SERIES 800
ROAD PAVEMENTS – UNBOUND, CEMENT AND OTHER HYDRAULICALLY BOUND MIXTURES

Contents

ROAD PAVEMENTS – UNBOUND, CEMENT AND OTHER HYDRAULICALLY BOUND MIXTURES

801 (02/16) General Requirements for Unbound Mixtures

(11/21) Unbound Mixtures for Subbase

1 (11/21) This Series is part of the Specification for Highway Works. Whilst this Series is particularly relevant to the subject matter in its title it shall be read in conjunction with the general requirements in Series 000 and 100 and with all other Series relevant to the specification for the particular works to be undertaken.

2 (11/21) Unbound mixtures shall be made and constructed to conform to BS EN 13285, the requirement categories in Table 8/1 and Clauses 802 to 807.

TABLE 8/1: (11/21) **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					
1) Designation	0/31,5 or 0/20	0/31,5	0/40	0/31,5	0/31,5
2) Maximum fines	UF_9 *or* UF_{12}	UF_9	UF_5	UF_9	UF_9
3) Oversize	OC_{75}	OC_{75}	OC_{80}	OC_{80}	OC_{75}
Grading requirement category 1) Overall grading	G_P	G_E	G_O	G_B	G_P

3 (11/21) The permitted alternatives for each part of the permanent works shall be as described in contract specific Appendix 7/1.

4 (11/21) The properties of aggregates used in unbound mixtures shall comply with the selected requirements of BS EN 13242 listed in Table 8/2.

TABLE 8/2: (11/21) **Requirements for Aggregates Used in 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				
Crushed, or broken and totally rounded particles – crushed rock, crushed manufactured and crushed recycled aggregates (see NOTE 1)	$C_{90/3}$	$C_{90/3}$	$C_{90/3}$		$C_{90/3}$
Crushed, or broken and totally rounded particles - crushed gravel	$C_{50/10}$ – see NOTE 2	C_{NR} (no requirement)	Not permitted		Not permitted
Resistance to fragmentation – Los Angeles test	LA_{50}	LA_{50}	LA_{30}		LA_{50}
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	V_5	Not permitted		V_5
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 contract specific Appendix 7/1.

5 (11/21) Where recycled coarse aggregate or recycled concrete aggregate is used in unbound mixtures complying with Clauses 802 to 807 as appropriate, it shall have been tested in accordance with Clause 710.

6 (11/21) Recycled coarse aggregate and recycled concrete aggregate used in unbound mixtures in accordance with Clauses 803, 804 and 807 shall also comply with the requirements of Table 8/3.

TABLE 8/3 (11/21) **Requirements for Recycled Coarse Aggregate and Recycled Concrete Aggregate Used in Type 1, Type 2 and Type 4 Unbound Mixtures**

Unbound Mixture	**Type 1**	**Type 2**	**Type 4 (asphalt arisings)**
Clause	**803**	**804**	**807**
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		
Floating Materials	≤ 5 cm^3/kg		

7 (11/21) The unbound mixture shall satisfy the minimum surface modulus requirement of contract specific Appendix 7/1 when tested in accordance with Procedure A in Clause 885.

8 (11/21) The mixture shall be tested at the density and moisture content likely to develop in equilibrium field conditions which will 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.

(11/21) **Limitations to Use**

(11/21) **Water-soluble sulphate**

9 (11/21) Unbound mixtures placed within 500 mm, or any other distances described in contract specific Appendix 7/1, of concrete, cement bound materials, other cementitious mixtures or stabilised capping forming part of the permanent works shall conform to requirements A and B below:

A Mixtures shall conform to the following two criteria:

(i) Water-soluble sulfate (WS) content determined in accordance with BS EN 1744-1 clause 10 not to exceed 1500 mg of sulfate (as SO_4) per litre;

(ii) Total sulfur (TS) content determined in accordance with BS EN 1744-1 clause 11 expressed as (S) not to exceed 1% for aggregates other than air cooled blast furnace slag or 2% for air cooled blast furnace slag.

B Mixtures shall conform to at least one of the following two options:

(i) When described in accordance with BS EN 932-3 and BS EN 13242 Annex A, limestone, chalk, dolomite, blast furnace slag, steel slag or crushed concrete are predominant; or

(ii) The sulfide content of the mixture determined in accordance with BS EN 1744-1 clause 13 is less than 0.5% (as SO_4).

10 (11/21) When determining WS, TS or sulfide content, at least five samples of each material shall be tested. The mean of the highest two values to 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 to be used for comparison with the limiting values. The pH of the mixture shall be reported.

11 (11/21) Unbound mixtures placed within 500mm, or any other distances described in contract specific Appendix 7/1, of metallic structural elements forming part of the permanent works shall conform to requirements C and D below.

C Mixtures shall conform to the following two criteria:

(i) Water-soluble sulfate (WS) content determined in accordance with BS EN 1744-1 clause 10 to not exceed 300 mg of sulfate (as SO_4) per litre;

(ii) Total sulfur (TS) content determined in accordance with BS EN 1744-1 clause 11 expressed as (S) to not exceed 1% for aggregates other than air cooled blast furnace slag or 2% for air cooled blast furnace slag.

D Mixtures shall conform to at least one of the following two options:

(i) When described in accordance with BS EN 932-3 and BS EN 13242 Annex A, limestone, chalk, dolomite, blast furnace slag, steel slag or crushed concrete are predominant;

or

(ii) The sulfide content of the mixture determined in accordance with BS EN 1744-1 clause 13 is less than 0.06% (as SO_4).

12 (11/21) When determining WS, TS or sulfide content, at least five samples of each material shall be tested. The mean of the highest two values to 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 to be used for comparison with the limiting values. The pH of the mixture to be reported.

13 (11/21) 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.

(11/21) **Frost Heave**

14 (11/21) Subject to the tolerances given in Table 7/1 and unless otherwise stated in contract specific 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.

15 (11/21) 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. Comparator specimens in accordance with Annex B of BS 812-124 will be used.

(11/21) **Aluminium Particles**

16 (11/21) Mixtures containing manufactured aggregates, other than air-cooled blast furnace slag and steel slag, covered with less than 150 mm asphalt shall meet the requirements of Table 8/4.

TABLE 8/4 (11/21) **Requirements for mixtures containing manufactured aggregates**

Constituent	Requirement	Test procedure
Aluminium particles	None retained on 14 mm sieve	Clause 801.17 – 18

17 (11/21) The following test procedure shall be followed.

(i) Obtain test portion in accordance with BS EN 932-1 1997, with a minimum mass of 10 kg.

(ii) Pass the test portion over a 14 mm test sieve conforming to BS EN 933-2 1999, discard particles passing the 14 mm sieve.

(iii) Spread particles retained on the 14 mm sieve onto a clean flat surface.

(iv) Separate by hand any aluminium particles and agglomerated particles that contain a portion of aluminium.

(a) Discard non-aluminium particles and agglomerated particles that do not contain a portion of aluminium.

(b) Place any aluminium particles in a tray.

(v) Separate the aluminium fraction from any agglomerated particles.

(a) Add any non-separated agglomerated particles to the tray.

(b) Discard any resulting non-aluminium fraction.

(c) Re-pass any resulting aluminium fraction over the 14 mm sieve and discard particles passing the 14 mm sieve.

(d) Add any resulting aluminium fraction retained on the 14 mm sieve to the tray.

(vi) The particles in the tray are classified as aluminium particles retained on 14 mm sieve.

18 (11/21) The test report shall include the following information:

(i) reference to this Clause;

(ii) name and location of the sample source;

(iii) date of sampling;

(iv) mass of test portion (kg);

(v) date of test;

(vi) number of aluminium particles retained on 14 mm sieve;

(vii) description of any retained particles.

802 (02/16) Transport, Laying, Compaction and Trafficking of Unbound Mixtures

(02/16) **Transporting**

1 (02/16) 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.

(02/16) **Laying**

2 (11/21) Unbound mixtures in a frozen condition shall not be incorporated in the works but may be used, if acceptable, when thawed.

3 (11/21) Unbound mixtures shall not be laid on any surface which is frozen or covered with ice.

4 (11/21) All unbound mixtures shall be placed and spread evenly.

5 (11/21) Spreading shall be undertaken either concurrently with placing or without delay.

6 (11/21) 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.

7 (11/21) Except where otherwise stated in contract specific 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.

