dpc's and attention is drawn to the relevant clauses in BS 6398.
- 6.15.3 Tanking and waterproofing of basement walls or retaining walls shall be carried out to the details as shown on the drawings and all materials are to be used in accordance with the manufacturer's recommendations.

6.16 Walls - Flashings and Weatherings

- 6.16.1 Flashings and weatherings shall comply with the requirements of BS 5628 : Part 3.
- 6.16.2 Wall flashings shall be built into or secured to the brickwork or blockwork in accordance with the details shown on the drawings. Care shall be taken to ensure that the flashing has adequate laps.

6.17 Floors - Plain and Granolithic Concrete

- 6.17.1 Plain and granolithic concrete floor finishes shall comply with the relevant provisions of BS 8204, Part 1.
- 6.17.2 Floor finishes shall be as directed by the architect.

6.18 Roofs - Timberwork

- 6.18.1 Wall plates for roofs shall be halved and lapped at joints, and fixed to walls. Roof members shall be scarfed, wedged, and bolted or spike jointed with connectors as specified.
- 6.18.2 Flats and gutters shall be covered with Type WBP plywood or tongued and grooved wrought boarding laid diagonally, fired to falls of not less than 1 in 120 for lead and copper and 1 in 60 for bitumen felt.
- 6.18.3 Pressure-impregnated prefabricated timber roof trusses shall be designed and manufactured strictly in accordance with IS 193 and shall be supplied by an approved manufacturer. They are to be stress graded to NSAI Specifications.

6.19 Roofs - Flashings

- 6.19.1 All flashings, verges and trims shall match the roofing covering and shall be of a proprietary type approved by the engineer. Lead flashings shall be 5lb. lead complying with IS EN 12588.

6.20 Tolerances for Building Works

- 6.20.1 Tolerances for building works, except where otherwise required in the Contract, shall not exceed the permissible deviations from levels and dimensions given in BS 5606, where applicable, for the corresponding types of work.

6.21 Paints and Painting Materials

- 6.21.1 Ready mixed paints for buildings shall be external quality. Materials shall comply with the following specification:

- Hard Gloss and Enamel Paints - IS 32
- Varnishes - IS EN 927 and BS EN 60464-1/-2.
- Emulsion Paint - IS 129
- Linseed Oil - IS EN 150, BS 544 and BS ISO 276
- Gold Size - IS 17

- 6.21.2 Paint colours for building purposes shall comply with the relevant provisions of BS 4800. Knotting for use as an impervious covering for knots and other resinous areas shall comply with IS 16.

- 6.21.3 Priming paint for wood shall comply with the relevant provisions of the appropriate British Standard as set out in Table 6.6 below:

Type	Standard
Ready Mixed Aluminium	B.S. 4756, Type 11
Water – thinned	B.S. 7956
Low-lead solvent-thinned	B.S. 7956

Table 6.6 – Priming paint for wood

- 6.21.4 Priming paint for metal shall comply with the relevant provisions of the appropriate British Standard as set out in Table 6.7 below:

Type	Standard
Lead based	B.S. 2523, Type B or C & B.S. 7956
Calcium plumbate	B.S. 3698, Type A
Metallic zinc-rich (organic media)	B.S. 4652

Table 6.7 – Priming paint for metal

- 6.21.5 Paint remover shall be non-flammable, solvent-based and comply with BS 3761.

- 6.21.6 All materials shall be obtained from an approved manufacturer and shall be used strictly in accordance with manufacturer's instructions. Where directed successive undercoats shall be in different colour tints.

- 6.21.7 Workmanship shall comply with BS 6150.

6.22 Painting

- 6.22.1 Painting shall comply with the relevant provisions of BS61 50 Section 5 and surfaces shall receive the number of applications stated in Table 6.8

Description	Iron & Steel	Galvanised Steel	Copper & Brass	Aluminium	Softwood External	Softwood Internal	Untreated Hardwood External	Walls & Ceilings
Degreasing solvent	1	1	1					
Red Lead Primer to BS 2523 & BS 7956 or Red Lead / Red Oxide Primer	2							
Zinc Chromate Primer				1				
Calcium Plumbate Primer to BS 3698 Types A & B		1						
Primer for Wood					1	1		
Oil-based or water thinned undercoat	1	1	1	2	2	2		

Alkyd gloss or other finishing coat	1	1	1	2	1	1		
Varnish – Exterior Grade – Full Gloss							4	
Acrylic Emulsion								3
Where Calcium Plumbate primer is used, the undercoat or finishing coat following the primer must be compatible with it.								

Table 6.8 – Painting applications**6.23 Mastic Asphalt for Building:**

- 6.23.1 Mastic asphalt for building shall have limestone aggregate and shall comply with the relevant provisions of the BS 6925 or IS 65 unless otherwise stated.

6.24 Plaster

- 6.24.1 Gypsum Plaster shall comply with IS 27. Plasterboard shall comply with IS EN 520.
- 6.24.2 Steel metal lathing for plastering walls and ceilings shall comply with the relevant provisions of IS EN 13658 and be plain expanded and ribbed expanded types respectively.
- 6.24.3 Lime for undercoats and finishing coats shall comply with IS EN 459-1.
- 6.24.4 The Contractor shall prepare sample panels of each type of finish shown on the drawings or specified for approval by the Engineer before starting work. All plastering shall be of equal standard to the approved samples.

6.25 Fixing Accessories for Building Purposes

- 6.25.1 Fixing accessories for corrugated roofing, gutters and above-ground pipes shall comply with the relevant provisions of BS 1494.

6.26 Nails

- 6.26.1 Nails shall comply with the relevant provisions of the appropriate British Standard as set out in Table 6.9 below:

Type	British Standard	Irish Standard
Steel	B.S. 1202, Part 1	I.S. 105, Part 1
Copper	B.S. 1202, Part 2	I.S. 105, Part 1
Aluminium	B.S. 1202, Part 3	I.S. 105, Part 1

Table 6.9 – Nails**6.27 Timber/Joinery**

- 6.27.1 Hardwood or softwood shall be as defined in IS EN 13556.
- 6.27.2 Timber materials shall comply with the following Specifications:-
- Timber Nomenclature - IS EN 13556
 - Timber Moisture Content - IS 96
 - Plywood - IS EN 636 and BS 1203
 - Blockboard - BS EN 8201
 - Chipboard - IS EN 120, 309, 310, 311, 312 & 317
 - Plastic Laminates - IS EN 438
 - Flush Doors - IS 48
 - Fire Check Doors - BS 8214
 - Joinery, Timber and Workmanship - BS 1186 – Part 2 & 3 and IS EN 942
 - Glues - IS EN 301 & IS EN 302
 - Grading Rules for Timber - BS 4978 and IS EN 975
 - Structural Softwoods, Characteristics - BS 4978

- 6.27.3 Where timber is described as pressure-impregnated it is to be vacuum/pressure-impregnated with "Tanalith C" preservative to a nett dry salt retention of 3kg. "Tanalith C" per cubic metre of timber, or other similar and approved process. Timber to be tanalised must be machined to its final dimensions. Where crosscutting and boring after treatment cannot be avoided all exposed surfaces should be liberally swabbed with "Ensele". Rip sawn pieces must be retreated.
- 6.27.4 All timber used in the Permanent Works shall be new. Timber for structural use shall comply with BS 4978 and be of General Structural Grade. Softwood to be used for structural purposes shall only include those timbers, which comprise Species Group S1 of Tables 9 and 9A of BS 5268.
- 6.27.5 Preservative treatment of timber, other than timber for structural purposes shall comply with the relevant provisions of BS 5589. Preservative treatment of timber for structural purposes shall comply with the relevant provisions of BS 5268, Part 5.
- 6.27.6 Insofar as is possible, cutting and shaping of all timber shall be completed before preservative treatment is carried out. Where any cutting or shaping has to be carried out after treatment, the surfaces so cut or worked shall be given 2 coats of the preservative. After treatment, timber shall be thoroughly dried out before use.
- 6.27.7 The quality of joinery timber shall comply with the relevant provisions of IS EN 942. The dimensions and sizes of sawn softwood and hardwoods shall comply with the relevant provisions of IS EN 1313 Parts 1 & 2 respectively. The sizes of small sections of softwood resawn from the basic sizes in IS EN 1313, Part 1 shall comply with the relevant provisions of that specification. The whole of the joinery shall be cut and framed together as soon after the commencement of the work as possible and workmanship shall comply with the relevant provisions of BS 1186 : Part 2.
- 6.27.8 Except where work is shown in the Contract as being to finished sizes, 3mm shall be allowed for each wrought face. Framed casings and other joinery and fittings shall be secured to hardwood fixing slips built in for the purpose. Where hardwood fixing slips have not been provided, receiving surfaces shall be plugged with hardwood plugs or approved proprietary type plugs. Manufactured units to be painted shall be primed at the place of manufacture.
- 6.27.9 All joinery, including sections, which have been primed or treated with preservative, shall be properly stacked and protected from the weather until erection.
- 6.27.10 Connectors for timber shall comply with the relevant provisions of IS EN 912.
- 6.27.11 Joist hangers for building into masonry walls, or the inner skin of cavity walls, shall comply with IS EN 845-1.

6.28 Concrete for Core Filling

- 6.28.1 The cement used shall be in accordance with IS EN 197-1 "Portland Cement" (CEM1).
- 6.28.2 The coarse aggregate shall have a nominal size of 10mm and shall typically have proportions by weight of 1: 2 ½ to 3 : 2 Ordinary Portland Cement (CEM1) : Sand (I.S. E.N. 12620) : Coarse Aggregate (I.S. E.N. 12620) 10mm Max Aggregate size.
- 6.28.3 Water shall be potable and free from impurities harmful to the concrete. Where the quality of the water is doubtful the water shall be tested in accordance with IS EN 1008.
- 6.28.4 Admixtures may only be used subject to the Engineer's prior WRITTEN agreement. The Contractor shall supply the Engineer with the appropriate data sheets giving the manufacturer's recommendations and submit:-
- Evidence of satisfactory performance of the admixture when properly used.
 - Details of his arrangements for the use of the admixtures.
 - An undertaking to conform to the manufacturer's specification.

6.29 Cement Grouts

- 6.29.1 Cement grout shall be mixed in the relevant proportions indicated in Table 6.10 below using the minimum quantity of water to ensure the necessary fluidity and to render it capable of penetrating the work.

Nominal Mix by Mass			
Class	Cement	Sand	PFA
G1	1	-	-
G2	1	3	-
G3	1	10	-
G4	1	-	10
G5	1	-	4
G6	1	-	0.5

Table 6.10 – Cement grout

- 6.29.2 Cement grout shall be used within one hour of mixing, except where containing a retardant admixture.
- 6.29.3 Sulphate-resisting cement shall not be used as a constituent of grouts containing pulverized fuel ash.

6.30 Plastic Sheeting and Sleeving

- 6.30.1 Plastic sheeting for waterproof underlay shall be free from tears and voids and be substantially free from pinholes and other discontinuities. It will have a composition in accordance with Clause 3 of BS 6076 and a nominal film thickness of 125 µm.

6.31 Nuts, Screws, Washers and Bolts

- 6.31.1 Mild and high strength nuts, screws, washers and bolts shall comply with the relevant provisions of the appropriate Standard as set out in Table 6.12 below:

Type	Standard
Black Hexagon Bolts, Screws and Nuts	BS 4190
Metal Washers for General Purposes	BS 4320
High Strength Friction Grip Bolts, Nuts and Washers	IS EN 14399
Black Cup and Countersunk Head Bolts and Screws with Nuts	BS 4933

Table 6.12 – Nuts, screws etc

- 6.31.2 Bolting for pipes and fittings shall comply with the relevant provisions of IS EN 1092, Part 1, except that spheroidal graphite iron bolts for use with ductile iron pipes and fittings shall be manufactured from metal complying with the provision of IS EN 1563 for Grade 500/7. Bolt lengths shall be sufficient to ensure that nuts are full-threaded when tightened in their final position.
- 6.31.3 Stainless steel nuts, screws, washers and bolts shall be manufactured from Grade 316S31 steel complying with IS EN 10029, 10048, 10051, 10083-1, 10084, 10085, 10087, 10095, 10250-4, IS EN ISO 9445.
- 6.31.4 Where bolting is incompatible with the material being fixed, suitable isolating washers and sleeves shall be used.

