ROAD PAVEMENTS - UNBOUND, CEMENT AND OTHER HYDRAULICALLY BOUND MIXTURES

Unbound Mixtures for Subbase

801 General Requirements for Unbound Mixtures

1 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: Mixture and Grading Requirement Categories for Unbound Mixtures

Unbound mixture	Type 1	Type 2	Type 3 (open graded)	Category B (close graded)	Type 4 (asphalt arisings)
Clause	**803**	**804**	**805**	**806**	**807**
Standard	BS EN 13285 Categories for unbound mixture properties				
Mixture requirement category			Not Used	Not Used	
			Not Used	Not Used	
			Not Used	Not Used	
- Designation	0/31,5	0/31,5	Not Used	Not Used	0/31,5
- Maximum fines	UF_9	UF_9	Not Used	Not Used	UF_9
- Oversize	OC_{75}	OC_{75}	Not Used	Not Used	OC_{75}
Grading requirement category			Not Used	Not Used	
			Not Used	Not Used	
			Not Used	Not Used	
- Overall grading	GP	GE	Not Used	Not Used	GP

2 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 1500 mg of sulfate (as SO_4) per litre (Test No.1); or

(ii) the oxidisable sulfides (OS) content exceeds 0.5% of sulfate (as SO_4) (Test No.2 and Test No. 4); or

(iii) the 2:1 water to soil extract prepared for the determination of water-soluble sulfate in (i) has a pH value of less than 7.2, when tested using the electrometric method of pH determination in accordance with BS 1377-3.

At least five samples of each material shall be tested for WS, OS and pH value. The mean of the highest two values shall be used for comparison with the limiting values. This also applies if six to nine results are available. If ten or more results are available, the mean of the highest 20% of the results shall be used for comparison with the limiting values.

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

(i) the water-soluble sulfate (WS) content exceeds 300 mg 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).

At least five samples of each material shall be tested for WS and OS. The mean of the highest two values shall be used for comparison with the limiting values. This also applies if six to nine results are available. If ten or more results are available, the mean of the highest 20% of the results shall be used for comparison with the limiting values.

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Table 8/2: Requirements for Aggregates Used in Unbound Mixtures

Unbound mixture	Type 1	Type 2	Type 3	Category B	Type 4
			(open graded)	(close graded)	(asphalt arisings)
Clause	**803**	**804**	**805**	**806**	**807**
Standard	BS EN 13242 Categories for aggregate properties				
Crushed, or broken particles - crushed rock, crushed artificial and crushed recycled aggregates - see NOTE 1	$C_{90/3}$	$C_{90/3}$	Not Used	Not Used	$C_{90/3}$
Resistance to fragmentation – Los Angeles test	LA_{50}	LA_{50}	Not Used	Not Used	LA_{50}
Water absorption	$WA_{24}NR$ (no requirement). The supplier shall state the value for the aggregate used.				
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. Not Used
3. See sub-Clauses 805.3 and 806.3 for additional requirements.

The requirements in (i) and (ii) above shall not apply to metallic items protected by concrete and ancillary metallic items such as the tops of chambers and gullies.

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

5 Where recycled coarse aggregate or recycled concrete aggregate is used in unbound mixtures in accordance with Clauses 802 to 807 as appropriate, it shall have been tested in accordance with Clause 710. Recycled coarse aggregate and recycled concrete aggregate used in unbound mixtures in accordance with Clauses 803, 804 and 807 shall also comply with the additional requirements of Table 8/3.

TABLE 8/3: (11/09) Additional Requirements for Recycled Coarse Aggregate and Recycled Concrete

Unbound Mixture	Type 1	Type 2	Type 4 (asphalt arisings)
Component Identified by Clause 710	**Maximum Permitted Content** (% by mass)		
Asphalt (Class Ra)	50	50	100
Glass (Class Rg)	25		
Other materials Class X), including wood, plastic and metal	1		

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 Not Used

8 Not Used

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

Transporting

1 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

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Deleted: 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.¶
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2 Not Used

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 (i) 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.

(ii) At the end of compaction as indicated in (i) the requisites indicated in (a) and (b) shall apply:

a. The compaction degree based on the Standard Proctor Test according to BS 1377: Part 4 shall not fall below D_{pr} = 103%.

b. When tested in according to the standard DIN 18134 the reaction modulus E_{v2} shall comply with the values indicated in Charts 1, 2, 3 and 5 of the Transport Malta Design and Construction Standards for Road Works, Volume 7, "Directives for the Standardization of Pavements for Traffic Areas". The ratio E_{v2}/E_{v1} shall not exceed 2.2. In only those cases where the value E_{v1} is at least 60% of the required E_{v2} value higher ratios than 2.2 may be submitted to the Overseeing Organisation for review, and subsequent acceptance or rejection.

c. The following tolerances are permissible in production control and control testing for (a) and (b):

- Less than five test values: all values have to be above the minimum value.
- Five or more test values: one value may fall below the required value by 10%.

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:

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).

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.

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.

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unbound mixtures are of unequal thickness, the lowest layer shall be the thickest layer.¶
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Compaction¶
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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.¶
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6 Full compaction shall be obtained over the full area including in the vicinity of both longitudinal and transverse joints.¶
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Deleted: 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.¶

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its area in contact with compacted material.

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

(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

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(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 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.

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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

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track rutting is demonstrated to comply with sub-Clause 12 of this Clause.

14 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 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 Type 1 Unbound Mixtures

1 Type 1 unbound mixture shall be made from crushed rock, crushed slag, crushed concrete or recycled aggregates.

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.

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Table 8/5: Summary Grading Requirements for Type 1 and Type 4 Unbound Mixtures

Sieve size, mm	Percentage by mass passing		
	Overall grading range	Supplier declared value grading range	Tolerance on the supplier 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 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 Not Used

8 Not Used

804 Type 2 Unbound Mixtures

1 Type 2 unbound mixture shall be made from crushed rock, crushed slag, crushed concrete or recycled aggregates.

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: 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		
31.5	75-99		
16	50-90		
8	30-75	No requirement	No requirement
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.

805 Type 3 (open graded) Unbound Mixtures

Not Used

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

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806 Category B (close graded) Unbound Mixtures

Not Used

2 Not Used

3 Not Used

4 Not Used

5 Not Used

2 Not used

Deleted: 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.

Deleted: 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.

Deleted: (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.

