IMPLEMENTATION SPECIFICATION FOR ROAD WORKS

SERIES IM/800

ROAD PAVEMENTS – UNBOUND AND CEMENT BOUND MIXTURES

This Specification Series implements the requirements in Subsidiary Legislation 499.57, Part II (New Roads and Road Works Regulations) in accordance with the Agency for Infrastructure Malta ACT XXVIII, CAP. 588, Part I

Date: **12 February 2021**

Version: **v1.0**

800 ROAD PAVEMENTS – UNBOUND AND CEMENT BOUND MATERIALS

801 General Requirements for Unbound and Cement Bound Materials

1 Sub-bases (foundation course) and unbound base courses shall be made and constructed using materials described in the following Clauses. The permitted alternatives for each part of the Works shall be as described in IM Appendix7/1.

2 Unbound mixtures shall be made and constructed to conform to MSA EN 13285, the requirement categories in Table 800-1 and Clauses 801 to 804. The permitted alternatives for each part of the permanent works shall be as described in contract specific IM Appendix7/1.

Table 800-1: Mixture and Grading Requirement Categories for Unbound Mixtures

Unbound mixture	Type 1	Type 4 (asphalt arisings)
Clause	**802**	**804**
Mixture requirement category		
Designation	0/37,5	0/37,5
Maximum fines	UF_9	UF_9
Oversize	OC_{75}	OC_{75}
Grading requirement category		
Overall grading	G_P	G_P

3 Unbound mixtures placed within 500mm, or any other distances described in the contract specific IM Appendix7/1, of metallic structural elements 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 MSA EN 1744-1 clause 10 shall not exceed 300 mg of sulfate (as SO_4) per litre;
   (ii) Total sulfur (TS) content determined in accordance with MSA EN 1744-1 clause 11 expressed as (S) shall not exceed 1% for aggregates

b) Mixtures shall conform to at least one of the following two options:
   (i) When described in accordance MSA EN 13242 Annex A, limestone, dolomite, or crushed concrete are predominant.
   (ii) The sulfide content of the mixture determined in accordance with MSA EN 1744-1 Clause 13 is less than 0.06% (as SO_4).

4 When determining WS, TS or sulphide content, at least five samples of each material shall be tested. 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. The pH of the mixture shall be reported.

5 The requirements in (b) (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.

6 The properties of aggregates used in unbound mixtures shall comply with the selected requirements of MSA EN 13242 listed in Table 800-2.

Table 800-2: Requirements for Aggregates Used in Unbound Mixtures

Unbound mixture	Type 1	Type 4 (asphalt arisings)
Clause	**802**	**804**
Crushed, or broken and totally rounded particles		
Crushed rock, crushed manufactured and crushed recycled aggregates See NOTE 1	$C_{90/3}$	$C_{90/3}$
Crushed gravel	$C_{50/10}$ - see NOTE 2	Not permitted
Resistance to fragmentation - Los Angeles test	LA_{50}	LA_{50}
NOTES: 1. MSA EN 13242 assumes that crushed rock aggregates comply with category $C_{90/3}$ without further testing. 2. Where permitted by contract specific IM Appendix7/1.		

7 Where recycled coarse aggregate or recycled concrete aggregate is used in unbound mixtures in accordance with Clauses 801 and 804 as appropriate, it shall have been tested in accordance with Clause 709. Recycled coarse aggregate and recycled concrete aggregate used in unbound mixtures in accordance with Clauses 802 and 804 shall also comply with the additional requirements of Table 800-3.

Table 800-3: Additional 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 4 (asphalt arisings)
Component Identified by Clause 709	**Maximum Permitted Content** (% by mass)	
Asphalt (Class Ra)	50	100
Glass (Class Rg)	25	
Other materials (Class X), including wood, plastic and metal	1	

8 When required by contract specific IM Appendix7/1 and Clause 802 as appropriate, the unbound mixture shall satisfy the minimum CBR requirement of contract specific IM Appendix7/1 when tested in accordance with clause 7 of BS 1377-4, with surcharge discs. The specimens shall be tested in a soaked condition. The mixture shall be tested at the density and moisture content likely to develop in equilibrium field conditions which shall be taken as being the density relating to the uniform air voids content of 5% and the value of optimum water content declared when tested as required by MSA EN 13285.

Transporting

9 Plant-mixed material shall, when mixed, be removed at once from the mixer, transported to the point where it is to be laid and protected from weather both during transit from the mixer to the laying site and whilst awaiting tipping.

Laying

10 All material shall be placed and spread evenly. Spreading shall be undertaken either concurrently with placing or without delay. Unbound and cement bound base course material shall be spread using a paving machine or a suitable spreader box and operated with a mechanism that levels off the material to an even depth. Mixtures are to be laid at a water content which is favourable for compaction.

11 Except where otherwise stated in IM Appendix7/1, material shall be spread so that after compaction the total thickness is at least as follows:

a) Aggregate mixture 0/31.5mm: 150mm

12 Laying of several layers is possible if the minimum laying thickness is observed. Where the layers of unbound material are of unequal thickness the lowest layer shall be the thickest layer.

Compaction

13 Compaction should be completed as soon as possible after the material has been spread and in accordance with the requirements for the individual materials.

