SERIES 800
ROAD PAVEMENTS - (11/04) UNBOUND, CEMENT AND OTHER HYDRAULICALLY BOUND MIXTURES

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ROAD PAVEMENTS - (11/04) UNBOUND, CEMENT AND OTHER HYDRAULICALLY BOUND MIXTURES

(11/04) Unbound Mixtures for Subbase

801 (11/04) General Requirements for Unbound Mixtures

1 (11/04) Unbound mixtures shall be made and constructed to conform to BS EN 13285, the requirement categories in Table 8/1 and Clauses 802 to 806. The permitted alternatives for each part of the Permanent Works shall be as described in Appendix 7/1.

Table 8/1: (11/04) Mixture and Grading Requirement Categories for Unbound Mixtures

Unbound mixture	Type 1	Type 2	Type 3 (open graded)	Category B (close graded)
Clause	803	804	805	806
Standard	BS EN 13285 Categories for unbound mixture properties			
Mixture requirement category				
- Designation	0/31,5	0/31,5	0/40	0/31,5
- Maximum fines	UF_9	UF_9	UF_5	UF_9
- Oversize	OC_{75}	OC_{75}	OC_{80}	OC_{80}
Grading requirement category				
- Overall grading	G_P	G_E	G_O	G_B

2 (11/04) Unbound mixtures shall not be deposited within 500 mm, or any other distances described in Appendix 7/1, of concrete, cement bound materials, other cementitious mixtures or stabilised capping forming part of the Permanent Works if, when tested in accordance with TRL Report 447 either:

(i) the water-soluble sulfate (WS) content exceeds 2.3 g of sulfate (as SO_4) per litre (Test No.1); or

(ii) the oxidisable sulfides (OS) content exceeds 0.46% of sulfate (as SO_4) (Test No.2 and Test No. 4); or

(iii) the total potential sulfate (TPS) content exceeds 0.6% of sulfate (as SO_4) (Test No. 4).

3 (11/04) Unbound mixtures shall not be deposited within 500 mm, or any other distances described in Appendix 7/1, of metallic items forming part of the Permanent Works if, when tested in accordance with TRL Report 447 either:

(i) the water-soluble sulfate (WS) content exceeds 0.3 g of sulfate (as SO_4) per litre (Test No.1); or

(ii) the oxidisable sulfides (OS) content exceeds 0.06% of sulfate (as SO_4) (Test No.2 and Test No. 4).

4 The properties of aggregates used in unbound mixtures shall comply with the selected requirements of BS EN 13242 listed in Table 8/2.

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Table 8/2: (11/04) **Requirements for Aggregates Used in Unbound Mixtures**

Unbound mixture	**Type 1**	**Type 2**	**Type 3** (open graded)	**Category B** (close graded)
Clause	803	804	805	806
Standard	BS EN 13242 Categories for aggregate properties			
Crushed, or broken and totally rounded particles				
- crushed rock, crushed artificial and crushed recycled aggregates - see NOTE 1	$C_{90/3}$	$C_{90/3}$	$C_{90/3}$	
- crushed gravel	$C_{50/10}$ - see NOTE 2	C_{NR} (no requirement)	Not permitted	
Resistance to fragmentation - Los Angeles test	LA_{50} - see NOTE 4	LA_{50} - see NOTE 4	LA_{40} - see NOTE 3	
Resistance to wear - micro-Deval test	M_{DE}NR (no requirement). The supplier shall state the value for the aggregate used.			
Resistance to freezing and thawing - magnesium sulfate soundness	MS_{35}			
Water absorption	WA_{24}NR (no requirement). The supplier shall state the value for the aggregate used.			
Volume stability of blast furnace slags	Free from dicalcium silicate and iron disintegration.			
Volume stability of steel (BOF and EAF) slags	V_5		Not permitted	
All other BS EN 13242 aggregate requirements	Category $_{NR}$ (no requirement).			

NOTES:
1. BS EN 13242 assumes that crushed rock aggregates comply with category $C_{90/3}$ without further testing.
2. Where permitted by Appendix 7/1.
3. See sub-Clauses 805.3 and 806.3 for additional requirements.
4. Aggregate with Los Angeles Values greater than 50, but less than 60 may be used where evidence can be presented to the Overseeing Organisation of source compliance with the previous Type 1 requirement of 50 kN Ten Per Cent Fines Value and a history of satisfactory use.

5 (11/04) Where recycled coarse aggregate or recycled concrete aggregate is used in unbound mixtures in accordance with Clauses 802 to 806 as appropriate, it shall have been tested in accordance with Clause 710. The other materials content of recycled coarse aggregate and recycled concrete aggregate shall be determined in accordance with Clause 710 and shall comply with the requirements in Table 8/3.

TABLE 8/3: Maximum Other Materials Content of Recycled Aggregates

Other Materials	**Maximum Permitted Content** (% by mass)
Asphalt arisings - where permitted by Appendix 7/1	100
Asphalt – other mixtures	50
Foreign materials including wood, plastic and metal	1

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6 (11/04) When required by Appendix 7/1 and Clauses 803 and 804 as appropriate, the unbound mixture shall satisfy the minimum CBR requirement of Appendix 7/1 when tested in accordance with clause 7 of BS 1377-4, with surcharge discs. The specimens shall be tested in a soaked condition. The mixture shall be tested at the density and moisture content likely to develop in equilibrium field conditions which shall be taken as being the density relating to the uniform air voids content of 5% and the value of optimum water content declared when tested as required by BS EN 13285.

Frost Heave

7 Subject to the tolerances given in Table 7/1 and unless otherwise stated in Appendix 7/1, material shall not be frost susceptible if it is used within 450 mm of the designed final surface of a road or paved central reserve, or 350 mm if the Mean Annual Frost Index (MAFI) of the site is less than 50.

8 (11/04) Material shall be classified as non-frost-susceptible if the mean heave is 15 mm or less, when tested in accordance with BS 812-124 : 1989, amended as follows:

3 Principle. Line 3. After '(SRU)' add 'and compared with reference specimens'.

5 Delete the NOTE and insert a new NOTE:

NOTE: The tolerances on the dimensions given in Figures 1 and 2, subject to the compatibility of parts, shall be:

Dimensions in excess of 100 mm	± 10 mm
Dimensions in excess of 25 mm	± 5 mm
Other dimensions	±1 mm

The dimensions of the support frame and push rods are nominal, and can be altered to suit the equipment.

5 Add additional items:

5.3.4.10 Filter paper - (Whatman No. 40 is suitable)

5.16 (11/04) Standard sand for reference specimens shall be clean silica sand from the Leighton Buzzard district and shall comply with the grading requirements of fraction C of BS 1881-131. The sand shall not have been used previously for any other test.

5.17 Standard filler for reference specimens shall be a limestone filler from the designated source (see NOTE).

(11/04) NOTE: The standard filler shall be obtained from Jacobs Babtie Engineering Laboratories, St Michaels Close, Aylesford, Kent ME20 7BU (Tel: 01622 605872).

6.1 Add "use a spirit level in the base of the specimen cradle when properly seated, to level the apparatus".

6.6 Add a Note after (j):

NOTE: The functioning of the CLD may be tested at the stage when the correct levels have been achieved, with the reservoir connected, but before specimens are put in place. This may be done as follows:

(i) Using a 100 ml bulb pipette and suction bulb, withdraw water from the cabinet until a bubble separates from the constant head capillary. Measure the volume withdrawn by discharging the pipette into a 100 ml measuring cylinder.

(ii) Allow the levels to come to equilibrium again (bubbling ceases) and repeat the measurement.

(iii) Typical results are 62 ml, 56 ml, 52 ml, Mean 57 ml. This demonstrates that a drop in water bath level of 0.23 mm is corrected by the CLD arrangement and represents an outside estimate of the differential over which the device works.

9 Add a new section 9.4:

9.4 **Preparation of Reference Test Specimens**

9.4.1 Take representative samples of the sand and filler. Oven-dry them separately to constant mass of 105°C - 110°C so that a mass of at least 7.5 kg of sand and 1.3 kg of filler is obtained. After drying, store the sand and filler separately in sealed containers and allow to cool to room temperature.

9.4.2 Weigh out to the nearest 1 g representative portions of 2338 g of sand and 412 g of filler and place both together in a suitable container (eg. a plastic bag). Shake the contents of the container in the dry state for half a minute to ensure that the sand and filler are thoroughly mixed.

9.4.3 Place the sand filler mixture into the mixer (see 5.6). Add 250 ml of distilled or demineralised water. Mix the sand, filler and water for five minutes. Store the mixed material in a sealed container for a minimum period of 16 hours before proceeding with the tests.

9.4.4 Weigh out to the nearest 1 g, 2562 g of the mixed material and prepare a frost-heave

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specimen as described in Clauses 9.3.1.2 - 9.3.3.1. Repeat to prepare two further reference specimens.

10.1.1 Add: "If fine grained material or soils are to be tested, place a filter paper on the porous disc".

Delete 10.1.2 and 10.1.3 and insert:

10.1.2 Locate thermocouples between the bottom of the porous disc and the copper carrier in each of the specimen positions 1, 3, 5, 7, 9 as in Figure 2. Ensure that the tip of the thermocouple is not in contact with the copper carrier and is 5 to 10 mm into the water bath when the carrier is loaded with specimens, and as central as possible in each specimen position. Also fix a thermocouple under the Tufnol disc in position 5, so that the junction is exposed at the centre of the disc and in contact with the upper surface of the test specimen.

10.1.3 Place the three reference specimens into positions 3, 5 and 7. Fill the other six positions with specimens which shall be a minimum of three for each material to be tested.

10.1.4 Delete the NOTE and insert a new NOTE:

NOTE: Support the dowels either by drilling holes of the correct diameter or by flexible tubing placed on the dowel ends which are then pushed onto preset studs on the floor of the cradle. Care should be taken to ensure that particles of sand do not get under the dowels thus raising the thermocouples.

11 Delete 11.2(a), (b) and (c) and 11.3
Insert revised 11.2(a) and (b) and 11.3:

11.2 (a) The mean heave of the three reference sand and filler specimens shall be in the range 13.6 ± 4.0 mm.

(b) The range (i.e. highest - lowest) of results of each of the three sets of specimens in the test run shall not exceed 6 mm.

11.3 If either of the conditions given in 11.2 (a) or 11.2 (b) is not satisfied the results of the whole test run shall be rejected. The operating procedure and equipment shall then be examined and adjusted as necessary to ensure that the requirements for the range and mean of the standard sand and filler specimens are satisfied.

11.4 Data obtained on the reference specimens shall be tabulated and plotted on forms and charts issued by the supplier of the filler. Completed forms shall be sent to the supplier of the filler once a year. (Ref. Clause 5.17 NOTE).

12.1 Line 1. After 'determined' add: "without reference specimens".

12 Add new Clauses 12.5 and 12.6.

12.5 (11/04) A further precision experiment included tests on Type 1 mixtures (crushed limestones) and on sand filler mixes. The reproducibility value (R_2) of the frost-heave of the crushed limestones was 11.3 mm. The use of reference sand filler mixes to exclude tests where the frost-heave of the sand filler mix deviated by more than 4.0 mm from the target value for the mix, reduced the value of R_2 to 7.1mm. This is the justification for the rule given in 11.2(a).

