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SECTION 52 EARTHWORKS

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SECTION 52

EARTHWORKS

Granular starter layers **52.001** Basal granular starter layers between embankment fill material and the subgrade shall comply with Classes 6B, C or D as appropriate to table 6/1 of the Highways Agency Specification for Highway Works (SHW).

Where a chalk embankment is constructed, a basal granular starter layer complying with Classes 6C or D as appropriate of table 6/1 of the SHW shall be provided.

Granular starter layers shall be not less than 300 mm thick and shall be formed in layers not exceeding 200 mm thick.

Fill materials **52.002** The Contractor shall be responsible for classifying and determining the acceptability of earthworks materials in accordance with table 6/1 of the SHW on the basis of tests carried out at the point of excavation for on-site materials, and at the point of deposition for imported materials. The source(s) of imported material shall be agreed with the Employer's Representative before any materials are permitted to be brought to site. If, in the opinion of the Employer's Representative, the material has become unacceptable for any reason, the acceptability tests given in table 6/1 of the SHW shall be repeated by the Contractor.

The Contractor shall undertake such tests as necessary to provide sufficient information for the Employer's Representative to approve the classification and acceptability of materials. A minimum frequency of testing by the Contractor is indicated in Table 52.001 of the Appendix to Section 52. The Employer's Representative may instruct further testing to check the results obtained by the Contractor. A copy of all test results for the selected fill materials shall be provided to the Employer's Representative.

The Employer's Representative may carry out compliance testing of materials proposed for incorporation into the Works or already in the Works. The Contractor shall remove or render acceptable any material not complying with the Specification. Such testing by the Employer's Representative shall not absolve the Contractor of any obligations under the Contract.

Acceptable material for use as general granular fill shall comply with the requirements for Classes 1 and 3 of table 6/1 of the SHW.

Acceptable material for use as free draining, uniformly graded, granular material shall comply with the requirements of Class 6C of table 6/1 of the SHW.

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The requirements in table 6/1 of the SHW for testing for the effective angle of friction for granular fill may be relaxed if, in the opinion of the Employer's Representative, the nature of the fill material demonstrates the effective angle of friction to be greater than the minimum specified.

Acceptable Class 3 material shall be excavated according to the working restrictions for Classes A or B defined in figure 5/1 of the Highways Agency Departmental Advice Note HA 44/91 (HA 44/91).

Acceptable fill to structures shall comply with the requirements of Class 6N of table 6/1 of the SHW.

Materials proposed for general fill shall not include plant toxins or have a pH greater than 9 or less than 5.

PFA shall be in accordance with BS 3892-2. The PFA shall be conditioned or stockpile conditioned PFA and in a state suitable for compaction. No furnace bottom ash shall be used. The maximum particle size shall be 3 mm.

The grading and the name of the power station supplying the PFA shall be submitted to the Employer's Representative for acceptance. A certificate of test results shall be provided to the Employer's Representative showing that the material complies with the requirements of BS 3892-2.

The use of well-burnt or un-burnt colliery shale, slag or any other industrial waste containing more than 0.2 per cent sulphate ion as determined by BS 1377-3 shall be subject to the following conditions:

- (a) The amount of organic matter in the material (which shall be determined by loss on ignition at 1000°C) shall not exceed 4 per cent.
- (b) Slag shall not be placed within 1 metre of the proposed finished level.
- (c) The aggregate crushing value of the material shall not exceed 30 when tested in accordance with Section 7 of BS 812-110.

Material used to form embankments, etc. and located under any paving or track blanketing and lying within 450 mm of the formation shall not contain more than 10 per cent of material finer than 0.06 mm.

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Trial pitting may be instructed by the Employer's Representative. Trial holes in any material other than hard material shall include the separation of excavated materials; the disposal of Unacceptable excavated materials; backfilling and compaction of Acceptable material; and finishing with 150 mm of topsoil as the adjacent area dictates. Trial holes in hard material shall include reinstatement of the hole with materials and thicknesses compatible with adjacent construction materials.