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

15 Compaction of unbound materials may be carried out by a method specified in Table 800-1. Independently of the methods in Table 800-1, the following shall also be carried out:

a) The Contractor shall at least 7 days before commencement of compaction make available the following to the Overseeing Organisation:

i. The values of maximum dry density and the optimum moisture content obtained in accordance with BS 1377: Part 4 (or EN 13286 – Part 2) using 4.5kg (modified) rammer method or equivalent BS 1377: Part 4 (EN 13286-Part 4) vibrating hammer.

ii. A graph of dry density plotted against moisture content from which each of the values in (i) above of the maximum dry density and optimum moisture content were determined.

iii. The California Bearing Ratio (CBR) in accordance with EN 13286-47 of the material at the following moisture values:

a. at the optimum moisture content

b. after saturation of 4 days

c. at the moisture percent of the mid-point of the range (optimum moisture content – saturation moisture).

b) Once the information contained in this sub-clause has been made available to the Overseeing Organisation it shall form the basis (reference) for compaction including the degree of compaction. EV2 values information may be interpolated from the CBR values at the moisture values tested for guidance in wet conditions.

16 The in situ (field) dry density shall be measured in accordance with BS 1377: Part 9, except that nuclear methods shall only be used where permitted by the Overseeing Organisation.

17 The in situ (field) dry density shall be compared to the reference baseline value from the laboratory proctor (4.5kg) to compute the percent degree of compaction.

18 When permitted by the Overseeing Organisation for informative purposes the in situ (field) dry density may also be measured using a non-nuclear electromagnetic tester for in-place density and water content of soil/aggregate complying with ASTM D7830 / 7830M Standard Test Method for In-Place Density (Unit Weight) and Water Content of Soil and correlated with the direct method of test (sand replacement).

Light Weight Deflectometer (Indirect Test)

19 The following equipment may be used as a supplementary informative test indication of the weakest location/s for the definitive normative test using the DIN 18134 plate:

i. Light Weight Deflectometer complying with the German FGSV "Supplementary Technical Terms and Conditions of Contract and Guidelines for Earthworks in Road Construction ZTVE-StB 94 and/or to ASTM E2835 – Standard Test Method for Measuring Deflections using a Portable Impulse Plate Load Test Device or approved equivalent (including the correlation to DIN 18134). The correlation to the DIN 18134 Ev2 shall be as described in FGSV ZTVE-StB 94.

20 The equipment shall be calibrated. The "indirect" DIN 18134 Ev2/Ev1 ratio shall not substitute the direct field density tests. The Overseeing Organization shall approve the extent to which the compaction control will be based on the relation Ev2/Ev1.

Stiffness (Indirect Test)

21 The Overseeing Organisation may also require supplementary informative testing to establish the stiffness value of the compacted granular layer using the electro-mechanical measuring gauge for in-place stiffness and modulus of soil (and soil-aggregate mixture) complying with ASTM D6758 Standard Test Method for Measuring Stiffness and Apparent Modulus of Soil and Soil-Aggregate In-Place by Electro-mechanical Method. The Overseeing Organization may permit the use of stiffness modulus values as normative values subject to approval.

22 Independently from all other density-related tests the following requirements shall also be achieve:

b) Plate Bearing test to DIN 18134:

i. The reaction modulus Ev2 according to DIN 18134 as shown in

ii. Table 800-4, Table 800-5, Table 800-6 and Table 800-7 ("Directives for the Standardization of Pavements for Traffic Areas") have to be achieved. The relation Ev2/Ev1 shall not exceed 2.2. Higher relations than 2.2 are permissible if the value Ev1 is at least 60% of the required Ev2 value.

Table 800-4: Standardisation for pavements with asphalt surfacing of traffic areas