8 (11/21) 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 to be 110 mm.

9 (11/21) Where the layers of unbound mixtures are of unequal thickness, the lowest layer shall be the thickest layer.

(02/16) **Compaction**

10 (11/21) Compaction shall be completed after the mixture has been spread and in accordance with the requirements for the individual mixtures.

11 (11/21) Full compaction shall be obtained over the full area including in the vicinity of both longitudinal and transverse joints.

12 (11/21) Compaction of unbound mixtures shall be carried out by a method specified in Table 8/5, unless it is demonstrated at site trials that a state of compaction achieved by an alternative method is equivalent to or better than that using the specified method.

13 (11/21) 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.

14 (11/21) All loose, segregated or otherwise defective areas shall be removed to the full thickness of the layer, and new material laid and compacted.

15 (11/21) For the purposes of Table 8/5 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 is 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 8/5 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 is 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 is 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 is 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:

(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 need to 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 is half the number given in Table 8/5 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 to 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 are to be classified as smooth-wheeled rollers.

(d) Vibratory rollers are to be operated with their vibratory mechanism operating at the frequency of vibration recommended by the manufacturer. All such rollers to be equipped, or provided with devices indicating the frequency at which the mechanism is operating and the speed of travel. Both devices to be capable of being safely 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 re to be operated at the frequency of vibration recommended by the manufacturer. They will normally be operated at travelling speeds of less than 1 km/h but if higher speeds are necessary, the number of passes are tol 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 is 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 is to be such proportion of the appropriate number in Table 3.15 (8/5) as will together produce the same total compactive effort as any one operated singly.

TABLE 8/5: (11/21) **Compaction Requirements for Unbound Mixtures**

Type of Compaction Plant	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	12	12

(02/16) **Use of Surfaces by Construction Plant and Other Traffic**

16 (11/21) 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.

17 (11/21) The wheels or tracks of plant moving over the various pavement courses shall be kept free from deleterious materials.

18 (11/21) Where it is proposed to use the unbound mixture layers for construction plant these layers shall be improved to accommodate the method of construction and the type of plant and vehicles which are to be used, in order to avoid damage to the laid layer(s), any capping and the subgrade.

19 (11/21) Any permanent thickening shall be across the whole width of the pavement.

20 (11/21) Temporary thickening shall not impede drainage of any layer or the subgrade.

(02/16) **Trafficking Trial**

21 (11/21) When required by contract specific Appendix 7/1, a Trafficking Trial shall be undertaken incorporating the unbound mixture proposed for use in the permanent works.

22 (11/21) A trial area shall be constructed, trafficked and assessed in accordance with the procedure described in sub-Clauses 25 to 29 of this Clause.

23 (11/21) 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 31 to 33 of this Clause.

24 (11/21) Proposals for trafficking trials shall be submitted to the Overseeing Organisation for review and acceptance five days in advance of construction.

(02/16) **Trial Procedure**

25 (11/21) 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 19 of this Clause.

26 (11/21) The trial area shall be at least 60 m long, and of sufficient width that when trafficked, the wheel paths of the test vehicle are at least 1 m from either edge of the top of the unbound mixture layer.

27 (11/21) The unbound mixture layer shall be compacted to the thickness specified in contract specific Appendix 7/1.

28 (11/21) The formation shall extend for a further 1 m either side of the unbound mixture layer.

29 (11/21) 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 is to 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.

(02/16) **Mixtures**

30 (11/21) The unbound mixture used in the trial shall be transported, laid and compacted using the equipment proposed for use in the works.

31 (11/21) 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.

32 (11/21) The transverse lines at the ends of the trial area shall be at least 5 m from the run off/run on areas.

33 (11/21) The average deformation of the two wheel tracks after 1000 standard axles shall be recorded.

(02/16) **Reporting and Acceptance of Trafficking Trial Area**

34 (11/21) A report on the Trafficking Trial, stating how the use of the unbound mixture was validated shall be provided.

35 (11/21) The main construction of the permanent works shall not start until the Trafficking Trial area has been accepted by the Overseeing Organisation.

803 (11/21) Type 1 Unbound Mixtures

1 (11/21) Type 1 unbound mixture shall be made from crushed rock, crushed slag, crushed concrete, recycled aggregates, manufactured 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 contract specific Appendix 7/1, crushed gravel complying with sub-Clause 803.7 may be used.

2 (11/21) The mixture shall meet the requirements of BS EN 13285 and Table 8/1. The grading requirements for the mixture are summarised in Tables 8/6a or 8/6b. Table 8/6b shall only be used for trench reinstatements and narrow widenings less than 1 m.

Table 8/6a (11/21) **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

Table 8/6b (11/21) **Summary Grading Requirements for Type 1 F Unbound Mixtures (0/20)**

Sieve size, mm	Percentage by mass passing		
	Overall grading range	Supplier declared value grading range	Tolerance on the supplier declared value
40	100	-	-
20	75 – 99	-	-
10	43 – 81	54 – 72	±15
4	23 – 66	33 – 52	±15
2	12 – 53	21 – 38	±15
1	6 – 42	14 – 27	±13
0.5	3 – 32	9 – 20	±10
0.063	0 – 12	-	-
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
4	10	7	30
2	4	7	30

3 (11/21) The properties of aggregates used in the mixture shall be in accordance with BS EN 13242 and the requirements of Table 8/2.

4 (11/21) 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 (11/21) Mixtures containing recycled coarse aggregate, or recycled concrete aggregate, shall meet the requirements of sub-Clause 801.5 and 801.6.

6 (11/21) The mixture shall be transported, laid and compacted without drying out or segregation.

7 (11/21) All mixtures shall meet the minimum surface modulus requirement in sub-Clause 801.7.

804 (02/16) Type 2 Unbound Mixtures

1 (11/21) Type 2 unbound mixture shall be made from natural sands, gravels, crushed rock, crushed slag, crushed concrete, recycled aggregates, manufactured aggregates or well burnt non-plastic shale.

2 (11/21) 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 (11/21) **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 supplier 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 (02/16) The properties of aggregates used in the mixture shall be in accordance with BS EN 13242 and the requirements of Table 8/2.

4 (02/16) 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 (11/21) Where the mixture contains recycled coarse aggregate or recycled concrete aggregate, it shall comply with sub-Clause 801.5 and 801.6.

6 (11/21) All mixtures shall meet the minimum surface modulus requirement in sub-Clause 801.7.

7 (02/16) 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 (02/16) Type 3 (open graded) Unbound Mixtures

1 (11/21) Type 3 (open graded) unbound mixture shall be made from crushed rock, crushed blast furnace slag, manufactured aggregates 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).

2 (11/21) 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: (11/21) **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 supplier 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

3 (02/16) The properties of aggregates used in the mixture shall be in accordance with BS EN 13242 and the requirements of Table 8/2.

4 (02/16) 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 (02/16) The mixture shall be transported, laid and compacted without drying out or segregation.

806 (02/16) Category B (close graded) Unbound Mixtures

1 (11/21) Category B (close graded) unbound mixture shall be made from crushed rock, crushed blast furnace slag, manufactured aggregates 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 (Class Ra) and not more than 1% other materials (Class X).

2 (11/21) 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 8/9.

Table 8/9 (11/21) **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 supplier declared value**
80	100	-	-
40	80 – 99	-	-
20	55 – 85	63 – 77	±8
10	35 – 68	43 – 60	±8
4	22 – 60	30 – 52	±8
2	16 – 47	23 – 40	±7
1	9 – 40	14 – 35	±5
0.5	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
10	16	10	25
4	8	10	25
2	4	7	20
1	2	4	15

3 (02/16) The properties of aggregates used in the mixture shall be in accordance with BS EN 13242 and the requirements of Table 8/2.

4 (02/16) 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 (02/16) The mixture shall be transported, laid and compacted without drying out or segregation.

807 (02/16) Type 4 (asphalt arisings) Unbound Mixtures

1 (11/21) Type 4 unbound mixture shall be made from recycled aggregates containing asphalt arisings, and may contain crushed rock, crushed slag, manufactured aggregates, crushed concrete or well burnt non-plastic shale and up to 10% by mass of natural sand that passes the 4 mm size test sieve.

2 (02/16) Asphalt arisings shall be either asphalt road planings or granulated asphalt, but excluding materials contaminated with 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 (11/21) Type 4 unbound mixture shall have an asphalt (Class Ra) content greater than 50% when tested in accordance with Clause 710.

