National Roads Authority

Manual of Contract Documents for Road Works (NRA MCDRW)

ERRATUM No. 1 (March 2011) to NRA Specification for Road Works Series 800 – Road Pavements - Unbound Cement Bound Mixtures Dated December 2010

The NRA Specification for Road Works (NRA MCDRW), Series 800 – Road Pavements - Unbound Cement Bound Mixtures, dated December 2010 is amended as follows:-

1. Page 3, Table 8/2
   Delete "Total Sulphur" and replace with "Sulphur Content".

2. Page 6, Table 8/4
   Delete Table 8/4 dated December 2010 and replace with Table 8/4 overleaf.

3. This Erratum shall be implemented forthwith.

4. All technical enquiries or comments on this Erratum or the NRA Series 800 should be sent in writing to:

   Specifications Section
   National Roads Authority
   St. Martins House
   Waterloo Road
   Dublin 4

Instructions For Use

The following version of the Manual of Contract Documents for Road Works (NRA MCDRW) incorporates the above changes.

Table 8/4: Compaction Requirements for Unbound Mixtures

Type of Compaction Plant	Category	Number of phases for layers not exceeding the following compacted thickness:		
		110mm	150mm	225mm
Smooth-wheeled roller	Mass per metre width of roll:	16	unsuitable	unsuitable
(or vibratory roller operating without vibration)	over 2700kg up to 5400kg	8	16	unsuitable
	over 5400kg			
Pneumatic-tyred roller	Mass per wheel:			
	over 4000kg up to 6000kg	12	unsuitable	unsuitable
	over 6000kg up to 8000kg	12	unsuitable	unsuitable
	over 8000kg up to 1200kg	10	16	unsuitable
Vibratory roller	Mass per metre width of vibrating roll:			
	over 700kg up to 1300kg	16	unsuitable	unsuitable
	over 1300kg up to 1800kg	6	16	unsuitable
	over 1800kg up to 2300kg	4	6	10
	over 2300kg up to 2900kg	3	5	9
	over 2900kg up to 3600kg	3	5	8
	over 3600kg up to 4300kg	2	4	7
Vibrating-plate compactor	Mass per metre of base plate:			
	over 1400kg/m_2 up to 1800kg/m_2	8	unsuitable	unsuitable
	over 1800 kg/m_2 up to 2100kg/m_2	5	8	unsuitable
	over 2100kg/m_2	3	6	10
Vibro-tamper	Mass:			
	over 50kg up to 65kg	4	8	unsuitable
	over 65kg up to 75kg	3	6	10
	over 75kg	2	4	8
Power rammer	Mass:			
	100kg-500kg	5	8	unsuitable
	over 500kg	5	8	12

ROAD PAVEMENTS – UNBOUND AND CEMENT BOUND MIXTURES

Contents

Road Pavements – Unbound and Cement Bound Mixtures

Unbound Mixtures for Subbase

801 General Requirements for Unbound Mixtures

1 Unbound mixtures shall be made and constructed to conform to IS EN 13285, the mixture and grading requirement categories in Table 8/1, and Clauses 802 to 809. The permitted alternatives for each part of the permanent Works shall be as described in Appendix 7/1. The Contractor shall ensure that the manufacturer of unbound mixtures has in place a system of factory production control that complies with the requirements of Annex C of IS EN 13242.

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

3 Where recycled coarse aggregate or recycled concrete aggregate is used in unbound mixtures in accordance with Clauses 803 and 807 as appropriate, the constituents of a sample of recycled aggregate shall be classified by hand-sorting the coarse aggregate particles in accordance with IS EN 933-11. The test shall be carried out by a suitably trained laboratory technician who has demonstrated competence in classifying the constituent classes in accordance with the test method. Recycled coarse aggregate and recycled concrete aggregate used in unbound mixtures in accordance with Clause 803 and 807 shall also comply with the additional requirements of Table 8/3.

Frost Heave

4 Subject to the tolerances given in Table 7/1 and unless otherwise stated in Appendix 7/1, material shall not be frost susceptible if it is used within 350 mm of the designed final surface of a road or paved central reserve.

5 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 shall be used.

6 Where unbound materials are to be placed adjacent to cement-bound materials or metallic structural components, refer to the additional requirements of Clauses 808 and 809.

Table 8/1: Mixture and Grading Requirement Categories for Unbound Mixtures

Unbound mixture	Type A	Type B	Type C (open graded)	Type D (wet mix macadam)	Type E (close graded)
Clause	803	804	805	806	807
Standard	IS EN 13285 Categories for unbound mixture properties				
Mixture requirement category	0/31,5 UF_7 OC_{80}	0/31,5 UF_7 OC_{80}	0/40 UF_7 OC_{80}	0/31,5 UF_7 OC_{85}	0/31,5 UF_9 OC_{80}
Grading requirement category	G_B	G_A	G_A	G_o	G_B

Table 8/2 Requirements for Aggregates Used in Unbound Mixtures for Subbase and Base

Unbound Mixture/Clause No.		803	804	805	806	807	808	809
Standard		IS EN 13242 Categories for aggregate properties						
Crushed or Broken and totally rounded particles								
-	Crushed Rock	$C_{90/3}$ (See Note 1)	$C_{90/3}$	Not permitted	$C_{90/3}$	$C_{90/3}$	$C_{90/3}$	$C_{90/3}$
-	Gravel	C_{nr}	Not permitted	C_{nr}	Not permitted	Not permitted	Not permitted	Not permitted
-	Crushed Gravel	C_{nr}	Not permitted	$C_{50/10}$	Not permitted	Not permitted	Not permitted	Not permitted
Shape of course aggregate – Flakiness Index		FI_{50}	FI_{35}	FI_{50}	FI_{35}	FI_{50}	FI_{35}	FI_{35}
Resistance to fragmentation – Los Angeles test		LA^{30}						
Fines Quality – Methylene – Blue Test		MB (see Note 2)						
Resistance to freezing and thawing	**Water Absorption**	$WA_{24}2$ If water absorption is not greater than 2% then aggregate shall be assumed to be freeze –thaw resistant						
	Magnesium Sulphate Soundness	MS_{25}						
Sulphur Content							(See Note 5)	
All other IS EN 13242 aggregate requirements		Category $_{nr}$ (no requirement) (See Note 3)						