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

Deleted: (11/09) Type 3 (open graded) unbound mixture shall be made from crushed rock, crushed blast furnace slag or recycled concrete aggregate. When tested in accordance with Clause 710, recycled concrete aggregate used in Type 3 (open graded) unbound mixtures shall not contain more than 5% asphalt (Class Ra) and not more than 1% other materials (Class X).

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Deleted: (11/09) Category B (close graded) unbound mixture shall be made from crushed rock, crushed blast furnace slag or recycled concrete aggregate. When tested in accordance with Clause 710, recycled concrete aggregate used in Category B (close graded) unbound mixtures shall not contain more than 5% asphalt

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

Not Used

807 Type 4 (asphalt arisings) Unbound Mixtures

1 Type 4 unbound mixture shall be made from recycled aggregates containing asphalt arisings, and may contain crushed rock, crushed slag or crushed concrete, that passes the 4 mm size test sieve.

2 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.

3 Type 4 unbound mixture shall have an asphalt (Class Ra) content greater than 50% when tested in accordance with Clause 710, and the recovered bitumen content of the asphalt shall be not more than 10% when tested in accordance with BS 598 102.

4 Type 4 unbound 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.

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

6 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.

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

8 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. The moisture content shall be determined by oven drying at a reduced temperature setting of 45ºC to 50ºC.

9 Where required by Appendix 7/1, Type 4 unbound mixtures shall be assessed using a trafficking trial complying with sub-Clause 802.12.

808 and 809 Not Used

Cement and Other Hydraulically Bound Mixtures

810 General Requirements for Cement and Other Hydraulically Bound Mixtures

1 Cement and other hydraulically bound mixtures (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 shall be deemed to have a 'No requirement' classification unless stated otherwise.

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3 The terms listed below shall apply to the HBM Clauses of this specification:

ASS	air cooled steel slag: Not Used
CBGM	cement bound granular mixture
CBR	California bearing ratio
CFA	cement treated fly ash: Not Used
E	modulus of elasticity
FA fuel	fly ash (also known as 'pulverized ash'): Not Used
FABM	fly ash bound mixture: Not Used
G_{vxx}	volumetric expansion category
GBS	granulated blast furnace slag: Not Used
ggbs	ground granulated blast furnace slag: Not Used
HBM	hydraulically bound mixture
HRB	hydraulic road binder (factory blended hydraulic binder for road use): Not Used
HRBBM	'hydraulic road binder' bound mixture: Not Used
IBI	immediate bearing index
Imm_{xx}	immersion category
IPI_{xx}	immediate bearing index category
LA	Los Angeles coefficient
LFA	lime treated fly ash: Not Used
MCV	moisture condition value
NR	no requirement
OWC	optimum water content
PTR	Pneumatic tyred roller
$Pulv_{xx}$	pulverisation category
R_c	compressive strength
R_t	direct tensile strength
R_{it}	indirect tensile strength
R_t,*E*	method of performance classification based on the combination R_t and *E*. Classes of R_t,*E* are designated T0 to T5, in BS EN 14227, where T designates R_t,*E* and the number indicates the performance class
SBM	slag bound mixture: Not Used
SC	soil treated by cement
SFA	soil treated by fly ash: Not Used
SHRB	soil treated by hydraulic road binder
SS	soil treated by slag: Not Used
t	time (hours) at constant temperature in defining maturity for calculating the construction period
T°C	ambient air temperature in defining maturity for calculating construction period
W_{xx}	water content category

4 HBM shall be tested in accordance with Clause 870 and the test methods specified in the following Clauses.

5 Before work commences, the Contractor shall submit a statement to the Overseeing Organisation that includes:

i. The information detailed in the 'Designation and Description' clause of the relevant BS EN Standard for the specified HBM, confirming compliance with the requirements of this Series and Appendix 7/1.

ii. Target proportions of constituents, including water.

iii. Mixture design details and results, in accordance with Clause 880.

iv. Method statement for the demonstration area and the main works, in accordance with Clause 817.

6 When required by Appendix 7/1, the coefficient of linear expansion of the mixture shall be determined in accordance with Clause 871.

811 Binder Constituents

1 Binder constituents shall comply with BS EN 14227 except that, unless otherwise agreed by the Overseeing Organisation:

i. Not Used

ii. Not Used

2 The binder content shall comply with Table 8/9, unless otherwise agreed by the Overseeing Organisation. The mixture proportions used for production shall be based on a laboratory mixture design procedure in accordance with Clause 880.

Deleted: fly ash shall be siliceous fly ash complying with BS EN 14227-4;

Deleted: quicklime shall comply with ¶ BS EN 14227-11 and have a grading that complies with particle size Category 1.

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TABLE 8/9: Minimum Binder or Binder Constituent Additions for HBM

Binder or binder constituent	Application	Minimum addition for mix-in-plant method of construction using batching by mass (by dry mass of mixture)	Minimum addition for mix-in-plant method of construction using volume batching and for mix-in-place construction (by dry mass of mixture)
Lime (quicklime or hydrated lime)	Not Used		
Cement	when used as the only binder constituent in CBGM	The appropriate value from BS EN 14227-1, Table 1	1% + (the appropriate value from BS EN 14227-1, Table 1)
Ground granulated blast Furnace slag (ggbs)	Not Used		
Air-cooled steel slag (ASS)	Not Used		
Dry fly ash (FA)	Not Used		
Granulated blast furnace	Not Used		
Wet (conditioned) fly ash (FA)	Not Used		
Hydraulic road binder	Not Used		

NOTE: Not Used

812 Storage of Constituents

1 Aggregates shall be stored on a firm and clean substrate avoiding contamination with other constituents. Fine aggregate shall be stored at the production location for at least 24 hours before use.

2 Cement shall be stored in silos.

3 Not Used

4 Not Used

813 General Requirements for Production and Layer Construction

1 HBM shall be produced and laid using one of the following methods, as specified in the following mixture Clauses:

(i) mix-in-plant method of construction using batching by mass, in accordance with Clause 814

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Deleted: Wet (conditioned) FA shall have no agglomerations greater than 10 mm size. This shall be determined by sieving samples through a 10 mm size test sieve using not more than 10 seconds of gentle agitation by hand. Wet (conditioned) fly ash shall be stored at the source or at the production location for at¶
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¶
least 72 hours before use, and have a minimum water content of 10%.
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(ii) mix-in-plant method of construction using volume batching, in accordance with Clause 815;

(iii) Not Used

2 Construction of layers, including multiple lift layers, and any re-working and re-use, shall be completed within the lesser of 8 hours, the construction period specified in Table 8/10 or the mixture setting time. The time shall be measured from the addition event defined in Table 8/10 to completion of compaction.