Pavement Construction	Construction Class	HD	I	II	III	IV	V	VI
	Equivalent 10 t - axle passes (mil) B	>32	>10 - 32	>3 - 10	>0.8 - 3	>0.3 - 0.8	>0.1 - 0.3	≤ 0.1
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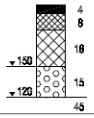
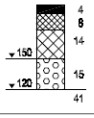
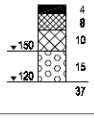
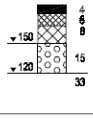
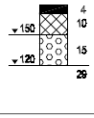
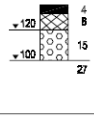
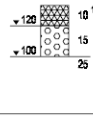
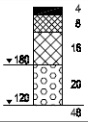
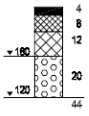
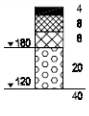
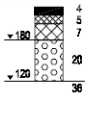
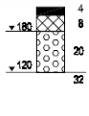
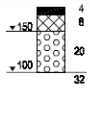
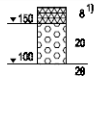
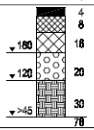
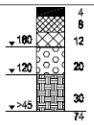
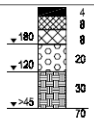
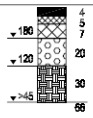
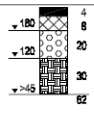
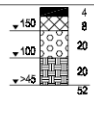
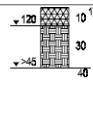
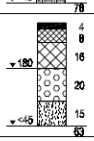
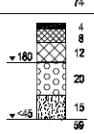
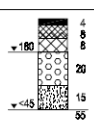
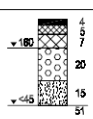
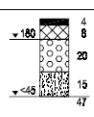
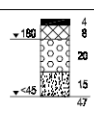
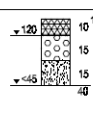
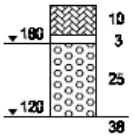
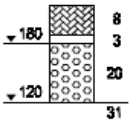
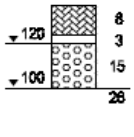
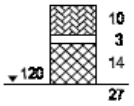
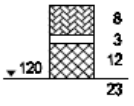
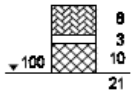
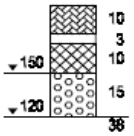
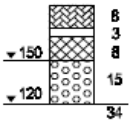
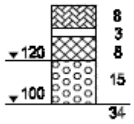
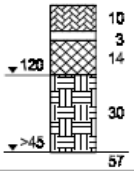
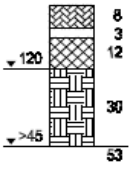
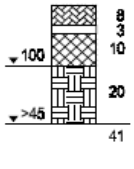
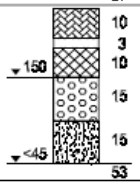
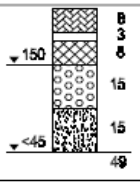
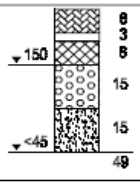
2 Asphalt Type 1	Wearing Course Binder Course Base Course Type 1 (15 cm)							
3 Asphalt Type 1	Wearing Course Binder Course Base Course Type 1 (20cm)							
4 Asphalt Type 1 Foundation course	Wearing Course Binder Course Base Course Type 1 Foundation Course							
5 Asphalt Type 1 Cement Stabilization	Wearing Course Binder Course Base Course Type 1 Cement stabilization							

[1] Combined base course / wearing course or asphalt construction in two layers

Note Thickness is in cm

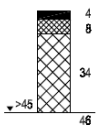
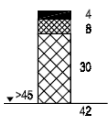
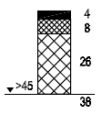
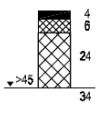
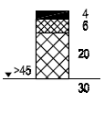
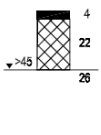
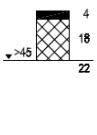
Table 800-5: Standardisation of pavements with sett surfacing of traffic areas

Pavement Construction	Construction Class Equivalent 10 t - axle passes (mil) B	III > 0.8 - 3	IV > 0.3 - 0.8	V and VI ≤ 0.3
1 Type 1	Sett paving [1] Bedding course Type 1			
2 Asphalt	Sett paving [1] Bedding course Asphalt base course			
3 Asphalt Type 1	Sett Paving [1] Bedding course Asphalt base course Type 1			
4 [2] Asphalt Foundation course	Sett Paving [1] Bedding course Asphalt base course Foundation course			
5 Asphalt Type 1 Cement Stabilization	Sett Paving Bedding course Asphalt base course Type 1 Cement Stabilization			

[1] **Thickness to be selected in accordance with the traffic loading and speed**

Note **Thickness is in cm**

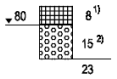
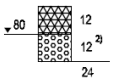
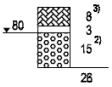
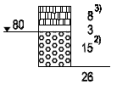
Table 800-6: Full depth asphalt pavement [1] of traffic areas

Construction Class	HD	I	II	III	IV	V	VI
Equivalent 10 t - axle passes (mil) B	>32	>10 - 32	>3 - 10	>0.8 - 3	>0.3 - 0.8	>0.1 - 0.3	≤ 0.1
Wearing Course Binder Course Base Course							

[1] **Instead of construction method No.4 or No.5 of Chart 1 to reduce depth of excavation (utilities)**

Note **Thickness is in cm**

Table 800-7: Standardisation for bicycle lanes and footpaths

Construction method with	Asphalt surfacing	Concrete surfacing	Sett surfacing	Flag surfacing
Surfacing Type 1				

Note Thickness is in cm

1 Combined base / wearing course or asphalt construction in two layers

2 Layer of type 1 may be left for SSI soils

2 **Lower thickness possible if pedestrian and / or bicycle traffic only**

Note: An approximate empirical relationship with CBR can be made as follows: CBR = 6.1x10-8 x (k762)1.733 % where k762 is the Modulus of Subgrade Reaction, defined as the applied pressure under the loading plate divided by the displacement (normally 1.25mm) with a plate of 762mm (30 inch) diameter. With this method the in-situ CBR can be checked against the design CBR.

c) The compaction degree (dry density when compared to the 4.5kg Proctor) when tested in accordance with BS 1377-9 shall not fall below D_{pr} = 98%

16 The following tolerances are permissible in production control and control testing:

a) Less than five test values: all values have to be above the minimum value.

b) Five or more test values: one value may fall below the required value by 10%.

17 The Site Engineer of the Overseeing Organisation decides to which extent the compaction control will be carried out based only on the gauges, light weight deflectometer or plate bearing analysis.

18 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, potholes, 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.

