

Technical Specification

T0007

Earth Structures Materials and Workmanship

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MAYOR OF LONDON



Contents

1	Purpose	3
2	Scope	3
3	Standards and Codes of Practice	3
4	General Requirements	4
5	Earthworks	7
6	RAMWALL	16
7	Soil Nailing	17
8	Ruglei Verge Protection System	26
9	Miscellaneous Retaining Walls	29
10	Piling and Embedded Retaining Walls	32
11	Steel Piles (including Sheet Piles and King Post Walls)	33
12	Concrete works	35
13	Reinforcement	35
14	Precast Concrete	35
15	Drainage	35
16	Geosynthetics including Reinforced Soil Systems	36
17	Miscellaneous Work	38
18	Ground Investigation	39
19	Monitoring	40
20	Landscaping	49
21	Responsibilities	54
22	Supporting information	55
23	References	55

1 Purpose

- 1.1 The purpose of this Standard is to provide material and workmanship specifications for all works associated with Earth Structure assets.

Earth Structures assets comprise the following:

- aa) Embankments of soil with slopes more than 1m high;
- ab) Cutting slopes of soil and rock (chalk) more than 1m high.

2 Scope

- 2.1 This Standard applies to Earth Structures owned by LU.
- 2.2 This Standard defines the requirements for work undertaken on Earth Structures asset through the following life cycle stages:
- a) Construction, installation, testing and commissioning
 - ac) Maintenance
 - ad) Strengthening and renewal

3 Standards and Codes of Practice

- 3.1 There is no reference in the Specification to satisfy legislation. This follows the general principle that the works are to be constructed to comply with all relevant statutes.
- 3.2 The design and construction of the works shall be undertaken in accordance with all relevant European Standards, British Standards, European execution standards, LU Engineering Standards and Highway Agency's Specification for Highway works (SHW) current at the date of issuing of the Subcontract Works Order unless noted otherwise. Where the requirements of these Standards or Codes of Practice are in conflict with this Specification, the Contractor shall refer to the Project Manager for clarification.

Note: In defining mandatory requirements specifically applicable to Earth Structures, reference shall be made to the LU Category 1 Standard S1050 (Civil Engineering – Common Requirements) and its supplementary standard S1054 (Civil Engineering – Earth Structures). Further guidance on how these mandatory requirements can be achieved is provided in the complementary Civil Engineering Guidance Documents G0050 and G0054A. For supporting structures such as retaining walls and piles, mandatory requirements are defined in LU Category 1 Standard S1051 (Civil Engineering – Bridge Structures); whilst for slope drainage, and vegetation and landscape management the requirements are included in LU Standards S1052 and 1-165 respectively. Standard S1054 does not deal with the requirements for slopes less than 1m high.

- 3.3 All goods, materials, testing and other procedures not otherwise specified shall be in accordance with the latest edition of the appropriate British or equivalent European or LUL Standards and Specification, where such exist at the time of Tender or unless otherwise accepted by the Project Manager.
- 3.4 Where the standard indicated on the drawings or in this specification has been superseded either by an alternative LUL, British or European Standard then the reference shall be deemed to refer to that current standard.

4 General Requirements

4.1 Pre-amble

- 4.1.1 This Specification is substantially based on the Department for Transport's Specification for Highway Works (SHW). Additional specification has been provided where the SHW is not adequate or requires modification to provide more relevance to works undertaken within the London Underground (LU) environment.
- 4.1.2 This Specification is, as far as possible, a performance based standard. However, given that the LU environment is rather unique in certain respects, some prescription remains in this document.
- 4.1.3 This document is generic in form and not tied to either the Institution of Civil Managers Conditions of Contract (Measurement Version)(7th Edition) or the Civil Engineering Standard Method of Measurement (3rd Edition) or the Manual of Contract Documents for Highway Works Volume 4 Bills of Quantities for Highway Works.
- 4.1.4 This document contains references to the 'Client', 'Project Manager' and 'Contractor'. It should be noted that in the context of this specification those terms shall be taken to have logical meaning in the broad senses of the words and shall be viewed as independent of the specific Conditions of Contract. Thus the term 'Client' shall be taken to mean Employer, Authority, Purchaser, etc; similarly 'Contractor' shall mean 'Contractor/sub contractor' in the traditional contractual sense if appropriate, or shall mean the relevant entity within other forms of contract such as alliancing and joint ventures, etc; and the term 'Project Manager' shall also be construed in a generic sense to mean Contract Administrator, Project Manager, or other London Underground representative as appropriate to the contract.