3 The construction period, in degree hours, shall be the summation of the products of the average air temperature above 3ºC (T ºC) and time for each period (t hours): i.e. construction period limit =Σ(T.t). The air temperature during the interval, t, shall not fluctuate by more than 4ºC.

TABLE 8/10: Construction Period for HBM Layers

Binder	**Addition event defining the start time for calculating maximum construction period**	**Maximum construction period (ºC hours)**
Cement	Addition of cement	35
Cement with FA or cement with ggbs	Not Used	
Lime with GBS or FA	Not Used	
Lime and gypsum for FABM 5	Not Used	
GBS + ASS	Not Used	
Lime with ggbs	Not Used	
HRB	Not Used	

4 Mixtures used in base layers shall be batched by mass and paver laid in a single lift. Construction of bases by other methods shall only be permitted in confined spaces where it is impracticable for a paver to operate, when agreed by the Overseeing Organisation.

5 Not Used

6 Laying shall be carried out in a way that avoids segregation and drying of the surface. The temporary intermediate surfaces within a multiple lift layer shall be sprayed with water to prevent surface drying.

7 The minimum compacted lift thickness in a multiple lift layer shall be 150 mm.

8 Making-up of level after initial compaction shall not be permitted for single lift working or the uppermost lift of multiple lift working.

9 The edge of previously compacted HBM or other material shall be vertical and straight before fresh HBM is laid against it.

10 Compaction of HBM layers, including the intermediate lifts of multiple lift working, shall be completed without drying out and before setting of any

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part of the layer and shall meet the requirements for density in clause 870.

11 Compaction of HBM shall be carried out by vibrating roller and/or pneumatic-tyred roller (PTR). Where vibrating roller compaction is used on mixtures specified in Clauses 830 to 835 it shall be followed by at least 8 passes of a PTR with a wheel loading of not less than 30kN.

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Deleted: . Only PTR compaction with a wheel loading of not less than 30kN shall be applied to FABM 5

12 On completion of compaction the surface shall be closed, free from ridges, cracks, loose material, visible voids, ruts, shear planes and other defects. All defective areas shall be rectified within the time period specified in sub-Clause 813.2. If rectification is not completed within the specified time period, the defective area shall be removed to the full thickness of the layer, and new mixture laid and compacted.

Cold and Wet Weather Working

13 During cold weather:

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

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(ii) Not Used

(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;

(iv) Not Used

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

(05/09) **Curing, Protection and Trafficking**

15 On completion of compaction the layer shall be cured to prevent loss of moisture by:

(i) application of a bitumen emulsion spray complying with Class C40B4, as specified in the UK National Foreword to BS EN 13808 to produce an even and complete coverage of at least 0.2 kg/m^2 of residual bitumen. Before spraying commences, the surface shall be free of all loose material and standing water. The curing membrane shall be protected from any damage until the construction of the overlaying layer;

(ii) application of a mist/fog/light spray of water, sufficient to keep the surface continuously wet until the specified strength of the HBM has been developed or the layer is overlaid.

16 Trafficking of HBM layers shall comply with the requirements set out in Table 8/11 and sub-Clause 813.17. Should any HBM layer exhibit signs of damage, trafficking shall cease immediately and shall only be resumed once the layer has gained sufficient stability to resist damage.

TABLE 8/11: Trafficking of HBM Layers

HBM Designation	Clause reference	Trafficking
CBGM	821, 822 and 823	Sub-Clause 813.17.
HBM	Not Used	
FABM 5 with cement	Not Used	
FABM 5 with lime	Not Used	
SC	840	Not restricted provided that the IBI requirements of Table 8/13 are satisfied I For mixtures containing cohesive soil, the test specimens made at the same time as the specimens required in clause 870 but cured under the same conditions as the insitu shall also have achieved an average strength of at least Class C0.8 / 1.0
SS, SHRB and SFA	Not Used	

17 CBGM shall not be trafficked for 7 days unless the layer complies with the following:

(i) the layer is compacted by both vibrating roller and PTR in accordance with sub-Clause 813.11 to comply with the requirements of sub-Clause 813.12;

(ii) the mixture contains at least 50% by mass of coarse aggregate complying with BS EN 13242, Category $C_{90/3}$ for 'crushed or broken particles';

(iii) test specimens made at the same time as the specimens required in Clause 870 but cured under the same conditions as the in-situ CBGM have achieved an average strength of at least Class C3/4.

18 Surface contamination shall be avoided as far as is practicable and any unavoidable contamination shall be removed prior to overlaying. Reworking and re-compaction of the layer shall only be permitted

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within the construction period set out in Table 8/10. Reworking shall only be permitted when the water content requirements of the reworked material are maintained within the limits stated in the method statement.

19 Before overlaying, any loose material shall be removed and replaced to the full depth of the layer or, if within the construction period set out in Table 8/10, reworked as specified in sub-Clause 813.18.

20 Daily record sheets complying with sub-Clause 817.4 shall be submitted to the Overseeing Organisation by start of work on the next working day, detailing:

(i) spread rate/batching record results;

(ii) depth measurements;

(iii) density test measurements;

(iv) sample and test locations;

(v) construction period records showing the time(s) of mixing, water addition, completion of compaction and application of curing membrane.

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

1 The HBM shall be produced in a stationary mixing plant that batches by mass and mixes in a forced-action mixer, allowing sufficient time in the mixer to produce a homogenous mixture.

2 The mixing plant shall have an automated surveillance and data collection system.
2 HBM shall be transported directly to the point where it is to be laid and protected from the weather during transit and whilst awaiting tipping, unless otherwise agreed by the

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

3 Where multiple lift working is used, the method statement shall detail the methods used to assure that bond between the individual lifts is achieved. The method statement shall also detail the procedures to be used to confirm that bond has been achieved in

3 HBM shall be transported directly to the point where it is to be laid and protected from the weather during transit and whilst awaiting tipping, unless otherwise agreed by the Overseeing Organisation.

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

1 The HBM shall be produced in a stationary mixing plant that batches by volume and mixes in a forced action mixer, allowing sufficient time in the mixer to produce a homogenous mixture.

Overseeing Organisation.