19 For the purposes of Table 800-1 the following shall apply:

a) 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).

b) The compaction plant in Table 800-1 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.

c) 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 spacing between the wheel tracks provided that each spacing does not exceed 230mm. Where the spacing exceed 230mm, the effective width shall be the sum of the widths of the individual wheel tracks only.

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

   i) 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.

   ii) Where the mechanical vibration is applied to two rolls in tandem, the minimum number of passes shall be half the number given in Table 800-1 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.

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

   iv) 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.

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

   i) 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.

ii) 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 1km/h but if higher speeds are necessary, the number of passes shall be increased in proportion to the increase in speed of travel.

f) 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.

g) Power rammers are machines, which are actuated by explosions in an internal combustion cylinder. The operator controls each of these explosions manually. One pass of a power rammer is considered as the instance when the compacting shoe has made one strike on the area in question.

h) 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 as will together produce the same total compactive effort as any one operated singly in accordance with Table 800-1.

Table 800-8: Compaction Requirements for Granular Sub-base Material Types 1 and 4

Type of compaction plant	Category	Number of passes 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 2700 kg up to 5400 kg	16	unsuitable	unsuitable
	over 5400 kg	8	16	unsuitable
Pneumatic-tyred roller	Mass per wheel:			
	over 4000 kg up to 6000 kg	12	unsuitable	unsuitable
	over 6000 kg up to 8000 kg	12	unsuitable	unsuitable
	over 8000 kg up to 12000 kg	10	16	unsuitable
	over 12000 kg	8	12	unsuitable
Vibratory roller	Mass per metre width of vibrating roll:			
	over 700 kg up to 1300 kg	16	unsuitable	unsuitable
	over 1300 kg up to 1800 kg	6	16	unsuitable
	over 1800 kg up to 2300 kg	4	6	10
	over 2300 kg up to 2900 kg	3	5	9
	over 2900 kg up to 3600 kg	3	5	8
	over 3600 kg up to 4300 kg	2	4	7

	over 4300 kg up to 5000 kg	2	4	6
	over 5000 kg	2	3	5
Vibrating-plate compactor	Mass per square metre of base plate:			
	over 1400 kg/m² up to 1800 kg/m²	8	unsuitable	unsuitable
	over 1800 kg/m² up to 2100 kg/m²	5	8	unsuitable
	over 2100 kg/m²	3	6	10
Vibro-tamper	Mass:			
	over 50 kg up to 65 kg	4	8	unsuitable
	over 65 kg up to 75 kg	3	6	10
	over 75 kg	2	4	8
Power rammer	Mass:			
	100 kg-500 kg	5	8	unsuitable
	over 500 kg	5	8	12

Use of Surfaces by Traffic and Construction Plant

20 Construction plant and 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.

21 Where the Contractor proposes to use the sub-base or base course layers for construction plant, he shall improve the sub-base or base 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 base course, sub-base, any capping and the subgrade. Any permanent thickening shall be across the whole width of the pavement. Temporary thickening shall not impede drainage of the sub-base or the subgrade.

802 Type 1 Unbound Mixtures

1 Type 1 unbound mixture shall be made from crushed rock, crushed concrete, recycled aggregates and may contain up to 10% by mass of natural sand that passes the 4mm test sieve. Where permitted by contract specific IM Appendix7/1, crushed gravel complying with Table 800-2 may be used.

2 The mixture shall comply with MSA EN 13285 and the requirements of Table 800-1. The grading requirements for the mixture are summarised in Table 800-9.

Table 800-9: 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

3 The properties of aggregates used in the mixture shall be in accordance with MSA EN 13242 and the requirements of Table 800-2.

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

5 Where the mixture contains recycled coarse aggregate or recycled concrete aggregate, it shall comply with sub-Clause 801.7.

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

803 Type 3 (open graded) Unbound Mixtures

1 Type 3 (open graded) unbound mixture shall be made from crushed rock or recycled concrete aggregate. When tested in accordance with Clause 709, 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 The mixture shall comply with MSA EN 13285 and the requirements of Table 800-1. The grading requirements for the mixture are summarised in Table 800-10.

3 The properties of aggregates used in the mixture shall be in accordance with MSA EN 13242 and the requirements of Table 800-2.

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

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

Table 800-10: Summary Grading Requirements for Type 3 (open graded) Unbound Mixtures

Percentage by mass passing			
Sieve size, mm	**Overall grading range**	**Supplier declared value grading range**	**Tolerance on the supplier declared value**
80	100		
40	80 – 99		
20	50 – 78		
10	31 – 60	58 – 70	± 8
4	18 – 46	39 – 51	± 8
2	10 – 35	26 – 38	± 8
1	6 – 26	17 – 28	± 7
0.500	0 – 20	11 – 21	± 5
0.063	0 – 5	5 – 15	± 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

804 Type 4 (asphalt arisings) Unbound Mixtures

1 Type 4 unbound mixture shall be made from recycled aggregates containing asphalt arisings, and may contain crushed rock, crushed slag, 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 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 Type 4 unbound mixture shall have an asphalt (Class Ra) content greater than 50% when tested in accordance with Clause 709, and the recovered bitumen content of the asphalt shall be not more than 10% when tested in accordance with MSA EN 12697-1.

