

Technical Specification

T0005

Bridges and Structures - Materials and Workmanship

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1 Purpose

- 1.1 The purpose of this Specification is to specify the workmanship and materials to be used for civil and structural works on London Underground.

2 Scope

- 2.1 This Specification applies to all work on London Underground that contains a civil or structural element

3 Requirements

3.1 Materials and Workmanship Specification General

- 3.1.1 All goods, materials, testing and other procedures not otherwise specified shall be in accordance with the latest edition of the appropriate European Standard, British Standard or Code where such exists at the time of tender.
- 3.1.2 Where the standard indicated on the drawings or in this specification has been superseded either by an alternative British or European Standard then the reference shall be deemed to refer to that standard.

3.2 Testing Authority

- 3.2.1 Before any work commences the Contractor shall obtain the Engineer's approval of the independent testing authority he proposes to use. All testing shall be carried out by this authority and a copy of all the test results and reports immediately sent to the Engineer except where otherwise specified or directed by the Engineer.

3.3 Notice of sampling and testing

- 3.3.1 Except as otherwise directed, a minimum of 7 days notice shall be given to the Engineer of all sampling testing and other trial operations to allow him or his representative to be present at such operations.

3.4 Inspecting and Testing

- 3.4.1 All materials and workmanship shall be the best of their respective kinds described and in accordance with the Engineer's instructions and shall be subject from time to time to such test as the Engineer may direct at the place of manufacture or fabrication or on the site or at all or other such places. The contractor shall provide such assistance, instruments, machines, labour and materials as the Engineer may require for examining measuring or testing the works and the quality of the materials used, and supply samples for testing as may be selected and required by the Engineer.
- 3.4.2 The Contractor shall obtain permission for the Engineer to inspect, examine and test at suppliers/sub-contractor's premises. Such inspection, examination, or testing if made, shall not release the Contractor from any obligation under the Contract.
- 3.4.3 The whole expense of such tests shall be borne by the Contractor unless the tests show that the workmanship or materials are in accordance with the Engineer's requirements.

3.5 Preliminary tests

- 3.5.1 Before any material is used in the Works, tests shall be carried out wherever relevant to prove that the material conforms to the Specification, and the results of these tests shall be submitted to the Engineer for his approval.
- 3.5.2 The procedure shall be repeated whenever the source, batch, type, quality or grading of material is changed, and includes concrete testing for the purpose of mix-design approval.

3.6 Samples

- 3.6.1 The Contractor shall supply to the Engineer upon his request and without charge, adequate samples of such materials or manufactured items as he may designate and no such materials or items may be used or incorporated in the Works until approved.
- 3.6.2 Approved samples will be retained by the Engineer until the completion of the Contract. In the event of any sample being rejected the whole consignment or quantity of materials from which the samples have been taken and which have been brought to the site shall forthwith be removed by the Contractor.

3.7 Alternative products

- 3.7.1 Except where a particular proprietary product is specifically called for in this specification, reference to a brand item is intended to indicate only the acceptable standard.
- 3.7.2 The Contractor may offer an alternative product to that specified or described in the Contract and in that event shall submit to the Engineer for approval technical descriptions and specifications, and drawings where relevant, and other such information as will enable the Contractor to demonstrate to the Engineer that the product proposed is the equivalent of that required by this specification or indicated elsewhere in the Contract.

3.8 Manufacturer's instructions

- 3.8.1 Where reference is made in this Specification to proprietary manufacturer's instructions or recommendations, the manufacturer's latest instructions or recommendations shall be adhered to unless otherwise directed in writing by the Engineer.

3.9 Skilled workmanship

- 3.9.1 In extension of the conditions of Contract, before employing any person to carry out a skilled operation in or about the execution of the works, the Contractor shall satisfy the Engineer that such a person has sufficient experience and skill to complete that operation satisfactorily.
- 3.9.2 This requirement shall also extend to any sub-Contractor proposed by the Contractor to be employed in or about the execution of the Works.

3.10 Plant operatives

- 3.10.1 The operatives of all plant on site shall be in possession of a current certificate of training for plant operations in the civil engineering industry as issued by the Construction Industry Training Board, unless otherwise agreed by the Engineer.

3.11 Assembly of members

- 3.11.1 Notwithstanding any dimensional deviation clauses in any British Standard or other specification, where members are to be located or joined together by means of fixings or fittings positioned on members, the Contractor shall ensure that any dimensional deviations relating to the setting up of such or fixings or fittings are kept sufficiently small to allow satisfactory assembly of members.

3.12 Asbestos

- 3.12.1 The use of asbestos or materials containing asbestos is prohibited.

3.13 Soil Investigation

3.13.1 General

- 3.13.1.1 The whole of the ground investigation shall comply with the "Site Investigation in Construction Part 3: Specification for Ground Investigation", published by the Institution of Civil Engineers in 1993, except where otherwise modified by the following clauses.

3.13.2 Information

- 3.13.2.1 The schedules referred to in Section 1 of the ICE Specification do not apply. Where reference is made to Schedules B to G the related information shall be sought elsewhere in the Contract Documents.

3.13.3 Supervision

- 3.13.3.1 At all times during the progress of the work the Contractor shall retain on the site a responsible supervisor experienced in making borings, taking samples and making on site tests.
- 3.13.3.2 The Contractor shall provide an engineer or Engineering Geologist of suitable experience and qualifications who shall be approved by the Engineer to be responsible for technical direction and output of the whole investigation.

3.13.4 Project Managers office

- 3.13.4.1 The Project Manager's office referred to in Section 2.10 (ICE SPEC) (Clause 3.13.1.1 above) will not be required.

3.13.5 Vehicles for the Project Manager

- 3.13.5.1 The transport referred to in Section 2.11 (ICE SPEC) (Clause 3.13.1.1 above) will not be required.

3.13.6 Mine workings

- 3.13.6.1 When boring in areas where there are known mine workings, shafts or other similar works, the Contractor shall consult the Engineer on any special requirements. Should any voids, disturbed ground, faulting, loss of drilling water or any other evidence suggesting mining be found during exploration the Contractor shall cease work, inform the Engineer immediately and await further instructions.

3.13.7 Site safety

- 3.13.7.1 The Contractor shall use cable avoidance tools (CAT scanners) to validate the position of buried cables and other services, as supplied by the service suppliers. The approved calibrated equipment is to be used by trained operatives. When used on the Underground, CAT scanners are currently restricted to passive mode. If known services cannot be located then the service shall be assumed to be present and "safe



dig" techniques employed (including the use of trial holes and hand tools for breaking hard surfaces). Work in the vicinity of services is only permitted once permission has been granted by a competent supervisor through a permit to dig system.

3.13.7.2 The Contractor shall take all necessary precautions to prevent damage being caused to any structure or buried service as a result of the carrying out of the Works. Special care shall be taken in respect of damage likely to be caused as a result of vibration. The Contractor shall also comply with any additional recommendations and requirements on avoiding the danger from underground services and risks to structures that can be found in:

- a) HSE Guidance [HSE47];
- b) LU Standard 1-021 (Works near mains, services and structures);
- c) LU Standard 1-002 (Work involving disturbance to signalling, communications and electrical systems);
- d) LU Standard 1-114 (Safe systems of work on or near Electrical Equipment);
- e) LU Standard 1-552 (Contract QUENSH Conditions - Section 50)

3.13.7.3 If the Contractor is of the opinion that any damage is likely to be caused to any structure or buried service as a result of the carrying out of the works he shall notify the Engineer immediately in writing and suspend work pending the receipt of instructions from the Engineer.

3.13.7.4 The Contractor shall maintain and leave the site in a safe condition and shall take all necessary precautions to avoid falls from height. Trial pits and excavated faces shall be properly supported during excavation and properly backfilled on completion of works as directed by the Engineer.

3.13.8 Environmental considerations

3.13.8.1 The Contractor shall comply with the relevant sections of the following environmental legislation:

- a) The Rivers (Prevention of Pollution) Act 1951, Section 2
- b) The Control of Pollution Act 1974;
- c) The environmental Protection Act 1990;
- d) The Water Resources Act 1991;
- e) The Special Waste Regulations 1996.
- f) The Waste Management Licensing Regulations 1994.

3.13.8.2 The method of disposal of excavated material and other waste shall be to the satisfaction of the Engineer and of any other authority or person having an interest in any land or watercourse over or in which water and waste products may be discharged. The requirements of this Clause shall not limit the Contractor's statutory obligations or liabilities.

3.13.9 Boreholes

3.13.9.1 Boreholes shall be lined wherever they pass through water bearing or weak strata or where the Engineer directs and such linings shall be sealed into adjoining strata to prevent inflow of water.

3.13.9.2 The materials extracted from boreholes are to be laid out on the Site as the work proceeds for examination from time to time by the Engineer.

3.13.10 Number and depth of boreholes

3.13.10.1 The number and depth of boreholes are shown on the drawings and in the Bill of Quantities. These may be revised in the light of information gained during the investigation. To this effect no boreholes may be terminated without the agreement of the Engineer.

3.13.11 Confidentiality and security

3.13.11.1 The Contractor shall at all times keep confidential between himself, the Engineer and the Employer all information obtained from carrying out of the Contract and all information relating thereto shall be communicated in any form to any person or body other than those named in written authorisation given by the Employer or Engineer

3.13.11.2 The Contractor shall as far as is reasonably practicable prevent the entry of unauthorised persons to the Site and shall safeguard samples taken from the borings of pits and records against unauthorised examination.

3.13.12 Care of samples

3.13.12.1 The Contractor shall, unless it is otherwise provided for in the Contract, take full responsibility for the care and storage of the samples and cores obtained from the investigation at his cost until 28 days after the issue of the report to the Engineer or in the case of a phased investigation, the relevant section of the report.