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

816 Mix-in-Place Method of Construction

Not Used

817 Method Statement and Demonstration Area

Method Statement

1 At least 10 days prior to constructing the demonstration area specified in sub-Clause 817.5, the Contractor shall provide a full method statement for the approval of the Overseeing Organisation. The statement shall detail the operatives, plant, materials and procedures for the construction of demonstration area(s) and of the works, including procedures. The statement shall also include procedures for induced cracking, if required by Appendix 7/1, and the procedures to be applied during inclement weather, plant breakdowns and other unscheduled events.

the demonstration area and in the works.

4 The method statement shall include a sample record sheet for the submission of the data required by sub-Clause 813.20.

Demonstration Area

5 Prior to the commencement of the main works, the Contractor shall construct a demonstration area of at least 800 m^2 conforming to the submitted method statement. The demonstration area shall include a transverse end-of-day joint and (if appropriate) multiple lift working. The demonstration area may be accepted into the permanent works, where agreed by the Overseeing Organisation. Where the Contractor can produce documentary evidence of similar work carried out to this specification during the previous 6 months, the Overseeing Organisation may allow the works to proceed without the demonstration area.

6 Where multiple lift working is used, the demonstration area

Deleted: **1** Mixed-in-place HBM shall be produced by an in-situ pulverizing-mixing process with the added mixing water injected directly into the mixture during the mixing process. The pulverizing-mixing process shall be repeated until a homogenous mixture is produced.¶
¶
2 When binder constituents are dispensed onto the surface to be pulverized-mixed, the rate of spread shall be confirmed by site checks carried out in accordance with Clause 870. 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 shall be within ±15% of the mean value of the group of 5 readings.¶
¶
3 The accuracy of the system used to dispense binder constituents shall be verified by reconciliation between constituent deliveries and the area and depth of completed layer for each 5000 m^2 of work, or part thereof, during each day's operations.¶
¶
4 Mixing of fresh material shall ensure a minimum overlap of 200 mm with previously mixed material.¶
¶
5 Where lime is used to granulate cohesive soils it shall be added and mixed with the soil using at least two passes of the pulverizer-mixer between 24 and 96 hours before the subsequent addition of cement, FA, HRB or ggbs. The surface of the layer shall be sealed by rolling immediately after adding and mixing lime. The MCV during this period, known as the mellowing period, shall comply with Clause 840.

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shall confirm the effectiveness of the procedures used to assure that bond between the individual lifts can be achieved.

7 Where induced cracking is required, the demonstration area shall include crack induction at the specified spacing. The effectiveness of the procedure used shall be checked within 28 days of construction, by recovering four evenly spaced 150 mm dia cores from the line of the induced cracks and assessing each core for compliance with sub-Clause 818.2.

8 The mixture constituents, proportions, laying and compaction plant and construction procedures used for the demonstration area shall not be changed unless the Contractor lays a further demonstration area or the changes are agreed by the Overseeing Organisation.

comply with the additional requirements for the proportion of the components listed in Table 8/12.

2 When required by Appendix 7/1, an existing pavement layer that is to used to produce HBM shall be tested to confirm compliance with sub-Clause 820.1.

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818 Induced Cracking of HBM

1 Where required by Appendix 7/1, transverse cracks shall be formed at the specified spacing with a tolerance of ± 150 mm. Where the pavement is made up of two or more layers of HBM with induced cracks, the cracks in the overlying HBM layer shall align with the induced cracks in the layer below with a tolerance of ± 100 mm.

2 Cracks shall be induced in fresh material after initial compaction. The transverse cracks shall be induced by grooving the fresh material to form straight vertical grooves not more than 20 mm wide, to a depth of between one half and two thirds of the layer thickness over the full width of the pavement. Bitumen emulsion shall be poured or sprayed into the grooves prior to final compaction, to form a crack inducing membrane. The bitumen emulsion shall comply with Class C40B4, as specified in the UK National Foreword to BS EN 13808. During final compaction of the mixture, the surface of the groove shall be fully closed throughout its full length. The bitumen in the groove shall be fully encased and remain continuous, with not less than 70% of the sides of the groove coated with bitumen.

3 Where required by Appendix 7/1, longitudinal cracks shall be induced using the procedure specified in sub-Clause 818.2.

819 Not Used

820 Aggregates

1 The aggregates used in HBM shall comply with BS EN 13242 and the selected requirements listed in Table 8/12. Where recycled coarse aggregate or recycled concrete aggregate is used in HBM, it shall also be tested in accordance with Clause 710 and

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Table 8/12.1: Aggregate Requirements for HBM

Clause reference	821	822	823	830	831	832	835
HBM designation	**CBGM A**	**CBGM B**	**CBGM C** (Not Used)	**FABM 1** (Not Used) **HRBBM 1** (Not Used	**SBM B2** (Not Used) **FABM 2** (Not Used) **HRBBM 2** (Not Used)	**SBM B3** (Not Used) **FABM 3** (Not Used) **HRBBM 3** (Not Used)	**SBM B1** (Not Used) **B1-2, B1-3 & B1-4** (Not Used)
Categories for aggregate properties, BS EN 13242							
Crushed or broken particles in coarse aggregate	C_{NR} (Note 1)	C_{NR} unless otherwise specified in Appendix 7/1		$C_{90/3}$ *or* $C_{50/30}$ as specified in Appendix 7/1		C_{NR} (Note 1)	C_{NR} as specified in Appendix 7/1
Resistance to fragmentation of coarse aggregate	LA_{50} or LA_{60} as specified in Appendix 7/1	LA_{40} as specified in Appendix 7/1	LA_{50}	LA_{50} or LA_{60} as specified in Appendix 7/1	LA_{50}	LA_{NR}	LA_{50}
Acid-soluble sulfate (Note 3)	Not Used						
Total sulfur content (Note 3)	Not Used						
Other requirements, BS 1377-2							
Fines quality (Note 4)	NR (Note 1)	*Non-plastic*				NR (Note 1)	*Non-plastic*
Proportion of components, Clause 710							
Maximum glass content (Class Rg)	*40*	*40*	*40*	*40*	*40*	*40*	*40*
Maximum impurities content (Class X)	*5*	*3*	*3*	*3*	*3*	*5*	*3*

NOTES:
1. The suffix $_{NR}$ denotes that the 'No requirement' category applies.
2. Not Used
3. Not Used
4. Where required, the size fraction of the aggregate passing the 0.425 mm size test sieve shall be non-plastic as defined by and tested in compliance with BS 1377-2.