12.6 The target value of 13.6 mm for the standard sand and filler mix specified in Clause 9.4 was established by a trial carried out in 1990 involving 13 test cabinets.

13 Delete and insert revised Clause 13:

13 (11/04) **Test Report**

The test report shall affirm that the frost-heave was determined in accordance with BS 812-124 : 1989 as amended by Clause 801 of the SHW and whether or not a copy of a certificate of sampling is available. If available, a copy of the certificate of sampling shall be provided. The test report shall contain the following information:

For the standard sand and filler mixture

(a) The maximum heave observed in 96 hours of each individual specimen to the nearest 0.5 mm.

(b) The mean result reported under (a) above calculated to the nearest 0.1 mm.

For each of the other aggregates

(a) Sample identification

(b) The dry density at which the specimens were prepared.

(c) The moisture content used to prepare the specimens.

(d) The particle size distribution of the test portion (8.1).

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(e) The particle-size distribution of the stable test specimen (8.2.2.7).

(f) The maximum heave observed in 96 hours of each individual specimen to the nearest 0.5 mm.

(g) The mean results reported under (f) above calculated to the nearest 0.1 mm.

802 (11/04) Transport, Laying, Compaction and Trafficking of Unbound Mixtures

Transporting

1 (11/04) Unbound mixtures shall be protected from drying out and segregation both during transit to the point where it is to be laid and whilst awaiting tipping.

Laying

2 Unbound mixtures in a frozen condition shall not be incorporated in the Works but may be used, if acceptable, when thawed. Unbound mixtures shall not be laid on any surface which is frozen or covered with ice.

3 All unbound mixtures shall be placed and spread evenly. Spreading shall be undertaken either concurrently with placing or without delay. Unbound mixtures shall be spread using a paving machine or a suitable spreader box and operated with a mechanism which levels off the material to an even depth.

4 Except where otherwise stated in Appendix 7/1, material up to 225 mm compacted thickness shall be spread in one layer so that after compaction the total thickness is as specified. Material of compacted thickness greater than 225 mm shall be laid in two or more layers and the minimum compacted thickness of any such layer shall be 110 mm. Where the layers of unbound mixtures are of unequal thickness, the lowest layer shall be the thickest layer.

Compaction

5 Compaction shall be completed as soon as possible after the mixture has been spread and in accordance with the requirements for the individual mixtures.

6 Full compaction shall be obtained over the full area including in the vicinity of both longitudinal and transverse joints.

7 Compaction of unbound mixtures shall be carried out by a method specified in Table 8/4, unless the Contractor demonstrates at site trials that a state of compaction achieved by an alternative method is equivalent to or better than that using the specified method.

8 The surface of any layer of material shall on completion of compaction and immediately before overlaying, be well closed, free from movement under construction plant and from ridges, cracks, loose material, pot holes, ruts or other defects. All loose, segregated or otherwise defective areas shall be removed to the full thickness of the layer, and new material laid and compacted.

9 For the purposes of Table 8/4 the following shall apply:

(i) The number of passes is the number of times that each point on the surface of the layer being compacted shall be traversed by the item of compaction plant in its operating mode (or struck, in the case of power rammers).

(ii) The compaction plant in Table 8/4 is categorised in terms of static mass. The mass per metre width of roll is the total mass on the roll divided by the total roll width. Where a smooth-wheeled roller has more than one axle, the category of the machine shall be determined on the basis of the axle giving the highest value of mass per metre width.

(iii) For pneumatic-tyred rollers the mass per wheel is the total mass of the roller divided by the number of wheels. In assessing the number of passes of pneumatic-tyred rollers the effective width shall be the sum of the widths of the individual wheel tracks together with the sum of the spacings between the wheel tracks provided that each spacing does not exceed 230 mm. Where the spacings exceed 230 mm the effective width shall be the sum of the widths of the individual wheel tracks only.

(iv) Vibratory rollers are self-propelled or towed smooth-wheeled rollers having means of applying mechanical vibration to one or more rolls:

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(a) The requirements for vibratory rollers are based on the use of the lowest gear on a self-propelled machine with mechanical transmission and a speed of 1.5-2.5 km/h for a towed machine or a self-propelled machine with hydrostatic transmission. If higher gears or speeds are used an increased number of passes shall be provided in proportion to the increase in speed of travel.

(b) Where the mechanical vibration is applied to two rolls in tandem, the minimum number of passes shall be half the number given in Table 8/4 for the appropriate mass per metre width of one vibrating roll but if one roll differs in mass per metre width from the other, the number of passes shall be calculated as for the roll with the smaller value. Alternatively the minimum number of passes may be determined by treating the machine as having a single vibrating roll with a mass per metre width equal to that of the roll with the higher value.

(c) Vibratory rollers operating without vibration shall be classified as smooth-wheeled rollers.

(d) Vibratory rollers shall be operated with their vibratory mechanism operating at the frequency of vibration recommended by the manufacturer. All such rollers shall be equipped, or provided with devices indicating the frequency at which the mechanism is operating and the speed of travel. Both devices shall be capable of being read by an inspector alongside the machine.

(v) Vibrating-plate compactors are machines having a base-plate to which is attached a source of vibration consisting of one or two eccentrically-weighted shafts:

(a) The mass per square metre of base-plate of a vibrating-plate compactor is calculated by dividing the total mass of the machine in its working condition by its area in contact with compacted material.

(b) Vibrating-plate compactors shall be operated at the frequency of vibration recommended by the manufacturer. They shall normally be operated at travelling speeds of less than 1 km/h but if higher speeds are necessary, the number of passes shall be increased in proportion to the increase in speed of travel.

(vi) Vibro-tampers are machines in which an engine driven reciprocating mechanism acts on a spring system, through which oscillations are set up in a base-plate.

(vii) Power rammers are machines which are actuated by explosions in an internal combustion cylinder; each explosion being controlled manually by the operator. One pass of a power rammer shall be considered to have been made when the compacting shoe has made one strike on the area in question.

(viii) Combinations of different types of plant or different categories of the same plant will be permitted; in which case the number of passes for each shall be such proportion of the appropriate number in Table 8/4 as will together produce the same total compactive effort as any one operated singly, in accordance with Table 8/4.

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TABLE 8/4: (11/04) **Compaction Requirements for Unbound Mixtures**

Type of CompactionPlant	Category	Number of passes for layers not exceeding the following compacted thicknesses: 110 mm	150 mm	225 mm
Smooth-wheeled roller (or vibratory roller operating without vibration)	Mass per metre width of roll:			
	over 2700 kg up to 5400 kg	16	unsuitable	unsuitable
	over 5400 g	8	16	unsuitable
Pneumatic-tyred roller	Mass per wheel:			
	over 4000 kg up to 6000 kg	12	unsuitable	unsuitable
	over 6000 kg up to 8000 kg	12	unsuitable	unsuitable
	over 8000 kg up to 12000 kg	10	16	unsuitable
	over 12000 kg	8	12	unsuitable
Vibratory roller	Mass per metre width of vibrating roll:			
	over 700 kg up to 1300 kg	16	unsuitable	unsuitable
	over 1300 kg up to 1800 kg	6	16	unsuitable
	over 1800 kg up to 2300 kg	4	6	10
	over 2300 kg up to 2900 kg	3	5	9
	over 2900 kg up to 3600 kg	3	5	8
	over 3600 kg up to 4300 kg	2	4	7
	over 4300 kg up to 5000 kg	2	4	6
	over 5000 kg	2	3	5
Vibrating-plate compactor	Mass per square metre of base plate:			
	over 1400 kg/m² up to 1800 kg/m²	8	unsuitable	unsuitable
	over 1800 kg/m² up to 2100 kg/m²	5	8	unsuitable
	over 2100 kg/m²	3	6	10
Vibro-tamper	Mass:			
	over 50 kg up to 65 kg	4	8	unsuitable
	over 65 kg up to 75 kg	3	6	10
	over 75 kg	2	4	8
Power rammer	Mass:			
	100 kg-500 kg	5	8	unsuitable
	over 500 kg	5	8	12

Use of Surfaces by Construction Plant and Other Traffic

10 Construction plant and other traffic used on pavements under construction shall be suitable in relation to the material, condition and thickness of the courses it traverses so that damage is not caused to the subgrade or the pavement courses already constructed. The wheels or tracks of plant moving over the various pavement courses shall be kept free from deleterious materials.

11 (11/04) Where the Contractor proposes to use the unbound mixture layers for construction plant he shall improve these layers where necessary, to accommodate the method of construction and the type of plant and vehicles which he proposes to use, in order to avoid damage to the laid layer(s), any capping and the subgrade. Any permanent thickening shall be across the whole width of the pavement. Temporary thickening shall not impede drainage of any layer or the subgrade.

Trafficking Trial

12 When required by Appendix 7/1, the Contractor shall undertake a Trafficking Trial incorporating the unbound mixture proposed for use in the Permanent Works. A trial area shall be constructed, trafficked and assessed in accordance with the procedure described in sub-Clauses 13 to 18 of this Clause. The mean vertical deformation after 1000 equivalent standard axles shall be less than 30 mm when measured in accordance with the procedure stated in sub-Clause 17 of this Clause.

Proposals for trafficking trials shall be submitted to the Overseeing Organisation for review and acceptance five days in advance of construction.

Trial Procedure

13 The trial area shall be located on a formation prepared in accordance with the Specification. The trial area may be located so that it can be incorporated within the Permanent Works if the resistance to wheel track rutting is demonstrated to comply with sub-Clause 12 of this Clause.

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14 (11/04) The trial area shall be at least 60 m long, and of sufficient width that when trafficked, the wheel paths of the test vehicle shall be at least 1 m from either edge of the top of the unbound mixture layer. The unbound mixture layer shall be compacted to the thickness specified in Appendix 7/1. The formation shall extend for a further 1 m either side of the unbound mixture layer.

15 A sufficient run off/run on area shall be constructed at each end of the trial area of the same width, and compacted to the same level, as the trial area, to ensure correct tracking by the test vehicle and minimise dynamic effects of the vehicle bouncing on its springs. Suitable guidance shall be given to assist the driver in maintaining the same track in each pass and to achieve channelled trafficking. Examples of suitable guides would be a string or painted line.

Mixtures

16 (11/04) The unbound mixture used in the trial shall be transported, laid and compacted using the equipment proposed for use in the Works.

17 Maximum vertical deformation shall be measured in both wheel tracks using optical or laser levels at pre-determined monitoring points on five transverse lines spaced equally along the length of the trial bay. The transverse lines at the ends of the trial area shall be at least 5 m from the run off/run on areas. The average deformation of the two wheel tracks after 1000 standard axles shall be recorded.

Reporting and Acceptance of Trafficking Trial Area

18 The Contractor shall provide the Overseeing Organisation, for acceptance, with a report on the Trafficking Trial, stating how the use of the unbound mixture was validated. The main construction of the Permanent Works shall not start until the Trafficking Trial area has been accepted by the Overseeing Organisation within two working days of receiving the Trafficking Trial area report.