Notes:

1 IS EN 13242 assumes that crushed rock aggregates comply with category C90/3 without further testing.
2 It will be necessary to continue to specify Liquid limits and Plasticity index, where appropriate, until further data on the Methylene Blue test has been collected and reviewed.
3 The contractor/supplier shall furnish current Methylene Blue values on the material as supplied.
4 If required where signs of "Sonnenbrand" of basalt are known, the loss of mass and resistance to fragmentation shall be determined in accordance with EN 1367-3 and 1097-2 (see clause NG 800 sub-clause 5).
5 Refer to particular requirements in Clauses 808 and 809. A petrographer's detailed mineralogical examination may be required as described under section 3.4.2 of SR 21.

TABLE 8/3: Additional Requirements for Recycled Coarse Aggregate and Recycled Concrete Aggregate in Unbound Mixtures

Unbound Mixture	Type A	Type B	Type C	Type D	Type E
Clause	**803**	**804**	**805**	**806**	**807**
Component[1]	**Maximum Permitted Content** (% by mass)				
Asphalt (Class A)	50	0	0	0	5
Glass (Class G)	25	0	0	0	0
Other materials (Class X), including wood, plastic and metal	1				

Note 1: The constituents of a sample of recycled aggregate shall be classified by hand-sorting the coarse aggregate particles in accordance with IS EN 933-11. The test shall be carried out by a suitably trained laboratory technician who has demonstrated competence in classifying the constituent classes in accordance with the test method.

802 Transport, Laying, Compaction and Trafficking of Unbound Mixtures

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

Laying

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

3 All unbound mixtures shall be placed and spread evenly. Spreading shall be undertaken either concurrently with placing or without delay. When laid beneath a pavement made up of three or less further layers 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. Unbound mixtures may only be spread by grader when overlaid by at least four further pavement layers.

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

Compaction

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

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

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

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

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

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

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

the machine shall be determined on the basis of the axle giving the highest value of mass per metre width.

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

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

(a) The requirements for vibratory rollers are based on the use of the lowest gear on a self-propelled machine with mechanical transmission and a speed of 1,5-2,5 km/h for a towed machine or a self-propelled machine with hydrostatic transmission. If higher gears or speeds are used an increased number of passes shall be provided in proportion to the increase in speed of travel.

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

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

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

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

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

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

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

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

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

Table 8/4: Compaction Requirements for Unbound Mixtures

Type of Compaction Plant	Category	Number of phases for layers not exceeding the following compacted thickness:		
		110mm	150mm	225mm
Smooth-wheeled roller (or vibratory roller operating without vibration)	Mass per metre width of roll: over 2700kg up to 5400kg over 5400kg	16 8	unsuitable 16	unsuitable unsuitable
Pneumatic-tyred roller	Mass per wheel: over 4000kg up to 6000kg over 6000kg up to 8000kg over 8000kg up to 1200kg over 12000kg	 12 12 10 8	 unsuitable unsuitable 16 12	 unsuitable unsuitable unsuitable unsuitable
Vibratory roller	Mass per metre width of vibrating roll: over 700kg up to 1300kg over 1300kg up to 1800kg over 1800kg up to 2300kg over 2300kg up to 2900kg over 2900kg up to 3600kg over 3600kg up to 4300kg over 4300kg up to 5000kg over 5000kg	 16 6 4 3 3 2 2 2	 unsuitable 16 6 5 5 4 4 3	 unsuitable unsuitable 10 9 8 7 6 5
Vibrating-plate compactor	Mass per metre of base plate: over 1400kg/m_2 up to 1800kg/m_2 over 1800 kg/m_2 up to 2100kg/m_2 over 2100kg/m_2	 8 5 3	 unsuitable 8 6	 unsuitable unsuitable 10
Vibro-tamper	Mass: over 50kg up to 65kg over 65kg up to 75kg over 75kg	 4 3 2	 8 6 4	 unsuitable 10 8
Power rammer	Mass: 100kg-500kg over 500kg	 5 5	 8 8	 unsuitable 12

Use of Surfaces by Construction Plant and Other Traffic

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

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

Trafficking Trial

12 When required by Appendix 7/1 for Type A or Type C materials, the Contractor shall undertake a Trafficking Trial incorporating the unbound mixture proposed for use in the permanent Works. A trial area shall be constructed, trafficked and assessed in accordance with the procedure described in sub-Clauses 13 to 18 of this Clause. The mean vertical deformation after 1000 equivalent standard axles shall be less than 30 mm when measured in accordance with the procedure stated in sub-Clause 17 of this Clause. Proposals for trafficking trials shall be submitted to the Employer's Representative five days in advance of construction.

Trial Procedure

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

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

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

Mixtures

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

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

Reporting and Acceptance of Trafficking Trial Area

18 A report on the Trafficking Trial, stating how the use of the unbound mixture was validated shall be submitted to the Employer's Representative, who shall raise any objection within two working days of receiving the report.

803 Granular Material Type A

1 Type A granular material shall be gravel, crushed rock, or recycled crushed mixed concrete aggregates as defined in Annex A of IS EN 13285, including recycled coarse aggregate complying with clause 801.3.

