SERIES NG 600
EARTHWORKS

Contents

NATIONAL ALTERATIONS OF THE OVERSEEING ORGANISATIONS OF SCOTLAND, WALES AND NORTHERN IRELAND

# denotes a Clause or Sample Appendix which has a substitute National Clause or Sample Appendix for one or more of the Overseeing Organisations of Scotland, Wales or Northern Ireland.

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EARTHWORKS

NG 600 Introduction

1 The Notes for Guidance on this Series are intended to assist in the preparation of the Contract. The design of the earthworks and selection of limits for soil properties for their construction will follow the ground investigation. Advice on these and other matters is available from the Overseeing Organisation and the Design Manual for Roads and Bridges (DMRB). Experience in the construction of road schemes has shown that certain materials may be utilised as 'acceptable' materials although processing, where appropriate, will be necessary to render unacceptable materials 'acceptable'. Appendix 6/1 should describe the requirement for processing of unacceptable material where this has been identified as appropriate. Unless there are specific reasons, the means of processing should be left to the Contractor. The aim should be to minimise the import of materials both for economic and environmental reasons and to allow use in fill areas those materials likely to arise in the cuttings as far as the earthworks design permits. However, since the Contractor, for economic reasons, should normally be left the choice of using Site-arising or imported materials, the Contract should not normally indicate from where on Site materials are to be obtained for the various zones of fill (but see also 6(ii) below). Certain selected fills will normally have to be imported.

2 The term 'rock' is used in the Specification to describe a constituent of certain selected fills having durability and strength requirements and also to describe material in cutting faces and formations requiring special methods of trimming or regulation.

3 (11/04) Particular requirements, not specifically stated in the SHW, for the Class of fill materials to be used or permitted, or for work to be undertaken should be included in Appendices 6/1 to 6/15. Additional Appendices may be used if necessary (see NG 000).

4 It is necessary to show the full extent of formation and where there is capping, the sub-formation. Most road configurations will be catered for by the appropriate cross-section and edge detail drawings contained in the HCD. These drawings should normally be used without modification and incorporated in the Contract by reference (in Appendix 0/4). In cases where they do not cover the work involved, Contract-specific drawings may be necessary which should be discussed with the Overseeing Organisation.

5 Appendix 6/1 should list only the properties needed to meet design requirements, omitting those which are unnecessary, eg. either mc or MCV, not both.

6 (05/04) Tenderers should be given the fullest available information about the materials to be excavated as required in Advice Note SA9 (MCHW 5.3.2). The following should be included, as appropriate:

(i) any strata or deposits designated as Hard Material;

(ii) the in situ material properties, related as far as possible to the general material description and the properties used for acceptability in Table 6/1, taken from the borehole logs, which may be re-plotted on the drawings of the long-sections of cuttings and below embankments where excavation will be required;

(iii) the total net volume of each cut (neglecting bulking or shrinkage) including:

- (a) estimated net volume of Class 5A material to be removed;
- (b) estimated net volume of acceptable material;
- (c) estimated net volume of unacceptable material above and below formation level including the volume to be processed to render it acceptable;
- (d) the Class and estimated net volume of fill to replace any excavation required below formation level;

(iv) the total net volume of fill in each fill area (neglecting bulking or shrinkage) including:

- (a) estimated net volume of topsoil to be removed, if any;
- (b) estimated net volume of unacceptable material below existing ground level to be removed including the volume to be processed to render it acceptable;
- (c) the Class and estimated net volume of fill required above and below existing ground level;
- (d) the Class, location and estimated net volume of capping material required or stabilisation of subgrade to form capping.

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NG 601 Classification, Definition and Uses of Earthworks Materials and Table 6/1: Acceptable Earthworks Materials: Classification and Compaction Requirements

1 The key to the use of materials both arising on Site and imported lies in Table 6/1. These materials have been classified into 9 principal Classes and sub-divided for compaction purposes or because of particular properties or applications.

2 Classes 1 and 2, general fills, comprise the greater part of the materials normally encountered and which are satisfactory as fill in most embankment construction. They incorporate chalk except when it is likely to be degraded by normal construction plant when it is designated in Appendix 6/1 as Class 3 general fill.

3 Classes 4 and 5 are for landscaping and topsoiling respectively.

4 Classes 6 to 9 selected fills all have a special role.

5 Many schemes will use only a few of the Classes in Table 6/1 and it will be unusual for every Class of material to be used on an individual scheme.

6 (11/04) Further sub-division of the Classes in Table 6/1 may be appropriate eg. 2A into 2A1 and 2A2 in order to obtain the better use of materials by zoning. This system is also applicable for Class U1B material that has been processed to meet the requirements of a particular Class, eg., for 2A this would be 2A1 for acceptable material and U1A that had been processed and 2A2 for U1B that had been processed. The additional requirements for 2A2 in terms of limiting values of contaminants and the methods of testing would be set out in 2A2.

7 Appendix 6/1 should include the relevant limits of acceptability for fill materials referred to in Table 6/1.

8 (11/04) The definition of contaminated materials Class U1B is based on the concept of risk assessment and is in accordance with the definition of contaminated land in Sections 78A(2), 78A(5) and 78A(6) of the Environmental Protection Act 1990 Part IIA (for Northern Ireland it is the Waste and Contaminated Land (Northern Ireland) Order 1997) and associated statutory guidance.

Where contaminated materials have levels of contamination below the limiting values in sub-Clause 601.2(ii)(a), they remain acceptable materials available for classification in accordance with Clauses 601 and 602 and Table 6/1.

9 (11/04) A site specific risk assessment should be undertaken for each earthwork section, as the degree of exposure to living organisms or the hydro-geological conditions can vary significantly within a scheme, leading to different limiting values in different sections. However, appropriate generic guideline values, which are based on a risk assessment model, may be used as default values. For human health, the series of Soil Guideline Values published by DEFRA and the Environment Agency may provide suitable default values.

10 (11/04) For general fills, the limiting values for harm to human health should normally be based on the 'commercial/industrial' end use category of guideline values, as there is a very low risk of exposure to the public from any contaminants in the fill. For landscaping fills, considerations of phytotoxicity will be important. Where slopes are to be returned to agricultural use, the limiting values should be based on the 'allotments' end use. The appropriate category should be decided for each section or sub-section of the scheme.

11 (11/04) Details of the limiting values adopted and explanations of their derivations should be given in Appendix 6/14 and Appendix 6/15.

12 (11/04) Materials, which would be classified as Class U1B because of contamination using generic guideline values, may be rendered acceptable by remedial techniques such as treatment with cementitious agents such as cement, lime or pulverized-fuel ash. The contaminant levels are not changed by the remedial treatment, and remain above the generic guideline values, but their ability to migrate is reduced. A site specific risk assessment must be carried out to demonstrate whether the risk to human health and living organisms, and of pollution of controlled waters, is acceptable before the remediated materials can be re-classified as acceptable fill materials.

13 (11/04) The limiting values in sub-Clauses # 601.14 and # 601.15 have been chosen to ensure that problems do not occur due to oxidation of reduced sulfur compounds such as pyrite. However, the limiting values only take account of the total amount of sulfur in each form, and do not allow consideration of factors such as grain size, mineralogy and access to air and water that affect the actual amount of oxidation that will take place in any given situation. As a result, the limiting values for oxidisable sulfides (OS) and total potential sulfate (TPS) are conservative, and may exclude materials that have been shown to perform satisfactorily as structural backfills. Examples of situations where materials may exceed the limiting values for structural backfills but still be acceptable include the following:

- Pyrite present as large cubic crystals visible to the naked eye. This will give high values of TPS and OS, but the rate of oxidation will

be very slow because of the low specific surface area of the pyrite crystals (eg sample TR8, Plate 8.3 of TRL Report 447).

- Unreactive sulfates such as barytes present as vein material or as a cement. This will give high values of TPS and OS, because the unreactive sulfate will be detected by the total sulfur (TS) test but not by the acid-soluble sulfate (AS) test (eg sample TR28 of TRL Report 447). However, such samples would give low values of total reduced sulfur (TRS). If OS is calculated directly from TRS for these materials, a more accurate value will be obtained.

Where this occurs, enquiries should be made as to whether there is any history of corrosion problems with the material. A programme of detailed testing should be carried out on the material, using the new test methods, to establish its chemistry and mineralogy and ascertain more clearly its potential to cause corrosion.

Mineralogical methods may include petrographic description using thin sections, X-ray diffraction or Scanning Electron Microscopy (SEM). If pyrite is present in framboidal form (Plates 8.1 and 8.2, sample TR11D of TRL Report 447), the material should be classified as unacceptable as structural backfill, because of the known tendency of this form of pyrite to oxidise rapidly in engineering situations.

The use of the material may be permitted as structural backfill if it can be established to the satisfaction of the Overseeing Organisation that:

- the material has been used in the past as structural backfill without leading to problems with sulfur compounds; and
- the reason why the material will not cause a problem is known, based on an understanding of its chemistry and mineralogy.

14 (11/05) A flowchart illustrating earthworks classification is shown in Figure NG 6/1.