4 (11/21) The recovered bitumen content of the asphalt shall be not more than 10% when tested in accordance with BS EN 12697-1.

5 (11/21) 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 8/6a.

6 (11/21) The properties of aggregates used in the mixture shall be in accordance with BS EN 13242 and the requirements of Table 8/2.

7 (11/21) 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.

8 (11/21) Where the mixture contains recycled coarse aggregate or recycled concrete aggregate, it shall comply with sub-Clause 801.5 and 801.6.

9 (11/21) 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 to be determined by oven drying at a reduced temperature setting of 45ºC to 50ºC.

10 (11/21) Where required by contract specific Appendix 7/1, Type 4 unbound mixtures shall be assessed using a trafficking trial complying with sub-Clause 802.21.

808 and 809 (02/16) Not Used

(02/16) Cement and Other Hydraulically Bound Mixtures

810 (02/16) General Requirements for Cement and Other Hydraulically Bound Mixtures

1 (11/21) Cement and other hydraulically bound mixtures (HBM) shall be produced, constructed and tested in accordance with the following Clauses.

2 (11/21) The permitted alternatives for each part of the works shall be as described in contract specific Appendix 7/1.

3 (11/21) Attributes shall be deemed to have a "No requirement" classification unless stated otherwise.

4 (11/21) The terms listed below in Table 8/10 shall apply to the HBM Clauses of this specification.

TABLE 8/10 (11/21) **Hydraulically Bound Mixture Terminology**

ASS	air cooled steel slag
CBGM	cement bound granular mixture
CBR	Californian Bearing Ratio
CFA	cement treated fly ash
E	modulus of elasticity
FA	fly ash (also known as 'pulverized fuel ash')
FABGM	fly ash bound granular mixture
G_{vxx}	volumetric expansion category
GBS	granulated blast furnace slag
GGBS	ground granulated blast furnace slag
HBM	hydraulically bound mixture
HBGM	hydraulically bound granular mixture
HRB	hydraulic road binder (factory blended hydraulic binder for road use)
HRBBGM	hydraulic road binder bound granular mixture
HSS	hydraulically stabilised soils
IBI	immediate bearing index
Imm_{xx}	immersion category
IPI_{xx}	immediate bearing index category
LA	Los Angeles coefficient
LFA	lime treated fly ash
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 Rt and E. Classes of Rt,E are designated T0 to T5, in BS EN 14227, where T designates Rt,E and the number indicates the performance class
SBGM	slag bound granular mixture
t	time (hours) at constant temperature in defining maturity for calculating the construction period
TºC	ambient air temperature in defining maturity for calculating construction period
W_{xx}	water content category

5 (11/21) HBM shall be tested in accordance with Clause 870 and the test methods specified in the following Clauses.

6 (11/21) Before work commences, a method statement shall be submitted 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 contract specific 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.

7 (11/21) The coefficient of linear expansion of the mixture shall be determined in accordance with Clause 871.

811 (02/16) Binder Constituents

1 (11/21) Binder constituents, other than lime, shall comply with BS EN 14227.

2 (11/21) Lime shall comply with BS EN 459-1

3 (11/21) Quicklime shall have a grading that complies with BS EN 459-1 – Category P2.

4 (11/21) The minimum binder content shall be those given in Table 8/11.

TABLE 8/11 (11/21) **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)	when used with another binder constituent	1.5%	2%
	when used as the only binder in Fly Ash Bound Granular Mixture (FABGM) 5	3%	4%
Cement	when used with another binder constituent	2%	3%
	when used as the only binder constituent in Cement Bound Granular Mixtures (CBGM)	3%	4%
	when used as the only binder constituent in Hydraulically Stabilised Soils (HSS)	3%	4%
Ground granulated blast furnace slag (GGBS)	when used with cement	2%	3%
	when used with lime	3%	4%
Air-cooled steel slag (ASS)	when used with GBS (see Note)	2.5%	3%
Dry fly ash (FA)	when used with cement	4%	5%
	when used with lime	5%	6%
Granulated blast furnace slag (GBS)	when used with lime	6%	8%
	when used with ASS (see Note)	2.5%	3%
Wet (conditioned) fly ash (FA)	All applications	6%	8%
Hydraulic road binder	All applications	3%	4%
NOTE: When GBS and ASS are used in combination, the sum of the two shall be not less than 11%.			

5 (11/21) The mixture proportions used for production shall be based on a laboratory mixture design procedure in accordance with Clause 880.

812 (02/16) Storage of Constituents

1 (11/21) Aggregates shall be stored on a firm and clean substrate avoiding contamination with other constituents.

2 (11/21) Fine aggregate shall be stored at the production location for at least 24 hours before use.

3 (11/21) Lime, cement, GGBS, HRB and dry FA shall be stored in silos.

4 (11/21) Wet (conditioned) FA shall have no agglomerations greater than 10 mm size. This is to be determined by sieving samples through a 10 mm size test sieve using not more than 10 seconds of gentle agitation by hand.

5 (11/21) Wet fly ash shall be stored at the source or at the production location for at least 72 hours before use, and have a minimum water content of 10%.

6 (11/21) GBS and ASS shall be stored as specified in sub-Clause 812.1 and used within 3 months of delivery to the production location.

813 (02/16) General Requirements for Production and Layer Construction

1 (11/21) HBM shall be produced and laid using one of the following methods:

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

(ii) mix-in-plant method of construction using volume batching, in accordance with Clause 815;

(iii) mix-in-place method of construction, in accordance with Clause 816.

2 (11/21) Construction of layers, including multiple lift layers, and any reworking and reuse, shall be completed within the lesser of 8 hours, the construction period specified in Table 8/12 or the mixture setting time.

3 (11/21) The time shall be measured from the addition event defined in Table 8/12 to completion of compaction.

4 (11/21) 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, which cannot fluctuate by more than 4ºC.

Table 8/12 (11/21) **Construction Period for HBM Layers**

Binder	Addition event defining the start time for calculating maximum construction period	Maximum construction period (ºC hours)
Cement, cement with FA or cement with GGBS	Addition of cement	35
Lime with GBS or FA	Addition of lime	1,600
Lime and gypsum for FABGM 5	Addition of lime and gypsum	70
GBS + ASS	Addition of ASS and GBS	3,000
Lime with GGBS	Addition of GGBS	200 if GGBS added after lime 1,600 if GGBS added before lime
HRB	Addition of HRB	Workability Period at 20°C determined in accordance with BS EN 13286-45 multiplied by 17

5 (11/21) Mixtures used in base layers shall be batched by mass and paver laid in a single lift.

6 (11/21) Construction of bases by methods other than a paver shall only be permitted in confined spaces where it is impracticable for a paver to operate.

7 (11/21) When quicklime is used, full hydration shall be complete prior to final compaction.

8 (11/21) Laying shall be carried out in a way that avoids segregation and drying of the surface.

9 (11/21) Temporary intermediate surfaces within a multiple lift layer shall be sprayed with water to prevent surface drying.

10 (11/21) The minimum compacted lift thickness in a multiple lift layer shall be 150 mm.

11 (11/21) Making-up of level after initial compaction shall not be permitted for single lift working or the uppermost lift of multiple lift working.

12 (11/21) The edge of previously compacted HBM or other material shall be vertical and straight before fresh HBM is laid against it.

13 (11/21) Compaction of HBM layers, including the intermediate lifts of multiple lift working, shall be completed without drying out and before setting of any part of the layer.

14 (11/21) Compaction of HBM layers shall meet the requirements for density in Clause 870.

15 (11/21) Compaction of HBM, other than FABGM 5, shall be carried out by vibrating roller and/or pneumatic-tyred roller (PTR).

16 (11/21) 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.

17 (11/21) Only PTR compaction with a wheel loading of not less than 30kN shall be applied to FABGM 5.

18 (11/21) On completion of compaction the surface shall be closed, free from ridges, cracks, loose material, visible voids, ruts, shear planes and other defects.

19 (11/21) All defective areas shall be rectified within the time period specified in sub-Clause 813.2.

20 (11/21) 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.