6.32 Fixings for Metalwork

- 6.32.1 Rag and indented foundation bolts and nuts shall comply with the relevant provisions of BS 1494. Mild steel bolts and nuts shall be hot dip galvanised in accordance with IS EN ISO 1461 and stainless steel bolts and nuts shall be manufactured from Grade 316S31 steel complying with BS 970, Part 1 or IS EN 10029, 10048, 10051, 10083-1, 10084, 10085, 10087, 10095, 10250-4, IS EN ISO 9445 and PD970:2005
- 6.32.2 Stainless steel proprietary fixing shall be manufactured from Grade 316S31 steel complying with BS 970, Part 1 or BS EN 10095:1999. Mild and high tensile steel proprietary fixings shall be protected in accordance with the relevant provisions of the appropriate Standard as set out in Table 6.13 below:

Type of Protection	Type of Fixing				
	Having no Machined Thread	Cast-In Not Exceeding 19mm diameter	Exceeding 19mm diameter	Expanding Not Exceeding 19mm diameter	Exceeding 19mm diameter
Hot Dipped Galvanised	IS EN 12329	-	-	-	-
Electroplated Cadmium	IS EN 12330 Cd4	BS 3382: Part 1	IS EN 12330 Cd4	BS 3382L Part 1	IS EN 12330 Cd4
Electroplated Zinc	IS EN 12329 Zn10	BS 3382: Part 2	IS EN 12329 Zn10	BS 3382: Part 1	IS EN 12329 Zn10

Table 6.13 – Fixings

- 6.32.3 Where required by the Contract, axial loading tests on structural fixings in concrete or masonry shall be carried out in accordance with the provisions of BS 5080, Part 1. The safe working load shall be as described in the Contract.
- 6.32.4 Where fixings are incompatible with the material being fixed, suitable isolating washers and sleeves shall be used.

7 PIPES AND PIPE LAYING

7.1 Pipes – General

- 7.1.1 All pipes, fittings and appurtenances used in the works shall be to relevant standards specified or described and shall be clearly marked with the standard mark where appropriate, manufacturer's name or mark, date of manufacture, nominal size and class of pipe.
- 7.1.2 In addition to the pipe bedding, trench backfilling, compaction and reinstatement requirements set out in this section for pipes and pipelaying, the Contractor shall comply with any backfilling and reinstatement details or drawings supplied as part of the Contract.

7.2 Concrete Pipes and Fittings

- 7.2.1 Unreinforced and reinforced concrete pipes and fittings with flexible or rigid spigot and socket joints shall comply with IS 6 and IS EN 1916 – concrete pipes and fitting, unreinforced, steel fibre and reinforced.

7.3 Prestressed Concrete Pipes and Fittings

- 7.3.1 Prestressed concrete pipes and fittings where proposed shall comply with the relevant provisions of EN 639:1995 and EN 642:1995.
- 7.3.2 Unless steam cured, no pipes or fittings shall leave the place of manufacture until they have been allowed to cure and mature under suitable conditions for a total period of not less than 28 days.

7.4 Ogee Jointed Concrete Pipes

- 7.4.1 Ogee Jointed Concrete Pipes shall comply with IS 166 for Concrete Surface Water Pipes.

7.5 Vitrified Clay Pipes

- 7.5.1 Fittings and Joints shall comply with IS EN 295, Class 160 or 200 Pipes.

7.6 Ductile Iron Pipes and Fittings

- 7.6.1 Ductile Pipes, fittings and joints shall comply with the relevant provisions of IS EN 545, IS EN 598 and IS EN 969. They are to have "Tyton" or similar approved compression ring flexible joints or flanged joints where indicated on Drawings.
- 7.6.2 All pipes and fittings shall be cement mortar lined internally in accordance with BS ISO 4179 and coated externally with an approved bituminous composition to BS 3416 Type 1 or 2 or 4147 Type 1 Grade "D". The pipes shall also be sleeved with a factory applied polyethylene external coating to comply with IS EN 14628.
- 7.6.3 Where Iron pipes are to be used these shall in general be Ductile Iron Pipes and the Engineers approval will be required if Cast Iron or Spun Iron Pipes or Fittings are to be substituted.
- 7.6.4 Split Puddle Flanges on Ductile Iron Pipes are to be used only in locations where they are not required to provide an anchorage for the pipe. The flanges are to be fitted to the pipe using a suitable non-toxic metallic sheeting to provide a packing between flange and pipe body and caulked after fixing.
- 7.6.5 Puddle flanges, which are required to provide anchorage for the pipe, are to be integrally cast on welded Puddle Flanges.

7.7 Spun Iron Pipes

- 7.7.1 Spun Iron Pipes shall comply with BS 4622 for Centrifugally Cast Spun Iron Pipes.

7.8 Grey Iron Pipes and Fittings

- 7.8.1 Grey Iron Pipes where proposed shall comply with IS 262 for Grey Iron Pipes for Water Gas and Sewage.
- 7.8.2 Where flanged pipes are specified these shall comply with BS 2035 for Cast Iron Flanged Pipes & Flanged Fittings. Cast Iron Flanged Specials shall be manufactured to BS 2035, BS 4772:1988, BS EN 545:2006

7.9 Unplasticised PVC Pipes and Fittings

- 7.9.1 Unplasticised PVC pipes and fittings for cold potable water shall comply with the relevant provisions of BS EN 1452, BS 4660, IS EN 13598-1:2003, BS 5481 and IS EN 1401-1:1998.
- 7.9.2 Unplasticized P.V.C. pipe for watermains shall be certified by National Standards Association of Ireland under the Department of the Environment Heritage and Local Government's Certification Scheme, as complying with the "Local Government" Provisional Specification reference P.L.G.A., and shall bear the appropriate Mark of Conformity. Manufacturers or suppliers may be called upon by the Engineer to produce evidence from the N.S.A.I. that their products are so certified.
- 7.9.3 Joints and fittings for pressure pipes shall be in accordance with BS 3505 and BS EN 1452:2000 shall comply with BS EN 1452 part 1 to 5.
- 7.9.4 Unplasticized PVC pipes, joints and fittings for gravity sewers and drains shall comply with BS EN 1401-1:1998 and BS EN 13598-1:2003.
- 7.9.5 Unplasticized PVC Sewer Pipes shall only be used in House Connection lines and in the connection of road gullies unless otherwise stated in the Contract.

7.10 Polyethylene Pipes

- 7.10.1 Polyethylene (PE) Pipes and fittings shall comply with the provisions of BS EN 12201 – Plastic Piping systems for water supply.
- 7.10.2 High Performance Polyethylene Pipes shall comply with BS EN 12201, Type PE 100.

7.11 Glass Fibre Reinforced Plastic (GRP) Pipes

- 7.11.1 Pipes shall be manufactured to BS EN 14364:2006 (drainage and sewerage pipes) and BS EN 1796:2006 (water supply pipes).
- 7.11.2 Pipes shall be produced using an automatic repetitive process with a metered supply of all raw materials.
- 7.11.3 All pipes and joints shall be individually identified in addition to the marking requirements of BS EN 14364:2006 and BS EN 1796:2006. Pipe joints shall be suitable for the operating conditions specified.
- 7.11.4 The minimum pipe wall thickness and minimum pipe stiffness shall be as stated in the "Particulars of Works". Every individual pipe's wall thickness shall be measured and recorded. Where the pipe's wall is less than the minimum thickness stated by the manufacturer it shall be rejected unless it can be shown to meet the minimum stiffness value specified.
- 7.11.5 All pressure pipes together with their joints shall be hydraulically tested to the requirements of BS EN 14364:2003 and BS EN 1796:2006. Pipe stiffness testing shall be carried out in accordance with BS EN 14364:2003 and BS EN 1796:2006.

- 7.11.6 Pipe corrosion testing shall be in accordance with BS EN 1 4364:2003 and BS EN 1796:2006. In addition, the manufacturer will be required to have demonstrated that the joint will also be suitable for the corrosive conditions specified.

7.12 Acrylonitrile - Butadiene - Styrene (ABS) Pipes & Fittings

- 7.12.1 Acrylonitrile-butadiene-styrene pressure pipes and fittings shall comply with the relevant provision of BS 5391 - 1 and BS 5392 - 1 respectively.

7.13 Steel Pipes

- 7.13.1 Steel Pipes and Fittings shall comply with EN 10224 – non alloy steel tubes and fittings for the conveyance of aqueous liquids including water for human consumption.

7.14 Nuts, Washers Etc.

- 7.14.1 Nuts and Bolts, Washers and Gaskets shall comply with BS 4190, BS 4320 and BS 7874 respectively.

7.15 Plastic Sleeving for Buried Pipes

- 7.15.1 Tubular polyethylene film for use as a protective sleeving for buried iron pipes and fittings shall comply with the relevant provisions of BS 6076, except that the nominal layflat width for use with 100mm and 150mm nominal internal diameter pipelines incorporating mechanical flexible joints shall be 280mm and 400mm respectively.

7.16 Pipes for Land Drainage and Temporary Drains

- 7.16.1 Pipes, joints and fittings for land drainage and temporary drains shall comply with the relevant provisions of the appropriate Standard as set out in Table 6.1 below:

Type	Standard
"Perforated" or "Surface Water" vitrified Clay Pipes and Fittings	BS 65 and IS EN 295
Clayware Field Drain Pipes	BS 1196
Plastic Pipes for use as Light Duty Sub Soil Drains	BS 4962

TABLE 6.1 – LAND AND TEMPORARY DRAINS

7.17 Pipes For Ducts

- 7.17.1 Pipes, joints and fittings for exposed ducts for building services shall comply with the relevant provisions of the appropriate Standard as set out in Table 6.2 below:

Type	Standard
Unplasticised PVC pipes for industrial purposes	BS 3506 Class "O"
Hollow Steel Sections (greater than 150mm OD)	BS EN 10210-2:2006
Steel Tubes (Not greater than 150mm OD)	BS EN 10296

TABLE 6.2 – EXPOSED DUCTS

- 7.17.2 Pipes, joints and fittings for buried ducts shall have flexible mechanical joints and comply with the relevant provisions of the appropriate Standard as set out in Table 6.3 below:

Type	Standard
Vitrified Clay	BS 65
Unplasticised PVC	BS EN 13598 & BS EN 1401

TABLE 6.3 - BURIED DUCTS

7.18 Rainwater Pipes and Gutters

- 7.18.1 Rainwater pipes, gutters, fixings and accessories shall comply with the relevant provisions of the appropriate Standard as set out in Table 6.4 below:

Material	Standard
Cast Iron	BS 460, Type A
Aluminium	BS 2997
Unplasticised PVC	BS 4576 Part 1, IS EN 12200-1:2004

TABLE 6.4 - RAINWATER GOODS

7.19 Soil, Waste and Ventilating Pipes

7.19.1 Soil, waste and ventilating pipes, fittings and accessories for above-ground drainage systems shall comply with the relevant provisions of the appropriate Standard as set out in Table 6.5 below.

Material	Standard
Cast Iron	BS 416 Type A, IS EN 877:2000 & 2006
uPVC (Soil & Ventilating)	BS 4514
Polypropylene (Waste)	IS EN 1451-1:1999
Plastic (Waste)	BS 5255, IS EN 1329-1:1999, IS EN 1455-1:1999, IS EN 1519-1:1999 IS EN 1565-1:1999, IS EN 1566-1:1999

TABLE 6.5 – SOIL, WASTE AND VENTILATING PIPES MATERIAL STANDARD

7.19.2 Washbasin and sink wastes shall comply with the relevant provisions of IS EN 274 Parts 1-3: 2002.

7.19.3 Plastic waste traps shall comply with the relevant provisions of IS EN 274 Parts 1-3: 2002.

7.20 Transport and Storage

7.20.1 The handling, transportation and storage of pipes and fittings shall be done in accordance with the manufacturer's recommendations and in accordance with the following:-

1. Unplasticized PVC Pipes (Pressure) Recommendation SR3 published by NSAI.
2. Unplasticized PVC Pipes (Gravity) Recommendation SR7 published by NSAI.