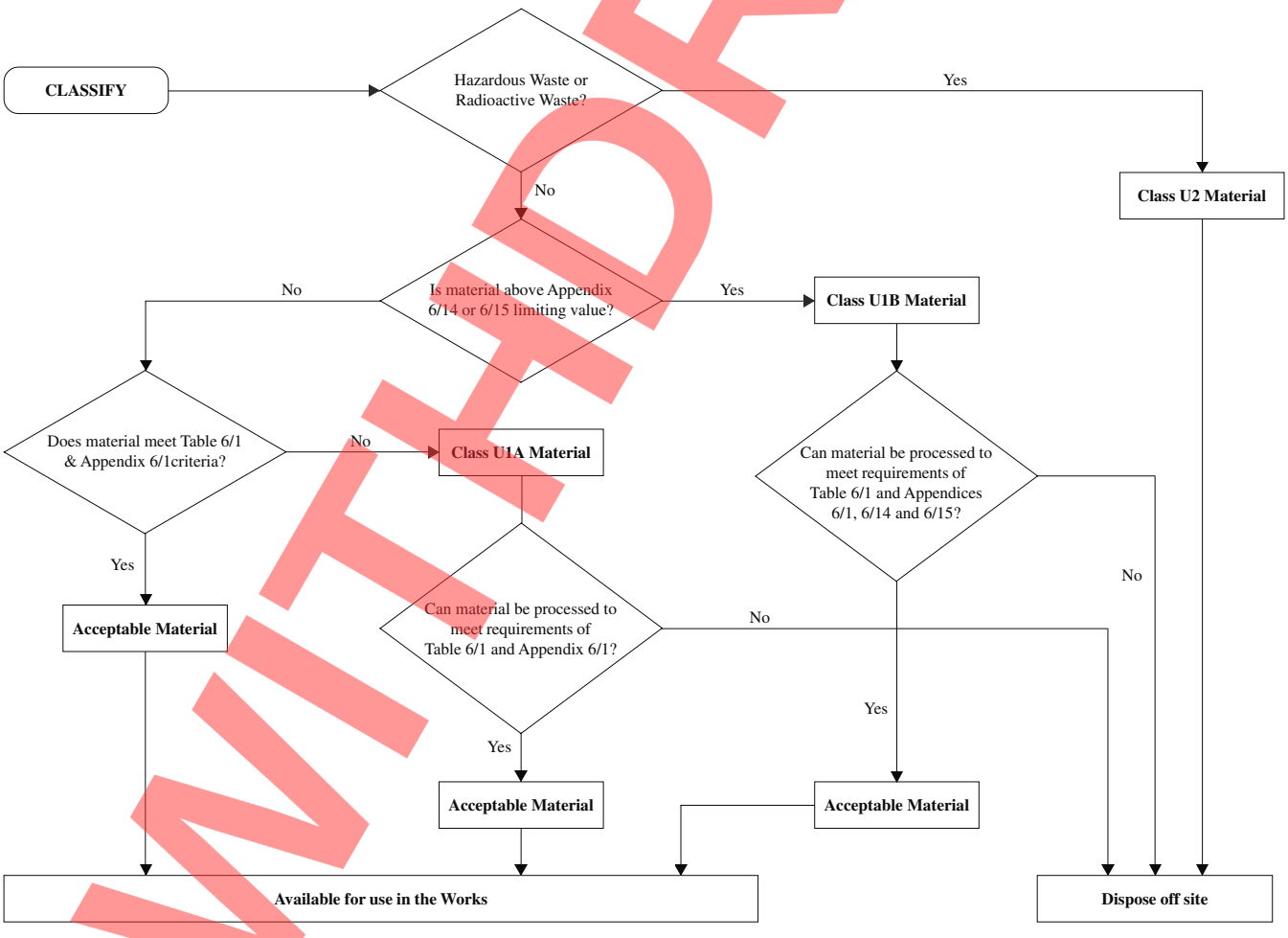

Figure NG 6/1 - Classificiation Flowchart

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NG 602 General Requirements

1 Special requirements for determining acceptability, eg. who classifies and where, and whether trial pitting is required, should be stated in Appendix 6/1 (see also NG 631).

2 All topsoil above cuttings and below embankments should normally be stripped for re-use with the depths of excavation given in Appendix 6/8 verified when stripping. There is frequently less topsoil in wooded areas than expected and this should be recognised when estimating volumes of topsoil. In soft or marshy areas disturbance of the crust of topsoil and vegetation may be unwarranted and such topsoil should be shown on the Drawings to be left in place and details given in Appendix 6/8. The Overseeing Organisation should be consulted concerning requirements for surplus topsoil, which should be stored whenever practicable rather than disposed of by the Contractor. Storage areas should be shown on the Drawings and details given in Appendix 6/8.

3 The Drawings should indicate where battering of excavations for foundations and trenches is permitted and details should be given in Appendix 6/3. It should not be unnecessarily restricted; in some instances it might be preferable so as to avoid leaving a wedge of material loosened by excavation. Where battering is permitted, the requirements for benching prior to backfilling and compaction should be shown on the Drawings and details given in Appendix 6/3.

4 Where groundwater is to be lowered as a design requirement, or to make wet unacceptable material into acceptable material where a shortfall in earthworks volumes is likely, the location and extent of such operations should be shown on the Drawings. These should be cross-referenced in Appendix 6/1.

NG 603 Forming of Cuttings and Cutting Slopes

1 The Drawings should show all changes in cross-section for cuttings and any requirements for limiting the extent of undercutting of slopes and toes of cuttings, making use of Appendix 6/3 as necessary.

2 Requirements for pre-split blasting, a technique for minimising overbreak and instability, should be stated in Appendix 6/3 for any substantial rock cuttings, where blasting will be permitted (See NG 607). Requirements for exposed cutting faces should be described in Appendix 6/3. Advice on specification requirements for pre-split blasting can be obtained from TRRL report LR 1094.

NG 604 Excavation for Foundations

1 (11/03) The lines and levels of foundation excavations should be shown on the Drawings together with any blinding concrete, and its reference, to Clause 2602.

2 The Drawings should indicate where the requirement in Clause 602 for not battering excavations for foundations can be relaxed and details should be given in Appendix 6/3 (see NG 602).

NG 605 Special Requirements for Class 3 Material

1 Class 3 material caters for chalk in cuttings composed mainly of chalk of a type that if left to normal earthmoving methods would be degraded, causing problems when used as general fill.

2 (11/05) Class 3 will only apply if material is so designated in Appendix 6/1, otherwise chalk for general fill is dealt with as a Class 1A or 1C material. The special requirements for Class 3 material need only apply to materials comprising the wetter and less dense Chalk Groups C and D.

3 (11/05) Class 3 should be designated utilising the ground investigation results and Advice Note HA 44 (DMRB 4.1.1). Where most of the material in a cutting meets Chalk Groups C and D of that Advice Note the whole cutting should be designated as Class 3. Thus Class 3 may be a mixture of Chalk Groups A to D or indeed, in small quantities, of harder chalks outside that classification. Class 3 can include small amounts of materials other than chalk unable to be separated during excavation e.g. flints and head. Further advice on these matters is available from the Overseeing Organisation and the DMRB (see DMRB 4.1.1).

4 (11/03) The period to be stated in Appendix 6/4 when earthworks involving Class 3 material should not be undertaken should be determined by reference to records of precipitation and air temperatures for the area concerned over previous years and other relevant factors.

NG 606 Watercourses

1 Cross-sections for all work in connection with existing or new watercourses (which includes all ditch work) should show the extent of all treatment and other requirements. See NG Sample Appendix 6/3.

NG 607 Explosives and Blasting for Excavation

1 Blasting needs should be considered in relation to the likely disturbance to the environment and remaining material beyond the cutting face. Where blasting is likely to lead to savings in excavation costs, pre-construction consultation with all who may be affected is a pre-requisite to permitting blasting in Appendix 6/3. Further guidance will be found, including benefits of pre-contract blasting trials during ground investigations, in TRRL report RR 53.

NG 608 Construction of Fills

1 The Drawings should show locations and particular requirements for selected fills and general fills in specific zones including any additional sub-divisions of Classes in Table 6/1.

2 The Drawings should also show how, where permitted, embankments may be initially constructed other than to their full width and to steeper batter slopes. These should be cross-referenced in Appendix 6/3.

3 Staged construction and any surcharging of embankments and benching should also be shown, with requirements for any instrumentation in Appendix 6/12.

4 The Drawings should show each change in cross-section of fills.

NG 609 Geotextiles Used to Separate Earthworks Materials

1 This Clause includes minimum properties for geotextiles used to separate earthworks materials except for durability where tests have yet to be developed to an acceptable standard. Evidence of longevity is, however, required from the Contractor.

2 The minimum life stated in Appendix 6/5 should relate to the main function of the geotextile. For example, if used beneath an embankment it should exceed the time for primary consolidation of the underlying soil. Rate of sampling should be given in Appendix 6/5 together with any other requirements.

3 The tests in this Clause may be used for specifying geotextiles for other purposes, using appropriate values of properties, by means of a different Appendix, eg. if used in strengthened embankments to Clause 621, Appendix 6/9 should be used. The requirements for a separating layer may however be quite different from those for other uses and the tests may need modification or extension. Advice may be obtained from the Overseeing Organisation.

4 The Drawings should show details of returns for anchorages and turn-ups at edges. Laps which are described in Clause 609.5 or Appendix 6/5 should not be shown on the drawings unless there are overruling design considerations for requiring laps at a particular location within the construction.

5 (11/03) Any testing laboratory used should be an appropriate organisation accredited in accordance with sub-Clauses 105.3 and 105.4 for the test.