3.13.13 Reporting requirements

3.13.13.1 In addition to the reporting requirements of Sections 8.3 and 10, the times during which site tests are carried out shall be recorded and the Journal shall be available for inspection at all times to the Engineer.

3.14 Site Clearance, Earthworks and Demolition

3.14.1 General

3.14.1.1 British Standards

Site clearance and earthworks shall generally be carried out in accordance with the requirements of the following British Standards unless modified or extended herein:

BS 1377:1990 Parts 1-9	Methods of tests for soils for civil engineering purposes
BS 6031:1981	Code of practice for earthworks
BS EN 1997-1	Geotechnical design General Rules
BS 6187:2000	Code of practice for demolition
BS 5228-1:2009	Noise and vibration control on construction and open sites. Code of practice for basic information and procedures for noise and vibration control
BS 5228-2:2009	Noise and vibration control on construction and open sites. Guide to noise and vibration control legislation for construction and demolition including road construction and maintenance
BS 5975:1996	Code of practice for temporary works procedures and permissible stress design.

3.14.1.2 Definitions

3.14.1.2.1 **Formation level** shall mean the finished level of earthworks upon which will be placed the track bed or road base construction or the Permanent Works.

3.14.1.2.2 **Top soil** shall mean a layer of soil that contains the appropriate nutrients and has appropriate texture to support the growth of vegetation.

It shall be free from stones larger than one half of the thickness of the finished topsoil layer, any oily matter and rubbish.

- 3.14.1.2.3 **Rock** shall mean hard natural materials, which if so confirmed by the Project Manager, necessitates the use of approved rock breaking plant and equipment or other special plant (other than clay spades) for their removal.
- 3.14.1.2.4 **Rock fill** shall consist of hard materials of a suitable size for deposition and compaction to the Project Engineer's satisfaction or in accordance with the specified compaction requirements hereof and shall comprise rock, as defined in this clause, broken stone, inert hard brick, good quality concrete, or any other comparable hard and inert material.
- 3.14.1.2.5 **Chalk** shall mean those geological strata indicate in the Contract to be regarded as such and any other deposits of soft white porous limestone if so confirmed by the Engineer.
- 3.14.1.2.6 **Soft material** in the context of excavation shall mean excavations in material other than rock.
- 3.14.1.2.7 **Artificial hard material** shall mean brickwork, masonry, plain and reinforced concrete which if so confirmed by the Engineer necessitates the use of blasting, approved pneumatic tools or other special plant for their removal.

3.14.2 Soil investigation

- 3.14.2.1 Where soil investigations are required the Contractor shall comply with the appropriate Specification clauses contained elsewhere in this Contract.
- 3.14.2.2 Where trial holes have been formed on the Site their positions shall be shown on the Drawings.

Borehole logs and results of any tests on soil samples will be made available for inspection by the Contractor in the Engineer's office.

3.14.3 Site Clearance

3.14.3.1 *Trees and bushes*

- 3.14.3.1.1 The site shall where necessary, or as directed by the Engineer, be cleared of all trees, shrubs and bushes which shall be cut down to ground level and removed by the Contractor.
- 3.14.3.1.2 Where stumps and roots of trees, hedges, shrubs and bushes prevent the setting up of the Site and the construction and performance of the works they shall be grubbed up and removed from the Site.
- 3.14.3.1.3 The removal and disposal of Japanese knotweed and other controlled plants and weeds shall be as directed by the Engineer.
- 3.14.3.1.4 A check for Tree preservation orders (TPOs) shall be made in the Local Land Charges register held by the local Authority.

No work of any kind shall be carried out on any tree subject to a TPO without the prior permission of the local Authority.

Trees in Conservation Areas are automatically subject to TPOs.

3.14.3.2 *Stripping of turf and topsoil*

- 3.14.3.2.1 Turf and topsoil shall be stripped to a depth of 150mm or as directed by the project manager, and if considered suitable for re-use shall be stored separately in positions approved by the Engineer.

3.14.3.3 Breaking out and storage of materials

- 3.14.3.3.1 Where existing railway tracks, road surfaces, pavements and structures are to be taken up, broken and removed, all re-usable items shall, unless otherwise directed by the Engineer, be carefully removed and stacked on the site by the Contractor ready for subsequent re-use on the site or despatched to another party's depot or store.

3.14.4 Excavation - General

3.14.4.1 Site Safety

- 3.14.4.1.1 The Contractor shall use cable avoidance tools (CAT scanners) to validate the position of buried cables and other services, as supplied by the service suppliers.

The approved calibrated equipment is to be used by trained operatives.

When used on the Underground, CAT scanners are currently restricted to passive mode.

If known services cannot be located then the service shall be assumed to be present and "safe dig" techniques employed (including the use of trial holes and hand tools for breaking hard surfaces).

Work in the vicinity of services is only permitted once permission has been granted by a competent supervisor through a permit to dig system.

- 3.14.4.1.2 The Contractor shall take all necessary precautions to prevent damage being caused to any structure or buried service as a result of the carrying out of the Works.

Special care shall be taken in respect of damage likely to be caused as a result of vibration.

The Contractor shall also comply with any additional recommendations and requirements on avoiding the danger from underground services and risks to structures that can be found in:

- a) HSE Guidance [HSE47];
- b) LU Standard 1-021 (Working near mains, services and structures);
- c) LU Standard 1-002 (Work involving disturbance to signalling, communications and electrical systems);
- d) LU Standard 1-114 (Requirements for working adjacent to power cables on LU premises);
- e) LU Standard 1-522 v12 (Contract QUENSH Conditions v12 - Section 50).

- 3.14.4.1.3 If the Contractor is of the opinion that any damage is likely to be caused to any structure or buried service as a result of the carrying out of the works he shall notify the Engineer immediately in writing and suspend work pending the receipt of instructions from the Engineer.

- 3.14.4.1.4 The Contractor shall maintain and leave the site in a safe condition and shall take all necessary precautions to avoid falls from a height.

Trial pits and excavated faces shall be properly supported during execution and properly backfilled on completion of the Works or as directed by the project Manager.

3.14.4.2 Equipment and method of excavation

- 3.14.4.2.1 All excavation shall be done carefully using equipment appropriate to the particular task.



Before starting work the Contractor shall obtain the Engineer's approval of the plant to be used, together with the method and sequence of operations.

3.14.4.3 Disturbance of material adjacent to excavations

3.14.4.3.1 The Contractor shall ensure that all material adjacent to and under the agreed limits of excavation shall remain undisturbed.

Any damage or disturbance to such material shall be corrected at the Contractor's expense by such methods as the Engineer may direct.

3.14.4.4 Supporting existing structures

3.14.4.4.1 Before commencing any excavation for new works in the proximity of any existing structure, the Contractor shall install appropriate temporary support to any parts of such structure which may be affected by the Contractor's operations.

3.14.4.4.2 The installation of any temporary support shall be carried out in such a manner that minimum damage will be caused to the structure, and any such damage shall be made good by the Contractor on completion of the Works, to the satisfaction of the owner of the property concerned.

3.14.4.4.3 The cost of temporary work and repairs referred to in these paragraphs shall be included by the Contractor in his rates for execution.

3.14.4.5 Underpinning

3.14.4.5.1 Underpinning of existing structures shall be carried out in short intermittent sections, each of which shall be capable of bearing the designed loading before any adjacent work is commenced.

The Contractor shall submit, for approval, the methods which he proposes to adopt and no work of underpinning shall be commenced until such approval has been obtained.

3.14.4.6 Drainage of excavations

3.14.4.6.1 The Contractor shall at all times during the execution of the Works and until completion thereof, keep any excavations free from general surface and spring water and shall be responsible for providing all labour, apparatus, equipment, tools and pumps etc necessary for that purpose.

3.14.4.6.2 Where pumps are necessary, suitable sumps and shallow grips shall be provided and maintained and the Contractor shall, on a like basis, lay down such pipes or ducts as are needed to convey the water clear of the Works so that none shall be permitted to stand in or upon any excavation.

The excavation, maintenance and backfilling of the including the making good of any damage arising out of the pumping and conveying of water, shall be the responsibility of the Contractor.

3.14.4.6.3 The Contractor shall ensure that any excavated material does not enter any manhole or blocked drainage gullies and on completion of the Works all drainage shall be cleared of any accumulated sediment.

3.14.4.7 Surface levels; bulking and shrinking etc of earthworks

3.14.4.7.1 Before work commences the levels of the existing ground, which will be disturbed, shall be agreed with the Engineer. In default, the levels shown on the drawings shall apply.

3.14.4.7.2 The Contractor, shall make due allowance for all bulking, shrinkage and settlement in the excavation of cuttings and the forming of embankments.

3.14.4.8 Trimming, forming and making good

3.14.4.8.1 The finished surfaces of all earthworks shall be smooth and graded to the designed sections and free from all irregularities, mud, slurry and debris.

Completion of the formation shall not be carried out until all necessary drainage and or the waterproofing has been laid and is in working order.

The Contractor shall make good any irregularity, deterioration, or damage, to the finished embankments, tips, borrow pits, or cuttings, arising out of the stacking of materials, the transport of plant or materials, the passage of workmen, or any other such cause.

3.14.4.8.1 Excavations shall not be taken down below a level of 300mm above the finished formation level or surface of cutting slope, unless otherwise agreed by the Engineer, until such time as the finished surface can, in the opinion of the Engineer, be exposed without risk of damage or deterioration.

3.14.4.9 Material arising from excavations

3.14.4.9.1 Generally all material arising from excavations shall be classified as unsuitable material

3.14.4.9.2 Should the contractor wish to classify any materials as suitable under this Contract for the purpose of filling, he must first obtain the Engineer's written agreement

3.14.4.10 Removal of surplus excavated materials and debris from the Site

3.14.4.10.1 The Contractor shall be responsible for removing from the Site all surplus excavated materials and debris arising out of the works including any stacking or spreading or double handling (including loading connected therewith), transporting to a tip to be provided by him and covering all charges and commissions and stipulations of the Highway Authority.