4.2 Suppliers

- 4.2.1 Prior to the commencement of the Works, the Contractor shall submit to the Project Manager a list of the suppliers from whom he proposes to purchase the materials necessary for the execution of the Permanent Works. No source of supply thereafter shall be changed without informing the Project Manager 7 days prior to any change.
- 4.2.2 Priority should be given to suppliers operating a Quality Management System to BS EN ISO 9001.

4.3 Alternative Products

- 4.3.1 Except where a proprietary product is specifically called for in this specification or on the contract drawings, reference to a brand item is intended to indicate only the minimal acceptable product specification.
- 4.3.2 LU maintains an approved products register (<http://www.lu-apr.co.uk>); only products appearing on that register may be incorporated into the works.
- 4.3.3 Should a supplier or contractor wish to use a product not on the approved product register, then special approval (from the LU) will need to be sought and granted before it can be incorporated in the works. The Contractor shall submit to the Project Manager for approval technical descriptions, specifications and drawings where relevant and other such information which will enable the Contractor to demonstrate to the Project Manager that the product proposed is the equivalent of that required by this Specification.
- 4.3.4 The use of asbestos or materials containing asbestos is prohibited.

4.4 Existing and As-built Survey Drawings

- 4.4.1 Where required by the contract, as-built drawings shall be provided in electronic format and comply with the current version of LU Category 1 Standard 1-037 Computer Aided Design Data.

4.5 Impact on Outside Party Assets

- 4.5.1 Where required by the contract, the impact on Outside Party assets shall be determined in accordance with the current version of LU Category 1 Standard 1-023 Infrastructure Protection.

4.6 Method of Work Statements

4.6.1 General

- 4.6.1.1 The Contractor shall provide to the Project Manager for approval, the proposed Safe Method of Work (SMoW) prior to commencement of works.

4.6.2 Skilled Workmanship

- 4.6.2.1 Before employing any person to carry out a skilled operation in or about the execution of the works, the Contractor shall satisfy the Project Manager that such person has sufficient competency, skill and experience to complete that operation satisfactorily.
- 4.6.2.2 This requirement shall also extend to any suppliers proposed by the Contractor to be employed in or about the execution of the Works.

4.6.3 Plant Operatives

- 4.6.3.1 The operatives on site shall be in possession of a current certificate of training for plant operatives in the civil engineering industry as issued by the Construction Industry Training Board (CITB) unless otherwise agreed by the Project Manager.

4.6.4 Protection to existing assets

- 4.6.4.1 The contractor shall ensure that adequate protection is provided to existing line side infrastructure, such as cable runs, to prevent damage during the works.

4.6.5 Manufacturer's Instructions

- 4.6.5.1 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 Project Manager.

4.7 Inspection and Test Plans

4.7.1 General

- 4.7.1.1 All materials and workmanship shall be as described in accordance with the Project Manager's instructions and shall be subject from time to time to such tests as the Project Manager may direct at the place of manufacture, or fabrication, or on site, or at all of any such places.
- 4.7.1.2 The Contractor shall submit the Inspection and Testing Plan and obtain approval from the LU Project Manager prior to commencement of the works. The plan shall include the nature of inspection, the testing requirements, the proposed testing equipment, the proposed testing organisation, the proposed format of the testing report and any other relevant technical details.
- 4.7.1.3 Before any work commences the Contractor shall obtain the Project Manager's approval of the independent testing authority proposed for use. All testing shall be carried out by this

approved authority and a copy of all test results and reports immediately sent direct to the Project Manager except where otherwise specified or directed by the Project Manager.

- 4.7.1.4 The Contractor shall provide such assistance, instruments, plant, labour and materials as the Project Manager 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 Project Manager.
- 4.7.1.5 To ensure construction works meet the tolerance and other requirements, the works shall be inspected during the construction by the Contractor and at practical completion by the LU client sponsor, LU CMO representative and LU Head of Profession.

4.7.2 Preliminary Tests

- 4.7.2.1 Before any material is used in the works, tests shall be carried out wherever relevant to prove that the material conforms to the Specification, detailed design report and Contract drawings, and the results of these tests shall be submitted to the Project Manager for approval.
- 4.7.2.2 The procedure shall be repeated whenever the source, batch, type, quality or grading of material is changed, including concrete testing for the purpose of mix-design approval.