821 Cement Bound Granular Mixtures A (CBGM A)

1 Cement bound granular mixtures A (CBGM A) shall comply with BS EN 14227-1 and have binder constituent proportions complying with the requirements of Clause 811.

2 Aggregate shall comply with the requirements of Clause 820 and shall have a combined grading that complies with Envelope A from BS EN 14227-1, Figure 1.

3 The strength after immersion shall be at least 80% of the non-immersed strength, when tested in

accordance
with the laboratory mixture design requirements specified in Clause 880.

4 The method of construction shall be in accordance with Clause 813 and either Clause 814 or Clause 815.

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Deleted: C_{NR} if FABM 1 contains at least 3% CEM 1 cement by dry mass of the mixture and trafficking is prevented for 7 days.
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5 The laboratory mechanical performance shall comply with the requirements of BS EN 14227-1, clause 6.5.2.2 (System I – Compressive Strength) and Table 8/12.2 when sampled and tested in accordance with Clause 870.

822 Cement Bound Granular Mixtures B (CBGM B)

1 Cement bound granular mixtures B (CBGM B) shall comply with BS EN 14227-1, and have binder constituent proportions complying with the requirements of Clause 811.

2 Aggregates shall comply with the requirements of Clause 820 and shall have a combined grading that complies with Envelope B from BS EN 14227-1, Figure 1. Alternatively, the total mixture grading shall comply with the grading envelope Category G2 from BS EN 14227-1, Annex B, Figure B2.

3 The strength after immersion shall be at least 80% of the non-immersed strength, when tested in accordance with the laboratory mixture design requirements specified in Clause 880.

4 The method of construction shall be in accordance with Clause 813 and Clause 814.

5 The laboratory mechanical performance shall comply with BS EN 14227-1, clause 6.5.2.2 (System I – Compressive Strength), and Table 8/12.2 when sampled and tested in accordance with Clause 870.

823 Cement Bound Granular Mixtures C (CBGM C)

Not Used

824 Cement Bound Granular Mixtures – Compressive Strength

~~Table 8/12.2 Characteristic Compressive Strength (R_{ck})~~ (System I)

	28-day compressive strength (MPa)		
	Cylinders	Cylinders or Cubes	Strength Class
CBM	H/D[a] = 2.0b	H/D[a] = 1.0[b]	
A	5.0 8.0	6.0 10.0	$C_{6/6}$ $C_{8/10}$
B	12	15	$C_{12/15}$

Notes
a H/D = ratio height/diameter of specimen
b H/D = 0.80 to 1.21

825 to 829 Not Used

830 Fly Ash Bound Mixture 1 (FABM 1) and Hydraulic Road Binder Bound Mixture 1 (HRBBM 1)

Not Used.

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

Not Used

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

833 (11/04) **Not Used**

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

Not Used

835 Slag Bound Mixtures B1-1, B1-2, B1-3 and B1-4 (SBM B1)

1 The mixture shall comply with

BS EN 14227-2 for SBM B1-1, SBM B1-2, SBM B1-3 or SBM B1-4, as specified in Appendix 7/1, and have binder constituent proportions complying with the requirements of Clause 811.

2 Aggregates shall comply with the requirements of Clause 820.

3 The strength after immersion shall be at least 80% of the non-immersed strength, when tested in accordance with the laboratory mixture design requirements specified in Clause 880.

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¶
2 (05/09) Aggregates shall comply with the requirements of Clause 820 and shall have a total mixture grading that complies with grading envelope Category G1 from BS EN 14227-1, Annex B, Figure B2 for 0/20 size mixtures, Figure B3 for 0/14 mm size mixtures or Figure B4 for 0/10 mm size mixtures.¶
¶
3 (05/09) The compacity of the mixture shall be at least 0.8, when calcula … [71]
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4 (05/09) The method of construction shall be in accordance with Clause 813 and 814.

5 (05/09) The laboratory mechanical performance shall comply with the requirements of Appendix 7/1, when sampled and tested in accordance with Clause 870.

836 to 839 Not Used

840 Soil Treated by Cement (SC)

1 The mixture shall be as specified in Appendix 7/1 and comply with the appropriate requirements selected from Table 8/13 and the following:

(i) BS EN 14227-10, for soil treated by cement (SC);

The mixture shall also have binder constituent proportions complying with the requirements of Clause 811.

2 Not less than 95% of the soil shall pass the 63 mm size test sieve when tested in accordance with EN 933-1 and the maximum particle size of the soil shall not exceed 25% of the layer depth.

3 When tested in accordance with TRL Report 447, Test No. 4, soil with a total potential sulfate (TPS) content less than 0.25% sulfate (as SO_4) shall be deemed suitable for treatment, if the laboratory mixture design procedure confirms that the mixture complies with the 'resistance to water' requirements specified in Table 8/13. Soil with a total potential sulfate (TPS) equal to or greater than 0.25% sulfate (as SO_4) shall only be deemed suitable for treatment where agreed by the Overseeing Organisation.

4 The method of construction shall be in accordance with Clause 813 and either Clause 814, Clause 815 or Clause 816.

5 (05/09) The laboratory mechanical performance shall comply with the requirements of Appendix 7/1, when sampled and tested in accordance with Clause 870.

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<#>BS EN 14227-13, for soil treated with hydraulic road binder (SHRB) ¶
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TABLE 8/13: Requirements for Soil Treated by Cement (SC)

Mixture parameter	Requirement Category		BS EN 14227-10
	Non-cohesive soil mixtures	Cohesive soil mixtures	
Minimum water content (Expressed as a proportion of the optimum water content, determined in accordance with BS EN 13286-4, Vibrating hammer method)	$W_{0,9}$	W_{NR} (Note 1)	Table 1
Degree of Pulverization (Determined in accordance with BS EN 13286-48)	$Pulv_{NR}$ (Note 1)	$Pulv_{60}$	Table 2
Immediate Bearing Index (Note 2) (Determined in accordance with Clause 880)	IPI_{40} (Note 3)	IPI_{15}	Table 3
Moisture Condition Value (Determined in accordance with BS EN 13286-46)	MCV_{NR} (Note 1)	$MCV_{8/12}$ at final mixing and compaction (Note 4)	Table 4
Laboratory mechanical performance (Compressive strength or tensile strength)	R_c or R_t,E, as specified in Appendix 7/1		Table 6 for R_c Figure 1 for R_t,E
Resistance to water - strength after immersion (R_i/R ratio, determined in accordance with Clause 880)	$I_{0.8}$		Table 7
Resistance to water - volumetric swelling (Determined in accordance with BS EN 13286-49)	NR (Note 1)	SC - G_{V5}	Table 9 (EN 14227-10)

NOTES:
1. The suffix $_{NR}$ denotes that the 'No requirement' category applies.
2. Where SC is not to be trafficked within 7 days, IPI_{NR} may be used.
3. IPI_{25} where the mixture is not subject to direct trafficking.
4. For cohesive soil mixtures, the requirement also applies during the mellowing period.