7.20.2 During loading, unloading, stacking and general handling of pipe on site care shall be taken to avoid damage to all materials and in particular the coating/wrapping of iron or steel pipes and fittings. During transportation pipes shall be adequately supported for their length on a flat surface. Pipes shall be lifted with approved slings to avoid damage.

7.20.3 Pipe fittings and accessories shall be stored on a secure level site in a neat and orderly manner. Only those items required for immediate use shall be deposited along pipeline route.

7.21 Setting Out Of Sewers & Rising Mains

7.21.1 The Contractor shall be held responsible for the proper setting out of the pipelines, which shall be laid to their proper levels and grades with the aid of a pipe-laying laser. If sight rails are permitted, the centre of pipelines shall be located, at points of change of gradient or direction, with strong durable and firmly fixed pegs, and strong rails not less than 150mm deep with top edges planed straight and true shall be fixed over the centre of each manhole or where a change of direction or gradient occurs, and at any other points which may be selected or decided upon by the Engineer or Resident Engineer for this purpose. Each sight rail shall be supported by a rigid wooden post at each end and its top edge shall be accurately fixed to a definite height in even metres above the level of the invert of the sewer to be constructed. As a safeguard against the accidental displacement of a sight rail there shall be at least three rails on each length of sewer to be constructed at any one gradient and in any event the maximum distance between adjoining sight rails shall not be greater than 50 linear metres. The centre line of the pipeline shall be denoted on each sight rail front and back with a single vertical line drawn thereon and for easy vision it is desirable that the rails be painted with contrasting colours.

- 7.21.2 Boning rods shall be accurately made to the various lengths required in even metres and the lower end of each rod shall have a shoe of sufficient projection to rest on the invert of the last pipe laid.
- 7.21.3 Sight rails shall be provided, fixed and maintained by the Contractor, who shall set out the positions and levels of the pipelines according to the Drawings or in accordance with any written instructions he may receive from the Engineer during the progress of the work. The Contractor shall be held entirely responsible for the correctness of the levels and positions of pipelines and structures so set out by him and he shall provide at his own cost all labour and materials necessary to enable the Engineer to check the levels and dimensions whenever he considers it necessary to do so.
- 7.21.4 The use of sight rails will only be allowed in certain circumstances and the Contractor shall in general use a pipelaying laser to establish the final surfaces of the trenches, the bedding levels and the pipe levels and shall include for this in his rate for pipelaying.
- 7.21.5 In the case of twin pipe trenches a separate laser instrument shall be used on each pipeline. Pipelaying lasers shall be self-levelling with digital read out of grade and with an accuracy of not less than 0.01%.
- 7.21.6 Accessories shall include suitable base plates and targets for the smaller diameter pipes up to 400mm diameter. For the larger diameter pipes up to 1800mm diameter suitably fabricated supports and centering devices shall be provided to allow for accurate setting of the instruments either on the invert of the pipeline or on the centreline.

7.22 Pipe Laying

- 7.22.1 All pipes shall be laid to the lines and levels shown on the drawings or to such other alignments and gradients as may be directed by the Engineer.
- 7.22.2 Pipes shall be laid with the sockets facing upstream and starting at the downstream end of the trench. For pressure pipelines, each pipe shall slope upwards in the direction of the air valve serving the section of line in which it is laid. Suitable measures shall be taken to prevent soil or other material from entering pipes, and to anchor each pipe to prevent flotation or other movement before the Works are complete.
- 7.22.3 All pipes and specials shall be inspected before laying and defective ones removed from site.
- 7.22.4 Peat or boggy material below formation level shall be removed and replaced by broken stone or other approved stable filling material. In special situations where piling may be required the Engineer should be notified immediately.
- 7.22.5 Where socketed pipes are required to be laid on a granular bed joint holes shall be formed in the bedding material to ensure that each pipe is uniformly supported throughout the length of its barrel and to enable the joint to be made.
- 7.22.6 Pipes shall be laid on setting blocks only where a concrete surround or cradle is used.
- 7.22.7 No protective cap, disc or other appliance on the end of a pipe or fitting shall be removed permanently until the pipe or fitting that it protects is about to be jointed. Pipes and fittings, including any lining or sheathing shall be examined for damage and the joint surfaces and components shall be cleaned immediately before laying.
- 7.22.8 The Contractor shall prevent disturbance or softening of wet fine grained soils such as clays, silts and fine sands in the trench bottom, by proper drainage and by placing a blanket of coarse sand and gravel or other approved granular bedding material on the virgin formation as soon as it is uncovered. No traffic in the trench bottom shall be allowed until the blanket is in place. In very soft ground this blanket shall be additional to the normal bedding required for the pipe. Extra soft spots shall be hardened to the general condition of the bottom by tamping in granular material before continuing with the blanket.
- 7.22.9 In mixed soils containing large boulders, stones or flints, any object which is near enough to the bottom to form a hard spot shall be removed and replaced by granular material.
- 7.22.10 Where ground water is likely to interfere with the pipes or bedding, a sub-drain, to natural outlets clear of the trench shall be provided and the trench bottom sloped toward the drain. Where the flow of ground water is likely to transport fine soil particles, water stops of puddled clay extending up through the bedding and side fill shall be placed across the trench at intervals along the line. When no longer needed, temporary drains shall be sealed permanently by grouting, and any sumps formed for pumping ground water shall be filled with well compacted selected material as for the bedding.

7.23 Pipe Jointing

- 7.23.1 Pipe jointing surfaces and components shall be kept clean and free from extraneous matter until the joints have been made or assembled. Care shall be taken to ensure that there is no ingress of grout or other extraneous material into the joint annulus after the joint has been made.
- 7.23.2 Where pipes with flexible joints are required to be laid to curves, the deflection at any joint as laid shall not exceed one half of the maximum deflection recommended by the manufacturer. This is to allow residual deflection capacity in the event of settlement of bed or backfill material.
- 7.23.3 Fusion welded joints in PE 100 polyethylene pipes shall be made only between pipes having the same physical characteristics. Joints between pipes from different manufacturers shall only be made with the specific approval of the Engineer.
- 7.23.4 The pipe section containing the completed weld shall achieve at least the same strength characteristics as the virgin pipe. When welds are made during inclement weather suitable protection shall be provided to ensure that constant temperature conditions are maintained at the joints.
- 7.23.5 For flanged Joints, flanges shall be properly aligned before any bolts are tightened. Jointing compounds shall not be used when making flanged joints, except that, to facilitate the making of vertical joints, gaskets may be secured temporarily to one flange face by a minimum quantity of clear rubber solution. Bolt threads shall be treated with graphite paste and the nuts tightened evenly in diametrically opposite pairs.
- 7.23.6 Unplasticized P.V.C. pipes shall be jointed strictly in accordance with "The Recommendations for Handling and Installation of Unplasticized P.V.C. Pipe" published by the NSAI.
- 7.23.7 Unless otherwise particularly specified or directed spun iron pipes shall be jointed using an approved "push-in" type joint to the manufacturer's instructions.
- 7.23.8 Joints in steel pipes shall be made with Johnson Couplings assembled in strict accordance with the manufacturer's instructions unless otherwise specified or directed.
- 7.23.9 Rubber Joint Rings for watermains and drainage purposes shall be Types 1 and 2 respectively, complying with the relevant provisions of BS EN 681, and shall be obtained from the pipe manufacturer. Additionally, the Contractor shall supply to the Engineer a certificate confirming that the material to be used for joint rings for water mains complies with the recommendations in Information and Guidance Sheet 4-40-01 published by the Standing Technical Committee on Sewers and Water Mains.
- 7.23.10 Joint lubricants for sliding joints shall have no deleterious effects on either the joint rings or pipes, and shall be unaffected by the liquid to be conveyed. Lubricants to be used for jointing water mains shall not impart to water taste, colour or any effect known to be injurious to health, and shall be resistant to bacterial growth. Only lubricants recommended by the pipe manufacturers should be used.
- 7.23.11 Flanges for pipes and pipeline fittings shall, unless otherwise required by the Contract, comply with IS EN 1092-1:2002, IS EN 1092-2:1997 and IS EN 1092-3:2003, for 16 bar nominal pressure rating.
- 7.23.12 Gaskets for flanged pipe joints shall be of the inside bolt circle type. The dimensions of gaskets shall comply with IS EN 1514-1 / -2 / -3 / -4 / -6 / -7 / -8. Gaskets shall be manufactured from material complying with the provisions of BS EN 681-1 / -2 / -3 and -4.

7.24 Cutting Pipes

- 7.24.1 Where it may be necessary to cut any lined or unlined pipe either as a closing length or to bring any special or valve into its required position, the cutting shall be done in such a manner as to make a clean even cut at right angles to the axis of the pipe. Care shall be taken in lined pipes that the lining is not damaged in any way by such operation and any such damage shall be made good by the Contractor at his own expense.
- 7.24.2 Where ductile pipes larger than 450mm diameter are to be cut to form non-standard lengths, the Contractor shall comply with the manufacturer's recommendations in respect of ovality correction to the cut spigot end. The manufacturers Guidelines on Health and Safety must be strictly observed and enforced.
- 7.24.3 Where concrete pipes are cut, any exposed reinforcement shall be sealed with an epoxy resin mortar.
- 7.24.4 Pre-stressed concrete pipes shall not be cut on site.

7.25 Pipe Support in Bad Ground

- 7.25.1 Where pipes are to be laid in bad ground, approved type joints shall be used and the pipes supported in such manner as may be particularly specified or directed.

7.26 Pipe Bedding and Surround

- 7.26.1 Pipe bedding and surrounds shall be in accordance with the DoEHLG publication titled "Guidelines for the Opening, Backfilling and Reinstatement of Trenches in Public Roads" (also referred to as 'the Purple Book') and in accordance with the NRA "Specification for Road Works".
- 7.26.2 Where the depth to the top of the pipe is greater than 1200mm in roads/pavements and 750mm in fields, the following specification clauses applies. Where the depths to the top of pipe are less than these figures, refer to the Concrete Arch, Bed and Surround Clauses.
- 7.26.3 Unless particularly specified or otherwise directed, granular material to Clause 503 of the NRA Specification for Roadworks, will be used for all bedding, haunch and surrounds to sewers and pressure pipelines. Clause 503 Granular Material (also can be referred to as Type A material) shall consist of an aggregate with a size and grading as shown on Table 6.6.

Nominal Bore of Pipe (mm)	Aggregate Size (mm)	
	Single Sized	Graded
Not Exceeding 140	10	-
140 – 400	10, 14, 20	14 to 5 or 20 to 5
Exceeding 400	10, 14, 20 or 40	14 to 5, 20 to 5 or 40 to 5

TABLE 6.6 – CLAUSE 503/Type A PIPE BEDDING AGGREGATE GRADING

- 7.26.4 Unless otherwise specified, the minimum thickness of granular material below the barrel of the pipe shall be:
- (i) 150mm for pipes up to 300mm diameter
 - (ii) 200mm for pipes from 375mm to 1200mm diameter
 - (iii) In rock or mixed soils containing rock bands, boulders or other hard spots the thickness of granular material shall be increased by 100mm.