4.7.3 Sampling and Testing

- 4.7.3.1 The Contractor shall supply to the Project Manager 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.
- 4.7.3.2 Approved samples will be retained by the Project Manager until the completion of the Contract. In the event of any sample being rejected because of its failure to meet the testing requirements or in the opinion of the Project Manager that the material is unsuitable, the whole batch or quantity of materials from which the samples have been taken and which have been brought to the site shall be removed immediately by the Contractor.
- 4.7.3.3 Samples for laboratory tests or test locations for in-situ tests shall be randomly selected by the Project Manager. In addition, the Project Manager shall be free to select samples he suspects to be defective. The test locations for in-situ tests so selected and, if applicable, the area / extent of works covered by the tests, shall be traceable by means of reference co-ordinates system, reference batch number with delivery date and other details or a location plan with defined test positions and levels.
- 4.7.3.4 Samples shall be taken on site under supervision of the Project Manager. Except where otherwise directed, a minimum of 7 days notice shall be given to the Project Manager of all sampling, testing and other trial operations to allow s/he or his/her representative to be present during such operations.
- 4.7.3.5 Samples shall be representative and of sufficient size to enable all specified tests to be made. Samples shall be clearly, indelibly and individually marked for identification.
- 4.7.3.6 Samples shall be protected, handled and stored in such a manner that they are not damaged nor contaminated such that the properties of the sample do not change. The method of storage shall comply with the requirements of the relevant test methods.
- 4.7.3.7 During transportation from the site to the specified place for testing, all samples shall be securely locked in containers or suitably modified vehicle compartments unless otherwise approved by the Project Manager.

4.8 Temporary Works

- 4.8.1 It is the Principal Contractor's sole responsibility to design, provide, erect, maintain and remove, on completion, all Temporary Works as may be necessary for the execution of

the Works, unless otherwise stated in the Contract Documents and shall consider the following:

- a) The design and construction of the works shall be undertaken in accordance with the requirements of S1062 and BS 5975:2008.
 - b) The use of Temporary Works shall only commence once the method statement, drawings and calculations have been accepted by the Project Manager.
- 4.8.2 The method statement for any Temporary Works shall include methods for the removal of the Temporary Works.
- 4.8.3 The loading and/or removal of the Temporary Works shall not be carried out without the acceptance of the Project Manager.
- 4.8.4 All Temporary Works shall be constructed, fabricated and erected to the same standard of Workmanship as the Permanent Works.
- 4.8.5 All materials used as load-carrying components shall conform to the relevant British/European Standards and where applicable the re-use of material shall be considered and used in the Temporary Works.
- 4.8.6 Health and safety issues relating to Temporary Works shall be taken into account throughout the whole process, from early in the design stage to the final removal and loading of the Permanent Works.
- 4.8.7 The adequacy of any temporary support shall be considered in its relationship with the loading on the permanent structure.
- 4.8.8 Appropriate drawings, calculations, specifications and any contributions to the construction-stage health and safety plan shall be prepared and followed.
- 4.8.9 Where any failure of these temporary works would have a significant adverse effect on the health and safety of persons or on the environment, they shall be the subject of an independent design check and risk assessment.
- 4.8.10 Once checked, changes shall only be made after direct consultation with the appropriate Temporary Works Designer.
- 4.8.11 The Principal Contractor shall appoint a competent person (Temporary Works Coordinator in accordance with BS 5975:2008) to ensure safety in the design, checking, construction and use of temporary works and shall encourage cooperation and coordination between Sub-contractors.

4.9 Matters Not Specified

- 4.8.1 In the event of any material or manufactured item or workmanship requirement not being specified herein, or in any European, British or LUL standard specification which may materially affect the requirements for materials and workmanship, the Contractor shall submit details of the methods and materials he proposes to use for approval by the Project Manager.

5 Earthworks

5.1 General

- 5.1.1 The SHW (latest edition) shall apply unless otherwise specified or approved by the Project Manager.



- 5.1.2 The finished profile of all earth works shall be graded and free from all irregularities, mud, slurry and debris. Any irregularity, deterioration, or damage to the finished surfaces of the formation, granular filters and to the slopes of any embankments, cuttings or other earthworks arising out of the stacking of materials, the transport of plant or materials, the passage of his workmen, or due to any other causes shall be rectified by the contractor at no additional cost.
- 5.1.3 During construction, areas of cut and fill shall be formed with a sufficient cross fall and surface smoothness to shed surface water. Adequate drainage or slope works should be provided within the site to ensure the site is free draining and water is not allowed to pond in trafficked areas.
- 5.1.4 Adequate drainage shall be provided around the site to ensure watercourses are adequately diverted away from the works. Where required, temporary trenches shall be formed to drain water from the earthworks. The contractor shall put in places means to prevent silt from discharging into permanent drainage systems.

