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Notes for Guidance on the Specification for Road Works Series NG 800 - Road Pavements - Unbound and Cement Bound Mixtures (including Erratum No. 1, dated June 2013)

CC-GSW-00800
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CC Construction & Commissioning

Standards

About TII

Transport Infrastructure Ireland (TII) is responsible for managing and improving the country's national road and light rail networks.

About TII Publications

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Each document within TII Publications has a range of attributes associated with it, which allows for efficient access and retrieval of the document from the website. These attributes are also contained on the inside cover of each current document, for reference. For migration of documents from the NRA and RPA to the new system, each current document was assigned with new outer front and rear covers. Apart from the covers, and inside cover pages, the documents contain the same information as previously within the NRA or RPA systems, including historical references such as those contained within NRA DMRB and NRA MCDRW.

Document Attributes

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For all documents that existed within the NRA DMRB or the NRA MCDRW prior to the launch of TII Publications, the NRA document reference used previously is listed above under 'historical reference'. The TII Publication Number also shown above now supersedes this historical reference. All historical references within this document are deemed to be replaced by the TII Publication Number. For the equivalent TII Publication Number for all other historical references contained within this document, please refer to the TII Publications website.

National Roads Authority

Manual of Contract Documents for Road Works (NRA MCDRW)

ERRATUM No. 1 (June 2013) to the Notes for Guidance to the NRA Specification for Road Works Series 800 - Road Pavements – Unbound and Cement Bound Mixtures, Dated March 2013

The Notes for Guidance to the NRA Specification for Road Works (NRA MCDRW), Series 800 – Road Pavements – Unbound and Cement Bound Mixtures, dated March 2013 is amended as follows:-

1. Page 8, Clause NG 808.8, Paragraph 1

   Insert the text “and 809.1” in the middle of the first sentence of this paragraph.

2. Page 9, Clause NG 808.8, Paragraph 2

   Correct sub-paragraph indexing by inserting number “(i)” and amending following sub-paragraph by deleting number “(i)” and inserting number “(ii)”.

3. Page 9, Clause NG 808.8, Paragraph 2, item (i)

   Correct sub-paragraph indexing sub-paragraph by deleting number “(i)” and inserting number “(ii)”.

4. Page 9, Clause NG 808.8, Paragraph 2, item (ii)

   Correct sub-paragraph indexing sub-paragraph by deleting number “(ii)” and assigning sub-paragraph to a new paragraph 2.

5. Page 9, Clause NG 808.8, Paragraph 2, item (ii)

   Insert the text “for approval” at the end of the second last sentence of this paragraph.

6. Page 9, Clause NG 808.8, Paragraph 2, item (ii)

   Delete the text of the final sentence of this sub-paragraph, which was “The Employer’s Representatives’ approval will then be required in advance of incorporating these materials into the works”.

7. Page 9, Clause NG 808.8, Paragraph 4

   Delete the text “to the satisfaction” within the first sentence of this paragraph, and replace with alternative text “with the written approval”

8. Page 9, Clause NG 808.8, after Paragraph 4

Insert a new paragraph at the end of paragraph 4, as set out below;

"Where the Contractor wishes to use materials approved by the Employer's Representative as set out above, but outside the limiting values included in Clauses 808 or 809, the use of such materials would only be accepted under an Approved Departure in accordance with NRA GD 100 Departures from Standards and Specification (Volume 0, Section 3, Part 2 of the NRA DMRB)."

ROAD PAVEMENTS – UNBOUND AND CEMENT BOUND MIXTURES

Contents

ROAD PAVEMENTS – UNBOUND AND CEMENT BOUND MIXTURES

NG 800 General

1 Advice on design and construction of subbases and bases (formerly roadbases) is published in the NRA Design Manual for Roads and Bridges (NRA DMRB) Volume 7. The Clauses in Series 800 refer to IS EN 13285, 'Unbound mixtures – Specification' and Parts 1, 2, 10 and 11 of IS EN 14227, 'Hydraulically bound mixtures – Specifications' which cover other hydraulically bound mixtures and now form the sub-Series 800. The cement bound Clauses of Series 1000 have been moved to Series 800. These are now part of sub-Series 800 referred to above. IS EN 13285 applies to unbound mixtures of natural, manufactured aggregates such as slags and recycled aggregates. The different parts of IS EN 14227 require aggregates to conform to IS EN 13242 which applies to aggregates obtained by processing natural or manufactured or recycled materials. The NRA DMRB also includes advice on the use of recycled materials, see NRA Addendum to HD 35.

Unbound Mixtures for Subbase

NG 801 General Requirements for Unbound Mixtures

1 IS EN 13285 specifies the requirements for unbound mixtures used for the construction and maintenance of roads and other trafficked areas. All unbound mixtures used should comply with IS EN 13285. The requirements for the properties of aggregates used in unbound mixtures are defined by appropriate cross-reference to IS EN 13242.

2 Because IS EN 13285 aims to satisfy differing custom and practice across many Member States (MS) of the European Economic Area (EEA), the standard contains many choices, which are set out in tables. The structure of the tables allows the user to choose an appropriate category for each mixture property. None of the combinations of categories from IS EN 13285 give a mixture that is directly equivalent to the established types of granular subbase material specified in previous editions of Specification for Road Works (SRW).

3 After detailed review of established practice and the capability of Irish suppliers, the unbound mixtures in Table 8/1 have been chosen. The Table defines each mixture using a combination of categories for:

i) designation - in terms of lower sieve size (*d*) and the upper sieve size (*D*). The lower size sieve (*d*) = 0 for all unbound mixtures defined by IS EN 13285.

ii) maximum fines - as measured by the percentage by mass passing the 0.063 mm size sieve.

iii) oversize - in terms of the percentage by mass of particles passing a sieve size two times the upper sieve size (2*D*) and retained on the upper sieve size (*D*).

iv) overall grading - the combination of overall grading category and designation define the grading envelope.

For some mixtures, the overall grading category defines additional requirements to control the grading of individual batches, as detailed in Tables 8/5, 8/6, 8/7, 8/8 and 8/9.

4 It is unlikely that a single source of supply will routinely comply with the requirements for all of the mixtures. Compliance depends upon the type of aggregate and the capability of the production process. Other IS EN 13285 mixtures not detailed in Table 8/1 should only be used after consultation with the Employer.