(11/21) **Cold and Wet Weather Working**

21 (11/21) During cold weather the following shall apply:

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

(ii) HBM is not to be laid on a frozen surface;

(iii) laying of HBM ceases when the air temperature falls below 3ºC;

(iv) laying of HBM does not resume until the rising air temperature reaches 3ºC;

(v) the laying of HBM using binders containing less than 3% of CEM 1 cement, by dry mass of mixture, is restricted in use to the period from 1 May to 30 September.

22 (11/21) In the case of heavy or persistent rain, production shall cease and any laid material shall be compacted immediately.

(11/21) **Curing, Protection and Trafficking**

23 (11/21) On completion of compaction the layer shall be cured to prevent loss of moisture by either a bitumen emulsion spray or a mist/fog/light spray of water.

24 (11/21) Where an application of a bitumen emulsion spray is used it shall be to Class C40B4, of the National Foreword to BS EN 13808 to produce an even and complete coverage of at least 0.2 kg/m² of residual bitumen. Before bitumen spraying commences, the surface is to be free of all loose material and standing water. The bitumen curing membrane is to be protected from any damage until the construction of the overlaying layer.

25 (11/21) Where a mist/fog/light spray of water is applied it shall be sufficient to keep the surface continuously wet until the specified strength of the HBM has been developed or the layer is overlaid.

26 (11/21) Trafficking of HBM layers shall be permitted as shown in Table 8/13.

TABLE 8/13 (11/21) **Trafficking of HBM Layers**

HBM Designation	Clause reference	Trafficking
CBGM 5, 1 and 2	821, 822 and 823	Sub-Clause 29
SBGM 1 and 2 FABGM 1 and 2 HRBBGM 1 and 2	830, 831 and 835	Not restricted
SBGM 3, FABGM 3 and HRBBGM 3	832	Not restricted provided that the IBI requirement of sub-Clause 832.6 is satisfied
FABGM 5 with cement	834	Not permitted for 7 days unless overlaid by at least 150mm of bound material within the construction period.
FABGM 5 with lime	834	Only the minimum amount of traffic required to construct the next layer is permitted.
HSS	840	Not restricted provided that the IPI requirements of Table 8/15 are satisfied. 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 in-situ treated soil shall also have achieved an average strength of at least Class C0.8/1.0.

27 (11/21) Should any HBM layer exhibit signs of damage, trafficking shall cease immediately.

28 (11/21) Trafficking of a layer exhibiting signs of damage shall only be resumed once the layer has gained sufficient stability to resist damage.

29 (11/21) 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 C90/3 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.

30 (11/21) Surface contamination shall be removed prior to overlaying.

31 (11/21) Reworking and re-compaction of the layer shall only be permitted within the construction period set out in Table 8/12.

32 (11/21) Reworking shall only be permitted when the water content requirements of the reworked material are maintained within the limits stated in the method statement.

33 (11/21) Before overlaying, any loose material shall be removed and replaced to the full depth of the layer if not within the construction period set out in Table 8/12.

34 (11/21) Daily record sheets complying with sub-Clause 817.4 shall be compiled by start of work on the next working day and submitted to the overseeing organisation 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 (02/16) Mix-in-Plant Method of Construction Using Batching by Mass

1 (02/16) 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 (02/16) The mixing plant shall have an automated surveillance and data collection system.

3 (11/21) 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.

815 (02/16) Mix-in-Plant Method of Construction Using Volume Batching

1 (02/16) 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.

2 (11/21) 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.

3 (02/16) 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 (02/16) Mix-in-Place Method of Construction

1 (11/21) 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.

2 (11/21) The pulverizing-mixing process shall be repeated until a homogenous mixture is produced. When binder constituents are dispensed onto the surface to be pulverized-mixed, the rate of spread to 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 to be within ±10% of the stated target rate and each individual value to be within ±15% of the mean value of the group of 5 readings.

3 (02/16) 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 m² of work, or part thereof, during each day's operations.

4 (11/21) Mixing of fresh material shall have a minimum overlap of 200 mm with previously mixed material.

5 (11/21) 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 to be sealed by rolling immediately after adding and mixing lime the MCV during this period, known as the mellowing period, to comply with Clause 840.

817 (02/16) Method Statement and Demonstration Area

(02/16) **Method Statement**

1 (11/21) At least 10 days prior to constructing the demonstration area specified in sub-Clause 817.5, a full method statement shall be provided which details:

(i) the operatives;

(ii) plant;

(iii) materials and procedures for the construction of demonstration area(s) and of the works;

(iv) procedures for induced cracking, if required by contract specific Appendix 7/1;

(v) procedures to be applied during inclement weather, plant breakdowns and other unscheduled events;

(vi) the intended mixture proportions with supporting data from trial mix results and/or historic records to justify the proportions;

(vii) the water content (or MCV) limits;

(viii) spread rates for all stages of the work (if applicable);

(ix) a sample record sheet for the submission of the data required by sub-Clause 813.34.

2 (11/21) Where multiple lift working is used, the method statement shall detail:

(i) the methods used to assure that bond between the individual lifts is achieved;

(ii) the procedures to be used to confirm that bond has been achieved in the demonstration area and in the works.

(02/16) **Demonstration Area**

3 (11/21) Prior to the commencement of the main works a demonstration area shall be constructed of at least 800 m² conforming to the submitted method statement. The demonstration area to include a transverse end of-day joint and (if appropriate) multiple lift working. The demonstration area may be accepted into the permanent works. A demonstration area may not be required where documentary evidence of similar work carried out to this specification during the previous 6 months is provided.

4 (11/21) Where multiple lift working is used, the demonstration area shall confirm the effectiveness of the procedures used to assure that bond between the individual lifts can be achieved.

5 (11/21) Where induced cracking is required, the demonstration area shall include crack induction at the specified spacing. The effectiveness of the procedure used to be checked within 28 days of construction, by recovering four evenly spaced 150 mm diameter cores from the line of the induced cracks and assessing each core for compliance with sub-Clause 818.3.

6 (11/21) The mixture constituents, proportions, laying and compaction plant and construction procedures used for the demonstration area shall not be changed unless a further demonstration area is laid.

818 (02/16) Induced Cracking of HBM

1 (11/21) Where required by contract specific Appendix 7/1, transverse cracks shall be formed at the specified spacing with a tolerance of ± 150 mm.

2 (11/21) 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.

3 (11/21) Cracks shall be induced in fresh material after initial compaction.

4 (11/21) 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.

5 (11/21) Bitumen emulsion shall be poured or sprayed into the grooves prior to final compaction, to form a crack inducing membrane.

6 (11/21) The bitumen emulsion shall comply with Class C40B4, as specified in the National Foreword to BS EN 13808.

7 (11/21) During final compaction of the mixture, the surface of the groove shall be fully closed throughout its full length.

8 (11/21) 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.

9 (11/21) Where required by contract specific Appendix 7/1, longitudinal cracks shall be induced using the procedure specified in sub-Clause 818.4

819 (02/16) Not Used

820 (02/16) Aggregates

1 (11/21) Aggregates used in HBGM shall comply with BS EN 13242 and Table 8/14.

2 (11/21) Where recycled coarse aggregate or recycled concrete aggregate is used in HBGM, it shall also be tested in accordance with Clause 710 and comply with the additional requirements for the proportion of the components listed in Table 8/14.

3 (11/21) An existing pavement layer that is to be used to produce HBGM shall be tested to confirm compliance with sub-Clause 820.1.

TABLE 8/14: (11/21) **Aggregate Requirements for HBGM**

Clause reference	821	822	823	830	831	832	835
HBM designation	**CBGM 5**	**CBGM 1**	**CBGM 2**	**FABGM 1 HRBBGM 1**	**SBGM 2, FABGM 2 HRBBGM 2**	**SBGM B3, FABGM 3 HRBBGM 3**	**SBGM 1**
Categories for aggregate properties, BS EN 13242							
Crushed or broken particles and totally rounded particles in coarse aggregate	C_{NR} (Note 1)	C_{NR} unless otherwise specified in contract specific Appendix 7/1		$C_{90/3}$ or $C_{50/30}$, as specified in contract specific Appendix 7/1 (Note 2)		C_{NR} (Note 1)	$C_{90/3}$ or $C_{50/30}$ as specified in contract specific Appendix 7/1
Resistance to fragmentation of coarse aggregate	LA_{NR}	LA_{50} or LA_{60} as specified in contract specific Appendix 7/1	LA_{50}	LA_{50} or LA_{60} as specified in contract specific Appendix 7/1	LA_{50}	LA_{NR}	LA_{50}
Acid-soluble sulfate content	Air-cooled blast-furnace slag – $AS_{1,0}$						
	Other aggregates – $AS_{0,8}$						
Total sulfur content	Air-cooled blast-furnace slag – S_2						
	Other aggregates – S_1						
Other requirements, BS 1377-2							
Fines quality	NR (Note 1)	Non-plastic (Note 3)				NR (Note 1)	Non-plastic (Note 3)
Proportion of components, Clause 710							
Maximum glass content (ClassRgG)	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. C_{NR} if FABGM 1 contains at least 3% CEM 1 cement by dry mass of the mixture and trafficking is prevented for 7 days.
3. 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 (11/21) Cement Bound Granular Mixtures 5 (CBGM 5)

1 (11/21) Cement bound granular mixtures 5 (CBGM 5) shall comply with BS EN 14227-1 and have binder constituent proportions complying with the requirements of Clause 811.