5.2 Excavation

5.2.1 General

- 5.2.1.1 The Contractor shall follow his "permit to dig" procedure.
- 5.2.1.2 Before any excavation is carried out, the levels of the existing ground to be disturbed shall be agreed with the Project Manager. In default the levels on the contract drawings shall apply.
- 5.2.1.3 The location and depth of existing services shall be determined prior to undertaking any excavation.
- 5.2.1.4 Excavation shall be undertaken in sections which shall not exceed 4m unless otherwise documented in the temporary works design.
- 5.2.1.5 Where material is to be placed on a slope, either as part of temporary or permanent works, the Contractor shall cut benches with step heights and width not exceeding 0.5m and 1.0m, respectively, into the existing ground profile.

5.2.2 Stability of Excavated Surfaces

- 5.2.2.1 Great care shall be taken to avoid the disturbance of the excavations after approval has been given as previously described and the Contractor must take all necessary steps to ensure this. If the Contractor wishes to employ heavy plant and vehicles over this surface, he shall take additional precautions, such as additional excavation combined with the protection by additional granular layers or concrete as directed by the Project Manager.
- 5.2.2.2 The Contractor shall provide and fix all planking, sheeting and strutting to uphold the sides of excavations, and remove the same when no longer required.
- 5.2.2.3 Excavations adjacent to the track, existing structures or lineside services shall be undertaken in suitable lengths and fully supported to ensure continuous support to the track and lineside services as the works progress. No excavation can be left unsupported overnight or at other times when there is no attendance from the Contractor
- 5.2.2.4 Unless otherwise agreed or directed by the Project Manager, 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.
- 5.2.2.5 In removing the temporary supports no settlement or subsidence shall take place in the surrounding ground.
- 5.2.2.6 Unless otherwise approved by the Project Manager, no excavation is allowed during periods of heavy rainfall.



5.2.3 Inspection of Excavated Surfaces

- 5.2.3.1 The ground shall be excavated to the level as noted on the contract drawings. Notice of completion of excavation shall be given to the Project Manager immediately and no concrete or fill shall be deposited until it is inspected and approval is given by the Project Manager. If the depth is considered to be insufficient by the Project Manager, the ground shall be excavated to such extra depth as directed by the Project Manager.
- 5.2.3.2 The excavation shall be backfilled using the specified material following approval given by the Project Manager.

5.2.4 Unauthorised and Extra Excavation for Foundations

- 5.2.4.1 If the Contractor by inadvertence, or without the instructions of the Project Manager, removes any materials below the level instructed by the Project Manager, the contractor shall make up the trench or excavation to the correct level by lean mix concrete or other method agreed with the Project Manager without any extra charge.
- 5.2.4.2 If after the formation has been approved by the Project Manager and concrete is not placed immediately, a further depth of excavation together with the additional concrete necessitated thereby may be ordered by the Project Manager, and this shall be carried out at the Contractor's expense.

5.2.5 Disposal of Excavated Materials

- 5.2.5.1 All excavated material not meeting the specification for reuse on site shall be disposed of as waste in accordance with the current legislation and guidance. The Contractor is responsible for characterising the waste, ensuring compliance with the "duty of care" requirements for disposal and any required registration of the site for production of hazardous waste.
- 5.2.5.2 Material excavated from the site shall be subject to Waste Acceptance Criteria (WAC) testing. One of each test per 200m³ shall be carried out, unless presence of contaminants is suspected visually or by smell, in which case frequency shall be increased with acceptance of the Project Manager. Material waste which meets the criteria noted in Table 5.1 is classified as acceptable for landfill disposal.

Item	Concentration (All units are mg/kg unless otherwise indicated)
General Parameters	
PH	5 – 10
Metals and Metalloids	
Total Arsenic	40
Boron (water soluble)	3
Total Cadmium	15
Chromium (Hexavalent)	25
Total Chromium	1000
Total Copper	130
Total Mercury	20
Total Lead	2000
Total Nickel	70
Total Selenium	6
Total Zinc	300
Inorganic Compounds	
Total Sulphate	0.24%
Water Soluble Sulphate (2:1 water/soil extract)	1200
Asbestos	Nil
Organic Compounds	
Toluene Extractable Material*	<1000
Note: * Higher values may be acceptable if additional testing demonstrates these to be due to non-carcinogenic materials.	

Table 5.1: Maximum Allowable Contaminant Concentrations for Acceptable Material

5.3 Filling

5.3.1 General

- 5.3.1.1 The Contractor shall submit the proposed method of deposition of fill to the Project Manager for approval. Where adjacent to existing structures or services, the proposed method shall meet the requirements imposed by the relevant utility companies and other authorities.
- 5.3.1.2 The Contractor shall provide details of the machines proposed for regrading works for approval by the Project Manager.
- 5.3.1.3 Preparation and surface treatment of the sub-formation including tolerances, shall be as shown on the Contract Drawings.