2 The mixture shall comply with Clause 801 and with the following sub-clauses. The overall grading requirements for the mixture are summarised in Table 8/5. Where recycled crushed mixed concrete aggregates are used the composition and method of testing of the mixture shall comply with Table A.1 and Annex A of IS EN 13285.

3 The material passing the 0,425mm BS sieve, when tested in accordance with BS 1377: Part 2, shall have a plasticity index of less than 6.

Table 8/5: Granular Material Type A

IS EN 13285 Categories -				
Mix Designation:		**0/31,5**		
Oversize Category:		**OC 80**		
Overall Grading:		**G_B**		
Sieves for Grading / Fines Category	**ISO Sieve Size (mm)**	**Percentage by Mass Passing**		
		Overall Grading Range	**Supplier Declared Value Grading Range**	**Tolerance on the Supplier Declared Value**
2D	63	100	No Requirement	No Requirement
D	31,5	80 - 99		
A	16	55 - 85	63 - 77	±8
B	8	35 - 68	43 - 60	±8
C	4	22 - 60	30 - 52	±8
E	2	16 - 47	23 - 40	±7
F	1	9 - 40	14 - 35	±5
G	0,5	5 - 35	10 - 30	±5
UF_7	0,063	0 - 7	No Requirement	No Requirement
LF_N	NR	NR		

Grading of individual batches – differences in values passing selected sieves

Retained sieve size, mm	Passing sieve size, mm	Percentage by mass passing	
		Not less than	Not more than
8	16	10	25
4	8	10	25
2	4	7	20
1	2	4	15

NOTE: The particle size shall be determined by the washing and sieving method of IS EN 933-1

4 The material passing the 20 mm BS sieve shall have a CBR of 50 per cent or more when tested in accordance with BS 1377: Part 4 at the maximum dry density and optimum moisture content for the material as determined by the vibrating hammer method test in accordance with (IS EN 13286-4).

5 The material shall be laid and compacted at a moisture content within the range 1 per cent above to 2 per cent below the optimum percentage determined in accordance with the vibrating hammer method test in (IS EN 13286-4), and without drying out or segregation.

6 The material shall be maintained within the moisture content range specified in sub-clause 803.5 whilst awaiting overlaying.

804 Granular Material Type B

1 Type B granular material shall be crushed rock. The mixture shall comply with Clause 801 and with the following sub-clauses. The overall grading requirements for the mixture are summarised in Table 8/6.

2 The material passing the 0,425 mm BS sieve shall have a liquid limit, determined in accordance with the cone penetrometer method (definitive method) in BS 1377: Part 2, not greater than 20 for limestone and 21 for all other rock types.

3 The material shall be laid and compacted at a moisture content within the range of the optimum to 2 percent below the optimum percentage determined in accordance with the vibrating hammer method test in (IS EN 13286-4), and without drying out or segregation.

4 The material shall be maintained within the moisture content range specified in sub-clause 804.3 whilst awaiting overlaying.

Table 8/6: Granular Material Type B

IS EN 13285 Categories -	
Mix Designation:	**0/31,5**
Oversize Category:	**OC 80**
Overall Grading:	**G_A**

Sieves for Grading / Fines Category	ISO Sieve Size (mm)	Percentage by Mass Passing		
		Overall Grading Range	Supplier Declared Value Grading Range	Tolerance on the Supplier Declared Value
2D	63	100	No Requirement	No Requirement
D	31,5	80 - 99		
A	16	55 - 85	63 - 77	±8
B	8	35 - 65	43 - 57	±8
C	4	22 - 50	30 - 42	±8
E	2	15 - 40	22 - 33	±7
F	1	10 - 35	15 - 30	±5
G	0,5	0 - 20	5 - 15	±5
UF_7	0,063	0 - 7	No Requirement	No Requirement
LF_N	NR	NR		

Grading of individual batches – differences in values passing selected sieves

Retained sieve size, mm	Passing sieve size, mm	Percentage by mass passing	
		Not less than	Not more than
8	16	10	25
4	8	10	25
2	4	7	20
1	2	4	15

NOTE: The particle size shall be determined by the washing and sieving method of IS EN 933-1

805 Granular Material Type C (Open Graded Unbound Mixtures)

1 Type C granular material shall be screened or crushed gravel. The mixture shall comply with Clause 801 and with the following sub-clauses. The overall grading requirements for the mixture are summarised in Table 8/7.

2 The material passing the 0,425 mm sieve shall have a liquid limit, determined in accordance with the cone penetrometer method (definitive method) in BS 1377: Part 2, not greater than 20 for limestone and 21 for all other rock types.

3 The material passing the 20 mm BS sieve shall have a CBR of 150 or more when tested in accordance with BS 1377: Part 4 at the maximum dry density and optimum moisture content for the material as determined by the vibrating hammer method test in accordance with (IS EN 13286-4).

4 The material shall be laid and compacted at a moisture content within the range of the optimum to 2 per cent below the optimum percentage determined in accordance with the vibrating hammer method test in (IS EN 13286-4), and without drying out or segregation.

5 The material shall be maintained within the moisture content range specified in sub-clause 805-4 whilst awaiting overlaying.