NG 610 Fill to Structures

1 The selection of the appropriate material Classes from 6N, 6P, 7A or 7B for fill to structures will be dependent on the assumptions made in the structure's design. Sometimes a Class 7A cohesive material which may be available on Site will offer savings which more than offset any increased cost of the structure to cope with increased earth pressure, but this is only possible if the design envisaged the use of such fill material. Where Class 7A is used, the effect of any possible long-term swelling should be taken into account (See 3 below). Similarly if the design has allowed for Class 7B pulverised-fuel ash only, then other materials should be excluded.

2 The required or permitted alternative Classes of material to be used should be stated in Appendix 6/6 for each structure together with their locations and extent, and any requirements for benching, cross-referring to Drawings where necessary. The acceptable limits of material properties for these Classes should be stated in Appendix 6/1. Choice of acceptable limits, eg. c and φ' or c' and φ' should depend on design assumptions and where they are used, values for moisture content or MCV may be unnecessary.

3 Class 7A material has requirements for plasticity limits imposed to minimise the risk of excessive swelling pressures occurring following construction. Even with cohesive materials having plasticity limits within those specified in Table 6/1, it is important to avoid compaction at moisture contents dryer than the eventual equilibrium moisture content, as swelling may still arise. For this reason both maximum and minimum levels of mc, MCV and shear strength should be specified in Appendix 6/1 with the aim of avoiding significant increases in moisture content following construction whilst still requiring shear strengths pertinent to the design of the structure.

4 (05/01) Lias Clay should only be used as fill to structures where it may be compacted to a low density. Any subsequent swelling pressure on wetting would then be reduced by volume changes. Therefore, Lias Clay should not be used where more rigorous control of density is required such as under pavements on compacted fill or on the approach to bridge abutments.

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The designer should take full account of any swelling pressure likely to occur. TRL project reports PR 72 and 152 should be referred to before using Lias Clay. Appendix 6/6 should strictly limit the use of Lias Clay as described above.

NG 611 Fill above Structural Concrete Foundations

1 Full details of extent and type of permitted materials for filling above structural concrete foundations should be shown in Appendix 6/6.

NG 612 Compaction of Fills

1 Method compaction will be used for the majority of earthworks. Table 6/4 compaction should produce a minimum state of compaction equal to 10% air voids at an mc at the dry limit for acceptability. The mc at which 10% air voids or less would be achieved is roughly equivalent to a maximum MCV of 12.5 for cohesive soils (Classes 2 and 7) and 5% or less will be achieved at MCV 11.5 or less. With granular soils the equivalent MCV will be higher eg. for a well graded sand an MCV of 14.5 will achieve 10% air voids or less.

2 End product compaction is restricted to pulverised-fuel ash in general fill and to some selected fills to structures including corrugated steel buried structures. Density testing of the materials to be used will be necessary in order to comply with an end-product specification.

NG 613 Sub-formation and Capping

1 The permitted constituents and material properties of capping materials for use on fills or in cutting have been drawn up to meet the requirements of sub-grade stiffness and strength used in Standard HD 25, which assume a capping CBR of 15% and, varying capping thickness depending on sub-formation. The Specification does not require minimum CBR, (except for bearing ratios in stabilised capping) of capping or sub-formation but such tests by the Overseeing Organisation may be useful to provide feedback on the long-term performance of pavements. See also NG 614 and NG 615.

2 The Contract, either on Contract-specific Drawings or in Appendix 6/7, should state if capping is required and in which locations. They should also show the required thicknesses of capping (including any details of sub-formation having a different slope to the formation above it eg. at flat areas of transition). Also permitted options for Classes of capping related to the properties of the material likely to form the sub-formation should be described.

As an example a sub-formation of cohesive fill should have the option of:

(i) (05/04) the whole thickness of capping formed in Class 9D (cohesive material Class 7E lime stabilised) or, part Class 9D overlain with Class 6F granular capping material; or

(ii) Class 6F granular capping material each forming the whole or sandwiched.

Other combinations, again depending on likely sub-formation material, should be investigated eg.:

(i) (05/04) Class 9A overlain with 6F granular capping material; and

(ii) multi-stabilised layers.

The lateral extent of capping/sub-formation should also be shown. See NG 600.5.

Appendix 6/7 should show the minimum thickness of capping or sub-base to be placed for weather protection, where the fill characteristics do not require the full thickness immediately.

3 The need for a demonstration area should be carefully considered. It will afford an opportunity for adjusting construction procedures and gaining experience of the materials to be used. Wherever possible suitable locations should be made available which may form part of the Permanent Works if the material meets the requirements of the Contract. Further information can be obtained from the Overseeing Organisation.

4 Where the subgrade CBR value is estimated to be of a value requiring capping for one type of pavement (eg. rigid or rigid composite) but not for others permitted for the same length of road, this should be allowed for in Appendix 6/7.

5 (05/04) The introduction of BS EN 13285 requires separate classes for Class 6F granular capping material from sources other than the excavated parts of the same Site. Class 6F4 is a fine graded unbound mixture complying with BS EN 13285. It is similar to Class 6F1, derived from the excavated parts of the Site. Class 6F5 is a coarse graded unbound mixture complying with BS EN 13285. It is similar to Class 6F2, derived from the excavated parts of the Site. BS EN 13285 unbound mixtures are made using aggregates complying with BS EN 13242.

6 (05/04) Crushed rock or sand filter layers of 50 mm minimum thickness, made using Class 6S granular filter layer material, can be used immediately below carriageway subbase layers to prevent the ingress of cohesive particles from the top of the subgrade into an open graded subbase. A filter layer is not required if a Class 6F granular capping layer is used.

NG 614 Cement Stabilisation to Form Capping

1 Cement stabilization of Class 6E granular materials with 2% cement, or of Class 7F silty cohesive material or Class 7G pulverised-fuel ash with the appropriate cement content to form Class 9A, Class 9B or Class 9C capping should be included as an option where laboratory tests or pre-Contract trials show it to be feasible. High contents of fine materials (silt and clay) will require more cement to achieve a 15% bearing ratio.

2 When the Overseeing Organisation wishes to include the option of Class 9A or Class 9B, or Class 9C capping and there are doubts as to the sufficiency of 2% cement, the results of any trials or testing should be made available to the tenderers, reference being made to them in Appendix 6/7. Notwithstanding the above, Appendix 6/7 should state that demonstration areas will be required to be constructed where layers of Class 9A or 9B material greater than 250 mm thickness are to be compacted.

NG 615 Lime Stabilisation to Form Capping

1 Lime stabilisation using 2.5% of available lime will, if compacted at the correct MCV give sufficient long-term strength for a capping. The appropriate lower value of MCV for Class 9D and of mc or MCV for Class 7E, (to be stated in Appendix 6/1), which will give an adequate strength and safety factor, may be determined from laboratory tests.

2 Additional tests for rate of spread may be required to ensure that no less than the minimum lime quantity required is provided at any point on the material being treated. If adopted, the requirements should be included in Appendix 6/7.

3 The upper limit of MCV for Class 9D material has been established as 12 for a wide range of glacial tills and some overconsolidated clays. The limits of MCV should be confirmed during the ground investigation. Higher values than 12 may lead to swelling after compaction and should be avoided if possible.

NG 616 Preparation and Surface Treatment of Formation

1 Where it is known that formations of rock will arise which cannot achieve the tolerances of sub-Clause 1 of Clause 616 the requirement to meet sub-Clause 4 should be stated in Appendix 6/7 and located on the Drawings.

NG 617 Use of Sub-formation or Formation by Construction Plant

1 The Overseeing Organisation may permit construction plant for the supply and deposition of sub-base to use formations of capping or of materials having similar characteristics, and this should be included in Appendix 6/7.

NG 618 (05/01) Topsoiling

1 See Clause 602 and NG 602 relating to stripping, use and storing of topsoil.

2 Where the ground investigation indicates that existing topsoil which is to be stripped for topsoiling, has a high clay content, the requirements of sub-Clause 618.3 to limit excavation etc. from topsoil stockpiles which have been open to prolonged rainfall should, following agreement of the Overseeing Organisation's Regional Horticulturist, be invoked in Appendix 6/8 to prevent degradation. The 100 mm rainfall figure in sub-Clause 618.3 may also need to be revised but it should not be over-restrictive. Further advice is available from the Overseeing Organisation.

NG 619 Earthwork Environmental Bunds

1 Earthwork environmental bunds may, depending on land availability and height and whether they are to have a fabricated environmental barrier installed on them, be constructed in various ways, eg. normal embankment, strengthened embankment, reinforced earth structure, anchored earth structure, or be treated as a landscape area utilising Class 4 fills to Clause 620. In the latter case no reference to an earthwork environmental bund should be made so as to avoid confusion.

2 Full details of earthwork environmental bunds should be shown on the Drawings with any requirements for early construction shown in Appendix 6/9.

NG 620 Landscape Areas

1 Landscape areas are areas where the standards of construction of fills and their material quality can afford to be of a lower standard than for normal embankment construction.

2 (11/04) General or selected fills should be allowed for Class 4 landscape fill with appropriate limits on material properties being stated in Appendix 6/1. These limits should draw in those materials, listed within Class U1A unacceptable material in Clause 601, which would be acceptable as landscape fill.

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3 Landscape areas should be shown on the Drawings cross-referenced in Appendix 6/9.