4 Type 4 unbound mixture shall comply with MSA EN 13285 and the requirements of Table 800-1. The grading requirements for the mixture are summarised in Table 800-9.

5 The properties of aggregates used in the mixture shall be in accordance with MSA EN 13242 and the requirements of Table 800-2.

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

7 Where the mixture contains recycled coarse aggregate or recycled concrete aggregate, it shall comply with sub-Clause 801.7.

8 The mixture shall be transported, laid and compacted without drying out or segregation, at a moisture content within the range 1% above to 2% below the declared value of optimum water content when tested as required by MSA EN 13285. The moisture content shall be determined by oven drying at a reduced temperature setting of 45°C to 50°C.

805 SuDS (Sustainable Drainage Systems) Unbound Mixtures 4/20 SuDS Unbound Mixtures

1 SuDS Mixtures shall comply with the requirements set in BS 7533-13 and this Specification.

2 SuDS Unbound Mixtures shall comply with the requirements set in BS 7533-13 and this Specification.

806 CE Marking

Declaration of Performance / Conformity

1 For the purposes of compliance for materials specified in Series 800 the Contractor shall submit to the Overseeing Organisation CE Markings and Declaration of Performance showing compliance with the relevant specifications.

807 General Requirements for Cement Bound Mixtures

1 Cement bound mixtures (CBGM) 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 contract specific IM Appendix7/1.

2 Attributes shall be deemed to have a “No requirement” classification unless stated otherwise.

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

CBGM	cement bound granular mixture
CBR	California bearing ratio
E	modulus of elasticity
G_{vxx}	volumetric expansion category
IBI	immediate bearing index
Imm_{xx}	immersion category
IPI_{xx}	immediate bearing index category
LA	Los Angeles coefficient
MCV	moisture condition value
NR	no requirement
OWC	optimum water content
PTR	Pneumatic tyred roller
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 MSA EN 14227, where T designates R_t,E and the number indicates the performance class
t	time (hours) at constant temperature in defining maturity for calculating the construction period
T°C	ambient air temperature in defining maturity for calculating construction period

W_{xx} water content category

4 CBGM shall be tested in accordance with Clause 817 and the test methods specified in the following Clauses.

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

a) The information detailed in the 'Designation and Description' clause of the relevant MSA EN Standard for the specified CBGM, confirming compliance with the requirements of this Series and contract specific IM Appendix7/1.
b) Target proportions of constituents, including water.
c) Mixture design details and results, in accordance with Clause 819.
d) Method statement for the demonstration area and the main works, in accordance with Clause 812.

6 When required by contract specific IM Appendix7/1, the coefficient of linear expansion of the mixture shall be determined in accordance with Clause 818.

808 Binder Constituents

1 Binder constituents shall comply with MSA EN 14227-1

2 The binder content shall comply with Table 800-11, unless otherwise agreed by the Overseeing Organisation. The mixture proportions used for production shall be based on a laboratory mixture design procedure in accordance with Clause 819.

Table 800-11: Minimum Binder or Binder Constituent Additions for CBGM

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 with another binder constituent	2%	3%
	when used as the only binder constituent in CBGM	The appropriate value from MSA EN 14227-1, Table 1	1% + (the appropriate value from MSA EN 14227-1, Table 1)
	when used as the only binder constituent in soil treated by cement (SC)	3%	4%
NOTE: When Granulated Blast Furnace Slag and Air-Cooled Steel Slag are used in combination, the sum of the two shall be not less than 11%.			

809 Storage of Constituents

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

2 Cement shall be stored in silos.

810 General Requirements for Production and Layer Construction

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

a) Mix-in-plant method of construction using batching by mass, in accordance with Clause 811;

2 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 800-12 or the mixture setting time. The time shall be measured from the addition event defined in Table 800-12 to completion of compaction.

3 The construction period, in degree hours, shall be the summation of the products of the average air temperature above 3°C (T °C) 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 4°C.

Table 800-12: Construction Period for CBGM Layers

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

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

5 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 150mm.

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 CBGM or other material shall be vertical and straight before fresh CBGM is laid against it.

9 Compaction of CBGM 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 817.

10 Compaction of CBGM shall be carried out by vibrating roller and/or pneumatic-tyred roller (PTR). Where vibrating roller compaction is used it shall be followed by at least 8 passes of a PTR with a wheel loading of not less than 30kN.

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 810.2. 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:

a) Night time winter placement - the temperature of CBGM shall not be less than 5°C at the time of laying; Laying of CBGM shall cease when the air temperature falls below 3°C, and laying shall not be resumed until the rising air temperature reaches 3°C;

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:

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

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

15 Trafficking of CBGM layers shall comply with the requirements set out in Table 800-13 and sub-Clause 810.16. Should any CBGM layer exhibit signs of damage, trafficking shall cease immediately and shall only be resumed once the layer has gained sufficient stability to resist damage.

Table 800-13: Trafficking of CBGM Layers

CBGM Designation	Clause reference	Trafficking
CBGM	815, 816	Sub-Clause 810.16

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

a) the layer is compacted by both vibrating roller and PTR in accordance with sub-Clause 810.10 to comply with the requirements of sub-Clause 810.11;

b) the mixture contains at least 50% by mass of coarse aggregate complying with MSA EN 13242, Category C90/3 for ‘crushed or broken particles’;

c) test specimens made at the same time as the specimens required in Clause 817 but cured under the same conditions as the in-situ CBGM have achieved an average strength of at least Class C3/4.