3.14.4.10.2 Excavated suitable material, other than that which is surplus to the requirements of the contract shall not be removed from the Site except with the written permission of the Engineer.

Material, which is unsuitable only by reason of being frozen, is to be retained on the Site.

Should the Contractor be permitted to remove suitable material from the Site to serve his operational procedure, then he shall make good, upon his own responsibility, any consequent deficit of filling arising there from.

3.14.4.11 Backfilling of working space

3.14.4.11.1 Additional excavation necessary to provide working space or other temporary works shall be backfilled with suitable material compacted in accordance with this Specification.

3.14.4.11.2 Unless otherwise specified all backfilling shall be deposited and rammed in layers, not exceeding 150mm in depth, when compacted, and where necessary the moisture content of the backfilling shall be adjusted to facilitate compaction.

Each layer shall be completed over the whole area to be filled before the succeeding layer is deposited.

Timbering, sheeting and framing, or other supports, shall be carefully withdrawn ahead of the layer to be compacted, care being taken to keep the sides of the excavation solid and to fill the voids which are left by the removal of timbering.

The removal of timbering at backfilling shall not relieve the Contractor of his responsibility for the stability of the work.

**3.14.4.12 Structures providing passive resistance**

- 3.14.4.12.1 Any backfilling located in front of the bases of retaining walls, gravity and strutted abutments etc, shall be completed (subject to the provisions of the next paragraph hereof) before the filling to the backs of the structures is commenced.
- 3.14.4.12.2 The Contractor may, if approved, substitute weak concrete, or concrete of any other mix, of low water/cement ratio, in lieu of other specified filling. Where the front of foundations, retaining walls, etc; of any type of structure shall be required to transmit passive resistance to adjacent ground the contractor shall provide weak concrete of low water/cement ratio for backfilling.
- 3.14.4.12.3 The extent and timing of any subsequent loading arising from other, and succeeding filling, which shall affect the concrete backfilling described in the preceding paragraph of this clause, shall be governed by the curing time of that concrete and be at the discretion of the Engineer.

3.14.4.13 Streams, watercourses and ditches

- 3.14.4.13.1 Excavations carried out in the diversion, enlargement or deepening of streams, watercourses, or ditches, shall be performed without causing pollution of slopes, contouring of beds, disposal of excavated materials, backfilling, pumping, timbering, steel sheet trenching or any other works and requisites necessary for dealing with the flow of the water.
- 3.14.4.13.2 Where watercourses have to be diverted from the future sites of embankments or other similar works, the original channels shall be cleared of all vegetable growths and soft deposits. The bed shall then be suitably formed and, thereafter carefully filled in with approved materials deposited and compacted as specified.
- 3.14.4.13.3 An open jointed drain shall be laid at the site of the original channel to an agreed line and level. Where land and other drains are in any way disturbed, severed, or removed, the same shall be made good as directed.

3.14.4.14 Gabions

- 3.14.4.14.1 Gabions shall be manufactured from hexagonal woven steel wire mesh or square welded steel wire mesh.
- Plastic gabions are not permitted due to the risk of damage by fire.
- 3.14.4.14.2 The gabions shall be sufficiently rigid to prevent undue deflection of the face during construction.
- 3.14.4.14.3 Hexagonal woven wire mesh shall be mechanically woven in a continuous sheet which can stretch or contract in two directions in its own plane so that a rectangular wire mesh box filled with stone can deform in any direction.
- 3.14.4.14.4 The gabion mesh shall be manufactured from steel wire complying with BS 1052:1980 having a minimum core diameter of 2.5mm.
- All wire shall be galvanised in compliance with BS EN 10244-2:2001.
- 3.14.4.14.5 Wire mesh shall be welded at every intersection.
- The shear strength of the welds at each intersection shall be at least 70% of the minimum ultimate tensile strength of the wire.
- 3.14.4.14.6 Where specified or directed to be PVC coated; the galvanised wire coating shall be black and shall be applied to a minimum thickness of 0.55mm for extruded coatings and to a minimum thickness of 0.25mm for bonded coatings.

3.14.4.14.7 Cages shall be laid bonded, wired together along all adjacent edges and stretched tight to present face free from bulges or depressions and shall include diaphragms and internal bracing wires, where required, in accordance with the manufacturer's instructions.

3.14.4.14.8 Filling shall consist of hard durable stone such as limestone or granite complying with the requirements of Class 6G materials (Table 6/1, Specification for Highway works, Volume 1, March 1998).

Soft friable material shall not be used.

The maximum size of the fill material shall be the lesser of 200mm and two thirds of the gabion compartment.

The minimum size shall be the greater of 100mm and the aperture size of the containing mesh.

3.14.4.14.9 The filling shall be placed uniformly and be compacted by hand so as to minimise voids. Gabion units shall be maintained square and with vertical sides during filling. Internal tie wires shall be inserted and units shall be tensioned in accordance with the manufacturer's instructions.

Gabion units shall be constructed so as to maintain tightness of mesh and shall be laced securely with wire complying with the standard required for the gabion mesh. The tolerance of the gabion wall line and level shall be +/- 50mm with no undue distortion in individual units.

3.14.4.14.10 The top surface of cages shall be overfilled to a level of 50mm with the smaller range of filling material to accommodate subsequent settlement.

Cage tops shall be tensioned and securely tied down.

3.14.4.14.11 Adjacent gabion boxes are to be fastened together using binding wire complying with the standard required for the gabion mesh and with the manufacturer's installation instructions.

3.14.4.14.12 Vertical joints of gabion baskets shall be staggered as in running bond brickwork to give a better appearance and to prevent the formation of weak vertical shear planes.

3.14.4.13 The lifting of filled gabions by crane into position will not be permitted.

3.14.5 Slips and settlements etc., in earthworks

3.14.5.1 The Contractor, in the event of the observance of an incipient slip, particularly where vibrations are set up by passing trains, shall take all precautions and stabilise and remedy the same all in accordance with any direction given by the Engineer in writing.

3.14.5.2 At the date of the commencement of the Period of Maintenance, the works shall be completed to the levels specified, or at such other levels as shall accommodate any future shrinkage, settlement, or other movement, which can be properly attributable to any earthworks formed in accordance with the Contract.

3.14.5.3 Notwithstanding anything contained in the preceding paragraph, in the event of shrinkage, settlement or other movements occurring during the period of maintenance which shall cause the contours of the earthworks to vary from those intended to an extent which is unacceptable to the Engineer, then these variations shall be the responsibility of the Contractor and shall be remedied by him.



3.14.6 Excavation for Foundations

3.14.6.1 General

3.14.6.1.1 Excavations for structural foundations are to be taken down to such depths as may provide a solid foundation to the satisfaction of the Engineer.

3.14.6.1.2 The surfaces of all excavations shall be properly trimmed to profile and all steppings shall be vertical unless shown otherwise on the Drawings.

3.14.6.2 Stability of excavated faces

3.14.6.2.1 The Contractor shall provide and fix necessary and proper planking, sheeting and strutting for upholding the sides of excavations, and remove the same when no longer required.

3.14.6.2.2 Unless otherwise agreed or directed by the Engineer, the method adopted by the Contractor for upholding the sides of the excavation must allow for the safe removal of the temporary supports as backfilling proceeds.

Payment will not be made for material left in the excavation because of the Contractor's failure to adopt such a method.

3.14.6.2.3 The method of removing supports shall be such that settlement or subsidence in the surrounding soil shall be prevented.

The Contractor shall include, in his rates, for the cost of material that needs to be left in place to prevent settlement or subsidence.

3.14.6.3 Inspection of foundations

3.14.6.3.1 The ground soil shall be excavated to the level of the bottom of the foundation as shown on the drawings or as directed.

3.14.6.3.2 Notice of completion of excavation shall be given to the Engineer immediately and no concrete shall be deposited until the bottom has been inspected and expressly approved by the Engineer.

3.14.6.3.3 If at any of the depths the bottom is considered unsatisfactory by the Engineer the ground shall be excavated to such extra depth as the Engineer shall direct and the space so excavated shall be built up with concrete.

3.14.6.3.4 Any such extra work will be measured and paid for at the applicable rates, unless in the opinion of the Engineer such extra work has been made necessary by neglect or delay on the part of the contractor.

3.14.6.4 Unauthorised and extra excavation

3.14.6.4.1 If the Contractor by inadvertence, or without the instructions of the Engineer, shall take out any materials below the level of the foundations either as shown on the drawings, or as authorised by the Engineer, he shall make up the trench or excavation to the correct level with lean concrete and without any extra charge.

3.14.6.4.2 If after the bottom has been passed by the Engineer concrete is not placed immediately, a further depth of excavation together with the additional concrete necessitated thereby may be ordered by the Engineer, and this shall be carried out at the Contractor's expense.

3.14.6.5 Protection of formation surface

3.14.6.5.1 The Contractor shall take all precautions to prevent the finished formation surface being disturbed.

3.14.6.5.2 Upon completion of the cutting down to the formation level the Contractor shall ensure that no further construction plant uses the surface apart from that necessary to lay either the track bed or road base materials.

3.14.6.5.3 If however the Contractor has no other alternative, construction plant may use the surface at the bottom of the cutting provided that at a thickness of at least 100mm of material is maintained above formation level.

Any damage to the sub-grade arising from such use of the surface shall be made good by the Contractor at his own expense with material having the same characteristics as the material prior to being damaged.

3.14.6.6 Drainage

3.14.6.6.1 Before excavating the final 300mm of material down to formation level the Contractor shall install all permanent drainage as shown on the Drawings.

3.14.6.6.2 Care shall be taken to ensure that any excavated spoil does not enter any manhole or block drainage gullies and on completion of the Works all drainage shall be cleared of any accumulated sediment.