5.3.2 Preparation

- 5.3.2.1 Exposed areas of sub-formation or formation shall be kept to a minimum and shall be covered to avoid deterioration during adverse weather.
- 5.3.2.2 Surfaces on which fill material is to be deposited on earthworks shall be prepared after site clearance in accordance with the following requirements:
- Topsoil, grass and other organic matter shall be removed.
 - Soft spots, boulders and other materials which in the opinion of the Project Manager are unsuitable or unstable to be removed and backfilled with suitable granular fill to the approval of the Project Manager.

- c) After stripping the topsoil before placement of the fill, the natural ground shall be compacted and scarified in accordance with the requirements of Clause 616 of the SHW
- d) Additional excavation necessary to provide working space or other temporary works shall be backfilled with suitable material compacted in accordance with the SHW

5.3.3 Protection of existing assets

- 5.3.3.1 Unless agreed by the Project Manager, no machinery shall be allowed within 2m from existing structures such as wing walls.
- 5.3.3.2 Great care shall be taken to avoid the disturbance of the lineside services due to the placement of the fill material.
- 5.3.3.3 Work shall be undertaken in accordance with LUL Standard S1114, Safe Systems of Work on or near Electrical Equipment.
- 5.3.3.4 Great care shall be taken to avoid damage to any existing structures. When working adjacent to existing structures a condition survey shall be carried out prior to start of the works followed by monitoring of the structure during construction in order to demonstrate that no damage to the structure has been caused.

5.3.4 Placement of Fill

- 5.3.4.1 No compaction of any material shall commence without prior permission of the Project Manager. Where compaction trials are required, no compaction shall commence until the compaction trials have been completed and satisfactory results obtained.
- 5.3.4.2 No filling shall be carried out when snow is lying on the ground or when the ground is frozen. Fill affected by frost shall be excavated and replaced with acceptable fill or, if granular, re-compacted as necessary to achieve a minimum of 95% of the maximum dry density of the fill.
- 5.3.4.3 Materials used within 450mm of the final finished surface shall not be frost susceptible.
- 5.3.4.4 Backfill in front of bases of retaining walls, gravity walls and strutted abutments etc, shall be completed before the filling to the back of the structure is commenced.
- 5.3.4.5 Unless otherwise specified all backfilling shall be deposited and rammed in layers, not exceeding the requirements specified in the SHW, when compacted.
- 5.3.4.6 Each layer shall be completed over the whole area to be filled before the succeeding layer is deposited. At no time shall the side slopes be steeper than those shown on the contract drawings.
- 5.3.4.7 Timbering, sheeting and framing, or other supports, shall be carefully withdrawn ahead of the layer to be compacted, care shall be taken to keep the sides of the excavation solid and to fill all 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.
- 5.3.4.8 In areas of fill formed of fill material, earthworks final surfaces sloping at a gradient exceeding 1 vertical to 3 horizontal shall be formed by overfilling and cutting back after compaction. Over-filling shall extend beyond the earthworks final surface by a horizontal distance of 0.5m or three times the thickness of the compacted layer, whichever is greater.
- 5.3.4.9 The finished top level of the widened cess shall be a minimum of 100mm below the bottom of the lowest cable unless noted otherwise on the contract drawings.
- 5.3.4.10 Completion of the formation shall not be carried out until all necessary drainage and or waterproofing has been laid and is in working order.
- 5.3.4.11 The finished level of the fill shall have a surface tolerance within +/- 20mm.

5.4 Fill Materials

5.4.1 General

- 5.4.1.1 Acceptable material for use as general fill shall be in accordance with the Contract drawings and comply with the requirements of Table 6/1 of the SHW, Series 600.
- 5.4.1.2 Demolition waste or similar material shall be classified as unacceptable material, Class U1.
- 5.4.1.3 Notwithstanding the requirements of the SHW, the permitted constituents for acceptable earthworks fill materials are Natural gravel, natural sand, crushed concrete, crushed rock other than argillaceous rock, or any combination of the foregoing.
- 5.4.1.4 All fill materials shall comply with the requirements described in Table 5.2 for the acceptability for use in the works and with the requirements of SHW for allowable contaminant concentrations.
- 5.4.1.5 The classification and confirmation of acceptability of the earthworks materials shall be carried out by the Contractor in accordance with the requirements of Table 6/1 of the SHW and Table 5.3 of this specification at:
- a) the point of excavation for material excavated from within the site in open excavations, or
 - b) the source and prior to transport to site for imported material. Locations for classification purposes shall be accepted by the Project Manager.
 - c) Locations for classification purposes shall be accepted by the Project Manager.
- 5.4.1.6 If in the opinion of the Project Manager, the material has altered its classification or become unacceptable for whatever reason, he may require the Contractor to repeat the classification and acceptability tests given in the SHW Table 6/1 and Table 5.2.
- 5.4.1.7 The Project Manager may carry out compliance testing of materials proposed for incorporation into the works or already in the works. The Contractor shall remove and render unacceptable any materials not complying with the specification. Such testing by the Project Manager shall not absolve the Contractor of any obligations under the contract.