806 Granular Material Type D (Wet Mix Macadam)

1 Wet-mix macadam shall be made and constructed in the following manner.

Table 8/7: Granular Material Type C

IS EN 13285 Categories -				
Mix Designation:		**0/40**		
Oversize Category:		**OC 80**		
Overall Grading:		**G_A**		
Sieves for Grading / Fines Category	**ISO Sieve Size (mm)**	**Percentage by Mass Passing**		
		Overall Grading Range	**Supplier Declared Value Grading Range**	**Tolerance on the Supplier Declared Value**
2D	80	100	No Requirement	No Requirement
D	40	80 - 99		
A	20	55 - 85	63 - 77	±8
B	10	35 - 65	43 - 57	±8
C	4	22 - 50	30 - 42	±8
E	2	15 - 40	22 - 33	±7
F	1	10 - 35	15 - 30	±5
G	0,5	0 - 20	5 - 15	±5
UF_7	0,063	0 - 7	No Requirement	No Requirement
LF_N	NR	NR		

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

NOTE: The particle size shall be determined by the washing and sieving method of IS EN 933-1

Aggregate

2 The mixture shall comply with Clause 801 and with the following sub-clauses. The coarse and fine aggregate shall consist of crushed rock. The overall grading requirements for the mixture are summarised in Table 8/8.

3 The material passing the 0,425 mm BS sieve shall have a liquid limit, determined in accordance with the cone penetrometer method (definitive method) in BS 1377: Part 2, not greater than 20 for limestone and 21 for all other rock types.

Moisture Content

4 The material shall be transported, laid and compacted at a moisture content within the range 0.5 to 1.5 percent below the optimum percentage determined in accordance with the vibrating hammer method test in (IS EN 13286-4) and without drying out or segregation.

Laying and Compaction

5 The compacted thickness of each layer shall not be more than 150 mm.

6 Compaction of wet-mix macadam shall be carried out in accordance with the requirements of Clause 802, using vibrating rollers having a mass per metre width of vibrating roll of at least 1800 kg.

7 The material shall be protected from weather during transit to the site, whilst awaiting tipping and during laying.

8 On completion of compaction the surface of the material shall be sealed with cationic bitumen emulsion (70 per cent bitumen) sprayed at a rate between 1.1 and 1.4 litre/m^2, covered with 2/6 mm chippings at a rate of spread of 6 to 8 kg/m^2, and lightly rolled.

Table 8/8: Granular Material Type D (Wet Mix Macadam)

IS EN 13285 Categories –				
Mix Designation:		**0/31,5**		
Oversize Category:		**OC 85**		
Overall Grading:		**Go**		
Sieves for Grading / Fines Category	**ISO Sieve Size (mm)**	**Percentage by Mass Passing**		
		Overall Grading Range	**Supplier Declared Value Grading Range**	**Tolerance on the Supplier Declared Value**
1,4D	40	100	No Requirement	No Requirement
D	31.5	85 - 99		
A	16	50 - 78	58 - 70	±8
B	8	31 - 60	39 - 51	±8
C	4	18 - 46	26 - 38	±8
E	2	10 - 35	17 - 28	±7
F	1	6 - 26	11 - 21	±5
G	0,5	0 - 20	5 - 15	±5
UF_7	0,063	0 - 7	No Requirement	No Requirement
LF	NR	NR		

Grading of individual batches – differences in values passing selected sieves

Retained sieve size, mm	Retained sieve size, mm	Retained sieve size, mm	
8	16	10	25
4	8	10	25
2	4	7	20
1	2	4	15

NOTE: The particle size shall be determined by the washing and sieving method of IS EN 933-1

807 Granular Material Type E (Close Graded Unbound Mixtures)

1 Granular Material Type E (close graded unbound mixture) shall be made from crushed rock or recycled concrete aggregate.

2 The mixture shall comply with Clause 801 and with the following sub-clauses. The grading requirements for the mixture are summarised in Table 8/9.

3 The properties of aggregates used in the mixture shall comply with clause 801.4 except that a value of Los Angeles coefficient greater than 30 may be accepted provided the Contractor submits evidence of satisfactory performance in similar mixtures to the Employer's Representative.

4 The material passing the 0,425 mm BS sieve shall have a liquid limit, determined in accordance with the cone penetrometer method (definitive method) in BS 1377: Part 2, not greater than 20 for limestone and 21 for all other rock types.

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

808 Unbound Materials Placed Adjacent To Cement-Bound Materials

1 Materials placed within 500mm of cement-bound materials, concrete pavements, concrete structures or concrete products shall be type B granular material complying with Clause 804 and have an acid soluble sulphate content not exceeding the Category AS0.2 when tested in accordance with IS EN 1744-1.

Table 8/9: Granular Material Type E (close graded unbound mixtures)

IS EN 13285 Categories -				
Mix Designation:		**0/31,5**		
Oversize Category:		**OC 80**		
Overall Grading:		**G_B**		
Sieves for Grading / Fines Category	**ISO Sieve Size (mm)**	**Percentage by Mass Passing**		
		Overall Grading Range	**Supplier Declared Value Grading Range**	**Tolerance on the Supplier Declared Value**
2D	63	100	No Requirement	No Requirement
D	31,5	80 - 99		
A	16	55 - 85	63 - 77	±8
B	8	35 - 68	43 - 60	±8
C	4	22 - 60	30 - 52	±8
E	2	16 - 47	23 - 40	±7
F	1	9 - 40	14 - 35	±5
G	0,5	5 - 35	10 - 30	±5
UF_9	0,063	0 - 9	No Requirement	No Requirement
LF_N	NR	NR		

Grading of individual batches – differences in values passing selected sieves

Retained sieve size, mm	Passing sieve size, mm	Percentage by mass passing	
		Not less than	Not more than
8	16	10	25
4	8	10	25
2	4	7	20
1	2	4	15

NOTE: The particle size shall be determined by the washing and sieving method of IS EN 933-1

809 Unbound Materials Placed Adjacent to Metallic Structural Elements

1 All unbound mixtures deposited within 500 mm, or any other distances described in Appendix 7/1, of metallic structural elements forming part of the Works shall be type B granular material complying with Clause 804 and, when tested in accordance with IS EN 1744-1 shall demonstrate both:

(i) a water-soluble sulfate (WS) content not exceeding 300 mg of sulfate (as SO_4) per litre; and

(ii) an oxidisable sulfides (OS) content not exceeding 0.06% of sulfate (as SO_4) determined by deducting acid soluble sulphate (as SO_4) from the total potential sulphate (as SO_4)

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

3 The requirements in sub-clause 1 above shall not apply to metallic items protected by concrete and ancillary metallic items such as the tops of chambers and gullies.