5 The scope of IS EN 13285 is limited to the properties of unbound mixtures at the point of delivery; it does not include water content or the properties of the finished layer. To assist in the selection of an appropriate source and to help control compaction, the system of factory production control required for the unbound mixture includes an annual declaration of a typical value of laboratory dry density and optimum water content for each unbound mixture.

6 Frost susceptibility, plasticity, CBR and trafficking trials are outside the scope of IS EN 13285. The requirements of Series 800 apply to these mixture properties.

Aggregates Used in Unbound Mixtures

7 IS EN 13285 requires the aggregates used in unbound mixtures to comply with IS EN 13242, Aggregates for Unbound and Hydraulically Bound Materials for use in Civil Engineering Work and Road Construction. Because IS EN 13242 aims to satisfy differing custom and practice across many member states of the EEA, the standard contains many choices, which are set out in tables. The structure of the tables allows the user to choose an appropriate category for each required aggregate property. IS EN 13242 also permits the use of the category "No requirement" for properties that are not relevant to a particular end use or origin of the mixture, in the interest of efficiency and economy. Further guidance on the use of IS EN 13242 is given in SR 21 "GUIDANCE ON THE USE OF I.S. EN 13242:2002 - AGGREGATES FOR UNBOUND AND HYDRAULICALLY BOUND MATERIALS FOR USE IN CIVIL ENGINEERING WORK AND ROAD CONSTRUCTION" published by NSAI.

8 The requirements for aggregates in Table 8/2 defines each aggregate used in the mixture as a combination of categories for:

i) **Crushed or broken particles - to ensure adequate aggregate interlock.** Crushed rock aggregates should be assumed to be in Category $C_{90/3}$ without further testing. Where permitted, the use of Category $C_{50/10}$ for crushed gravels ensures that not more than 10% of the particles are fully rounded.

ii) **Los Angeles coefficient - to control resistance to fragmentation.** The Los Angeles test replaces the Ten Percent Fines (TPV) and the Aggregate Impact Value (AIV) tests. The Los Angeles test can only test aggregate in a dry condition. There is not a direct correlation between the Los Angeles test and the BS 812 tests it replaces.

iii) **Magnesium sulfate soundness - to ensure resistance to freezing and thawing.** Category MS_{25} provides a level of resistance that is directly equivalent to the BS 812-121 value of greater than 65. The magnesium sulfate soundness test should initially be used for source approval of aggregates and thereafter only in cases where the Employer's Representative [Specialist responsible for the design] suspects their durability. Where local experience indicates that an aggregate with a higher soundness category than that specified may be acceptable, this value should be inserted in Appendix 7/1. The water absorption test can be used as a routine check test of such aggregates. Where required, details of the tests should be scheduled in Appendix 1/5.

9 The use of the Methylene Blue test is used to determine the quality of the fines component. It will be necessary to continue to specify Liquid limits and Plasticity index, where appropriate, until further data on the Methylene Blue test has been collected and reviewed. The contractor/supplier is required to furnish current Methylene Blue values on the material as supplied.

10 The supplier of the mixture is required to monitor water absorption values as part of the system of factory production control required by IS EN 13242. The value for the aggregate used should be stated. If any result from the tests on routine deliveries exceeds the declared value (d) by more than 0.5% further investigation will be required. Routine water absorption tests are not generally required for aggregates with a declared value of 2.0% or less.

Recycled Aggregates

11 IS EN 13285 includes recycled aggregates within its scope without specific mention in the requirement clauses. The approach adopted is blind to the source of the aggregate used in the mixture. The suitability of mixtures containing recycled aggregates for use in subbase should be assessed in accordance with the requirements of the Series 800 Clauses.

13 The test procedure adopted for identifying and quantifying constituent materials in recycled coarse aggregate and recycled concrete aggregate is a qualitative method. Where constituents other than those deemed to comply with the particle density requirements by the qualitative classification can be shown to be of a higher particle density, they may be included within these higher density fractions provided that written agreement has been given by the Employer.

14 Sub-Clauses 803.3, 804.2, 805.2, 806.3 and 807.4 describe requirements for material passing the 0.425 mm sieve. Where the foreign materials component of recycled coarse aggregate or recycled concrete aggregate is ‘clay lumps’, the material may fail these tests and hence fail to meet the Specification.

Unbound Mixtures Produced as Part of The Works

15 IS EN 13242 (see Annex C) and IS EN 13285 (see Annex D) specify the operation of a factory production control system to confirm conformance with the relevant requirements of the standards. Although unbound mixtures produced on site as part of the permanent Works are not placed on the market, a factory production control system (or a quality plan with equivalent requirements) is still required to provide the necessary level of assurance.

Frost Heave

16 The frost heave test described in BS 812-124 is costly and time consuming and is not suitable for routine control checks on Site. The test has been developed from earlier test methods to overcome problems of repeatability and reproducibility. The test is primarily intended as a method to establish whether or not an aggregate from a particular source is likely to be frost-susceptible when used in an unbound condition within that part of the road pavement subject to frost penetration. Material for the frost heave test should be representative of the source and comply with all other requirements of the Specification otherwise the test is superfluous. Once a material has been established as non-frost-susceptible the test need only be repeated if the material varies from the original sample, or where the source is changed.

17 Clause 6 of BS 812-124 sets down the procedure for adjusting the water level in the self-refrigerated unit (SRU). A possible problem has been identified that with the tolerances given to the dimensions for the cradle and specimen carriers it is possible for the porous discs in the specimen carriers to be located incorrectly in relation to the water level. In order to guard against this it is recommended that before testing commences the cradle and specimen carriers be put into the SRU without samples. A check is then made to ensure that discs are set at the level specified in the above-mentioned standard.

NG 802 Transport, Laying, Compaction and Trafficking of Unbound Mixtures

1 Sub-Clause 802.9 (viii) permits combinations of different types of compaction equipment provided each type contributes its correct proportion of the total compactive effort. Thus if a machine when operated singly is require in Table 8/4 to apply a minimum of X passes and that same machine actually applies K passes, then the sum of the values of K/X for each of the types of plant used in combination should equal or exceed unity.

2 A Trafficking Trial should be considered when unbound materials Type A or Type C are used beneath flexible pavements carrying a traffic loading of more than 2 msa.