- 7.26.5 Where the bottom of the trench is in rock or in mixed soils containing boulders or hard spots the above bedding depths shall be increased by 100mm.
- 7.26.6 Unless otherwise specified, the minimum thickness of granular material above the barrel of the pipe shall be 300mm.
- 7.26.7 Allowance shall be made for pipe joints and couplings when forming the pipe bed.
- 7.26.8 Clause 503 granular material shall be placed by hand in the excavation below the level of the pipe barrel and shall be tamped and rammed by hand in layers not exceeding 150mm thick before compaction to provide a dense well compacted bed free from soft spots throughout the length of the pipeline between joint and sling holes. After the pipes have been properly bedded and tested Clause 503 granular material shall be carefully placed into the spaces between the pipe and the sides of the trench to the level of half pipe. The Clause 503 material shall be thoroughly packed and rammed by careful hand tamping in layers not exceeding 150mm thick before compaction. The placing and the tamping of the material shall proceed equally on both sides of the pipe.
- 7.26.9 Where waterlogged soil conditions are encountered the final excavation of the trench for the pipe bed shall not be carried out until the Contractor is in a position to place the granular bed. If required, a 75mm drainpipe shall be provided in the granular material.

7.27 Testing Of Pipe Bedding and Surround Material

- 7.27.1 For testing pipe bedding and surround material, a representative sample of about 40kg. shall be heaped onto a clean surface and quartered to obtain approximately 10kg. The moisture content of the sample should not differ materially from that of the main body of material, at the time of use in the trench.
- 7.27.2 A 150mm internal diameter open ended cylinder, 250mm high, shall be placed on a firm flat surface and loosely filled, without tamping, from the 10kg. sample. Any surplus material shall be struck off level with the top of the cylinder. The area around the filled cylinder shall be cleared of all surplus material and the cylinder then lifted clear of its contents and placed alongside the material. Approximately one quarter of the material shall then be placed into the cylinder and compacted by tamping vigorously with a 40mm diameter metal rammer weighing about 1kg. until no further compaction can be obtained. This operation shall then be repeated for each of the remaining quarters, tamping the final surface as level as possible. The distance from the top of the cylinder to the surface of the final layer shall then be measured and this value, divided by the height of the cylinder, shall be taken as the Compaction Fraction.

7.28 Concrete Bed Haunch Surround and Arch

- 7.28.1 Where the cover over the pipe is less than 1200 mm in roads/paved areas or 750mm in fields a concrete arch to the dimensions shown on the drawings shall be placed over the pipeline.
- 7.28.2 Where the cover over the pipe is less than 600mm in roads/paved areas or 500mm in fields the pipe shall be bedded and surrounded in concrete to the dimensions given on the 'Typical Details' drawings.
- 7.28.3 Concrete for bed, haunch, surround or arch to pipes shall be (C16/20 to IS EN 206-1:2002) and no back filling of the trench shall be carried out until the 2 concrete has reached a strength of 15 N/mm².
- 7.28.4 Compressible filler for interrupting concrete protection to pipelines shall consist of bitumen impregnated in sulating board to IS EN 316:2000, IS EN 321:2002, IS EN 322:1993, IS EN 323:1993, IS EN 324-2:1993, IS EN 325:1993, IS EN 382-1:1993, IS EN 622-1:2003, IS EN 622-2:2004 and IS EN 622-3:2004 or other equally compressible material. The thickness of compressible filler shall be as per Table 6.7 below:

Nominal Bore of Pipe (mm)	Thickness of Compressible Filler (mm)
Less than 450	18
450 – 1200	36
Exceeding 1200	54

TABLE 6.7 – COMPRESSIBLE FILLER

Compressible packing for use between pipes and precast concrete setting blocks shall consist of bitumen dampproof sheeting complying with BS 743, Type G, BS 6398:1983, BS 6515:1984 and BS 8215:1991.

- 7.28.5 For bed, haunch and surround, before placing, concrete pipes shall be supported near each joint on a precast concrete block or engineering brick with a padding of two layers of hessian based damp proof course or material of similar yield between the barrel of the pipe and the supporting block. The surface of the support shall be perfectly smooth for at least 75mm x 75mm under the pipe. Precast setting blocks for pipes shall have rectangular faces, with sufficient plan area to provide an adequate seating for the pipes. They shall be manufactured from (C16/20 to IS EN 206-1:2002) concrete using the same type of cement as in the adjacent concrete bed, and be cast in an approved mould. Blocks shall not be used until they have achieved a cube strength of 13.5 N/mm².

- 7.28.6 Concreting of bedding, haunching, arch or surrounding shall not be carried out until the pipes have been jointed and inspected. The concrete shall be tamped or vibrated into place under the pipe and the concrete shall be in full contact with the underside of the barrel of the pipe throughout its length. The concrete shall be placed in one operation and shall be well worked to form a homogeneous mass. There shall be no horizontal construction joint in the concrete below the level of the half pipe. The pipe shall be carefully anchored against flotation.
- 7.28.7 Concrete bedding, haunching, arch or surround to pipes shall be discontinuous at flexible pipe joints. Shaped formwork made from fibreboard, polystyrene or other equally compressible material of the thickness stated on the Drawings and of size and shape equal to the net section of the concrete protection to the pipes shall be used and left at the pipe joints as shown on the Drawings. The formwork shall be neatly cut and properly supported by temporary struts and rails where necessary.
- 7.28.8 Where the concrete is not carried up to the crown of the pipe the spaces between the barrel of the pipe and the sides of the trench shall be filled with carefully compacted Clause 503 granular material, in roads, road margins and in fields where suitable excavated material is not available. Clause 503 material should be at least 300mm deep after compacting and the full width of the trench, it shall be placed in two equal layers over the crown of the pipe each layer being lightly tamped by hand.

7.29 Backfilling of Trenches

- 7.29.1 Backfilling of pipe trenches shall be in accordance with the DEHLG "Guidelines for the Opening, Backfilling and Reinstatement of Trenches in Public Roads" and in accordance with the NRA "Specification for Road Works".
- 7.29.2 Clause 804 granular backfill material, as defined by the NRA "Specification for Road Works" is generally to be used. The backfill material shall be compacted in layers in accordance with Clause 802.
- 7.29.3 In locations other than roads and footpaths (i.e. fields and grass margins where trench is over 1 metre from paved road edge) and where suitable selected material is available from original excavations, the material shall be placed into the spaces between the pipe and the sides of the trench to the level of the crown of the pipe. The fill shall be thoroughly packed and rammed by careful hand tamping in layers not exceeding 150mm thick before compaction. The placing and the tamping of the material shall proceed equally on both sides of the pipe. Unless particularly specified or otherwise directed, the fill material at least 300mm deep after compaction and the full width of the trench, shall be placed in two equal layers over the crown of the pipe, each layer being lightly tamped by hand.
- 7.29.4 Selected backfill material whether selected from locally excavated material or imported shall consist of uniform readily compactable material free from vegetable matter, building rubbish and frozen material or materials susceptible to spontaneous combustion. It shall exclude materials of excessively high moisture content, clay lumps, retained on a 75mm sieve and stones retained on a 25mm sieve.
- 7.29.5 In fields where suitable excavated material is not available and in all roads and road margins, Clause 503 material shall be placed into the spaces between the pipe and the sides of the trench to the level of the crown of the pipe. This material shall be thoroughly packed and rammed by careful hand tamping in layers not exceeding 150mm thick before compaction. The placing and the tamping of the material shall proceed equal on both sides of the pipe. Unless particularly specified or otherwise directed, Clause 503 granular material at least 300mm deep after compaction and the full width of the trench, shall be placed in two equal layers over the crown of the pipe, each layer being lightly tamped by hand.

7.30 Testing of Pressure Pipelines

- 7.30.1 Gauges used for testing pressure pipelines shall either be of the conventional circular type, not less than 300mm diameter, calibrated in metres head of water, or shall have a digital indicator capable of reading increments of 0.1 metre head. Before any gauge is used, the Contractor shall arrange for it to be checked independently, and a dated certificate of its accuracy shall be provided.
- 7.30.2 The pipelines shall be tested in lengths determined by the Course of Construction in accordance with a Programme approved by the Engineer. Initially the testing will be carried out on Sections of maximum length of 500 metres.
- 7.30.3 In general and unless otherwise stated the site test pressure of any pipe shall be not less than 1.5 times the working pressure and shall not exceed the works test pressure for that pipe material. Further information on testing pipes is contained in the relevant Standard Specification for that pipe material
- 7.30.4 Before testing, valves shall be checked and sealed, the Sections of main filled with water and the air released. After having been filled, pipelines shall be left under working pressure for a period of 24 hours so as to achieve conditions as stable as possible for testing.

- 7.30.5 The pressure in the pipeline shall then be raised steadily until the specified test pressure is reached in the lowest part of the section and the pressure shall be maintained at this level, by pumping if necessary for a period of one hour. At the end of this period the original pressure shall be restored by pumping and the loss measured by drawing off water from the pipeline until the pressure as at the end of the test is again reached. The permissible loss shall not exceed 2 litres per 100mm nominal bore per kilometre length per 10 metres head (calculated as the average head applied to the section) per 24 hours.
- 7.30.6 In addition to the tests on separate sections, the whole pipeline shall be tested on completion to the same pressure and by the same procedures as that outlined for individual sections.
- 7.30.7 All defective pipes whether cracked, porous, leaky or showing other faults shall be replaced with new pipes. All leaking joints shall be made good.
- 7.30.8 Before testing any pipeline, the Contractor shall ensure that it is anchored adequately and that thrusts from bends, branch outlets or from the pipeline ends are transmitted to solid ground or to a suitable temporary anchorage. Open ends shall be stopped with plugs, caps or blank flanges properly jointed. The Contractor shall ensure that the pipelines are tested in a safe manner.
- 7.30.9 The Contractor shall notify the Engineer at least one clear working day beforehand of his intention to test a section of pipeline.

7.31 Testing of Gravity Pipelines

- 7.31.1 Gravity pipelines laid in open cut shall be tested after they are jointed and before any concreting or backfilling is commenced, other than such as may be necessary for structural stability whilst under test. The pipeline shall be tested by means of an air or water test or by a visual examination, in lengths determined by the course of construction, in accordance with a programme approved by the Engineer. A further test shall be carried out after the backfilling is complete. Any defective leaky or porous pipes shall be immediately replaced and the testing repeated.
- 7.31.2 Water Test. The test pressure for gravity pipelines shall be not less than 1.2 metres head of water above the pipe soffit at the highest point and no greater than 6 metres head at the lowest point of the section. Steeply graded pipelines shall be tested in stages in cases where the maximum head, as stated above, would be exceeded if the whole section were tested in one length. The pipeline shall be filled with water and a minimum period of two hours shall be allowed for absorption, after which water shall be added from a measuring vessel, at intervals of 10 minutes and the quantity required to maintain the original water level noted. Unless otherwise specified, the length of pipeline shall be accepted if the quantity of water added over a 30 minute period is less than 0.5 litres per lineal metre per metre of nominal bore. Notwithstanding the satisfactory completion of the above test, if there is any discernible leakage of water from any pipe or joint, the pipe shall be replaced and/or the joint remade, as appropriate, and the test repeated until leakage is stopped.
- 7.31.3 Air Test. Gravity pipelines to be air tested shall have air pumped in by suitable means until a pressure of 100mm head of water is indicated in a U-tube connected to the system. The pipelines shall be accepted if the air pressure remains above 75mm head of water after a period of 5 minutes without further pumping following a period for requisite stabilisation. Drains, which incorporate traps, can be tested only to 50mm head of water. The permissible loss is then 12.5mm head of water in 5 minutes. Air pressure can be affected by temperature changes or by defects in the testing apparatus. Consequently, failure to pass this test is not conclusive and, when failure does occur, a water test should be made and the leakage rate determined before a decision as to acceptance or rejection is made.
- 7.31.4 Gravity pipelines and manholes shall be tested for infiltration after the backfilling. All inlets to the system shall be effectively closed, and any residual flow shall be deemed to be infiltration. The pipeline, including manholes shall be accepted as satisfactory if the infiltration, including infiltration into manholes, in 30 minutes does not exceed 0.5 litres per lineal metre per metre of nominal bore. Notwithstanding the satisfactory completion of the above test, if there is any discernible flow of water entering the pipeline at a point which can be located either by visual or TV inspection, the Contractor shall take such measures as are necessary to stop such infiltration.