Cement Bound Mixtures for Subbase and Base

810 General Requirements for Cement Bound Mixtures

1 Cement bound mixtures (hereafter referred to by the generic term HBM, Hydraulically Bound Mixture) shall be produced, constructed and tested in accordance with the following Clauses. The permitted alternatives for each part of the Works shall be as described in Appendix 7/1.

2 Attributes shall be deemed to have a 'No Requirement' classification unless stated otherwise.

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

CBGM cement bound granular mixture

CBR California bearing ratio

E modulus of elasticity

G_{vxx} volumetric expansion category

HBM hydraulically bound mixture

IBI immediate bearing index in accordance with IS EN 13286-47

Imm_{xx} immersion category

IPI_{xx} immediate bearing category

LA Los Angeles coefficient

MCV moisture condition value

NR no requirement

OWC optimum water content

$Pulv_{xx}$ pulverisation category

R_c compressive strength

R_t direct tensile strength

R_{it} indirect tensile strength

R_t,E method of performance classification based on the combination R_t and E. Classes of R_t,E are designated T0 to T5, in IS EN 14227, where T designates R_t,E and the number indicates the performance class

SC soil cement time (hours) at constant temperature in defining maturity for calculating the construction period T°C ambient air temperature in defining maturity for calculating construction period

Wxx water content category

Conditions of cement supply

4 In accordance with the note to clause 1 of IS EN 197-1, the exchange of additional information between the manufacturer and the user should be made in accordance with, but not limited to the following:

Identification

Cement should be identified on the bag or the delivery note, and on any test report, with the following particulars:

(i) the name, trade mark or other means of identification of the manufacturer to facilitate traceability to the factory in which the cement was manufactured;

(ii) the designation/name, the notation / type and strength class of the cement; e.g.

Portland cement CEM I 42,5N;

Portland-limestone cement CEM II/A-LL 42,5N;

Blastfurnace cement CEM III/A 42,5N;

(iii) the number and date of the Irish Standard e.g. IS EN 197-1:2007;

(iv) the standard notation of any admixture, where applicable;

(v) the CE marking plus associated information;

and in the case of bagged supply only:

(vi) the weight of a bag packed with cement.

Packed/bagged cement

Where cement is supplied in a bag for manual handling, the weight should be 25 kg, or less, within permitted tolerances.

Testing

5 HBM shall be tested in accordance with Clause 825 and the test methods specified in the following clauses.

Mix designation

6 The Contractor shall submit a statement to the Employer's Representative that includes:

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

(ii) Target proportions of constituents, including water.

(iii) Mixture design details and results, in accordance with Clause 826.

(iv) Method statement in accordance with Clause 817.

811 Binder Constituents

1 Binder constituents shall comply with IS EN 14227 except that quicklime used in the pre-treatment of soil cement shall comply with IS EN 14227-11 and have a grading that complies with particle size Category 1.

2 The binder content shall comply with Table 8/10. The mixture proportions used for production shall be based on a laboratory mixture design procedure in accordance with Clause 826.

812 Storage of Constituents

1 Aggregates shall be stored on a firm and clean substrate avoiding contamination with other constituents. Aggregate stockpiles shall be managed in such a way as to minimise variation in water content. Fine aggregate shall be stored at the production location for at least 24 hours before use.

2 Lime and cement shall be stored in silos.

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

813 General Requirements for Production and Construction

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

3 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 8/11 or the mixture setting time. The time shall be measured from the addition event defined in Table 8/11 to completion of compaction.

4 Mixtures used in base layers shall be batched by mass and paver laid in a single lift. Construction of bases by other methods shall only be permitted when alternative proposals are submitted to the Employer's Representative to address confined spaces where it is impracticable for a paver to operate.

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

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

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

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

9 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 and shall meet the requirements for density in clause 825.

Table 8/10: 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)
Cement	When used as the only binder constituent in CBGM	The appropriate value from IS EN 14227-1, Table 1	1% + (the appropriate value from IS EN 14227-1, Table 1)
	When used as the only binder constituent in soil treated by cement (SC)	3%	4%

Table 8/11: Construction Period for HBM Layers

Binder	Addition event defining the start time for calculating maximum construction period	Maximum construction period (°C hours)
Cement	Addition of cement	35

10 Compaction of HBM shall be carried out by vibrating roller and/or pneumatic-tyred roller (PTR).

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

Cold and Wet Weather Working

12 During cold weather:

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

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

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

(iv) the laying of HBM using binders containing less than 3% of CEM 1 cement, by dry mass of mixture, shall be restricted in use to the period from 1 May to 30 November, unless otherwise agreed by the Employer's Representative.

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

Curing, Protection and Trafficking

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

(i) application of a bitumen emulsion spray complying with Class C40B4, as specified in the IS EN 13808 to produce an even and complete coverage of at least 0.2 kg/m2 of residual bitumen. Before spraying commences, the surface shall be free of all loose material and standing water. The curing membrane shall be protected from any damage until the construction of the overlaying layer;

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

15 Trafficking of HBM layers shall comply with the requirements set out in Table 8/12 and sub-Clause 813.16. Should any HBM layer exhibit signs of damage, trafficking shall cease immediately and shall only be resumed once the layer has gained sufficient stability to resist damage.