803 (11/04) Type 1 Unbound Mixtures

1 (11/04) Type 1 unbound mixture shall be made from crushed rock, crushed slag, crushed concrete, recycled aggregates or well burnt non-plastic shale and may contain up to 10% by mass of natural sand that passes the 4 mm test sieve. Where permitted by Appendix 7/1, crushed gravel complying with sub-Clause 803.7 may be used.

2 The mixture shall comply with BS EN 13285 and the requirements of Table 8/1. The grading requirements for the mixture are summarised in Table 8/5.

Table 8/5: (11/04) **Summary Grading Requirements for Type 1 Unbound Mixtures**

Sieve size, mm	Percentage by mass passing		
	Overall grading range	Supplier declared value grading range	Tolerance on the suppler declared value
63	100		
31.5	75 - 99		
16	43 - 81	54 - 72	± 15
8	23 - 66	33 - 52	± 15
4	12 - 53	21 - 38	± 15
2	6 - 42	14 - 27	± 13
1	3 - 32	9 - 20	± 10
0.063	0 - 9		
Grading of individual batches - differences in values passing selected sieves			
Retained sieve size, mm	Passing sieve size, mm	Percentage by mass passing	
		Not less than	Not more than
8	16	7	30
4	8	7	30

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3 The properties of aggregates used in the mixture shall be in accordance with BS EN 13242 and the requirements of Table 8/2.

4 (11/04) The size fraction of the unbound mixture passing the 0.425 mm size test sieve shall be non-plastic as defined by BS 1377-2 and tested in compliance therewith.

5 Where the mixture contains recycled coarse aggregate or recycled concrete aggregate, it shall comply with sub-Clause 801.5.

6 The mixture shall be transported, laid and compacted without drying out or segregation.

Additional Requirements for Mixtures Containing Crushed Gravel

7 For the purposes of this Clause, gravel is defined as aggregate derived from a natural, unconsolidated, coarse-grained sedimentary deposit consisting of water-worn rock fragments. Crushed gravel aggregate shall be derived from natural cobbles retained on the 63 mm test sieve and comply with the crushed, broken and totally rounded particles requirement in Table 8/2.

8 Where required by Appendix 7/1, mixtures containing crushed gravel coarse aggregate shall comply with the minimum CBR requirement in sub-Clause 801.6. Where required by Appendix 7/1, mixtures containing crushed gravel coarse aggregate shall be assessed using a trafficking trial complying with sub-Clause 802.12.

804 (11/04) Type 2 Unbound Mixtures

1 (11/04) Type 2 unbound mixture shall be made from natural sands, gravels, crushed rock, crushed slag, crushed concrete, recycled aggregates or well burnt non-plastic shale. Where permitted by Appendix 7/1, the mixture may contain more than 50% asphalt arisings.

2 The mixture shall comply with BS EN 13285 and the requirements of Table 8/1. The grading requirements for the mixture are summarised in Table 8/6.

Table 8/6: (11/04) **Summary Grading Requirements for Type 2 Unbound Mixtures**

Sieve size, mm	Percentage by mass passing		
	Overall grading range	**Supplier declared value grading range**	**Tolerance on the suppler declared value**
63	100	No requirement	No requirement
31.5	75 - 99		
16	50 - 90		
8	30 - 75		
4	15 - 60		
1	0 - 35		
0.063	0 - 9		
Grading of individual batches - differences in values passing selected sieves			
Retained sieve size, mm	Passing sieve size, mm	Percentage by mass passing	
		Not less than	Not more than
8	16	5	35
4	8	5	35

3 The properties of aggregates used in the mixture shall be in accordance with BS EN 13242 and the requirements of Table 8/2.

4 (11/04) The size fraction of the unbound mixture passing the 0.425 mm size test sieve when tested in compliance with BS 1377-2 shall have a plasticity index of less than 6.

5 Where the mixture contains recycled coarse aggregate or recycled concrete aggregate, it shall comply with sub-Clause 801.5.

6 Where required by Appendix 7/1, the mixture shall satisfy the minimum CBR requirement when tested in accordance with sub-Clause 801.6.

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7 The mixture shall be transported, laid and compacted without drying out or segregation, at a moisture content within the range 1% above to 2% below the declared value of optimum water content when tested as required by BS EN 13285.

Additional Requirements for Mixtures Containing More Than 50% Asphalt Arisings

8 Asphalt arisings shall be either asphalt road planings or granulated asphalt, but excluding materials containing tar or tar-bitumen binders. Asphalt planings are defined as materials derived from the asphalt layers of the pavement using a mobile machine fitted with milling cutters. Granulated asphalt is defined as asphalt bound material recycled from roads under reconstruction or surplus asphalt material destined for bound pavement layers, but unused, which has been granulated.

9 (11/04) Where the mixture has an asphalt arising content greater than 50%, the recovered bitumen content of the arisings shall be not more than 10% when tested in accordance with BS 598-102.

10 Where the mixture has an asphalt arising content greater than 50%, the moisture content shall be determined by oven drying at a reduced temperature setting of 45ºC to 50ºC.

11 Where required by Appendix 7/1, mixtures with an asphalt arising content greater than 50% shall be assessed using a trafficking trial complying with sub-Clause 802.12.

805 (11/04) Type 3 (open graded) Unbound Mixtures

1 (11/04) Type 3 (open graded) unbound mixture shall be made from crushed rock, crushed blast furnace slag or recycled concrete aggregate. Recycled concrete aggregate used in Type 3 (open graded) unbound mixtures shall not contain more than 5% asphalt, when determined in accordance with Clause 710.

2 The mixture shall comply with BS EN 13285 and the requirements of Table 8/1. The grading requirements for the mixture are summarised in Table 8/7.

Table 8/7: (11/04) **Summary Grading Requirements for Type 3** (open graded) **Unbound Mixtures**

Sieve size, mm	Percentage by mass passing		
	Overall grading range	**Supplier declared value grading range**	**Tolerance on the suppler declared value**
80	100		
40	80 - 99		
20	50 - 78	58 - 70	± 8
10	31 - 60	39 - 51	± 8
4	18 - 46	26 - 38	± 8
2	10 - 35	17 - 28	± 7
1	6 - 26	11 - 21	± 5
0.500	0 - 20	5 - 15	± 5
0.063	0 - 5		
Grading of individual batches - differences in values passing selected sieves			
Retained sieve size, mm	Passing sieve size, mm	Percentage by mass passing	
		Not less than	Not more than
10	20	10	25
4	10	10	25
2	4	7	20
1	2	4	15

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3 The properties of aggregates used in the mixture shall be in accordance with BS EN 13242 and the requirements of Table 8/2. Evidence of satisfactory performance in similar mixtures shall be provided when aggregates with a value of Los Angeles coefficient greater than 30 are used.

4 (11/04) The size fraction of the unbound mixture passing the 0.425 mm size test sieve shall be non-plastic as defined by BS 1377-2 and tested in compliance therewith.

5 The mixture shall be transported, laid and compacted without drying out or segregation.

806 (11/04) Category B (close graded) Unbound Mixtures

1 Category B (close graded) unbound mixture shall be made from crushed rock, crushed blast furnace slag or recycled concrete aggregate. Recycled concrete aggregate used in Category B (close graded) unbound mixtures shall not contain more than 5% asphalt, when determined in accordance with Clause 710.

2 The mixture shall comply with BS EN 13285 and the requirements of Table 8/1. The grading requirements for the mixture are summarised in Table 8/8.

Table 8/8: (11/04) **Summary Grading Requirements for Category B (close graded) Unbound Mixtures**

Sieve size, mm	Percentage by mass passing		
	Overall grading range	Supplier declared value grading range	Tolerance on the suppler declared value
63	100		
31.5	80 - 99		
16	55 - 85	63 - 77	± 8
8	35 - 68	43 - 60	± 8
4	22 - 60	30 - 52	± 8
2	16 - 47	23 - 40	± 7
1	9 - 40	14 - 35	± 5
0.500	5 - 35	10 - 30	± 5
0.063	0 - 9		

Grading of individual batches - differences in values passing selected sieves			
Retained sieve size, mm	Passing sieve size, mm	Percentage by mass passing	
		Not less than	Not more than
8	16	10	25
4	8	10	25
2	4	7	20
1	2	4	15

3 The properties of aggregates used in the mixture shall be in accordance with BS EN 13242 and the requirements of Table 8/2. Evidence of satisfactory performance in similar mixtures shall be provided when aggregates with a value of Los Angeles coefficient greater than 30 are used.

4 The size fraction of the unbound mixture passing the 0.425 mm size test sieve shall be non-plastic as defined by BS 1377-2 and tested in compliance therewith.

5 The mixture shall be transported, laid and compacted without drying out or segregation.

807 to 809 (11/04) Not Used

Cement and Other Hydraulically Bound Mixtures for Subbase and Base

810 (11/04) General Requirements for Cement and Other Hydraulically Bound Mixtures

1 Cement and other hydraulically bound mixtures (HBM) (hereafter called HBM) shall be produced, constructed and tested in accordance with the following Clauses. The permitted alternatives for each part of the Works shall be as described in Appendix 7/1.

2 Attributes not assigned a specific value shall be deemed to have a no requirement specification unless stated otherwise in Appendix 7/1.

3 The terms listed below shall apply to the Clauses that follow:

ASS	air cooled steel slag
BS EN	European standard published by BSI
CBGM	cement bound granular mixture
CBR	California bearing ratio
CFA	cement treated fly ash
E	modulus of elasticity
EN	European standard
FA	fly ash (PFA)
FABM	fly ash bound mixture
G_{vxx}	volumetric expansion category
GBS	granulated blast furnace slag
GGBS	ground granulated blast furnace slag
HBM	hydraulically bound mixture

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HRB	hydraulic road binder (factory blended hydraulic binder for road use)
HRBBM	'hydraulic road binder' bound mixture
IBI	immediate bearing index
Imm_{xx}	immersion category
IPI	immediate bearing category
LA	Los Angeles coefficient
LFA	lime treated fly ash
MCV	moisture condition value
N/A	not applicable
NR	no requirement
OWC	optimum water content
prEN	Draft European Standard
$Pulv_{xx}$	pulverisation category
R_c	characteristic compressive strength (Strength categories in the BS ENs are designated Cxx/yy, where C denotes compressive strength, i.e., value of strength below which 5% of the population of all possible strength determinations of the area of HBM under consideration, are expected to fall; xx indicates the strength value of cylinders with a slenderness ratio of 2 and yy indicates the strength value of cylinders with a slenderness ratio of 1 or cubes.)
R_t	characteristic direct tensile strength, i.e., value of strength below which 5% of the population of all possible strength determinations of the area of HBM under consideration, are expected to fall
$R_t E$	method of performance classification for thickness design purposes based on the combination of tensile strength and modulus of elasticity (categories in the BS ENs are designated T_{suffix}, where T designates $R_t E$ and the suffix indicates the performance category)
R_{it}	characteristic indirect tensile strength, i.e., value of strength below which 5% of the population of all possible strength determinations of the area of HBM under consideration, are expected to fall
SBM	slag bound mixture
SC	soil cement
SFA	soil treated by fly ash
SH	soil treated by hydraulic binder
SHRB	soil treated by hydraulic road binder
SL	soil treated by lime
SS	soil treated by slag
$Swell_{xx}$	linear swelling class
W_{xx}	water content category

4 HBM shall be selected by reference to Table 8/9 and shall satisfy the requirements of the relevant BS EN, the general and specific requirements of Clauses 810 to 818, 820 to 823, 830 to 832, 834, 840 and 880 and be tested in accordance with Clause 870.