2 (11/21) Aggregate shall comply with the requirements of Clause 820 and have a mixture grading complying with the requirements of BS EN 14227-1 Table 3.

3 (02/16) 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 (02/16) The method of construction shall be in accordance with Clause 813 and either Clause 814, Clause 815 or Clause 816.

5 (02/16) The laboratory mechanical performance shall comply with the requirements of contract specific Appendix 7/1, when sampled and tested in accordance with Clause 870.

822 (11/21) Cement Bound Granular Mixtures 1 (CBGM 1)

1 (11/21) Cement bound granular mixtures 1 (CBGM 1) shall comply with BS EN 14227-1, and have binder constituent proportions complying with the requirements of Clause 811.

2 (11/21) Aggregates shall comply with the requirements of Clause 820 and be either a 0/31.5 mm, a 0/20 mm or a 0/14 mm mixture with a grading complying with the requirements of BS EN 14227-1 Figure 1, 2 and 3 using the G1 limits.

3 (02/16) 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 (02/16) The method of construction shall be in accordance with Clause 813 and Clause 814.

5 (02/16) The laboratory mechanical performance shall comply with the requirements of contract specific Appendix 7/1, when sampled and tested in accordance with Clause 870.

823 (11/21) Cement Bound Granular Mixtures 2 (CBGM 2)

1 (11/21) Cement bound granular mixtures 2 (CBGM 2) shall comply with BS EN 14227-1, and have binder constituent proportions complying with the requirements of Clause 811.

2 (11/21) Aggregates shall comply with the requirements of Clause 820 and be either a 0/20 mm, a 0/14 mm or a 0/10 mm mixture with a grading complying with the requirements of BS EN 14227-1 Figures 4, 5 and 6 using the G1 limits.

3 (11/21) The compacity of the mixture shall be at least 0.8, when calculated in accordance with BS EN 14227-2, Annex C.

4 (11/21) 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.

5 (11/21) 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.

6 (11/21) The method of construction shall be in accordance with Clause 813 and Clause 814.

7 (11/21) The laboratory mechanical performance shall comply with the requirements of contract specific Appendix 7/1, when sampled and tested in accordance with Clause 870.

824 to 829 (02/16) Not Used

830 (11/21) Fly Ash Bound Granular Mixture 1 (FABGM 1) and Hydraulic Road Binder Bound Granular Mixture 1 (HRBBGM 1)

1 (11/21) The mixture shall comply with the requirements of BS EN 14227-3 for Fly Ash Bound Granular Mixture 1 (FABGM 1) or the requirements of BS EN 14227-5 for Hydraulic Road Binder Bound Granular Mixture 1 (HRBBGM 1) and have binder constituent proportions complying with the requirements of Clause 811.

2 (02/16) Aggregate shall comply with the requirements of Clause 820.

3 (11/21) FABGM 1 shall be a 0/31.5 mm mixture with a grading complying with the requirements of BS EN 14227-3 Figure 1.

4 (11/21) HRBBGM 1 shall be a 0/31.5 mm mixture with a grading complying with the requirements of BS EN 14227-5 Figure 1.

5 (11/21) 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.

6 (11/21) The method of construction shall comply with Clause 813 and Clause 814.

7 (11/21) The laboratory mechanical performance shall comply with the contract specific requirements of Appendix 7/1, when sampled and tested in accordance with Clause 870.

831 (11/21) Slag Bound Granular Mixture 2 (SBGM 2), Fly Ash Bound Granular Mixture 2 (FABGM 2) and Hydraulic Road Binder Bound Granular Mixture 2 (HRBBGM 2)

1 (11/21) The mixture shall comply with the requirements of BS EN 14227-2 for Slag Bound Granular Mixture 2 (SBGM 2), the requirements of BS EN 14227-3 for Fly Ash Bound Granular Mixture 2 (FABGM 2) or the requirements of BS EN 14227-5 for Hydraulic Road Binder Bound Granular Mixture 2 (HRBBGM 2) and have binder constituent proportions complying with the requirements of Clause 811.

2 (02/16) Aggregate shall comply with Clause 820.

3 (11/21) SBGM 2 shall be a 0/20 mm, a 0/14 mm or a 0/10 mm mixture with a grading complying with the requirements of BS EN 14227-2 Figure 4, 5 and 6 using the G1 or G2 limits.

4 (11/21) FABGM 2 shall be a 0/20 mm, a 0/14 mm or a 0/10 mm mixture with a grading complying with the requirements of BS EN 14227-3 Figure 3, 5 and 7 using the G1 or G2 limits.

5 (11/21) HRBBGM 2 shall be a 0/20 mm, a 0/14 mm or a 0/10 mm mixture with a grading complying with the requirements of BS EN 14227-5 Figure 2, 3 and 4 using the G1 or G2 limits.

6 (02/16) 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 (02/16) The method of construction shall be in accordance with Clauses 814 and 813.

8 (02/16) The laboratory mechanical performance shall comply with the requirements of contract specific Appendix 7/1, when sampled and tested in accordance with Clause 870.

832 (11/21) Slag Bound Granular Mixture 3 (SBGM 3), Fly Ash Bound Granular Mixture 3 (FABGM 3) and Hydraulic Road Binder Bound Granular Mixture 3 (HRBBGM 3)

1 (11/21) The mixture shall comply with the requirements of BS EN 14227-2 for Slag Bound Granular Mixture 3 (SBGM 3), the requirements of BS EN 14227-3 for Fly Ash Bound Granular Mixture 3 (FABGM 3) or the requirements of BS EN 14227-5 for Hydraulic Road Binder Bound Granular Mixture 3 (HRBBGM 3) and have binder constituent proportions complying with the requirements of Clause 811.

2 (02/16) Aggregate shall comply with the requirements of Clause 820.

3 (11/21) The mixture grading shall comply with the requirements of BS EN 14227-2 Table 3 for SBGM 3, the requirements of BS EN 14227-3 Table 2 for FABGM 3 or the requirements of BS EN 14227-5 Table 2 for HRBBGM 3.

4 (11/21) 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.

5 (11/21) The method of construction shall be in accordance with Clause 813 and either Clause 814, Clause 815 or Clause 816.

6 (11/21) The laboratory mechanical performance shall comply with the requirements of contract specific Appendix 7/1, when sampled and tested in accordance with Clause 870.

7 (11/21) The mixture design procedures specified in Clause 880 shall include the determination of the immediate bearing at the target water and binder content.

8 (11/21) The mixture shall comply with Immediate Bearing Index Category IPI40.

9 (11/21) The requirements of Clause 832.8 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.

833 (02/16) Not Used

834 (11/21) Fly Ash Bound Granular Mixture 5 (FABGM 5)

1 (11/21) The mixture shall comply with BS EN 14227-3 for Fly Ash Bound Granular Mixture 5 (FABGM 5), and have binder constituent proportions complying with the requirements of Clause 811.

2 (02/16) 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 (11/21) 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.

4 (11/21) For other mixtures, the method of construction permitted shall comply with Clause 813 and either Clause 814, Clause 815 or Clause 816.

5 (11/21) The laboratory mechanical performance shall comply with the requirements of contract specific Appendix 7/1, when sampled and tested in accordance with Clause 870.

835 (11/21) Slag Bound Granular Mixture 1 (SBGM 1)

1 (11/21) Slag Bound Granular Mixture 1 (SBGM 1) shall comply with BS EN 14227-2 and have binder constituent proportions complying with the requirements of Clause 811.