16 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 813.10 to comply with the requirements of sub-Clause 813.11;

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

(iii) test specimens made at the same time as the specimens required in Clause 825 but cured under the same conditions as the in-situ CBGM have achieved an average strength of at least Class C3/4.

Table 8/12: Trafficking of HBM Layers

HBM Designation	Clause reference	Trafficking
CBGM	821, 822 and 823	Sub-Clause 813.16
SC	824	Not restricted provided that the IBI requirements of Table 8/14 are satisfied. For mixtures containing cohesive soil or chalk, the test specimens made at the same time as the specimens required in Clause 825 but cured under the same conditions as the insitu treated soil shall also have achieved an average strength of at least Class C0.8/1.0.

17 Surface contamination shall be avoided as far as is practicable and any unavoidable contamination shall be removed prior to overlaying. Reworking and re-compaction of the layer shall only be permitted within the construction period set out in Table 8/11. Reworking shall only be permitted when the water content requirements of the reworked material are maintained within the limits stated in the method statement required under Clause 817.

18 Before overlaying, any loose material shall be removed and replaced to the full depth of the layer or, if within the construction period set out in Table 8/11, reworked as specified in sub-Clause 813.17.

19 Daily record sheets complying with sub-Clause 817.4 shall be submitted to the Employer's Representative by start of work on the next working day, detailing:

(i) spread rate/batching record results;

(ii) depth measurements;

(iii) density test measurements;

(iv) sample and test locations;

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

Work may proceed during the period for objection, which shall be 24 hours.

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

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

2 The mixing plant shall have an automated surveillance and data collection system.

3 HBM shall be transported directly to the point where it is to be laid in covered trucks and protected from the weather both during transit and whilst awaiting tipping.

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

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

2 HBM shall be transported directly to the point where it is to be laid and protected from the weather during transit and whilst awaiting tipping.

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

816 Mix-in-Place Method of Construction

1 Mixed-in-place HBM shall be produced by an in-situ pulverizing-mixing process with the added mixing water injected directly into the mixture during the mixing process. The pulverizing-mixing process shall be repeated until a homogenous mixture is produced.

2 When binder constituents are dispensed onto the surface to be pulverized-mixed, the rate of spread shall be confirmed by site checks carried out in accordance with Clause 825. For each group of 5 readings the mean rate of spread of material shall be within ±10% of the stated target rate and each individual value shall be within ±15% of the mean value of the group of 5 readings.

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

4 Mixing of fresh material shall ensure a minimum overlap of 200 mm with previously mixed material.

5 Where lime is used to granulate cohesive soils it shall be added and mixed with the soil using at least two passes of the pulveriser-mixer between 24 and 96 hours before the subsequent addition of cement. The surface of the layer shall be sealed by rolling immediately after adding and mixing lime. The MCV during this period, known as the mellowing period, shall comply with Clause 824.

817 Method Statement

Method Statement

1 At least 10 days prior to constructing areas of HBM, the Contractor shall submit a full method statement to the Employer's

Representative. The statement shall detail the operatives, plant, materials and procedures for the construction of the works, including procedures. The statement shall also include procedures for induced cracking, if required by Appendix 7/1, and the, procedures to be applied during inclement weather, plant breakdowns and other unscheduled events.

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

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

4 The method statement shall include a sample record sheet for the submission of the data required by sub-Clause 813.19.

818 Induced Cracking of HBM

1 Where the HBM layer in the pavement construction comprises HBM with a strength class equal to or exceeding C8/10, C9/12 or T3 that layer shall have cracks induced during construction, as described in sub-clause 4 below, at a maximum longitudinal spacing of 3 m ± 5%.

2 Where HBM layers with a strength class equal to or exceeding C 8/10, C 9/12 or T3 are constructed in widths exceeding 4.75m, longitudinal cracks must be induced, as described in sub-clause 4 below, at not more than 4.750m centres. Longitudinal construction joints or induced cracks shall not be located more than 150mm from the lane line, or edge line marking. Longitudinal construction joints or induced cracks shall not be located within the left hand lane of dual carriageways. At tapers and other changes in section the construction joint or induced crack layout shall be agreed with the Employer's Representative [Specialist responsible for the design], and where necessary may also be permitted within 150mm of the mid-point of the traffic lane.

3 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.

4 Cracks shall be induced in fresh material after initial compaction. The transverse cracks shall be induced by grooving the fresh material to form straight vertical grooves not more than 20 mm wide, to a depth of between one half and two thirds of the layer thickness over the full width of the pavement.

5 Bitumen emulsion shall be poured or sprayed into the grooves prior to final compaction, to form a crack inducing membrane. The bitumen emulsion shall comply with Class C40B4, as specified in IS EN 13808. During final compaction of the mixture, the surface of the groove shall be fully closed throughout its full length. The bitumen in the groove shall be fully encased and remain continuous, with not less than 70% of the sides of the groove coated with bitumen, as determined by a trial procedure prior to commencement of operations.

819 Determination of the Coefficient of Linear Thermal Expansion

Scope

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

Apparatus

2 The following apparatus shall be used:

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

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

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

Test procedure

3 The following test procedure shall be followed:

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

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

(iii) Cure the specimens using the procedure specified for the determination of mechanical laboratory performance in Table 8/16.

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

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

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

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

Calculations

4 Calculate the Coefficient of Linear Thermal Expansion (CLE) as follows:

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

CLE′ = (L2 – L1) / (T2 – T1), giving 9 results in total.

(ii) Reject the highest and lowest results and record the mean value of CLE′ for the remaining 7 results.

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

CLE′′ = (L2 – L3) / (T2 – T3), giving 9 results in total.