4 Environmental bunds should not be constructed on landscape fill (Class 4) unless special foundations are provided or the fill is improved.

NG 621 Strengthened Embankments

1 Strengthening by interlayering geotextiles or geomeshes into an embankment or an embankment shoulder will resist the tendency for the outer edges to soften and slip after considerable time. This technique will reduce future maintenance costs and enable steeper slopes to be built. Embankments including, for example, earthwork environmental bunds may thus be built to a greater height within the available base width.

2 The properties of geotextiles (see NG 609) and geomeshes should be described in Appendix 6/9 together with construction requirements, cross-referring to Drawings where necessary.

NG 622 Earthworks for Reinforced Soil and Anchored Earth Structures

1 (05/04) Classes of fill required or permitted and acceptability limits for their material properties, as referred to in Table 6/1, and Table 6/3 where appropriate, should be stated in Appendix 6/1 and identified on the Drawings. The thickness and types of drainage layer required or permitted should also be shown. Only sand complying with BS EN 12620 should be used for pfa fill. Where Type B filter drain material is used for horizontal drainage of pfa fill it should be covered by a layer of sand complying with BS EN 12620.

2 Drawings should show the maximum height to which fill may be placed above the wall during construction.

3 (05/04) Further details on the requirements for earthworks associated with reinforced soil and anchored earth structures are given in Standard BD 70 (DMRB 2.1.5).

NG 623 Earthworks for Corrugated Steel Buried Structures

1 Acceptability limits for MCV, if required, for Class 6K (lower bedding) and Class 6M (surround) fills, as referred to in Table 6/1, should be stated in Appendix 6/1.

2 Where ground investigations have shown that the existing material adjacent to the location of the corrugated steel buried structure has a constrained soil modulus less than the value assumed in the design, or a corrosivity classification determined in accordance with Standard BD 12 at which corrosion of metal components could occur, the extent of additional width etc. of excavation should be shown on the Drawings. The Drawings should also show the extent of selected fill materials to be used for the construction of embankments over the structure.

3 (05/04) Further details on the requirements for earthworks associated with corrugated steel buried structures are given in Standard BD 12 (DMRB 2.2.6).

NG 624 Ground Anchorages

1 Unless there are special reasons, the Contractor should design ground anchorages for anchored structures. Full requirements should be shown on the Drawings and described in Appendix 6/10.

2 BS 8081 and the Overseeing Organisation can give further advice.

NG 625 Crib Walling

1 Outlines shown on the Drawings should allow for the full range of alternative systems. Design requirements should be given in Appendix 6/10, and the Overseeing Organisation should be consulted in formulating these.

2 Where the design retained height exceeds 1.5 m, an outline Approval in Principle form should be included in Appendix 6/10.

NG 626 Gabions

1 If extensive use is to be made of gabions Clause 626 may need extending by means of Appendix 6/10.

2 The Drawings should allow for the full range of alternative systems, except that plastic materials should not be permitted where there is a risk of damage by fire unless further protection is provided.

NG 628 Disused Mine Workings

1 Full requirements, including location, probing to determine extent, filling methods and materials, any grouting and details of mass or reinforced concrete caps should be described in Appendix 6/11.

NG 629 Instrumentation and Monitoring

1 Full requirements including all details of equipment position, depths, protection to pipe or cable connections, installation techniques, and methods of calibration and reading should be described in Appendix 6/12.

NG 630 Ground Improvement

Dynamic Compaction

1 Only one system of dynamic compaction, end-product or method, should be used in the Contract and the appropriate requirements should be listed in Appendix 6/13. Further advice may be obtained from the Overseeing Organisation.

Ground Treatment by Vibrated Stone Columns

2 Vibroreplacement is used in soft silts and clay soils to reduce their compressibility. The method uses a vibrator and air or water circulation to remove material to the required depth. This is subsequently replaced with granular fill to form a column up to 1.5 m in diameter. The fill is placed through the annular space between the vibrator and the surrounding soil and compaction is achieved by vibration as the equipment is removed.

3 Vibrodisplacement is used in stronger clays and granular soils again to reduce compressibility. This method displaces the existing material and the vibrator is generally taken to the required depth of treatment then removed completely before backfilling. Some proprietary systems use a different method. Lifts of granular fill of the order of 1 m are often used to achieve adequate compaction of the stone column.

4 In granular soils compaction will also occur in the ground around the vibrator. In cohesive soils this effect is not evident and the stone columns only serve to reinforce and stiffen the ground.

General

5 BS 8004: "Code of Practice for Foundations" provides some guidance on ground treatment using vibrated stone columns.

6 Guidance on the preparation of Appendix 6/13 for ground treatment by vibrated stone columns may be found in the following document:

Specification for Ground Treatment
Institution of Civil Engineers
Thomas Telford Limited, 1987

7 To enable ground treatment using vibrated stone columns to be considered, it is necessary to have relevant and sufficient geotechnical information available.

8 The Overseeing Organisation may design the ground treatment scheme by providing a method specification or the responsibility for the design may be placed on the Contractor in the form of a performance specification.

9 Where the Overseeing Organisation prepares a design, the method chosen must be based on a non-proprietary system. This does not, however, preclude the Overseeing Organisation from accepting an alternative proposal from the Contractor in the event that the Contractor has proprietary plant and equipment ideally suited to the project requirements. In the event that such a proposal is offered by the Contractor, it must be demonstrated that such a proposal can achieve treatment at least equal to the method originally specified by the Overseeing Organisation. Any proposal must be compatible with the site environment.

10 The Instructions for Tendering may require the Contractor to submit with the Tender the name of any ground treatment specialist he proposes to employ. This is to enable the Overseeing Organisation to assess the suitability of the ground treatment sub-contractor's methods. In general, if the Contractor wishes to change his sub-contractor after the Contract has been awarded, the Overseeing Organisation should be prepared to agree if he is satisfied that any alternative method of treatment is technically acceptable.

11 When a performance specification is adopted by the Overseeing Organisation, the details of the Specialist Contractor's proposed methods should be made available to the Overseeing Organisation. It is advisable to prepare the Contract Documents to include an item which will allow preliminary areas to be treated and tested to confirm compliance with the performance specification. It should be made clear that any necessary design changes to the ground treatment process would be the responsibility of the Specialist Contractor.

12 The purpose of requiring the Contractor to give early warning of ground conditions different from those expected from his interpretation of the ground investigation report is to enable the Overseeing Organisation to determine without delay whether the Permanent Works will be affected. When such differences are reported, it may be desirable to obtain confirmation by having a supplementary ground investigation carried out.

13 The following information should be shown on the Drawings, as appropriate (cross-referenced in Appendix 6/13):

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Location of treatment, including any Preliminary Areas.

Layout and minimum dimensions of stone columns, including estimated length.

Any restrictions on the sequence of construction.

Any other relevant information as identified in Table 6/7.

Any preparatory works such as earthworks.

Materials

14 (05/04) Appropriate material for forming stone columns is likely to be satisfied by any material complying with classes 6K, 6M, 6N or 6P (Table 6/1) or Type 2 unbound mixture for subbase (Clause 804) Single sized coarse aggregate can have a proportion of oversize particles in the size fraction D/2D.

15 If it is necessary to make up ground levels, prior to commencing the ground treatment, the Contract should specify granular material Class 1 (Table 6/1).

Method of Ground Treatment

16 Ground treatment by vibrated stone columns can use either the wet or dry process. The former method is more appropriate in weak silts and clay soils.

17 Where the wet process is used, the vibrator must be kept in the hole continuously during backfilling in order to ensure the stability of the walls of the hole.

18 Where the dry process is used, the ground to be treated must be sufficiently strong to keep the hole open until the backfilling process is complete. The Contractor should be asked to demonstrate that the hole is kept open whilst backfilling takes place, ensuring clean placement of a vibrated stone column from the base of the hole to the working surface. Alternatively, the Contractor may demonstrate that he has plant and equipment which allow feeding of backfill material to the base of the hole without removing the vibrator. Further information on the method can be found in the reference in NG 630.6.

Design Considerations

19 The Overseeing Organisation may undertake design of the method of ground treatment or invite proposals from tendering Contractors.

20 Where a scheme is designed by the Overseeing Organisation, consultation with experienced geotechnical specialist Contractors is recommended. In conjunction with a detailed ground investigation, this approach should allow the selection of the most appropriate materials and column spacing. Columns are typically 1.0 m in diameter although the maximum diameter depends on the properties of the existing ground. As a guide loads up to 300 kN have been supported by columns formed in clays although this could be much less for weaker clays and soft silts.

21 Vibroreplacement is unlikely to be a successful means of treatment in cohesive soils with immediate undrained shear strengths less than 15 kN/m². Similarly, this method of ground treatment is not recommended in organic silts and clays, deposits of peat or household refuse.

22 To complete a design for ground treatment by vibrated stone columns, the Overseeing Organisation or Contractor, as appropriate, will provide a specification in Appendix 6/13.

23 The Drawings and the specification in Appendix 6/13 will address the following aspects:

(i) Method of Ground Treatment.

(ii) Sources of material.

(iii) Performance criteria (End product specification).

(iv) Depth of treatment, spacing and size of columns.

(v) Areas to be treated including any preparatory work such as levelling and grading of the existing site.

(vi) Water supply and effluent/slurry disposal (wet process).

(vii) Verticality and positional tolerances.

(viii) Dealing with known and unforeseen obstructions.