NG 803 Granular Material Type A

1 Current design requirements exclude Type A unbound mixtures from flexible roads carrying a traffic loading of more than 5 msa. Where local experience indicates that these materials can be used successfully at higher traffic levels, the Employer may require that a Substitute Clause should be written to permit their use. Mixtures containing a high proportion of asphalt arisings have been shown to perform well in other countries at design traffic levels higher than 5 msa, but performance should be assessed using a Trafficking Trial.

2 Table 8/5 in Clause 803 includes requirements for the calculated difference between the values of percentage by mass passing selected adjacent sieves. These requirements are taken from IS EN 13285 and ensure a 'well graded' mixture by controlling the continuity of the grading curve.

3 Although parameters related to the control of the construction of the pavement layer are outside the scope of IS EN 13285, it is appropriate to make information available to assist the purchaser's choice of unbound mixture. IS EN 13285 requires the laboratory dry density and optimum water content of an unbound mixture to be declared at least once each year, as part of the system of factory production control. IS EN 13285 permits choice from a list of four test methods for these properties, reflecting the range of mixtures and techniques used across Europe.

In Ireland, it is recommended that the vibrating hammer test (IS EN 13286-4) is used. This method is very similar to the established UK method defined in BS 1377-4. IS EN 13286-4 also includes a test method similar to that developed as BS 5835. That test procedure for the determination of optimum moisture content was developed specifically for graded aggregates and gives more reproducible results than the vibrating hammer test for these materials.

NG 804 Granular Material Type B

1 IS EN 13285 details additional requirements to control individual batches of unbound mixtures with an overall grading Category G_A, within a system of factory production control. Table 8/6 in Clause 804 illustrates this. The supplier should nominate a supplier declared value for the intermediate sieves in the grading envelope as part of the system of factory production control for the mixture. The nominated value should lie within the supplier declared value grading range in Table 8/6. Individual batches are then assessed using the tolerances in Table 8/6, applied to the supplier declared values. As explained in Annex B (informative) of IS EN 13285, the use of tolerances does not change the overall grading range.

3 Table 8/6 also includes requirements for the calculated difference between the values of percentage by mass passing selected adjacent sieves. These requirements are taken from IS EN 13285 and ensure a 'well graded' mixture by controlling the continuity of the grading curve.

4 Because the requirements for aggregates used in the unbound mixtures now refer to the requirements of IS EN 13242, confirmation of conformity with the categories for Los Angeles coefficient and magnesium sulfate soundness can be obtained from the CE Mark Certificate for the aggregates used in the mixture. If a CE Mark Certificate is not available to confirm the suitability of the source, test certificates should be provided from a testing laboratory accredited by an appropriate organisation accredited in accordance with Series 100 for the test, showing a value in excess of the minimum specified and dated not more than 6 months prior to use of the material within the Works.

NG 805 Granular Material Type C (Open Graded Unbound Mixtures)

1 In the past gravel meeting the specification requirements for Granular material Type C has performed successfully in Irish road pavements. In areas where suitable crushed rock is not available locally, consideration should be given to using gravel complying with Clause 805 on less heavily trafficked roads. Because of the variability in naturally occurring gravels, control of the quality of such materials is important. The use of open graded mixtures may have advantages in circumstances where a free draining layer is to be preferred.

2 IS EN 13285 details additional requirements to control individual batches of unbound mixtures with an overall grading Category G_A, within a system of factory production control. Table 8/7 in Clause 805 illustrates this. The supplier should nominate a supplier declared value for the intermediate sieves in the grading envelope as part of the system of factory production control for the mixture. The nominated value should lie within the supplier declared value grading range in Table 8/7. Individual batches are then assessed using the tolerances in Table 8/7, applied to the supplier declared values. As explained in Annex B (informative) of IS EN 13285, the use of tolerances does not change the overall grading range.

3 Table 8/7 also includes requirements for the calculated difference between the values of percentage by mass passing selected adjacent sieves. These requirements are taken from IS EN 13285 and ensure a ‘well graded’ mixture by controlling the continuity of the grading curve.

4 Because the requirements for aggregates used in the unbound mixtures now refer to the requirements of IS EN 13242, confirmation of conformity with the categories for Los Angeles coefficient and magnesium sulfate soundness can be obtained from the CE Mark Certificate for the aggregates used in the mixture. If a CE Mark Certificate is not available to confirm the suitability of the source, test certificates should be provided from a testing laboratory accredited by an appropriate organisation accredited in accordance with Series 100 for the test, showing a value in excess of the minimum specified and dated not more than 6 months prior to use of the material within the Works.

5 The chosen category for resistance to fragmentation in Table 8/2 is LA_{30}.

NG 806 Granular Material Type D (Wet Mix Macadam)

1 Experience has shown that limestone aggregate produces the most satisfactory wet-mix macadam where satisfactory production systems are in place. Satisfactory wet-mix macadam can be produced with aggregates other than limestone, but requires a greater control during production and a higher rate of quality control testing than is necessary with limestone.

2 Past experience indicates that most well graded wet-mix macadams have an optimum moisture content of about 3%- 4%, and that high in situ strengths can be mobilised in wet-mix macadam if it is compacted in accordance with the requirements of Table 8/4 at about 0.5%-1.0% below the optimum moisture content. However the optimum moisture content for some unbound materials with low fines content may be difficult to determine accurately and, where uncertainty about the optimum moisture content occurs, guidance on the most suitable moisture content range for laying and compaction can be obtained by carrying out CBR tests at a range of moisture content so that the appropriate moisture content range for mobilising maximum strength can be determined. The compaction technique to be used for this purpose should be the vibrating hammer method described in IS EN 13286 - 4. Further information on this topic is given in An Foras Forbartha report RC188 and Environmental Research Unit report RC 358.

3 IS EN 13285 details additional requirements to control individual batches of unbound mixtures with an overall grading Category G_O, within a system of factory production control. Table 8/8 in Clause 806 illustrates this. The supplier should nominate a supplier declared value for the intermediate sieves in the grading envelope as part of the system of factory production control for the mixture. The nominated value should lie within the supplier declared value grading range in Table 8/8. Individual batches are then assessed using the tolerances in Table 8/8, applied to the supplier declared values. As explained in Annex B (informative) of IS EN 13285, the use of tolerances does not change the overall grading range.

4 Table 8/8 also includes requirements for the calculated difference between the values of percentage by mass passing selected adjacent sieves. These requirements are taken from IS EN 13285 and ensure a 'well graded' mixture by controlling the continuity of the grading curve.