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TABLE 8/9: Cement and Other Hydraulically Bound Mixtures

HB designation	General description	BS EN 14227: Hydraulically bound mixtures - Specifications part reference	Clause reference
CBGM A	Graded aggregate mixture including fine aggregate mixture	-1: Cement bound granular mixtures	821
CBGM B	Graded aggregate mixture	-1: Cement bound granular mixtures	822
CBGM C	Graded mixture	-1: Cement bound granular mixtures	823
SBM B1-2	0/31,5 mm graded mixture	-2: Slag bound mixtures	830
FABM 1	0/31,5 mm graded mixture	-3: Fly ash bound mixtures	
HRBBM 1	0/31,5 mm graded mixture	-5: Hydraulic road binder bound mixtures	
SBM B2	Graded mixture with compacity requirement	-2: Slag bound mixtures	831
FABM 2	Graded mixture with compacity requirement	-3: Fly ash bound mixtures	
HRBBM 2	Graded mixture with compacity requirement	-5: Hydraulic road binder bound mixtures	
SBM B3	0/6,3 mm mixture	-2: Slag bound mixtures	832
FABM 3	0/6,3 mm mixture	-3: Fly ash bound mixtures	
HRBBM 3	0/6,3 mm mixture	-5: Hydraulic road binder bound mixtures	
FABM 5	Treated fly ash	-3: Fly ash bound mixtures	834
SC	Treated soil	-10: Soil cement	840
SS	Treated soil	-12: Soil treated by slag	
SHRB	Treated soil	-13: Soil treated by hydraulic road binder	
SFA	Treated soil	-14: Soil treated by fly ash	

5 Prior to the commencement of the Works, the Contractor shall provide the Overseeing Organisation with the information detailed in the 'Designation and Description' clause of the relevant BS EN for the selected HBM and other requirements specified in Clauses 810 to 818, 820 to 823, 830 to 832, 834, 840, 870 and 880 including constituent proportions, mixture design results, method statement and other requirements of the relevant HBM Clause.

811 (11/04) Constituents of Cement and Other Hydraulically Bound Mixtures

1 Aggregates, binders, hydraulic combinations, and other constituents for HBM shall comply with the requirements of Clauses 810 to 818, 820 to 823, 830 to 832, 834, 840 and 880 and be tested in accordance with Clause 870. In this Specification, fly ash shall mean siliceous fly ash in accordance with BS EN 14227-4 and lime shall mean quick lime or hydrated lime in accordance with BS EN 14227-11. Calcareous fly ash in accordance with BS EN 14227-4 shall only be permitted with the agreement of the Overseeing Organisation.

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2 Unless otherwise agreed with the Overseeing Organisation, the proportions of HBM binder shall comply with Table 8/10. The proportions shall be increased by 1% for 'mix-in-plant' using volume batching and 2% for 'mix-in-place' production. Actual proportions shall be based on a laboratory mixture design procedure in accordance with Clause 880 and both the proportions and the mixture design results reported.

TABLE 8/10: Minimum Binder Percentages by Total Dry Mass of HBM Produced by Mix-in-Plant Production Using Batching by Mass

HBM designation	Minimum binder addition including activator where appropriate
CBGM A	As stated in BS EN 14227-1
CBGM B	As stated in BS EN 14227-1
CBGM C	As stated in BS EN 14227-1
SBM B1-2	13%* in the case of GBS or 6%* in the case of GGBS
FABM 1	7%** for dry FA or 10%** by dry mass for conditioned FA
HRBBM 1	3.5%
SBM B2	13%* in the case of GBS or 6%* in the case of GGBS
FABM 2	7%** for dry FA or 10%** for conditioned FA
HRBBM 2	3%
SBM B3	13%* in the case of GBS or 6%* in the case of GGBS
FABM 3	6%** for dry FA or 8%** for conditioned FA
HRBBM 3	4%
FABM 5	3% lime or 4% cement (Plant-mixed material)
SC	3%
SS	4%*
SHRB	4%
SFA	6%** for dry FA or 8%** for conditioned FA
* including a minimum of 1.5% by dry mass of the mixture for powder activators (e.g. lime or cement) and 2.5% by dry mass of the mixture for granular activators, where permitted, (e.g. ASS). Percentage of activator to be increased by 0.5% for 'mix-in-plant' using volume batching production and by 1% for 'mix-in-place' production. ** including a minimum of 2% lime by dry mass of the mixture as activator (2.5% for 'mix-in-plant' using volume batching, 3% for 'mix-in-place' production). Where cement is used instead of lime, these percentages shall be increased by 0.5%.	

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812 (11/04) Storage of Constituents for Cement and Other Hydraulically Bound Mixtures

1 Aggregates shall be stored on a firm and clean substrate avoiding contamination with other constituents. Aggregate stockpiles shall be managed in such a way as to minimise variation in water content.

2 Lime, cement, GGBS, dry FA and HRB shall be stored in silos.

3 Conditioned FA shall have no agglomerated particles greater than 10 mm and be stored as specified in sub-Clause 812.1.

4 GBS shall be stored as specified in sub-Clause 812.1 and used within 3 months of delivery to the point of production.

5 Storage and use of other constituents shall be as described in the method statement in accordance with Clause 817.

813 (11/04) General Requirements for Production of HBM and Construction of HBM Layers

1 HBM shall be produced and HBM layers constructed using one of the following methods:

(i) mix-in-plant using batching by mass in accordance with Clause 814;

(ii) mix-in-plant using volume batching in accordance with Clause 815; and

(iii) mix-in-place in accordance with Clause 816.

2 After the introduction of the binder, the compaction, including any reworking and reuse, shall be completed within the construction stated in Table 8/11. The construction period, in degree hours, shall be the summation of ambient air temperature in °C, above 3°C, recorded at 1-hour intervals.

TABLE 8/11: Construction Period for HBM

Binder	Construction period
Cement alone	35 degree hours from addition of cement
Cement with FA and or GGBS	70 degree hours from addition of cement
Lime activated GBS and/or FA	1200 degree hours from addition of GBS and or FA
Lime and gypsum activated FA	70 degree hours from addition of lime and gypsum
GBS + ASS activator	3000 degree hours from addition of GBS
GGBS + lime	400 degree hours from addition of GGBS
HRB and binders not listed above	Workability Period at 20°C determined in accordance with BS EN 13286-45 multiplied by 17.

3 The contractor shall provide a method statement and a demonstration area in accordance with Clause 817.

4 All plant-produced mixtures shall be paver laid. Laying by other methods shall only be permitted in confined spaces where it is impracticable for a paver to operate and/or as agreed by the Overseeing Organisation.

814 (11/04) Mix-in-Plant Method of Construction Using Batching by Mass for HBM

1 HBM shall be produced in a mixing plant that batches by mass and mixes in a forced-action mixer.

Facilities for Batching

2 The plant shall have sufficient hoppers appropriate for the constituents and their condition. For base mixtures in accordance with Clauses 822, 823, 830, 831 the aggregate shall be added as a minimum of two separate fractions unless the Contractor can demonstrate to the satisfaction of the Overseeing Organisation that consistent compliant gradings can be obtained using single fraction aggregate batching.

Compliance for Batching

3 All constituents shall be batched to within 97% to 103% of the proportion stated in accordance with sub-Clause 810.5.

Transport, Laying and Compaction

4 HBM shall be transported directly to the point where it is to be laid and protected from the weather both during transit and whilst awaiting tipping unless otherwise agreed by the Overseeing Organisation. Segregation shall be prevented during loading, transport and discharge.

5 Longitudinal construction joints shall not be more than 150 mm from the centre of traffic lanes, or at the lane line markings, with individual bay widths not exceeding 4.75 m. At tapers and other changes in section the construction joint layout shall be as detailed on the Drawings.

6 HBM shall be laid in thicknesses that enable the specified density and surface tolerance to be achieved with the equipment being used. Laying shall be carried out avoiding segregation and drying out. Minimum lift thickness shall be 150 mm.

7 Making-up of level after initial compaction shall not be permitted for one lift working or the uppermost lift of multiple lift working. For multiple lift working scarifying of compacted HBM surfaces is required between lifts.

8 Surface trimmed mixture and HBM arisings from ramps at the end of a day's work or elsewhere can be used in the layer provided it is within the construction period of the binder as stated in Table 8/11, is uncontaminated and has not dried excessively.

9 The face of previously compacted HBM or other material shall be vertical.

10 Compaction of HBM layers shall be completed without drying out and before setting of the mixture. The full depth of the layer shall be compacted to an average wet density of not less than 95% of the average wet density of the strength specimens made in accordance with Clause 870.

11 Compaction of HBM layers shall be carried out by vibrating roller (VR) and/or pneumatic-tyred roller (PTR). Where VR compaction is used on mixtures specified in Clauses 830, 831 and 832, it shall be followed by least 8 passes of a PTR with a wheel load of not less than 3 tonnes operating at a minimum tyre pressure of 4 bar.

12 On completion of compaction the surface shall be well-closed, free from ridges, cracks, loose material, pot-holes, ruts, shear planes and other defects. All defective areas shall be rectified within the construction period for the binder stated in Table 8/11. If rectification is not completed within the construction period, the defective area shall be removed to the full thickness of the layer, and new mixture laid and compacted.

13 FABM 5 shall only be compacted by PTR.

Cold and Wet Weather Working

14 During cold weather:

(i) the temperature of HBM shall not be less than 5ºC at the time of laying;

(ii) HBM shall not be laid on a surface with a temperature below 3ºC;

(iii) laying of HBM shall cease when the air temperature falls below 3ºC, and laying shall not be resumed until the rising air temperature reaches 3ºC; and

(iv) The laying of HBM using binders containing less than 3% cement by dry mass of mixture shall be restricted in use to the period 1st April to 31st October unless otherise agreed with the Overseeing Organisation.

15 In the case of heavy or persistent rain, production shall cease and laid material shall be compacted immediately.

Curing, Protection and Trafficking of HBM to Clauses 821, 822 and 823 and Other Mixtures Containing at Least 3% CEM 1 Cement by Dry Mass of Cement

16 At no time after compaction, and prior to the placing of the next lift or application of a curing membrane, shall the surface of the HBM be allowed to dry out.

17 HBM shall be cured for a minimum period of 7 days by one of the following methods:

(i) Application of a bituminous emulsion spray complying with BS 434-1 to achieve an even and continuous coverage applied at a minimum rate of 0.35 l/m^2. Before spraying commences, the surface shall be free of all loose material and standing water.