(ix) Site Control:

Records
Ground Heave
Overtreatment
Debris
Surface Compaction

24 Performance criteria will apply to designs produced by the Overseeing Organisation or the Contractor as the case may be. Generally, load/displacement criteria will be developed for the proposed construction on the treated site and in situ testing should be designed to measure the performance. Appropriate tests are indicated in sub-Clauses 630.12, 13 and 14 and the Overseeing Organisation should decide on a testing frequency which will be representative of the entire treated area. The Overseeing Organisation should also determine if any other tests are appropriate and detail these in Appendix 6/13. It is strongly recommended that a trial area is included in the Contract, with in situ testing to assess performance.

If necessary appropriate modifications can be made to the treatment process on review of preliminary area testing.

25 Depth of treatment, spacing and size of columns depend on the thickness and strength of the existing soils. Consultation with specialist geotechnical contractors is the recommended approach to ground treatment schemes designed by the Overseeing Organisation.

26 Where proposals are invited from Contractors, based on a performance specification, the Overseeing Organisation should appraise the Contractor's design with a view to verification by field testing in preliminary treatment areas. In the event that successful performance is achieved in preliminary treatment areas, these can be incorporated in the Permanent Works.

27 The Specification must clearly state that the Contractor is wholly responsible for the supply of clean water and the disposal of effluent and slurry arising from jetting and flushing operations.

28 Verticality and positional tolerances should be set by the Overseeing Organisation or Contractor, as appropriate. Generally, column centres should be within 150 mm of the positions shown on the Contract Drawings. Top surfaces of columns should be finished between 0 mm and +75 mm from the specified levels. Overall design should allow for final levelling and compaction of the area of treatment as a whole to establish an even bearing surface.

During the penetration stage, a maximum deviation of 1 in 20 from the vertical is normally permitted although endeavours should be made to reduce this further if possible. However, it should be appreciated that unduly close tolerances will usually adversely affect the costs.

Obstructions

29 Known obstructions will need to be removed if treatment is required at such positions. Alternatively, it may be economically more viable to leave known obstructions in place and use other methods such as piling at these locations.

30 Unforeseen obstructions will necessitate either investigation and removal of the obstruction or modification of the layout of the ground treatment scheme.

Site Control

31 Site control of operations is essential in monitoring the correct installation and performance of the treatment. Records should be maintained as required in sub-Clause 630.20 with any further information detailed in Appendix 6/13. It is advisable that work is carried out under the control of a Specialist who is conversant with the methods to be used.

Particular attention should be given to potential overtreatment recognised by either excessive heave of the ground or the addition of excessive backfill.

Testing of Ground Treatment

32 The performance criteria for treated ground should be stated in Appendix 6/13.

33 The Overseeing Organisation should specify types and frequencies of testing appropriate to the area to be treated and the type of construction proposed at the treated site. Sub-Clauses 630.12, 13 and 14 identify appropriate test methods.

34 Standard Penetration Tests, Dutch Cone Tests or dynamic cone penetration tests should be used before and after treatment between compaction centres to indicate increase in relative density. The spacing should be chosen to give a representative overall picture of the treated area. It is suggested that tests be undertaken at 10 m to 20 m centres depending on the size of the site.

35 It is recommended that a minimum testing frequency of one zone or plate test for each 2000 m² of treated ground is adopted.

36 Ideally, trial areas should be treated and tested to establish performance (sub-Clause 630.15).

Records and Reports

37 The minimum requirements for records of treatment and testing are identified in sub-Clauses 630.19 and 20. Further information may be stipulated in Appendix 6/13 with regard to project specific needs.

Other Methods

38 Other methods of ground improvement such as vertical drains, vibro-flotation and vibrated concrete or lime columns should be detailed on the Drawings and listed in Appendix 6/13, where they are required.

NG 631 Earthworks Materials Tests

1 Where the limiting values of acceptability are determined from tests which are relatively time consuming, other tests may be considered for rapid evaluation during construction. For example moisture content determination may be obtained using quicker drying methods than are required by BS 1377 : Part 2 or nuclear moisture gauges may be permitted. See also NG 633.

2 Appendix 6/1 should state whether the Contractor or the Overseeing Organisation will be responsible for

testing and, where the Contractor is responsible, the testing details should be given in Appendix 1/5 and cross-referenced in Appendix 6/1.

3 (11/03) Where the Overseeing Organisation is carrying out testing Appendix 1/1 should list the apparatus and materials required, and Appendix 1/6 should list details of samples. For some unusual tests such as 300 mm and 60 mm shear box tests, redox potential and resistivity it may be more appropriate for testing to be carried out by a commercial testing laboratory. Any testing laboratory used should be an appropriate organisation accredited in accordance with sub-Clauses 105.3 and 105.4 for the test. The 300 mm shear box should not normally be required on Site.

4 See also NG 602.1.

#NG 632 Determination of Moisture Condition Value (MCV) of Earthworks Materials

1 Appendix 6/1 should state whether the MCV/mc relationship of all imported material requiring an MCV property should also be plotted and whether the rapid assessment procedure for material acceptability may be used.

NG 633 Determination of Undrained Shear Strength of Remoulded Cohesive Material

1 Where shear strength is used as the acceptability criterion, routine site testing may be more conveniently carried out by eg. hand vane or hand penetrometer monitored by periodic triaxial test comparison to give adequate correlation. (See NG 631.)

NG 636 Determination of Effective Angle of Internal Friction (φ′) and Effective Cohesion (c′) of Earthworks Materials

1 For granular Class 6N, 6P, 6I and 6J materials, consistency of supply may be checked by comparing samples with the grading, particle shape, plasticity and other characteristics of the material used for the shear box test.

2 For Class 7B material it may be more appropriate to use triaxial testing to determine effective stress strength parameters rather than shear box tests. This is particularly so when longer term strength parameters are required.

3 Where the results of control tests using the 60 mm shear box for Class 7C and 7D materials differ from the initial values obtained during the initial determination of fill properties by more than 20%, the variability should be investigated, and if necessary, further tests using the 300 mm box should be carried out to check that the material remains within the limits of acceptability.

NG 637 Determination of Resistivity (r_s) to Assess Corrosivity of Soil, Rock or Earthworks Materials

1 When laboratory tests are required, Appendix 6/1 (1/5) should state which of the three types of test described in BS 1377 : Part 3 should be employed.

2 For in situ tests:

(i) Proper contact between the electrodes and the fill should be obtained particularly where the electrode penetration is shallow.

(ii) Tests should be carried out at the anticipated maximum natural moisture content in order to obtain the lowest resistivity.

(iii) Locations should be chosen so as to cover the entire area of the structure, cutting, borrow pit or stockpile. The distance between locations should exceed three times the maximum spacing of the electrodes but not be more than 50 m.

(iv) The field testing procedure is not suitable for massive rock material which is to be crushed before use in the Permanent Works. In this case laboratory tests should be carried out on samples of crushed material using a procedure given in Appendix 6/1.

NG 638 Determination of Redox Potential (E_h) to Assess Corrosivity of Earthworks Materials for Reinforced Soil and Anchored Earth Structures

1 Appendix 6/1 should contain the following:

(i) The number of tests to be carried out on each soil type and the locations within the area of the cutting or of the proposed borrow pit or stockpile. A minimum of five locations should be included. It is normally sufficient to test material at a depth of 1 m below original ground level. However, it will be necessary to test at lower levels where the type of material is known to vary with depth, and the depth of such tests should be given in Appendix 6/1.

(ii) When possible, tests should be carried out at the anticipated maximum natural moisture content in order to obtain the lowest redox potential.

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(iii) The pH of the fill at each location should be determined before measuring redox potential. Where the pH of the fill lies outside the range 5.5 to 9.5, and it is known that it will remain so for the life of the structure, redox potential measurements may not be required since it is considered that micro-biological corrosion is unlikely to occur under these conditions.

(iv) The field testing procedure is not suitable for massive rock material which is to be crushed before use in the Permanent Works. In this case laboratory tests should be carried out on samples of crushed material using a procedure given in Appendix 6/1.

NG 639 Determination of Coefficient of Friction and Adhesion between Fill and Reinforcing Elements or Anchor Elements for Reinforced Soil and Anchored Earth Structures

1 The test for reinforcing elements should be carried out for each type of element and each fill material proposed to be used.

2 Sub-Clause 639.5 for anchor elements is drafted so that such a test may be introduced in future when it is developed. Appendix 6/1 (1/5) should not require a test until that time.

NG 640 Determination of Permeability of Earthworks Materials

1 Details of tests for the permeability of soils and fills are given in BS 1377 : Part 5 and Part 6. Details of a test for the horizontal permeability of road drainage layers are given in Advice Note HA 41.

NG 642 Determination of the Constrained Soil Modulus (M*) of Earthworks Materials

1 (11/03) BS 5930 and PP 5930 : 2002 "Site investigations. A guide for higher education to BS 5930 : 1990. Code of practice for site investigations" give further information on, and illustrations of, suitable plate loading test equipment.

2 (11/03) Determination of M* from Standard Penetration resistance test results and/or from the coefficient of volume compressibility is normally carried out during the ground investigation stage of a scheme from tests in and/or specimens obtained from boreholes through the existing ground. The ground investigation should be designed to ensure that sufficient information is provided to determine the M* of the existing ground. The plate loading test is the preferred method for determining the M* of granular fill, during the construction stage to validate the design, but can also be used on existing ground of various soil types.