5 Because the requirements for aggregates used in the unbound mixtures now refer to the requirements of IS EN 13242, confirmation of conformity with the categories for Los Angeles coefficient and magnesium sulfate soundness can be obtained from the CE Mark Certificate for the aggregates used in the mixture. If a CE Mark Certificate is not available to confirm the suitability of the source, test certificates should be provided from a testing laboratory accredited by an appropriate organisation accredited in accordance with Series 100 for the test, showing a value in excess of the minimum specified and dated not more than 6 months prior to use of the material within the Works.

6 The chosen category for resistance to fragmentation in Table 8/2 is LA_{30}.

NG 807 Granular Material Type E (Close Graded Unbound Mixtures)

1 For selected end uses where greater control of particle size distribution and consistency of performance is required than is available using the standard Type B unbound mixture, an unbound mixture with designation 0/31,5 and an overall grading category G_B can be used. This is known as a close graded granular mixture. The tighter tolerances of category G_B are unlikely to be achievable without special production regimes, probably involving batch blending of different aggregate sizes.

2 IS EN 13285 details additional requirements to control individual batches of unbound mixtures with an overall grading Category G_B, within a system of factory production control. Table 8/9 in Clause 807 illustrates this. The supplier should nominate a supplier declared value for the intermediate sieves in the grading envelope as part of the system of factory production control for the mixture. The nominated value should lie within the supplier declared value grading range in Table 8/9. Individual batches are then assessed using the tolerances in Table 8/9, applied to the supplier declared values. As explained in Annex B (informative) of IS EN 13285, the use of tolerances does not change the overall grading range.

3 Table 8/9 also includes requirements for the calculated difference between the values of percentage by mass passing selected adjacent sieves. These requirements are taken from IS EN 13285 and ensure a 'well graded' mixture by controlling the continuity of the grading curve.

4 Because the requirements for aggregates used in the unbound mixtures now refer to the requirements of IS EN 13242, confirmation of conformity with the categories for Los Angeles coefficient and magnesium sulfate soundness can be obtained from the CE Mark Certificate for the aggregates used in the mixture. If a CE Mark Certificate is not available to confirm the suitability of the source, test certificates should be provided from a testing laboratory accredited by an appropriate organisation accredited in accordance with Series 100 for the test, showing a value in excess of the minimum specified and dated not more than 6 months prior to use of the material within the Works.

5 The chosen category for resistance to fragmentation in Table 8/2 is LA_{30}.

6 Whilst there is no specified moisture content for laying and compacting materials to Clause 807, in order to satisfy the requirements of sub-Clauses 802.7, 802.8 and 807.5 it will be necessary to carry out these operations at optimum moisture content or thereabouts.

NG 808 Additional Requirements for Unbound Materials Placed Adjacent To Cement-Bound Materials

1 Tests for sulfate and total sulfur are mandatory for all unbound 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. Furthermore the oxidation of pyrite within a calcareous fill may lead to the growth of gypsum and therefore pyrite related heave within constrained granular fills.

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 outlined in IS EN 1744: Part 1 Sections 10, 11 and 12 should be employed to assess the situation.

4 The correct chemical form of sulfate is SO4 and this form is used in BRE Special Digest 1 However, results reported following the convention in BS 1377 : Part 3 are reported as SO3. Results may be converted from SO4 to SO3 using the following factors:

SO4 (%, mg/l) = 1.2 x SO3 (%, mg/l)

SO3 (%, mg/l) = 0.83 x SO4 (%, 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 The results for water-soluble sulfate may be expressed in either g / l or %. As the water:soil ratio for the test is fixed at 2:1, the results can be converted from percentage to grams/litre by multiplying by 5.

7 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 808 and 809 and 820 follow the principles set out in BRE Special Digest 1.

8 The limiting values in sub-Clauses 808.1 and 809.1[1] have been chosen to ensure that problems do not occur due to oxidation of reduced sulfur compounds such as pyrite. The oxidation of pyrite results in the production of sulphuric acid, which can attack concrete and/or exposed metallic elements, and lead to the formation of gypsum, which may result in heave. 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 backfill. Examples of situations where materials may exceed the limiting values for select granular fill but still be acceptable include the following:

(i) Pyrite present as large cubic crystals visible to the naked eye, as opposed to the fine grained and therefore more reactive framboidal pyrite. 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).[2]

(ii) 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.[3]

[4]Where this occurs, enquiries should be made by the Contractor to the supplier 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. The results of this testing should be provided to the Employer's Representative for approval[5].[6]

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 with the written approval[7] of the Employer's Representative that:

(i) the material has been used in the past as structural backfill without leading to problems with sulfur compounds; and

[1] *Amended as per Erratum No. 1, item 1*

[2] *Amended as per Erratum No. 1, item 2*

[3] *Amended as per Erratum No. 1, item 3*

[4] *Amended as per Erratum No. 1, item 4*

[5] *Amended as per Erratum No. 1, item 5*

[6] *Amended as per Erratum No. 1, item 6*

[7] *Amended as per Erratum No. 1, item 7*

(ii) the reason why the material will not cause a problem is known, based on an understanding of its chemistry and mineralogy.

Where the Contractor wishes to use materials approved by the Employer's Representative as set out above, but outside the limiting values included in Clauses 808 or 809, the use of such materials would only be accepted under an Approved Departure in accordance with NRA GD 100 Departures from Standards and Specification (Volume 0, Section 3, Part 2 of the NRA DMRB).[8]

TRL 447 available from the Transport Research Laboratory (www.trl.co.uk).provides further background to these requirements should a particular aggregate source require close consideration in this regard.

NG 809 Additional Requirements for Unbound Materials Placed Adjacent To Metallic Structural Elements

1 The limiting values for sulfate characteristics in Clauses 809 have been chosen to ensure that problems do not occur due to oxidation of reduced sulfur compounds such as pyrite leading to acid attack on metallic structural components. This is particularly relevant to reinforced earth structures and corrugated steel culverts. TRL 447 available from the Transport Research Laboratory (www.trl.co.uk).provides further background to these requirements should a particular aggregate source require close consideration in this regard. See also Clause NG 808.