5.4.2 Class 1A

- 5.4.2.1 Class 1A material shall be used for re-profiling the slope and constructing berms.
- 5.4.2.2 The permitted constituents for acceptable earthworks fill material are natural gravel, natural sand, crushed gravel, crushed concrete, crushed rock other than argillaceous rock or any combination of the foregoing. Chalk is not permitted.
- 5.4.2.3 The grading shall be to the requirements for Class 1A material, as given in section 600 of the SHW.

5.4.3 Type 1

- 5.4.3.1 Type 1 material shall be used as the surface layer material for walkways.
- 5.4.3.2 Type 1 material shall comply with the classification and definitions as contained in Series 800 of the SHW.

5.4.4 Topsoil

- 5.4.4.1 Topsoil shall be classified and placed as Class 5 material in accordance with Series 600 of the SHW.
- 5.4.4.2 Where possible, topsoil is to be recovered from site works and reused. Such material shall be classified as Class 5A material. The Contractor shall supply to the Project Manager the

requisite evidence to support the suitability of the recovered material for reuse. Such material arising shall be separately stockpiled and protected.

5.4.5 Type B (20/40) Granular fill

- 5.4.5.1 Type B Material shall be used as a backfill for filter drains and trenches.
- 5.4.5.2 Type B material may also be used as backfill to retaining structures, as specified in the Contract drawings, where compaction is not feasible due to space limitation. This material is considered to require no compaction due to its limited grading range.
- 5.4.5.3 Type B material shall comply with the classification and definitions contained in Series 500 of the SHW.

5.4.6 Re-use of Excavated Material

- 5.4.6.1 Generally all material arising from excavations shall be classified as unacceptable material Class U1 in accordance with the SHW.
- 5.4.6.2 Should the Contractor wish to classify any material as suitable under this Contract for the purpose of filling, he must first demonstrate to the Project Manager that the materials comply with the requirements described in the SHW.
- 5.4.6.3 Before any material is used in the works, tests shall be carried out wherever relevant to prove that the material conforms to the requirements described in the SHW, and the results of these tests shall be submitted to the Project Manager for approval.

5.4.7 Transport, Storage and Handling

- 5.4.7.1 Materials shall be carefully conveyed and stored on site and placed so as to avoid any possibility of contamination. Any material which in the opinion of the Project Manager is contaminated shall be removed from site.
- 5.4.7.2 Earthworks materials shall not be handled or stored in a manner which will result in segregation, deterioration, erosion or instability of the material.
- 5.4.7.3 Different types of earthworks material shall be kept separate from each other.
- 5.4.7.4 Topsoil stockpiled for reuse shall not be compacted and should not exceed 2 m in height.

5.5 Sampling and Testing

The test schedule is provided in Table 5.3. Where in the opinion of the Project Manager more tests are required, the Contractor shall provide sufficient samples and necessary equipment.

The Contractor shall supply to the Project Manager 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.

Samples for laboratory tests or test locations for in-situ tests shall be randomly selected by the Project Manager. In addition, the Project Manager shall be free to select samples he suspects to be defective. The test locations for in-situ tests selected and, if applicable, the area/extent of works covered by the tests shall be traceable by means of either reference co-ordinates system or a location plan with defined test positions and levels.



Material	Material Properties Required for Acceptability (In addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631 (Specification for Highway Works))				Compaction Method
	Property	Defined and Tested in Accordance with	Acceptable Limits within:		
			Lower	Upper	
Class 1A	Grading	BS 1377:Part 2	SHW Table 6/2	SHW Table 6/2	End product: 95% of maximum dry density of BS 1377: Part 4 (vibrating hammer test).
	Uniformity Coefficient	BS 1377:Part 2 – D ₆₀ / D ₁₀	10	-	
	Dry Density	BS 1377:Part 4 – vibrating hammer test	95%	-	
	Moisture Content	BS 1377:Part 2	-	-	
	Effective angle of friction, ϕ'	SHW CL636 – Shear Box Test (300 mm square)	35°	-	
	Chemical Properties	SHW Clause 601/14,15			
Type 1	Grading	BS 1377:Part 2	SHW Table 8/2	SHW Table 8/2	SHW Table 8/1 subject to CL610
	10% fines value	SHW CL 635	50 kN	-	
	Plasticity Index	BS 1377:Part 2	Non-plastic	Non-plastic	
	Soundness	BS 812:Part 121	65		
	Chemical Properties	SHW Clause 601/14,15			
Type B	Grading	Refer Table 5/5 SHW			Self Compacting
	10% fines value	NA			
	Plasticity Index	NA			
	Soundness	SHW CL 601/14, 15			