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 800-12. Reworking shall only be permitted when the water content requirements of the reworked material are maintained within the limits stated in the method statement.

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 800-12, reworked as specified in sub-Clause 810.17.

19 Daily record sheets complying with sub-Clause 812.4 shall be submitted to the Overseeing Organisation by start of work on the next working day, detailing:

a) spread rate/batching record results;

b) depth measurements;

c) density test measurements;

d) sample and test locations;

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

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

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

812 Method Statement and Demonstration Area

Method Statement

1 At least 10 days prior to constructing the demonstration area specified in sub-Clause 812.5, the Contractor shall provide a full method statement for the approval of the Overseeing Organisation. The statement shall detail the operatives, plant, materials and procedures for the construction of demonstration area(s) and of the works, including procedures. The statement shall also include procedures for induced cracking, if required by contract specific IM Appendix7/1, 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 work.

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

4 The method statement shall include a sample record sheet for the submission of the data required by sub-Clause 810.19.

Demonstration Area

5 Prior to the commencement of the main works, the Contractor shall construct a demonstration area of at least 60 m^2 conforming to the submitted method statement. The demonstration area shall include a transverse end-of-day joint and (if appropriate) multiple lift working. The demonstration area may be accepted into the permanent works, where agreed by the Overseeing Organisation. Where the Contractor can produce documentary evidence of similar work carried out to this specification during the previous 6 months, the Overseeing Organisation may allow the works to proceed without the demonstration area.

6 Where multiple lift working is used, the demonstration area shall confirm the effectiveness of the procedures used to assure that bond between the individual lifts can be achieved.

7 Where induced cracking is required, the demonstration area shall include crack induction at the specified spacing. The effectiveness of the procedure used shall be checked within 28 days of construction, by recovering four evenly spaced 150mm dia cores from the line of the induced cracks and assessing each core for compliance with sub-Clause 813.2.

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

813 Induced Cracking of CBGM

1 For CBGM having a compressive 28-day strength ≥ 10 MPa and where required by contract specific IM Appendix7/1, transverse cracks shall be formed at the specified spacing with a tolerance of ± 150 mm. Where the pavement is made up of two or more layers of CBGM with induced cracks, the cracks in the overlying CBGM layer shall align with the induced cracks in the layer below with a tolerance of ± 100 mm.

2 Cracks shall be induced in fresh material after initial compaction. The transverse cracks shall be induced by grooving the fresh material to form straight vertical grooves not more than 20 mm wide, to a depth of between one half and two thirds of the layer thickness over the full width of the pavement. Bitumen emulsion shall be poured or sprayed into the grooves prior to final compaction, to form a crack inducing membrane. The bitumen emulsion shall comply

with Class C40B4, as specified in the National Foreword to MSA EN 13808. During final compaction of the mixture, the surface of the groove shall be fully closed throughout its full length. The bitumen in the groove shall be fully encased and remain continuous, with not less than 70% of the sides of the groove coated with bitumen.

3 Where required by contract specific IM Appendix7/1, longitudinal cracks shall be induced using the procedure specified in sub-Clause 813.2.

814 Aggregates

1 The aggregates used in CBGM shall comply with MSA EN 13242 and the selected requirements listed Table 800-14. Where recycled coarse aggregate or recycled concrete aggregate is used in CBGM, it shall also be tested in accordance with Clause 709 and comply with the additional requirements for the proportion of the components listed in Table 800-14.

2 When required by contract specific IM Appendix7/1, an existing pavement layer that is to used to produce CBGM shall be tested to confirm compliance with sub-Clause 814.1.

Table 800-14: Aggregate Requirements for CBGM

Clause reference	**815**	**816**
CBGM designation	**CBGM A**	**CBGM B**
Categories for aggregate properties, MSA EN 13242		
Resistance to fragmentation of coarse aggregate	LA_{NR}	LA_{50} or LA_{60} as specified in contract specific IM Appendix7/1
Acid-soluble sulfate content (Note 3)	$AS_{1,0}$	
Total sulfur content (Note 3)	S_2	
Other requirements, BS 1377-2		
Fines quality (Note 4)	NR (Note 1)	*Non-plastic*
Proportion of components, Clause 709		
Maximum glass content (ClassRgG)	*40*	*40*
Maximum impurities content (Class X)	*5*	*3*

NOTES:

1. The suffix $_{NR}$ denotes that the 'No requirement' category applies.
2. Where the Contractor is able to provide evidence of mixture stability over an extended period then the Overseeing Organisation may consider the use of higher limits.
4. Where required, the size fraction of the aggregate passing the 0.425 mm size test sieve shall be non-plastic as defined by and tested in compliance with BS 1377-2.

815 Cement Bound Granular Mixtures A (CBGM A)

1 Cement bound granular mixtures A (CBGM A) shall comply with MSA EN 14227-1 and have binder constituent proportions complying with the requirements of Clause 808.

2 Aggregate shall comply with the requirements of Clause 814 and shall have a combined grading that complies with Category G2 from MSA 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 819.