Cement Bound Mixtures for Subbase and Base

NG 810 General Requirements for Cement Bound Mixtures

General

1 Cement bound mixtures, form a sub-series of Series 800 of the specification. The term 'hydraulically bound mixtures' is used to conform to IS EN 14227, Hydraulically bound mixtures, Specifications. While IS EN 14227 covers a range of potential binders, Series 800 only includes mixtures bound with cement. The Parts of IS EN 14227 provide specifications for mixture composition and laboratory mechanical performance but do not cover production and construction methods. Series 800 Clauses provide options from which mixtures may be selected to suit design requirements and provide specifications for the construction of the pavement layers. The variety of terms introduced within the HBM family has prompted the inclusion of a glossary in Clause 810.

2 Throughout IS EN 14227 there are options, from which the designer and compiler may choose. Where the designer wishes to use materials covered by IS EN 14227 but not included in Series 800, the use of such materials should be referred to the Employer for approval under the Departure from Standards procedure.

3 IS EN 14227 is published in Parts to allow the specification of mixtures with different types of hydraulic binder. Separate part numbers are used for mixtures made with granular aggregates and for mixtures made with soil. Hydraulically bound mixtures (HBM) are grouped within Series 800 by reference to their aggregate type as indicated in Table NG 8/1. The mixtures are then defined by their strength. Test methods for HBM are published in the Parts of IS EN 13286.

[8] *Amended as per Erratum No. 1, item 8*

Table NG 8/1: Cement Bound Mixtures - Classification

HBM designation	General description	Principal binder or binder constituent	SHW Clause number	IS EN 14227: - Specification part reference
CBGM A	Mixtures with broad grading envelope	Cement	821	-1: Cement bound granular mixtures
CBGM B	Graded aggregate mixture		822	
CBGM C	0/20 mm, 0/14 mm or 0/10 mm well graded mixture with compacity requirement		823	
SC	Soil		824	-10: Soil treated by cement

HBM Grading Characteristics

4 Cement bound granular mixture (CBGM) is relatively fast setting, in comparison with most other types of HBM. It also generally contains less binder for a specified strength. Because of this, the mass of the binder has less influence on the total grading than it does for other types of HBM. This means the grading of CBGM is generally defined for the aggregate alone. However, where CBGM is required to take early trafficking, or where special considerations of shrinkage or density apply, it may be specified using the mixture grading, including the binder. This can be done by specifying CBGM C using Clause 823 or by specifying the alternative mixture grading for CBGM B in Clause 822.

Strength Classification

5 Two methods of strength classification are included in Series 800 for all granular and soil mixtures. Classification by compressive strength using unconfined cylindrical or cubic specimens and measured in accordance with IS EN 13286-41 is the more commonly applied. However, classification by tensile strength in combination with elastic modulus (R_t,E) provides a modelling regime closer to the performance of bound pavement layers.

6 The R_t,E classification requires that materials be placed into tensile strength/elastic stiffness category envelopes. Tensile strength can be measured on cylindrical specimens either by direct tensile testing in accordance with IS EN 13286-40 or indirect (cylinder-splitting) testing in accordance with IS EN 13286-42. Elastic modulus (*E*) is measured in accordance with IS EN 13286-43, either in direct compression or tension or in indirect tension tests. Measurement of tensile strength in indirect tension and *E* in direct compression is considered to be adequate for the purposes of classification and compliance testing.

7 The mechanical performance class will be determined by the design requirements. Further guidance is given in NRA HD 25-26 (DMRB 7.2.2).

8 Appendix 7/1 should show the allowable alternatives of strength and the associated layer thickness. The designation should be the mix specification name followed by the appropriate strength class in IS EN 14227. For example, for a CBGM A mixture with C5/6 class the designation should be ‘CBGM A C5/6’. For a mixture defined using the R_tE system, an equivalent designation may be ‘CBGM A T2’.

9 IS EN 14227-1 defines strength using a characteristic strength based on the average values for three test specimens. However, for the purposes of the Series 800 Clauses the strength of CBGM mixtures is defined using the mean value of any consecutive five results.

10 Wherever possible, curing times longer than 28 days should be used in order to establish a robust relationship between early age strength and the strength at 360 days. For site control purposes, HBM may be assessed at ages earlier than 28 days where the Contractor so requests, provided that a robust correlation is established between strength test results at the required age and results at 28 days using representative samples of the aggregates and binder used in the Works.

11 When assessing the acceptability of the aggregate grading for fast setting mixtures such as CBGM, allowance should be made for the grading of the added binder. This is usually 100% by mass passing the 0.063 mm test sieve.

12 The Specification allows the use of mixtures with a compressive strength below 3 MPa. Because this value is considered to be the lowest strength at which frost heave resistance is always likely to be achieved within a reasonable time, other factors should be considered if a mixture is not expected to have a compressive of 3 MPa before the 1 November. The factors to be considered should include:

(i) whether a sufficient depth of overlying layers will give protection against temperatures less than 0ºC;

(ii) the position of the water table;

(iii) the nature of any seal to the surface of the HBM layer;

(iv) the indirect tensile strength of the mixture – this should be greater than 0.25 MPa at the time of the first frost.

NG 811 Binder Constituents

1 Care should be taken when mixing HBM when the proportion of binder or binder constituent is very low, as it may be difficult to obtain complete dispersion throughout the mixture.

2 HBM has been mixed successfully using volume batching and in-situ stabilisation with the total binder content at, or close to, the minimum values shown in Table 8/10. Success at such low cement contents depends on:

(i) grading and cleanliness of the soil to be stabilised;

(ii) close control of the binder addition rates;

(iii) efficiency of the binder dispenser or spreader;

(iv) mixing efficiency.

3 The minimum binder requirements of Table 8/10 for cement based HBM, may be reduced if recent and well-documented evidence shows that consistent mixing can be achieved with the same plant and operators using similar soils or aggregates. If evidence is not available, a trial should be carried out over a period of not less than 5 full working days, covering a total area of not less than 3000 m^2. The success of the trial should be judged on the cubes or cylinders made from samples taken at a minimum of 10 evenly spaced locations per day and tested for strength after not less than 7 days curing. A trial should normally be considered successful if the results showed consistent compliance with the specification, after adjusting the test results to reflect the age of test specimens using a laboratory correlation of strength against age. A successful trial may be incorporated into the permanent Works.

4 Any variation to the minimum binder content agreed by the Employer should be subject to reassessment if the source materials, method of working or the operatives change.