(ii) Application of an approved resin based aluminised curing compound to achieve an even and continuous coverage applied at a minimum rate of 0.27 l/m^2. The compound shall contain sufficient flake aluminium in finely divided dispersion to produce a complete coverage of the sprayed surface. The compound shall become stable and impervious to evaporation of water from the concrete surface with 60 minutes of application and have an efficiency index of 90% when tested as described in BS 7542. Prior to application, the contents of any containers shall be thoroughly agitated.

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18 HBM to Clauses 821, 822 and 823 shall not be trafficked for 7 days unless the layer is compacted by both VR and PTR in accordance with sub-Clause 814.11 to comply with the requirements of sub-Clause 814.12.

Curing, Protection and Trafficking of HBM to Clauses 830, 831, 832, 834 and 840

19 At no time after compaction and prior to the placing of the next lift or cure coat, shall the surface of the HBM be allowed to dry out. To avoid this, the Contractor shall apply a mist/fog/light spray of water to the surface as necessary.

20 Careful and controlled trafficking of the layer shall be in accordance with Table 8/12. Surface contamination of the layer shall be avoided and removed prior to overlaying. Reworking and re-compaction of the layer, watering if necessary, shall only be permitted within the construction period for the binder stated in Table 8/11.

TABLE 8/12: Trafficking of HBM to Clauses 830, 831, 832, 834 and 840

HBM Designation/Clause reference	Trafficking
830	Immediate provided the layer complies with sub-Clause 814.12 and is free from movement under the PTR compaction specified in sub-Clause 814.11
831	
832	
CFA to Clause 834	Not permitted for 7 days
LFA to Clause 834	Immediate within the Construction Period. Not permitted outside the Construction Period unless overlain with the next layer
840	Immediate provided the layer complies with sub-Clause 814.12 and is free from movement under the PTR compaction specified in sub-Clause 814.11

21 As an alternative to light spraying with water, and before drying out of the surface, the surface of the HBM shall be sprayed in accordance with sub-Clause 814.17(i). In this case, careful and controlled trafficking of the layer in accordance with Table 8/12 is permitted provided measures are taken to prevent the bituminous emulsion from being removed by vehicle tyres.

22 Trafficking shall be avoided in wet conditions.

23 Before overlaying, loose material shall be removed and replaced to the full depth of the layer or, if within the construction period of Table 8/11, reworked as described in sub-Clause 814.7.

815 (11/04) Mix-in-Plant Method of Construction Using Volume Batching for HBM

1 All aspects of the construction process shall be as for mix-in-plant using batching by mass except that:

(i) all mixture fractions shall be batched to within 90% to 110% of the stated design mixture value; and

(ii) aggregate may be added as a single fraction.

816 (11/04) Mix-in-Place Method of Construction for HBM

1 Added constituents shall be dispensed such that for each group of 5 readings the mean rate of spread of material shall be within 10% of the stated target rate and each individual value should be within 15% of the mean value verified by site checks carried out in accordance with Clause 870.

Dispensing accuracy shall also be verified by reconciliation between constituent deliveries and the area of completed layer for each 5000 m^2 of work, or part thereof, during each day's operations.

2 Mixing of fresh material shall ensure a minimum overlap of 200 mm with previously mixed material. Compaction, curing and protection shall be in accordance with Clause 814 except that lift thicknesses up to 350 mm may be undertaken subject to construction of a satisfactory demonstration area in accordance with sub-Clause 817.4 and compliance with this Specification.

3 Where lime is used to deflocculate cohesive soils it shall be added and mixed with the soil using at least two passes of the stabilizing machine 24 to 96 hours before the subsequent addition of FA, GGBS, cement or HRB. Immediately after the addition of the lime the surface of the layer shall be sealed by rolling. The MCV during this period shall be in accordance with Clause 840.

4 The depth of mixing shall be checked in accordance with Clause 870. The depth of mixing shall ensure that the level of the underside of the layers meets the requirements of Clause 616.1. Where in-situ stabilisation is used to form the base layer the depth of mixing shall ensure that the requirements for surface level of subbase given in Table 7/1 are met.

817 (11/04) Method Statement and Demonstration Area for All Methods of Construction of HBM

Method statement

1 At least 10 days prior to constructing the demonstration area described below, the Contractor shall provide a full method statement for approval, indicating his intended procedures including, where applicable:

(i) storage of constituents;

(ii) plant;

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

(iv) site preparation;

(v) lime deflocculation stage;

(vi) mixing;

(vii) transport;

(viii) compaction and levelling;

(ix) curing and protection;

(x) production control checks including, where applicable:

a. site preparation;

b. powder spreading;

c. mixing and pulverization;

d. water addition;

e. batching and mixing records;

f. MCV;

g. depth of mixing;

h. compaction;

i. in-situ density measurement;

j. level control;

k. finishing rolling.

2 The method statement shall include the intended mixture proportions, supporting data to justify the proportions, the water content (or MCV) limits and spread rates if applicable for all stages of the Work.

3 The method statement shall include a sample record sheet for completion for both the lime deflocculation stage (where applicable) and main construction stage detailing, construction times, sample and check locations, and check results. These sheets shall be completed at the end of each day's work and made available to the Overseeing Organisation by the start of the next working day.

4 Prior to the commencement of the main works, the Contractor shall undertake a satisfactory and complying demonstration area of at least 800 m^2 conforming to the submitted method statement. The demonstration area shall consist of at least 2 full-width bays so as to include a transverse end-of-bay joint. The demonstration area may be accepted into the permanent works with the agreement of the Overseeing Organisation. Where the Contractor can produce documentary evidence of similar work carried out satisfactorily during the previous 6 months, the Overseeing Organisation may allow the works to proceed without the demonstration area.

5 The mixtures and mixture proportions shall not be changed without the agreement of the Overseeing Organisation. The laying and compaction plant and construction procedures shall not be changed unless the Contractor lays a further trial area or agrees the changes with the Overseeing Organisation.

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818 (11/04) Induced Cracking of HBM

1 Where the HBM layer in the pavement construction comprises HBM with a strength class equal to or exceeding C 8/10, C 9/12 or T3 that layer shall have cracks induced during construction, as described below, at a maximum longitudinal spacing of 3 m ± 10%. Where any underlying pavement construction comprises cracked HBM the cracks in the overlying HBM shall align with cracks in the underlying construction.

2 Cracks shall be induced in fresh material. The transverse cracks shall be induced by grooving the fresh material to a depth which leaves a vertical groove not more than 20 mm wide, between one half and two thirds the layer thickness after compaction, over the full width of the pavement. A crack inducing material, as specified in Appendix 7/20, shall be inserted into the groove prior to final compaction, extending from the bottom of the groove to not less than half the height of the groove. During final compaction of the material, the groove shall be closed at the surface and the crack inducing material shall be fully encased and remain continuous within the closed groove.

819 (11/04) Coefficient of Linear Thermal Expansion

1 To determine if the coefficient of linear thermal expansion of CBGM B or CBGM C containing crushed rock or slag coarse aggregate is above or below 10×10^{-6} per °C it shall be measured by an appropriate organisation accredited in accordance with sub-Clauses 105.3 and 105.4 for the test.

The test procedure shall be based on the method outlined in Current Practice Sheet 3PC/06/01 "Thermal Movement of Concrete" by R D Brown, Concrete Journal; November 1972. It shall be carried out in a temperature controlled water bath on three test samples of nominal size 100 x 100 x 500 mm water cured for at least 28 days at 20°C. The change in length of the samples shall be measured as the temperature is raised in 20°C increments over the range 20°C to 60°C and the results plotted to demonstrate that a reasonably linear relationship has been achieved. The coefficient of linear thermal expansion of each sample shall be calculated from the linear change over the full temperature range and the mean value determined.

820 (11/04) Aggregates for HBM

1 Aggregates for HBM shall conform to BS EN 13242 and the specific requirements of Table 8/13.

2 Where a rock coarse aggregate is required in Appendix 7/1 the mixture shall have a coarse aggregate with a coefficient of linear thermal expansion below 10×10^{-6} per °C, when tested in accordance with Clause 819. All other coarse aggregates shall be classed as gravel.

821 (11/04) Cement Bound Granular Mixtures A

1 Cement bound granular mixtures A shall comply with BS EN 14227-1 using constituent proportions complying with the requirements of Clause 811.

2 Aggregate shall comply with the grading of envelope A of Figure 1 in BS EN 14227-1 and the selected requirements of BS EN 13242 listed in Table 8/13. At mixture design stage, specimens of the mixture shall satisfy the strength after immersion requirements of Clause 880.

3 The mixture shall have a water content not less than 95% of the OWC determined on the mixture using BS EN 13286-4 and shall be produced and constructed in accordance with Clause 814, 815 or 816 and comply with the general construction requirements of Clause 813.

4 The laboratory mechanical performance shall comply with the requirements of this Specification if either:

(i) the compressive strength shall not be less than the characteristic compressive strength R_c for the required mechanical performance class C_x given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength; or

(ii) the tensile strength shall not be less than the characteristic tensile strength R_t for the required mechanical performance class T_x given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength.

822 (11/04) Cement Bound Granular Mixtures B

1 Cement bound granular mixtures B shall comply with BS EN 14227-1, using constituent proportions complying with the requirements of Clause 811.

2 Aggregate shall comply with the grading of envelope B of Figure 1 in BS EN 14227-1 and the selected requirements of BS EN 13242 listed in Table 8/13. At mixture design stage, specimens of the mixture shall satisfy the strength after immersion requirements of Clause 880.

Table 8/13: Aggregate Requirements for HBM

	Requirement							
Clause reference	**821**	**822**	**823**	**830**	**831**	**832**	**834**	**840**
HBM designation / **Aggregate parameter**	CBGM A	CBGM B	CBGM C	SBM B1-2, FABM 1, HRBBM 1	SBM B2, FABM 2, HRBBM 2	SBM B3, FABM 3, HRBBM 3	FABM 5	SC, SS, SHRB, SFA
Crushed or broken particles or totally rounded particles	C_{NR}	C_{NR}	C_{NR}	$C_{90/3}$ or $C_{50/30}$ as specified in Appendix 7/1 (Note 1)	$C_{90/3}$ (Note 1)	C_{NR}	N/A	N/A
Fines quality	Note 2	The size fraction of the aggregate passing the 0.425 mm size test sieve shall be non-plastic as defined by BS 1377-2 and tested in compliance therewith.				Note 2	N/A	N/A
Category of Los Angeles Coefficient	LA_{50} or LA_{60} as specified in Appendix 7/1.					LA_{NR}	N/A	N/A
Glass content - (maximum % by mass)	40							N/A
Impurities Limit - wood (maximum % by mass)	2	1	1	1	1	2	2	N/A
Impurities limit (Maximum % by mass), unless otherwise agreed by the Overseeing Organisation	5	3	3	3	3	5	5	N/A

Note 1: C_{NR} if mixture contains at least 3% CEM 1 cement by dry mass of the mixture and trafficking is prevented for 7 days.
Note 2: No requirements if < 10% passing 0.063 mm sieve. If > 10%, the size fraction passing the 0.425 mm sieve when tested in compliance with BS 1377-2 shall have a plasticity index of not more than 6.

3 The mixture shall have a water content not less than 95% of the OWC determined on the mixture using BS EN 13286-4 and shall be produced and constructed in accordance with Clause 814 and comply with the general construction requirements of Clause 813.