4 The method of construction shall be in accordance with Clause 810 and Clause 811.

5 Unless described otherwise in IM Appendix7/1 the laboratory mechanical performance shall comply with the following requirements when sampled and tested in accordance with Clause 817:

i. C3/4

ii. C5/6

816 Cement Bound Granular Mixtures B (CBGM B)

1 Cement bound granular mixtures B (CBGM B) shall comply with MSA EN 14227-1 and have binder constituent proportions complying with the requirements of Clause 808.

2 Aggregates shall comply with the requirements of Clause 814 and shall have a combined grading that complies with Category G1 from MSA EN 14227-1, Figure 1. Alternatively, the total mixture grading shall comply with the grading envelope Category G2 from MSA EN 14227-1, Figure 2.

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 819.

4 The method of construction shall be in accordance with Clause 810 and Clause 811.

6 Unless described otherwise in IM Appendix7/1 the laboratory mechanical performance shall comply with the following requirements when sampled and tested in accordance with Clause 817:

i. C12/15

817 Testing, Control and Checking of CBGM

General

1 Tests, controls and checks shall be carried out in accordance with the requirements in Table 800-15 and the following sub-Clauses at locations determined by the Overseeing Organisation, unless otherwise stated in contract specific IM Appendix1/5. Where the Overseeing Organisation is satisfied that a consistent quality of work is being achieved it may order the frequency of testing to be reduced to half that required in Table 800-15. Where a test reference is shown in Table 800-15, the testing shall be carried out in compliance with the requirements of Clause 105 and be undertaken by an organisation accredited in accordance with MSA EN ISO/IEC 17025 for the test method.

Sampling

2 Sampling shall be in accordance with BS 1924-1. Where a bulk sample of CBGM is taken from a layer, it shall be taken from the full depth of the layer, used without further mixing, and not combined with other bulk samples.

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

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

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 leveling of the stabilized soil interface (or other techniques approved by the Overseeing Organisation) to ensure that the level at the underside of the stabilized layer is in accordance with the specified requirements.

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

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

test shall consist of at least 3 measurements at 120 degrees to each other using the same source rod hole and the density taken as the average of the higher 2 results.

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

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

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

9 For a subbase layer, the average in-situ wet density of the area specified in sub-Clause 817.8 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 817.8 shall be not less than 95% of the wet density of the CBGM at its optimum moisture content, measured using the vibrating hammer method detailed in MSA 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 CBGM at its optimum moisture content.

Laboratory Mechanical Performance

11 A bulk sample of CBGM shall be taken from each of the locations in sub-Clause 817.8, 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 MSA EN 13286-51. Where cubes are used for the determination of compressive strength, the specimens shall be 150 mm size, unless agreed otherwise by the Overseeing Organisation.

Table 800-15: Requirements for Testing, Control and Checking of CBGM

Test/control/check	Test frequency	Test reference
Water content of aggregate or soil sources on site	3 per 1000 m^2	BS 1924-1, Clause 7.1
Grading of aggregate or soil sources on site	1 per 1000 m^2	Aggregates: MSA EN 1097-5

		Soils: BS 1924-1, Clause 7.1
Plasticity of aggregate or soil sources on site	1 per 1000 m^2	BS 1924-1, Clause 7.3
Constituents sourced off-site	Aggregates - Results of routine control tests from the factory production control system required by MSA EN 13242, Annex C to be provided weekly. Cement - Certificates to be provided monthly for each cement type, in accordance with MSA EN 197-1, National Annex NB.	-
Batching records for 'mix-in-plant' method of construction using batching by mass	Continuously using the automated surveillance and data collection system	-
Mixture grading, including binder	1 per 1000 m^2 but not less than 3 per day	MSA EN 933-1
Water content at final compaction	1 per 1000 m^2 but not less than 3 per day	BS 1924-2, Clause 1.3
MCV at mixing and final compaction and, in the case of cohesive mixtures, during the mellowing period	3 per 1000 m^2 but not less than 4 per day	MSA EN 13286-46
Depth of mixing for 'mix-in-place' method of construction at each stage of the mixing process (sub-Clause 817.4)	5 per 1000 m^2 but not less than 4 per day	-
In-situ wet density	5 per 1000 m^2 or part thereof laid each day (measured at the locations detailed in sub-Clause 817.8)	Sub-Clause 817.5
Laboratory mechanical performance	5 per 1000 m^2 or part thereof laid each day (with test specimens prepared from a bulk sample taken from	As required by Table 800-16

	each of the locations detailed in sub-Clause 817.8)	
Strength after immersion in water	Laboratory mixture design procedure	As required by Clause 819

Table 800-16: Laboratory Mechanical Performance Testing Requirements for CBGM

Clause	Mixture	Curing regime	Curing temperature	Test method	Age at test
815, 816	GBGM A, CBGM B	1 Day Cured in mould at (20 ± 5) °C followed by 27 Days Cured at 90 % to 100 % humidity at (20 ±2) °C	20°C	RC - MSA EN 13286-41	28 days - or other age agreed by the Overseeing Organisation (see Note)
NOTE: For site control purposed, CBGM may be assessed on the basis of 7 days strength (or other agreed age) where the Contractor so requests, provided that a robust correlation is established between 7 days and 28 days strength using representative samples of the aggregates and binder used in the works.					