NG 813 General Requirements for Production and Layer Construction

1 Three methods of blending and mixing are recognised in Clause 813; in-plant mixing with batching by mass, in-plant mixing with batching by volume, and in-situ mixing for which batching can only be carried out by volume. Continuous mixing plants, where the mass of the aggregate and binder are constantly recorded using load cells or similar devices, are considered to be mass batching plants. Where a mixture is mixed insitu and then excavated and transported to the point of laying, the construction requirements for in-situ mixing should apply. This technique has advantages over normal insitu methods because it can improve the consistency of mixing, aid compliance with surface level tolerances and help to disperse potentially harmful minerals.

2 The values of construction period in Table 8/11 allow for the variation in the rate of hydration of different types of HBM binder with temperature. Until further research indicates otherwise, no hydration is assumed at temperatures below 3ºC. Although this is an established figure for cement it may be that other hydraulic binders have higher threshold temperatures and/or may have strength temperature development curves that cannot be approximated by a linear relationship. Where problems related to this factor are of concern (e.g. for a binder without local or independently documented performance data) laboratory trials should be carried out.

3 For the mix-in-plant method of construction, the mixture can be placed using a grader, a dozer or a paver. If pavement foundation layers are constructed in 2 lifts, the depth of the lower lift should be compatible with the strength of the subgrade. A thicker first lift is needed over a weak subgrade, to enable effective compaction of the first lift without damage to itself or the subgrade beneath it. The thicker first lift will also minimise movement during the construction of the second lift, particularly if the first is still workable. This helps to ensure proper compaction. It will also prevent degradation of the lower lift when the construction of the second lift takes place after the lower one has set.

4 Care should be taken during spreading to control the depth of uncompacted mixture so that trimming can be undertaken quickly and effectively within the construction period. The trimming of over-thick layers can also result in segregation.

5 Clause 813.4 requires base layer mixtures to be laid using a paver, to assure consistent compaction and compliance with surface level tolerance. The Employer may permit the use of other laying methods, if the Contractor can confirm satisfactory performance using a method statement, as required by Clause 817, and demonstrated within a demonstration area.

6 The Contractor is responsible for protecting the works from weather damage. To protect HBM from drying or wetting during transport, it is normally necessary to sheet delivery vehicles. Some slow setting HBM is suitable for stockpiling and for hauling over a long distance. Care is needed to avoid surface or local drying and segregation when a mixture is stockpiled or double handled in any way. If a visual inspection or test confirms that the water content is variable, the load or stockpile should be rejected or reprocessed through a mixing plant, adding water if necessary.

7 Segregation can be seen as zones of coarse aggregate without enough fine aggregate to fill the gaps between the larger particles. It should be avoided because it leads to an increase in the proportion of air voids. Large air voids can fill with water, giving rise to a large reduction in strength of the mixture and destruction of local inter-layer bond. Coarse and rounded aggregates and non-cohesive mixtures are prone to segregation. When a mixture is found to be prone to segregation, consideration should be given to reducing the specified aggregate size. Clause 823 for CBGM C mixtures also has a requirement for compacity. Compliance with the compacity requirement requires close control of the volume of air and free water in the mixture. This usually results in a mixture that is less prone to segregation.

8 Segregation can occur with the mix-in-plant methods if an all-in aggregate is used, because segregation often occurs in the aggregate stockpile prior to mixing. Segregation at the mixing stage can be minimised by using a number of aggregate fractions, each with a separate aggregate feed hopper.

9 To assure layer integrity, the surface must be free of surface shearing and aggregate degradation. Fine graded and uniformly graded mixtures are often prone to surface shearing, when a thin plate of compacted mixture becomes detached from the top surface. Surface shearing can be mitigated by using a combination of vibratory compaction followed by a pneumatic tyred roller (PTR). Aggregate degradation by the crushing of weaker particles in some aggregates such as sandstone, limestone, chalk or recycled aggregate can also be reduced by the use of pneumatic tyred rollers.

10 The water content in the top part of the layer can be adversely affected by high temperatures and/or low humidity, particularly when associated with a high wind speed. This makes compaction difficult and can prevent setting and hardening in the top part of the layer. In order to maintain the water content, it may be necessary to spray water on the surface during compaction and start the curing stage immediately on completion of compaction.

11 A good bond between the lifts of a multi-lift layer is an important factor in achieving the expected pavement stiffness and durability. Because of this, Clause 817 requires the Contractor's method statement to include multi-lift working when necessary, and the methods of assuring and checking that a good bond has been achieved. Bond can usually be encouraged by making sure that the lower lift is not allowed to dry out before the upper lift is placed. It may also be necessary to scarify the surface of the lower lift.

12 The rate of hydration of HBM binders slows down at low temperatures and hydration can stop if the mixture temperature falls to close to 0°C. If freezing occurs in a mixture which has yet to attain full strength it may disrupt the bond between the binder and the aggregate. The formation of ice lenses can also displace aggregate from some HBM mixtures. The HBM mixture chosen by the Contractor should develop sufficient tensile strength to resist internal freezing, if it is likely to be subject to temperatures close to 0°C. Strength develops relatively quickly in a HBM mixture with a cement content of at least 3%, so it is unlikely to be affected by low temperatures. When a HBM mixture has a cement content of less than 3%, there is a danger of hardening taking place so slowly that the integrity of the mixture is put at risk by low temperatures. Construction using HBM mixtures with a cement content of less than 3% is usually not allowed in the winter, particularly if the layer is to be left exposed. However, where rapid construction of the overlaying layers is proposed, the overlaying layers can provide adequate insulation to enable the winter working restrictions to be relaxed. The Contractor should use a risk assessment approach to evaluate and define appropriate weather and construction time criteria for the HBM layers by considering:

(i) the depth of cover provided by the overlying layers;

(ii) the type and durability of the aggregates used in the mixture;

(iii) the likely strength gain of the mixture prior to overlay;

(iv) the site location;

(v) the likely construction date.

13 Rain can degrade HBM mixtures, particularly if the mixture has a high proportion of fine aggregate or if the mixture is to be trafficked soon after laying. Because of this, Clause 817 requires the Contractor's method statement to clearly define the action to be taken to mitigate any adverse effects caused by rain. If the rain is light, it may be possible to continue laying by adjusting the amount of water added during production of the mixture.

15 Early trafficking of the pavement may be permitted, if the traffic is well controlled. It should be noted that:

(i) well-graded mixtures made with crushed hard aggregate should be suitable for immediate trafficking without demonstration;

(ii) subject to performance when compacted using a PTR, well-graded mixtures made with 100% crushed weak aggregate should be suitable for immediate trafficking;

(iii) subject to performance when compacted using a PTR and provided the IBI is greater than 50, well graded mixtures with not less than 50% crushed hard aggregate should be suitable for immediate trafficking;

(iv) subject to performance when compacted using a PTR and provided the IBI is greater than 40, mixtures with a high proportion of fine aggregate should be suitable for immediate trafficking.