Where required, full-scale field tests shall be carried out in accordance with Appendix 52/1.

**Placing,
compacting and
in situ testing of
fill material**

52.003 No compaction of any material shall commence without prior permission of the Employer's Representative. Where compaction trials are required, no compaction shall commence until the compaction trials have been completed and satisfactory results obtained.

At least seven days prior to commencement of Works subject to end-product testing, the Contractor shall make the following information available to the Employer's Representative:

- (a) values of the maximum dry density and the optimum moisture content obtained in accordance with BS 1377-4 using the compaction method appropriate for the fills intended for use which meet the requirements of the permitted Class or Classes. The Class shall be sub-divided where the fill within a Class contains materials having different maximum dry densities and optimum moisture contents.
- (b) a graph of density against moisture content from which the values in (a) above were derived, and for each Class 7A material a plot of the 5 per cent air voids curve.

A nuclear surface density/moisture gauge may be used for measuring the field dry density provided the Contractor can demonstrate to the Employer's Representative that the results are repeatable and comparable with laboratory tests on the same material.

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, recompacted as necessary to achieve a minimum of 95 per cent of the maximum dry density of the fill.

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Notwithstanding the other requirements of this Clause, the Employer's Representative may require the rate of filling to be varied to control the build up of pore water pressures, etc.

At no stage shall the side slopes be steeper than those shown on the Contract Drawings.

At the end of each working day or when construction is to be halted for 12 hours or more the surface shall be fully compacted.

Where the crossfall exceeds an inclination of 1 in 15, longitudinal benching shall be provided, stepped transversely, to the dimensions shown on the Contract Drawings.

Granular fill and PFA

For those Classes of fill subject to end-product compaction testing, sand replacement tests shall be carried out in accordance with BS 1377-9. The results of these tests shall confirm that a field dry density equal to or greater than the percentage given in table 6/1 of the SHW of the maximum dry density for the relevant Class of fill (previously made available to the Employer's Representative) has been achieved. Moisture content tests in accordance with BS 1377-2 shall be carried out immediately following compaction. The moisture content of fill shall be within the range specified for that relevant Class of fill.

Sand replacement tests shall be taken at the following minimum frequencies:

- Granular fill: one per 50m³
- PFA: one per 20m³

Cohesive Class 2 fill

Cohesive fill is generally compacted to a method specification. Where required Moisture Condition Value tests shall be carried out and/or undisturbed samples of the compacted fill shall be taken to demonstrate that the properties of the compacted fill lie within the specified limits for the relevant Class of material.

Chalk fill

Chalk shall be placed according to the restrictions for Classes A or B defined in figure 5/1 of the HA 44/91. Filling using chalk and trafficking over chalk shall not be carried out during wet weather. Wet weather shall be taken as during rain or snow, within 2 hours of cessation of rain or snow, when snow is lying on the ground surface or when the ground is frozen.

Chalk to be used as fill material shall be placed and compacted within 72 hours of excavation.

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Unless specified otherwise in Appendix 52/2, embankments constructed of Class 3 materials shall be left for a period of 3 months (or as otherwise directed by the Employer's Representative) either 600 mm below formation level or above formation level where a protective layer has been placed.

Layering of Class 3 material with other material shall not be permitted.

Where local instability results on compaction of Class 3 material used to form embankments, a minimum rest period of 1 day shall be allowed between successive fill layers to allow for drying.

A copy of all test results for the placed and compacted fill material shall be provided to the Employer's Representative.

All embankments shall be constructed so that at the date for completion a minimum of 90 per cent of subgrade consolidation shall be achieved.

Embankments shall be finished to the profiles shown on the Contract Drawings to a tolerance of ± 20 mm for the upper surface of the fill material and ± 50 mm for the side slopes, or other tolerance that shall accommodate any future shrinkage, settlement, or other movement, attributable to the embankment formed in accordance with the Specification.