7.32 Cleaning of Pipelines

- 7.32.1 On completion of construction, and before any sterilisation of watermains or before any connections are made to sewers internal surfaces of pipelines shall be cleaned thoroughly in such a way as to remove all oil, grit and other deleterious matter without damage to the pipes.

7.33 Inspection of Gravity Pipelines

- 7.33.1 A C.C.T.V. Inspection shall be carried out on all gravity sewers of diameter less than 1200mm while a visual inspection shall be carried out on Sewers of 1200mm nominal diameter or over. Where internal inspection of pipelines by closed circuit television is required, the Contractor shall provide all necessary equipment, including suitable covered accommodation for viewing the monitor screen, together with personnel experienced in the operation of the equipment and interpretation of results.
- 7.33.2 The intensity of illumination within the pipe and the rate of draw of the camera shall be such as to allow a proper examination of the inside of the pipe. Provision shall be made for the movement of the camera to be stopped and its position recorded and for permanent photographs to be taken at any point requested by the Engineer.
- 7.33.3 For the Visual Inspection of gravity sewer lines of nominal diameter 1200mm or over the Contractor shall provide lighting by means of generator or otherwise. The Contractor shall include for having Photographs taken in the pipelines in conjunction with the visual inspection at the locations required by the Engineer but based on two photographs at intervals of 25 metres. The Contractor shall also provide assistance for the carrying out of such visual inspection.

7.34 Anchorage of Pipes and Fittings

- 7.34.1 Except where self-anchoring joints are used, thrusts, where there is a change of direction, a cap end, tee connection or gradient exceeding 1 in 6, shall be resisted by concrete thrust blocks cast in contact with undisturbed ground. The blocks shall be constructed in (C16/20 to IS EN 206-1:2002) concrete.
- 7.34.2 Any additional excavation required to accommodate thrust blocks shall be carried out after the bend or branch is in position and the thrust face shall be trimmed back to remove all loose or weathered material immediately prior to concreting. Thrust blocks shall be allowed to develop adequate strength before any internal pressure is applied to the pipeline
- 7.34.3 No joint or part of a joint shall be encased in an anchor block.

7.35 Flushing and Sterilizing Watermains

- 7.35.1 Before the works are handed over the Contractor shall flush out and sterilise the entire pipeline system. Flushing and sterilizing shall be carried out before house connections are made unless otherwise directed. Any connections, which may have been made to the mains, shall be closed. Water for the flushing operation shall be potable water. The flushing and sterilizing shall continue until the Engineer is satisfied that all foreign matter of deleterious character has been entirely removed from the mains or rendered innocuous.
- 7.35.2 For sterilization, liquid chlorine, dry chlorine, or calcium hypochlorite may be used, and the various supply and distribution systems shall be divided into convenient sections and systematically treated with sterilant. Before starting the work the Contractor shall submit full details of his proposals including disposal of the chlorinated water to the Engineer for his approval.
- 7.35.3 Chlorine shall be injected at the upstream end of the pipeline section to be sterilised at such a rate that the residual chlorine available at the downstream (Scour) end shall be 10 parts per million. When this residual has been achieved the mixture in the main shall be allowed to stand for two hours minimum. The main shall then be emptied and thoroughly flushed. Care shall be taken in the chlorination, emptying and flushing of the main that the heavily chlorinated mixture does not contaminate existing watermains or existing watercourses, drains or streams.
- 7.35.4 The disposal of this chlorinated water must strictly comply with current disposal legislation and must be in accordance with the requirements of the Local Authority.

7.36 Water Fittings

- 7.36.1 6.36.1 Water fittings shall comply with the relevant provisions of the appropriate Standards as set out in Table 6.8 below:

Water Fitting	Type/Material	Standard
Service Pipes, Pump Delivery Pipes, Distributing Pipes & Fittings	Copper Copper and Copper Alloy fittings for use with copper tubes, Polyethylene (Type 32) Polyethylene (Type 50) Copper and Copper Alloy Compression Fittings for Polyethylene Pipes Polyethylene Joints and Fittings (Performance) uPVC Pipes uPVC Joints and Fittings (Solvent Welded) uPVC Joints and Fittings (Mechanical)	IS EN 1057:2006 BS 864-2 and IS EN 1254 Parts 1-5 BS 6572, BS 6730, BS EN 12201-1/-2/-5 IS 135 BS 864 Part 3 BS 5114 BS 3505 and IS EN 1452 Parts 1-5 BS 4346 Part 1 and 2 IS EN 1452 Parts 1-5
Drainage Taps	Screw down pattern Type 1 nominal size .5	BS 2879
Draw Off Taps	Metal Bodied (Performance) Plastic Bodied	BS 5412 BS 5412
Stop Valves	Above ground, screw down pattern Underground, crutch type	BS 1010, Part 2 BS 5433
Float Operated Valves	Diaphragm Type (Brass body) Diaphragm Type (Plastic body)	BS1212, Part 2 BS 1212, Part 3
Floats for Ballvalves	Copper Plastics	BS 1968 BS 2456
Storage Cisterns and Covers	Mild Steel Grade A Polyethylene or Polypropylene	BS 417, Part 2 BS 4213
Wash Basins	Ceramic with Pedestal Metal Hand Rinse	BS 1188 BS 1329 & BS 6731
Sinks	Glazed Fireclay Metal	BS 1206 IS EN 13310:2003
W.C. Pans	Horizontal Outlet	IS EN 33:2003 IS EN 37:1997 IS EN 997:2003 AMD 2006
Connectors	Plastic Connectors	BS 5627
WC Seats and Covers	Plastic Type 1	BS 1254
WC Flushing Cisterns	Dual Flush Type	BS 1125
Urinals	Stainless Steel Slab Vitreous China Bowl	BS 4880 Part 1 BS 5520
Automatic Flushing Cisterns for Urinals	Lidded	BS 1876

TABLE 6.8 – WATER FITTINGS

7.37 Manholes & Chambers - General

- 7.37.1 Manholes & chambers shall be constructed to the dimensions and details shown on the drawings. Manholes shall be watertight and not liable to infiltration. Construction of all foul manholes must be such to resist sulphate attack.
- 7.37.2 Unless otherwise particularly specified or directed, manholes for foul sewer networks shall be Cast In-Situ Manholes.
- 7.37.3 Cast In-Situ Manholes & Chambers. Manholes shall be reinforced or unreinforced as described on the Standard Manhole Drawings. Wall thickness shall vary in depth and chamber size as described on the Drawings but shall be a minimum of 225mm thick. Manholes shall be constructed in In-Situ C28/35 concrete. Internal and external finish to surfaces shall be fairfaced and all exposed internal arises shall be finished with 25mm x 25mm chamfers.
- 7.37.4 Precast Concrete Manholes. The use of precast concrete manholes may be allowed in certain circumstances. They shall not be constructed without the permission in writing of the Engineer. If permission is granted they shall be constructed to BS 5911 as fully watertight chambers and shall be fully backed for their entire depth with Concrete (C16/20 to IS EN 206-1:2002) to a minimum thickness of 150mm. Backing Concrete shall be shuttered to provide a fairfaced finish.
- 7.37.5 Units which bed onto bases, or onto which cover slabs or reducing slabs sit, shall be manufactured so that imposed vertical loads are transmitted directly to the full wall thickness of the unit. For joints between units and the underside of slabs, spigot-ended sections shall only be used where the soffit of the slab is recessed to receive them.
- 7.37.6 Precast concrete cover slabs shall be a minimum of 300mm thick C28/35 reinforced concrete as described on the Drawings with minimum steel cover of 40mm.
- 7.37.7 Manhole chambers shall be subjected to water test as directed by the Engineer. The chambers to be tested shall be filled with water and allowed to stand full for 48 hours. They shall then be tested and deemed to be watertight if the drop in water level is not more than 12mm in a further 24 hours. Any chambers which fail the test shall be repaired and made watertight at the Contractor's expense and retested to the satisfaction of the Engineer.
- 7.37.8 The standard Manhole Drawings set out the detailed arrangement of standard manholes.
- 7.37.9 Pipes in and out of manholes shall be as short as practicable and shall be as detailed on the Standard Manhole Drawings. Pipes shall be built in monolithically with the manhole and made fully watertight. Where line, level and pipe diameter permit the pipeline may be laid unbroken through the manhole position subject to the pipe joints external to the manhole not occurring at greater distance than 600mm from the inner face of the manhole wall. Refer also to Rocker Pipe clause.

7.38 Manholes – Cover and Frames

- 7.38.1 Manhole covers and frames shall comply with the requirements of IS EN 124. Loading requirements are as follows:-

Location	Loading
All Roads	Class D400
Heavy Trafficked Roads	Class E600
Public Footpaths	Class C250
Private Footpaths, Driveways and Parking Areas	Class B125
Gardens, Fields etc.	Class B125

- 7.38.2 Each cover and frame shall have clearly marked IS EN 124 and Class Letter/Number, the name and identification mark of the manufacturer, the year and place of manufacture and the mark of the certification body.
- 7.38.3 Generally frames shall be square, with double triangular covers with closed keyway in each half cover, which shall be bolted together so that the complete covers cannot fall through into the manhole shaft. The minimum cover opening shall be 600mm x 600mm and a minimum depth of 100mm. Heavily trafficked roads will require a 150mm deep frame. All covers must be of a non-rock design.
- 7.38.4 Access covers for house connections shall be Class D400 with 600mm x 450mm clear openings where vehicular access is possible. For locations inaccessible to motor vehicles on house connection lines IS EN 124 Class C250 covers and frames in Ductile Iron and with 600mm x 450mm openings shall be permitted. All access covers shall have closed keyways.
- 7.38.5 In certain locations where flooding is anticipated fully watertight covers to special design as specified shall be provided and fixed as detailed on the Drawings.
- 7.38.6 Manhole covers and frames shall be fixed in the positions indicated. Frames shall be solidly bedded in sand/cement mortar (2:1) so that the covers when in position are fair and even with adjacent surfaces. Where indicated on the Drawings or described in the Specification frames shall be bedded on from one to three courses of engineering brickwork in cement mortar.

7.39 Manholes – Step Irons and Ladders

- 7.39.1 Manhole rungs shall be formed from 25mm hot dipped galvanised mild steel to the dimensions shown on the drawings and embedded 150mm into walls. Rungs shall have both ends split and lugged and the entire rung shall be galvanised as described in IS EN ISO 1462:1999 to a minimum mass of 720 grams per square metre and finally P.V.C. coated.
- 7.39.2 Rungs are not required where the depth to benching is less than 900mm and the diameter of the largest pipe is less than 450mm. Channels greater than 750mm in depth shall be provided with recessed rungs built into channel benching and have a handrail or post within easy reach.
- 7.39.3 Rungs shall be provided at 230mm vertical centres with the uppermost rung not greater than 675mm from the top of the manhole cover.
- 7.39.4 Where indicated on the Standard Manhole Drawings, Mild Steel Ladders hot dipped galvanised after fabrication in accordance with IS EN ISO 1462:1999 shall be provided instead of rungs. Ladders shall comply with the relevant provisions of BS 4211 and shall be galvanised to a minimum mass of 720 grams per square metre.
- 7.39.5 Stainless steel ladders for vertical fixing shall be fabricated from Grade 316S31 steel complying with [IS EN 10083-1:2006, IS EN 10084:1998, IS EN 10085:2001, IS EN 10087:1999, IS EN 10088-1 / -3:2005, IS EN 10095:1999, IS EN 10250-4:2000 and PD970:2005] or [IS EN 10029:1991, IS EN 10048:1997, IS EN 10051:1991:AMD1:1998, IS EN 10095:1999 and IS EN ISO 9445:2006] and shall comply with any dimensional provisions of BS 4211.
- 7.39.6 Aluminium ladders for vertical fixing shall be fabricated from Grade 6082 aluminium complying with IS EN 12020-2:2001, IS EN 573-3:2003, IS EN 573-4, IS EN 755-2:1997 and IS EN 755. It shall also comply with any relevant provisions of BS 4211. After fabrication, aluminium ladders shall be anodised in accordance with IS EN 12373-1:2001 Grade AA25.