(11/03) NG 644 Determination of Sulfate Content

1 Tests for sulfate and total sulfur are mandatory for structural backfills and all fill materials placed within 500 mm or other stated distance of concrete or metallic elements, because of the risk of attack on construction materials. However, the oxidation of pyrite and leaching of sulfate, metals and acidity from fill materials can also cause environmental damage to surface water and groundwater, and can lead to clogging of drains with precipitates of ochre.

2 A highway embankment is a very favourable environment for the oxidation of pyrite and other sulfides. Experience from embankment dams has shown that the oxidation of even a small proportion of the pyrite in a fill material can lead to the drainage from the embankment requiring treatment before it can be discharged to watercourses downstream.

3 Consideration should be given to the possibility of environmental problems with bulk fill at design stage, and expert geochemical advice taken if necessary. If a potential problem is identified, based on the known properties of the proposed fill material and experience elsewhere, the tests in TRL Report 447 should be employed to assess the situation.

4 (11/05) The correct chemical form of sulfate is SO_4, and this form is used in BRE Special Digest 1. However, results reported following the convention in BS 1377 : Part 3 are reported as SO_3. Results may be converted from SO_4 to SO_3 using the following factors:

$$SO_4\ (\%, mg/l) = 1.2 \times SO_3\ (\%, mg/l)$$
$$SO_3\ (\%, mg/l) = 0.83 \times SO_4\ (\%, mg/l)$$

5 The form in which sulfate is determined should be clearly stated in the analytical report, to avoid confusion and possible misclassification. A discussion of the different forms of sulfur and conversion factors between them is given in TRL Report 447.

6 (11/05) Because of the variability of sulfur compounds in natural and artificial materials, it is important that a sufficient number of samples are tested and that the values selected for comparison with the limiting values are based on the highest values. The requirements set out in Clause 601 and 644 follow the principles set out in BRE Special Digest 1.

7 (11/05) Limiting values for WS, OS and TPS are based on values in BRE Special Digest 1. This was revised in June 2005 and as a result the limiting values for WS and OS for materials within 500 mm of concrete, cement bound materials, other cementitious materials or stabilised capping forming part of the Permanent Works have been reduced. Also, the units for sulfate in solution have been changed from g/l to mg/l.

NG SAMPLE APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING ETC. OF EARTHWORKS MATERIALS

[Note to compiler: This should include:]

1 Acceptable limits for the fills in Table 6/1 appropriate to the Contract *[Table 6/1, 602.1 and 608.1]* and including:

(i) permitted Classes where alternatives are listed in the Specification;

(ii) (11/04) those materials, which may be used for landscape fill Class 4 *[601.2(i)(b)]*;

(iii) cross-references to Drawings showing location of 'zoning' of general and selected fills;

(iv) (11/04) additional sub-divisions of Classes in Table 6/1 required for the Contract, eg. to set out environmental requirements for processed Class U1B material;

(v) alternative and additional requirements for triaxial and shear box tests *[633 and 636]*;

(vi) Class 9D lime stabilised material *[615.5, 615.16]*.

2 (11/04) Special requirements for determining acceptability, who classifies and where, and whether trial pitting is required *[602.1]*. *[Where the Contractor is responsible for testing, the tests required should be scheduled in Appendix 1/5.]*

3 (11/03) Designation (if required) of material as Class 3. *[If necessary referring to Drawings for extent eg. volume/strata (601.5(ii), 605.1)]*.

4 (11/04) Any requirement for processing to render unacceptable material (other than Class U2) acceptable, cross-referring to Drawings where necessary, for each type of material to be processed and class of material to be produced. *[Wherever possible the means of processing should be left to the Contractor] [601.1(ii), 601.1(iii) and 601.4]*.

5 Requirements for groundwater lowering or other treatment *[602.17]*.

6 Minimum MCV required immediately before compaction for lime stabilised Class 9D material *[615.13]*.

7 Contract-specific (local) requirements for acceptability and testing of unburnt colliery spoil *[601.15]*.

8 Any permitted use of the rapid assessment procedure for material acceptability *[632.3]*.

9 Requirements (if any) for removal off site of excavated acceptable material or unacceptable material requiring processing *[602.3]* or retention of surplus material on site *[602.5]*.

10 Permitted use (if any) of acceptable or unacceptable material required to be processed for purposes other than for general fill *[602.4]*.

11 Requirements for In Situ Resistivity Tests *[637.2]*.

12 Requirements for In Situ Redox Potential Tests *[638.2 and 5]*.

13 (05/01) Bearing ratio requirements for class 6R and 7I material *[643.6]*.

14 (11/03) Requirements for the assessment of the effects of water soluble (WS) sulfate, oxidisable sulfides and total potential sulfate in accordance with TRL Report 447, Test Nos. 1 to 5 *[644.1]*.

15 (11/03) Requirements for the magnesium sulfate (MS) soundness test *[635.2]*.

NG SAMPLE APPENDIX 6/2: (11/04) REQUIREMENTS FOR DEALING WITH CLASS U1B AND CLASS U2 UNACCEPTABLE MATERIALS

[Note to compiler: This should include:]

1 (11/04) Drawing references for excavation and disposal of known Class U1B and Class U2 material. *[602.5]*

2 (11/04) Pre-agreed requirements of the environmental authority for disposal including specific sites. *[602.18]*

3 (11/04) List of known hazardous materials likely to be encountered. *[602.5 and 602.18]*

4 (11/04) Methods of excavation, precautions and requirements for handling. *[602.5 and 602.18]*

5 (11/04) Special requirements for dealing with leachate and contaminated water. *[602.5 and 602.18]*

6 (11/04) Requirements for special drainage and for sealing exposed surfaces of contaminated materials. *[602.5 and 602.18]*

7 (11/04) Test methods to be used for chemical analysis of hazardous materials, leachate and contaminated water should be scheduled in Appendix 1/5. *[602.5 and 602.18]*

NG SAMPLE APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)

[Note to compiler: This should include:]

1 The drawing numbers of all drawings which give related earthworks requirements including line and level.

2 Blasting for excavation:

(i) Whether blasting is required or is a permitted alternative to normal excavation methods *[607.1]*.

(ii) Pre-split blasting requirements *[603.4]*.

(iii) Locations where blasting is required or permitted *[607.1]*.

(iv) Time limits when blasting can take place *[607.1]*. *[Ensure compatibility with Clause 109 and Appendix 1/9 requirements for noise and vibration]*.

(v) Limits of vibrational amplitude and resultant peak particle velocity if differing from those in Clause 607.

(vi) Overseeing Organisation's arrangements for Contractor to monitor noise and vibration in property off Site.

3 Cutting faces - requirements for:

(i) Undercutting restrictions - extent and limitations for sequential excavation and backfilling, where Contractor is required to undercut slopes or toes of cuttings *[603.2]*. *[Note that where similar requirements exist for embankments eg. where drainage excavations are close to the toe, these should also be covered in this Appendix]*.

(ii) Clearing loose material, where no topsoiling is required, by airline hose including maximum pressure and nozzle arrangements *[603.5(iv)]*.

(iii) Making face stable, where no topsoiling is required, including tolerances of irregularities in the cut face, depth of cut-back and thickness of cementitious material to be applied if different from Clause 603, extent of cementitious material to be applied, location and type of reinforcement and details of weep holes. *[Rock bolting should be described in Appendix 6/10.]*

(iv) Protecting face of soft or insecure material interlayered with rock, where no topsoiling is required, including depth of back and details of masonry infill.

(v) Making good prior to topsoiling *[indicating which, if any, of the measures in 603.7 are required, and where.]*

4 Watercourses including ditches etc.

(i) New or modifying old - details including protection, lining etc. *[606.1]*.

(ii) Redundant - where draining and clearing required, extent of excavation and Classes of fill for their infilling *[606.4]*.

5 Embankment Construction:

(i) Limits on oversteepening or in increase in width *[608.5]*.

(ii) Stage construction of fills - details and rates of controlled filling *[608.6]*.

(iii) Surcharging - details including time period, type of surcharge material, initial level of top of surcharge above designed formation or sub-formation *[608.7]*.

(iv) Minimum thickness of capping or of sub-base as appropriate for weather protection of sub-formation or formation *[608.9(i)] [cross-referring to Drawings if necessary]*.

(v) Description of location, class and thickness of starter layers *[608.2]*.

6 Compaction *[612]*:

(i) General:

(a) Requirements if compaction not to comply with Clause 612 *[612.1]*.

(ii) Method compaction:

(a) Locations where extra compaction in top 600 mm for Classes 1A, 1B, 2A, 2B, 2C and 2D is not required for full width of embankment or between outer extremities of verges. *[List Drawing Nos. of appropriate cross-sections (612.10(ii))]*.

(b) Requirements for compaction of drainage materials other than Class 6H.

(c) Frequency of field dry density testing *[612.9]*

(iii) End-product compaction:

(a) Whether a nuclear surface density gauge is to be used or is permitted for measuring field dry densities *[612.15]*.

7 (11/03) Limiting distance for deposition of materials referred to in sub-Clauses 601.13, 601.14 or 601.17.

8 Locations of excavations that are permitted to be battered and requirements for benching prior to backfilling and compaction *[602.12]*.

9 (05/04) Locations where excavation supports are to be left in position *[602.12 and 505.8]*.