4 The laboratory mechanical performance shall comply with the requirements of this Specification if either:

(i) the compressive strength shall not be less than the characteristic compressive strength R_c for the required mechanical performance class C_x given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength; or

(ii) the tensile strength shall not be less than the characteristic tensile strength R_t for the required mechanical performance class T_x given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength.

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823 (11/04) Cement Bound Granular Mixtures C

1 Cement bound granular mixtures C shall comply with BS EN 14227-1, using constituent proportions complying with the requirements of Clause 811.

2 The mixture shall comply with the grading of Figure B2 Category G1 of Annex B in BS EN 14227-1 and the selected requirements of BS EN 13242 listed in Table 8/13. At mixture design stage, specimens of the mixture shall satisfy the strength after immersion requirements of Clause 880.

3 The mixture shall have a water content not less than 95% of the OWC determined on the mixture using BS EN 13286-4 and shall be produced and constructed in accordance with Clause 814 and comply with the general construction requirements of Clause 813.

4 The laboratory mechanical performance shall comply with the requirements of this Specification if either:

(i) the compressive strength shall not be less than the characteristic compressive strength R_c for the required mechanical performance class C_x given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength; or

(ii) the tensile strength shall not be less than the characteristic tensile strength R_t for the required mechanical performance class T_x given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength.

824 (05/05) Cold Recycled Cement Bound Material

Scope

1 Recycled cement bound material shall be designed and produced to form the foundation or main structural layer of a road pavement. The primary aggregate source shall be obtained by cold pulverisation of all or part of the existing road structure. The stabilising agent shall be hydraulic cement with Portland cement CEM I as the main component. The aggregate grading may be adjusted by the addition of a filler. Lime may also be used to modify any cohesive subgrade soil incorporated in the pulverised layer.

2 Prior to commencing the pulverisation and stabilisation works, the Contractor shall demonstrate, to the satisfaction of the Overseeing Organisation, using the results of the concrete design procedures described in sub-Clauses 824.43-824.49 of this Clause, that the existing pavement materials in the sections of the works defined in Appendix 7/19, are capable of being recycled by pulverisation to form the primary aggregate component of a recycled cement bound material which can meet the specified end-product performance requirements.

Component Materials

Aggregates and Fillers

3 The pulverised road material when mixed with any supplementary aggregate and/or filler shall normally be granular material with not less than 5% and not more than 20% passing the 0.063 mm sieve (Zone A graded material in accordance with Table 8/14). Approval for use of pulverised granular material containing up to 35% passing the 0.063 mm sieve (Zone B graded material in accordance with Table 8/14) shall require confirmation by the Overseeing Organisation, subject to the results of the mixture design procedures described in sub-Clauses 43 to 49 of this Clause.

4 The pulverised granular material shall contain not more than 2% of organic matter as determined in accordance with BS 1377-3, clause 3.

Table 8/14: (05/05) **Particle Size Distribution of Granular Material for Recycling**

Sieve size (mm)	Percentage by mass passing	
	Zone A Graded Material	Zone B Graded Material
63	100	-
31.5	87 - 100	-
20	66 - 100	100
10	48 - 75	75 - 100
6.3 (or 4)	39 - 62 (31 - 52)	62 - 97 (52 - 90)
2.8 (or 2)	27 - 47 (23 - 40)	47 - 82 (40 - 73)
0.500	12 - 27	27 - 49
0.250	9 - 23	23 - 45
0.063	4 - 20	20 - 33

NOTE: Aggregate grading shall have a coefficient of uniformity [C^u] exceeding 10.

Cement, Filler and Lime

5 The constituents and required quality standards of hydraulic cement, filler and lime shall be certified by the supplier, whose manufacturing and delivery processes shall be implemented using quality management systems in accordance with the BS EN ISO 9001 series of standards and certified by an accredited body.

6 The primary binder shall be Portland cement CEM I or Portland slag cement or Blastfurnace cement or Portland fly ash cement in accordance with sub-Clause 1001.3.

7 PFA shall be in accordance with BS 3892-1.

8 Lime for lime stabilisation (or as a modifier for plastic fines) shall be either quicklime or hydrated lime, as stated in Appendix 7/19, complying with sub-Clause 615.33.

Water

9 Water for moisture content control of the pulverised granular material shall normally be obtained from a water company supply and used without testing. Water from an alternative source shall comply with BS EN 1008 and be approved by the Overseeing Organisation.

Pulverisation and Stabilisation

10 The Contractor shall satisfy the Overseeing Organisation that the plant used for pulverisation is capable of uniformly pulverising the existing road in a single pass, to a depth specified in Appendix 7/19. The plant used for stabilisation shall be capable of uniformly mixing controlled amounts of water and cementing agent(s) into the full depth of the pulverised layer. For either operation, the plant shall be equipped with a means of controlling the depth of processing to ±15 mm of the required depth.

11 The plant used for stabilisation shall be equipped with a spraybar system within the mixing chamber capable of uniformly distributing water at a monitored and controlled rate. Evidence confirming the capabilities of the plant and calibration of flow meters, shall be submitted to the Overseeing Organisation prior to the stabilisation works commencing.

12 The material shall be pulverised and stabilised in a single layer if the compacted thickness is 300 mm or less. If the compacted thickness is greater than 300 mm, the material shall be pulverised and stabilised in a minimum number of layers between 150 mm and 300 mm thick. Where more than one layer is required, the Contractor shall satisfy the Overseeing Organisation that the lower layer has achieved adequate stability in accordance with sub-Clause 27 of this Clause before proceeding with the overlying layer.

Pulverisation Process

13 Pulverisation of the existing road structure shall be carried out in a systematic pattern, to the required depth, to ensure that all parts of the existing road designated in Appendix 7/19 are included in the works. An overlap of at least 150mm shall be made between adjacent passes of the machine. Any material missed along hard edges or around obstructions shall be excavated and placed in the path of subsequent passes of the machine until a uniform fully pulverised aggregate is obtained. The pulverised material shall not be contaminated with material drawn in from the verge.

14 All longitudinal and transverse joints shall be clean cut and vertical. Where work continues adjacent to previously recycled material, transverse joints shall be reformed a minimum 0.5 m into the previously treated construction. Where a layer of material for stabilisation is placed over a layer previously stabilised, the depth of pulverisation/stabilisation of this layer shall be set to cut into the underlying stabilised layer by at least 20 mm.

15 Excess pulverised material shall be removed by the grader and/or excavator for use elsewhere on the site or transported to stockpile at locations given in Appendix 7/19. The surface of the layer shall be graded nominally to the required profile and provisionally compacted.

16 Moisture content of the pulverised aggregate immediately prior to stabilisation shall be measured in accordance with BS EN 1097-5. The moisture content shall be uniform throughout the layer within the range 0% to +4% of the optimum moisture content for the unstabilised aggregate, including any designed proportion of filler, determined in accordance with clause 2.1 of BS 1924-2 using vibratory compaction.

17 If the moisture content of the unstabilised pulverised aggregate fails to meet the specified moisture content range, corrective action shall be taken either by aeration to reduce the moisture content or by controlled addition of water to increase the moisture content.

18 Aeration of the affected area shall be achieved by full depth passes of the recycling machine to disturb and loosen the material and assist the evaporation of excess moisture. The material shall be kept in a loose condition until subsequent moisture content tests show that the treated material has reached the required moisture content range. The layer shall be re-graded nominally to the required profile and provisionally compacted in preparation for stabilisation.

19 An increase in the moisture content of the affected area shall be achieved by the controlled addition of water through an adjustable spraybar system in conjunction with full depth passes of the recycling machine to achieve a uniform distribution of the water throughout the layer. Water shall be added in increments and mixed in until subsequent moisture content tests show that the material has reached the required moisture content range. The layer shall be re-graded nominally to the required profile and provisionally compacted in preparation for stabilisation.

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Stabilisation Process

20 Stabilisation shall not be carried out during or after periods of rainfall where the duration and intensity are likely to cause the stabilised mixture to exceed the specified moisture content criteria and compromise the stability of the layer under compaction as described in sub-Clause 27 of this Clause. Stabilisation of frozen materials shall not be permitted.

21 Prior to stabilisation, pulverised materials within 100 mm of restricted hard edges such as kerbs and channels, or around obstructions such as gullies, shall be removed and spread uniformly over the remaining full width of the pulverised material.

22 Cement binder, filler, hydrated lime or quicklime shall be spread full-width on the surface of the layer using a mechanical spreader capable of distributing the material(s) in a uniform manner. The rate of spread of these materials shall be calculated to achieve mixture composition determined in accordance with sub-Clauses 43 to 49 of this Clause and monitored as the spreading operation proceeds in accordance with sub-Clause 31 of this Clause.

23 The stabilisation shall be carried out to the required depth in a systematic pattern similar to that used for the pulverisation process, with an overlap of at least 150mm between adjacent passes of the machine. Where necessary, additional water shall be introduced and distributed through the spraybar system, directly into the rotor and mixing box of the stabiliser.

24 The layer of stabilised material shall be graded to level and compacted within two hours of the final pass of the stabilising plant, unless a curing or "maturing" period of aeration is required. Any furrow formed by prior excavation of edge materials shall be re-filled by grading the adjacent stabilised material into the space using a minimum amount of re-working.

25 The compaction of each layer shall be carried out using compaction plant approved by the Overseeing Organisation, until such time as the density complies with the minimum compaction field requirements as specified in the Clause 816 and the stabilised layer provides a stable and dense surface. Any open or segregated surface area shall be re-mixed by machine during stabilisation.

26 Where specified in the Appendix 7/19 a system for inducing transverse cracks shall be installed into the fresh stabilised material in accordance with sub-Clauses 50 to 60 of this Clause. The installation shall be carried out after grading to level and application of initial compaction, then completed by final compaction.

27 The stability of the layer under compaction shall be deemed adequate if the finished surface does not move, rut or exhibit transverse cracking under the load of subsequent construction traffic.

28 Where required by the Overseeing Organisation, the stability of a layer in any area shall be assessed after a curing period of at least 24 hours by channelled trafficking using a rigid three-axle tipper truck loaded to a gross mass of 24 tonnes (assumed equivalent to three standard axles). The vertical deformation shall be measured in all wheeltracks at monitoring points on each of 5 transverse sections set 1 m apart after 5, 15, 30 and 40 passes of the truck. The mean vertical deformations at the above trafficking increments shall be plotted against the respective number of truck passes and the mean vertical deformation corresponding to 100 standard axles shall be interpolated. The layer shall be deemed acceptable if the mean vertical deformation corresponding to 100 standard axles is less than 10 mm.

29 On completion of compaction the surface shall be sealed using a sprayed membrane of Class K1 - 40 bitumen emulsion complying with Clause 920. The bitumen emulsion shall be sprayed at the rate stated in Appendix 7/19. Where the surface is opened to traffic, the sealing membrane shall be blinded with fine aggregate or sand applied at a rate of 5.5 to 7.0 kg/m^2.

Process Control

30 The sampling and testing of the recycled cement stabilised base shall be carried out as required for cement bound materials (CBM) in accordance with the relevant Clauses of Series 800.