7.40 Manholes - Safety Chains and Handrails

- 7.40.1 All manholes on pipes of 450mm diameter and over shall be provided with safety chains for placing across the mouth of the pipes on the downstream side where people are at work. Safety chains with links 40mm by 5mm diameter shall be of stainless steel and shall be permanently fixed on one side by means of a 16mm Rawl Bolt with eye and fixed into the manhole wall. On the other side 2 No. 16mm diameter hook type rawl bolts, shall be built into the positions indicated to allow placement of chain on either as required.
- 7.40.2 Stainless steel safety chain shall be manufactured from Grade 316 S 31 steel complying with IS EN 10083-1:2006, IS EN 10084:1998, IS EN 10085:2001, IS EN 10087:1999, IS EN 10088-1 / -3 :2005, IS EN 10095:1999, IS EN 10250-4:2000 PD970:2005. Chain links shall be welded and have an internal length not exceeding 40mm and an internal width of between 12mm and 18mm. The fins caused by welding shall be removed and the weld shall be smoothly finished all round. When tested in accordance with Clause 7.3 of BS 4942 Part 2, each chain shall withstand a breaking force of 30 kN and a proof force of 15 kN.

7.40.3 Double handrailing of modular type as described on the in the drawings shall be hot-dip galvanised to IS EN ISO 1461:1999 to a minimum mass of 720 grams per square metre and shall be provided on the edges of all benchings, platforms etc.

7.40.4 Handrails and balusters shall be manufactured from material complying with the relevant provisions of the appropriate Standard as set out in Table 6.9 below. Protective barriers shall comply with the provisions of BS 6180 for Building - use Category 6.

Materials	Handrails				Balusters			
	Solid		Tubular		Solid		Tubular	
	Standard	Grade	Standard	Grade	Standard	Grade	Standard	Grade
Mild Steel	IE EN 10025 – 1/2/4 : 2004, BS 7668, IS EN 10029, IS EN 10210-1	43A	IS EN 10255:2004, Or IS EN 10296-1:2003	HFW2	IS EN 10025 – 1/3/4:2004, BS 7668, IS EN 10029, IS EN 10210-1	43A	IS EN 10255:2004, Or IS EN 10296-1:2003	HFW2
Stainless Steel	IS EN 10083-1:2006, IS EN 10084:1998, IS EN 10085:2001, IS EN 10087:1999, IS EN 10095:1999, IS EN 10250-4:2000, PD970:2005	316-S31	IE EN 10296-2:2006	LW17KM	IS EN 10083-1:2006, IS EN 10084:1998, IS EN 10085:2001, IS EN 10087:1999, IS EN 10088-1/3:2005, IS EN 10095:1999, IS EN 10250-4:2000, PD 970:2005	316-S31	IS EN 10296-2:2006	LW17K
Aluminium	IS EN 12020-2, IS EN 573-3/4, IS EN 755-2/3/4/6/7/8/9	6082	IE EN 12020-2, IE EN 573-3/4, IS EN 755-2/3/4/6/7/8/9, IS EN 573-3/4, IS EN 754-1/2/7	6082		LM6	IS EN 12020-2, IS EN 573-3/4, IS EN 755-2/3/4/6/7/8/9 Or IS EN 573-3/4, IS EN 754-1/2/7	6082

TABLE 6.9 – HANDRAILS AND BALUSTERS HANDRAILS BALUSTERS

After manufacture, mild steel and aluminium handrails and balusters shall be hot dip galvanized or anodized, as appropriate, in accordance with IS EN ISO 1461:1999 or IS EN 12373-1:2003.

7.41 Manholes – Bases and Benching

- 7.41.1 Bases and benching shall be formed in Concrete C28/35 and benching shall be rendered in Granolithic Concrete 25mm thick trowelled smooth and shall slope towards the main channel at a slope of 1 in 12.
- 7.41.2 Granolithic rendering shall consist of 2 Parts Portland Cement (CEMI to EN 197) (by Volume) and 5 Parts clean whinstone chippings graded 10mm to dust. Mastercron hardener, or other approved equivalent hardeners, shall be added to the mixture at the rate of 10kg. per 0.1 m³ and the whole shall be thoroughly mixed to a uniform colour. The water cement ratio shall be kept to the minimum required to obtain a workable mixture, which shall be of uniform consistency throughout.
- 7.41.3 Except where detailed to the contrary in the Bill of Quantities the rendering shall have a minimum thickness of 25mm and the surface shall be lightly panned by wooden beaters and floated to true planes throughout and thoroughly worked and polished with plasterers irons.

7.42 Manholes – Invert Channels

- 7.42.1 The depth of the main channel shall not be less than the diameter of the largest pipe. Branch pipes shall join manholes with their soffits no lower than the soffit of the main sewer. Where possible main channel inverts for pipes up to and including 300mm diameter shall be vitrified clay, or pre-cast concrete channels or where the sewer is constructed of steel or cast iron pipes the channels may be of the same material. Main channel inverts for pipes over 300mm diameter may be as the foregoing or may be formed in Granolithic Concrete trowelled smooth. Where pipes have been laid unbroken through the manhole position the crown of the pipe shall be broken out to the half diameter over the full length of the manhole and the benching completed as shown on the Drawings.
- 7.42.2 Branch bends up to and including 150mm diameter shall be vitrified clay of half section curved in the direction of flow and set to deliver over the main channel invert. Branch bends over 150mm diameter shall be curved in the direction of flow and shall be formed in Granolithic Concrete trowelled smooth. Spaces between branch bends shall be completely filled with concrete and the faces above the main and branch channel inverts shall be trowelled smooth.

7.43 Manholes – Backdrop Manholes

- 7.43.1 Backdrop manholes shall be constructed where indicated on Longitudinal Section Drawings and as detailed on the Drawings. They shall be constructed complete with rodding eye and vertical drop formed with a tumbling bay on the incoming sewer.
- 7.43.2 The tumbling bay and drop pipe shall be of precast concrete and shall be of the diameter indicated on the Standard Manhole Drawings. The drop shall terminate with a special strength concrete 90 degree spigot and socket bend complete with a make up length of concrete pipe, all of the same diameter. The back drop pipe, tumbling bay and 90 degree bend shall be surrounded with Concrete (C28/35 to IS EN 206-1:20 02) to a minimum thickness of 150mm and shall be finished with a fairfaced surface externally.
- 7.43.3 A 6mm thick stainless steel splash plate shall be bolted to the manhole wall using 4 No. 6mm diameter stainless steel rawl-bolts.

7.44 Pipeline Penetrations/Rocker Pipes

- 7.44.1 All pipelines at entry to, or exit from, all tanks, chambers and thrust blocks shall be fitted with a flexible joint/rocker pipe detail, configured as follows:-
 - (i) Flexible Coupling.
 - (ii) Plain Ended Ductile Iron Spacer piece, minimum length one metre.
 - (iii) Flexible Coupling.

7.45 Sluice Valves and Scour Valves

- 7.45.1 Sluice Valves and Scour Valves shall comply with the requirements of BS 5163 and BS EN 1074-1:2000 and have a 16 Bar Rating unless otherwise detailed in the Contract and have N.P. 16 flanges. Valves are to be inside screw valves with non-rising spindles. The spindles of underground valves shall be fitted with cast iron caps secured with setscrews or pins, while valves above ground shall be fitted with cast iron hand wheels, on which the direction of opening is to be marked. All valves are to be clockwise closing.
- 7.45.2 Valves are to be hydraulically tested during manufacture in accordance with BS 5163 and BS EN 1074 and a manufacturer's test certificate shall be produced for each valve on request. All sluice valves are to be flanged unless otherwise specified.
- 7.45.3 Where necessary valves shall be fitted with extension spindles or universal joint operating rods and headstocks or spindle caps as appropriate.
- 7.45.4 All valves shall be closed and open-end tested.
- 7.45.5 All machined surfaces of valves shall be supplied with a protective coating of a non-toxic bituminous composition applied by a hot-dipped process. Machined surfaces, liable to rusting, shall be well covered with a rust preventative composition.
- 7.45.6 All valves shall be clearly marked with the appropriate schedule reference number. Large items shall be so marked in two places for ease of identification.
- 7.45.7 Unless otherwise specified the Sluice Valve Surface Boxes shall be Cast Iron 100mm diameter with a clear opening 200mm deep.
- 7.45.8 Electric actuators for Sluice Valves are to be sealed watertight actuators of approved manufacture, suitable for use in the Hydraulic Conditions pertaining.

7.46 Air Valves

- 7.46.1 Air Valves, whether for sewage or potable water, shall comply with the requirements of BS EN 12380:2002, air admittance valves for drainage systems.
- 7.46.2 Air Valves, whether for sewage or potable water, shall be the product of an approved manufacturer and shall have bodies and covers of best tough cast iron, with flanged inlets of the size specified below. Unless otherwise specified, Dual (Double) Air Valves shall be used, having a large and a small air escape orifice, with rubber or vulcanite balls and rubber seatings. They shall be fitted with screw down type isolating valve having a forged bronze screwed spindle with cast iron cap and gunmetal valve and seat.
- 7.46.3 The small orifice shall be capable of permitting the escape of air under the maximum working pressures appropriate to the Class of pipe and the Valves shall be tested during manufacture to at least 50% in excess of the maximum working pressure.
- 7.46.4 Kinetic Double Air Valves where specified are to be mounted on butterfly isolating valves. They are to have flanged inlets of not less than 80mm diameter.
- 7.46.5 Unless otherwise specified the Air Valve Surface Boxes shall be Cast Iron 450mm x 300mm x 150mm deep with a perforated cast iron cover.

7.47 Hydrants

- 7.47.1 Hydrants, hydrant boxes and covers shall comply with the relevant provisions of BS 750:2006. Hydrants shall be screw down streamline pattern with 80mm inlets and 63mm male thread outlets.
- 7.47.2 Hydrant box covers shall be provided with recesses for lifting keys.
- 7.47.3 Hydrant indicator plates shall comply with relevant provisions of BS 3251.
- 7.47.4 Unless otherwise specified the Hydrant Surface Boxes shall be Cast Iron 375mm x 225mm x 150mm deep with an approved identification mark on cover.

7.48 Surface Boxes and Guards

- 7.48.1 Small surface boxes shall comply with the relevant provisions of BS 5834-2:1983. Guards for underground stopvalves shall comply with the relevant provisions of BS 5834-1:1985.

7.49 Pipeline Fittings and Accessories

- 7.49.1 Unless otherwise particularly specified or directed the following standards shall apply to fittings:- Stopcocks BS 5433
- 7.49.2 Unless otherwise specified the materials, dimensions and finishes of appurtenances shall be as follows. Stopcock Covers: Cast Iron 90mm clear opening 50mm deep. Cover to be hinged and appropriately marked.
- 7.49.3 All valve and hydrant chambers shall be constructed to the details shown on the drawings.

7.50 Road Gullies

- 7.50.1 Precast concrete gullies shall comply with the relevant provisions of BS 5911-4:2002 and IS EN 1917:2002.
- 7.50.2 In-Situ concrete gullies shall be constructed in C28/35 concrete. Brickwork gullies to be constructed in 215mm thick engineering blocks or 225mm mass concrete blocks. Gullies to be founded on 150mm thick mass concrete base slab.
- 7.50.3 Backfilling to gullies shall be with CI 804 or lean mix concrete.
- 7.50.4 Road gully gratings and frames shall be cast iron and shall comply with IS EN 124:1994 Class D400. Gratings and frames shall have clearly marked the IS EN 124 Class D400, name/symbol of manufacturer and place and year of manufacture. Frames and gratings shall not be lockable unless specifically required under the contract. Slots in the gratings or between gratings and frames shall not be oriented parallel to the direction of traffic. Gratings shall be bedded with the hinges on the side nearest on-coming traffic.
- 7.50.5 Gully chambers shall be constructed to the details shown on the standard detail drawings which form part of the Contract Documents.