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841 to 869 Not Used

870 Testing, Control and Checking of HBM

General

1 Tests, controls and checks shall be carried out in accordance with the requirements in Table 8/14 and the following sub-Clauses at locations determined by the Overseeing Organisation, unless otherwise stated in Appendix 1/5. Where the Overseeing Organisation is satisfied that a consistent quality of work is being achieved it may order the frequency of testing to be reduced to half that required in Table 8/14. Where a test reference is shown in Table 8/14, the testing shall be carried out in compliance with the requirements of Clause 105 and be undertaken by an organisation accredited in accordance with BS EN ISO/IEC 17025 for the test method.

Sampling

2 Sampling shall be in accordance with BS1924-1. Where a bulk sample of HBM is taken from a layer, it shall be taken from the full depth of the layer, used without further mixing, and not combined with other bulk samples.

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

3 Not Used

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

4 Not Used

Standardisation of Nuclear Density Gauges and Measurement of In-situ Wet Density

5 The in-situ wet density of a compacted mixture shall be measured using a calibrated nuclear density gauge in accordance with BS 1924-2 and the following sub-Clauses, except that 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.

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 immediately prior to the construction of the demonstration area and at least once every 28 days thereafter.

7 The gauge shall be used in the direct transmission mode of operation with the source rod lowered to within 25 mm of the bottom surface of the layer. The in-situ wet density shall be determined within two hours of completing compaction.

8 The in-situ wet density of a subbase layer shall be taken as the average value of five determinations equally spaced along a line that bisects each 1000 m^2 or part thereof laid each day. The first and fifth positions shall be located 300 mm from the edges of the laid area, or other positions agreed by the Overseeing Organisation.

9 For a subbase layer, the average in-situ wet density of the area specified in sub-Clause 870.8 shall be not less than 95% of the average wet density of the test specimens taken to determine the laboratory mechanical performance of the same area.

10 For a base layer, the average in-situ wet density of the area specified in sub-Clause 870.8 shall be not less than 95% of the wet density of the HBM at its optimum moisture content, measured using the vibrating hammer method detailed in BS 13286-4. The result of each single determination of in-situ wet density shall be not less than 92% of the wet density of the HBM at its optimum moisture content.

Laboratory Mechanical Performance

11 A bulk sample of HBM shall be taken from each of the locations in sub-Clause 870.8, after the in-situ wet density has been determined. Test specimens used to determine laboratory mechanical performance shall be made using vibratory hammer compaction, in accordance with BS EN 13286-51. Where cubes are used for the determination of compressive strength, the specimens shall be 150 mm size, unless agreed otherwise by the Overseeing Organisation.

Deleted: 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 the spreading machine. The trays (or mats) shall be positioned at points equally spaced along a diagonal bisecting line the area of coverage so as to assess the full width of discharge from the spreading machine.

Deleted: The depth of mixing shall be checked by excavation and inspection on completion of each stage of the pulverizing-mixing process. The depth of mixing shall be referenced to the design levels for the pavement by precise leveling of the stabilized soil interface (or other techniques approved by the Overseeing Organisation) to ensure that the level at the underside of the stabilized layer is in accordance with the specified requirements.

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TABLE 8/14: Requirements for Testing, Control and Checking of HBM

Test/control/check	Test frequency	Test reference
Water content of aggregate or soil sources on site	3 per 1000 m^2	BS 1924-1, Clause 7.1
Grading of aggregate or soil sources on site	1 per 1000 m^2	Aggregates: EN 1097-5 Soils: BS 1924-1, Clause 7.1
Plasticity of aggregate or soil sources on site	1 per 1000 m^2	BS 1924-1, Clause 7.3
Constituents sourced off-site	Aggregates - Results of routine control tests from the factory production control system required by BS EN 13242, Annex C to be provided weekly. Cement - Certificates to be provided monthly for each cement type, in accordance with BS EN 197-1, UK National Annex NB. Slag – Not Used Fly ash – Not Used Other constituents - certificates to be provided weekly to confirm compliance with the specification agreed as part of the factory production control system for the mixture.	-
Batching records for 'mix-in-plant' method of construction using batching by mass	Continuously using the automated surveillance and data collection system	-
Batching records for 'mix-in-plant' method of construction using batching by volume	Dispensing accuracy shall be verified by reconciliation between constituent deliveries and the area and depth of completed layer for each 5000m^2 of work, or part thereof, during each day's operation	-
Spread checks for 'mix-in-place' method of construction at each stage of the mixing process (sub-Clause 870.3)	Not Used	-
Mixture grading, including binder	1 per 1000 m^2 but not less than 3 per day	BS EN 933-1
Water content at final compaction	1 per 1000 m^2 but not less than 3 per day	BS 1924-2, Clause 1.3
MCV at mixing and final compaction and, in the case of cohesive mixtures, during the mellowing period	3 per 1000 m^2 but not less than 4 per day	BS EN 13286-46
Pulverization (cohesive mixtures only)	Not Used	BS EN 13286-48
Depth of mixing for 'mix-in-place' method of construction at each stage of the mixing process (sub-Clause 870.4)	Not Used	-
In-situ wet density	5 per 1000 m^2 or part thereof laid each day (measured at the locations detailed in sub-Clause 870.8)	Sub-Clause 870.5
Laboratory mechanical performance	5 per 1000 m^2 or part thereof laid each day (with test specimens prepared from a bulk sample taken from each of the locations detailed in sub-Clause 870.8)	As required by Table 8/15
Strength after immersion in water	Laboratory mixture design procedure	As required by Clause 880

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Table 8/15: Laboratory Mechanical Performance Testing Requirements for HBM

Clause	Mixture	Curing regime	Curing temperature	Test method	Age at test
821, 822 & 823	CBGM A, CBGM B and CBGM C	Regime A from, BS EN 14227-1, Annex C	20°C	R_C - BS EN 13286-41	28 days - or other age agreed by the Overseeing Organisation (see Note)
830, 831, 832 & 835 - Not Used	SBM, HRBBM (Not Used) and FABM (Not Used), Except FABM 5 (Not Used)	BS EN 13286-51	40°C		
	FABM 5 treated with lime (Not Used)	BS EN 13286-51	40°C		
834 - Not Used	FABM 5 treated with cement (Not Used)	BS EN 13286-51	20°C	R_{it} - BS EN 13286-42	
840 – SC only	SC	Regime A1 from BS EN 14227-10, Annex B	20°C	E_c - BS EN 13286-43	
	SS & SFA (Not Used)	BS EN 13286-51	40°C		

NOTE:
For site control purposed, HBM may be assessed on the basis of 7 days strength (or other agreed age) where the Contractor so requests, provided that a robust correlation is established between 7 days and 28 days strength using representative samples of the aggregates and binder used in the works.