The upper surface of embankment fill shall be in accordance with Clause 52.005.

**Particular
requirements for
PFA
embankments**

52.004 Where a PFA embankment is constructed, a granular filter complying with the requirements of Class 6D in table 6/1 of the SHW shall be provided.

PFA shall not be spread in conditions of high wind. In drying conditions the surface shall be sprayed with water: adequate water storage, fed from a mains supply, shall be provided and maintained for this purpose.

PFA shall not be used within 450 mm of the formation.

The finished surface of the embankment shall be protected from scour or erosion from any cause. All traffic shall be kept off finished surfaces.

**Requirements
for finished
subgrade and
capping**

52.005 California bearing ratio (CBR) tests, in accordance with BS 1377-9, shall be carried out on the finished subgrade once every 250 m². The finished subgrade shall have a minimum CBR value of 15 per cent.

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The location, extent and thickness of capping shall be as stated on the Contract Drawings.

The capping shall be constructed with the appropriate class of materials and compacted as detailed in tables 6/1 and 6/4 of the SHW.

Preparation and surface treatment of the sub-formation, including tolerances, shall be as shown on the Contract Drawings.

Exposed areas of formation or sub-formation shall be kept to a minimum and shall be covered to avoid deterioration during adverse weather.

The Contractor shall provide demonstration areas at locations agreed by the Employer's Representative to demonstrate the methods, equipment and materials proposed for use in the laying and compacting of the capping layer. The demonstration area, once proved by the Contractor to be acceptable by testing, may be included in the Permanent Works.

Materials used within 450 mm of the final finished surface shall not be frost susceptible.

In cuttings where the subgrade comprises cohesive material or loose granular material, the sub-formation shall be compacted with a smooth wheeled vibrating roller.

Preparation and surface treatment of the formation and sub-formation shall be carried out immediately prior to laying the capping or sub-base. If at any time the subgrade becomes softened due to precipitation, the subgrade shall be stripped by at least 40 mm to expose a competent sub-formation and this shall be recompacted.

Preparation of the sub-formation shall be carried out only after installation of adequate and fully operational subgrade/sub-formation drainage. In cuttings, adequate drainage shall be the installation of permanent filter drains that shall be operational for a period of at least two weeks prior to excavation to sub-formation level. At embankments, temporary measures to allow drainage of the sub-formation and placed capping will be sufficient. Fin drains and narrow filter drains shall not be used for the removal of surface water during the Works.

The sub-formation Works shall not be undertaken in poor construction conditions.

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Where required by Appendix 52/3, incremental loading plate bearing tests, in accordance with BS 1377-9, shall be carried out on the finished subgrade. Areas of low subgrade strength shall be dealt with as detailed in Appendix 52/3.

Where rock with an undrained modulus of greater than 130 MN/m² occurs naturally at or near the subgrade level, blanketing in accordance with Clause 52.014 shall be placed and compacted to provide a formation with an undrained modulus of less than 130 MN/m².

A copy of all test results for the subgrade shall be provided to the Employer's Representative.

Protection against attack by sulphates **52.006** Fill with a water soluble sulphate content exceeding 1500 mg/l (Design Sulfate Class DS-2 of BRE Special Digest No. 1, 2005) shall not be placed within 500 mm of concrete/cementitious structures unless these structures are designed for that Class of sulphate concentration.

Filling to mobilise passive resistance to structures **52.007** Backfilling to the front of bases of retaining walls, gravity and strutted abutments etc. shall be completed before the filling to the back of the structure commences.

Where required by Appendix 52/4, alternative fill materials may be placed in front of foundations, retaining walls, etc. to mobilise passive resistance to the structure.

Carrying of earthworks over and adjacent to bridges, culverts, walls, etc. **52.008** Earthworks shall be carried up to, over or adjacent to bridges, culverts, or walls and raised concurrently and uniformly on either side and placed in previously agreed layer thicknesses over the top of bridges and culverts.