7.51 Pipelines in Public Roads

- 7.51.1 The location of pipelines in roads will generally be as shown on the Drawings but the actual final position will be agreed on site with the Engineers Representative and the Local Authority. Without prejudice to the generality of Clause 29 of the General Conditions of Contract, the Site along pipelines in roads (unless the road is closed under Road Closing Order) shall be so limited that in all cases a free passage along such roads shall be maintained for vehicular traffic and pedestrians. The Contractor shall provide access to all properties including garages fronting on such roads. He shall also comply in all respects with any "Traffic Management Plan" which accompanies this Specification.
- 7.51.2 The Contractor shall take great care and all reasonable precautions to ensure that roads and thoroughfares used by him either for the construction of the works or for the transport of plant labour and materials are not dirtied as a result of such construction or transport and in the event of their becoming thus dirtied in the opinion of the Engineer's Representative the Contractor shall take all necessary and immediate steps to clean them.
- 7.51.3 For pipeline construction both along and across public roads the Contractor shall take all factors likely to affect his tender into consideration. Special claims for adverse physical conditions or traffic experienced during construction will not be entertained.
- 7.51.4 All material excavated for sewers in public roads and road margins, with the exception of road surfacing material which complies with the Specification as being suitable for re-use, shall be removed to spoil continuously as excavation proceeds. In no circumstances will the Contractor be permitted to retain spoil heaps at the sides of trenches.

7.52 Pipelines in Private Property

- 7.52.1 In the preparation of the ground for pipelines which are intended to be laid in private property, the Contractor shall other than along the area of Wayleave provided by the Client make his own arrangements, at his own expense, for all necessary entries for plant and machinery, and for any necessary temporary sites which he may require for workshops or for the servicing of excavators, dumpers, mixers and miscellaneous plant. If a holding is divided into two separate parcels of land while a trench is open, and if the landowner wishes to transfer stock, or if he himself wishes to pass from one parcel to the other the Contractor shall, as a general obligation, and without extra charge on the Contract, provide all temporary bridges and footways necessary for the safe carriage of pedestrians, animals or other traffic.

- 7.52.2 Upon completion of work in property privately owned, garden or forecourt boundary walls and all other boundary fences shall be made good to a condition at least equal to that in which they were found at the time of entry on private property. All surplus excavated material shall be removed to tip separately arranged by the Contractor at his own expense, and all tracks, tools, machinery and other items of temporary works shall be removed from the aforesaid private properties. The Contractor shall, as part of his obligations under the Contract fully restore all surfaces disturbed within the wayleaves area and he shall similarly restore areas outside the wayleave limits separately leased by him at his own expense. The Contractor shall indemnify the Employer against all claims for damage and from all costs, charges and expenses of any kind whatsoever, including third party and solicitor and client costs arising out of or in respect of any damage real or alleged.

7.53 Maintain Flow in Existing Sewers

- 7.53.1 Provision shall be made by the Contractor for the continuous discharge of all existing sewers or drains interfered with during the construction of the works.

7.54 Connections to Existing Sewers

- 7.54.1 Connections shall be made using standard preformed junctions where possible. Saddle connections to existing sewers shall only be allowed when the internal diameter of the major pipe is at least 150mm greater than the internal diameter of the branch pipe.
- 7.54.2 Pipe saddles for concrete or clay sewers shall be bedded in Class M1 Mortar and a mortar fillet formed to give a cover of at least 50mm to the base of the saddle.
- 7.54.3 The ends of connections and pipes not required for immediate use shall be closed with purpose made stoppers, disks or joiners. The positions of all junctions shall be recorded by measurement from the nearest manhole.

7.55 House Connections to Sewers

- 7.55.1 All connections to sewers shall be made with oblique angle junctions set at the correct angle to minimise the use of bends all as generally described on the detailed Drawing.
- 7.55.2 The open ends of all house connections and other pipes not required for immediate use shall be sealed up with purpose-made stoppers secured in position. The ends of connections and all junction positions shall be clearly marked by posts and painted boards of a type and size to be approved by the Engineer and the boards shall be plainly marked with the letter "IS" and the size and depth below kerb level or ground level. A length of No. 7 gauge galvanised iron wire shall be fixed to the collar of the last pipe and to the marking post. Every care shall be taken to prevent the marking boards being disturbed and the Contractor shall take the responsibility for their safety. The information shall also be painted on the kerbs in an approved manner when all works are complete and the Contractor shall record the position of all branches giving distances from the manhole immediately downstream of the branch.
- 7.55.3 The pipes for house connections shall be 100mm diameter generally except where varied by the Engineer and they shall be of vitrified clay or uPVC according to Local Authority requirements, laid, jointed and tested as specified herein for sewers. House connections shall be at a minimum gradient of 1 in 60 and shall be connected to the splay junctions by means of a 45-degree bend which can be located between the gradient of the incoming pipe connection and the angle of the splay branch. House connections shall be provided and laid to points as indicated on the site by the Engineer and these in general shall be adjacent to the boundary of each premises. All house connections and branches shall be tested in conjunction with the sewer length to which they have been fitted.

- 7.55.4 Deep cut connections shall be constructed wherever directed by the Engineer, which in general will be at points where the depth of the sewer exceeds 2.50 m. Swept Tee branches shall, unless otherwise directed, be used for this purpose when directed by the Engineer. The vertical pipe of each deep cut connection shall be supported by a concrete collar 150mm in thickness, cast around the sides of the branch and up from the trench formation to a point 150mm over the crown of the lateral pipe.

7.56 Manholes to be Abandoned

- 7.56.1 Existing Manholes to be abandoned shall have the cover slab and cover removed. The manhole shall be broken out to a minimum depth of 1.2m below ground level. The manhole shall be thoroughly cleaned using a high pressure water cleaning equipment to remove all grease and organic materials from inside of the manhole. All incoming and outgoing sewers, connections, etc. will be plugged in accordance with this specification. Holes shall be drilled in the walls of the manhole at locations and centres as agreed with the Engineer to allow the manhole to drain the surrounding ground.
- 7.56.2 The manhole shall be filled to formation level with suitable selected excavated material, or where no suitable material is available, with imported Clause 804 material. The material shall be compacted in layers not exceeding 150mm thickness. In roads, a 300mm thick layer of Grade C12/15 concrete may be constructed just below formation level, at the instruction of the Engineer.
- 7.56.3 The ground reinstatement shall be to match the existing surrounding ground or as per this specification, in accordance with the Engineers requirements.

7.57 Sewers to be abandoned

- 7.57.1 Sewers to be abandoned shall be cleaned out by dragging, jetting or flushing as required, to remove any debris, silt, grease or organic material. Backfilling shall be carried out using Class G4 grout, or other as approved by the Engineer. Backfilling of sewers shall be carried out using grouting pipes inserted at suitable intervals to be determined on site. The grouting intervals shall be such as to allow the grout to fully fill the sewer, and to penetrate to any surrounding voids in the ground.
- 7.57.2 The contractor shall carry out any on site tests as may be necessary to demonstrate the effectiveness of his grouting procedure.

7.58 Clay Puddle

- 7.58.1 Where the Engineer considers that ground conditions might result in the pipe trench acting as a longitudinal drain for groundwater he may instruct that clay stanks be incorporated in the pipe bedding.
- 7.58.2 Clay puddle shall be impervious to water, and be free from sand, grit, stones and other deleterious matter.
- 7.58.3 The clay on being dug shall be exposed to the air for at least 24 hours and thereafter shall be worked with water into a consistency suitable for punning. A roll of clay 300mm long and 40mm in diameter shall support its own weight when suspended from one end.
- 7.58.4 The Engineer may instruct that specific provision for drainage along the pipe trench be made by means of Concrete or other Land Drainage pipes where the Water Table level so requires.

7.59 Ventilating Columns

- 7.59.1 Ventilating columns shall be provided at the head of all main sewers in locations to be agreed by the Engineer.
- 7.59.2 Ventilating columns shall be of green G.R.P. or steel, 150mm in diameter and standing 7.60m high overground, with cast iron ornamental bases 1200mm high. If in steel the shaft shall consist of galvanised steel tube not less than 5mm thick terminating at the top with a copper wire ball having 10 B.W.G. vertical wires, and 14 B.W.G. spirals. The steel tube shall be painted externally and internally once before erection, internal painting being executed with the aid of long arm brushes or a drag.
- 7.59.3 The base of the column shall be of heavy cast iron to a design approved by the Engineer. It shall have an airtight door giving access to a chained removable dust box. The whole shall finally be painted with approved bitumastic paint of suitable shade and with two coat work to the satisfaction of the Engineer.

- 7.59.4 The Contractor shall supply and fix all the ventilating columns shown on the Layout Plans. Ventilating Columns shall be as above specified and in accordance with the Drawings. The column shall be buried in the ground to a depth of 800mm and shall be surrounded with a block of concrete 1200mm square and 1200mm deep with C20/25 (to IS EN 206-1:2002) concrete. The shaft shall be connected to the sewers or manholes with suitable short lengths of 150mm dia. concrete pipe. After erection of the base the tube shall be set central therein plumbed and grouted.

7.60 Draw Cord

- 7.60.1 Draw cord for duct threading shall be 8mm diameter 3 Strand hawser laid polypropylene rope complying with IS EN ISO 1141 or IS EN ISO 1346.

7.61 PTFE Tape

- 7.61.1 Unsintered polytetrafluoroethylene (PTFE) tape for thread sealing applications shall comply with BS 7786.

7.62 Marker Tape and Marker Posts

- 7.62.1 Marker tape for all buried services shall comply with the provisions of the DoEHLG "Guidelines for the Opening, Backfilling and Reinstatement of Trenches in Public Roads". Marker tape shall be PVC or polyethylene mesh or ribbon at least 150mm wide, incorporating a corrosion resistant tracing system and shall be printed with the words of the service i.e. Water Main, Electricity, Telecommunications, Waste Water, Pressure Main as appropriate.
- 7.62.2 Marker Posts shall comply with the provisions of IS 162. Valve or pipeline marker posts shall be precast reinforced concrete 1120mm high unless otherwise stated in the contract. The top of the marker posts shall be fixed so that their finished level is 500-600mm above final surface. Marker posts shall be fitted with a 180 x 205mm indicator plate to indicate WO, AV or FH as appropriate, together with main size and distance from post.

8 ROADWORKS

8.1 Roadworks - General

- 8.1.1 Roadworks, materials and workmanship shall comply with the "Specification for Roadworks" issued by the National Roads Authority (NRA).
- 8.1.2 Roadways shall be constructed in accordance with the details shown on the drawing or as more particularly specified.
- 8.1.3 The Contractor shall take all necessary precautions to prevent damage to sub-base, base or wearing surfaces by construction plant and equipment and shall make good any such damage at his own expense.