NG 814 Mix-in-Plant Method of Construction Using Batching by Mass

1 Forced action mixers should be used so that relatively small proportions of binder or activator are distributed and thoroughly mixed with the aggregates or soils. This forced action is normally produced by one of the following methods:

(a) a batch mix system using a vertical axis rotating pan mixer with fixed location vertical blades to force the flow to the centre of the pan and prevent the agglomeration of fine material at the pan wall;

(b) a continuous mix system where horizontal pairs of counter rotating helical blades blend and then mix the constituents as they are fed into the mixer.

2 The free flow of constituents into the mixer is essential for the production of a mixture with consistent characteristics. With fine graded, silty or clayey constituents, it is usually necessary to use hoppers with a number of design features that assist free flow, such as vibrators and friction reducing internal coatings.

3 Further advice about the mix-in-plant construction method can be found in CCIP-009 available from the Concrete Centre (www.concretebookshop.com) and in TRL611 available from the Transport Research Laboratory (www.trl.co.uk).

NG 815 Mix-in-Plant Method of Construction Using Volume Batching

1 Batching by volume assumes that the mixture constituents are fed into the mixer at a constant rate that is varied in a predictable way by changing the settings of the control system. This means that any variation in the density and flow characteristics of a mixture component will affect the consistency of the HBM mixture. Because of this potential variability, Clause 813 does not permit volume batching for mixtures used in base layers.

2 The guidance given in NG 814 also applies to volume batching.

NG 816 Mix-in-Place Method of Construction

1 Mix in place methods can produce high quality mixtures when the process is carefully controlled. It is essential that the pulveriser-mixer used has sufficient power to fully pulverise cohesive and bound agglomerations at a water content high enough to comply with the Moisture Condition Values (MCV) specified in Table 8/14. It is also essential that water is introduced into the mixture in a controlled way so that a consistent mixture is produced. The required degree of pulverisation and MCV limits must be rigorously maintained if full integration and activation of binder(s) is to be effective. Thorough dispersion of sufficient mixing water is necessary to ensure rapid slaking of quick lime, if used. This is needed to promote satisfactory reactions between the lime and clay, and helps to prevent long-term volume stability problems. The introduction of mixing water from a spray bar under the mixing hood is currently the only effective method of adding water in a reliable enough way for pavement construction.

2 Binders and activators are usually laid in front of the pulveriser-mixer by a separate metered spreader but can be distributed directly by some types of pulveriser-mixer. The second method can be particularly helpful on sites when fine powdered materials could cause a dust nuisance.

3 Uniformity of binder distribution and depth of pulverisation and mixing are important factors in achieving the expected pavement stiffness and durability. Because of this, sub-Clause 825.4 requires the excavation of trial pits to check the depth of mixing. It is essential that the binder be distributed to the full depth of pulverisation to avoid the formation of a residual layer of loosed unbound soil.

4 Further advice about the mix-in-place construction method can be found in CCIP-009, available from the Concrete Centre (www.concretebookshop.com) and in TRL Report TRL611, available from the Transport Research Laboratory (www.trl.co.uk).

NG 817 Method Statement

1 The method statement prepared by the Contractor should describe the proposed method of working for the main works. It should contain a description of all stages of construction, including:

(i) facilities for storing of constituents;

(ii) plant to be used for mixing, transport and laying;

(iii) estimated time durations and intervals between the main stages of the work;

(iv) site preparation details prior to laying the HBM layer;

(v) lime flocculation stage, control and timing;

(vi) mixing method, time of residence in mixer, output, etc;

(vii) transport, journey time, protection during transport etc;

(viii) compaction and levelling;

(ix) curing and protection;

(x) action to be taken during inclement weather

(xi) production control checks including:

(a) site preparation;

(b) powder spreading;

(c) mixing and pulverization;

(d) water addition;

(e) batching and mixing records;

(f) controlling MCV;

(g) depth of mixing;

(h) compaction;

(i) in-situ density measurement;

(j) level control for bottom and top of layer;

(k) procedures to assure and check the integrity of any multiple lift layers.

NG 818 Induced Cracking of HBM

1 The need for inducing transverse and longitudinal cracks in HBM is determined by the design requirements. Minimum requirements are defined in Clause 818. Further guidance is given in NRA HD 25-26 (DMRB 7.2.2).

NG 820 Aggregates

1 Table 8/13 gives requirements for aggregates using the Categories from IS EN 13242. See also Clause NG 808.

2 For some HBM mixtures, a Category for the proportion of crushed or broken particles in coarse aggregate is specified. This is because crushed rock aggregate will support construction and in-service traffic better than rounded aggregate with the same grading curve.

3 The Los Angeles coefficient of coarse aggregate is a measure of its resistance to fragmentation and an indicator of mechanical strength. A lower value indicates greater resistance. The selection of Category LA_{50} is appropriate for HBM layers subject to heavy traffic, particularly if the layer is used by site traffic before an overlying pavement layer is constructed.

4 Requirements for Categories that specify acid-soluble sulfate content and total sulfur content are introduced to the current edition, pending the results of continuing research into correlation of sulfate and sulfur swelling induced damage to the loss of strength after immersion tests. Feedback on the performance of sulfate bearing aggregates in the immersion tests and, where appropriate, in the works would be welcomed by the National Roads Authority, even when the acid-soluble sulfate and total sulfur contents are below the critical values.

The upper limits stated in Table 8/13 for impurities have been set to encourage the use of processed recycled aggregates and aggregates from secondary sources. A separate requirement is given for the maximum proportion of glass for similar reasons.

5 It is often difficult to determine the characteristics of the aggregate components of an existing bound pavement layer before it is recycled. If the site investigation indicates that there are no problems with durability or chemical characteristics, it is usual to assume that aggregates derived from an existing pavement will comply with the requirements of Clause 820 and Table 8/13. If necessary, additional testing of the processed recycled aggregate before it is used in a mixture can be specified in Appendix 7/1.

Further guidance about recycling existing pavement layers can be found in TRL Report TRL611, available from the Transport Research Laboratory (www.trl.co.uk).