12 Compliance of the area specified in sub-Clause 817.8 shall be assessed using the results for test specimens that are cured and tested in accordance with Table 800-16 using either compression or indirect tensile testing as appropriate to the class of mechanical performance specified in contract specific IM Appendix7/1. Assessment shall be made using the following criteria:

a) Compressive strength:

The requirement specified in clause 515 and 816 or in contract specific IM Appendix7/1 shall be deemed to be satisfied if the average compressive strength of the group of specimens in Table 800-15 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.

b) Indirect tensile strength:

The requirement specified in contract specific IM Appendix7/1 shall be deemed to be satisfied if the average indirect tensile strength of the group of specimens in Table 800-15 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 819.

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

818 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 CBGM 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:

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

b) 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.

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

Test procedure

3 The following test procedure shall be followed:

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

b) 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 120° around the circumference of the specimens, aligned parallel to the axis, and not more than 30 mm from each end of the specimen.

c) Cure the specimens using the procedure specified for the determination of mechanical laboratory performance in Table 800-16.

d) 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%.

e) 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.

f) 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).

g) 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:

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

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

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

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

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

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

Calculate:

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

h) 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 818.3.

Reporting of Results

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

819 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 CBGM, based on the mixture design procedure described in this Clause.

2 The mixture design procedure shall determine the properties of the CBGM 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, 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 MSA 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:

a) 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.

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

5 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.

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

Property	CBM1	CBM1A	CBM2	CBM2A	CBM3	CBM4	CBM5
Cement	Portland cement only or blends with GGBS(≤65%) or PFA(≤50%)						
Aggregate	Any				BS 882		
Aggregate grading	Any		Broad		Restrictive		
Aggregate 10% fines value	No requirement		≥50 kN		≥50 kN		
Minimum average cube strength (MPa) of 5 specimens compacted to refusal at 7 days	4.5	10	7	10	10	15	20
Minimum individual cube strength (MPa) at 7 days	2.5	7	4.5	6.5	6.5	10	13
Volume stability and durability	Immersed cube strengths not less than 80% of strengths of sealed specimens				Assumed okay		
Primary application	Subbase				Base		

Table 800-17: CBM Schedule as in the ASDT Series 800 Specification

BS EN 14227–1	BS EN 14227–2,3,5	Nearest equivalent in SHW pre-November 2004
–	SBM A	No direct equivalent, but depending on selected strength class, SBM A can be considered equivalent to at least CBM1 or 2
CBGM A with no requirements for aggregate	SBM B4 FABM 4 HRBBM 4	CBM 1 & 1A
–	FABM 5	No direct equivalent, but depending on selected strength class, FABM 5 can be considered equivalent to either CBM1 or 2
CBGM A, possibly with selected aggregate properties (see Table 8)	SBM B3 FABM 3 HRBBM 3	CBM 2 & 2A
CBGM B	SBM B1 FABM 1 HRBBM 1	CBM 3, 4 & 5
CBGM C	SBM B2 FABM 2 HRBBM 2	No direct equivalent, but superior to CBM3/4/5 since mixture grading requirements for the new HBMs are superior to those for CBM3/4/5.

Table 800-18: CBM Schedule equivalence: ADT Series 800 (Column 3) and EN 14227-1 (Column 1)

Equivalence required to	From the new standards
CBM1	CBGM A – C5/6 (or T1) SBM B4 – C3/4 (or C6/8 or T1) FABM4 – C3/4 (or C6/8 or T1) HRBBM4 – C3/4 (or C6/8 or T1) SBM A – C3/4 (or C6/8 or T1 or CBR50/35) and FABM5 – C3/4 (or C6/8 or T1) No requirement should be selected for the aggregate properties.
CBM1A	As for CBM1 above except the strength level shall be C10/12 (or T3) for CBGM A and C9/12 (or T3) for the other mixtures
CBM2	CBGM A – C5/6 (or C8/10 or T2) SBM B3 – C6/8 (or T2) FABM3 – C6/8 (or T2) HRBBM3 – C6/8 (or T2) SBM A – C6/8 (or T2) and FABM5 – C6/8 (or T2) Aggregate property requirements can be set as N/R, although for strict equivalence, an aggregate hardness level of LA50 should be selected where applicable.
CBM2A	As for CBM2 above except the strength level shall be C10/12 (or T3) for CBGM A and C9/12 (or T3) for the other mixtures.
CBM3	CBGM B – C10/12 (or T3) SBM B1 – C9/12 (or T3) FABM1 – C9/12 (or T3) and HRBBM1 – C9/12 (or T3) Aggregate shall be non-plastic, hardness shall be LA50, and proportion of crushed material shall be selected for the type B1 and Type 1 mixtures as discussed in Table 9.
CBM4	As for CBM3 above but use C12/15 (or T4) for CBGM B and C12/16 (or T4) for the Type B1 and Type 1 mixtures.
CBM5	As for CBM3 & 4 above but use C16/20 (or T5) for CBGM B and C15/20 (or C18/24 or T5) for the Type B1 and Type 1 mixtures.

Table 800-19: CBM Schedule Equivalence: Transition Guidance ADT Series 800 (Column 1) and EN 14227-1 (Column 2)