8.2 Road Formations

- 8.2.1 The road formation shall be the surface obtained after completion of any earthworks and shall be in accordance with Clause 616 of the NRA Specification for Roadworks. The preparation and surface treatment of formation shall be carried out after the reinstatement of any excavations for services. All exposed formations shall be inspected by the Engineer and no sub-base material shall be placed until the formation has been approved by the Engineer.
- 8.2.2 The sequence of operation for preparation of road formations shall be as follows:
 - (i) Formation of Soft Material
 - (a) All surfaces below roads and hardstanding shall, after reinstatement of any soft areas, be well cleaned and freed from mud and slurry.
 - (b) The surface shall be compacted by 4 passes of a smooth-wheeled roller of having a mass per metre width of 4500kg to 6500kg or equivalent.
 - (c) The formation shall be regulated and trimmed to a horizontal alignment of +20mm and -30mm relative to its design level.
 - (d) The trimmed formation shall be rolled by 1 pass of a 2100kg/metre width of a smooth-wheeled roller or equivalent. Construction of the sub-base shall follow immediately the completion of the formation.
 - (e) If the completed formation is not immediately covered with sub-base or roadbase material, it shall when directed be protected by sealing with cut-back bitumen of approved viscosity applied as follows: -
 - (i) For single coat the binder shall be applied at the rate of 1-1.2 l/m² immediately blinded with 6mm size chippings at the rate of 5.5-6.7 kg/m² and rolled with a smooth wheeled or rubber tyred roller of 2.5 tonnes. For two coats the binder shall be applied at a total rate of spread of 1.17 l/m². The first coat shall be applied at 0.91 l/m², immediately blinded with 3mm size chippings at a rate of 5.5-6.7 kg/m² and rolled as at (e) above. The second coat shall be as the first with the exception that the chippings shall be 6mm size. If the Contractor allows the moisture content of accepted compacted material to reach a value above the maximum permitted for the revert to an acceptable moisture content and, if directed, make good at this own expense to surface by recompaction before laying the sub-base or road-base.
 - (iii) Formation of Rock-Fill
 - (iv) The formation shall be thoroughly blinded to the design tolerances with approved fine graded material to seal the surface, and shall then be completed in accordance with paragraphs (c) and (d) above.
 - (ii) Formation of Rock Cuttings
 - (v) The material shall be excavated below the formation level to the depth described or as agreed with the Engineer. The excavated material shall be processed and redeposited and compacted in accordance with Clause 616 4 (i) of the NRA Specification. Alternatively, where the surface is tabular it shall be regulated by depositing and compacting lean mix concrete in accordance with Clause 313 4 (ii) of the NRA Specification.

- 8.2.3 Once the formation has been prepared constructional traffic shall not be allowed to run thereon without the permission of the Engineer.
- 8.2.4 To avoid deterioration of the subgrade the final 150mm of excavation to formation level shall not be affected until the Contractor is ready to place the sub-base materials on the prepared formation. The method used to effect the final excavation to formation level shall be approved by the Engineer and the Contractor shall not carry out this work in weather which would cause serious deterioration of the formation.
- 8.2.5 The formation shall be finally shaped and regulated to the prescribed level parallel to the finished surface level of the road and thereafter it shall not be subjected to any constructional or other traffic until the road surfacing has been laid and opened to traffic.
- 8.2.6 Where peat or other soft unsuitable material is encountered at formation level or immediately thereunder, it shall be excavated to such level and widths as may be directed by the Engineer. The material arising from these excavations will be disposed of in a suitable location, provided by the Contractor and to the approval of the Engineer. The voids thus formed shall be backfilled with approved materials compacted to the satisfaction of the Engineer.

8.3 Sub-Base Construction

- 8.3.1 Within 48 hours of completion of a road formation, granular sub-base material to Clause 804 or Clause 806 of the NRA Specification for Roadworks shall be spread and compacted to the required thickness. Compaction shall be carried out in accordance with Clause 802 of the NRA Specification and in accordance with Table 8.1 below:

Type of Compaction Plant	Category	Number of Passes per Layer		
		110mm	150mm	225mm
Smooth wheeled roller (or vibratory roller operating over 5,400kg without vibration)	Mass per metre width of roll:			
	Over 2,700kg up to 5,400 kg Over 5,400kg	16 8	Unsuitable 16	Unsuitable Unsuitable
Pneumatic-tyred roller	Mass per wheel:			
	Over 4,000kg up to 6,000kg	12	Unsuitable	Unsuitable
	Over 6,000kg up to 8,000kg	12	Unsuitable	Unsuitable
	Over 8,000kg up to 12,000kg	10	16	Unsuitable
Vibratory Roller	Over 12,000kg	8	12	Unsuitable
	Mass per metre width of vibrating roll:			
	Over 700kg up to 1,300kg	16	Unsuitable	Unsuitable
	Over 1,300kg up to 1,800kg	6	16	Unsuitable
	Over 1,800kg up to 2,300kg	4	6	10
	Over 2,300kg up to 2,900kg	3	5	9
	Over 2,900kg up to 3,600kg	3	5	8
	Over 3,600kg up to 4,300kg	2	4	7
Vibrating Plate Compactor	Over 4,300kg up to 5,000kg	2	4	6
	Over 5,000kg	2	3	5
	Mass per unit area of base plate			
Vibro – Tamper	Over 1,400kg/m ² up to 1,800kg/m ²	8	Unsuitable	Unsuitable
	Over 1,800kg/m ² up to 2,100kg/m ²	5	8	Unsuitable
	Over 2,100kg/m ²	3	6	10
Power Rammer	Mass:			
	Over 50kg up to 65kg	4	8	Unsuitable
	Over 65kg up to 75kg	3	6	10
	Over 75kg	2	4	8
	Mass:			
	100kg – 500kg	5	8	Unsuitable
	Over 500kg	5	8	12

Table 8.1 – Compaction requirements for unbound materials in road pavements

8.4 Wet Mix Macadam Construction

- 8.4.1 Wet mix macadam shall be made and constructed in accordance with Clause 806 of the NRA Specification for Roadworks. Wet mix macadam shall spread evenly on the sub-base and compacted in layers of not more than 150mm thickness.
- 8.4.2 Spreading shall be undertaken concurrently with placing. Compaction shall be completed as soon as possible after the material has been spread and carried out in accordance with Table 8.1 above.
- 8.4.3 Bituminous macadam shall comply with BS 4987-1/-2:2005, BS 594987:2007 and IS EN 12591.

8.5 Lean Concrete Construction

- 8.5.1 Lean concrete for roads shall be spread evenly on the sub-base and laid compacted in layers of not more than 200mm thickness.
- 8.5.2 Spreading shall be undertaken concurrently with placing. Compaction shall be completed as soon as possible after the material has been spread and carried out in accordance with Table 8.1 above. The maximum period of time between mixing of materials and final compacting of any given material shall be two hours.
- 8.5.3 Where practicable, joints against hardened material shall be avoided. Where such joints are unavoidable, the hardened material shall be cut back vertically for the full depth of the layer before placing any further adjacent material.
- 8.5.4 Lean concrete shall be cured for a period of not less than seven days. No vehicular traffic shall be allowed to run on the base during this time.

8.6 Laying Coated Macadam

- 8.6.1 Transportation, laying and compaction of all coated macadam shall be carried out in accordance with Clauses 900 series of the NRA Specification for Roadworks and in accordance with the relevant provisions of BS 4987, BS 594987 and IS EN 12591.
- 8.6.2 A two course bituminous macadam surfacing shall be laid over the sub-base where specified. It shall consist of a macadam base course in accordance with BS 4987 rolled with a power roller to a consolidated thickness of 63mm. A second course of bituminous macadam in accordance with BS 4987 is to be laid over and rolled with a power roller to a consolidated thickness of 25mm giving 88mm consolidated for the two layers.

8.7 Laying Rolled Asphalt (Hot Process)

- 8.7.1 Transportation, laying and compaction of rolled asphalt (hot process) shall be carried out in accordance with Clause 910 of the NRA Specification for Roadworks and in accordance with the relevant provisions of BS 594 and BS 594987.

8.8 Precast Concrete Kerbs Channels Edgings and Quadrants

- 8.8.1 Precast concrete kerbs, channels, and edgings shall be hydraulically pressed, and they and precast concrete quadrants shall comply with IS 146 & EN 1340:2003, Concrete kerb units – requirements and test methods. Where kerbs or channels are required to be laid to a radius of 12 metres or less, components of the appropriate radius shall be used.
- 8.8.2 Kerbs, edgings, channels and quadrants shall be laid and bedded on a layer of Class M1 mortar, either on the concrete carriageway or on a Grade C16/20 concrete foundation, as detailed on the Drawings. They shall be butt-joined except where otherwise shown in the Contract, save that where laid on concrete carriageways they shall be provided with joints coincident with the carriageway movement joints, of widths and with filler identical to that used in the carriageway joints. All kerbs shall be backed with Grade C16/20 concrete.
- 8.8.3 For radii of 12 metres or less, kerbs and channels of the appropriate radius shall be used.
- 8.8.4 Alignment of kerbs and channels shall not deviate from that shown on the Drawings by more than 6mm with no lipping of visible faces.

8.9 In-Situ Concrete Kerbs

- 8.9.1 Where cast in situ concrete kerbs are proposed they shall be either 250mm deep by 150mm thick laid on a 150mm thick x 300mm wide concrete bed and haunch or be designed to sit 50mm on to finished concrete carriageway surface being 175mm thick on top section and 125mm thick on lower section. Concrete throughout shall be Grade C20/25 concrete with maximum size of aggregate 20mm. Where precast kerbs are used they shall be 250mm x 125mm complying with IS 146 and shall be laid on a 150mm thick by 300mm wide concrete bed and haunched in Grade C16/20 concrete. Alternative kerb types at carriageway edges shall be subject to the approval of the Engineer.

8.10 Precast Concrete Flags

- 8.10.1 Precast concrete flags shall be hydraulically pressed and shall comply with the relevant provisions of BS EN 1339:2003. Unless otherwise described in the Contract, flags shall be 50mm thick.
- 8.10.2 Precast concrete flags shall be laid to the required falls on sub-base material as shown on the Drawings, bonded with joints at right angles to the kerb, and continuously bedded with no lipping of top surfaces. The flags shall be laid on a dry mix mortar bed nominal thickness 25mm, consisting of 1 part lime or cement to 3 parts building sand by volume. All flags should be firmly laid on the concrete mortar bed and tamped into position with a paviour as well. It is essential to ensure that the flags do not rock after laying. A dry mortar mix consisting of 1 part cement to 3 parts sand by volume should then be well brushed into the joints and any surplus material removed from the completed pavement.
- 8.10.3 Flags shall be cut to fit around surface boxes and other furniture and, on circular work where the radius is 12 metres or less, all flags shall be radially cut on both edges to the required lines.

8.11 Foundations for Footways

- 8.11.1 Foundations for footways shall consist of Clause 804 granular sub-base material spread evenly and compacted in layers of not more than 100mm thickness.
- 8.11.2 Compaction to the correct levels shall be carried out using a vibratory roller having a static load of at least 1000 kg/metre width of roll.

8.12 Tolerances for Finished Carriageway Surfaces

- 8.12.1 Tolerances in the Surface Levels of Pavement Courses shall be in accordance with Clause 702 of the NRA Specification for Roadworks or otherwise specified in the contract documents and as reproduced below in Table 8.2:

Surface Course Type	Tolerance
Road Surfaces	±6mm
Basecourse	±6mm
Roadbase	±15mm
Sub-base under concrete pavement surface slabs laid in full thickness in one operation by machines with surface compaction.	±10mm
Sub-bases other than those above	+10mm -30mm
<i>* The lower layer of Roadbase or Basecourse laid in more than one layer shall comply with the tolerances for Roadbase or Basecourse appropriately</i>	

Table 8.2 – Surface Levels of Pavement Courses

- 8.12.2 The maximum allowable irregularity of the wearing surface below a three-metre straight edge shall be 3mm.

8.13 Natural Stone and Hardcore

- 8.13.1 Natural stone shall be of durable quality, uniform in texture and free from iron bands, spots, sandholes, flaws shakes and other imperfections which would adversely affect its strength and appearance. The dimensions of stones shall be adequate for proper coursing and bonding.
- 8.13.2 Hardcore shall consist of clean, hard, durable material either broken stone, bricks or concrete graded from 200mm to 50mm and be free from extraneous matter.

8.14 Dressed Natural Stone Kerbs, Channels, Quadrants and Sets

- 8.14.1 New dressed granite and whinstone kerbs, channels, quadrants and sets shall comply with the relevant provisions of BS EN 1342 and BS EN 1343.
- 8.14.2 Second hand stone kerbs, channels, quadrants and setts shall not be excessively weathered, worn or chipped, and shall be free from all bedding and jointing materials. Faces which are to remain exposed on completion of the Works shall be free from stains.

8.15 Cast Stone

- 8.15.1 Cast stone shall comply with the relevant provisions of BS1217.

8.16 Coping Units

Precast concrete, cast stone, clayware, natural stone and slate coping units shall comply with the relevant provisions of BS 5642-2:1983. Slate coping units shall be Type B unless otherwise described in the Contract.