(iv) Reject the highest and lowest results and record the mean value of CLE′′ for the remaining 7 results.

(v) Calculate:

CLE = 0.5 ((Mean value of CLE′) + (Mean value of CLE′′)).

(vi) Check that the mean values of CLE′ and CLE′′ lie in the range 0.95CLE to 1.05CLE. If the mean values lie outside this range, repeat the procedure in sub-Clause 871.3.

Reporting of Results

5 Report the value of CLE using units of m.10-6/ºC, expressed to the nearest whole number.

820 Aggregates for HBM

1 The aggregates used in HBM shall comply with IS EN 13242 and the selected requirements listed in Table 8/13. Where recycled coarse aggregate or recycled concrete aggregate is used in HBM the material shall comply with the additional requirements for the proportion of the components listed in Table 8/13. The constituents of a sample of recycled aggregate shall be classified by hand-sorting the coarse aggregate particles in accordance with IS EN 933-11. The test shall be carried out by a suitably trained laboratory technician who has demonstrated competence in classifying the constituent classes in accordance with the test method.

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

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

Table 8/13: Aggregate Requirements for HBM

Requirement			
Clause reference	**821**	**822**	**823**
HBM Designation	**CBGM A**	**CBGM B**	**CBGM C**
Categories for aggregate properties, IS EN 13242			
Crushed or broken particles or totally rounded particles	C_{NR}	C_{NR} *unless otherwise specified in Appendix 7/1*	
Resistance to fragmentation of coarse aggregate	LA_{NR}	LA_{50} *or* LA_{60} *as specified in appendix 7/1*	LA_{50}
Acid-soluble sulphate content (Note 1)	$AS_{0,2}$		
Total sulphur content (Note 1)	S_1		
Other requirements, BS 1377-2			
Fines quality	NR	The fines fraction passing the 0,425mm test sieve shall be non-plastic as defined by and tested in compliance with BS 1377-2	
Proportion of components (Note 2)			
Maximum glass content (Class Rg)	40		
Maximum impurities content (Class X)	5	3	3

Note 1: Where the Contractor is able to provide evidence of mixture stability over an extended period then the National Roads Authority Head of Engineering may consider the use of higher limits.

Note 2: The constituents of a sample of recycled aggregate shall be classified by hand-sorting the coarse aggregate particles in accordance with IS EN 933-11. The test shall be carried out by a suitably trained laboratory technician who has demonstrated competence in classifying the constituent classes in accordance with the test method.

821 Cement Bound Granular Mixtures A (CBGM A)

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

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

3 The strength after immersion shall be at least 80% of the non-immersed strength, when tested in accordance with the laboratory mixture design requirements specified in Clause 826.

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

5 The laboratory mechanical performance shall comply with the requirements of Appendix 7/1, when sampled and tested in accordance with Clause 825.

822 Cement Bound Granular Mixtures B (CBGM B)

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

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

3 The strength after immersion shall be at least 80% of the non-immersed strength, determined in accordance with the laboratory mixture design procedure specified in Clause 826.

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

5 The laboratory mechanical performance shall comply with the requirements of Appendix 7/1,

when sampled and tested in accordance with Clause 825.

823 Cement Bound Granular Mixtures C (CBGM C)

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

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

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

4 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 826.

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

6 The laboratory mechanical performance shall comply with the requirements of Appendix 7/1, when sampled and tested in accordance with Clause 825.

824 Soil Cement (SC)

1 The mixture shall be as specified in Appendix 7/1 and shall comply with the appropriate requirements selected from Table 8/14 and the following:

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

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

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

3 When tested in accordance with IS EN 1744-1, 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 8/14. Soil with a total potential sulfate (TPS) equal to or greater than 0.25% sulfate (as SO_4) shall only be deemed suitable for treatment where agreed by the National Roads Authority Head of Engineering.

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

5 The laboratory mechanical performance shall comply with the requirements of Appendix 7/1, when sampled and tested in accordance with Clause 825.

825 Testing, Control and Checking of HBM

General

1 Tests, controls and checks shall be carried out in accordance with the requirements in Table 8/15 and the following sub-Clauses at locations determined by the Employer's Representative, unless otherwise stated in Appendix 1/5. Where the Employer's Representative is satisfied that a consistent quality of work is being achieved he may direct the frequency of testing to be reduced to half that required in Table 8/15. Where a test reference is shown in Table 8/15, the testing shall be carried out in compliance with the requirements of Clause 105 and be undertaken by an organisation accredited in accordance with IS EN ISO/IEC 17025 for the test method.

Sampling

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

Table 8/14: Requirements for Soil Treated by Cement (SC)

Mixture parameter	Requirement Category		IS EN 14227 -10, -12, -13, -14 reference
	Non cohesive soil mixtures	Cohesive soil mixtures	
Minimum water content (Expressed as a proportion of the optimum water content, determined in accordance with IS EN 13286-4, Vibrating Hammer method)	$W_{0,9}$	W_{NR} (Note 1)	Table 1
	$W_{1.0}$ for mixtures containing quicklime		
Degree of pulverisation (determined in accordance with IS EN 13286-48)	$Pulv_{NR}$ (Note 1)	$Pulv_{60}$	Table 2
Immediate Bearing Index (Note 2) (Determined in accordance with Clause 826)	IPI_{40} (Note 3)	IPI_{15}	Table 3
Moisture Condition Value (determined in accordance with IS EN 13286-46)	MCV_{NR} (Note 1)	$MCV_{8/12}$ at final mixing and compaction (Note 4)	Table 4
Laboratory mechanical performance (compressive strength or tensile strength)	R_c or $R_{t,E}$, as specified in Appendix 7/1		Table 6 for R_c, Figure 1 for $R_{t,E}$
Resistance to water – strength after immersion (R_1/R ratio, determined in accordance with Clause 826)	$I_{0,8}$		Table 7
Resistance to water – volumetric swelling (determined in accordance with IS EN 13286-49)	NR (Note 1)	G_{V5}	Table 9 (EN 14227-10)

NOTES:

1 The suffix $_{NR}$ denotes that the 'No requirement' category applies

2 Where SC is not to be trafficked within 7 days, IPINR 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

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

3 The rate of spread of added constituents shall be determined by weighing the amount of material retained on five trays (or mats) of known area laid in the path of the spreading machine. The trays (or mats) shall be positioned at points equally spaced along a diagonal line bisecting the area of coverage so as to assess the full width of discharge from the spreading machine.