To avoid interfering with the erection of new bridge abutments, wing walls, or other structures, work shall be suspended at places determined by the Employer's Representative until such time as, in the opinion of the Employer's Representative, the erection of such structures is sufficiently advanced and has acquired sufficient strength to permit the completion of the earthworks.

Where a deck forms a strut between the abutments of portal frame type bridges, and other similar types, no fill shall be deposited behind the abutment, or other adjacent walls until the deck has been constructed and is, in the opinion of the Employer's Representative, capable of taking load. This requirement is waived where the abutment and/or walls have been strutted apart beforehand with temporary struts, but only provided that the struts are not removed until the bridge deck has been completed and has acquired sufficient strength.

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Fill placed against structures shall consist of a wedge of Class 6N or 6P granular fill and shall be deposited and compacted in accordance with tables 6/1 and 6/4 of the SHW. Filling to spandrels and other voids, located within single and multi-span arch bridges, shall be deposited such that there is symmetrical loading of the structure during filling operations and, if so directed, temporary loading shall be applied to the crown of any arch while filling is being deposited over the haunches.

In depositing and compacting the filling, care shall be taken to avoid damage to any waterproofing course applied to the arch and the haunching. A 150 mm layer of sand to BS EN 13139, or other accepted material devoid of stones, shall be deposited and rolled on the exposed waterproofing before any other fill is placed.

Drainage

52.009

The Contractor shall construct slope drains neatly and as square as possible with the minimum of overbreak. The excavated trenches shall be backfilled within 48 hours of completion of excavation. Backfill shall be Type A drainage material in accordance with SHW clause 505, placed in layers not exceeding 225 mm thick with each layer being nominally tamped.

Fin drains

The materials used in fin drains shall have a minimum design life of 60 years.

The fin drain shall comprise a geocomposite core with a positive connection into a 100 mm diameter carrier pipe surrounded with geotextile. The geocomposite shall be capable of sustaining a minimum flow of 80 l/m²/s normal to its principal plane under a constant head of 100 mm. The fin drain shall have a minimum in-plane flow of 1 l/m/s at a confining stress of 100 kN/m² at a unit hydraulic gradient. The geocomposite shall have a puncture resistance of 1.5 kN and a tensile strength of 10 kN/m.

The carrier pipe shall have a maintained gradient to outfalls. The pipe shall be perforated throughout its top half and have an unperforated lower half. The pipe shall be manufactured to allow for a positive connection to the geocomposite.

The geotextile wrapping to the pipe shall have a pore size distribution such that the mean D₉₀ is between 100 and 300 microns. The geotextile shall allow water to flow through in its principal plane, in either direction, at a rate of not less than 0.7 l/m/s at a confining stress of 100 kN/m² and a hydraulic gradient of 1 when tested in accordance with BS EN ISO 12958.

The geotextile shall have a minimum CBR Puncture Value of 1200 kN when determined in accordance with BS EN ISO 12236.

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The geotextile shall have a Trapezoidal Tear Resistance of at least 200 N when tested in accordance with ASTM Standard D4533-04.

The geotextile shall have a minimum short-term tensile strength of 5 kN/m and a minimum failure strain of 10 per cent determined in accordance with BS EN ISO 10319 in a "wide strip" tensile test.

The geotextile shall have 300 mm wide minimum laps between adjacent sheets.

Outlet pipes shall be 150 mm in diameter and shall be located at 100 metre intervals or at specific low points as detailed on the Contract Drawings.

The geotextile and geocomposite materials shall be inert to all chemicals naturally found in soils. They shall not be susceptible to hydrolysis, shall be resistant to aqueous solutions of salts, acids and alkalis, and shall be non-biodegradable.

Permeable backing to earth retaining structures

52.010 Permeable backing to earth retaining structures shall comply with SHW clause 513 and the requirements of Appendix 52/5.