2 (11/21) Aggregates shall comply with the requirements of Clause 820 and be a 0/31.5 mm mixture with a grading complying with the requirements of BS EN 14227-2 Figure 1.

3 (11/21) 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 (11/21) The method of construction shall be in accordance with Clause 813 and 814.

5 (11/21) The laboratory mechanical performance shall comply with the requirements of contract specific Appendix 7/1, when sampled and tested in accordance with Clause 870.

836 to 839 (02/16) Not Used

840 (11/21) Hydraulically Stabilised Soils (HSS)

1 (11/21) Hydraulically Stabilised Soils (HSS) shall comply with BS EN 14227-15 and the requirements from Table 8/15, and have binder constituent proportions complying with the requirements of Clause 811.

2 (11/21) A minimum of 95% of the soil shall pass the 63 mm size test sieve when tested in accordance with BS EN 933-1.

3 (11/21) The maximum particle size of the soil shall not exceed 25% of the layer depth.

4 (11/21) When tested in accordance with BS EN 1744-1 clause 10, 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 8/15.

5 (11/21) The method of construction shall be in accordance with Clause 813 and either Clause 814, Clause 815 or Clause 816.

6 (11/21) The laboratory mechanical performance shall comply with the requirements of contract specific Appendix 7/1, when sampled and tested in accordance with Clause 870.

TABLE 8/15 (11/21) **Requirements for Hydraulically Stabilised Soils (HSS)**

Mixture parameter	**Requirement Category**		**BS EN 14227-15**
	Non-cohesive soil mixtures	**Cohesive soil mixtures reference and chalk mixtures**	
Minimum water content (Expressed as a proportion of the optimum water content, determined in accordance with BS EN 13286-4, Vibrating hammer method)	$W_{0,9}$ $W_{1,0}$ for mixtures containing quicklime	W_{NR} (Note 1)	Table 2
Degree of Pulverization (Determined in accordance with BS EN 13286-48)	$Pulv_{NR}$ (Note 1)	$Pulv_{60}$	Table 3
Immediate Bearing Index (Note 2) (Determined in accordance with Clause 880)	IPI_{40} (Note 3)	IPI_{15}	Table 4
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 5
Laboratory mechanical performance (Compressive strength or tensile strength and modulus of elasticity)	R_c or R_t,E, as specified in contract specific Appendix 7/1		Table 7 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 8
Resistance to water – volumetric swelling (Determined in accordance with BS EN 13286-49)	NR (Note 1)	G_{V5}	BS 14227-15 clause 9.1.4

NOTES:
1. The suffix $_{NR}$ denotes that the 'No requirement' category applies.
2. Where HSS 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.

841 to 869 (02/16) Not Used

870 (02/16) Testing, Control and Checking of HBM

(11/21) General

1 (11/21) Tests, controls and checks shall be carried out in accordance with the requirements in Table 8/16 and the following sub-Clauses at locations stated in contract specific Appendix 1/5.

2 (11/21) Where a test reference is shown in Table 8/16, 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.

TABLE 8/16 (11/21) **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 m²	BS 1924-1, Clause 7.1
Grading of aggregate or soil sources on site	1 per 1000 m²	Aggregates: BS EN 1097-5 Soils: BS 1924-1, clause 7.1
Plasticity of aggregate or soil sources on site	1 per 1000 m²	BS 1924-1, clause 7.3
Constituents sourced off-site	Aggregates – Declaration of performance determined in accordance with 104.3 BS EN 13242, Annex C. Cement – Declaration of performance determined in accordance with BS EN 197-1, National Annex NB. Slag – Declaration of performance determined in accordance with the requirements of BS EN 14227-2, Clause 5. Fly ash – Declaration of performance determined in accordance with the requirements of BS EN 14227-4. 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 and mix-in-place	Dispensing accuracy shall be verified by reconciliation between constituent deliveries and the area and depth of completed layer for each 5000m² 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)	1 determination per 1000 m² but not less than 4 per day	
Mixture grading, including binder	1 per 1000 m² but not less than 3 per day	BS EN 933-1
Water content at final compaction	1 per 1000 m² 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 m² but not less than 4 per day	BS EN 13286-46
Pulverization (cohesive mixtures only)	2 per 1000 m² but not less than 4 per day	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)	5 per 1000 m² but not less than 4 per day	-
In-situ wet density	5 per 1000 m² 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 m² 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)	BS 9227 Table 5
Strength after immersion in water	Laboratory mixture design procedure	As required by Clause 880

(11/21) **Sampling**

3 (11/21) Sampling shall be in accordance with BS 1924-1. 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

4 (11/21) 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.

5 (11/21) 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.

(11/21) **Depth of Mixing for the Mix-in-Place Method of Construction**

6 (11/21) The depth of mixing shall be checked by excavation and inspection on completion of each stage of the pulverizing-mixing process.

7 (11/21) The depth of mixing shall be referenced to the design levels for the pavement by precise leveling of the stabilized soil interface to ensure that the level at the underside of the stabilized layer is in accordance with the specified requirements.

(11/21) **Standardisation of Nuclear Density Gauges and Measurement of In-situ Wet Density**

8 (11/21) Where Nuclear Density Gauges cannot be used a correlation shall be established for each alternative measuring device used.

9 (11/21) 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 will 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.

10 (11/21) The operation, warming-up period if any, and standardisation of the gauge shall be carried out in compliance with the manufacturer's recommendations.

11 (11/21) 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.

12 (11/21) 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.

13 (11/21) The in-situ wet density shall be determined within two hours of completing compaction.

14 (11/21) 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.

15 (11/21) The first and fifth positions shall be located 300 mm from the edges of the laid area.

16 (11/21) For a subbase layer, the average in-situ wet density of the area specified in sub-Clause 870.14 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.

17 (11/21) For a base layer, the average in-situ wet density of the area specified in sub-Clause 870.14 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 EN 13286-4.

18 (11/21) 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.

(11/21) **Laboratory Mechanical Performance**

19 (11/21) A bulk sample of HBM shall be taken from each of the locations in sub-Clause 870.14, after the in-situ wet density has been determined.

20 (11/21) The sample shall be tested in accordance with Table 8/17

TABLE 8/17 (11/21) **Laboratory Mechanical Performance Testing Requirements for HBM**

Clause	Mixture	Curing regime	Curing temperature	Test method	Age at test
821, 822 & 823	GBGM 5, CBGM 1 and CBGM 2	BS EN 14227-1	20°C	R_C – BS EN 13286-41	28 days (see Note)
830, 831, 832 & 835	SBGM, HRBBGM and FABGM, (except FABGM 5)	BS EN 13286-51	40°C		
834	FABGM 5 treated with lime	BS EN 13286-51	40°C	R_{it} – BS EN 13286-41	
	FABGM 5 treated with cement	BS EN 13286-51	20°C		
840	HSS with not less than 3% cement	BS EN 14227-15, Annex A	20°C	E_C – BS EN 13286-43	
	Other HSS	BS EN 13286-51	40°C		

NOTE:
For site control purposes, 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.

21 (11/21) Test specimens used to determine laboratory mechanical performance shall be made using vibratory hammer compaction, in accordance with BS EN 13286-51.

22 (11/21) Where cubes are used for the determination of compressive strength, the specimens shall be 150 mm size.

23 (11/21) Compliance of the area specified in sub-Clause 870.14 shall be determined using the results for test specimens that are cured and tested in accordance with Table 8/16 using compression or indirect tensile testing appropriate to the class of mechanical performance specified in contract specific Appendix 7/1.

24 (11/21) Assessment shall be made using the following criteria which supersede any reference to 'characteristic strength' in BS EN14227-1.

(i) Compressive strength: The requirement specified in contract specific Appendix 7/1 will be satisfied if the average compressive strength of the group of specimens in Table 8/16 is equal to or greater than the minimum for the specified Rc class and no individual test result is less than 67% of the minimum strength requirement for the Rc class.

(ii) Indirect tensile strength: The requirement specified in contract specific Appendix 7/1 will be satisfied if the average indirect tensile strength of the group of specimens in Table 8/16 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.

871 (02/16) Determination of the Coefficient of Linear Thermal Expansion

(02/16) **Scope**

1 (11/21) 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.

2 (11/21) The test method shall be carried out using hardened specimens.

(02/16) **Apparatus**

3 (11/21) 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.