10 (05/01) Requirements for benching or shaping to natural or earthworks slope faces to receive fill *[608.12]*. Location of and benching requirements for cutting slopes to receive topsoil, and areas of cutting slopes which do not need harrowing or harrowing depth if not 50 mm *[603.7]*.

11 Permitted variation (if any) in the maximum difference in fill level of Class 6M material on opposite sides of corrugated steel buried structures from 250 mm *[623.7]*.

12 Contract-specific permitted depth of any protection layer over corrugated steel buried structures *[623.13]*.

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13 Contract-specific permitted mixing of excavated materials where a combination of acceptable and unacceptable material is revealed in excavations *[602.6]*.

14 Fill to excavated voids or natural voids in excavation for foundations where ST1 concrete is not required or an alternative is permitted or required *[604.1 and 2]*.

15 Additional requirements for corrugated steel buried structures *[623.2] [cross-referring to Drawings if necessary]*.

NG SAMPLE APPENDIX 6/4: REQUIREMENTS FOR CLASS 3 MATERIAL

[Note to compiler: This should include:]

1 Requirements for Class 3 material *[605]* when Appendix 6/1 has designated that there will be Class 3 in the Contract:

(i) (11/03) Periods when earthworks involving Class 3 should not be carried out *[605.1(i)]*.

(ii) Minimum height of Class 3 excavation if different from 3 m *[605.1(iii)]*.

(iii) Requirements for haulage vehicles if different from sub-Clause *[605.1(v)]*.

(iv) Requirements for layering Class 3 with other material *[605.1(vii)]*.

(v) Whether embankments of Class 3 material are to be left for 4 weeks (or other period to be stated here) either 600 mm below formation or after continuing above formation with a weather protection layer *[605.1(viii)]*.

(vi) Whether omitting rolling or different rolling of Class 3 fill is required at end of each working day *[605.1(x)]*.

NG SAMPLE APPENDIX 6/5: GEOTEXTILES USED TO SEPARATE EARTHWORKS MATERIALS

[Note to compiler: This should include:]

1 Drawing references for locations where geotextiles are to be used in separation layers *[609.1]*.

2 Whether the geotextiles are to be of synthetic or other fibres *[609.1]*.

3 Minimum life expectancy *[609.2]*.

4 Distribution and numbers of samples for subsequent testing *[609.4]*.

5 Testing criteria if different from those in sub-Clause 609.4.

6 Details of laying and lapping if other than as in sub-Clause 609.5.

7 Number of tests on samples *[609.8]*.

8 Length of time samples are to be kept by Contractor *[609.7]*.

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NG SAMPLE APPENDIX 6/6: FILL TO STRUCTURES AND FILL ABOVE STRUCTURAL FOUNDATIONS

[Note to compiler: This should include:]

1 Drawing references for fill to structures and fill above structural foundations.

2 Whether Classes 6N, 6P and 7B require full scale determination of stable slope, and value of slope if not 1 to 1.5 *[610.6]*.

NG SAMPLE APPENDIX 6/7: SUB-FORMATION AND CAPPING AND PREPARATION AND SURFACE TREATMENT OF FORMATION

[Note to compiler: This should include:]

1 Drawing references which show locations where capping is required and its thickness *[613.1]* and where capping will only be required when one of the pavement types is adopted *[eg. rigid or rigid composite where sub-grade CBR > 5 and ≤ 15]*.

2 Allowed surface level tolerance *[616.1]*.

3 (05/04) Permitted Classes of capping singly and in combination *[613.3]*.

4 In cuttings and on embankments, the procedure to be adopted for construction of capping, or which alternatives are permitted *[613.11 and 613.12 respectively. This is mostly governed by material Classes in (3) above]*.

5 Requirements for a demonstration area or areas [613.4] including location and protection *[613.5]*. Requirements for removal and reinstatement of demonstration area if not forming part of the Permanent Works *[613.6]*.

6 Drawing references [including use of appropriate Drawings, by reference, in HCD which give shaping requirements for sub-formation *[613.8)]*.

7 Whether quicklime, hydrated lime or other form of lime should be used for lime stabilisation.

8 Locations where treatment of formation in accordance with sub-Clause 616.4(i) or 616.4(ii) is required.

9 Details of any additional tests for rate of spread of lime *[615.6]*.

10 Intervals for preparation and availability of chemical analysis reports if different to weekly *[615.4]*.

11 Preparation of formation on existing sub-base material *[616.6]*.

12 (05/01) Requirements for cement type in lime and cement stabilisation *[643.5]*.

13 (05/01) Requirements for alternative thickness of layers to be stabilised *[643.9]*.

14 (05/01) Alternative treatment requirements for layers to be stabilised *[643.10 & 16]*.

NG SAMPLE APPENDIX 6/8: (05/01) TOPSOILING

[Note to compiler: This should include:]

1 The compiler is required to designate on the Drawings, those areas of Class 5A material *[602.9. The compiler should be satisfied that such material is suitable for the landscape planting proposals]*.

2 Drawing references which show the locations where topsoil and vegetation is to be left in place and where topsoil is to be stripped as turf *[602.9]*.

3 Drawing references which show depths to which topsoil is to be stripped *[602.9]*.

4 Height limits of topsoil stockpiles permitted, if other than 2 m *[602.10]*.

5 Reference period of time for when topsoil can be stockpiled if different from sub-Clause 602.10.

6 Whether surplus topsoil is to be stored or disposed of by the Contractor. Details of topsoil storage areas such as location, height, contours and batter slopes *[602.11]*.

7 Details of slopes of Classes 2E and 7B fill material to be immediately covered by topsoil *[608.11]*.

8 Whether imported topsoil Class 5B is required or permitted *[618.2]*.

9 Details of topsoil treatment in areas to be turfed. Locations as detailed in Appendix 30/5 *[618.4]*

10 Whether the requirements of sub-Clause 618.3 apply, stating where necessary, the cumulative rainfall if not 100 mm and location of measuring point.

11 Permitted areas (if any) of non-removal and disposal off site of stones or other debris with dimensions greater than 100 mm equivalent diameter *[618.4]*.

12 Thickness of topsoil to be deposited and when a tracked vehicle may not be used for spreading. *[618.4(i)]*

NG SAMPLE APPENDIX 6/9: EARTHWORK ENVIRONMENTAL BUNDS, LANDSCAPE AREAS, STRENGTHENED EMBANKMENTS

[Note to compiler: This should include:]

1 Earthwork Environmental Bunds

(i) References to Drawings which show locations and which state type of construction *[619.1, 2 and 3]*:

(a) a normal embankment to Clause 608; if so whether method compaction to Clause 612 is required and which Method in Table 6/4 to adopt and Classes of fill permitted or required;

(b) a strengthened embankment to Clause 621; if so requirements as listed in 3 below;

(c) a reinforced or anchored earth structure to Clause 622; if so full details of construction.

(ii) Requirements for early construction.

(iii) (05/01) Requirements for topsoiling

2 Landscape Areas

(i) References to Drawings which show locations.

(ii) If compaction to be 'method' to Clause 612 and if so which method in Table 6/4 to adopt.

(iii) Details of contouring required.

(iv) Locations where landscape areas may be constructed simultaneously with adjoining embankments.

(v) (05/01) Requirements for topsoiling

3 Strengthened Embankments

(i) Reference to Drawings which show locations, details of construction and Classes of fill.

(ii) Requirements for strengthening materials. *[See NG 609.3]*.

NG SAMPLE APPENDIX 6/10: GROUND ANCHORAGES, CRIB WALLING AND GABIONS

1 Ground Anchorages *[624]*

[Note to compiler: Include here:]

(i) Design requirements. *[Where the design retained height exceeds 1.5 m. include the requirement for the design to comply with Standard BD 2 and the outline Approval in Principle form.]*

(ii) References to Drawings showing installation and construction requirements, including:

(a) specifications for drilling, tendons, grouting and tensioning;

(b) proof loading, monitoring and re-tensioning;

(c) trial installations;

(d) rock bolting.

2 Crib Walling *[625]*

[Note to compiler: Include here:]

(i) Design requirements. *[Where the design retained height exceeds 1.5 m, include the requirement for the design to comply with Standard BD 2 and the outline Approval in Principle form.]*

(ii) References to Drawings showing locations and outlines.

3 Gabions *[626]*

[Note to compiler: Include here:]

(i) References to Drawings showing locations and details including:

(a) additional requirements and type of mesh *[626.1 and 3]*;

(b) core dia. and its BS for mesh if different from 626.3(i);

(c) properties of plastic geomesh, if permitted *[626.3(ii)]*;

(d) size of mesh openings and gradings of fill *[626.5]*.

NG SAMPLE APPENDIX 6/11: SWALLOW HOLES AND OTHER NATURALLY OCCURRING CAVITIES AND DISUSED MINE WORKINGS

[Note to compiler: This should include:]

1 Drawing references showing locations of voided ground or abandoned workings. *[627 and 628]*.

2 Location methods for identifying and inspecting shallow workings or voids where required.

3 Requirements for bulk fill and methods of placement.

4 Grouting, types and procedures.

5 Details of excavation, clearance and flushing of soft infilling.

6 Details of other treatments or support requirements.

7 Requirements for concrete caps to voids or soft areas.

8 Requirements for inspecting, monitoring, clearing, flushing, filling, caps or other treatments of disused mine workings. *[628.1]*.