Soil nails

52.011 The soil nailing locations, setting out and other details are shown on the drawings.

The following Clauses assume that the proposed works have been designed pre-tender. The design for the soil nails is detailed in Appendices 52/6 to 52/8 and the following Clauses, which have been based on TRL Research Report 380 and standards such as HA 68/94, BS 8006 and BS 8081.

Work Package Plan

The work shall be carried out in accordance with a Work Package Plan approved by the Employer's Representative. Approval shall be sought at least three weeks prior to installing the first soil nails or carrying out associated earthworks.

The Work Package Plan shall include, as appropriate, details of plant, materials, drilling and grouting systems, temporary support, the sequence of Works etc. The Work Package Plan shall also include the following details:

- (i) methods of drilling and soil nail installation, including measures to minimise ground movements above the nailed slope,
- (ii) grouting procedures, methods of testing and quality control,

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- (iii) the method of forming the facing and connecting the soil nails to the facing,
- (iv) the method of assessing damage to protective coatings (where appropriate),
- (v) the minimum time between the completion of one soil nail and the start of the next,
- (vi) the time after installation before a nail is considered to be fully operational,
- (vii) the method of installing surface geogrid,
- (viii) drainage methods (if appropriate),
- (ix) earthworks, if appropriate, including maximum unsupported excavation width and depth,
- (x) methods of performing field tests,
- (xi) the form of the test records,
- (xii) a Health and Safety plan.

Once the Work Package Plan has been approved, details shall not be amended without the prior approval of the Employer's Representative.

Standards and code of practices

Materials and workmanship shall conform to the appropriate International, European and British Standards current at the time of tender, unless they conflict with this Model Clause, in which case the latter shall take precedence.

Contractor's alternative design

If the Contractor proposes an alternative design for consideration by the Employer's Representative, full details of the ground model and method of analysis shall be provided for comment prior to undertaking the design.

Alternative designs shall be carried out following the methods set out in HA 68/94 and BS 8006. The pullout resistance of the nails shall be taken as the lower value of the resistance based on the strength of the nail and the interface friction developed with the soil. The design shall be based on the available ground investigation information.

The alternative design shall be subject to Technical Approval in accordance with the requirements of RT/CE/S/003.

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The Contractor shall submit Working Drawings of the alternative design, for the approval of the Employer's Representative at least three weeks prior to the installation of any soil nails or carrying out any associated excavations. The Working Drawings shall include the location of soil nails, connections and splices or couplers, drainage, test nails, facing details, etc.

Design life

Corrosion allowances, creep behaviour and other time dependent aspects of the soil nails shall be designed for the design life detailed in Appendix 52/6.

Protective coatings to the soil nails, including the steel head plates, connections and exposed bar, shall satisfy the design life of the Works.

Sources of material supply

The Employer's Representative shall approve sources of supply of soil nails and other materials and such sources shall not be changed without the prior approval of the Employer's Representative.

Soil nails and other materials covered by this Model Clause shall be supplied to the Site at such times as not to hinder or delay the execution of the Works. Materials shall be delivered to the Site in an undamaged condition and shall be handled, stored and protected in such a manner as to avoid corrosion and physical damage. Soil nails or other such materials covered by this Model Clause not conforming to these requirements shall be notified to the Employer's Representative for acceptance or rejection. Rejected materials shall be removed promptly from the Site.

Fabrication

Soil nails shall be fabricated and delivered to the Site ready for installation in the Works. Soil nails shall be installed by suitably trained personnel to the approved Work Package Plan and to the pattern and dimensions shown on the Contract Drawings.

Where the diameter of the reinforcing bar is specified on the Contract Drawings, it includes an allowance for the required design life and specified protective coatings.

Soil nails formed from high yield deformed steel bars, and their connections, shall comply with BS 4449 or an equivalent European national standard. The fabricated nail and connections to the facing shall have long-term corrosion protection in the form of hot dip galvanising in accordance with BS EN ISO 1461.