12 Compliance of the area specified in sub-Clause 870.8 shall be assessed using the results for test specimens that are cured and tested in accordance with Table 8/15 using either compression or indirect tensile testing as appropriate to the class of mechanical performance specified in Appendix 7/1. Assessment shall be made using the following criteria:

(i) Compressive strength:

The requirement specified in Appendix 7/1 shall be deemed to be satisfied if the average compressive strength of the group of specimens in Table 8/14 is equal to or greater than the minimum for the specified R_c class and no individual test result is less than 67% of the minimum strength requirement for the R_c class.

(ii) Indirect tensile strength:

The requirement specified in Appendix 7/1 shall be deemed to be satisfied if the average indirect tensile strength of the group of specimens in Table 8/14 is equal to or greater than the minimum requirement and no individual result is less than 67% of the minimum requirement appropriate to the E value determined during the laboratory mixture design procedure specified in Clause 880.

For the purposes of this specification, any reference to 'characteristic strength' in BS EN14227-1 shall be superseded by the requirements of this sub-Clause.

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871 Determination of the Coefficient of Linear Thermal Expansion

Scope

1 The test method described in this Clause shall be used to determine the coefficient of linear thermal expansion of HBM within the normal range of temperature for pavement layers. The test method shall be carried out using hardened specimens.

Apparatus

2 The following apparatus shall be used:

(i) A water bath with sufficient capacity to accommodate three test specimens and capable of maintaining predetermined temperatures between 15ºC and 60ºC.

(ii) A device capable of measuring linear dimensions of not less than 275 mm to an accuracy of ± 0.002 mm, with a known temperature correction factor.

(ii) Vibrating hammer compaction apparatus capable of producing 150 mm diameter cylindrical test specimens, in accordance with BS EN 13286-51. The apparatus shall be suitably modified to manufacture 300 mm long test specimens.

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Test procedure

3 The following test procedure shall be followed:

(i) Compact three 150 mm diameter test specimens, 300 mm in length, in accordance with BS EN 13286-51 but using six layers, each with a nominal depth of 50 mm.

(ii) Mark each specimen with 3 pairs of permanent reference points, aligned longitudinally. One of each pair shall be at opposite ends of the specimen. Each pair shall be located at 120º around the circumference of the specimens, aligned parallel to the axis, and not more than 30 mm from each end of the specimen.

(iii) Cure the specimens using the procedure specified for the determination of mechanical laboratory performance in Table 8/15.

(iv) Saturate the test specimens, either at atmospheric pressure or under vacuum, until the increase in the surface dried mass of each specimen, determined using two readings taken at least 24 hours apart, is less than 1%.

(v) Immerse the specimens in the water bath at a constant temperature (T1), maintained to an accuracy of ± 2ºC, for 24 ± 2 hours. Then measure the length (L1) of each test specimen at the locations defined by the three pairs of reference points. Repeat the measurement of length every 24 hours, until the change in length between successive measurements is less than 0.004 mm.

(vi) Raise the temperature of the water bath by at least 30ºC and record the temperature (T2). T2 shall not exceed 55ºC. Maintain the temperature at T2 ± 2ºC for 24 ± 2 hours and measure the length (L2) using the procedure in (v).

(vii) Lower the temperature of the water bath by at least 30ºC and record the temperature (T3). Maintain the temperature at T3 ± 2ºC for 24 ± 2 hours and measure the final length (L3) using the procedure in (v).

Calculations

4 Calculate the Coefficient of Linear Thermal Expansion (C_{LE}) as follows:

(i) For each pair of reference points for the heating sequence calculate:

$C_{LE}' = (L2 - L1) / (T2 - T1)$, giving 9 results in total.

(ii) Reject the highest and lowest results and record the mean value of C_{LE}' for the remaining 7 results.

(iii) For each pair of reference points for the cooling sequence calculate:

$C_{LE}'' = (L2 - L3) / (T2 - T3)$, giving 9 results in total.

(iv) Reject the highest and lowest results and record the mean value of C_{LE}'' for the remaining 7 results.

(v) Calculate:

C_{LE} = 0.5 ((Mean value of C_{LE}') + (Mean value of CLE´´)).

(vi) Check that the mean values of C_{LE}' and C_{LE}'' lie in the range $0.95C_{LE}$ to $1.05C_{LE}$. If the mean values lie outside this range, repeat the procedure in sub-Clause 871.3.

Reporting of Results

5 Report the value of C_{LE} using units of $m.10^{-6}/ºC$, expressed to the nearest whole number.

872 to 879 Not used

880 Laboratory Mixture Design Procedure

1 Prior to the commencement of the work or any change in mixture constituents, the Contractor shall determine the target proportions of the constituents, including water, for the specified HBM, based on the mixture design procedure described in this Clause.

2 The mixture design procedure shall determine the properties of the HBM at a minimum of 3 values of binder contents, and a minimum of 2 values of water content for each value of binder content.

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Immediate Stability

3 When required, the mixture design procedure shall include the determination of the immediate bearing index (IBI) at the selected design water and binder content, measured in accordance with BS EN 13286-47. The IBI value shall be taken as the average value for a set of 3 test specimens.

Resistance to Water – Strength After Immersion

4 The strength after immersion in water shall be assessed by comparing the average strength and condition of:

(i) 3 specimens initially cured in a sealed condition for 14 days at the test temperature; and then removed from their moulds and immersed in aerated water for 14 days at the same test temperature.

(ii) 3 specimens cured in sealed condition for 28 days at the same test temperature.

The immersed specimens shall be unconfined and have water in contact with all surfaces. On completion of the immersion stage of the test the specimens shall show no signs of cracking or swelling.