Note: Taken from SHW

Table 5.2: Specification for Fill Materials



Material	Test	Frequency of Testing	Test Certificate	Comments
Class 1A	Grading	Two per 200m ³ , minimum two per imported batch	Required	Source to be agreed by Project Manager in advance .
	Uniformity			
	Moisture Content	Two per 200m ³ , minimum two per imported batch	Required	
	Optimum Moisture Content	Two per batch	Required	
	Particle density	Two per batch	Required	
	Dry density/moisture content - Vibrating hammer test	Two per 200m ³ , minimum two per imported batch	Required	
	Effective angle of friction, ϕ'	Two per 200m ³ , minimum two per imported batch	Required	
	Chemical Properties (SHW Clause 601/14,15)	Two per 200m ³ , minimum two per imported batch	Required	
	In-situ density (sand replacement method (large pouring cylinder method))	Four per 200m ³	N/A	
Type 1	Grading	Two per batch	Required	Source to be agreed by Project Manager in advance .
	10% fines value			
	Plasticity Index			
	Soundness			
	Chemical Properties (SHW Clause 601/14,15)			
Type B	Grading	Two per batch	Required	Source to be agreed by Project Manager in advance .
	Soundness			
	Chemical Properties (SHW Clause 601/14,15)			

Note 1: Batch means a single type of material from a given source

Table 5.3: Testing Schedule for Fill Materials

6 RAMWALL

6.1 General

- 6.1.1 RAMWALL™ is an acronym for 'Reinforced Aggregate Matrix – Wall'.
- 6.1.2 RAMWALL is essentially a gravity retaining wall, similar to a gabion, constructed from welded wire fabric grids factory bent into a series of zig-zag panels filled with crushed aggregate. The basic components for the system are the welded wire fabric mats, side and end mesh panels, steel dowels and aggregate fill.
- 6.1.3 All components of the RAMWALL system are made from standard grades of steel and shall have adequate corrosive protection as specified by the design in consultation with the supplier.
- 6.1.4 All steel components except steel rebar are galvanised to BS EN ISO 1461:2009, minimum thickness 87µm.

6.2 Materials

6.2.1 Fabric Mat Panels

- 6.2.1.1 The standard fabric mat panel is 2.2m long, 1metre wide and 165mm high.
- 6.2.1.2 The mat comes in two types, alternately layered to form a three-dimensional reinforcement matrix.
- 6.2.1.3 Type 1 has zig-zags aligned across the width of the panel and Type 2 has these aligned along the length.
- 6.2.1.4 Type 1 & Type 2 panels shall be manufactured from 8mm diameter, BS 4483:2005, A252, CARES Approved, welded steel wire fabric.

6.2.2 Side and End Mesh Panels

- 6.2.2.1 The standard mesh dimensions are 50mm wide by 50 mm long. However, depending on the size of the fill material smaller size mesh may be required in order to contain the fill.
- 6.2.2.2 The mesh panels shall be manufactured from 5mm diameter, BS 4483:2005, CARES Approved, welded steel fabric.
- 6.2.2.3 Corrosion protection shall be as specified on the Contract drawings,

6.2.3 Steel Dowels

- 6.2.3.1 The steel dowels (also referred to as Rebar spikes) shall be manufactured from 25mm diameter 1500 or 2000 long ribbed steel rebar to BS 4449: 2005
- 6.2.3.2 The steel dowels shall be pointed at one end and shall be spaced at about 1m intervals throughout the structure.

6.2.4 Fill

- 6.2.4.1 The aggregate used to fill the RAMWALL mesh cage can comprise construction and demolition waste (concrete, brick, slate, masonry, hardcore), industrial waste and by-products (slag, klinker, brick, ceramic, glass, used railway ballast) or Commercial waste (mine and quarry waste, shredded used tyres, broken glass) which meet the requirements of Table 8.2 of this specification.
- 6.2.4.2 The smallest particle size of the fill shall be larger than the size of the mesh in order to ensure that the fill will be contained within the mesh.



- 6.2.4.3 The contractor shall submit the proposal for the type of fill with the supporting documentation to the Project Manager for approval.