3.14.7 Embankments

3.14.7.1 Preparation of existing ground

3.14.7.1.1 After site clearance has been carried out, any organic or other unsuitable material uncovered shall be removed and all voids or depressions filled with approved material and compacted.

3.14.7.1.2 Any drainage ditches or other watercourses not specifically covered by other parts of this Specification shall be diverted away from the base area upon which the embankment filling is to be placed.

3.14.7.1.3 Where existing slopes are to be altered or built upon, the Contractor shall cut steps into the existing ground profile in a manner to be agreed with the Engineer so that the new filling may bond to the existing ground profile in a satisfactory way.

3.14.7.2 Fill material

3.14.7.2.1 All material used in embankment construction shall be as specified herein and samples of the material shall have been approved by the Engineer.

3.14.7.3 Compaction

3.14.7.3.1 Before proceeding with embankment construction the Contractor shall submit, for the Engineer's approval, details of his proposed method of compacting the fill material. Earthmoving equipment will not be acceptable for this purpose.

3.14.7.3.2 For the Contractor's guidance details of acceptable methods are set out in the Specification for Highway works, Volume 1, 1998, clause 608.

3.14.7.3.3 At the commencement of compaction, the Contractor shall satisfy the Engineer that the method being used produces a compacted fill material having a field density of at least 95% of the maximum bulk density previously determined for that particular material.

At the Engineer's discretion lower values may be used in certain areas.

3.14.7.4 Forming embankment

3.14.7.4.1 Any drainage ditches or other watercourses not specifically covered by other parts of this Specification shall be diverted away from the base area upon which the embankment filling is to be placed.

- 3.14.7.4.2 The filling for all embankments is to be evenly spread in layers not exceeding 200mm in depth before compaction.
- All lumps are to be broken up and the material shall be reasonably uniform in character.
- 3.14.7.4.3 All filling material shall be compacted to produce layers of maximum possible density having an optimum moisture content and in general all means shall be taken to form a solid embankment having profiles as shown on the Drawings.
- 3.14.7.4.4 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:
- a) make good by removing the material from the Site, or stockpiling it elsewhere until it is in a physical condition suitable for re-use, and replacing it with suitable material;
 - or**
 - b) making good the material by mechanical or chemical means;
 - or**
 - c) cease work on the material until its physical condition is again such that it can be compacted as described in the Contract.
- 3.14.7.4.5 During construction of the embankment the surface of the Earthworks shall be graded in order to facilitate the shedding of rainwater and minimise absorption of water.
- 3.14.7.4.6 The engineer may arrange at any time for compaction tests to be carried out as specified in BS 1377.
- 3.14.7.5 Protection of formation surface**
- 3.14.7.5.1 The Contractor shall take all precautions to prevent the finished formation surface from being disturbed.
- 3.14.7.5.2 Upon completion of the embankment up to formation level the Contractor shall ensure that no further construction plant uses the surface apart from that necessary to lay either the track bed or road base materials.
- 3.14.7.5.3 If the Contractor has no other alternative but to use the embankment for the passage of construction plant he shall either place a further 300mm of suitable temporary protective material above the formation level or temporarily stop construction of the embankment 300mm below the formation level.
- Any damage to the sub-grade arising from such use of the embankment shall be made good by the Contractor at his own expense with material having the same characteristics as the material prior to being damaged.
- 3.14.8 Fill materials**
- 3.14.8.1 Classification, definitions and uses
- 3.44.8.1.1 The classification, definitions and uses contained in clause 601 of the Specification for Highway Works, Volume 1, 1998 shall apply unless specified or approved by the Engineer.
- 3.14.9 Soiling and vegetation**
- 3.14.9.1 Soiling**
- 3.14.9.1.1 Except where otherwise specified, areas to be grassed or planted shall be covered with topsoil which shall be reduced to a fine tilth and lightly compacted to the thickness described in the Contract.

3.14.9.2 Fertilizer

3.14.9.2.1 Prior to seeding or planting, an approved fertilizer shall be evenly spread over the topsoil at a rate of not less than 75g per square metre.

3.14.9.2.2 The fertilizer shall consist of an approved compound containing not less than:
10% Nitrogen
15% Phosphoric acid
10% Potash

3.14.9.2.3 The Contractor may add any additional plant nutrients which he considers the construction of the soil to warrant.

3.14.9.3 Grass Seed

3.14.9.3.1 Grass seed shall be sown on the specified areas of topsoil at the rate of 35kg per square metre and the surface lightly raked.

3.14.9.3.2 The grass seed shall consist of:
75% dwarf Ayreshire rye grass
25% red clover
or other mixture as approved by the Project Manager.

3.14.9.3.3 The seed shall have been treated with an effective bird repellent, be obtained from an approved seed merchant and achieve a standard of 90% minimum germination.

3.14.9.3.4 The Contractor shall pay due regard to the season and weather conditions before sowing grass seed and shall take all reasonable measures to promote its growth.

3.14.10 Demolition**3.14.10.1 Standards**

3.14.10.1.1 Demolition shall generally be carried out in accordance with the requirements of the following British Standards:

BS 6187:2000 Code of Practice for demolition;

BS 5228-1:2009 Code of practice for noise and vibration control on construction and open sites. Part 1: Noise

BS 5228-2:2009 Code of practice for noise and vibration control on construction and open sites. Part 2: Vibration

3.14.10.1.2 Demolition shall comply with all statutory provisions, including, in particular:

- a) The Health and Safety at Work Act 1974;
- b) The Management of Health and Safety at Work Regulations 2006;
- c) The Construction (Design and Management) Regulations 2007;
- d) The Noise at Work Regulations 2005.

3.14.10.2 Sub-leasing and Approval of Sub-contractor

3.14.10.2.1 Should the Contractor wish to sub-let any demolition or dismantling work then the Contractor's proposals for sub-letting will require approval by the Project Manager.

3.14.10.3 Method Statement

3.14.10.3.1 The Contractor shall submit method statements in a format agreed by the project Manager.



3.14.10.4 Screens and Hoardings

- 3.14.10.4.1 The Contractor shall arrange for screens, shores, needles or other supports, fans, hoardings and any other protection necessary for the safety of the public, his own and LU's employees, road and rail traffic and of any adjoining buildings and occupants.

3.14.10.5 Noise, vibration and pollution

- 3.14.10.5.1 The Contractor shall limit the noise and vibration levels throughout the Works and concurrently with demolition, allay dust by the frequent use of sprays of water or by other means approved by the Project Manager.

3.14.10.6 Extent of Demolition

- 3.14.10.6.1 Demolition shall be carried out to the extent and in such sections, manner, and times specified in the document and drawings and approved in writing with particular reference to the maintenance of stability.
- 3.14.10.6.2 Unless otherwise stated in the drawings, the buildings or structures are to be taken down completely and all foundations, basements, floors, pits or other obstructions shall be grubbed up in their entirety and the materials arising there from removed from the Site.

Thereafter ground levels shall be reinstated to accord with the surface of the adjacent ground.

- 3.14.10.6.3 Where buildings or structures are to be only partially demolished the Contractor shall take suitable precautions during the demolition to ensure the complete safety and dryness of the remaining portion of any building or structure and shall, on completion, satisfy the Project Manager that the precautions taken and condition of the building or structure is in accordance with LU's requirements after completion of the Contract.

3.14.10.7 Demolition of pre-stressed concrete

- 3.14.10.7.1 The Contractor shall undertake the demolition of pre-stressed concrete in accordance with BS 6187.

3.14.10.8 Burning, cutting or fires

- 3.14.10.8.1 No burning or lighting of fires shall be carried out without the presence of a fire watchman and the approval of the Engineer.
- 3.14.10.8.2 The Contractor shall not light fires on site for the disposal of demolished or other, materials without the approval of the Engineer.

Any such approved fires shall be specifically confined to locations authorised by the Engineer, who may at any time withdraw his approval, if smoke or sparks are found to become a hazard, or constitute a nuisance to LU or to any other parties. In particular, exposed railway cables and the visibility of railway signals must not be affected.

- 3.14.10.8.3 In the event of withdrawal of the Engineer's approval, any fire shall be promptly extinguished and the Contractor shall supply and keep ready an effective means to quench the same.

3.14.10.9 Precaution in respect of asbestos

- 3.14.10.9.1 Notwithstanding the requirements of the Contract Safety Conditions, the Contractor shall, if required by the Engineer, employ an approved specialist firm for the carrying out of any work involving the removal or disturbance of asbestos.

3.14.10.10 *Noxious or inflammable substances*

3.14.10.10.1 The Contractor shall not store any noxious or inflammable substances within the Railway Operational Boundary.

3.14.10.11 *Use of Explosives*

3.14.10.1 The use of explosives for demolition will not be allowed.

3.15 Piling

3.15.1 General

3.15.1.1 *British Standards and Codes*

Piling shall comply with the following codes, except where otherwise modified by the following clauses:

BS 3416:1991	Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water.
BS 5930:1999	Code of practice for site investigations
BS 8004:1986	Code of practice for foundations;
BS8008:1996	Safety precautions for the construction and descent of machine - bored shafts for piling and other purposes
BS EN 1011-1:1998 Welding	Welding – Recommendations for welding of metallic materials Part 1: General guidance for arc welding.
BS EN 1011-2:2001	Welding- recommendations for welding of metallic materials Part 2: Arc welding of ferritic steels.
BS EN 1997-1	Eurocode 7 – Geotechnical design Part 1: General rules
BS EN 10025:2004	Parts 1 to 5 Hot rolled products of structural steels
BS EN 10300:2005	Specification for bitumen based hot applied coating materials for protecting iron and steel, including suitable primers where required.
BS EN ISO 14688-2:2004	Geotechnical investigation and testing. Identification and classification of soil. Principles for a classification

“Specification for piling and embedded walls” - Institution of Civil Engineers – 1996

3.15.1.2 Safety procedures for large diameter bore holes, shafts and excavations for foundation, shall be in accordance with BS 8008.