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

(02/16) **Test procedure**

4 (11/21) 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 to be at opposite ends of the specimen. Each pair to 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 8/17.

(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 not to exceed 55ºC. Maintain the temperature at T2 ± 2ºC for 24 ± 2 hours and measure the length (L2) using the procedure in (5).

(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 (5).

(02/16) **Calculations**

5 (11/21) The Coefficient of Linear Thermal Expansion (C_{LE}) shall be calculated 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 C_{LE}'')).

(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 871.4.

(02/16) **Reporting of Results**

6 (11/21) The value of C_{LE} using units of m.10-6/ºC, expressed to the nearest whole number shall be reported.

872 to 879 (02/16) Not used

880 (02/16) Laboratory Mixture Design Procedure

1 (11/21) Prior to the commencement of the work or any change in mixture constituents, the target proportions of the constituents, including water, for the specified HBM, based on the mixture design procedure described in this Clause shall be determined.

2 (02/16) 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.

(02/16) **Immediate Stability**

3 (11/21) 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.

4 (11/21) The IBI value shall be taken as the average value for a set of 3 test specimens.

(02/16) **Resistance to Water – Strength After Immersion**

5 (11/21) 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.

6 (11/21) 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 to show no signs of cracking or swelling.

7 (11/21) For mixtures containing less than 3% by dry mass of the mixture of cement, the test temperature shall be (40 ± 2)ºC.

8 (11/21) For mixtures containing 3% or more cement, the test temperature shall be (20 ± 2)ºC.

(02/16) **Resistance to Frost Heave**

9 (11/21) 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 8/17.

881 (03/20) Laboratory Stiffness Testing

(03/20) **Scope**

1 (11/21) The test methods described in this Clause shall determine the stiffness values for use within a performance foundation design.

(03/20) **Cement and Other Hydraulically Bound Mixtures**

2 (03/20) The mean modulus of elasticity in compression (Ec) of hydraulically bound mixtures shall be determined in accordance with BS EN 13286-43.

3 (11/21) Specimens shall be:

(i) manufactured in accordance BS 1924-2 7.2.2 with a 2:1 height diameter ratio; and

(ii) cured in accordance with Table 8/17.

882 (03/20) Determination of the Construction Subgrade Surface Modulus

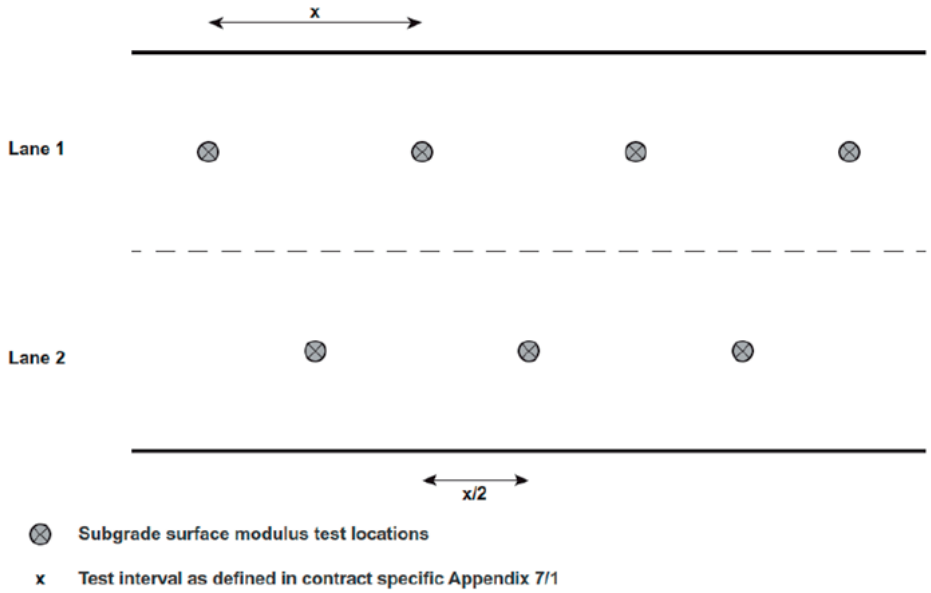
(03/20) **Scope**

1 (03/20) The test methods described in this Clause shall be used for the determination of the subgrade surface modulus of the foundation prior to the commencement of construction of the overlying layers.

(03/20) **Procedure**

2 (03/20) The construction subgrade surface modulus shall be determined in accordance with this Clause at intervals suitable for the type of subgrade material and its condition, with a maximum spacing of 60 m along each lane of prepared subgrade and staggered to the mid-point between adjacent lanes, see Figure 8/1.

FIGURE 8/1: (03/20) **Subgrade Surface Modulus Test Locations**



3 (03/20) At least 10 tests shall be carried out for each prepared foundation area.

4 (03/20) The measurement of the construction subgrade surface modulus shall be taken at formation level or at sub-formation level if capping is part of the foundation design.

5 (03/20) The test site shall be free from standing water, ice and snow.

6 (03/20) Where the construction subgrade surface modulus is found to be less than the design subgrade modulus, the area shall either be improved or the foundation redesigned in accordance with CD 225 (DMRB).

(03/20) **Construction Subgrade Surface Modulus Measurement**

7 (03/20) The subgrade surface modulus shall be determined using one of the following devices:

(i) Dynamic Cone Penetrometer (DCP);

(ii) Falling Weight Deflectometer (FWD); or

(iii) Lightweight Deflectometer (LWD).

(03/20) **Dynamic Cone Penetrometer (DCP) Testing**

8 (03/20) Dynamic Cone Penetrometer (DCP) testing shall be undertaken following the procedure outlined within CS 229 (DMRB).

9 (03/20) Result expressed as mm/blow shall be converted to a California Bearing Ratio (CBR) value, expressed as a percentage, using the following relationship:

EQUATION 8/1: (03/20) **DCP (mm/blow) to CBR Relationship**

$$Log_{10}(CBR) = 2.48 - 1.057 * Log_{10}(mm/blow)$$

10 (03/20) The CBR value obtained in sub-Clauses 883.6 to 883.8 shall then be converted to surface modulus (E) using the following equation:

EQUATION 8/2: (03/20) **CBR to Subgrade Surface Modulus Equation**

$$E = 17.6(CBR)^{0.64}\ MPa$$

(03/20) **Falling Weight Deflectometer (FWD) Testing**

11 (03/20) FWD testing shall be undertaken using a calibrated FWD in accordance with BS 1924-2.

(03/20) **Lightweight Deflectometer Testing (LWD)**

12 (03/20) LWD testing shall be undertaken using a calibrated LWD in accordance with BS 1924-2.

13 (03/20) In accordance with BS 1924-2, an LWD device shall only be used with a site-specific correlation versus a FWD or if it has an annual correlation certificate.

14 (03/20) Testing shall either be undertaken to:

(i) Procedure A – the standard target stress as per BS 1924-2; or

(ii) Procedure B – a range of target stresses centred around 100 KPa to determine stress dependency.

883 (03/20) Demonstration Area for Performance Foundation Designs

(03/20) **Scope**

1 (03/20) The procedure described in this Clause is to demonstrate the adequacy of performance of a foundation design together with the methods used to construct the foundation prior to the commencement of the permanent works.

2 (03/20) Demonstration areas are required for performance design foundations and when specified in contract specific Appendix 7/1.

(03/20) **Demonstration Area for Performance Foundations**

3 (03/20) For each foundation area, a demonstration area shall be prepared using the same methods, materials, thickness and compaction as proposed for the permanent works. Each demonstration area shall be not less than 400 m² and not less than 60 m long. For foundations constructed using HBM to Clause 810, the demonstration area shall comply with the requirements of Clause 817.

4 (03/20) The demonstration area shall have a sufficient and suitable run off/run on area as outlined in Clause 802.15 to ensure the trafficking trial can be undertaken.

5 (03/20) The materials placed in the demonstration area may form part of the permanent works, provided that they meet the requirements of the permanent works.

(03/20) **Procedure**

6 (03/20) Measure subgrade surface modulus in accordance with Clause 882 and confirm that the value is greater to or higher than the design subgrade surface modulus value.

7 (03/20) If the measured subgrade surface modulus is lower than the design subgrade modulus, a foundation redesign is required.