6.3 Transport, Storage and Handling

- 6.3.1 The components will be stored in a manner which will not result in damage to the component or the corrosive protection.
- 6.3.2 Materials shall be carefully stored and transported to site and placed so as to avoid possibility of contamination. Different types of earthworks material shall be kept separate from each other

6.4 Installation and Tolerances

- 6.4.1 The installation and tolerance details shall be agreed with the Project Manager in consultation with the Contractor.
- 6.4.2 The RAMWALL should be constructed in lifts not greater than 1m. Compaction of the fill is not necessary.
- 6.4.3 The top of the structure may be left open and the fill levelled off, or provided with a capping layer suitable for use as a walkway. The finished level of the fill shall have a surface tolerance within ± 20 mm.
- 6.4.4 The face of the RAMWALL shall be erected to a smooth alignment with no abrupt irregularities.
- 6.4.5 Care shall be taken to ensure minimum damage to the galvanising during filling activities.

6.5 Sampling, Testing and Monitoring

- 6.5.1 The Contractor shall submit certificate to the Project Manager for approval to demonstrate that the products meet the requirements specified by the designers/suppliers.
- 6.5.2 If in the opinion of the Project Manager extra sampling and testing is required, the Contractor shall provide all necessary equipment. Test certificate shall be provided for the Project Manager approval.

7 Soil Nailing

7.1 General

- 7.1.1 Soil nailing will be carried out in accordance with the guidance supplied in CIRIA C637 Soil Nailing – best practice guidance 2005.

7.2 Materials and Components

7.2.1 Supply

- 7.2.1.1 The sources of supply of soil nails, reinforcement, concrete and such other materials as are covered by this specification shall be approved in writing by the Project Manager and sources of supply shall not be changed without prior approval of the Project Manager.
- 7.2.1.2 Soil nails and other materials shall be supplied to site at such times as not to hinder or delay the execution of the works. Soil nails, reinforcement and associated components shall be delivered to site in undamaged condition and shall not be damaged by site handling or storage. Appropriate quality control measures shall be utilised, to include in particular, Manufacturers Certification documents.



- 7.2.1.3 Any soil nails or other such materials covered by this specification not conforming to stipulated requirements shall be rejected and not used in the works. Rejected materials shall be removed promptly from the site.

7.2.2 Soil Nails

- 7.2.2.1 The soil nails shall be prefabricated and delivered to site ready for installation in the works. The soil nails shall be Ischebeck Titan hollow soil nails or similar approved suitable for installation by simultaneous drilling and grouting. The soil nails shall have a characteristic yield stress of 500 N/mm².

- 7.2.2.2 Soil nails shall be manufactured from high quality high yield steel with low carbon content complying with the requirements of BS4449 and EN 10210 or EN 10219. The corrosion protection shall be in accordance with the Contract drawings.

- 7.2.2.3 Any galvanise coating shall be in accordance with BS EN ISO 1461 and BS EN ISO1413.

- 7.2.2.3 The soil nails shall provide a minimum service life of 120 years.

7.2.3 Couplers

- 7.2.3.1 These shall be Ischebeck Titan couplings or similar approved suitable for use with Ischebeck Titan soil nails. These shall be manufactured of the same material and offer the same corrosion protection as the soil nails and provide a service life in excess of 120 years.

- 7.2.3.2 The strength of the joint shall be as a minimum equal to the strength of that of the nail itself.

7.2.4 Plastic Sheaths

- 7.2.4.1 No plastic sheaths shall be required as the nails shall be self-drilling.

7.2.5 Centralisers

- 7.2.5.1 A minimum of 3 centralisers shall be provided at suitable intervals over the total length of the nail with the last centraliser to be located at a distance of 0.3 m from the end of each soil nail to ensure the required minimum cover of 30 mm grout is achieved.

- 7.2.5.2 The centralisers shall be fabricated from materials which have no deleterious effects on the soil nailing system.

- 7.2.5.3 To permit free flow of grout centralisers shall have a minimum diameter of 10 mm less than the nominal diameter of the drill hole.

- 7.2.5.4 Centralisers shall be manufactured by Ischebeck Titan or similar approved suitable for use with Ischebeck Titan soil nails or equivalent..

7.2.6 Cementitious Grout

- 7.2.6.1 Unless otherwise specified by the Project Manager, grout for the soil nails shall comprise a neat cement grout consisting of a pumpable mixture of cement and water with a 28 days cube strength of 40 N/mm². Cubes shall be made and tested in accordance with BS 1881. The type of cement shall be as specified in the Contract drawings.

- 7.2.6.2 The water/cement ratio shall not exceed 0.45 in order to reduce loss of grout into surrounding ground. The grout shall not be subject to bleeding in excess of 2% after 3 hours.

- 7.2.6.3 Admixtures which can control bleed or retard set of the grout shall be used only when approved in writing by the Project Manager. Their use shall be strictly according to the manufacturer's instructions.in