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

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

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

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

6 The operation, warming-up period if any, and standardisation of the gauge shall be carried out in compliance with the manufacturer's recommendations. The gauge shall be calibrated in accordance with BS 1924 immediately prior to the construction of the Works to be tested and at least once every 28 days thereafter.

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

8 The in-situ wet density of a subbase layer shall be taken as the average value of five determinations equally spaced along a line that bisects each 1000 m2 or part thereof laid each day. The first and fifth positions shall be located 300 mm from the edges of the laid area, or other positions agreed by the Employer's Representative.

9 For a subbase layer, the average in-situ wet density of the area specified in sub-Clause 825.8 shall be not less than 95% of the average wet density of the test specimens taken to determine the laboratory mechanical performance of the same area.

10 For a base layer, the average in-situ wet density of the area specified in sub-Clause 825.8 shall be not less than 95% of the wet density of the HBM at its optimum moisture content, measured using the vibrating hammer method detailed in IS EN 13286-4. The result of each single determination of in-situ wet density shall be not less than 92% of the wet density of the HBM at its optimum moisture content.

Laboratory Mechanical Performance

11 A bulk sample of HBM shall be taken from each of the locations in sub-Clause 825.8, after the in-situ wet density has been determined. Test specimens used to determine laboratory mechanical performance shall be made using vibratory hammer compaction, in accordance with IS EN 13286-51. Where cubes are used for the determination of compressive strength, the specimens shall be 150 mm size.

12 Compliance of the area specified in sub-Clause 825.8 shall be assessed using the results for test specimens that are cured and tested in accordance with Table 8/16 using either compression or indirect tensile testing as appropriate to the class of mechanical performance specified in Appendix 7/1. Assessment shall be made using the following criteria:

(i) Compressive strength: The requirement specified in Appendix 7/1 shall be deemed to be satisfied if the average compressive strength of the group of specimens in Table 8/15 is equal to or greater than the minimum for the specified R_c class and no individual test result is less than 67% of the minimum strength requirement for the R_c class.

(ii) Indirect tensile strength: The requirement specified in Appendix 7/1 shall be deemed to be satisfied if the average indirect tensile strength of the group of specimens in Table 8/15 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 826.

13 For the purposes of this specification, any reference to 'characteristic strength' in IS EN 14227-1 shall be superseded by the requirements of this sub-Clause.

Table 8/15: 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 1000m²	BS 1924-1, Clause 7.1
Grading of aggregate or soil sources on site	1 per 1000m²	Aggregates: EN 1097-5 Soils: BS 1924-1, Clause 7.1
Plasticity of aggregate or soil sources on site	1 per 1000m²	BS 1924-1, Clause 7.3
Constituents sourced off-site	Aggregates – Results of routine control tests from the factory production control system required by IS EN 13242, Annex C to be provided weekly. Cement – Certificates to be provided monthly for each cement type, in accordance with Clause 810. 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-plant' method of construction at each stage of the mixing process (sub-Clause 825.3)	1 determination per 1000m² but not less than 4 per day	-
Mixture grading, including binder	1 per 1000m² but not less than 3 per day	IS EN 933-1
Water content at final compaction	1 per 1000m² 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 1000m² but not less than 4 per day	IS EN 13286-46
Pulverization (cohesive mixtures only)	2 per 1000m² but not less than 4 per day	IS EN 13286-48
Depth of mixing for 'mix-in-place' method of construction at each stage of the mixing process (sub-Clause 825.4)	5 per 1000m² but not less than 4 per day	-
In-situ wet density	5 per 1000m² or part thereof laid each day (measured at the locations detailed in sub-Clause 825.8)	Sub-Clause 825.5
Laboratory mechanical performance	5 per 1000m² or part thereof laid each day (with test specimens prepared from a bulk sample taken from each of the locations detailed in sub-Clause 825.8)	As required by Table 8/16
Strength after immersion in water	Laboratory mixture design procedure	As required by Clause 826

Table 8/16: Laboratory Mechanical Performance Testing Requirements for HBM

Clause	Mixture	Curing regime	Curing temperature	Test method	Age at test
821, 822 & 823	CBGM A, CBGM B and CBGM C	Regime A from IS EN 14227-1 Annex C	20°C	R_C – IS EN 13286-41 R_{it} – IS EN 13286-42 E_C – IS EN 13286-43	28 days – or other age agreed by the Employer's Representative (see Note)
824	SC	Regime A1 from IS EN 14227-10 Annex B			

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.

826 Laboratory Mixture Design Procedure

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

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

Immediate Stability

3 When required by Table 8/14, the mixture design procedure for soil cement shall include the determination of the immediate bearing index (IBI) at the selected design water and binder content, measured in accordance with IS EN 13286-47. The IBI value shall be taken as the average value for a set of 3 test specimens.

Resistance to Water – Strength after Immersion

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

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

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

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

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

Resistance to Frost Heave

6 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 8/16.