NG 821 Cement Bound Granular Mixtures A (CBGM A)

1 The grading curve for the aggregates for CBGM A is specified using Envelope A from IS EN 14227-1, Figure 1. This grading envelope covers a wide range of readily available aggregates from 0/2 (*MP*) size fine aggregate to 0/31.5 size all-in aggregate.

NG 822 Cement Bound Granular Mixtures B (CBGM B)

1 The grading curve for the aggregates for CBGM B is specified using Envelope B from IS EN 14227-1, Figure 1. Envelope B covers a more restricted range of available aggregates when compared to those permitted for CBGM A. It has much lower limits for the proportion of particles passing the 2 mm size and 0.063 mm size test sieves.

2 As an alternative, a 20 mm size mixture may be specified using the mixture grading envelope from IS EN 14227-1, Figure B2 (Category G2). This grading envelope applies to the whole mixture, including the binder.

3 As explained in NG 820.2, resistance to traffic can be improved by ensuring a high proportion of crushed or broken particles by specifying Category $C_{90/3}$ in Appendix 7/1.

NG 823 Cement Bound Granular Mixtures C (CBGM C)

1 Clause 823 allows the option of specifying a CBGM that can be expected to have enhanced and more consistent structural and trafficking properties when compared to CBGM A and CBGM B.

2 The grading curve for the aggregates for CBGM C are specified using the mixture grading envelopes from IS EN 14227-1, Annex B2 (Category G1). The specified grading envelopes allow a choice of 0/20 mm size, 0/14 mm size and 0/10 mm size mixtures, each with a tightly controlled grading curve and a compacity requirement to control the proportion of air voids. The grading curve applies to the whole mixture, including the binder.

3 Compliance with the tightly controlled grading curve will usually require a mixing plant with a number of aggregate feed hoppers so that different aggregate sizes can be added to the mixer in a controlled way.

4 As explained in NG 820.2, resistance to traffic can be improved by ensuring a high proportion of crushed or broken particles by specifying Category $C_{90/3}$ in Appendix 7/1.

NG 824 Soil Treated by Cement (SC)

1 European experience and research carried out at in the UK by TRL in full-scale trials has shown that satisfactory foundation layers that are suitable for direct trafficking can be made using hydraulically bound mixtures with a compressive strength of about 1 MPa. It has also been shown that hydraulic binders can be used with types and sizes of aggregates and soil (including cohesive soil) that are not routinely used to produce subbase layers. More details can be found in HA 74 (DMRB 4.1.6).

2 Clause 824 gives requirements for soil treated by cement (SC). Use of this technique often gives environmental and economic benefits by minimising the need to transport aggregates. The need to dispose of surplus soil from excavations can also be minimised.

3 The requirements for cohesive soils in Table 8/14 assume a minimum of 15% by mass passing the 0.063 mm test sieve and a plasticity index (PI) greater than 10.

4 When cohesive soils are stabilised, a two stage process is required. The first step is flocculation with lime to give a more granular soil. This then allows efficient mixing with a second binder to develop the specified strength.

5 The limiting value for Total Potential Sulfate (TPS) has been chosen to control the risk of problems due to oxidation of reduced sulfur compound such as pyrite. If the TPS is in excess of the specified limit, reference should be made to the National Roads Authority. The soil should be tested to determine the form of the sulfur species present and the associated risk evaluated. More details can be found in TRL 447 (updated in 2005) and HA 74 (DMRB 4.1.6).

6 Many overconsolidated clays and some alluvial sands and gravels contain significant concentrations of sulfates and sulfides, which could affect the stabilization process. The occurrence of sulfate and sulfide minerals in various UK soil types is summarised in Appendix B of HA 74 (DMRB 4.1.6). This may be of guidance when considering similar materials in Ireland.

7 Where the TPS exceeds the limiting value, its effect can be modelled by volumetric expansion tests with samples of soil and the proposed proportions of the intended binder combinations prepared as mixed and cured specimens. As sulfur bearing minerals are not uniformly distributed in natural soil care needs to be taken that tested samples model the true level of the relevant minerals. Specimens should be analysed on completion of the tests to determine their individual TPS values to check that they correctly modelled the site conditions.

8 The volumetric expansion test is preferred to the CBR swell test. The presence of sulfate or potential sulfate may not mean that the soil is unable to be permanently stabilised, but it could mean that special measures need to be taken. These could include additional mixing, mellowing, temperature limitations, and consideration of alternative binder types (subject to departures from standards approval).

9 Current best practice for the stabilisation of sulfate and sulfide bearing soils can be found in Britpave document BP/16, 'Stabilisation of sulfate-bearing soils', obtained from www.britpave.org.uk

10 There are no limitations on the level of individual impurities in treated soils, because unacceptable levels of deleterious constituents will result in failure to pass the requirements of the immersion test. However, an excess of reactive glass will not be revealed by the immersion test and alkali aggregate susceptibility will need to be investigated. Where the receptor soil is 'made ground', secondary or recycled material, the aggregate requirements given in Table 8/13 for Clause 821 mixtures can be taken as a guide to the level of impurities likely not to be deleterious to the performance of treated soil.

NG 825 Testing, Control and Checking of HBM

1 HBM specified using IS EN 14227 are tested using the test methods in the relevant Parts of IS EN 13286. The scope of the test methods is restricted to mixture tests and tests on specimens made from mixtures. Tests for water content and plasticity are found in BS 1924-1, grading in IS EN 933-1, and in-situ density in BS 1924-2.

NG 826 Laboratory Mixture Design Procedure

1 A schedule of testing similar to that shown in Table NG 8/2 should be used for each combination of binder and water content.

2 The Contractor should provide evidence of strength development over a minimum of 28 days. This information should be used by the Contractor to declare the age of testing for site control purposes.

TABLE NG 8/2: Suggested Schedule of Testing for Laboratory Mechanical Performance of One Combination of Binder and Water Content

HBM Type	**Curing Temperature**	**Age of Sealed Specimens at Time of Test (3 Specimens for Each Test Age)**					
		7 days	**14 days**	**28 days**	**56 days**	**91 days**	**1 year**
With cement	20°C	✓	✓	✓	✓	✓	✓

NOTES:
1. Testing at ages beyond 28 days is optional.
2. For mixtures using binders containing cement, cylindrical or cube specimens compacted to refusal, cured at 20°C and tested at 28 days have been found to be equivalent to 80% of the 360-day strength at 20°C curing.

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