3.15.2 Bored piles

3.15.2.1 *General*

3.15.2.1.1 Bored piles are herein regarded as those piles formed by using an augering machine or tripod rig to perform the excavation process.

3.15.2.1.2 The piles shall be installed using such a system as will keep noise and ground vibration to a minimum.

3.15.2.1.3 The piling operation for any pile shall be carried out, as far as practicable, continuously from the commencement of boring until completion of concreting.

3.15.2.2 Pile size

- 3.15.2.2.1 The piles shall be of such diameters and lengths as may be indicated on the Drawings and these dimensions shall be treated as minimum values.
- 3.15.2.2.2 Variation in piles diameter or length shall only be made with the approval of the Project Manager.
- 3.15.2.2.3 Should the Contractor wish to construct piles to a larger diameter than specified, the rates quoted in the Bill of Quantities shall be deemed to include the extra costs involved.

3.15.2.3 Boring

- 3.15.2.3.1 During the process of boring, a steel tube lining shall be installed to a depth as agreed by the Project Manager to prevent ingress of groundwater, damage to the shaft, or entry of soil or other materials either from the surface or from weak sections of the bore.
- 3.15.2.3.2 Piles shall be bored, and subsequently filled, in such a manner as to ensure that no damage is sustained to previously formed piles in adjacent positions.
- 3.15.2.3.3 Upon completion of boring the excavation shall be cleaned of all loose material, any water shall be removed, and the bottom punned.

3.15.2.4 Tolerances

- 3.15.2.4.1 The maximum permitted deviation on plan of the pile centre at the pile head from its correct setting out position shall be 75mm in any direction.
- 3.15.2.4.2 The minimum permitted deviation of the finished vertical pile from the vertical shall be 1 in 75.
- 3.15.2.4.3 The maximum permitted deviation of the finished raked pile from the specified rake shall be 1 in 25.

3.15.2.5 Disposal of water

- 3.15.2.5.1 Where piles are bored into permeable strata and it is not possible to prevent water being discharged onto the surrounding ground surface, the Contractor shall take every precaution to collect the water and only discharge it into appropriate watercourses and piped drainage systems after removal of all suspended solids and any harmful dissolved substances.
- 3.15.2.5.2 The Contractor shall obtain all consents and agreements with appropriate drainage authorities and owners before discharging any water into an existing drainage system.

3.15.2.6 Machine augered piles

- 3.15.2.6.1 In addition to the requirements for all piles, for machine augered piles drilling mud shall only be used with the prior permission of the Engineer. On no account shall water be used as a drilling aid.
- 3.15.2.6.2 The enlarged base of under reamed piles shall be formed from ground level by extending the rotary arms of the cutting tool outwards at an angle beyond the circumference of the pile shaft.

The bottom of the pile excavation shall not be enlarged by hand without the prior permission of the Engineer.

3.15.2.7 Soil samples

- 3.15.2.7.1 When required by the Engineer, the contractor shall take from the pile excavation undisturbed soil samples in accordance with BS 5930. Such samples shall be subjected to laboratory tests and if the nature of the strata should vary from that

anticipated from the site investigation report, the Engineer shall be notified immediately.

3.15.2.8 Inspection of shafts with diameter less than 750mm

3.15.2.8.1 Each pile excavation shall be carefully inspected on completion by a competent person employed by the Contractor.

3.15.2.8.2 The Contractor shall provide all facilities for the Project Manager to make a similar inspection.

Equipment to be provided by the Contractor shall include electric illumination suitable for lowering down the shaft, and a separate strong light with a narrow beam capable of illuminating the base from the top of the pile.

3.15.2.9 Inspection of shafts with diameter 750mm or greater

3.15.2.9.1 Each pile excavation shall be carefully inspected on completion by a competent person employed by the Contractor.

Such inspection shall be carried out throughout the depth of the shaft and at the base to ensure that all loose soil is removed.

3.15.2.9.2 Where an under-reamed base is to be formed this inspection must be made before under-reaming is commenced and no under-reaming shall be commenced without the approval of the Engineer.

The Contractor shall provide all necessary facilities to enable the Engineer to make a similar inspection when required.

3.15.2.10 Safety precautions

3.15.2.10.1 Where the construction of any borehole of or exceeding 750mm diameter is required, and into which a man may descend for inspection, the Contractor shall comply with BS8008.

3.15.2.11 Reinforcement in piles

3.15.2.11.1 The reinforcement in piles shall be of steel to grades and dimensions as shown on the Drawings and shall comply with all relevant sections of the specification for concrete work.

3.15.2.12 Concrete in piles

3.15.2.12.1 The concrete in piles shall comply with all relevant sections of the specification for concrete work and shall be of the grade shown on the Drawings.

3.15.2.12.2 Sand/cement grout may be used in mini piles instead of concrete. The constituents, mix design placing and compaction of grout shall comply with the requirements given in "Specification for piling and embedded retaining walls" – Institution of Civil Engineers.

The water: cement ratio shall not exceed 0.4.

The concrete or grout mix design shall be submitted to the Project Manager for approval.

3.15.2.13 Placing of concrete

3.15.2.13.1 The concrete for each pile shall be placed in one continuous operation in a manner preventing segregation.

3.15.2.13.2 Any lining shall be withdrawn as concreting proceeds so that its bottom edge is kept between 250mm and 1,250 below the top surface of the concrete.



3.15.2.13.3 Where it is not possible to place pile concrete within a dry bore, the concrete shall be placed using an appropriate tremie pipe technique which will ensure that any pile reinforcement is accurately maintained in position throughout the concreting operation.

3.15.2.13.4 The piles shall be concreted to a level at least 200mm above the finished level shown on Drawings and, after hardening, the surplus concrete shall be cut away.

3.15.2.13.5 Any defective concrete below the required finished level shall be rectified in accordance with the relevant sections of the specification for concrete work.

3.15.2.14 Placing of concrete under water or drilling fluid

3.15.2.14.1 The Engineer's approval is required before placing concrete under water or drilling fluid and the Contractor must demonstrate to the Engineer's satisfaction that a bore cannot be sealed against the ingress of water or, where the method of forming the bore incorporates a head of water or drilling fluid, it cannot be removed without causing instability of the bore.

3.15.2.14.2 Concrete to be placed under water or drilling fluid shall be placed by tremie unless otherwise approved by the Engineer.

Piles must be tremied to the full height so that all water and slurry is brought to the surface.

Tremieing must continue until good clean concrete is formed up to cut-off level.

3.15.2.14.3 The internal diameter of the tremie pipe shall not be less than 150mm for concrete made with 20mm aggregate and not less than 200mm for concrete made with 40mm aggregate.

The internal diameter of the pipe shall be free from projections and any projections on the external surface should be minimised in size and number to allow the tremie pipe to pass through the reinforcing cage without displacing the cage or causing damage.

3.15.2.15 Additional work due to unsatisfactory piles

3.15.2.15.1 If, in the opinion of the Engineer, any additional work is necessary due to any pile being constructed in a position or to a line which is not within the tolerances specified, or if, in the opinion of the Engineer, a pile is not capable of permanently supporting the specified load due to damage by ground water, or soil, or the operations of the Contractor on other piles, or by the failure of the Contractor to conform in any respect with the requirements of this Specification, the Engineer shall specify such additional work, or such modifications to the structures to be supported by the piles, as he may consider necessary and the cost of such additional work, or such modifications to the structures, shall be borne by the Contractor.

3.15.2.16 Piling records

3.15.2.16.1 The Contractor shall keep detailed logs of all piling operations and duplicate copies of such logs shall be submitted to the Engineer upon completion of each pile. The logs shall include the following:-

- a) Identification of pile and dates of boring and concreting;
- b) Nominal diameter constructed;
- c) Ground level at pile location, referred to the Engineer's temporary bench mark;
- d) Base level of temporary casing installed;
- e) Details of strata penetrated;
- f) All water levels encountered;
- g) Depths at which "undisturbed" samples were taken;

- h) Base level of pile;
- i) Time interval between boring and concreting;
- j) Volume of concrete placed in pile;
- k) Level to which concrete was placed;
- l) Type of reinforcement cage placed;
- m) Obstructions encountered, delay times, standing times, etc

3.15.3 Hand dug cylinder piles

3.15.3.1 *Pile size*

- 3.15.3.1.1 The piles shall be of such diameters and lengths as may be indicated on the Drawings and these dimensions shall be treated as minimum values.
- 3.15.3.1.2 Variations in pile diameter or length shall only be made with the approval of the Engineer.
- 3.15.3.1.3 Should the contractor wish to construct piles to a larger diameter than specified, the rates quoted in the Bill of Quantities shall be deemed to include the extra costs involved.

3.15.3.2 *Excavation*

- 3.15.3.2.1 The shafts and enlarged bases shall be excavated by hand in the positions and to the levels and diameters shown on the Drawings.
- 3.15.3.2.2 Excavations shall be carried out as rapidly as possible to reduce the length of time in which the sides of the excavation are exposed to the atmosphere.
- 3.15.3.2.3 The Contractor shall construct a kerb around the top of the shaft and take such other precautions as deemed necessary by the Engineer to prevent water entering the excavation.
- 3.15.3.2.4 During wet weather a waterproof cover shall be erected over the top of the shaft. Should water penetrate into the excavation in spite of such measures, it shall be removed as soon as possible.
- 3.15.3.2.5 Excavation in the lined portion of the shafts shall not proceed below the lining by more than two rings of segments or 1.5m whichever is less.

3.15.3.3 *Additional excavation*

- 3.15.3.3.1 Shafts shall be excavated to a greater depth than shown on the drawings if the Engineer shall so direct and any soft or loose soil in the bottom of the excavation shall be removed by the Contractor.
- 3.15.3.3.2 Payment for such additional excavation will be at the appropriate rate in the Bills of Quantities provided that, in the opinion of the Engineer, the Contractor's operations or method of working did not contribute to the need for additional excavation.