31 The rate of spread of cement, filler, hydrated lime or quicklime shall be measured by weighing the amount of material retained on each of five trays or mats of known area laid in the path of the spreading machine. The trays shall be positioned approximately at points equally spaced along a diagonal bisecting the area of coverage. The mean rate of spread and percentage addition of the material shall be determined and recorded for each assessment area.

32 As directed by the Overseeing Organisation, where lime has been used to modify a cohesive soil component of the pulverised aggregate, the acceptability of the modified materials shall be tested in accordance with sub-Clause 615.13.

End Product Performance of Recycled Cement Bound Material

33 The end-product performance of the recycled cement bound material shall be assessed on the basis of measurements and tests carried out on samples provided from five locations equally spaced along a diagonal that

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bisects each 800 m^2 or part thereof completed each working day.

34 Within 24 hours of completion, the as-installed performance of the stabilised layer shall be evaluated using a dynamic plate loading or penetrometer technique to determine values of elastic modulus at points on a nominal grid pattern, as described in Appendix 7/19. The elastic modulus at each point and the mean elastic modulus for the assessment area shall comply with the minimum standards stated in Appendix 7/19. Additionally, before proceeding with construction of the overlying pavement, the evaluation process shall be repeated to demonstrate that the elastic modulus value at all points and that of the mean value have increased over the respective as-installed values by not less than the percentage values stated in Appendix 7/19. Where these criteria are not met, the full extent of the non-compliant material shall be determined and appropriate remedial measures implemented. Remedial action shall comprise either a delay in construction to allow further curing and stiffening of the layer to occur or a repeat of all or part of the recycling process, followed by re-evaluation, until a compliant material is achieved.

35 Within 270 days of completion of the surfacing works, a Falling Weight Deflectometer survey shall be carried out and analysed in general accordance with HD 29 (DMRB 7.3.2). In particular, the measurements shall be taken on the finished road surface in the nearside wheelpath, at a uniform and maximum spacing of 10 m. The survey shall be carried out during a period when the pavement temperature at a depth of 50 mm is within the range 15°C to 25ºC. The FWD results shall be analysed using a linear elastic FWD back-analysis computer program, with the pavement modelled as a two layer system. Layer 1 shall represent the combined design thickness of the bound materials (i.e. the combined recycled material and overlying surfacing materials) and layer 2 shall represent the unbound foundation layer of infinite depth. End-product performance shall be defined in terms of the calculated stiffness of layer 1, uncorrected for temperature. Compliance shall be achieved when the rolling mean of 10 results is not less than the figure specified in Appendix 7/19 and no individual result is less than 85% of the figure specified.

36 In the event that the layer 1 stiffness requirements of sub-Clause 35 of this Clause are not met, the full extent of the non-compliant material shall be determined by further investigation involving coring and laboratory testing. For each area of non-compliance, cores shall be extracted through the full depth of the stabilised layer at locations directed by the Overseeing Organisation, at a minimum rate of one x 150 mm diameter core per 75 m^2.

37 The Contractor shall be responsible for extraction of the cores with the minimum of force or disruption. Air flush coring shall be allowed for materials that are disturbed by water flush coring. After extraction, each core shall be labelled and photographed and, prior to testing, shall be stored in sealed polythene bags, in a uniformly supported position, at a temperature of 20ºC ± 5ºC. The thickness of the recycled layer shall be measured and recorded.

38 Reinstatement of all core holes shall be completed before opening the area to traffic. All backfill materials shall comply with sub-Clause 903.19.

39 If, at any of the prescribed core locations, it is not possible to extract an intact core of suitable size or condition for the end-product performance testing, using a maximum of three attempts in an area of 1.5 m radius, the material in the vicinity shall be deemed not to comply with the end-product performance specification.

40 In the laboratory, each core extracted successfully shall be trimmed to remove surfacing materials and any underlying material prior to the measurement of core density and air voids content in accordance with the standards listed in Table 8/15.

41 Following the measurement of density and air voids content, each core shall be prepared and tested to determine the compressive strength of the core, in accordance with the procedures and standards given in Table 8/16.

42 The results obtained shall be used to judge the expected performance of the recycled stabilised material in the works in relation to the performance of equivalent hydraulically bound materials. The recycled stabilised material in the assessment area shall be deemed acceptable if the compliance criteria described in Table 8/17 are met.

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TABLE 8/15: (05/05) **Procedures and Standards to be Used to Determine the Density of Core Samples of Recycled Cement Bound Material**

Procedure	Procedure Stage	Standard to be Used
Core preparation for density testing	Measurement of core dimensions and accuracy of measurement Methods of trimming core to length	BS EN 12504-1
	Test specimen type, shape and moisture condition	BS EN 12390-7
Core testing for density	Apparatus specification Measurement of volume dimensions Volume by water displacement Measurement of mass Equations of density Accuracy and units of density	BS EN 12390-7

TABLE 8/16: (05/05) **Procedures and Standards to be Used to Determine the Compressive Strength of Core Samples of Recycled Cement Bound Material**

Procedure	Procedure Stage	Standard to be Used
Core preparation for density testing	Measurement of core dimensions and accuracy of measurement Assessment of voids Maximum and minimum dimensions for strength testing	BS EN 12504-1
	Methods of capping core	BS EN 12390-3 Annex A
	Suitability of core for strength testing Storage of cores before capping	BS EN 12504-1
Core testing for strength	Type of strength test Minimum period of testing after end-preparation Method of curing core prior to testing Measurement of core test specimen dimensions and accuracy Equation for calculating core strength	BS EN 12504-1
	Testing machine specifications Rate of loading	BS EN 12390-4 BS EN 12390-3
	Correction for length/diameter ratio	Draft prEN 13877-2: (January 2002)

TABLE 8/17: (05/05) **Compliance Criteria for Recycled Cement Bound Material Based on Results of Tests on Cores Extracted from the Works**

Property	Individual cores	Mean from cores in each surveyed area
Core density relative to refusal density	93%	5% minimum
Excess voidage*	3.0%	2.0% maximum
Layer thickness [from core measurement]	± 25 mm	± 15 mm of specified
Equivalent cube compressive strength	**CBM equivalence	**CBM equivalence

* Excess voidage of a core is defined as the amount by which the actual air voids content exceeds the air voids content of the fully compacted moulded cube of the same cement bound material.

** Compliance criteria is quoted in relation to the design 7 day cube compressive strength appropriate to the equivalent CBM classification of the recycled material.

Mixture Design and Characterisation

43 Mixture design characterisation of recycled cement bound material for each site, or section of site, including details of the cementing agent and/or stabilising agent(s) and their quantities, shall be submitted to the Overseeing Organisation at least one week prior to commencement of the recycling works. Where the site investigation has identified significant variation of existing pavement materials between different sections of the site, a CBM design shall be submitted for each section of the site. The proposed plan area and depth of the different sections, covered by each mixture design, shall be approved by the Overseeing Organisation.

44 The mixture design for recycled cement bound material shall use the same method of mixture design as that used for plant mixed CBM specified in Clause 816. The permitted alternatives and equivalent recycled mixture designs for each part of the Works shall be as described in Appendix 7/19.

45 The laboratory crushed and processed aggregate with a particle (or "lump") sized distribution complying with sub-Clause 3 of this Clause shall be thoroughly mixed with measured proportions of the cement to produce trial mixtures with different cement contents. The type and grade of the cement used in the trial mixtures shall be the same as that used in the finished works.

46 If lime is required for stabilisation and/or modification of clay included from pulverisation of the upper subgrade layer, the same proportion of lime shall be added into the trial mixture.

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47 The cement content of the recycled cement bound mixture shall be determined in the same manner as the cement content for plant mixed CBM. The minimum cement content shall be 3% by weight.

48 The mixture design process shall be repeated until an acceptable mixture design is achieved. To achieve this the target composition of the mixture shall be systematically adjusted and the mixture design tests repeated.

49 In addition to the other requirements, the average compressive strength determined after 7 days immersion in water of five test specimens of the target composition mixture, prepared in accordance with sub-Clause 3 of this Clause, shall be not less than 80% of the average compressive strength of five control specimens when subjected to the test procedure described in BS 1924-2, clause 4.3. After 7 days immersion, the specimens shall not show any signs of cracking or swelling.

Induced Cracks

50 Recycled cement bound material shall have cracks induced during construction as described in Clause 818 and in Appendix 7/1.

825 to 829 (05/05) Not Used

830 (11/04) Slag Bound Mixture B1-2 (SBM B1-2), Fly Ash Bound Mixture 1 (FABM 1) and Hydraulic Road Binder Bound Mixture 1 (HRBBM 1)

1 The mixture including water content shall comply with BS EN 14227-2, -3 or -5, as appropriate, using constituent proportions complying with the requirements of Clause 811.

2 Aggregate shall comply with the selected requirements of BS EN 13242 listed in Table 8/13. The mixture shall satisfy the strength after immersion requirements of Clause 880.

3 The grading of the mixture shall comply with the relevant part of BS EN 14227.

4 The method of construction shall be in accordance with Clause 814 and comply with the general construction requirements of Clause 813. Where quick lime is used in the mixture, Category 1 quick lime in accordance with BS EN 14227-11 shall be used ensuring full hydration of the quick lime is achieved prior to final compaction.

5 The laboratory mechanical performance shall comply with the requirements of this Specification if either:

(i) the compressive strength shall not be less than the characteristic compressive strength R_c for the required mechanical performance class C_x given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength; or

(ii) the tensile strength shall not be less than the characteristic tensile strength R_t for the required mechanical performance class T_x given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength.

831 (11/04) Slag Bound Mixture B2 (SBM B2), Fly Ash Bound Mixture 2 (FABM 2), Hydraulic Road Binder Bound Mixture 2 (HRBBM 2)

1 The mixture including water content shall comply with BS EN 14227-2, -3 or -5, as appropriate, using constituent proportions complying with the requirements of Clause 811.

2 Aggregate shall comply with the selected requirements of BS EN 13242 listed in Table 8/13. The mixture shall satisfy the strength after immersion requirements of Clause 880.

3 The grading of the mixture shall comply with the 0/20 G1 grading requirements of the relevant part of BS EN 14227.

4 The method of construction shall be in accordance with Clause 814 and comply with the general construction requirements of Clause 813. Where quick lime is used in the mixture, Category 1 quick lime in accordance with BS EN 14227-11 shall be used ensuring full hydration of the quick lime is achieved prior to final compaction.

5 The laboratory mechanical performance shall comply with the requirements of this Specification if either:

(i) the compressive strength shall not be less than the characteristic compressive strength R_c for the required mechanical performance class C_x given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength; or

(ii) the tensile strength shall not be less than the characteristic tensile strength R_t for the required mechanical performance class T_x

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given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength.

832 (11/04) Slag Bound Mixture B3 (SBM B3), Fly Ash Bound Mixture 3 (FABM 3) and Hydraulic Road Binder Bound Mixture 3 (HRBBM 3)

1 The mixture including water content shall comply with BS EN 14227-2, -3 or -5, as appropriate, using constituent proportions complying with the requirements of Clause 811.