NG SAMPLE APPENDIX 6/12: INSTRUMENTATION AND MONITORING

[Note to compiler: This should include:]

1 Drawing references showing locations and extent of instrumentation including that required for staged construction *[(629.1 and 2 and 608.6). Note: instrumentation and monitoring for blasting should be covered in Appendix 6/3 and for dynamic compaction in Appendix 6/13]*.

2 Schedules of instruments by type and description with alternatives where possible.

3 Details of housings required.

4 Installation techniques.

5 Calibration requirements.

6 Protection to instruments, connections and housing.

7 Requirements for electric power.

8 Frequency of reading and method of reporting readings where the Contractor is required to carry out these tasks.

NG SAMPLE APPENDIX 6/13: GROUND IMPROVEMENT

[Note to compiler: This should include:]

1 Dynamic Compaction

(i) Drawing references showing locations where dynamic compaction is required.

(ii) For end-product: performance requirements in terms of tolerable further settlement after process has been completed.

(iii) For method, the following where applicable:

(a) Special drainage requirements *[eg. de-watering; 602.17]*.

(b) Class and thickness of granular layer.

(c) Mass, shape and contact area of pounder.

(d) Height(s) of drop and spacing of imprints.

(e) Number of drops.

(f) Arrangements and numbers of passes.

(g) Requirements, including class of material, for filling of imprints.

(h) Requirements for instrumentation, monitoring and testing.

2 Vibrated Stone Columns

[Note to compiler: include here:]

(i) Whether the design has been prepared by the Overseeing Organisation or if the design is to be carried out by the Contractor to meet the Overseeing Organisation's performance specification.

(ii) Drawing references showing locations where vibrated stone columns are required *[630.7]*.

(iii) Materials to be used *[630.5 and 8]*

(iv) Method of Ground Treatment and Testing of Treated Ground including

- (a) wet or dry process *[630.4]*
- (b) column layout *[630.4]*
- (c) tolerances on columns *[630.7]*
- (d) performance criteria *[630.9]*
- (e) tests to be carried out *[630.12, 13, 14]*
- (f) alternative tests permitted and testing frequency *[630.11]*
- (g) additional information (if any) required *[630.20]*

(v) Trial Areas including

- (a) areas to be treated *[630.15]*
- (b) tests to be carried out *[630.17]*
- (c) testing frequency *[630.17]*

3 Other Methods

For other methods of ground improvement:

(i) Drawing references showing location and type.

(ii) Details of spacing, depth, size etc. referring to drawings if necessary.

(iii) Specification details.

NG SAMPLE APPENDIX 6/14: (11/04) LIMITING VALUES FOR POLLUTION OF CONTROLLED WATERS

The limiting values for pollution of controlled waters shall be:

[Compiler: This should include the following:]

1 Limits on the amount of contaminants in a material above which there is a significant possibility that controlled waters (surface water and groundwater) will be polluted. These may be expressed as total concentrations in the material or, preferably, as concentrations or cumulative leached amounts in standard leaching tests carried out on the materials. *[601.2(ii)(a)]*

2 An explanation of the derivation of the limits (eg. generic guideline values for given soil conditions, or values derived from site specific risk assessment quoting relevant input parameters and methods). *[601.2(ii)(a)]*

3 Testing requirements should be scheduled in Appendix 1/5. These should include frequencies, certifications and any other scheme specific requirements.

NG SAMPLE APPENDIX 6/15: (11/04) LIMITING VALUES FOR HARM TO HUMAN HEALTH AND THE ENVIRONMENT

The limiting values for harm to human health and the environment shall be:

[Compiler: This should include the following:]

1 Limits on the amount of contaminants in a material which, if exceeded, will lead to a significant possibility of significant harm to human health or the environment. *[601.2(ii)(a)]*

2 An explanation of the derivation of the limits (e.g. generic guideline values, such as the Soil Guideline Values published by DEFRA and the Environment Agency or values derived from site specific risk assessment quoting relevant input parameters and methods). *[601.2(ii)(a)]*

3 Testing requirements should be scheduled in Appendix 1/5. These should include frequencies, certifications and any other scheme specific requirements.

NATIONAL ALTERATIONS OF THE OVERSEEING ORGANISATION OF SCOTLAND

NG 601SE (11/05) Classification, Definitions and Uses of Earthworks Materials

1 (11/05) The definition of Class U2 materials in Scotland has been based on the Special Waste Amendment (Scotland) Regulations 2004. This supersedes the Special Waste (Scotland) Regulations 1996.

NG 632SE (05/01) Determination of Moisture Condition Value (MCV) of Earthworks Materials.

General

1 The earthworks clauses have been drawn up in the interests of economy, to encourage the best use of all materials. Schemes should be designed on the basis that, with the exception of materials defined in Clause 601.2 (i) and (ii) (a) to (j), maximum use can be made of all materials on site where this is advantageous. It is vital that site investigations should be thorough and performed sufficiently in advance of the design and tender stages to enable proper appraisal to be made of the materials which will be encountered. The use of trial pits for this purpose is strongly advocated. Where trial pits cannot be used, for instance in the case of materials at depth, then boreholes, or similar techniques, will be required. Care should be taken to ensure that samples for testing are representative of the material being sampled.

2 To estimate the volumes of acceptable and unacceptable material in a particular scheme it will be necessary to characterise each major soil type in terms of acceptability. For most soils, this is best accomplished through the use of the Moisture Condition Apparatus (MCA). Soils which can be tested by the MCA are cohesive to granular in type, and have relatively low to medium permeability. Such soils are able to develop excess porewater pressures: there is therefore an accompanying decrease in shear strength during compaction. The acceptability of soils not able to be tested by the MCA can be determined by other techniques such as establishing the relationship of dry density with moisture content. A guide to determining whether the MCA test can be applied can be obtained by considering the proportions of fines, sand and gravel (deduced from a particle size distribution test performed on the excavated soil). Three categories can thus be defined:

(i) MCA can be used.

(ii) MCA cannot be used.

(iii) MCA may be useable.

3 If the fines content lies between the limits defined in TRL Report 273 for 2(i) and 2(ii) above then the MCA may still be useable. A single MCV test performed on the material in a saturated state can provide further guidance on whether a calibration line should be attempted. If the result of such a test indicates that there is a potential for unacceptability then a calibration line should be attempted. If a calibration line with a clearly defined section of negative slope and a satisfactory correlation coefficient is obtained then the MCA can be used over that specific range of moisture contents.

4 Details of the MCA, test procedures and applications can be found in TRL Report 273. MCV calibration lines should be attempted for all soils satisfying 2(i) and for all those for which a potential for unacceptability exists in 2(iii) above. MCV tests at natural moisture contents will enable the in situ state of the soil to be evaluated in terms of a calibration line. Means of interpreting and applying the results are given in the above-mentioned TRL Report. Estimates and quantities of acceptable and unacceptable material derived from the site investigation do not allow for seasonal, climatic, local or other variations in weather and moisture contents, and these must be allowed for during the construction stage.

5 Consideration should be given at the design stage, when setting an MCV limit for the contract or portion of the contract, to the extent to which drainage layers with a higher MCV can be incorporated into the fill and be effective. Depending on particular contract circumstances the adoption of stronger material in the top metre of an embankment may be advisable. Where material of doubtful value for fill or subgrade is encountered then compaction trials will be necessary. These can be carried out as part of the site investigation or as a separate exercise during the design stage for the main contract.

6 In general the principle should be that if materials can be excavated, transported and compacted they are acceptable for most earthworks. The MCA is effective in determining acceptability for both earthmoving and

compaction. MCV tests performed on materials immediately prior to use will enable their acceptability to be established. As a general guide an MCV of 8.5 is recommended as a lower limit of acceptability: a soil having an MCV less than this limit is thus deemed unacceptable. Specific conditions on site may require that the 8.5 limit be lowered or raised marginally. This should be based on the local situation, the known behaviour of the material and the type of plant a competent Contractor could be expected to use on the Site. The behaviour of materials with high stone contents, for example, stony tills, can be dominated by either the matrix materials (less than 20 mm) or the stones. Application of the MCA is confined to those materials which are matrix dominated (stone content less than 45% to 50% by weight). Although the MCV may be determined on the matrix material, all comparative tests, such as natural moisture content MCVs and MCV limits/calibration lines, must be carried out on the same portion of the sample. This should be taken into consideration when setting MCV limits on the Site and a correspondingly lower MCV limit may be able to be used.

7 The types of plant which can be used on earthworks and their efficiency of operation is related to the MCV of the soils being worked. Providing that the site investigation is adequate and gives information on the in situ soil characteristics then the responsibility is that of the Contractor to select and use plant which can operate effectively in the particular conditions and not to assume that he can always use machines with the highest potential productivity available. Guidance on the selection of plant in terms of MCV can be obtained from TRL Research Report RR130.

8 It is recognised that the compaction specification could exceptionally produce overstress of some soils, even when the MCV is above the limit specified in the contract, or if the Contractor persists in working in unsuitable weather conditions or by methods which allow the MCV to decrease below the specified limit or by the use of unsuitable plant on weaker soils.

9 Whilst permission to use material having an MCV below the specified limit will encourage the maximum use of available material it will require a continuous appreciation of the earthworks situation during construction and that such material is capable of forming a stable fill and will not impair the satisfactory operation of the construction plant.

10 Appendix 6/1 should state that the MCV/moisture content relationship of imported materials should also be determined where appropriate.