3.15.3.4 *Shaft lining*

- 3.15.3.4.1 The shaft of the cylinder foundations shall be lined with concrete, steel or cast iron segments of a design approved by the Engineer.

Details of the shaft lining shall be submitted to the Engineer before the commencement of the works.

- 3.15.3.4.2 Shaft linings shall be erected complete with all bolts, grommets and packing, and the space between the back of the lining and the earth shall be completely filled with cement grout immediately after each ring of segments is fixed.

- 3.15.3.4.3 Cement grout shall consist of ordinary Portland cement and clean sharp sand in the proportion of 1:1:5 (by volume) with mixing water to obtain a free flowing grout to the approval of the Engineer.
- 3.15.3.4.4 Segments shall be provided with no less than four grouting holes per ring approximately equally spaced around the circumference of the shaft.
- 3.15.3.4.5 Cement grout shall be injected by means of an approved pump under pressure into one hole with all the plugs removed and the plugs inserted progressively as the grout appears at each hole around the circumference.
- 3.15.3.4.6 Each 3 metre depth of shaft lining shall be re-grouted to the Engineer's satisfaction as soon as it is completed to ensure that no voids remain behind the lining.
- 3.15.3.4.7 Prior to the excavation of enlarged bases the lining shall be properly supported from the ground below.

The stability of the sides and roof of the enlarged base shall be secured with any necessary sheeting and strutting.

Notwithstanding any approval by the Engineer, the Contractor shall remain responsible for the safety of the excavation against failure or collapse.

3.15.3.5 Soil samples

- 3.15.3.5.1 When required by the Engineer, the Contractor shall take from the pile excavation undisturbed soil samples in accordance with BS 5930.

Such samples shall be subjected to laboratory tests and if the nature of the strata should vary from that anticipated from the site investigation report, the Engineer shall be notified immediately.

3.15.3.6 Inspection of shafts

- 3.15.3.6.1 The Contractor shall continuously inspect the excavated faces of the pile shaft and shall immediately report to the Engineer any variations of ground conditions from that indicated in the site investigation report.

3.15.3.7 Reinforcement in piles

- 3.15.3.7.1 The reinforcement shall be of steel to grades and dimensions as shown on the Drawings and shall comply with all relevant sections of the specification for concrete work.

3.15.3.8 Concrete in piles

- 3.15.3.8.1 Concreting of piles shall begin as soon as possible, and in all cases not longer than 12 hours, after completion of the excavation and approval of the same by the Engineer.
- 3.15.3.8.2 The concrete in piles shall comply with all relevant sections of the specification for concrete work and shall be of the grade shown on the Drawings.
- 3.15.3.8.3 A minimum of 75mm concrete cover to the reinforcement within the lining shall be ensured by the use of pre-cast concrete spacers attached to the bars at not more than 1.5 metres centres, or by any other means approved by the Engineer. For mini piles (275 to 350mm diameter) the cover shall be not less than 40mm unless otherwise agreed by the Engineer.
- 3.15.3.8.4 The concrete for each pile shall be placed in one continuous operation.
- 3.15.3.8.5 Vibrators shall be used to produce compaction of the concrete throughout the pile unless self compacting concrete is used, in which case vibrators shall not be used.



- 3.15.3.8.6 Self compacting concrete shall be to an approved mix design, agreed with the Engineer, and shall contain superplasticizer and stabiliser.

The mix shall be tested for strength and consistence compliance before use in piles.

3.15.3.9 Additional work due to unsatisfactory piles.

- 3.15.3.9.1 If, in the opinion of the Engineer, any additional work is necessary due to any pile being constructed in a position or to a line or level which is not within the tolerances specified, or if, in the opinion of the Engineer, any pile is not capable of permanently supporting the specified load due to damage by ground water, or soil, or operations of the Contractor on other piles, or by the failure of the Contractor to conform to this specification, the Engineer shall specify such additional work, or such modifications to the structures to be supported by the piles, as he may consider necessary and the cost of such additional work, or such modifications to the structures, shall be borne by the Contractor.

3.15.4 Steel sheet piling

3.15.4.1 Material

- 3.15.4.1.1 The steel sheet piling shall be Frodingham, Larssen or similar type and shall be of the sections, numbers and lengths complete with all necessary corner, junction and special piles as required.

- 3.15.4.1.2 The steel shall be of a European manufacture throughout and obtained from a manufacturer approved in writing by the Project Manager.

- 3.15.4.1.3 The material shall comply with all relevant sections of BS EN 10025.

- 3.15.4.1.4 The grade of steel shall be as specified on the Drawings.

- 3.15.4.1.5 The lengths are to be the minimum required for design purposes.

The Contractor shall allow for the piles to be of such greater length as necessary to permit the attachment of driving apparatus.

- 3.15.4.1.6 The maximum rolling margins shall be as follows:-

4% over and 2.5% under theoretical mass;

75mm over and 50mm under scheduled lengths.

3.15.4.2 Working drawings

- 3.15.4.2.1 The contractor shall submit triplicate copies of his working drawings to the Project Manager and obtain his approval of these before starting any work.

3.15.4.3 Storage

- 3.15.4.3.1 Where piles have to be stored they shall be placed on sufficient supports on firm ground to avoid damage by excessive bending.

3.15.4.4 Driving

- 3.15.4.4.1 The system of pile driving shall be such as to reduce ground vibration and noise to a minimum.

- 3.15.4.4.2 The Engineer shall be notified 24 hours before the commencement of driving. The piles shall be driven true to the lines and levels shown on the Drawings.

- 3.15.4.4.3 Taper piles shall not be introduced in order to correct piles which have developed a lean, unless the approval of the Engineer is first obtained.



3.15.4.4.4 Piles which reach refusal before achieving the designed penetration shall not be cut off without the approval of the Engineer.

3.15.4.4.5 All holes in the piling for reinforcement, tie rods, anchor bolts, weep holes etc, shall be made at the Site after the piling has been driven to the correct levels.

3.15.4.4.6 After the piles have been finally driven, the heads shall be trimmed and shall have a neat appearance.

3.15.4.5 Lengthening of piles

3.15.4.5.1 Full penetration butt welds shall be used for all pile lengthening. Sections to be joined shall be maintained in true alignment and position.

After welding, the affected area shall be thoroughly cleaned and protected in the same way as adjacent surfaces.

All welding shall be carried out in accordance with the following British Standards:

- a) BS EN 1011-1:1998 Welding – Recommendations for welding of metallic materials Part 1: General guidance for arc welding.
- b) BS EN 1011-2:2001 Welding- recommendations for welding of metallic materials Part 2: Arc welding of ferritic steels.

3.15.4.6 Surplus length

3.15.4.6.1 Any length of pile that is surplus to that required for incorporation in the structure shall be cut off and removed from the site.

3.15.4.7 Risen piles

3.15.4.7.1 Piles that have risen as a result of driving adjacent piles shall be re-driven to the requirements of the Engineer.

3.15.4.8 Additional work due to unsatisfactory piles

3.15.4.8.1 If, in the opinion of the Engineer, any additional work is necessary due to any pile being located in a position or to a line which is not within tolerances shown on the Drawings or because of the failure of the Contractor to conform in any respect with the Specification, the Engineer shall specify such additional work or such modifications to the structures to be supported by the piles as he may consider necessary and the cost of such additional work or such modifications to the structures shall be borne by the Contractor.

Such additional work may include the extraction, replacement if necessary, and re-driving of misplaced piles.

3.15.4.9 Piling records

3.15.4.9.1 The Contractor shall keep detailed logs of all piling operations and duplicate copies of such logs shall be submitted to the Engineer upon completion of each pile.

The logs shall include the following:-

- a) Dimensions and section type and number;
- b) Depth driven and depth of pile toe;
- c) Sequence of driving in groups;
- d) Final set for last 10 blows;
- e) Type and weight of hammer used;
- f) Type and condition of the packing on the pile head, and the dolly of the helmet;
- g) Details of any interruption in driving;
- h) Details of re-driving;
- i) Details of cutting of piles (if any)



- j) Details of any welds;

3.15.4.10 Protection of steel piles against corrosion

- 3.15.4.10.1 All surfaces of the steel sheet piles shall receive the protective coating treatment unless modified herein.
- 3.15.4.10.2 Before dispatch from the manufacturers works the surface of the steel sheet piles shall be coated with bitumen manufactured to British Standard;
- a) BS 3416:1991 - Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water.
- OR
- b) BS EN 10300:2005 Specification for bitumen based hot applied coating materials for protecting iron and steel, including suitable primers where required.
- 3.15.4.10.3 Pile surfaces that are to be embedded in concrete shall be left uncoated.
- 3.15.4.10.4 On completion of the Works the permanently exposed pile surfaces shall be cleaned of all soil and dirt to 750mm below finished ground level and given a further coat of bitumen.

3.15.5 Pile Testing

3.15.5.1 General

- 3.15.5.1.1 Before commencing the installation of permanent piles, the Contractor shall construct a test pile, or piles, with dimensions and method of construction similar to that proposed for the permanent piles, as directed by the Engineer.
- 3.15.5.1.2 The test pile shall be located away from the permanent piles in a position as shown on the Drawings or as may be agreed with the Engineer.
The position shall be representative of the foundation plies.
Adequate time shall be allowed for the pile material to achieve the required strength and for pore-pressures to have regained their initial values.
A of one month will normally be required for piles in soft clay unless agreed otherwise by the Engineer.
- 3.15.5.1.3 On completion of testing, the test pile and any associated anchor pile and other equipment foundations shall be demolished to such levels as will permit the satisfactory construction of the works to allow the ground in the vicinity of the test pile to be restored to its original position.