2 Aggregate shall comply with the selected requirements of BS EN 13242 listed in Table 8/13. The mixture shall satisfy the strength after immersion requirements of Clause 880.

3 The method of construction shall be in accordance with either Clause 814, 815 or 816 and comply with the general construction requirements of Clause 813. Where quick lime is used in the mixture, Category 1 quick lime in accordance with BS EN 14227-11 shall be used ensuring full hydration of the quick lime is achieved prior to final compaction.

4 The laboratory mechanical performance shall comply with the requirements of this Specification if either:

(i) the compressive strength shall not be less than the characteristic compressive strength R_c for the mechanical performance class given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength; or

(ii) the tensile strength shall not be less than the characteristic tensile strength R_t for the mechanical performance class given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength.

5 At mixture design stage, the mixture, made to the target water content, shall satisfy the immediate bearing index category IPI_{40}. This requirement shall not apply where the mixture contains at least 3% cement by mass of the dry mixture and trafficking is not permitted for 7 days.

833 (11/04) Not Used

834 (11/04) Fly Ash Bound Mixture 5 (FABM 5)

1 The mixture including water content shall comply with BS EN 14227-3, using constituent proportions complying with the requirements of Clause 811.

2 For lime-treated fly ash mixtures gypsum added as an additional constituent, the method of construction shall be in accordance with Clause 814. For other mixtures, the method of construction permitted shall comply with Clause 814, 815 or 816. In all cases, construction shall comply with the general construction requirements of Clause 813. When quick lime is used in the mixture, Category 1 quick lime in accordance with BS EN 14227-11 shall be used ensuring full hydration of the quick lime is achieved prior to final compaction.

3 The laboratory mechanical performance shall comply with the requirements of this Specification if either:

(i) the compressive strength shall not be less than the characteristic compressive strength R_c for the mechanical performance class given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength; or

(ii) the tensile strength shall not be less than the characteristic tensile strength R_{tk} for the mechanical performance class given in Appendix 7/1. No individual test result shall be less than 85% of the characteristic strength.

4 The mixture shall satisfy the strength after immersion requirements of Clause 880.

835 to 839 (11/04) Not Used

840 (11/04) Soil Cement (SC), Soil Treated by Slag (SS), Soil Treated by HRB (SHRB), and Soil Treated by Fly Ash (SFA)

1 (05/05) The mixture shall comply with BS EN 14227-10, -12, -13 or -14, as appropriate and the specific requirements listed in Table 8/18, using constituent proportions complying with the requirements of Clause 811.

2 The maximum particle size within the mixture shall not exceed 25% of the layer depth. The particle size distribution of the soil to be treated shall be finer than the coarse limit of the grading of envelope A of Figure 1 in BS EN 14227-1.

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3 The method of construction shall be in accordance with either Clause 814, 815 or 816 and comply with the general construction requirements of Clause 813. Where quick lime is used in the mixture, full hydration of the quick lime shall be achieved prior to final compaction. Where the construction does not employ a mellowing period of at least 24 hours after the addition of lime and before a final mixing stage, the choice of lime shall be restricted to slaked lime or Category 1 quick lime in accordance with BS EN 14227-11.

TABLE 8/18: (05/05) **Requirements for SC, SS, SHRB and SFA**

Mixture parameter	Requirement		BS EN 14227 -10, -12, -13, -14 reference
	Non-cohesive mixtures	Cohesive mixtures	
Minimum water content determined using BS EN 13286-4	$W_{0,9}$	W_{NR}	Table 1
	$W_{1,0}$ for mixtures containing quicklime		
Degree of pulverization	$Pulv_{NR}$	$Pulv_{30}$: for mixtures containing lime $Pulv_{60}$: for mixtures without lime	Table 2
Immediate Bearing Index*	IPI_{30}	IPI_{15}	Table 3
MCV	MCV_{NR}	$MCV_{8/12}$ with a target of 10 during mellowing, $MCV_{8/12}$ at final compaction	Table 4
Laboratory mechanical performance	R_c or R_t,E as specified in Appendix 7/1		Table 6 or Figure 1 respectively
Resistance to water for R_c/R_tE performance classification	$Imm_{0,8}$		Table 7
Resistance to water alternative	G_{v3}		Table 9
* Where SC is not to be trafficked within 7 days IPI_{NR} may be used			

841 to 869 (11/04) Not Used

Testing, Control and Checks for Cement and Other Hydraulically Bound Mixtures

870 (11/04) Testing, Control and Checking of Cement and Other Hydraulically Bound Mixtures

General

1 (05/05) Unless otherwise stated in Appendix 1/5, tests controls and checks shall be carried out in accordance with Table 8/19 and sub-Clauses below, at locations determined by the Overseeing Organisation. All testing shall be undertaken by an appropriate organisation accredited in accordance with sub-Clauses 105.3 and 105.4 for such tests. All submitted test results shall be provided with test certificates.

Sampling

2 Where samples are taken, they shall be taken from the full depth of the layer and used without further mixing and shall not be combined with other samples.

Spread checks for the Mix-in-Place Method of Construction

3 The rate of spread of added constituents shall be determined by weighing the amount of material retained on five trays or mats of known area laid in the path of

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the spreading machine. The trays, or mats, shall be positioned approximately at points equally spaced along a diagonal bisecting the area of coverage.

Depth of Mixing for the Mix-in-Place Method of Construction

4 The depth of mixing shall be checked, by excavation and inspection, on completion of each stage of the mixing process with reference to design levels, to ensure that the level at the underside of the layer is in accordance with the specified requirements.

Density

5 The in-situ wet density shall be measured using a calibrated nuclear density gauge in accordance with BS 1924-2. Each test shall consist of at least 3 measurements at 120 degrees to each other using the same source rod hole and the density taken as the average of the higher 2 results.

TABLE 8/19: (05/05) **Requirements for Tests, Controls and Checks**

Test/control/check	Test frequency	Test reference
On aggregate/soil compliance where required:		
Water content	1 per 1000 m^2	BS 1924-1, clause 7.1
Grading	1 per 1000 m^2	BS 1924-1, clause 7.2
Plasticity	1 per 1000 m^2	BS 1924-1, clause 7.3
On imported constituents where required:	Supplier certificate weekly	
Batching records for 'mix-in-plant' using batching by mass	Continuously	N/A
Batching records for 'mix-in-plant' using batching by volume	Continuously	N/A
Spread checks for 'mix-in-place' only	1 determination per 1000 m^2 but not less than 4 per day	Collection test as described in sub-Clause 870.3
On the HBM where required:		
Water content at mixing and final compaction	3 per 1000 m^2 but not less than 4 per day	BS 1924-2, clause 1.3
MCV at mixing and final compaction	3 per 1000 m^2 but not less than 4 per day	BS EN 13286-46
Pulverization (cohesive mixtures only)	2 per 1000 m^2 but not less than 4 per day	BS EN 13286-48
Depth of mixing at all relevant stages ('mix-in-place' only)	5 per 1000 m^2 but not less than 4 per day	Sub-Clause 870.4
In-situ wet density	5 per 1000 m^2 but not less than 4 per day	Sub-Clause 870.5
Laboratory mechanical performance	5 per 1000 m^2 but not less than 4 per day	As described in Table 8/20

Standardisation of Nuclear Density Gauges

6 The operation, warming-up period, if any, and standardisation of the gauge shall be carried out in compliance with the manufacturer's recommendations. The gauge shall be calibrated in accordance with BS 1924-2.

7 The gauge shall be used in the direct transmission mode of operation.

8 The determination of bulk density by direct transmission shall be in accordance with BS 1924-2.

9 Prior to the preliminary trial and whenever the constituents of the mixture are altered the HBM shall be checked by the procedure given in BS 1924-2.

Laboratory Mechanical Performance

10 (05/05) The mechanical performance of the mixture shall be assessed on specimens manufactured, cured and tested in accordance with Table 8/20.

11 Where the $R_{tx}E$ class is specified in Appendix 7/1, the minimum tensile strength applicable to the proposed mixture shall be fixed by reference to the modulus of elasticity of that mixture. The modulus of elasticity shall be the mean of a minimum of five determinations from specimens manufactured over the range of binder contents likely to be used during production.

12 Specimen manufacture shall be to BS EN 13286-51. Cubes for compression testing shall be 150 mm unless agreed otherwise by the Overseeing Organisation.

Table 8/20: (05/05) **Laboratory Mechanical Performance Testing Requirements for HBM**

Clause	Mixture	Curing regime	Test method BS EN 13286	Age at test
821	CBGM A	Regime A, Annex C BS EN 14227-1	-41 for R_c, -42 for R_{it}, -43 for E	28 days
822	CBGM B	Regime B, Annex C, BS EN 14227-1	-41 for R_c, -42 for R_{it}, -43 for E	28 days
823	CBGM C	Regime B, Annex C, BS EN 14227-1	-41 for R_c, -42 for R_{it}, -43 for E	28 days
830	SBM B1-2, FABM1, HRBBM 1	40°C in sealed conditions to prevent water loss	-41 for R_c, -42 for R_{it}, -43 for E	28 days
831	SBM B2, FABM2, HRBBM 2	40°C in sealed conditions to prevent water loss	-41 for R_c, -42 for R_{it}, -43 for E	28 days
832	SBM B3, FABM 3, HRBBM 3	40°C in sealed conditions to prevent water loss	-41 for R_c, -42 for R_{it}, -43 for E	28 days
834	FABM 5	40°C in sealed conditions to prevent water loss	-41 for R_c, -42 for R_{it}, -43 for E	28 days
840	SC	Regime A1, Annex B, BS EN 14227-10	-41 for R_c, -42 for R_{it}, -43 for E	28 days
840	SS, SHRB, SFA	40°C in sealed conditions to prevent water loss	-41 for R_c, -42 for R_{it}, -43 for E	28 days

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871 to 879 (11/04) Not used

880 (11/04) Laboratory Mixture Design Procedure for HBM

1 Prior to the commencement of the Works or any change in mixture constituents, the Contractor shall provide the proposed proportions of the HBM, based on the mixture design procedure described in this Clause, to meet the requirements of this Specification and the particular requirements stated in Appendix 7/1.

2 The composition of HBM shall be based on mixture design testing carried out using a minimum of 3 binder contents at a minimum of 2 water contents, usually OWC and 1.2xOWC.

3 Where required for the selected HBM, the immediate stability at the design water content, as measured by the Immediate Bearing Index test in accordance with BS EN 13286-47, shall be determined at the mixture design stage.

4 HBM shall be assessed at the mixture design stage for volume stability by comparing the strength of specimens cured by immersion in water to non-immersed specimens. For mixtures containing less than 3% by dry mass of the mixture of cement, the immersion period shall be 14 days following 14 days sealed curing 'out-of-water', both periods using 40°C. The strength/stiffness of specimens subject to this curing shall be compared to the strength/stiffness of specimens subject to 'out-of-water' sealed curing at 40°C and shall be greater than 80%. In the case of mixtures containing 3% or more cement, the procedure and requirement shall be the same except that 20°C shall be used instead of 40°C.

5 Where used within the depth of frost penetration, HBM with a mechanical performance category less than C 3/4 shall be assessed for frost resistance at the mixture design stage.