5 For mixtures containing less than 3% by dry mass of the mixture of cement, the test temperature shall be (40 ± 2)ºC. For mixtures containing 3% or more cement, the test temperature shall be (20 ± 2)ºC.

Resistance to Frost Heave

Not Used

Deleted: (05/09) HBM shall be deemed resistant to frost heave where the compressive strength class is C3/4 or greater or R_{it} is greater than 0.25 MPa, when cured in accordance with Table 8/15.

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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		MS35

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Volume stability of blast furnace					
slags					
Volume stability of steel (BOF and EAF) slags					

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requirements		Category $_{NR}$ (no requirement).			

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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

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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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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

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when used with another

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	when used as the only binder in FABM 5	3%	4%
Cement	when used with another binder constituent	2%	3%

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	when used as the only binder constituent in soil treated by cement (SC)	3%	4%

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when used with cement

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when used with lime

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when used with GBS

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when used with cement

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	when used with lime	5%	6%

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when used with lime

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	when used with ASS (see Note)	2.5%	3%

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(05/09) G

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BS and ASS shall be stored as specified in sub-Clause 812.1 and used within 3 months of delivery to the production location.

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HBM shall not be laid on a frozen surface

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	832	Not restricted provided that the IBI requirement of sub-Clause 832.6 is satisfied.

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		least 150mm of bound material within the construction period.

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Only the minimum amount of traffic required

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to construct the next layer is permitted.

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requirements of Table 8/13 are satisfied.

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		For mixtures containing cohesive soil or chalk, the test specimens made at the same time as the specimens required in Clause 870 but cured under the same conditions as the insitu treated soil shall also have achieved an average strength of at least Class C0.8/1.0.

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1 (05/09) Cement bound granular mixtures C (CBGM C) shall comply with BS EN 14227-1, and have binder constituent proportions complying with the requirements of Clause 811.

2 (05/09) Aggregates shall comply with the requirements of Clause 820 and shall have a total mixture grading that complies with grading envelope Category G1 from BS EN 14227-1, Annex B, Figure B2 for 0/20 size mixtures, Figure B3 for 0/14 mm size mixtures or Figure B4 for 0/10 mm size mixtures.

3 (05/09) The compacity of the mixture shall be at least 0.8, when calculated in accordance with BS EN 14227-2, Annex C. The maximum dry density value used for the calculation shall be determined in accordance with BS EN 13286-50, using the modified Proctor (4.5 kg rammer) procedure from BS EN 13286-2.

4 (05/09) The strength after immersion shall be at least 80% of the non-immersed strength, when tested in accordance with the laboratory mixture design requirements specified in Clause 880.

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5 The method of construction shall be in accordance with Clause 813 and Clause 814.

6 The laboratory mechanical performance shall comply with the requirements of Appendix 7/1, when sampled and tested in accordance with Clause 870.

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1 The mixture shall comply with the requirements of BS EN 14227-2 for Slag Bound Mixture B2 or the requirements of BS EN 14227-3 for Fly Ash Bound Mixture 2 or the requirements of BS EN 14227-5 for Hydraulic Road Binder Bound Mixture 2, as specified in Appendix 7/1, and have binder constituent proportions complying with the requirements of Clause 811.

2 (05/09) Aggregate shall comply with the requirements of Clause 820.

3 (05/09) SBM B2 shall have a total mixture grading that complies with grading envelope Category G1 or G2 from BS EN 14227-2, Figure 5 for 0/20 size mixtures, Figure 6 for 0/14 mm size mixtures or Figure 7 for 0/10 mm size mixtures..

4 (05/09) FABM 2 shall have a total mixture grading that complies with grading envelope Category G1 or G2 from BS EN 14227-3, Figure 3 for 0/20 size mixtures, Figure 5 for 0/14 mm size mixtures or Figure 7 for 0/10 mm size mixtures.

5 (05/09) HRBBM 2 shall have a total mixture grading that complies with grading envelope

Category G1 or G2 from BS EN 14227-5, Figure 2 for 0/20 mm size
mixtures, Figure 3 for 0/14 mm size mixtures and Figure 4 for 0/10 mm size mixtures

6 (05/09) The strength after immersion shall be at least 80% of the non-immersed strength, when tested in accordance with the laboratory mixture design requirements specified in Clause 880.

7 (05/09) The method of construction shall be in accordance with Clauses 814 and 813.

8 (05/09) The laboratory mechanical performance shall comply with the requirements of Appendix 7/1, when sampled and tested in accordance with Clause 870.

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1 (05/09) The mixture shall comply with the requirements of BS EN 14227-2 for Slag Bound Mixture B3 or the requirements of BS EN 14227-3 for Fly Ash Bound Mixture 3 or the requirements of

BS EN 14227-5 for Hydraulic Road Binder Bound Mixture 3, as specified in Appendix 7/1, and have binder constituent proportions complying with the requirements of Clause 811.

2 (05/09) Aggregate shall comply with the requirements of Clause 820.
6 (05/09) The mixture design procedures specified in Clause 880 shall include the determination of the immediate bearing at the target water and binder content. The mixture shall comply with Immediate Bearing Index Category IPI_{40}. When approved by the Overseeing Organisation, and where the mixture is not subject to direct trafficking, the mixture shall comply with Immediate Bearing Index Category IPI_{25}.

7 (05/09) The requirements of Clause 832.6 shall not apply if the mixture contains at least 3% cement by mass of the dry mixture and traffic is not permitted to use the layer for the first 7 days.

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the requirements of Appendix 7/1,

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1 (05/09) The mixture shall comply with

BS EN 14227-3 for Fly Ash Bound Mixture 5, and have binder constituent proportions complying with the requirements of Clause 811.

2 (05/09) The strength after immersion shall be at least 80% of the non-immersed strength, when tested in accordance with the laboratory mixture design requirements specified in Clause 880.

3 (05/09) For lime-treated fly ash mixtures with gypsum added as an additional constituent, the method of construction shall be in accordance with Clause 813 and 814. For other mixtures, the method of construction permitted shall comply with Clause 813 and either Clause 814, Clause 815 or Clause 816.

4 (05/09) The laboratory mechanical performance shall comply with the requirements of Appendix 7/1, when sampled and tested in accordance with Clause 870.

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Annex NB.

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declared values required by BS EN 14227-2, Clause 5.

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compliance with the requirements of BS EN 14227-4.