3.15.5.2 Pile loading

- 3.15.5.2.1 The Contractor shall submit for the approval of the Engineer detailed proposals for the pile load test which shall be carried out using the system of maintained loads, as described in BS EN 1997-1:2004 "Code of Practice for foundations".
- 3.15.5.2.2 All equipment used to measure loads and displacements shall be calibrated prior to the test.
- 3.15.5.2.3 The working and expected ultimate pile loads are indicated on the Drawings. The sequence of loading shall be:-
- a) up to working load in five increments, load held for 20 minutes at each increment and for one hour at working load;
- b) removal of load in decrements as above, but holding load for 10 minutes;
- c) leave unloaded for one hour;

- d) up to working load in increments as above, load held for 10 minutes at each increment;
- e) hold at working load for six hours;
- f) continue up to 1.5 times working load in five increments and hold for 10 minutes at each increment
- g) hold at 1.5 times working load for six hours;
- h) increase load up to ultimate load in increments of 10% working load, hold load for 5 minutes at each increment.
Failure load is deemed to be maximum load that can be sustained by the piles, or the load causing a penetration of 10% of the nominal pile diameter. Piles need not be tested to more than twice working load;
- i) removal of all load in at least five equal stages, load held for 10 minutes at each stage
- j) continue recording pile movement for one hour after fully unloading.

3.15.5.2 Test results

- 3.15.5.2.1 The Contractor shall within 24 hours of the completion of the test, submit to the Engineer, for each pile tested, a preliminary report of the test including graphical plots of all readings taken, and shall submit a full report within 7 days.
- 3.15.5.2.2 The Contractor shall not commence the permanent piling work until the Engineer has considered the report and agreed the depth to which the piles are to be formed.

3.16 Concrete works

3.16.1 General

3.16.1.2 British Standards

- 3.16.1.2.1 Concrete shall comply with the requirements of the following British Standards

BS EN 206-1:2000	Concrete – Part 1: Specification, performance, production and conformity.
BS 8500-1:2002	Concrete – Complementary British Standard to BS EN 206-1. Part 1: Method of specifying and guidance for the specifier.
BS 8500-2:2002	Concrete – Complementary British Standard to BS EN 206-1. Part 2: Specification for constituent materials and concrete.
BS 8000-2.1:1990	Workmanship on building sites. Part 2 – Code of practice for concrete work. Section 2.1 – Mixing and transporting concrete
BS 8000-2.2:1990	Workmanship on building sites. Part 2 – Code of practice for concrete work. Section 2.2 – Sitework with in situ and precast concrete
BS 5606:1990	Guide to accuracy in building.
BS EN ISO 9000	Quality management and quality assurance

3.16.2 Constituent materials

3.16.2.1 Cements

3.16.2.1.1 Only the following cements complying with the following standards shall be used in works on LU:

- a) CEM I Portland cement or
- b) CEM 2 Portland – composite cement to:
 - i) BS EN 197-1:2000 Cement – Part 1: Composition, specifications and conformity criteria for common cements;

and shall be supplied from manufacturers who are BSI registered firms of assessed capability who operate appropriate quality management assurance systems in accordance with BS EN ISO 9000.

Conformity of cements shall be evaluated in accordance with:

- a) BS EN 197-2:2000 Cement – Part 2: Conformity evaluation.

3.16.2.1.2 Pulverized-fuel ash (pfa) in Portland – composite cement shall comply with the requirements of:

- a) BS EN 450-1:2005 Pulverized-fuel ash. Specification for pulverized-fuel ash for use with Portland cement

3.16.2.1.3 Ground granulated blastfurnace slag (ggbfs) for use in Portland –composite cement shall comply with:

- a) BS EN 15167-1:2006 Ground granulated blast furnace slag for use in concrete, mortar and grout
Part 1: Definitions, specifications and conformity Criteria
- b) BS EN 15167-2:2006 Ground granulated blast furnace slag for use in concrete, mortar and grout
Part 2: Conformity evaluation

3.16.2.1.4 Ground granulated blast-furnace slag (ggbfs) and pulverised fuel ash (pfa) shall not be used in prestressed concrete work, unless specified.

3.16.2.1.5 Sulphate resisting cement shall comply with:

- a) BS 4027:1996 Specification for sulfate resisting Portland cement

3.16.2.1.6 Where sulphate resisting cement complying with BS 4027 is used, guidance shall be taken from BRE Digest 363.

3.16. 2.1.7 No ggbfs, pfa or cement combinations including either of them shall be included in concrete mixes containing sulphate resisting cement to BS 4027.

3.16.2.1.8 Where low heat cements are required they shall comply with:

- a) BS 1370:1979 Specification for low heat Portland cement
or
- b) BS EN 14216:2004 Cement. Composition, specifications and conformity criteria for very low heat special cements.

3.16.2.1.9 High alumina cement shall not be used under any circumstances.

3.16.2.2 Aggregates

3.16.2.2.1 All aggregates shall comply with BS EN 12620:2002.

3.16.2.2.2 The designation of coarse aggregate for concrete strength grades 20 and above shall be 4/20 unless otherwise stated and shall be graded in accordance with Table 2 of BS EN 12620:2002.

3.16.2.2.3 The designation of fine aggregate shall be 0/6.3 in accordance with Table 2 of BS EN 12620:2002.

3.16.2.2.4 The all-in aggregate for lean mix and blinding concrete shall be graded in accordance with Table 6 of BS EN 12620:2002.

3.16.2.2.5 Marine aggregates shall not be used in prestressed concrete or steam cured concrete.

3.16.2.2.6 Aggregates liable to suffer from the action of freezing and thawing shall not be used in concrete that may be exposed to such conditions.

3.16.2.3 Water

3.16.2.3.1 Mixing water shall comply with:

- | | |
|--------------------|--|
| a) BS EN 1008:2002 | Mixing water for concrete.
Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete. |
|--------------------|--|

3.16.2.4 Admixtures

3.16.2.4.1 Admixtures shall only be used with the prior approval of the Engineer

3.16.2.4.2 Admixtures shall comply with the following British Standards:

- | | |
|---------------------|---|
| a) BS EN 934-2:2001 | Admixtures for concrete, mortar, grout. Concrete admixtures Definitions, requirements, conformity, marking and labelling. |
| b) BS EN 934-6:2001 | Admixtures for concrete, mortar and grout. Sampling, conformity control and evaluation of conformity. |
| c) BS EN 480 | Admixtures for concrete, mortar and grout- Test Methods |

3.16.2.4.3 Calcium chloride or admixtures based on chlorides shall not be used.

3.16.2.4.4 Any admixture or combination of admixtures shall be checked to ensure it causes no adverse reactions with concrete containing pfa, ggbs or sulphate resisting cement.

3.16.3 Durability

3.16.3.1 General

3.16.3.1.1 Unless otherwise specified, the Contractor shall comply with Section 4 of BS 8500-1:2006 to achieve hardened concrete which will perform satisfactorily in the working environment during its anticipated service life.

3.16.3.2 Alkali-silica reaction

3.16.3.2.1 The concrete mix shall comply with detailed guidance given in BRE digest 330, Part 2 2004. The total weight of Na₂O equivalent per cubic metre of finished concrete shall not exceed the amounts given in table 1 of that digest.

3.16.4 Properties of fresh concrete and concrete mixes

3.16.4.1 General

- 3.16.4.1.1 Properties of fresh concrete shall comply with those specified, in accordance with BS EN 206-1 and with BS 8500 Parts 1 and 2.
- 3.16.4.1.2 Care shall be taken to ensure that the hardened concrete is not adversely affected when placed in hot or cold weather conditions.
- 3.16.4.1.3 Measures detailed in BS 8500-1:2002, Annex A clause A.11 shall be taken, as appropriate.
- 3.16.4.1.4 Immature concrete that has been frozen must to be broken out and replaced at the Contractor's expense.

3.16.4.2 Designed mixes

- 3.16.4.2.1 All concrete mixes shall be designed and shall comply with the requirements of BS 8500 (except blinding and lean mix concrete), unless stated otherwise.
- 3.16.4.2.2 All designed mixes shall be strength tested to assess compliance.
- 3.16.4.2.3 The strength grades, minimum cement content and maximum water/cement (w/c) ratio shall be as stated in the drawings or bill items and shall comply with Table 1 below.
- 3.16.4.2.4 Where composite cements are used an appropriate k factor shall be applied to the partial cement replacement material to determine the w/c ratio in accordance with BS EN 206-1:2000, clause 5.2.5.2.
- 3.16.4.2.5 Where minimum cement content or the maximum w/c ratio is not specified the w/c ratio and minimum cement content appropriate to the exposure conditions shall be taken from BS8500.
- 3.16.4.2.6 The characteristic compressive strengths at 28 days of the strength grades specified shall be those given in Table 1 below.

Grade	Characteristic strength		Maximum Aggregate size mm	Minimum Cement Content kg/m ³	Maximum Water/Cement Ratio
	Cylinder	Cube			
C40/50	40	50	20	360	0.40
C32/40	32	40	20	340	0.40
C28/35	28	35	20	320	0.45
C25/30	25	30	20	300	0.50
C16/20	16	20	20	280	0.50

Note: for surfaces exposed to de-icing agents or sulphate attack, additional protection in the form of coating the surface should be considered.

Table 1 Designed Mixes Exposure Class XC4 Consistence class S3

3.16.4.3 Prescribed mixes

- 3.16.4.3.1 The prescribed mixes shall be supplied in accordance with the relevant clauses of BS 8500-1.

- 3.16.4.3.2 Lean mix concrete shall be composed of a well graded all-in aggregate, having a maximum nominal size not exceeding 40mm, mixed with cement such that the ratio of cement to aggregate by weight is not less than 1:15.

The lowest possible water/cement ratio shall be used consistent with the requirements of placing and compacting the concrete.

- 3.16.4.3.3 No-fines concrete shall be composed of rounded aggregate graded between 40mm maximum and 20mm minimum size, mixed with cement such that the ratio of cement to aggregate by weight is not less than 1:15.