8 (03/20) Where the measured subgrade surface modulus is greater than design subgrade surface modulus, an adjustment factor should be applied to the measurements of foundation surface modulus values in this clause using Equation 8/3.

EQUATION 8/3: (03/20) Foundation Surface Modulus Adjustment

$$E_F(adjusted) = E_F\left(1 + \left(0.28 * ln\left(\frac{E_S(measured)}{E_S(designed)}\right)\right)\right)$$

Notes:

1 EF (adjusted) Adjusted foundation surface modulus.

2 EF Measured foundation surface modulus.

3 ES (measured) Measured subgrade surface modulus.

4 ES (design) Design subgrade surface modulus.

9 (03/20) Construct foundation as proposed for permanent works.

10 (11/21) Measure foundation surface modulus in accordance with Clause 885 to confirm the foundation surface modulus requirements for the foundation are in accordance with the requirements of Table 8/18.

11 (03/20) Undertake trafficking trial in accordance with sub-Clause 883.16.

12 (03/20) Repeat measurement of foundation surface modulus in accordance with Clause 885 to confirm the foundation surface modulus requirements for the foundation are in accordance with the requirements of Table 6/1.

13 (03/20) Where the completed demonstration area meets all of the specification requirements, the methods, materials and thicknesses used shall not be changed for the construction of the main works without an additional demonstration area being constructed.

14 (03/20) Where the demonstration area fails to meet all of the specification requirements, the design and construction practices shall be reviewed, and the demonstration area reconstructed until the specification requirements have been met.

15 (03/20) Records of the performance test results for each construction stage, referenced to the following condition details shall be stored and presented on request to the Overseeing Organisation in a digital spreadsheet format:

(i) Subgrade surface modulus value immediately before foundation construction;

(ii) Date and time of mixing (for stabilised and slow-setting materials);

(iii) Date and time of placing and compaction;

(iv) Date of performance testing;

(v) Values of surface modulus recorded;

(vi) Values of material properties including density and layer thickness;

(vii) Weather conditions including temperature; and

(viii) Sampling and testing records in the demonstration area.

(03/20) **Trafficking Trials**

16 (03/20) The Contractor shall undertake a controlled trafficking trial on top of the constructed foundation in the demonstration area.

(03/20) **Trial Procedure**

17 (03/20) Mark out intended running track for the vehicle to ensure same wheelpath is followed in each pass.

18 (03/20) Using a heavy goods vehicle, undertake a number of passes of the demonstration area along the marked out running track to achieve a number of passes equivalent to 1000 standard axles.

19 (03/20) At 10 metre intervals and where instructed by the Overseeing Organisation, measure vertical deformation in the wheelpath in accordance with Clause 886 using a straight edge with a length of at least 2 m.

20 (03/20) The wheelpath deformation shall not exceed the limits in Clause 886 along any section of trial length.

884 (03/20) Permanent Works Performance Assessment for Performance Foundations

(03/20) **Scope**

1 (03/20) This Clause outlines the performance testing required when constructing a performance foundation in addition to other compliance testing outlined in the specification.

(03/20) **Information Required**

2 (03/20) For each foundation area, records of the performance test results for each construction stage, referenced to the following condition details shall be stored and presented on request to the Overseeing Organisation in a digital spreadsheet format:

(i) Subgrade surface modulus value immediately before foundation construction;

(ii) Date and time of mixing (for stabilised and slow-setting materials);

(iii) Date and time of placing and compaction;

(iv) Date of performance testing;

(v) Values of foundation surface modulus recorded;

(vi) Values of material properties including density and layer thickness;

(vii) Weather conditions including temperature; and

(viii) Sampling and testing records.

(03/20) **Performance Assessment**

3 (03/20) Within 48 hours prior to construction of the overlying pavement layers, the foundation surface modulus shall be tested in accordance with Clause 885 at 20 m intervals along each lane, staggered by 10 m between adjacent lanes. Tests shall coincide with subgrade surface modulus and density tests where appropriate.

4 (11/21) The foundation surface modulus values achieved shall meet or exceed that detailed in Table 8/18 for the corresponding material and foundation class.

5 (11/21) A foundation containing unbound materials that fails to comply with the performance requirements detailed in Table 8/18 when the recorded moisture content is in excess of that in the demonstration area, may be re-tested for compliance when the foundation moisture content has reduced to that in the demonstration area.

6 (11/21) Where surface modulus performance values do not meet the requirements detailed in Table 8/18 the foundation is required to be re-designed. Where detailed in contract specific Appendix 1/10 the Contractor shall redesign the foundation in accordance with CD 225 (DMRB), and another demonstration area constructed.

7 (03/20) Ruts that develop under construction traffic, measured in accordance with this Clause, shall nowhere exceed the limits in Clause 886.

885 (03/20) Top of Foundation Performance Assessment

(03/20) **Scope**

1 (03/20) The procedure described in this clause is for establishing the foundation surface modulus of newly constructed performance foundations.

(03/20) **Foundation Surface Modulus Measurement**

2 (03/20) The foundation surface modulus shall be measured using either:

(i) FWD; and

(ii) LWD based on a site-specific correlation versus an FWD.

3 (03/20) FWD testing shall be undertaken using a calibrated FWD in accordance with BS 1924-2.

4 (03/20) LWD testing shall be undertaken using a calibrated LWD in accordance with BS 1924-2 and requires a site-specific correlation versus a FWD undertaken in the performance foundation demonstration area.

5 (03/20) The site specific correlation for an LWD shall be established in accordance with BS 1924-2.

6 (03/20) Where a Lightweight Deflectometer is being used, testing shall either be undertaken to:

(i) Procedure A – the standard target stress as per BS 1924-2; or

(ii) Procedure B – a range of target stresses centred around 100 kPa specified in order to determine stress dependency.

7 (11/21) Table 8/18 gives the mean foundation surface modulus and minimum foundation surface modulus values, for each foundation class, and for different categories of materials, that shall be met at the top of foundation level immediately prior to the construction of the overlying pavement layers.

TABLE 8/18 (11/21) **Foundation Surface Modulus Requirements**

Foundation Class		Class 1	Class 2	Class 3	Class 4
Mean of 5 foundation surface modulus tests (MPa)	Unbound mixtures	40	80	N/A	N/A
	Fast-setting mixtures	50	100	300	600
	Slow-setting mixtures	40	80	150	300
Minimum of any foundation surface modulus test (MPa)	Unbound mixtures	30	50	N/A	N/A
	Fast-setting mixtures	30	50	150	300
	Slow-setting mixtures	30	50	75	150

886 (03/20) Wheelpath Deformation Measurement

(03/20) **Scope**

1 (03/20) This procedure shall be used at the top of a pavement foundation to measure and provide limitations to deformation in the foundation under construction trafficking.

(03/20) **Procedure**

2 (03/20) Apparatus required:

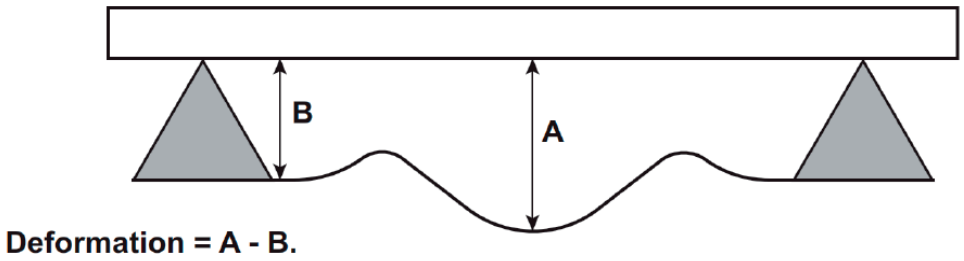
(i) Straight edge with a minimum length of 2 m;

(ii) Two identical blocks; and

(iii) Ruler.

3 (03/20) The straight edge shall be placed transverse to the rut and raised clear from the rut by two identical blocks. The blocks shall be placed on undisturbed material outside the wheel path. The amount of deformation shall be the difference of the foundation (A) and the height of the blocks (B), see Figure 8/2.

FIGURE 8/2: (03/20) **Wheelpath Deformation**



4 (03/20) Ruts that develop under construction traffic, measured in accordance with this Clause, shall nowhere exceed the following limits:

(i) All bound surfaces – 10 mm;

(ii) < 250 mm design thickness of granular material – 30 mm; and

(iii) ≥ 250 mm design thickness of granular material – 40 mm.