The lowest possible water/cement ratio shall be used consistent with satisfactory coating of the aggregate.

Concrete shall be hand placed and not vibrated. Moist curing is required.

3.16.5 Information to be provided by the contractor

- 3.16.5.1 Before any concrete is supplied and during the production of concrete, the Contractor shall provide to the Project Manager unless otherwise agreed, the following information in accordance with the requirements of BS EN 206-1:2000:

- a) cement type and strength class;
- b) type of aggregates;
- c) type and approximate content of admixtures;
- d) type and approximate content of other additions;
- e) target water./cement ratio;
- f) results of the relevant previous tests for the concrete e.g. from production control or from initial tests;
- g) strength development;
- h) sources of the constituent materials;

3.16.6 Production of concrete

3.16.6.1 General

- 3.16.6.1.1 Best practice detailed in BS EN 13670-1:2009 – “Execution of concrete structures, Common” should be followed wherever appropriate.

- 3.16.6.1.2 The production of concrete unless otherwise stated shall comply with the relevant sections of BS EN 206-1:2000 and BS 8500.

- 3.16.6.1.3 The delivery tickets for each consignment shall contain a declaration of conformity to BS EN 206-1:2000 and shall include the information required in clause 7.3. A copy shall be supplied for retention by the Engineer.

3.16.6.2 Storage and handling of materials

- 3.16.6.2.1 Further to the requirements of BS 8500-2, section 11, the Contractor shall submit his proposals for storage and obtain written approval from the Engineer.

- 3.16.6.2.2 Cement which, in the Engineer's opinion, has deteriorated or has become damp, shall be removed from the site immediately.

- 3.16.6.2.3 Materials shall be handled in accordance with relevant COSHH regulations.

3.16.6.3 Transport of concrete

- 3.16.6.3.1 Transport of concrete shall be in accordance with the requirements of BS 8500-2, unless otherwise stated.

3.16.7 Concreting

3.16.7.1 British Standards

3.16.7.1.1 Placing, compacting and curing of concrete shall comply with the recommendations of clause 4 of BS EN 1992-1-1:2004, unless otherwise modified or extended herein.

3.16.7.2 Record of air temperatures

3.16.7.2.1 A maximum and minimum thermometer of approved design and manufacture for measuring atmospheric shade temperature shall be kept fixed at all times in a position close to the Works in a position approved by the Engineer.

3.16.7.2.2 A daily record of maximum and minimum shade temperatures and their mean shall be maintained on the Site by the contractor and copied to the Engineer when requested.

3.16.7.3 Placing and compacting of concrete

3.16.7.3.1 Unless otherwise approved by the Engineer, blinding concrete, formwork or other approved separating layers shall be used to prevent any concrete, except lean mix and "no-fines" from being placed directly against the ground.

3.16.7.3.2 Before any concrete is placed, the Contractor shall examine and clean out any formwork, check the reinforcement and obtain the Engineers approval.

3.16.7.3.3 Unless otherwise agreed, concrete shall not be discharged vertically through a height greater than 2 metres or more than 1 metre from a chute if a chute is used to discharge the concrete into the formwork, the design and inclination of a chute should be such that the concrete shall be kept free from coatings of hardened concrete.

3.16.7.3.4 Pumping of concrete may be permitted, but only with the prior approval by the Engineer of the details, layout and method of operation of the plant which the Contractor proposes to use.

3.16.7.3.5 Concreting of any unit or section shall be carried out in one continuous operation as quickly as possible.

Sufficient labour and equipment, including reserve equipment, shall be kept available on Site to ensure this.

If the Work is interrupted without the Engineers approval the section may be classed as defective work.

3.16.7.3.6 The Contractor shall keep on the Site a complete record of the Works showing the time, date and location of all the concrete placed in each part of the Works. This record shall be available at all times for inspection by the Engineer.

3.16.7.3.7 The Contractor shall ensure that the vibrators used for compaction do not displace the reinforcement, inserts or formwork from their intended position.

3.16.7.3.8 The Contractor shall provide, at his own expense, a sufficient number of vibrator units, as standby equipment, during any period of concreting.

3.16.7.4 Curing and protection

3.16.7.4.1 Before concreting the Contractor shall obtain the Engineers approval of his proposals for curing and protecting the concrete, which shall normally be based on recommendations of clause 3.2.3 of BS 8000-2.2:1990.

3.16.7.4.2 Covering the surface with a damp absorbent material or application of water to the surface shall not be used to cure concrete whenever there is a possibility of frost occurring.

- 3.16.7.4.3 From the time of placing, all concrete shall be protected from distortion, shock, vibration and anything likely to interfere with the process of setting and hardening.
- 3.16.7.4.4 No loads of any kind shall be imposed on any portion of the concrete work before, during or after removal of the formwork until permission is given by the Engineer.
- 3.16.7.4.5 Full account shall be taken of any requirements for reducing the curing time that may occur in the vicinity of railways. Further guidance may be sought from Comité Euro-International du Béton – Durable Concrete Structures.
- 3.16.7.5 Concreting in cold weather**
- 3.16.7.5.1 Concrete shall not normally be placed when the shade temperature is below, or likely to fall below 2° C before the section of work can be completed.
- 3.16.7.5.2 Where, in the opinion of the Engineer, the work is of such urgency that it must continue in such circumstances the Contractor shall take such measures as are recommended in clause 3.2.3.4, BS 8000-2.2:1990 and as the Engineer shall approve to ensure the specified strengths, soundness and satisfactory appearance of the work.
- 3.16.7.6 Placing concrete under water**
- 3.16.7.6.1 Unless otherwise approved by the Engineer, concrete to be placed under water shall be placed by tremie and shall be discharged freely into the water.
- 3.16.7.6.2 The concrete shall be placed in a manner such that segregation will not occur. The tremie shall be clean and watertight throughout. The tremie pipe shall extend to the bottom of the excavation and a watertight sliding plug or barrier shall be placed in the pipe to prevent direct contact between the first charge of concrete in the tremie pipe and the water.
- 3.16.7.6.3 The pipe shall at all times penetrate the concrete which has previously been placed and shall not be withdrawn from the concrete until completion. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the water. The internal diameter of the tremie pipe shall be not less than 150mm for concrete made with 20mm aggregate and not less than 200mm for concrete made with 40mm aggregate.
- 3.16.8 Sampling and testing**
- 3.16.8.1 General**
- 3.16.8.1.1 Unless otherwise specified herein all sampling and testing of concrete shall be in accordance with the requirements of BS EN 206-1:2000 and BS 8500-2, clause 10.
- 3.16.8.1.2 Sampling and testing of concrete for compliance shall be carried out by organisations accredited by the National Measurement Accreditation Service (NAMAS) for the relevant test.
- 3.16.8.2 Testing equipment**
- 3.16.8.2.1 The Contractor shall provide, to the Engineer's satisfaction, the equipment for all tests except those to be carried out by the approved testing authority, and shall provide for maintaining all such equipment in proper working order to the Engineer's satisfaction.
- 3.16.8.2.2 The workability shall be within the specified limits. Concrete shall not be placed if it is outside the workability limits. The design of the mix for the non-compliant concrete grade shall be adjusted to the Engineer's satisfaction before placing re-commences.

3.16.8.3 *Strength testing*

- 3.16.8.3.1 Sampling and testing for strength shall be carried out in accordance with the requirements of BS EN 206-1:2000, clause 8.
- 3.16.8.3.2 Compliance for compressive strength shall comply with the requirements of BS EN 206-1:2000, clause 8.2 and BS 8500.
- 3.16.8.3.3 If the Contractor wishes to make and test concrete cubes to justify his subsequent working procedures, (e.g. removal of supports, casting superimposed concrete, lifting members from moulds, etc.), the cubes shall be taken in the presence of the project Manager's representative as specified herein, but all costs relating to the manufacture and testing of such cubes shall be at the Contractor's expense.

3.16.8.4 *Test results*

- 3.16.8.4.1 Results of all works tests and test analysis shall be recorded and kept in the site and copies shall be sent to the Engineer as soon as the results are available. All records of work and tests shall indicate clearly which part of the structure each sample of concrete represents.

3.16.9 Formwork

3.16.9.1 *General*

- 3.16.9.1.1 Unless modified or extended herein, all formwork shall comply with the requirements of BS EN 8000-2.2:1990 Subsection 4.
- 3.16.9.1.2 Before construction commences, the Contractor shall obtain the Engineers approval of the general method and system he proposes to use and when so directed shall submit detailed drawings of the formwork for the Engineer's approval.
- 3.16.9.1.3 Permanent formwork where specified shall be of non combustible material unless otherwise agreed by the Engineer.
- 3.16.9.1.4 Formers for all chases, grooves, recesses, etc, shall be securely fixed as part of the formwork.
- No part of the concrete work shall be cut away for any such item, or for any other reason, without the Engineer's permission.
- 3.16.9.1.5 Notwithstanding the requirements of clause 4.1.3 of BS 8000-2.2:1990, the Contractor shall obtain the Engineers permission before striking any formwork or casing or removing a support.
- 3.16.9.1.6 Notwithstanding any permission, approval or advice given by the Engineer, the Contractor shall be responsible for any injury to the work caused by, or arising from, the easing, striking or removal of formwork or supports and for any consequent damage or delay; and shall rectify the same at his own cost.

3.16.9.2 *Surface finish of concrete*

- 3.16.9.2.1 Except where otherwise indicated or approved, formwork shall be used for all surfaces except horizontal top surfaces, and all formed surfaces shall be left as struck.
- 3.16.9.2.2 The Contractor shall obtain the Engineer's approval of the methods to be used for inclined or surcharged top surfaces.
- 3.16.9.2.2 Standards of finish are specified, for both formed and unformed surfaces, except as otherwise indicated on the Drawings: