

**MANUAL OF CONTRACT DOCUMENTS FOR HIGHWAY WORKS  
VOLUME 1 SPECIFICATION FOR HIGHWAY WORKS**

**SERIES 1000  
ROAD PAVEMENTS – CONCRETE  
MATERIALS**

**Contents**

Clause	Title	Page	Clause	Title	Page
1000	General	2	1028	(02/16) Trial Length	30
1001	(02/16) Strength Classes of Concrete and Constituent Materials for Pavement Layers	2	1029	(01/20) Texturing of Hardened Concrete by Transverse Grooves	32
1002	(02/16) Air Content	7	1030	(01/20) Lower Strength Concrete	32
1003	(02/16) Density	7	1031	(02/16) Measurement of Macrottexture Depth – Volumetric Patch Technique	34
1004	(02/16) Pavement Concrete Strength	8	1032	(02/16) Thin Bonded Repairs	34
1005	(02/16) Consistence (Workability)	9	1033	(01/20) Full Depth Repairs	34
1006	(02/16) Not Used	9	1034	(02/16) Bay Replacement	35
1007	(02/16) Separation and Waterproof Membranes	9	1035 to 1038	(01/20) Not Used	36
1008	(02/16) Steel Reinforcement	9	1039	(02/16) Summary of Rates for Sampling and Testing Concrete for Pavement Layers	36
1009	(02/16) Transverse Joints	11	1040 to 1042	(02/16) Not Used	37
1010	(02/16) Longitudinal Joints	12	1043	(02/16) Foamed Concrete	37
1011	(02/16) Dowel Bars	13	1044	(02/16) Pavements with an Exposed Aggregate Concrete Surface	37
1012	(02/16) Tie Bars	14	1045	(02/16) Weather Conditions for Laying of Cementitious Materials	41
1013	(02/16) Joint Grooves	16	1046 to 1047	(02/16) Not Used	41
1014	(02/16) Groove Formers and Bottom Crack Inducers	16	1048	(02/16) Use of Surfaces by Traffic and Construction Plant	41
1015	(02/16) Joint Filler Board	17	1049 to 1050	(01/20) Not Used	42
1016	(02/16) Preparation and Sealing of Joint Grooves	18	(01/20) <b>Roller Compacted Concrete Mixtures</b>	42	
1017	(02/16) Joint Seals	20	1051	(01/20) General Requirements for Roller Compacted Concrete (RCC) mixtures	42
1018	(02/16) Joints at Manhole and Gully Slabs	21	1052	(01/20) RCC Constituents	43
1019	(02/16) Inspection of Dowel Bars	22	1053	(01/20) Storage of RCC Constituents	44
1020	(02/16) Side Forms, Rails and Guide Wires	22	1054	(01/20) General Requirements for Production and Layer Construction of RCC	44
1021 to 1022	(02/16) Not Used	23	1055	(01/20) Production of Roller Compacted Mixtures	47
1023	(02/16) Transport and Delivery	23	1056	(01/20) Method Statement and Trial Length of RCC	47
1024	(02/16) Construction by Machine	23			
1025	(02/16) Construction by Small Paving Machines or Hand Guided Methods	26			
1026	(02/16) Finished Surface Requirements	26			
1027	(02/16) Curing	30			

MANUAL OF CONTRACT DOCUMENTS FOR HIGHWAY WORKS  
VOLUME 1 SPECIFICATION FOR HIGHWAY WORKS

---

Clause	Title	Page
1057	(01/20) Induced Cracking of RCC	48
1058	(01/20) Roller Compacted Concrete Mixtures	48
1059	(01/20) Testing, Control and Checking of RCC	49
1060	(01/20) Determination of the Coefficient of Linear Thermal Expansion of RCC	51F
1061	(01/20) RCC Laboratory Mixture Design Procedure	51F

SUPERSEDED

# ROAD PAVEMENTS – CONCRETE MATERIALS

## 1000 (02/16) General

- 1 (02/16) This Series is part of the Specification for Highway Works. Whilst this Series is particularly relevant to the subject matter in its title it must be read in conjunction with the general requirements in Series 000 and 100 and with all other Series relevant to the specification for the particular works to be undertaken.
- 2 (01/20) The Contractor shall undertake the testing of concrete pavements as detailed in the Clauses of this Series unless detailed otherwise in contract specific Appendices 1/5, 1/6 or 7/1.

## 1001 (02/16) Strength Classes of Concrete and Constituent Materials for Pavement Layers

- 1 (02/16) Concrete in rigid or rigid composite pavements shall be one of the classes given in Table 10/1, in accordance with the pavement design alternatives permitted in contract specific Appendix 7/1.
- 2 (02/16) Unless otherwise specified in contract specific Appendix 7/1 concrete shall conform with the requirements of BS EN 13877-2 and the requirements of this Series. The constituents of the concrete shall conform with BS EN 206 and BS 8500-1 and BS 8500-2 and BS EN 13877-1 and the requirements of this Series.

**TABLE 10/1: (01/20) Pavement Layers — Concrete Strength Classes**

Pavement Layer		BS EN 206, BS 8500-2, BS EN 13877-2			BS 8500-1 BS EN 13877-1	Clause
		Designed Concrete	Standardised Prescribed Concrete	Designated Concrete		
(i)	Surface slabs: Unreinforced concrete (URC) Jointed reinforced concrete (JRC) Continuously reinforced concrete pavement (CRCP)	C40/50**			C32/40**	1001 to 1039 and 1044
(ii)	Continuously reinforced concrete base (CRCB)	C40/50**			C32/40**	
(iii)	CRCP and CRCB ground beam anchorages	*			C25/30	
(iv)	Lower Strength concrete 4)	For bases or sub-bases as required in contract specific Appendix 7/1	ST4	GEN 3	C16/20	1030
(v)	Lower Strength concrete 3)		ST3	GEN 2	C12/15	
(vi)	Lower Strength concrete 2)		ST2	GEN 1	C8/10	
(vii)	Lower Strength concrete 1)		ST1	GEN 0	C6/8	

NOTE: \* Cores shall not be taken from ground beam anchorages. \*\* Minimum permitted concrete class.

## (02/16) Cement

- 3 (01/20) The general term ‘cement’ in this Series means any of the materials in (i) or the combinations in (ii) below:

- |  |  |
|--|--|
| <ol style="list-style-type: none"> <li>(i) Cements                     <ol style="list-style-type: none"> <li>(a) Portland cement CEM I</li> <li>(b) Portland-slag cement CEM II/A-S and CEM II/B-S</li> <li>(c) Blastfurnace cement CEM III/A and CEM III/B</li> <li>(d) Portland-fly ash cement CEM II/A-V and CEM II/B-V</li> <li>(e) Pozzolanic cement CEM IV/A</li> </ol> </li> </ol> | Complying with:<br>BS EN 197-1<br>BS EN 197-1<br>BS EN 197-1<br>BS EN 197-1<br>BS EN 197-1 |
|--|--|

- (ii) Combinations
  - (a) Portland cement CEM I with ground granulated blastfurnace slag (ggbs) for use with Portland cement CEM I  
BS EN 197-1  
BS EN 15167-1 and  
BS EN 15167-2
  - (b) Portland cement CEM I with fly ash (fa) for use as a cementitious component in structural concrete  
BS EN 197-1  
BS EN 450-1 and  
BS EN 450-2
  - (c) Portland cement CEM I with pozzolanic additive having current certification complying with a product acceptance scheme as described in sub-Clauses 104.15 and 104.16.  
BS EN 197-1
- (iii) In each cubic metre of fully compacted concrete the cement content shall be in accordance with Table 10/2. For 20 mm maximum size aggregate add 20 kg/m<sup>3</sup>, and for < 20mm maximum size add 40 kg/m<sup>3</sup>.
- (iv) When used, the proportion of silica fume to CEM I shall be 10 ± 1%.
- (v) For materials required to comply with BS EN 197-1 and/or BS EN 450-1 the Contractor shall submit the relevant material declarations of performance to the Overseeing Organisation prior to the inclusion of the materials into the works. The declarations of performance shall demonstrate that the materials meet the requirements for the specification.

**TABLE 10/2: (01/20) Minimum Cement or Combination Contents with 40 mm Maximum Aggregate**

Class (BS 8500-1)	C40/50	C32/40	C32/40 In surface slabs overlaid by 30 mm minimum thin surface course system complying with Clause 942	C25/30	C16/20	C12/15	C8/10	C6/8
<b>Cement</b>								
Min. Portland cement CEM I, BS EN 197-1 (kg/m <sup>3</sup> )	Ref BS8500-1	320	320	280	180	160	130	120
Min. other cements or combinations permitted in sub-Clauses 3(i) and 3(ii) (kg/m <sup>3</sup> )		340	340	300	180	160	130	120
For mixtures pre-blended or mixed on site								
Maximum proportion of ggbs (%)	50	50	35	65	65	65	65	65
Max/min. proportion of fa (%)	35/15	35/15	25/15	35/15	35/15	50/0	50/0	50/0
Min. CEM I content (kg/m <sup>3</sup> )	220	220	255	200	160	–	–	–

(02/16) **Water**

4 (01/20) Water from a water company supply may be used without testing. Water from other sources may be used if it conforms to BS EN 1008. The water content shall be the minimum required to provide the specified consistence for full compaction of the concrete to the required density, as determined by trial concrete mixes or other means, and the maximum free water/cement ratio shall be 0.45 for strength classes C32/40 and C25/30 and 0.60 for strength classes C16/20 and C12/15. The requirements for standardised prescribed concrete shall be in accordance with BS EN 206 and BS 8500-2.

(02/16) **Admixtures**

5 (01/20) Concrete in at least the top 50 mm of surface slabs shall incorporate an air-entraining admixture complying with BS EN 934-2, except:

- (i) for pavements with an exposed aggregate concrete surface constructed to Clause 1044 where at least the top 40 mm of the surface slab shall be air entrained;
- or
- (ii) for surface slabs of pavements with at least a class C40/50 concrete;
- (iii) for surface slabs of pavements with a class C32/40 concrete which are to be overlaid by a 30 mm minimum thickness thin surface course system complying with Clause 942; and
- (iv) for surface slabs of pavements with a class C35/45 concrete which are to be overlaid by a 20 mm minimum thickness thin surface course system complying with Clause 942.

Plasticisers or water reducing admixtures shall comply with BS EN 934-2. Admixtures containing calcium chloride shall not be used.

The Contractor shall submit the declaration of performance for each admixture to the Overseeing Organisation prior to the incorporation of the admixture into the works. The declaration of performance shall demonstrate that the admixture meets the specification requirements.

(02/16) **Aggregate**

6 (01/20) Aggregates for all pavement concrete, including Lower Strength, shall comply with BS EN 12620. Crushed concrete, which complies with the quality and grading requirements of BS EN 12620 and Table 2 of BS 8500-2, may also be used in all pavement concretes except aggregate concrete surface complying with Clause 1044. Alternatively, coarse aggregate may be crushed air-cooled blastfurnace slag complying with BS EN 12620 and shall be Category FI<sub>50</sub> or FI<sub>35</sub> for concrete of classes C16/20 to C25/30 and over class C25/30, respectively. FA when used as part of the aggregate shall comply with BS EN 450. Once the appropriate gradings have been determined they shall not be varied without the approval of the Overseeing Organisation. Irrespective of source, the aggregate will be considered suitable if:

- (i) the resistance to freezing and thawing complies with BS EN 12620 clause 5.7.1 for pavement and Lower Strength concrete;
- and
- (ii) the resistance to fragmentation complies with category LA<sub>35</sub> of BS EN 12620 clause 5.2 for concrete surface slabs and LA<sub>40</sub> of BS EN 12620, clause 5.2 for concrete bases and Lower Strength concrete.

The Contractor shall submit the declaration of performance for each aggregate to the Overseeing Organisation prior to the incorporation of the aggregate into the works. The declaration of performance shall demonstrate that the aggregate meets the specification requirements.

The water absorption (WA) of the coarse aggregate shall be determined and declared in accordance with BS EN 12620. Where recycled coarse aggregate or recycled concrete aggregate is used in this Series, it shall comply with the limits specified in Table 2 of BS 8500-2 and the constituents shall be declared.

7 (02/16) The maximum size of coarse aggregate (D) shall not exceed 40 mm. When the spacing between longitudinal reinforcement is less than 90 mm, the maximum size of coarse aggregate (D) shall not exceed 20 mm.

8 (02/16) Sand (i.e. fine aggregate) containing more than 25% by mass of acid-soluble material as determined in accordance with BS EN 196-2, in either the fraction retained on, or the fraction passing the 0.500 mm sieve, shall not be used in the top 50 mm of surface slabs. This requirement will not apply for pavements with an exposed aggregate concrete surface constructed to Clause 1044 or if it can be shown that the sand (ie fine aggregate) retained on, or the fraction passing the 0.500 mm sieve, contains less than 25 per cent by weight of calcium carbonate.

9 (01/20) The water absorption of flint coarse aggregate containing white flints for use in concrete surface slabs, when determined in accordance with BS EN 1097-6 shall not exceed:

3.5% for any separate nominal size fraction;

2.0% for the total combination of coarse aggregates in the proportions to be used in the concrete.

Contract compliance tests shall be carried out during stockpiling or paving, once a week, or at a lesser rate when authorised by the Overseeing Organisation.

#### (02/16) Source of Recycled Aggregates

10 (02/16) Where recycled coarse aggregate or recycled concrete aggregate is used, only crushed concrete resulting from reclamation or processing of concrete previously used in construction which originates from appropriate identified structures with a known history of use shall be used.

#### (02/16) Chloride Content

11 (01/20) The chloride ion content of the aggregate to be used in concrete shall be as stated in BS EN 206. The chloride class of reinforced concrete or concrete containing embedded metal shall be Cl 0,40 and unreinforced concrete shall be Cl 1,0. The water soluble chloride content of the aggregates shall be determined in accordance with BS EN 12620 and declared. The acid soluble chloride content of recycled aggregates shall be determined in accordance with BS EN 12620 and declared.

#### (02/16) Chemical Requirement

##### 12 (01/20) Acid-soluble sulfate

Acid-soluble sulfate content of the aggregates and filler aggregates for concrete pavements, including Lower Strength, shall comply with BS EN 12620, clause 6.3.1 and shall be Category AS<sub>1,0</sub> for air-cooled blast furnace slag and for other aggregates Category AS<sub>0,8</sub>.

##### 13 (02/16) Total sulfur

Total sulfur content of recycled coarse aggregates, recycled concrete aggregates, aggregates and filler aggregates, shall comply with BS EN 12620, clause 6.3.2.

## 1002 (02/16) Air Content

1 (01/20) In the top 50mm concrete requiring air entrainment to satisfy Clause 1001.5 shall meet the requirement for exposure class XF4 in BS EN 206. With the exception of concrete class C40/50 as defined in BS8500 this shall be achieved by the use of an air-entraining agent. The minimum quantity of air in air-entrained concrete as a percentage of the volume of the concrete shall be as in Table 10/3:

**TABLE 10/3: (01/20) Minimum Air Contents**

Maximum aggregate size mm	Minimum air content %	Maximum air content %
20	3.5	6.5
40	3	5.5

2 (02/16) The air content shall be determined at the point of delivery to the paving plant by the pressure gauge method in accordance with BS EN 12350-7, at the rate of one determination per 300 m<sup>2</sup> of slab or at least 6 times per day, whichever is the greater, in conjunction with tests for consistence and strength. For areas less than 300 m<sup>2</sup> the rate shall be at least one determination to each 20 m length of slab or less constructed at any one time or at least 3 times per day. If the air content is outside the specified limits in BS EN 206 the Contractor shall remove the concrete from the works.

3 (02/16) The air-entraining agent shall be added at the mixer, by an apparatus capable of dispensing the correct dose within the tolerance for admixtures given in BS EN 206, to ensure uniform distribution of the agent throughout the batch during mixing.

## 1003 (02/16) Density

### (01/20) The Permanent Works

- 1 (01/20) With the exception of the trial length, the density shall be measured by non-destructive methods.
- 2 (01/20) A correlation shall be established for each mix and each measuring device and shall be established from the trial length where cores have been taken. The correlation established shall be provided to the Overseeing Organisation before commencement of the permanent works. The device chosen shall achieve a repeatability of at least 90%.
- 3 (01/20) The concrete density measured by the device shall not be less than 95% of the average density of at least six fully compacted saturated moulded specimens made from the same mix in the trial area and tested at the same age.
- 4 (01/20) The density shall be measured routinely at a distance of 0.8 to 1.2m from the edge of the slab and at the rate shown in Table 10/12.
- 5 (01/20) If a non-compliance in an area is indicated then cores shall be taken as required in the trial area. Density measurements shall be taken at the locations at which material is placed that has been sampled for cube testing.

### (01/20) The Trial Length

- 6 (01/20) In the trial length as required in Clause 1028 the density of a saturated core cut from the full depth of the concrete pavement shall not be less than 95% of the average density of at least six fully compacted saturated moulded specimens made from the same concrete and tested at the same age.
- 7 (01/20) The density of the concrete pavement shall be determined in accordance with BS EN 13877-2. The density of a saturated core cut from the full depth of the concrete pavement shall be determined in accordance with BS EN 12390-7. The determination of the saturated density of the fully compacted moulded specimens shall be in accordance with BS EN 12350-1, BS EN 12390-1 and BS EN 12390-2.

- 8 (01/20) The core shall have an average diameter of at least four times the nominal maximum aggregate size, and in any case not less than 100 mm diameter. Where different concrete mixes are used in separate layers, the density of each layer shall be separately determined by splitting or cutting the cores between the layers.
- 9 (01/20) Cores shall be taken at the rate given in Clause 1028 for the trial. If the density of any core is below the minimum required, the concrete across the whole width of the slab constructed at the time relating to that core shall be removed. In unreinforced concrete the whole slab length between joints shall be removed. For reinforced slabs, in order to determine the limit of the defective area of concrete which shall be removed, additional cores shall be taken at 5 m intervals on each side of any defective core until concrete of satisfactory density is found. Defective areas shall be made good with new material in accordance with the specification.
- 10 (01/20) In calculating the density, allowance shall be made for any steel in the cores.
- 11 (01/20) Core holes shall be reinstated with compacted concrete with mix proportions of 1 part of Portland cement CEM I: 2 parts of sand: 2 parts of 10 mm single sized coarse aggregate by mass.

#### 1004 (02/16) Pavement Concrete Strength

- 1 (01/20) A trial length shall be constructed in accordance with Clause 1028.
- 2 (01/20) Concrete cores of 150mm diameter shall be taken from the trial length, cured and tested in accordance with BS EN 12504-1 with the exception that the core shall be cured under water at  $20^{\circ}\text{C} \pm 2^{\circ}\text{C}$  from as soon as practically possible. A minimum of 9 cubes and 6 cores taken and at a minimum of 3 locations shall be taken from the trial length. For each set of 6 cores, three shall be tested at 7 days and three at 28 days
- 3 (01/20) The end preparation of the core shall be by grinding and the height/diameter (h/d) ratio of the tested specimen shall be between 1 and 2.
- 4 (01/20) The ratio of core density to non-destructive density measurement taken within 1m of the core location shall be determined from the trial length as described in Clause 1003.
- 5 (01/20) If multi-layer construction is being used the cores shall be tested for adequacy of bond between layer in accordance with BS EN 13877-2 with  $f_v=1\text{mPa}$  at 7 days.
- 6 (01/20) Once a satisfactory trial construction has been achieved strength monitoring of the main construction will be by the use of cubes cast at the rate of a set of 3 cubes for every 400 m<sup>2</sup> of concrete laid. A minimum of 6 sets of cubes shall be taken each day with each set being from a different delivery of concrete.
- 7 (01/20) If the 7-day cube strength fails to conform with the requirements of BS EN 206 table B1 sampling and testing for, and compliance with the specified characteristic core strength of designed concretes shall be undertaken by compressive strength testing in accordance with BS EN 13877-2 on cores cut from the full depth of the slab.
- 8 (01/20) The strength of the concrete slab shall be evaluated in accordance with BS EN 206 (Annex B – Identity Testing: Table B.1).
- 9 (01/20) To assess the time for use of a concrete slab by traffic, the strength development rate may be predetermined by cubes stored at  $20^{\circ}\text{C}$  made from trial concrete mixes and maturity meters placed in the pavement. Alternatively, pairs of cubes may be made for each 400 m<sup>2</sup> or less and stored alongside the pavement in containers or in such a way that their sides are well insulated. If thermal insulation is used for accelerated curing the cubes shall be similarly insulated. Pairs of cubes shall be tested at the intervals specified in contract specific Appendix 7/1.

## 1005 (02/16) Consistence (Workability)

1 (01/20) The consistence shall be determined by the Degree of Compactibility (Compaction Index) test in accordance with BS EN 12350-4, or the Vebe test in accordance with BS EN 12350-3. Alternatively for concrete class C16/20 or below, consistence may be determined by the slump test in accordance with BS EN 12350-2. The sampling for all concrete classes shall be undertaken in accordance with BS EN 12350-1 and the rate of testing in accordance with Table 17 of BS EN 206. Consistence shall be carried out at the point of placing, in conjunction with tests for strength and any tests for air content. The consistence shall be maintained at the optimum within the limits specified in BS EN 206.

2 (02/16) If any determination of consistence gives a result outside the tolerance, a further test shall be made immediately on the next available load of concrete. The average of the two consecutive results and the difference between them shall be calculated. If the average is not within the tolerance or the difference is greater than 0.1 for CI or 20 mm for slump, or 6 seconds for Vebe, subsequent samples shall be taken from the delivery vehicles, which shall not be allowed to discharge into the works until compliance with the specification has been established.

## 1006 (02/16) Not Used

## 1007 (02/16) Separation and Waterproof Membranes

1 (01/20) Over a bound sub-base a waterproof membrane shall be provided, which shall be a bituminous spray in accordance with Clause 920. Where a bituminous spray has been used to cure cement-bound material or low strength concrete then only those areas, which have been damaged or degraded, shall be resprayed after making good.

## 1008 (02/16) Steel Reinforcement

### (02/16) General

1 (01/20) Reinforcement shall comply with any of the following standards and shall be cut and bent in accordance with BS 8666. The reinforcement materials shall be obtained from an organisation which has current, valid product acceptance scheme certification, such as CARES certification, in accordance with sub-Clause 104.16. Re-bending of carbon steel bars and fabric reinforcement on site shall not be permitted:

#### Hot Rolled and Cold Worked Carbon Steel Bars

- (i) BS EN 10080 and BS 4449 (Grade B500B or B500C).

#### Steel Wires

- (ii) BS EN 10080 and BS 4482 (Ribbed Grade B500).

#### Steel Fabric

- (iii) BS EN 10080 and BS 4483 (Grade B500A, B500B or B500C). Steel fabric reinforcement shall have a minimum nominal bar size of 6 mm (8 mm for Grade B500A). Steel fabric reinforcement shall be delivered to site in flat mats or pre-bent.

2 (02/16) For hot rolled and cold worked carbon steel bars, and for steel fabric reinforcement, the bond property requirements for BS 4449 shall be complied with based on the surface geometry requirements of that standard. For steel wire, the bond property requirements of BS 4482 shall be complied with based on the surface geometry requirements of that standard.

- 3 (01/20) Spacing of bars shall not be less than twice the maximum size of aggregate used. Laps in longitudinal bars shall be not less than 35 bar diameters or 450 mm whichever is greater. In continuously reinforced concrete slabs (CRCP or CRCB), only one third of the laps may be in any one transverse section, except in single bay width construction where half the laps may be in any one transverse section. There shall be a minimum of 1.2 m longitudinally between groups of transverse laps or laps in prefabricated reinforcement sheets.
- 4 (02/16) Laps in any transverse reinforcement shall be a minimum of 300 mm. Where prefabricated reinforcement sheets are used and longitudinal and transverse laps would coincide, no lap is required in the transverse bars within the lap of the longitudinal reinforcement. These transverse bars may be cropped or fabricated shorter so that the requirements for cover are met. Alternatively, prefabricated sheets incorporating splices (ie flying ends) may be used to provide nesting of reinforcement in both directions at lap positions. The lengths of the laps shall be the minimum values previously stated.
- 5 (01/20) If the reinforcement is positioned prior to concreting, it shall be fixed on chairs conforming with the requirements of BS 7973 and retained in position at the required depth below the finished surface and distance from the edge of the slab so as to ensure that the required cover is achieved. Reinforcement assembled on site shall be tied, or firmly fixed, at sufficient intersections to provide sufficient rigidity to ensure that the reinforcement remains in the correct position during construction of the slab.
- 6 (02/16) Alternatively, when a reinforced concrete slab (JRC, CRCP or CRCB) is constructed in two layers, the reinforcement in the form of prefabricated sheets may be placed on or into the bottom layer which shall be spread and compacted to such a level that it will support the reinforcement without distortion at the required position in the slab. The sheets shall be tied together at overlaps and after the second layer has been spread and compacted, the reinforcement shall have the required cover.
- 7 (02/16) When a reinforced concrete slab is constructed at maximum width as in Clause 1010 the transverse reinforcement in the centre of each slab width shall be a minimum of 12 mm nominal diameter bars at 600 mm centres. This reinforcement shall be at least 600 mm longer than one third of the width of the slab and be lapped to other transverse reinforcement bars or sheets, or be continuous across the whole width of each slab.

(02/16) **Jointed Reinforced Concrete Slabs**

8 (02/16) The reinforcement shall be so placed that after compaction of the concrete, the cover below the finished surface of the slab is  $50 \pm 10$  mm for slabs less than 200 mm thick,  $60 \pm 10$  mm for slabs 200 mm or more but less than 270 mm thick,  $70 \pm 20$  mm for slabs 270 mm thick or more. The negative vertical tolerance shall not be permitted beneath road stud recesses. Where traffic signal detector loops are to be installed, the minimum cover to the reinforcement from the surface shall be 100 mm. The vertical cover between any longitudinal joint groove forming strip and any reinforcement or tie bars shall be a minimum of 30 mm. Any transverse bars shall be at right angles to the longitudinal axis of the carriageway.

Any transverse reinforcement shall terminate at  $125 \pm 25$  mm from the edges of the slab and longitudinal joints, where tie bars as in Clause 1012 are used. No longitudinal bars shall lie within 100 mm of a longitudinal joint. The reinforcement shall terminate  $300 \text{ mm} \pm 50$  mm from any transverse joint, excluding emergency construction joints.

(02/16) **Continuously Reinforced Concrete Slabs (CRCP or CRCB)**

- 9 (01/20) The reinforcement shall be Grade B500B or B500C deformed steel bars with the diameters and spacings as described in contract specific Appendix 7/1.
- 10 (02/16) The reinforcement shall consist of bars assembled on site, or of prefabricated sheets. Except where otherwise shown on the drawings the longitudinal bars shall be parallel to the centre-line of the road.
- 11 (01/20) The reinforcement shall be positioned so that, after compaction of the concrete, it shall be at the mid depth of the specified thickness of the slab  $\pm 25$  mm. No longitudinal bar shall lie within 100 mm of a longitudinal joint. Reinforcement longitudinal bars shall be placed immediately above any transverse bars, which shall be at right angles to the longitudinal axis of the carriageway. Any transverse reinforcement shall terminate  $125 \pm 25$  mm from the edges of the slab and longitudinal joints where tie bars as in Clause 1012 are used.

## 1009 (02/16) Transverse Joints

### (02/16) General

- 1 (02/16) Transverse joints shall be provided in unreinforced and jointed reinforced concrete slabs and shall be contraction, expansion or warping joints at the spacings described in contract specific Appendix 7/1, such that for unreinforced concrete slabs the length/width ratio shall be not greater than 2.0. The spacings may be increased by 20% if limestone coarse aggregate is used throughout the depth of the slab.
- 2 (02/16) Joints in the surface slab and sub-base shall be staggered so that they are not coincident vertically and are at least 1 m apart.
- 3 (02/16) Transverse joints shall be straight within the following tolerances along the intended line of the joint, which is the straight line transverse to the longitudinal axis of the carriageway, except at road junctions or roundabouts where the positions shall be as shown on the drawings.
  - (i) deviations of the filler board or bottom crack inducer from the intended line of the joint shall be not greater than  $\pm 10$  mm;
  - (ii) the best fit straight line through the joint groove as constructed shall be not more than 25 mm from the intended line of the joint;
  - (iii) deviations of the joint groove from the best fit straight line of the joint shall be not greater than 10 mm.
- 4 (02/16) Transverse joints on each side of a longitudinal joint shall be in line with each other and of the same type and width. The position of the joints relative to manholes and gullies shall be in accordance with Clause 1018.
- 5 (02/16) Concrete pavement layers shall be isolated from fixed structures by expansion joints, or earthworks or a granular layer over the structure, or by bridge-type expansion joints, or by lengths of fully flexible pavement construction. End of pavement surface slabs shall have a transition bay as shown on the drawings, leading into the fully flexible construction.
- 6 (02/16) Transverse joints shall have a sealing groove which shall be sealed in compliance with Clause 1016.

### (02/16) Contraction Joints

- 7 (02/16) Contraction joints shall consist of:
  - (i) a sawn joint groove complying with Clause 1013;
  - (ii) dowel bars complying with Clause 1011;
  - (iii) a sealing groove complying with Clause 1016.

### (02/16) Expansion Joints

- 8 (02/16) Expansion joints shall consist of:
  - (i) a joint filler board complying with Clause 1015;
  - (ii) dowel bars complying with Clause 1011;
  - (iii) a sealing groove complying with Clause 1016.
- 9 (02/16) The filler board shall be positioned vertically within the prefabricated joint assemblies along the line of the joint within the tolerances given in sub-Clause 3 of this Clause, and at such depth below the surface as will not impede the passage of the finishing beams on the paving machines. The joint filler board together with the sealing groove shall provide a complete separation of adjacent slabs and any spaces around dowel bars and between the sub-base and the filler board shall be packed with a suitable compressible material after fixing the joint assembly.

(02/16) **Warping Joints**

- 10** (02/16) Warping joints shall consist of:
- (i) a sawn joint groove complying with Clause 1013;
  - (ii) tie bars complying with Clause 1012;
  - (iii) a sealing groove complying with Clause 1016.

(02/16) **Construction Joints**

**11** (02/16) Construction joints made at the end of a working day in unreinforced concrete slabs and jointed reinforced concrete slabs shall be contraction joints. In the event of mechanical breakdown of the concreting machinery, or at the onset of adverse weather, emergency joints may be formed.

**12** (02/16) Emergency joints in unreinforced concrete slabs shall be contraction joints not less than 2.5 m from the preceding or succeeding joint position.

**13** (02/16) Emergency joints in jointed reinforced concrete slabs shall be not less than 2.5 m from the preceding or succeeding joint position. The stop end formwork shall be sufficiently rigid to ensure that dowel bars, tie bars or reinforcement will be held in position in compliance with the specification, and placed in such a position that it permits the longitudinal reinforcement to project through the joint for a distance of at least 750 mm.

**14** (02/16) Construction joints in continuously reinforced concrete slabs (CRCP and CRCB) at end of day or in an emergency shall not be constructed within 1.5 m of any lap in the longitudinal reinforcement. The stop end formwork shall be sufficiently rigid to ensure that the longitudinal reinforcement and the tie bars as required in sub-Clause 1012.7 which project through the joint are held in the correct position.

**1010** (02/16) **Longitudinal Joints**

(02/16) **General**

**1** (02/16) Sawn or wet-formed longitudinal joints shall be provided in surface slabs between or at the centre of traffic lanes within the allowable positions as shown on the drawings, so that bay widths are not greater than 4.2 m (or 5.0 m with limestone aggregate) for unreinforced slabs, or 6 m (or 7.6 m with limestone aggregate) for reinforced concrete surface slabs with transverse reinforcement as in sub-Clause 1008.7. Longitudinal joints shall be provided in CRCB between lanes or at the centre of lanes, within a tolerance of  $\pm 150$  mm so that bay widths are not greater than 6 m (or 7.6 m with limestone aggregate).

Joints in the surface slab, base or sub-base shall be staggered so that they are not coincident vertically and are at least 300 mm apart.

**2** (02/16) Wet-formed longitudinal joints shall consist of wet-formed joint grooves complying with Clause 1013, a bottom crack inducer complying with Clause 1014 and tie bars complying with Clause 1012, except where transverse reinforcement is permitted in lieu.

**3** (02/16) Longitudinal joints shall be constructed within the following tolerances:

- (i) deviations of the bottom crack inducer from the intended line of the joint, parallel to the axis of the road shall be not greater than  $\pm 13$  mm;
- (ii) the joint groove shall be located vertically above the bottom crack inducers within a horizontal tolerance of  $\pm 25$  mm;
- (iii) the best fit line along the constructed joint groove, shall be not more than 25 mm from the intended line of the joint;
- (iv) deviations of the joint groove from the best fit line of the joint shall be not greater than 10 mm.

**4** (02/16) Sawn longitudinal joints shall consist of joint grooves complying with Clause 1013.

5 (02/16) Tie bars may be replaced by continuous transverse reinforcement across the joints in continuously reinforced concrete slabs which are constructed in more than one lane width in one operation, provided that the transverse reinforcement is a minimum of 12 mm diameter bars at 600 mm centres. The transverse reinforcement in these circumstances shall be protected by suitable bituminous paint or equivalent coating for a distance of at least 75 mm either side of the joint.

#### (02/16) Longitudinal Construction Joints

6 (02/16) Longitudinal construction joints between separate slabs shall have tie bars as in Clause 1012 with a joint groove as in Clause 1013. Alternatively, if split forms are used, the transverse reinforcement, if 12 mm diameter or more, may be continued across the joint for a minimum of 500 mm or 30 times the diameter of the transverse reinforcement bars, whichever is the greater. The transverse reinforcement in these circumstances shall be protected by suitable bituminous paint or equivalent coating for a distance of at least 75 mm either side of the joint. A joint sealing groove is not required in construction joints in continuously reinforced concrete bases. Where the edge of the concrete slab is damaged it shall be made good before the adjacent slab is constructed.

### 1011 (02/16) Dowel Bars

1 (01/20) Dowel bars shall meet the requirements of BS EN 13877-3 with a minimum tensile strength of 250MPa and shall be free from oil, dirt, loose rust and scale. They shall be straight, free of burrs and other irregularities and the sliding ends sawn cleanly with no protrusions outside the normal diameter of the bar. For expansion joints, dowel bars shall be 25 mm diameter at 300 mm spacing and 600 mm long for slabs up to 239 mm thick and 32 mm diameter for thicker slabs. For contraction joints, dowels shall be 20 mm diameter at 300 mm spacing and 400 mm long for slabs up to 239 mm thick, and 25 mm diameter at 300 mm spacing and 600 mm long for thicker slabs.

The Contractor shall submit the declaration of performance for the dowel bars to the Overseeing Organisation prior to the incorporation of the dowel bars into the works. The declaration of performance shall demonstrate that the dowel bars meet the specification requirements.

2 (02/16) Dowel bars shall be supported on cradles in prefabricated joint assemblies positioned prior to construction of the slab. For contraction joints, as an alternative to prefabricated assemblies, dowel bars may be mechanically inserted with vibration into the concrete by a method which ensures full recompaction of the concrete around the dowel bars and the surface finished by a diagonal finishing beam, or a longitudinal oscillating float travelling across the slab.

3 (02/16) Dowel bars shall be positioned at mid-depth from the surface level of the slab  $\pm 20$  mm. They shall be aligned parallel to the finished surface of the slab, to the centre line of the carriageway and to each other within the following tolerances:

- (i) for bars supported on cradles prior to construction of the slab and for inserted bars in two layer construction prior to placing the top layer:
  - (a) all bars in a joint shall be within  $\pm 3$  mm per 300 mm length of bar;
  - (b) two thirds of the bars shall be within  $\pm 2$  mm per 300 mm length of bar;
  - (c) no bar shall differ in alignment from an adjoining bar by more than 3 mm per 300 mm length of bar in either the horizontal or vertical plane;
- (ii) for all bars, after construction of the slab:
  - (a) twice the tolerances for alignment as in (i) above;
  - (b) equally positioned about the intended line of the joint within a tolerance of 25 mm.

4 (02/16) Cradles supporting dowel bars shall not extend across the line of the joint.

5 (02/16) Dowel bars, supported on cradles in assemblies, when subjected to a load of 110 N applied at either end and in either the vertical or horizontal direction (upwards and downwards and both directions horizontally) shall not deflect more than the following limits:

- (i) two thirds of the number of bars of any assembly tested shall not deflect more than 2 mm per 300 mm length of bar;
- (ii) the remainder of the bars in that assembly shall not deflect more than 3 mm per 300 mm length of bar.

6 (02/16) The assembly of dowel bars and supporting cradles, including the joint filler board in the case of expansion joints shall have the following degree of rigidity when fixed in position:

- (i) For expansion joints the deflection of the top edge of the filler board shall be not greater than 13 mm, when a load of 1.3 kN is applied perpendicular to the vertical face of the joint filler board and distributed over a length of 600 mm by means of a bar or timber packing, at mid depth and midway between individual fixings, or 300 mm from either end of any length of filler board, if a continuous fixing is used. The residual deflection after removal of the load shall be not more than 3 mm.
- (ii) The joint assembly fixings to the sub-base shall not fail under the 1.3 kN load applied for testing the rigidity of the assembly but shall fail before the load reaches 2.6 kN.
- (iii) The fixings for contraction joints shall not fail under a 1.3 kN load and shall fail before the load reaches 2.6 kN when applied over a length of 600 mm by means of a bar or timber packing placed as near to the level of the line of fixings as practicable.
- (iv) Failure of the fixings shall be deemed to be when there is displacement of the assemblies by more than 3 mm with any form of fixing, under the test load. The displacement shall be measured at the nearest part of the assembly to the centre of the bar or timber packing.

7 (01/20) Dowel bars shall be covered by a flexible polymeric corrosion resistant coating, bonded onto the previously cleaned bar. The coating shall be smooth and free of indentations. During coating, the bar shall be supported at each end. Minimum thickness shall be 0.3 mm. The coating shall also be able to withstand 250 hours immersion in a salt fog cabinet complying with BS EN ISO 7253, without showing any visible crazing or corrosion of the protected bar. The coated bar shall comply with the following pull out test:

- (i) Four bars shall be taken at random from stock and without any special preparation shall be coated as required in this Clause. The dowel bars which have been coated shall be cast centrally into concrete specimens 150 x 150 x 450 mm, made of the same concrete mix proportions to be used in the pavement, but with a maximum aggregate size of 20 mm and cured in accordance with BS EN 12390-2. At 7 days a tensile load shall be applied to achieve a movement of the bar of at least 0.25 mm. The average bond stress to achieve this movement shall be not greater than 0.89 N/mm<sup>2</sup>.

8 (02/16) For expansion joints, a closely fitting cap 100 mm long consisting of waterproofed cardboard or suitable synthetic material shall be placed over one end of each dowel bar. An expansion space 10 mm greater than the thickness of the joint filler board shall be formed between the end of the cap and the end of the dowel bar.

### 1012 (02/16) Tie Bars

1 (02/16) Tie bars in transverse or longitudinal joints shall conform to Clause 1008, in accordance with the requirements given below and Table 10/5.

2 (01/20) Tie bars for use across joints shall have corrosion protection in the form of a flexible polymeric corrosion resistant coating, bonded centrally onto 200 mm of the previously cleaned centre section of the bars. Where tie bars are to be cranked for construction joints and later straightened, the coating shall be shown to be capable of being straightened through 90 degrees without cracking.

The coating for both straight and cranked bars after straightening shall be able to withstand 250 hours immersion in a salt fog cabinet complying with BS EN ISO 7253, without showing any visible crazing or cracking, or corrosion of the protected part of the bar.

- 3 (02/16) Tie bars in warping joints and wet-formed longitudinal joints shall be made up into rigid assemblies with adequate supports and fixings to remain firmly in position during the construction of the slab.
- 4 (02/16) Alternatively, tie bars at longitudinal joints may be mechanically inserted by vibration from above using a method which ensures recompaction of the concrete around the tie bars.
- 5 (02/16) At longitudinal construction joints, tie bars may be adequately fixed to side forms or inserted into the side of the slab by a method which ensures recompaction of the concrete around the tie bars and adequate bond.
- 6 (02/16) Tie bars in warping joints shall be positioned from the top surface of the slab within +20, -10 mm of the mid depth of the slab.

Tie bars in other joints shall be positioned and remain within the middle third of the slab depth, approximately parallel to the surface and approximately perpendicular to the line of the joint, with the centre of each bar on the intended line of the joints within a tolerance of  $\pm 50$  mm, and with a minimum cover of 30 mm below any top crack inducer of joint groove for slabs 200 mm thick or more, or 20 mm for slabs up to 200 mm thick.

- 7 (02/16) At transverse construction joints in continuously reinforced concrete, tie bars shall be 1.5 m long and of the same Grade and size as the longitudinal reinforcement, and shall be fixed at twice the normal spacing midway between the longitudinal reinforcement bars so that 750 mm  $\pm$  50 mm extends each side of the joint at the same level as the longitudinal reinforcement and be tied to the transverse reinforcement. Where paving from a construction joint is not resumed within 5 days, an extra longitudinal reinforcement bar 8 m long shall be lapped and tied to each tie bar. These extra bars may be combined with the tie bars. Where the spacing between longitudinal reinforcement and the extra 8 m long bars is less than 90 mm, the nominal size of aggregate shall be 20 mm for a sufficient number of concrete batches to complete that section of pavement.

**TABLE 10/5: (01/20) Tie Bar Details**

Joints	Diameter mm	Grade of Steel	Length mm	Spacing mm
Transverse construction joints in continuously reinforced concrete	As for main reinforcement	Grade B500B or B500C	1500	Twice the spacing of main reinforcement
Emergency construction joints in jointed reinforced concrete slabs other than at contraction or expansion joints	12	Grade B500B or B500C	1000	600
			750	600
Warping joints	12	Grade B500B or B500C	1000	300
			750	600
Longitudinal All joints, except where Transverse reinforcement is permitted in lieu	12	Grade B500B or B500C	1000	600
			750	600
	or 16	Grade B500B or B500C	600	600
	or 20	Grade B500B or B500C	500	600
Transition from rigid to flexible construction	20	Grade B500B or B500C	1000	300

NOTE: The transverse reinforcement may be continued across the joint in reinforced concrete if the bars are of a minimum nominal diameter of 12 mm and the bars are protected from corrosion and the cover is as required in this Clause.

- 8 (02/16) Where tie bars are used in longitudinal joints in continuously reinforced concrete they shall be placed at the same level as the transverse reinforcement and tied to the longitudinal reinforcement.

## 1013 (02/16) Joint Grooves

### (02/16) General

- 1 (02/16) Transverse contraction or warping joint grooves shall be sawn in the hardened concrete.
- 2 (02/16) Transverse joint grooves which are initially constructed less than the full width of the slab shall be completed by sawing through to the edge of the slab and across longitudinal joints as soon as any forms have been removed and before an induced crack develops at the joint.

### (02/16) Sawn Transverse and Longitudinal Joint Grooves

- 3 (02/16) Sawing shall be undertaken as soon as possible after the concrete has hardened sufficiently to enable a sharp edged groove to be produced without disrupting the concrete and before random cracks develop in the slab. The grooves shall be between 1/4 and 1/3 of the specified depth of the slab and of any convenient width not less than 3 mm. The sealing groove may be sawn to the required width later. Expansion joint sealing grooves shall be sealed as soon as practical after sawing.

### (02/16) Wet-formed Longitudinal Joint Grooves

- 4 (02/16) When slabs are constructed in more than one lane width in one operation a joint groove shall be formed by inserting a groove former ahead of the finishing beams from dispenser. The concrete so displaced shall be recompacted by a vibrating compactor or similar device, at least 300 mm wide operating symmetrically along the line of the joint. After finishing the concrete, the groove forming strip shall be in the correct position and alignment, within 10° of the vertical, and to sufficient depth below the surface to allow for the passage of the finishing beam within the range 0-3 mm below the finished level of the slab. Groove forming strips in wet-formed longitudinal joint grooves shall be left in place.

### (02/16) Construction Joint Grooves in Surface Slabs

- 5 (02/16) The grooves shall be formed by fixing a groove-former or strip or cork seal along the top edge of the slab already constructed, before concreting the adjacent slab. Where the edge of the concrete is damaged it shall be ground or made good before fixing the groove forming strip. Alternatively the subsequent slab may be placed adjacent to the first and a sealing groove sawn later in the hardened concrete to the minimum depth required in Table 10/6 or to the manufacturer's instructions if greater, and to sufficient width to eliminate minor spalling of the joint arris, up to a maximum of 25 mm for longitudinal joints and 40 mm for transverse joints. The joint shall be sealed in compliance with Clause 1016.

## 1014 (02/16) Groove Formers and Bottom Crack Inducers

### (02/16) General

- 1 (02/16) Except where joint grooves are sawn, a bottom crack inducer shall be provided at each longitudinal joint position.
- 2 (02/16) The bottom crack inducer shall be triangular or inverted Y-shaped fillet, with a base width not less than the height, made of timber or rigid synthetic material. It shall be firmly fixed to the sub-base so as to remain in position during the whole process of constructing the slab.
- 3 (02/16) The combined depth of groove formers and bottom crack inducers shall be between 1/4 and 1/3 of the depth of the slab and the difference between the depth of the groove former and the height of the bottom crack inducer shall not be greater than 20 mm.

### (02/16) Longitudinal Joints

- 4 (02/16) Groove forming sealing strips for wet-formed longitudinal joints shall be of firm compressible strips of ethylene vinyl acetate foam of minimum density 90 kg/m<sup>3</sup>, or synthetic rubber, or equivalent material. They shall have a minimum thickness of 5 mm and shall be sufficiently rigid to remain vertical and straight in the concrete without curving or stretching. They shall be inserted continuously along the joint.

(02/16) **CRCP Universal Beam Anchorage Transverse Joint**

5 (02/16) One side of the beam shall be separated from the CRCP slab by an expansion joint filler board against the vertical face and ethylene vinyl acetate foam in accordance with HCD Drawing C20.

**1015 (02/16) Joint Filler Board**

1 (01/20) Joint filler board for expansion joints and manhole and gully slab joints shall be 25 mm thick unless otherwise shown in the drawings, within a tolerance of  $\pm 1.5$  mm. It shall be a firm compressible material or a bonded combination of compressible and rigid materials of sufficient rigidity to resist deformation during the passage of the concrete paving plant. The depth of the joint filler board for manhole and gully slabs shall be the full depth of the slab less the depth of the sealing groove. In expansion joints, the filler board shall have a ridged top as shown on the drawings, except where a sealing groove former is indicated on the drawings.

Holes for dowel bars shall be accurately bored or punched out to form a sliding fit for the sheathed dowel bar.

2 (01/20) The joint filler board shall meet the requirements given when tested in accordance with the procedures in the following sub-Clauses:

(i) Weathering Test

- (a) Three specimens, each 115 mm square  $\pm 2.5$  mm, shall be placed in a ventilated drying oven maintained at a temperature of  $55^{\circ}\text{C} \pm 5^{\circ}\text{C}$  for 7 days, after which they shall immediately be immersed in water at room temperature of between  $16^{\circ}\text{C}$  and  $21^{\circ}\text{C}$  for 24 hours. They shall then be subjected to five cycles of freezing and thawing in the following manner.
- (b) The specimens shall be placed in a watertight weathering test pan having a ribbed bottom and a fitted slotted lid designed to hold the three specimens vertically on edge. The pan shall be filled with water to half the depth of the specimens and then frozen to minus  $7^{\circ}\text{C}$  or below, for at least four hours after the initial freezing of the water. The pan shall then be placed in a water bath maintained at  $18^{\circ}\text{C}$  to  $38^{\circ}\text{C}$  without disturbing the specimens and shall remain there for one hour after thawing has completed. The pan and specimens shall then be returned to the refrigerator and freezing and thawing shall be repeated in precisely the same manner until five cycles of the process have been completed. The specimens shall be removed from the pan and air dried at room temperature for 48 hours before examination.
- (c) The material shall be deemed to have passed the weathering test if the specimens show no signs of disintegration or shrinkage.

(ii) Compression and Recovery Test

- (a) Two of the specimens which pass the weathering test, and two new specimens, each trimmed to 100 mm square  $\pm 0.5$  mm, maintained at room temperature and humidity for 24 hours, shall be subjected to three applications of load at 24 hour intervals in a compression test machine complying with BS EN ISO 7500-1, with auxiliary platens 100 mm<sup>2</sup>, minimum 13 mm thick. During each application of load each specimen shall be compressed to 50% of its original thickness at a rate of strain of 1.3 mm per minute. The load required to achieve this amount of compression shall be:
  - not less than 0.7 N/mm<sup>2</sup> nor more than 10 N/mm<sup>2</sup> for material to be used in pavements; and
  - not less than 0.7 N/mm<sup>2</sup> and not more than 0.4 N/mm<sup>2</sup> for material to be used in bridge joints.

The load shall be released immediately the required degree of compression is reached and after the third application a recovery period of 30 minutes shall be allowed after which the thickness of the specimen shall be measured.

- (b) This thickness, expressed as a percentage of the original thickness, is the 'recovery' value of the specimen. The thicknesses shall be measured to an accuracy of 25 micron. The two new specimens shall be weighed before and after testing. The difference in mass shall be determined with an accuracy of 0.1% and shall be expressed as a percentage of the original mass of the specimen.
  - (c) The material shall be deemed to have passed the test if all four specimens have recovery values of at least 70% and the two new specimens have not suffered a reduction of mass in excess of 1%.
- (iii) Extrusion Test
- (a) The third sample which passes the weathering test shall be trimmed to 100 mm square  $\pm 0.5$  mm and be subjected to the following extrusion test.
  - (b) The extrusion mould shall be 100 mm x 100 mm (+ 0.5 mm, - 0) internally, of sufficient depth to test the sample as received, open on one side only and fixed rigidly to a base plate. The mould shall be provided with a closely fitting pressure plate which shall fit without binding, and with an accurate horizontal measuring dial gauge or measuring device accurate to 25 microns. The specimen shall be mounted in the extrusion mould and loaded once as described in the compression and recovery test. The extrusion at the open side of the mould shall be measured with the gauge when the specimen is compressed to 50% of its original thickness and before release of the load.
  - (c) The material shall be deemed to have passed the test if the extrusion of the free edge does not exceed 6 mm.

## 1016 (02/16) Preparation and Sealing of Joint Grooves

### (02/16) General

1 (02/16) All transverse joints in surface slabs, except for construction joints in CRCP shall be sealed using one of the joint seals described in Clause 1017. Additionally longitudinal joints which are sawn or widened, shall be sealed.

### (02/16) Preparation of Joint Grooves for Sealing

2 (02/16) Joint grooves shall be prepared in accordance with BS 5212 : Part 2 and sub-Clauses 3 to 8 of this Clause.

3 (02/16) That part of the groove former used to form the sealing groove or any temporary seal shall be removed cleanly without damaging the joint arrises to a minimum depth of 25 mm where compression seals are used or otherwise to such depth as will provide an applied seal to the dimensions shown in Table 10/6, after allowing for any necessary caulking material described in sub-Clause 6 of this Clause. If joint grooves are not initially constructed to provide the minimum dimensions for the joint seals as given in Table 10/6, they shall be widened by sawing. Joint grooves formed by tapered formers need not be widened. The sealing grooves shall be cleaned out immediately after sawing using high pressure water jets, to remove all slurry from the joint, before the slurry hardens.

4 (02/16) If rough arrises develop when grooves are made they shall be ground to provide a chamfer approximately 5 mm wide. If the groove is at an angle up to  $10^\circ$  from the perpendicular to the surface, the overhanging edge of the sealing groove shall be sawn or ground perpendicular. If spalling occurs or the angle of the former is greater than  $10^\circ$  the joint sealing groove shall be sawn wider and perpendicular to the surface to encompass the defects up to a maximum width, including any chamfer, of 40 mm for transverse joints and 25 mm for longitudinal joints. If the spalling cannot be so eliminated then the arris shall be repaired by suitable thin bonded arris repair using cementitious materials as specified in Clause 1032.

5 (02/16) For applied sealants the sides of the joint sealing groove shall be scoured by dry abrasive blasting. This shall not be carried out before the characteristic compressive strength of the concrete is expected to reach 15 N/mm<sup>2</sup>. When compression seals are used, the sides of the groove may be ground or wire brushed.

**6** (02/16) For hot and cold applied sealants, compressible caulking material, debonding strip or tape or cord compatible with the sealant, of a suitable size to fill the width of the sealing groove, shall be firmly packed or stuck in the bottom of the sealing groove to such a depth so as to provide the correct depth of seal as described in Table 10/6 with the top of the seal at the correct depth below the surface of the concrete.

**7** (02/16) All grooves shall be cleaned of any dirt or loose material by air blasting with filtered, oil-free compressed air. The groove shall be clean and dry at the time of priming and sealing.

**8** (02/16) For applied sealants the joint grooves shall be primed with the relevant primer for the hot or cold applied sealant in accordance with the manufacturer's recommendations and with BS 5212 : Part 2, except that when necessary the joint grooves may be primed and sealed earlier than 14 days after construction, as soon as the grooves have been grit-blasted and cleaned.

**TABLE 10/6: (01/20) Dimensions of Applied Joint Seals**

Type and Spacing of Joints (m)	Minimum Width mm	Minimum Depth of Seal (Note 1)		Impregnated Foam Compression Strips mm	Depth of Seal Below the Concrete Surface mm
		Cold Applied mm	Hot Applied mm		
Contraction					
15 and under	13 (Note 2)	13	15	30	5 ± 2
Over 15 to 20	20	15	30	30	5 ± 2
Over 20 to 25	30	20	25	40	5 ± 2
Expansion	30	20	25	40	7 ± 2
Transverse Warping	10	10	13	30	5 ± 2
Longitudinal Joints (if sealed)	10	10	13	30	0 to 5
Gully and Manhole Slabs	20	15	20	30	0 to 3

NOTE (1): The depth of seal is that part in contact with the vertical face of the joint groove. The depth of seal below the surface shall be taken at the centre of an applied seal relative to a short straight edge, 150 mm long, placed centrally across the joint within 7 days of sealing.

NOTE (2): For cork seals other than in construction joints, grooves shall be 20 mm width, 50 mm depth.

**(02/16) Sealing with Applied Sealants**

**9** (02/16) Sealing shall be carried out continuously along the full length of joint in any one rip, except for remedial areas. When hot or cold applied sealants are used the sealant shall be applied within the minimum and maximum drying times of the primer recommended by the manufacturer. Priming and sealing with applied sealants shall not be carried out when the naturally occurring temperature in the joint groove to be sealed is below 10°C except between 8°C and 10°C it may be carried out when the temperature is rising.

**10** (02/16) Hot-applied sealants shall be prepared and applied in accordance with the manufacturer's instructions.

**11** (02/16) The components of cold-applied sealants shall be thoroughly mixed in the correct proportions in accordance with the manufacturer's instructions. As soon as possible after mixing and within the worklife of the sealant, the material shall be dispensed into the joint, or applied using a caulking gun, to the correct level below the concrete surface. The tack-free time shall be achieved within 3 hours for machine dispensed material, or within 12 hours for hand applied material.

(02/16) **Testing of Applied Sealants**

**12** (01/20) No additional testing of sealants is required provided a declaration of performance for cold-applied sealants in accordance with BS EN 14188-2 or for BS EN 14188-1 has been provided to the Overseeing Organisation.

(02/16) **Sealing with Compression Seals**

**13** (02/16) When compression seals are used, the widths of the seal shall be selected in relation to the width of the sealing groove, the bay lengths and manufacturer's recommendations so that the estimated maximum width of the joint opening shall be not more than 70% of the original width of the seal, the estimated maximum width being calculated on the basis of a movement of 4 mm per 10 m run of slab. The maximum calculated width of sealing groove shall be 30 mm. The depth of groove shall be such that the contact face of the seal with the side of the groove shall be not less than 20 mm and that the top of the seal shall be a minimum of 3 mm below the surface of the concrete.

**14** (02/16) Compression seals shall be inserted into the grooves without prior extension or rotation and, where recommended by the manufacturer, with a lubricant adhesive which is compatible with the seal and the concrete. The adhesive shall be applied to both sides of the sealing groove or the seal, or to both. The seal shall be positioned with its axis perpendicular to the concrete surface. Excess adhesive on top of the seal shall be removed to prevent adhesion of the top faces of the seal under compression. Except when compression seals are used in longitudinal joints the transverse joint seal shall be continuous across the slab and the longitudinal joint groove forming strips shall be cut to the required depth after the concrete has hardened for the transverse seal to be inserted. If compression seals are used in longitudinal joints where the grooves have been sawn after construction of the slab they shall be continuous across transverse joints, with the transverse seals butted and fixed to the longitudinal seals with adhesive.

**1017** (02/16) **Joint Seals**

**1** (01/20) Joint seals shall consist of hot or cold applied sealants or compression seals complying with this Clause. The colour of the joint seal material shall comply with the requirements of contract specific Appendix 7/2.

For hot-applied and cold applied sealants the Contractor shall submit the declaration of performance for each sealant to the Overseeing Organisation prior to the incorporation of the sealant into the works. The declaration of performance shall demonstrate that the sealant meets the specification requirements.

(02/16) **Hot-applied Sealants**

**2** (01/20) Hot-applied sealants shall be Type N1 or Type F1 or Type F2, as stated in contract specific Appendix 7/1, and conforming to BS EN 14188-1.

**3** (02/16) For joints between concrete surface slabs and bituminous surfacing, hot applied Type N1 sealants conforming to BS EN 14188-1 shall be used. Alternatively polymer modified bitumen sealing strips may be used and shall be applied in accordance with the manufacturer's instructions. Hot-applied Type N1 sealants may be used in joints in asphalt kerbs laid on concrete pavements.

(02/16) **Cold-applied Sealants**

**4** (01/20) Cold-applied sealants shall be Type N conforming to BS EN 14188-2 except that Type F shall be used for lay-bys and hardstandings.

**5** (02/16) For joints in kerbs and joints other than in pavements, seals may be any of the pavement sealants if they have the suitable characteristics for the application, or gunning grade cold applied plasticised bituminous rubber sealant or gunning grades of two part polysulphide-based sealants complying with BS 4254 may be used. Alternatively, polyurethane-based sealing compounds may be used provided their performance is not inferior to BS 4254 material.

(02/16) **Compression Seals**

6 (01/20) Compression seals shall be pre-compressed neoprene impregnated expanding foam sealing strip having current product acceptance scheme certification in accordance with sub-Clauses 104.15 and 104.16 such as HAPAS certification, or rubber seals made of polychloroprene elastomers complying with BS 2752 and conforming with the requirements of ASTM Standard D2628-91. Seals of butadiene-acrylonitrile or other synthetic rubbers may be used if certificates are produced to show that they conform to the performance requirements of ASTM Standard D2628-91 for oven ageing, oil and ozone resistance, low temperature stiffening and recovery. Seals made of ethylene vinyl acetate in microcellular form and other synthetic materials may be used in longitudinal joints and in structures if test certificates are produced to show adequate resistance to heat ageing when tested in accordance with BS EN ISO 2440 and resistance to fuel oils. The compression set of any seal shall not be greater than 15% when the specimen is subjected to a 25% compression in accordance with BS EN ISO 1856. When immersed in standard oils for 48 hours at 25°C in accordance with BS ISO 1817, the volume change shall not be greater than 5%.

7 (02/16) Compression seals shall be shaped so that they will remain compressed at all times in accordance with Clause 1016 and shall have a minimum of 20 mm contact face with the sides of the sealing groove. If lubricant-adhesive is used, it shall be compatible with the seal and the concrete and shall be resistant to abrasion, oxidization, fuels and salt.

**1018 (02/16) Joints at Manhole and Gully Slabs**

1 (02/16) Manhole covers, gullies and their frames shall be isolated from the pavement slabs and be contained in separate small slabs, which shall be larger than the exterior of the manhole and gully shafts, including any concrete surround less than 150 mm below the underside of the sub-base layer. The joint around the manhole or gully slab shall be vertical and incorporate joint filler board as in Clause 1015 but without dowel bars and tie bars.

2 (02/16) Gully slabs in unreinforced concrete slabs shall be adjacent to or straddle a transverse joint, extending the gully slab as necessary to a maximum of 2 m. Where this is impractical, an extra tied warping joint shall be provided adjacent to or within the gully slab and at least 2 m from the next transverse joint. If the edge of an isolator slab is within 1 m of any longitudinal joint the isolator slab shall be extended to that joint.

3 (02/16) Manhole slabs in unreinforced concrete slabs shall be adjacent to or straddle transverse or longitudinal joints. If the manhole is within the middle third of the bay length a warping joint shall be constructed on one side of the manhole slab across the whole width of the bay to the nearest longitudinal joint.

4 (02/16) Reinforcement as shown on the drawings shall be placed in the main concrete slabs in the corners between the manhole and gully slabs and the transverse or longitudinal joints. Extra reinforcement as described in the Contract shall be placed in reinforced concrete slabs around the manhole or gully slabs.

5 (02/16) Manhole and gully slabs shall have square corners, at all corners which are not adjacent to a transverse or longitudinal joint in the main slab.

6 (01/20) Reinforcement as shown on the drawings shall be placed in the gully or manhole slab and concrete Class C32/40 shall be placed by hand in the space between the main slab and the manhole frame. The concrete shall be fully compacted and finished in compliance with Clause 1025.

7 (02/16) A sealing groove shall be made directly above the joint filler board and sealed in compliance with Clause 1016.

### 1019 (02/16) Inspection of Dowel Bars

- 1 (02/16) Compliance with Clause 1011 for the position and alignment of dowel bars at contraction and expansion joints shall be checked by measurement relative to the side form or guide wires.
- 2 (01/20) When the slab has been constructed, the position and alignment of dowel bars and any filler board shall be measured after carefully exposing them across the whole width of the slab. When the joint is an expansion joint the top of the filler board shall first be exposed sufficiently in the plastic concrete to permit measurement of any lateral or vertical displacement of the board. During the course of normal working these measurements shall be carried out at a rate of one joint per 1500 m length of slab or one per 5 days whichever occurs the sooner. For small areas the rate shall be one joint for up to each 100 joints. For trial lengths measurements shall be carried out at two consecutive joints.
- 3 (02/16) If the position or alignment of the bars in a single joint in the slab is unsatisfactory then the next two joints shall be inspected. If only the one joint of the three is defective, the rate of checking shall be increased to one joint per day until compliance is being achieved. In the event of non-compliance in two or more successive joints, the Contractor shall revert to the construction of trial lengths and make any necessary alterations to the concrete mix, paving plant or methods until the dowel bar position and alignment is satisfactory.
- 4 (02/16) After the dowel bars have been examined, the remainder of the concrete shall be removed 500 mm on each side of the line of the joint, and reinstated to the requirements of the specification. Alternatively if the dowels are examined in the penultimate joint of a day's work that joint shall be made a construction joint for the next day's work and the remainder of the concrete in the last slab may be discarded.

### 1020 (02/16) Side Forms, Rails and Guide Wires

#### (02/16) Side Forms and Rails

- 1 (01/20) All side forms and rails shall be made of steel or timber and be sufficiently robust and rigid to support the weight and pressure caused by the paving equipment. Side forms for use with wheeled paving machines shall incorporate metal rails firmly fixed at a constant height below the top of the forms.
- 2 (02/16) The forms shall be secured by using not less than three pins for each 3 m length having one pin fixed at each side of every joint. Forms shall be tightly joined together by a locked joint, free from play or movement in any direction. Forms shall be cleaned and oiled immediately before each use. The rails or running surface shall be kept clean in front of the wheels of any paving machines. The forms shall be straight within a tolerance of 3 mm in 3 m.
- 3 (02/16) The forms shall be bedded on low moisture content cement mortar or concrete class C6/8 and set to the pavement surface level as shown on the drawings within a tolerance of  $\pm 3$  mm. The bedding shall not extend under the slab. There shall be no vertical step between the ends of adjacent forms greater than 3 mm. The horizontal alignment for forms shall be to the required alignment of the pavement edge as shown on the drawings within a tolerance of  $\pm 10$  mm. The Contractor shall ensure that the forms are set to the correct profile immediately prior to concreting. The mortar or concrete bedding shall be broken out after use.
- 4 (02/16) Side forms shall not be removed earlier than 6 hours after the completion of the construction of the slab. Care shall be taken to prevent damage to the concrete and any projecting tie bars during the removal of the forms. If the removal of forms results in any damage to the concrete the period of 6 hours shall be increased to that which is necessary to avoid further damage and the Contractor shall make good the damaged areas.

#### (02/16) Guide Wires

- 5 (01/20) Unless a laser or electronically controlled level system capable of meeting the vertical and horizontal tolerances stated below is used, a guide wire shall be provided along each side of the slab to be constructed by slip form paving plant. Each guide wire shall be at a constant height above and parallel to the required edges of the slab as shown on the drawings, within a vertical tolerance of  $\pm 3$  mm. Additionally one of the wires shall be at a constant horizontal distance from the required edge of the pavement as shown in the drawings within a lateral tolerance of  $\pm 10$  mm.

6 (02/16) The guide wires shall be supported from stakes not more than 8 m apart by connectors capable of fine horizontal and vertical adjustment. The guide wire shall be tensioned on the stakes so that a 500 gramme weight shall produce a deflection of not more than 20 mm when suspended at the mid-point between any pair of stakes. The ends of the guide wires shall be anchored to fixing points which shall be not closer to the edge of the slab than the row of stakes and in no circumstances shall a guide wire be anchored to a stake.

7 (02/16) The stakes shall be positioned and the connectors maintained at their correct height and alignment from 1200 hours on the day before concreting takes place until 36 hours after the concrete has been finished. The guide wire shall be erected and tensioned on the connectors at any section for at least two hours before concreting that section.

### 1021 to 1022 (02/16) Not Used

### 1023 (02/16) Transport and Delivery

1 (02/16) The number of delivery vehicles provided shall be sufficient to ensure a constant supply of concrete to enable the paving plant to proceed continuously.

### 1024 (02/16) Construction by Machine

1 (02/16) The concrete slab shall be constructed in a continuous process by either slip-form or by fixed form paving plant in accordance with this Clause or by small paving machines or hand guided methods as in Clause 1025.

2 (01/20) The slab may be constructed in either one or two layers. In two layer construction the thickness of the top layer shall be not less than 40 mm or twice the maximum size of the coarse aggregate, whichever is the greater, and shall be at least 15 mm thicker than the depth of the groove former, if used.

#### (02/16) Construction by Fixed Form Paving Machines

3 (02/16) A fixed form paving train shall consist of separate, powered machines which spread, compact and finish the concrete in a continuous operation.

4 (02/16) Concrete shall be discharged without segregation into a hopper spreader which is equipped with the means of controlling its rate of deposition on to the sub-base or on to the lower layer. The concrete shall be spread in each layer without segregation and to a uniform uncompacted density over the whole area of the slab. The deposited concrete shall be struck off to the necessary level by the underside of the hopper as it is traversed across the spreading machine. The machine shall be capable of being rapidly adjusted for changes in average and differential surcharge necessitated by changes in slab thickness or crossfall. When the slab is constructed in two layers, the spreading of the concrete in the top layer shall follow the completion of the bottom layer within the times given in Table 10/7.

**TABLE 10/7: (01/20) Maximum Working Times**

Temperature of concrete at discharge from the delivery vehicle  Time is function of degree hours see RCC	Reinforced concrete slabs constructed in two layers, without retarding admixtures		All other concrete slabs	
	Mixing first layer to finishing concrete	Between layers	Mixing first layer to finishing concrete	Between layers in two layer work
Not more than 25°C hours	3 hours	half hour	3 hours	1.5 hours
Exceeding 25°C hours but not exceeding 30°C hours	2 hours	half hour	2 hours	1 hour
Exceeding 30°C hours	Unacceptable for paving	–	Unacceptable for paving	–

- 5** (02/16) Prior to being compacted, the surface level of each loose spread layer shall be adjusted to the correct surcharge by means of rotating strike-off blades or a screw device.
- 6** (02/16) The concrete shall be compacted by vibration or by a combination of vibration and mechanical tamping so as to comply with Clause 1003 throughout the full depth of the slab. Poker vibrators shall be used in each layer adjacent to the side forms and the edge of a previously constructed slab.
- 7** (02/16) The initial regulation and finish to the surface of the slab shall be effected by means of a beam oscillating transversely or obliquely to the longitudinal axis of the pavement. This beam shall be readily adjustable for both height and tilt.
- 8** (02/16) Joint grooves shall be constructed in compliance with Clause 1013. When grooves are wet-formed, the concrete shall be re-compacted around the former by a hand held vibrating plate compactor drawn along or on each side of the joint, prior to the final regulation of the surface by a longitudinal oscillating float.
- 9** (02/16) The regulation and finishing of the surface of the slab shall be carried out by a machine which incorporates twin oblique oscillating finishing beams which shall be readily adjustable for both height and tilt. The beams shall weigh not less than 170 kg/m, be of rectangular section and span the full width of the slab. The leading beam shall be vibrated. The beams shall be supported on a carriage, the level of which shall be controlled by the average level of not less than four points evenly spaced over at least 3.5 m of the supporting rail, beam, or slab, on each side of the slab that is being constructed. Except for CRCB slabs, the final regulation of the surface of the slab shall be provided by a longitudinal oscillating float, travelling across the slab. After the final regulation and before the macrotexture is applied, any excess concrete on top of the joint groove former, where present, shall be removed. Additionally the longitudinal oscillating float shall complete the traverse of the slab in both directions within the length of the float and shall have a total longitudinal stroke of 200 mm to 300 mm.
- 10** (02/16) The longitudinal oscillating float shall have a minimum length of 3 m and a minimum constant width of 250 mm with a maximum weight of 10 kg/m. The edges of the float shall be curved or chamfered.
- 11** (02/16) A minimum length of 500 mm of longitudinal oscillating float shall be within the length of the machine tracks or wheels.
- 12** (02/16) When a concrete slab is constructed in more than one width, flanged wheels on the paving machines shall not be run directly on the surface of any completed part of the slab. The second or subsequent slabs shall be constructed either by supporting machines with flanged wheels on flat-bottom section rails weighing not less than 15 kg/m laid on the surface of the completed slab, or by replacing the flanged wheels on that side of the machines by smooth flangeless wheels. Before flangeless wheels or rails are used, the surface regularity of the slab over which they are to pass shall comply with Clause 702 and its surface shall be thoroughly cleaned and brushed to remove all extraneous matter. Flangeless wheels or rails shall be positioned sufficiently far from the edge of the slab to avoid damage to that edge.

**(02/16) Construction by Slip-form Paving Machine**

- 13** (02/16) A slip-form paving train shall consist of powered machines which spread, compact and finish the concrete in a continuous operation.

- 14 (02/16) The slip-form paving machine shall compact the concrete by internal vibration and shape it between sliding side forms or over fixed side forms by means of either a conforming plate or by vibrating and oscillating finishing beams.
- 15 (02/16) The concrete shall be deposited without segregation in front of the slip-form paver across its whole width and to a height which at all times is in excess of the required surcharge. The deposited concrete shall be struck off to the necessary average and differential surcharge by means of a strike-off plate or a screw auger device extending across the whole width of the slab. The equipment for striking off the concrete shall be capable of being rapidly adjusted for changes of the average and differential surcharge necessitated by changes in slab thickness or crossfall.
- 16 (02/16) The level of the conforming plate and finishing beams shall be controlled automatically from the guide wires by sensors attached at the four corners of the slip form paving machine. The alignment of the paver shall be controlled automatically from the guide wire by at least one sensor attached to the paver. The alignment and level of ancillary machines for finishing, texturing and curing of the concrete shall be automatically controlled relative to the guide wire or to the surface and edge of the slab.
- 17 (02/16) Slip-form paving machines shall have vibration of variable output, with a maximum energy output of not less than 2.5 kW per metre width of slab per 300 mm depth of slab for a laying speed of up to 1.5 m per minute or pro rata for higher speeds. The machines shall be of sufficient mass to provide adequate reaction on the traction units to maintain forward movements during the placing of concrete in all situations.
- 18 (02/16) Except for CRCB slabs, the final regulation of the surface slab shall be provided by a longitudinal oscillating float travelling across the slab. The longitudinal float shall comply with the requirements of sub-Clauses 9, 10 and 11 of this Clause. Additionally, the longitudinal float shall either be a separate machine closely following a slip-form paver or alternatively it shall be attached to a slip-form paver in such a manner that it functions effectively and does not adversely affect the performance of the paver or the surface of the slab.
- 19 (02/16) Joint grooves shall be constructed in compliance with Clause 1013. Where grooves are wet-formed the concrete shall be compacted around the former by a separate vibrating plate compactor with twin plates. The groove former shall be compacted to the correct level by a vibrating pan which may be included with the transverse joint finishing beam. Final finishing shall be carried out in accordance with sub-Clause 18 of this Clause. Any excess concrete on top of the groove former shall be removed before the surface is macrotextured.
- 20 (02/16) Where a concrete slab is constructed in more than one width or where the edge needs to be matched for one level to another section of surface slab, and the surface levels at the edges are not achieved, the slab shall be supported by separate side forms placed before or after the paver to ensure that edge levels meet the required tolerances.
- (02/16) **General**
- 21 (01/20) While the concrete is still plastic its surface shall be treated to comply with the macrotexture requirements specified in Clause 1026. The surface and edges of surface slabs and CRC bases shall be cured in compliance with Clause 1027. Lower Strength concrete bases and subbases shall be cured in compliance with Clause 1030.
- 22 (01/20) The spreading, compacting and finishing of the concrete shall be carried out as rapidly as possible and the paving operation shall be so arranged as to ensure that the time between the mixing of the first batch of concrete in any transverse section of the slab and the application of the sprayed curing membrane to the surface of that section shall not exceed those given in Table 10/7. This working time is a function of degree hours see sub-Clause 1054.3.
- 23 (02/16) Each bay in jointed concrete surface slabs shall be consecutively numbered near the verge, next to a transverse joint while the concrete is plastic. In continuously reinforced concrete pavement the slab shall be marked with the chainage at intervals not greater than 50 m apart.

## 1025 (02/16) Construction by Small Paving Machines or Hand Guided Methods

- 1 (01/20) As an alternative to fixed form or slip-form paving trains, the concrete slab may be constructed using parts of trains, small paving machines, truss type finishing beams, roller beams or hand guided methods. Hand tamping beams may only be used for short lengths or infill bays or tapers. Reinforcement, dowel bars and tie bars shall be supported in position in accordance with Clauses 1008, 1011 and 1012 respectively, except where two layer construction is used and reinforcement is placed on the bottom layer.
- 2 (01/20) The concrete shall be spread uniformly without segregation or varying amounts of pre-compaction, by conveyor, chute, blade or auger. The concrete shall be struck off by a screed or auger so that the average and differential surcharge is sufficient for the surface of the slab to be at the correct levels after compaction of the concrete.
- 3 (02/16) The concrete shall be compacted by vibrating finishing beams across the slab and with vibrating pokers adjacent to the side forms or the edge of a previously constructed slab. In addition, internal poker vibration shall be used for slabs thicker than 200 mm and may be used for lesser thicknesses. When used, the pokers shall be at points not more than 500 mm apart over the whole area of the slab, or drawn continuously across the slab in front of the finishing beams.
- 4 (02/16) The finishing beams shall be metal with a contact face at least 50 mm wide. They shall be rigid or supported by a frame or truss without sag across the width of slab being paved. The beams shall be supported on rails or forms or an adjacent slab and shall be moved forward at a steady speed of 0.5 m to 2 m per minute whilst vibrating, to compact the concrete and to produce a smooth surface finished to the correct crossfalls, crowns and levels relative to the top of the forms or adjacent slab.
- 5 (02/16) Joint grooves shall be constructed in compliance with Clause 1013. Any irregularities at wet-formed joint grooves shall be rectified by means of a vibrating float at least 1.0 m wide drawn along the line of the joint. The whole area of the slab shall be regulated by two passes of a scraping straight edge not less than 1.8 m wide or by a further application of a twin vibrating finishing beam. Any excess concrete on top of the groove former shall be removed before the surface is macrotextured.
- 6 (02/16) The surface shall be brush-textured as described in Clause 1026.
- 7 (02/16) The surface shall be cured in compliance with Clause 1027, within the time to completion given in Table 10/7.

## 1026 (02/16) Finished Surface Requirements

### (02/16) Macrotexture of Running Surfaces

- 1 (01/20) The macrotexture of running surfaces for pavement widening, partial reconstruction and repair shall comply with sub-Clauses 2 to 6 of this Clause, other pavements shall comply with sub-Clause 2 and sub-Clauses 7 to 27 of this Clause.
- 2 (01/20) The finished surface of the pavement shall comply with the requirements of Clause 702. Where a pavement area does not comply with the specification in any respect the full extent of the surface which does not comply shall be rectified in accordance with Clause 702.

### (02/16) Brush Finish Macrotexture

- 3 (02/16) After the final regulation of the surface of the slab and before the application of the curing membrane, the surface of concrete slabs to be used as running surfaces shall be brush-macrotextured in a direction at right angles to the longitudinal axis of the carriageway. The macrotexture shall be applied evenly across the slab in one direction by a brush not less than 450 mm wide. The macrotexture shall be uniform both along and across the slab.

4 (02/16) The macrotexture depth shall be determined by the volumetric patch technique as described in BS EN 13036-1. Tests shall be taken within 100 m of commencement of paving and thereafter at least once for each day's paving at the times after construction as given below and in the following manner: 10 individual measurements of the macrotexture depth shall be taken at least 2 m apart anywhere along a diagonal line across a lane width between points 50 m apart along the pavement. No measurement shall be taken within 300 mm of the longitudinal edges of a concrete slab constructed in one pass.

5 (02/16) Macrotexture depths shall be as required in Table 10/8.

6 (02/16) Where the required macrotexture depth is found to be deficient the Contractor shall make good the texture across the full lane width over lengths necessary to comply with the requirements of Table 10/9, by retexturing the hardened concrete surface as described in Clause 1029. Failure to achieve a satisfactory minimum macrotexture depth by random grooving shall result in the removal of the full thickness of the slab to the extent required to permit reconstruction of the slab in accordance with the specification. If the macrotexture depth is excessive the surface shall be planed or ground or otherwise treated over lengths necessary to comply with the requirements of Table 10/8. The treatment shall not affect the requirements of Clause 702 in respect of surface levels or surface regularity.

**TABLE 10/8: (01/20) Macrotexture Depths**

Time of Test	Required Macrotexture Depth (mm)		
		Specified value	Tolerance
(i) Between 24 hours and 7 days after the construction of the slab or until the slab is first used by vehicles	An average of 10 measurements	1.00	+0.25 -0.10
(ii) Not later than 6 weeks before the road is opened to public traffic	An average of 10 measurements	1.00	+0.25 -0.10

**(02/16) Performance Characteristics of Concrete Road Surfaces**

7 (01/20) The surface macrotexture shall meet the performance requirements stated in Table 10/8.

8 (01/20) The Contractor shall demonstrate that the 'as installed' concrete pavement can meet the requirements of the specification. This shall be demonstrated by the system meeting the stated material requirements and by having undergone a System Installation Performance Trial (SIPT) for the surface finish. The SIPT shall comply with the requirements of sub-Clauses 9 to 27 of this Clause and the requirements of sub-Clause 104.16. The Contractor shall submit details of the SIPT for the systems to be used in the contract as required in sub-Clause 15 to the Overseeing Organisation for acceptance.

With respect to the requirements of this Clause 'the system' shall be the combination of materials, equipment and working methods to be used in the works. The SIPT shall have been undertaken with the same materials, equipment and working methods.

**(01/20) System Installation Performance Trial (SIPT) Requirements**

9 (01/20) The surface finish used in the SIPT shall meet the performance requirements of the surface course to be supplied under the contract. The SIPT shall demonstrate, and enable verification of, the performance of the road surface.

10 (01/20) The SIPT shall be undertaken during daylight hours and shall be a minimum of 200 metres in length and 3.5 metres wide.

11 (01/20) The system shall be assessed, tested and certified by a Certification Body using one or more trial areas of pavement. The Certification Body shall be accredited to BS EN 45011 by UKAS or equivalent European Accreditation organisation which is party to a multi-lateral agreement (MLA) with UKAS or any equivalent International Accreditation Forum MLA signatory with a scope that includes relevant standard(s) or scheme(s).

**12** (01/20) The average locked wheel friction of the SIPT road surface macrotexture depth of the surface shall be measured in accordance with ASTM E274/E274M – 11, at a speed of 90 km/hr rather than 40 mph in the test method, using a tyre that complies with ASTM E524 – 08.

**13** (01/20) A SIPT method statement shall be prepared. The SIPT shall demonstrate, and enable verification of, the installation procedures given in the SIPT method statement. This will include working methods and equipment, any limitations, aftercare, testing methods and frequency of testing.

**14** (01/20) A SIPT inspection protocol shall be prepared. It shall demonstrate qualitatively and quantitatively the applicability of the SIPT for the system in order to satisfy the performance requirements.

**15** (01/20) The SIPT method statement, SIPT inspection protocols, all inspection and testing results and the SIPT certification shall be submitted to the Overseeing Organisation prior to the commencement of concrete pavement construction.

**16** (01/20) The SIPT shall include the following to be undertaken by the Certification Body:

- (i) verification that the system installation trial has been undertaken in accordance with the SIPT method statement;
- (ii) assessment of the data from the site performance tests detailed in sub-Clause 17

**17** (01/20) The installed performance of the system over the two-year trial period shall be assessed at the intervals specified in Table 10/9. Data relating to properties in Table 10/9 shall be provided to the Overseeing Organisation

**TABLE 10/9:** (01/20) **Installed Performance Characteristics**

Property	Frequency	Requirement
Average locked wheel friction (L-Fn90) measured at 90km/hr. by Pavement Friction Tester	Initial, 12 and 24 months	>0.3 L-Fn90
Noise (Voluntary assessment and declaration)	Between 12 and 24 months	Table 10/11

(02/16) **Noise**

**18** (01/20) Where noise characteristics for the surface are specified in contract specific Appendix 7/1 the SIPT shall include the assessment and measurement of the road/tyre noise levels. The road/tyre noise level of the concrete shall be assessed as detailed in sub-Clauses 19 to 27 of this Clause, and declared as NR, 0, 1, 2 or 3 as described in Table 10/10. If the SIPT site conditions are not appropriate for testing an alternative site shall be selected and nominated.

**TABLE 10/10:** (01/20) **Road/Tyre Noise Levels**

Level	Equivalence to Traditional Surfacing Materials	Road Surface Influence RSI
3	Very quiet surfacing material	-3.5 dB(A)
2	Quieter than HRA surfacing materials	-2.5 dB(A)
1	Equivalent to HRA surfacing materials	-0.5 dB(A)
0	Noisier than HRA Surfacing materials	+1.2 dB(A)
NR	No requirement	No requirement

**19** (01/20) The influence of the road surface on traffic noise using the statistical pass-by method shall be established at the SIPT site between 12 and 24 months after opening to traffic in accordance with ISO 11819-1: 2002, Sections 7 and 8.

- 20** (01/20) Acoustic measurements shall only be carried out when the road surface is dry and the meteorological conditions specified in ISO 11819-1: 2002, Section 11 are met.
- 21** (01/20) The air and surface temperatures are monitored in accordance with the procedure described in ISO 11819-1: 2002, Clause 8.5. The road surface temperature,  $T_{\text{surface}}$ , must be within  $5^{\circ}\text{C}$  to  $50^{\circ}\text{C}$  during acoustic measurements. The air temperature,  $T_{\text{air}}$ , must be within  $5^{\circ}\text{C}$  to  $30^{\circ}\text{C}$ .
- 22** (01/20) The test location road speed category shall be classified as either Medium or High as defined in ISO 11819-1: 2002, clause 3.3. Not less than two test locations are selected for each road speed category, which may be at the same site, provided the locations are at least 100 m apart or on different carriageways. Each test location shall be representative in terms of road speed category and traffic level. Each of the test sites selected must meet the requirements of ISO 11819-1: 2002 Section 6 and ISO/CD 11819-2: 2000. The road must be essentially straight, or bends with a radius of curvature greater than 500 m for medium-speed, and 1000 m for high-speed road categories. The crossfall of the test lane at the test site must not exceed 4%.
- 23** (01/20) The apparatus described in ISO 11819-1: 2002 Section 5 are used. The frequency range of between 100 and 5000 Hz (centre frequencies of the one-third octave bands) should be covered.
- 24** (01/20) The macrotexture of the road surface used for the noise assessment shall be measured in the nearside wheel-track along the whole length of test material in accordance BS EN 13036-1: 2010. The macrotexture depth of the nearside wheel-track in front of a test location must be within 10 per cent of the average macrotexture measured along the site.
- 25** (01/20) The microphone location at each measurement site shall be recorded accurately and marked with appropriate methods such that the position can be readily identified for a period of at least two years.
- 26** (01/20) When sufficient vehicle pass-bys' have been measured, a linear regression analysis shall be performed in accordance with ISO 11819-1: 2002, Clause 9.1. In the case of the high-speed road category, measurements must not be taken of vehicles travelling at speeds of less than 60 km/h in accordance with AFNOR Standard S31-119.
- 27** (01/20) For each category of vehicle defined in Table 10/11, the Vehicle Sound Level,  $L_{\text{veh}}$ , shall be calculated as the ordinate sound level of the regression line at the reference speed for the category of road. All levels shall be calculated to two decimal places and rounded to one decimal place.

**TABLE 10/11: (02/16) Reference speeds (km·h<sup>-1</sup>) for different road speed categories**

Vehicle category	Road speed category (km·h <sup>-1</sup> )	
	Medium	High
L	80	110
H1	70	90
H2	70	90

Category L vehicles — light vehicles including passenger cars and car derived vans, excluding vehicles towing trailers.

Category H1 vehicles — commercial trucks with 2 axles and greater than 3.5 tonnes.

Category H2 vehicles — commercial trucks with more than 2 axles and greater than 3.5 tonnes.

**(02/16) Texture of Concrete Bases**

- 28** (01/20) The surface of wet-laid concrete bases (prior to the application of a bituminous overlay) shall be roughened before the application of any curing compound by brushing with a wire brush or stiff broom to achieve min 0.5 mm texture depth.

## 1027 (02/16) Curing

- 1 (01/20) Immediately after the surface treatment described in Clause 1026, the surface and exposed edges of the surface shall be cured, without disturbance, for a minimum period of 7 days, by the application of a resin based aluminised curing compound, or polythene sheeting or a sprayed plastic film which hardens into a peelable plastic sheet and which shall be removed before road marking and opening to traffic. Where the concrete is to receive a thin surfacing overlay, the surface and exposed edges shall be cured for a minimum of 7 days by the application of a curing agent. If the concrete is to be overlaid by bituminous surfacing the curing agent shall be compatible with the bond coat and installation requirements for the thin surfacing in accordance with Series 900.
- 2 (02/16) Resin based aluminised curing compound shall contain sufficient flake aluminium in finely divided dispersion to produce a complete coverage of the sprayed surface with a metallic finish. The compound shall become stable and impervious to evaporation of water from the concrete surface within 60 minutes of application and shall have an efficiency index of 90% when tested as described in BS 7542.
- 3 (02/16) The curing compound shall not react chemically with the concrete to be cured and shall not crack, peel or disintegrate within three weeks after application.
- 4 (02/16) Prior to application, the contents of any containers shall be thoroughly agitated. The curing compound shall be mechanically applied using a fine spray on to the surface at a rate of at least 0.22 l/m<sup>2</sup>. For the sides of slip-formed slabs or when the side forms are removed within 24 hours and for small areas where mechanical application cannot be used, the compound shall be sprayed by hand lance at a rate of at least 0.27 l/m<sup>2</sup>. The rate of spread shall be checked during construction of each trial length and for each 1000 m<sup>2</sup> of treated slab.
- 5 (02/16) The mechanical sprayer shall incorporate an efficient mechanical device for continuous agitation and mixing of the compound in its container during spraying.
- 6 (02/16) Continuously reinforced concrete bases shall be cured in accordance with this Clause. Immediately prior to laying the bituminous surfacing or upper base, a cationic bituminous tack coat shall be applied in accordance with Clause 920 at a rate between 0.35 l/m<sup>2</sup> to 0.55 l/m<sup>2</sup>.
- 7 (01/20) To achieve high early strength for early use by vehicles, insulation blankets as described in Clause 1045 may be used for accelerated curing.

## 1028 (02/16) Trial Length

### (02/16) General

- 1 (01/20) Except in rapid construction projects and unless otherwise described in contract specific Appendix 7/1, at least 2 weeks prior to the construction of the trial length of surface slabs or CRCB the Contractor shall submit a detailed description of the proposed constituent materials, concrete proportions, plant, equipment and construction methods to the Overseeing Organisation. No trials of new constituent materials, plant, equipment or construction methods; nor any development of them shall be permitted either during the construction of the trial length or in any subsequent paving work, unless they form part of further satisfactory trials.
- 2 (02/16) Unless otherwise described in contract specific Appendix 7/1, the Contractor shall demonstrate the constituent materials, concrete proportions, plant, equipment and methods of construction that are proposed for concrete paving, by first constructing a trial length of slab, at least 150 m but not more than 300 m long for mechanised construction, and at least 30 m long for hand guided methods. The concrete proportions decided by trial concrete mixes may be adjusted during the trial but shall not be changed once the trial length has been satisfactorily completed unless the Contractor lays a further trial area to assess the suitability of the proposed changes.
- 3 (02/16) The trial length shall be constructed in two parts over a period comprising at least part of two separate working days, with a minimum of 75 m constructed each day when mechanised paving plant is used and a minimum of 15 m on each day for hand guided methods. The trial length shall be constructed at a similar rate to that which is proposed for the main construction in the permanent works.

4 (02/16) At least two transverse joints and one longitudinal joint of each type that are proposed for unreinforced concrete slabs and jointed reinforced concrete slabs in the main construction in the permanent works shall be constructed and assessed in the trial length. If in the trial length expansion joints are not demonstrated, the first 2 expansion joints and at least the first 150 m of longitudinal construction joint for mechanised paving, or 30 m for hand guided method of construction laid in the main construction in the permanent works, shall be considered the trial length for these joints. One construction joint shall be demonstrated in each trial length of CRCP or CRCB.

(02/16) **Assessment**

5 (02/16) The trial length shall comply for strength and density with the specification in all respects, with the following additions and exceptions:

(02/16) **Surface Levels and Irregularity**

- (i) In checking for compliance with Table 7/1 the levels shall be taken at intervals of not more than 2.5 m along any line or lines parallel to the longitudinal centre line of the trial length.
- (ii) The maximum number of permitted irregularities of pavement surfaces shall comply with the requirements of Table 7/2 for 300 m lengths. Shorter trial lengths shall be assessed pro-rata based on values for a 300 m length.

(02/16) **Joints**

- (iii) At least 3 cores of minimum diameter 100 mm shall be taken from the slab at joints to check the lateral and vertical location of joint grooves and bottom crack inducers.
- (iv) Alignment of dowel bars shall be inspected as described in Clause 1019 in any two consecutive transverse joints. If the position or alignment of the dowel bars at one of these joints does not comply with Clause 1011 but if that joint remains the only one that does not comply after the next 3 consecutive joints of the same type have been inspected then the method of placing dowels shall be deemed to be satisfactory. In order to check sufficient joints for dowel bar alignment without extending the trial length unduly, the Contractor may construct joints at more frequent joint intervals than the normal spacing required in contract specific Appendix 7/1.
- (v) If there are deficiencies in the first expansion joint that is constructed as a trial the next expansion joint shall be a trial joint. Should this also be deficient further trial expansion joints shall be made as part of a trial length. Deficient expansion joints shall not form part of the permanent works.

(02/16) **Position of Reinforcement and Tie Bars**

- (vi) Compliance with Clause 1008 for the position of steel reinforcement and Clause 1012 for the position and alignment of tie bars shall be checked by drilling additional cores from the slab unless they can be determined from cores taken for density assessment.

(02/16) **Completion of Trial**

6 (02/16) The Contractor shall not proceed with normal working unless the trial length complies with the specification and any earlier defective trial lengths have been removed, unless they can be remedied to comply with the specification.

7 (02/16) After satisfactory completion of the trial length, the constituent materials, concrete proportions, plant, equipment and construction methods shall not thereafter be changed, except for normal adjustments and maintenance of plant, unless the Contractor lays a further trial length as described in this Clause to demonstrate that the changes will not adversely affect the permanent works or agrees the changes with the Overseeing Organisation.

(02/16) **Rejection and Further Trials**

8 (02/16) Trial lengths which do not comply with the specification, with the exception of areas within the pavement surface which can be remedied in accordance with Clause 1029, shall be removed and the Contractor shall construct a further trial length.

**1029 (02/16) Texturing of Hardened Concrete**

1 (01/20) Worn, rain damaged or inadequately textured surface slabs shall be macrotextured by sawing grooves in the hardened concrete surface at right angles to the longitudinal axis of the pavement with machines using diamond or other abrasive cutting discs. This produces a high noise surface and shall only be carried out with the agreement of the Overseeing Organisation.

2 (02/16) Grooves shall be irregularly spaced and shall be not less than 2 mm and not more than 5 mm wide. The sequence of distances between groove centres in mm shall be: 40, 45, 35, 45, 35, 50, 30, 55, 35, 30, 50, 30, 45, 50, 30, 55, 50, 40, 35, 45, 50, 40, 55, 30, 40, 55, 35, 55. A tolerance of  $\pm 3$  mm shall be allowed on each of the spacings. The minimum width of grooving head shall be 500 mm and a head not providing a complete sequence of spacings shall use the number of spacings appropriate to its width commencing at the start of the sequence.

3 (02/16) Groove depths shall be measured using a tyre tread depth gauge and measurements shall be taken as follows:

- (i) At 10 locations at least 2 m apart along a diagonal line across a lane width between points 50 m apart longitudinally. No measurement shall be taken within 300 mm of the longitudinal edge of a slab.
- (ii) At each of the 10 locations the depth of 10 adjacent grooves shall be measured.
- (iii) Where a grooved area is less than 50 m in length the locations where measurements are taken shall be as (i) but the number shall be proportional to the requirements for 50 m.
- (iv) The average of each set of 10 measurements shall be not less than 3 mm, nor greater than 7 mm.

4 (02/16) Slurry from the sawing process shall be prevented from flowing into joints, drains or into lanes being used by traffic, and all resultant debris from the grooving shall be removed.

**1030 (01/20) Lower Strength Concrete**

(02/16) **Grades and Constituents**

1 (01/20) The strength for Lower Strength concrete shall be as described in Clause 1001 with the following constituents:

- (i) cements as described in sub-Clause 1001.3 and water/cement ratio as described in sub-Clause 1001.4;
- (ii) aggregate shall be in accordance with sub-Clause 1001.6.

(02/16) **Consistence (Workability)**

2 (02/16) Consistence shall comply with Clause 1005.

(02/16) **Placing**

3 (01/20) Lower Strength concrete shall be spread uniformly, without segregation and without varying degrees of pre-compaction. The concrete shall be struck off to a level so that the surcharge is sufficient to ensure that after compaction the surface is at the required level.

(02/16) **Compaction**

4 (01/20) The spread Lower Strength concrete shall be compacted using internal or external vibration, or a combination of both to meet the required density. Compaction and finishing to level shall be completed within the times given in Table 10/7.

(02/16) **Joints**

5 (02/16) At transverse and longitudinal construction joints between two separately constructed slabs, the previously laid slab end or edge shall present a vertical face before construction of subsequent slabs.

6 (01/20) Longitudinal joints in Lower Strength concrete shall be staggered by at least 300 mm from the position of longitudinal joints in any superimposed concrete slab, and by 1m for transverse joints.

(02/16) **Curing**

7 (01/20) The surface shall be cured, without disturbance, for a minimum period of 7 days, by the application of a resin based aluminised curing compound, or polythene sheeting or a sprayed plastic film which hardens into a peelable plastic sheet.

(02/16) **Sampling for Testing**

8 (02/16) Sampling shall be as specified in Clause 1003.

(02/16) **Density**

9 (02/16) The density shall be determined as required in Clause 1003.

(02/16) **Strength**

10 (02/16) The strength shall be determined as in Clause 1004.

(02/16) **Trial Concrete Mixes**

11 (02/16) Trial concrete mixes shall conform with BS 8500-2 for designed concretes for strength class C12/15 and above or CC14 and above, unless recent data relating entirely to the proposed concrete, satisfies the requirements of the specification.

(02/16) **Trial Length**

12 (01/20) At least 10 days before the start of the main Lower Strength concrete works a trial length of at least 400 m<sup>2</sup> for mechanised construction and 30 m for hand-guided methods shall be constructed. The trial length shall be laid to assess the suitability of the proposed material, plant, equipment and construction methods to meet the requirements of the specification. The main construction in the permanent works shall not start unless the trial length complies with the specification. If any trial length does not conform to the specification another trial length shall be constructed. Trial lengths not complying shall be removed unless they can be rectified to comply with the specification.

13 (02/16) After satisfactory completion of the trial, the material, plant, equipment and construction methods shall not be changed unless the Contractor lays a further trial length to assess the suitability of the proposed changes or agrees the changes with the Overseeing Organisation.

(02/16) **Surface Finish**

14 (01/20) The surface of the Lower Strength concrete after compaction and finishing and before overlaying shall be free from ridges, loose material, pot holes, ruts or other defects.

### 1031 (02/16) Measurement of Macrotexture Depth – Volumetric Patch Technique

1 (01/20) For repairs and widening of existing concrete pavements only the macrotexture depth of the road surface will be determined using the method described and the equipment specified in BS EN 13036-1.

### 1032 (02/16) Thin Bonded Repairs

#### (02/16) Materials

- 1 (01/20) Cement mortar shall be used for depths less than 20 mm and fine concrete for greater depths. Resin mortar may be used for patch repairs where insufficient time for adequate curing of a cementitious cement mortar exists.
- 2 (02/16) The cements, aggregates, admixtures and water shall comply with Clause 1001. The sand (ie fine aggregate) for mortars or fine concrete shall be within the limits of 0/4 (CP), 0/4 (MP), 0/2 (MP) or 0/2 (F/P) of BS EN 12620. Coarse aggregate for fine concrete shall be (4/10) single sized aggregate complying with BS EN 12620. All aggregates shall have the same thermal properties as the aggregate in the original concrete, and match other properties as closely as possible. Filler and aggregate for resin mortars shall be prepacked in the correct proportions and mixed with the resin all in accordance with the manufacturer's instructions.
- 3 (01/20) The proportions of cement, admixtures, additives to water and aggregates shall be sufficient to provide high early strength mortar or fine concrete or concrete complying with Clauses 1001, 1003 and 1004. For cement mortar the sand (ie fine aggregate) to cement ratio shall not be greater than 3. For resin mortar the sand content shall be in accordance with the manufacturer's requirements in the range between 7 and 11 to 1 of resin. High early strength concrete shall be able to achieve 25 N/mm<sup>2</sup> before opening to traffic. For thin bonded repairs using high early strength concrete, air entrainment is not required.

### 1033 (01/20) Full Depth Repairs

#### (02/16) General

- 1 (01/20) Full depth repairs shall be repairs which will require full depth reinstatement of the concrete slab in accordance with this Clause to the extent instructed by the Overseeing Organisation, repairs may also require reinstatement of sub-base. Full width repairs shall be repairs over the full width of a bay or bays. Part width repairs shall be repairs over part of the width of a bay or bays. A bay shall be that portion of the concrete pavement bounded by adjacent longitudinal and transverse joints.
- 2 (01/20) For continuously reinforced concrete slabs (CRCP or CRCB) the edge of the repair shall be not less than 0.5 m from the nearest crack and not less than 3 m from a transverse construction joint at ground beam anchorages. Where this and the provisions of sub-Clause 3 of this Clause would otherwise require a longitudinal repair joint within 1 m of the existing longitudinal joint or edge, the repair shall be extended to align with that longitudinal joint or edge.
- 3 (01/20) High early strength concrete shall be able to achieve 25 N/mm<sup>2</sup> before opening to traffic. For full depth repairs using high early strength concrete, air entrainment is not required.

#### (02/16) Part Width Repairs

- 4 (01/20) Providing all the following criteria are met, part width repairs may be carried out in accordance with sub-Clause 4 of this Clause:
  - (i) the transverse width of the repair shall not exceed 45% of the width of the slab under repair; and
  - (ii) the longitudinal joint which would be formed by the repair shall not occur within the wheeltrack; and
  - (iii) the minimum transverse width of the repair shall not be less than 1.0 m.

If these criteria and those in sub-Clause 2 of this Clause cannot be met, a full-width repair shall be made in accordance with this Clause.

(02/16) **Full Width Repairs**

- 5** (01/20) For full width repairs the following criteria shall apply unless otherwise specified in contract specific Appendix 7/2:
- (i) Repair lengths which do not replace an existing transverse joint shall be constructed with two transverse contraction joints and the longitudinal joint shall have tie bars in repair lengths which are greater than 1 metre.
  - (ii) Repair lengths which replace a single existing transverse joint shall be constructed with two transverse joints: one expansion and one contraction. The new expansion joint shall be formed at the end which will have the shortest longitudinal distance between this joint and the joint in the adjacent lane(s). The longitudinal joint(s) between the existing joint(s) and the new expansion joint shall be constructed without tie bars and shall have 5 mm thick compressible foam within the joint for the full depth of the concrete slab. The longitudinal joint between the new contraction joint and the joint in the adjacent bay(s) shall be constructed with tie bars where the exposed length so permits.
  - (iii) Repair lengths which replace more than one existing transverse joint shall be constructed with transverse joints to match expansion and contraction joints in the adjacent bay(s). Where the repair length does not replace an existing expansion joint, one end joint shall be formed as an expansion joint. Except for the end joints all transverse joints shall be formed to coincide with the existing transverse joints. Where one end joint is an expansion joint, the longitudinal joint(s) between the existing joint(s) and the new expansion joint shall be constructed without tie bars and shall have 5 mm thick compressible foam within the joint for the full depth of the concrete slab. All other longitudinal joints shall be constructed with tie bars.

(02/16) **Repair Work**

- 6** (01/20) Any replacement dowels and tie bars shall comply with the requirements of Clauses 1011 and 1012 respectively. Epoxy mortar shall be to the manufacturer's recommendation for this specific application.

Where repairs straddle a movement joint with an adjacent slab, tie bars shall be omitted and the joint between the slabs debonded to ensure that movement patterns are not restricted.

(02/16) **Crack Repairs**

- 7** (01/20) Stitched crack repairs shall be either:

Type 1 – Staple Tie Bar Repair

Type 2 – Diagonal Tie Bar Repair

as described in contract specific Appendix 7/2 and compliant with sub-Clauses 7 and 8 of this Clause.

- 8** (01/20) For Type 1 crack repairs, slots 25 – 30 mm wide by 470 mm long at 600 mm centres and at right angles to the line of the crack shall be chased out to a depth such that, when bedded, the tie bars lie between 1/3 and 1/2 of the depth of the slab below the surface.

- 9** (01/20) For Type 2 crack repairs drilling points shall be at a distance from the crack equivalent to the depth of the slab, at 600 mm intervals along the crack with alternate points on opposite sides of the crack.

**1034** (02/16) **Bay Replacement**

- 1** (01/20) Where individual bays are to be replaced they shall match the design thickness of the original concrete including reinforcement if originally included.
- 2** (01/20) The replacement bay shall be connected to the surrounding concrete with new dowel and tie bars at transverse and longitudinal joints in accordance with Clause 1011.
- 3** (01/20) Grooves shall be formed in accordance with Clause 1013.

- 4 (01/20) A surface texture as specified in Clause 1026 shall be applied and a sprayed resin based, aluminized curing compound.
- 5 (01/20) Joints surrounding the new bay shall be sealed specified in Clause 1016.

**1035 to 1038** (01/20) **Not Used**

**1039** (02/16) **Summary of Rates for Sampling and Testing Concrete for Pavement Layers**

- 1 (02/16) Unless otherwise stated in contract specific Appendix 1/5, Table 10/12 summarises the minimum rates of sampling and testing of specimens to the specification.
- 2 (02/16) Samples for testing shall be taken at the point of placing or from the relevant pavement layer.

**TABLE 10/12:** (01/20) **Rates for Sampling and Testing Concrete for Pavement Layers**

Clause	Test	Rate (the greater number shall be used)	
1002	Air content	a) Main slab	1 per 300 m <sup>2</sup> or 6 per day
		b) Slabs less than 300 m <sup>2</sup>	1 per 20 m length or 3 per day
1003	Density	a) Trial length	A minimum of 3 cores at a rate of 1 core per 1000 m <sup>2</sup> sets of 3 cubes for every 400m <sup>2</sup> of concrete laid
		b) Main Slab	
1004	Strength	a) Main slab	3 cubes per 400m <sup>2</sup> not less than 6 sets per day. 1 to be tested at 7 days and 2 at 28 days.
		b) Trial length	At least 9 cubes, 3 to be tested 7 days and 6 at 28 days
1005	Consistence	a) Main Slab – Initial 50 m <sup>3</sup> – Subsequently	3 samples 1 per 150 m <sup>3</sup> or 1 per production day
		b) Slabs less than 150 m <sup>3</sup>	3 samples in the first 50 m <sup>3</sup> then 1 more
1019	Inspection of dowel alignment	a) Main slab	1 joint per 1500 m length or 1 joint per 5 days whichever is the sooner
		b) Slabs less than 1500 m in length	At a rate of one joint for up to each 100 joints
		c) Trial lengths	2 consecutive joints. If one defective, inspect next 3 consecutive joints
1026	Macrottexture depth	Each lane width	One within 100 m of commencement of paving and thereafter at least one set of 10 measurements per day's work.
1030	Lower Strength concrete	As in Clause 1003 and 1004	A minimum of 3 cores at a rate of 1 core per 1000 m <sup>2</sup>
	In situ density		
	Strength	a) Main slab	
		b) Trial length	3 cubes per 600m <sup>2</sup> not less than 6 sets per day At least 6 cubes, half to be tested 7 days and half at 28 days

## 1040 to 1042 (02/16) Not Used

### 1043 (02/16) Foamed Concrete

- 1 (02/16) Foamed concrete used in reinstatements shall comply with the requirements of the “Specification for the Reinstatement of Openings in Highways” issued by the Highway Authorities and Utilities Committee.
- 2 (02/16) Foamed concrete used for backfilling excavations, including trench reinstatement, under road pavements shall have the following compressive strengths:
  - (i) A minimum cube compressive strength of 4 N/mm<sup>2</sup> at an age of 7 days.
  - (ii) A maximum cube compressive strength of 10 N/mm<sup>2</sup> at an age of 7 days.

(The compressive strength shall be determined by testing foamed concrete cubes which have been made in accordance with BS EN 12390-1 except that the foamed concrete shall be placed in the mould without any tamping or vibration other than gently rocking the mould on a firm base. The test cubes shall be cured in accordance with BS EN 12390-2 and tested for compressive strength in accordance with BS EN 12390-3.

- 3 (02/16) All aggregate used in foamed concrete shall pass a 6.3 mm sieve and shall comply with the MP and FP grading limits given in BS EN 12620. Larger size aggregate may be used provided it can be shown to be practicable.
- 4 (02/16) After placing, foamed concrete shall not be tamped, or otherwise compacted.
- 5 (02/16) Reinstatement of the sub-base and base over the foamed concrete shall not be carried out until the foamed concrete has attained sufficient strength to allow compaction of the sub-base and base material.

### 1044 (02/16) Pavements with an Exposed Aggregate Concrete Surface

#### (02/16) General

- 1 (01/20) Pavements with an exposed aggregate concrete surface shall comply with all the requirements of this Series except Clause 1026 and where otherwise specified in this Clause.
- 2 (02/16) The Contractor shall complete contract specific Appendix 10/1 and submit this with his tender documents. If after acceptance the Contractor wishes to change the proposals contained in contract specific Appendix 10/1 this change shall only be with the consent of the Overseeing Organisation.
- 3 (02/16) The concrete slab shall be laid in either a single layer or in two layers as stated in contract specific Appendix 10/1. If laid in two layers the surface layer shall be laid monolithically with the lower layer.
- 4 (02/16) The Contractor shall carry out trials, as specified in sub-Clauses 31 to 39 of this Clause, to demonstrate that the materials, concrete proportions and methods for exposing the aggregate will meet the requirements of this Clause.

#### (02/16) Quality of Concrete in the Slab

- 5 (02/16) The surface layer concrete shall comply with the following requirements:
  - (i) The surface layer shall be not less than 40 mm thick. The coarse aggregate shall comply with the size requirements of contract specific Appendix 7/1.
  - (ii) For 6.3/10 mm coarse aggregate or 4/8 mm coarse aggregate as required in contract specific Appendix 7/1, the amount of aggregate retained on the 10 mm sieve and 8 mm sieve respectively shall not exceed 3% by mass. The aggregate passing the 6.3 mm sieve and 4 mm sieve respectively shall not exceed 10% by mass.
  - (iii) The fine aggregate grading shall comply with the 0/2 (FP) or 0/1 (FP) grading in BS EN 12620 except that not less than 99% of the mass of the material shall pass the 2 mm sieve.

- (iv) The coarse aggregate shall comprise at least 60% by mass of the oven dry constituents of the concrete.
- (v) The polished stone value (PSV) and the aggregate abrasion value (AAV) of the coarse aggregate determined in accordance with BS EN 1097-8 shall be as specified in contract specific Appendix 7/1. The Category of flakiness index of the aggregate is FI15.
- (vi) Hardness and durability of the coarse aggregate shall be as described in sub-Clause 901.2.
- (vii) The type of cement used in the concrete shall be limited to Class 42.5N/42.5R Portland cement CEM I complying with BS EN 197-1. The minimum cement content of the concrete shall be 375 kg/m<sup>3</sup> and the maximum free water/cement ratio shall be 0.40.
- (viii) The air content, density and strength requirements shall be as required in Clauses 1002, 1003 and 1004 respectively.

#### (02/16) General Construction Requirements

6 (02/16) The concrete paving equipment shall comply with contract specific Appendix 10/1 as completed by the Contractor and submitted at Tender stage for approval by the Overseeing Organisation before the work commences. The general construction requirements shall be in accordance with the requirements of this Series except where otherwise stated in this Clause:

- (i) The concrete carriageway paving operation shall be undertaken as not less than a single lane width of construction using either slip-form paving machines or fixed form paving machines.
- (ii) The concrete surface layer shall be fed, spread, compacted, regulated and finished using equipment with elements to obtain the required uniform distribution and bonded embedment of the selected aggregate in the finished road surface.
- (iii) The spread concrete shall be compacted in such a manner that base layer concrete is not drawn into the surfacing and selected aggregate is uniformly present in the finished road surface.
- (iv) The surface layer shall be compacted and shaped to line and level by a combination of either internal vibration and fixed conforming plate or vibrating conforming plate.
- (v) The final regulation of the surface layer shall be provided by a transverse finishing screed in advance of a longitudinal oscillating float in accordance with Clause 1024, travelling across the slab before the application of a retarder complying with BS EN 934-2.

#### (02/16) Finished Surface Requirements

7 (02/16) The finished surface of the pavement shall comply with the requirements of Clause 702. Where a pavement area does not comply with the specification for regularity, surface tolerance, thickness, material properties or compaction or contains surface depressions, the full extent of the surface which does not comply with the specification shall be rectified by cutting out the full depth of the slab. It shall be replaced with a new slab complying with the procedures set out in Clause 1033 to the extent required to obtain compliance with the specification.

#### (02/16) Production of an Exposed Aggregate Surface

8 (02/16) In order to obtain a suitable exposed aggregate surface the main requirement shall be the removal of the surface mortar from the top of the slab to produce an exposed aggregate finish. This objective may be achieved by the application of a suitable cement set retarder which is sprayed on the surface of the fresh concrete immediately after it has been levelled and finished. Retarded mortar shall be removed by wet or dry brushing as stated in contract specific Appendix 10/1, generally no sooner than when the surface concrete has reached a maturity of 16 hours at 20°C or after a suitable interval determined by trial, to achieve the requirements of sub-Clause 27 of this Clause.

(02/16) **Retarder**

9 (02/16) The composition and viscosity of the retarder shall be such that it can be spread at an adequate and uniform rate over the surface of the concrete slab in order to ensure adequate aggregate exposure during the subsequent brushing operation.

10 (02/16) The retarder shall contain a pigment in sufficient quantity to give an even uniform colour after it has been sprayed on to the slab surface. The pigment shall be fully degraded by exposure to ultra-violet light without leaving any residue that is detrimental to the surface of the concrete.

11 (02/16) The chemical composition of the retarder and of the curing compound shall be such that they do not react adversely following the application of the curing compound to the exposed aggregate surface.

12 (02/16) The Contractor shall use the retarder which he has nominated in contract specific Appendix 10/1. This shall be of a type and composition to satisfy the requirements of this Clause.

(02/16) **Application of the Retarder**

13 (02/16) The retarder shall be spread evenly on to the surface of the wet concrete slab as soon as practicable after the surface layer has been levelled and finished, by a spray bar over the full width of the slab in one pass. To achieve this uniformity of spread, the spraying system shall consist of a spray bar, provided with nozzles, mounted on a machine spanning the slab. Temporary works materials and equipment shall be chosen in order to permit inspection to ensure adequate coverage of retarder immediately after spraying and before protection of the surface.

14 (02/16) Before commencing work, the level of the spray bar, the rate of delivery of the retarder from the nozzles of the spray bar, and the forward speed of the spraying machine shall be adjusted to achieve the required rate of spread. Means shall be provided and steps shall be taken to avoid excess retarder flowing on the surface of the slab.

15 (02/16) Back-up spraying equipment shall be available on the site at all times for use in case of a breakdown of the spraying machine.

(02/16) **Protection of the Surface after the Application of the Retarder**

16 (02/16) The finished surface of the pavement concrete after application of retarder shall be protected against precipitation, moisture loss, contamination and dispersal of the retarder by air movements as stated in contract specific Appendix 10/1. This protection shall be applied immediately after the application of the retarder.

17 (02/16) Where waterproof sheeting is used it shall be laid onto the surface of the concrete immediately after the retarder has been sprayed. It shall be retained in position until immediately prior to exposing of the aggregate.

18 (02/16) The protection system shall not adversely affect either the finish, the line or the level of the concrete surface or the even distribution of the retarder in any way. Where sheeting is used, any air bubbling or blistering shall be prevented.

(02/16) **Exposing the Aggregate Surface**

19 (02/16) Brushing equipment shall be used to expose the concrete surface aggregate. Where the brushing equipment runs on the slab the concrete shall have gained sufficient strength to avoid any damage to the concrete.

20 (02/16) Removal of the protection system shall take place as brushing proceeds. If waterproof sheeting is used as a protection system it shall be maintained in position until immediately in advance of the brushing operation.

21 (02/16) The Contractor shall complete the process of exposing the aggregate before the retarder becomes ineffective. Failure to do so shall entail the remedial measures specified in sub-Clauses 29 and 30 of this Clause.

(02/16) **Brushing System**

22 (02/16) Sufficient brushing capability shall always be maintained on site to complete the exposure of the aggregate before the retarder becomes ineffective. An adequate back-up brushing facility shall be available on the site at all times for use in case of a breakdown of the brushing equipment.

**23** (02/16) The brushing equipment nominated by the Contractor in contract specific Appendix 10/1 shall be used to produce an even macrotexture on the surface of the slab. Brushing shall be carried out in the longitudinal direction of the concrete slab.

**24** (02/16) The brushing equipment shall be capable of maintaining an adequate brush rotational speed which in conjunction with the forward working speed is sufficient to remove the surface mortar. Adequate dust suppression and collection measures shall be in operation at all times.

**25** (02/16) When complying with the requirements of sub-Clause 19 of this Clause, the wheels of any brushing equipment which may run on the slab shall be fitted with tyres with a shallow tread pattern and a low inflation pressure and be sufficiently wide to avoid damage to the concrete.

(02/16) **Protection of the Surface Layer After Exposure of the Aggregate**

**26** (02/16) Within one hour of completing exposure of the aggregate the surface shall be dampened with water. A curing compound shall be applied to the entire exposed aggregate surface of the slab in accordance with Clause 1027. In wet weather the curing compound shall be applied as soon as practicable after the rain stops. The surface may, alternatively, be covered by hessian provided it is maintained in a wet condition at all times during the curing period of the concrete.

(02/16) **Surface Macrotexture Depth and Remedial Measures**

**27** (02/16) The texture depth of the surface of the concrete shall be measured using a volumetric patch technique described in BS EN 13036-1. The average macrotexture depth of each 1000 m section of carriageway lane, or each carriageway lane where less than 1000 m, shall comply with the requirements of contract specific Appendix 7/1. Any individual result shall be neither greater than the maximum, nor be less than the minimum value of macrotexture depth stated in contract specific Appendix 7/1.

**28** (02/16) During brushing, initial interim spot check measurements of the surface macrotexture depth shall be made as soon as it is considered that the required texture depth has been reached. This shall continue until the specified macrotexture depth has been achieved.

**29** (02/16) In the event that it is not possible to achieve the specified minimum macrotexture depth by further exposure, the Contractor shall treat the surface in accordance with Clause 1029 to achieve the specified macrotexture depth. This treatment shall not be applied until the concrete has reached an age of 28 days and shall not affect the requirements of sub-Clauses 702.2 to 702.4 and 702.5 to 702.9.

**30** (02/16) Failure to achieve a satisfactory minimum macrotexture depth by mechanical means shall result in removal of the full thickness of the slab to the extent required to permit reconstruction of the slab in accordance with the specification. Where the maximum macrotexture depth is exceeded suitable remedial measures shall be employed.

(02/16) **Preliminary Trials**

**31** (02/16) The Contractor shall carry out preliminary trials to demonstrate to the Overseeing Organisation, not less than one month prior to the commencement of the trial length referred to in sub-Clauses 37 to 39 of this Clause, the materials, concrete proportions and methods for achieving the macrotexture depth requirements defined in contract specific Appendix 7/1.

**32** (02/16) Preliminary trial panels shall be constructed off-line incorporating a top surface of exposed aggregate concrete similar to that specified for the permanent works. These panels shall be 20 m long and not less than 100 mm deep, and the maximum intended paving width. They shall be used to enable the Contractor to determine the required application rate of the retarder and the amount of brushing required to achieve the specified macrotexture depth.

**33** (02/16) The trial panels may alternatively be constructed on-site, but in this case, they may only form part of the permanent works if they meet all the requirements of the specification, otherwise they shall be removed after they have served their purpose.

**34** (02/16) The surface macrotexture depth shall be determined by volumetric patch technique at approximately 2 m spacings along a diagonal line across each trial panel, and shall follow the procedure described in BS EN 13036-1.

**35** (02/16) The average value of each set of 10 individual measurements shall be taken as the resulting macrotexture depth which shall be assessed against the specification.

**36** (02/16) The materials including all the aggregates, plant and equipment used in the preliminary trials shall be equivalent to that which will be used in the Trial Length.

(02/16) **Trial Length**

**37** (02/16) In addition to the requirements of Clause 1028, the macrotexture depth shall be tested for compliance in accordance with sub-Clauses 38 and 39 of this Clause.

**38** (02/16) Macrotexture depth shall be assessed by the volumetric patch technique for each 50 m length of the trial length and for each lane, and shall follow the procedure in BS EN 13036-1.

**39** (02/16) During the construction of the Trial Length, spot checks shall be made as soon as it is considered that the required macrotexture depth has been reached. Should the texture depth be found to be inadequate, further exposure of the aggregate shall be undertaken until the specified macrotexture depth has been achieved. Where the macrotexture depth is not achieved, and the trial was intended to form part of the running surface of the permanent works, the remedial measures described in sub-Clauses 29 and 30 of this Clause shall apply.

**1045** (02/16) **Weather Conditions for Laying of Cementitious Materials**

**1** (01/20) Road pavement materials in a frozen condition shall not be incorporated in the works.

**2** (02/16) Road pavement materials shall not be laid on any surface which is frozen or covered with ice.

**3** (01/20) The temperature of concrete in any pavement layer shall not be less than 5°C at the point of delivery. These materials shall not be laid when the air temperature falls below 3°C and laying shall not be resumed until the rising air temperature reaches 3°C unless all surfaces of the concrete slabs are protected by thermal insulation blankets laid immediately after placing and finishing the concrete. The insulation shall be placed before the temperature of the concrete surface has dropped below 2°C. It shall be retained for a minimum of 3 days or until the concrete is assessed to have reached 50% of the specified characteristic 5 N/mm<sup>2</sup> compressive strength based on testing of samples cured adjacent to the placed concrete provided the air temperature is above 0°C and rising at that time. Thermal insulation blankets shall be closed cell polyethylene foam sheets, minimum 10 mm thick with a 'U' value of 4 watts/m °C (or K value of 0.04 watts/m Kelvin) or suitable material with an equivalent or lower thermal conductivity. They shall be sufficiently robust and capable of being held in place against variations in wind and weather conditions for the necessary curing time.

**1046 to 1047** (02/16) **Not Used**

**1048** (02/16) **Use of Surfaces by Traffic and Construction Plant**

**1** (02/16) 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.

**2** (02/16) Concrete slabs may be used by traffic when the cube compressive strength is assessed to have reached 25 N/mm<sup>2</sup> for pavement surface slabs, or 20 N/mm<sup>2</sup> for bases with asphalt surfacing. The method of assessing the time when this strength is reached shall be as described in Clause 1004.

3 (02/16) In the absence of test data establishing compliance with sub-Clause 2 of this Clause, no vehicle with an axle loading greater than 2 tonnes shall run on concrete slabs within a period of 14 days after placing the concrete. Vehicles with rubber tyres with an axle loading less than 2 tonnes, or wheels or tracks of concreting plant, shall not use any part of a newly constructed pavement within 7 days. The above periods before traffic may run on the pavement shall be increased if the 7 day cube strength is below that required in the specification. These periods shall be extended by one day for each night on which the temperature of the layer falls to 0°C or below.

**1049 to 1050 (01/20) Not Used**

(01/20) **Roller Compacted Concrete Mixtures**

**1051 (01/20) General Requirements for Roller Compacted Mixtures**

1 (01/20) Roller Compacted Concrete (RCC) shall be produced, constructed and tested in accordance with Clauses 1051 to 1060. Unless otherwise specified in Clauses 1051 to 1060 the works shall conform to the requirements of this Series.

2 (01/20) The terms listed below shall apply to the RCC Clauses of this specification:

RCC	Roller Compacted Concrete
FA	fly ash (also known as ‘pulverized fuel ash’)
$G_{vxx}$	volumetric expansion category
IBI	immediate bearing index
Imm <sub>xx</sub>	immersion category
IBI <sub>xx</sub>	immediate bearing index category
LA	Los Angeles coefficient
NR	no requirement
OWC	optimum water content
PTR	Pneumatic tyred roller
$R_c$	compressive strength
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

3 (01/20) The strength class for RCC shall be a minimum mean strength C40/50 in accordance with sub-Clauses 1059.9 to 1059.13.

4 (01/20) RCC shall be tested in accordance with contract specific Appendix 1/5, Clause 1059 and the test methods specified in the following Clauses.

5 (01/20) Before work commences, the Contractor shall submit a statement to the Overseeing Organisation that includes:

- (i) the information detailed in the ‘Designation and Description’ clause of the relevant BS EN Standard for the specified RCC, confirming compliance with the requirements of this Series and contract specific Appendix 7/1;
- (ii) target proportions of constituents, including optimum moisture content;
- (iii) mixture design details and results, in accordance with Clause 1060.
- (iv) Method statement for the trial length and the main works, in accordance with Clause 1056.

## 1052 (01/20) RCC Constituents

### (01/20) Cement and combinations

1 (01/20) The permitted cement and combinations and the required minimum cement content or combination content are listed in Table 10/13. RCC mixture proportions used for production shall be based on a laboratory mixture design procedure in Clause 1060.

**TABLE 10/13: (01/20) Minimum Cement or Combination Content for RCC**

Cement and combinations	Minimum Cement or Combination Content
(a) Portland cement CEM I conforming to BS EN 197-1	270 kg/m <sup>3</sup>
(b) Portland-slag cement CEM II/A-S and CEM II/B-S conforming to BS EN 197-1	270 kg/m <sup>3</sup>
(c) Portland-fly ash cement CEM II/A-V and CEM II/B-V conforming to BS EN 197-1	
(d) Pozzolanic cement CEM IV/A (V) conforming to BS EN 197-1	
See NOTE 1	
(f) A BS 8500-2 combination of Portland cement CEM I conforming to BS EN 197-1 with not more than 35% fly-ash for use as a cementitious component in structural concrete conforming to BS EN 450-1 (SEE NOTE 2)	270 kg/m <sup>3</sup>
NOTE 1:	
CEM II/A-V has a maximum siliceous fly ash content of 20%	
CEM II/B-V has a maximum siliceous fly ash content of 35%	
CEM IV/A (V) has a maximum siliceous fly ash content of 35%	
NOTE 2: Siliceous fly ash conforming to EN 14227-4 may be used where it meets the BS 8500-2:2015 Annex A compressive strength requirements.	

For materials required to comply with BS EN 197-1 and/or BS EN 450-1 the Contractor shall submit the relevant material declarations of performance to the Overseeing Organisation prior to the inclusion of the materials into the works. The declarations of performance shall demonstrate that the materials meet the requirements for the specification.

### (01/20) Aggregates

2 (01/20) The aggregates used in RCC shall comply with BS EN 12522 and have declared values for the requirements listed in Table 10/14. The Contractor shall submit the declaration of performance for the aggregate to the Overseeing Organisation prior to the inclusion of the aggregate in the works. The declaration of performance shall demonstrate that the aggregate meets the requirements for the specification.

**TABLE 10/14: (01/20) Aggregate Requirements for RCC**

Reference	Declared Values for aggregate properties
<b>Crushed or broken particles in coarse and fine aggregate</b>	C100/0 (crushed gravels, manufactured and recycled aggregates are not permitted)
<b>Resistance to fragmentation of coarse aggregate</b>	LA35 or as specified in contract specific Appendix 7/1
<b>Magnesium sulfate</b>	MS <sub>18</sub>
<b>Total sulphur content</b>	S1 (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.)
<b>Acid-soluble sulfate content</b>	AS0.2 (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.)
<b>Fines quality</b>	Aggregate passing 425 µm shall be non-plastic as defined by and tested in compliance with BS 1377-2

### 1053 (01/20) Storage of RCC Constituents

- 1 (01/20) Aggregates shall be stored on a firm and clean substrate avoiding contamination with other constituents.
- 2 (01/20) Cement, and dry FA shall be stored in silos.
- 3 (01/20) Wet (conditioned) to BS EN 450-1 FA shall have no agglomerations greater than 10 mm size.
- 4 (01/20) Wet (conditioned) FA shall be stored at the source or at the production location for at least 72 hours before use, and have a minimum water content of 10%.

### 1054 (01/20) General Requirements for Production and Layer Construction

#### (01/20) Production

- 1 (01/20) RCC shall be produced by the mix-in-plant method using batching by mass, in accordance with Clause 1055. RCC shall be produced in plants which operate a production control quality management system which follows the guidance in BS EN 14227-1 Annex B.

#### (01/20) Layer Construction

- 2 (01/20) Construction of layers and any reworking and reuse shall be completed within the maximum construction period specified of 30 °C hours. The time shall be measured from the addition of binder to completion of compaction.
- 3 (01/20) 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). If the air temperature during the interval, t, fluctuates by more than 4°C, interval t shall be re-calculated.
- 4 (01/20) Mixtures shall be batched by mass and paver laid in a single lift. The mixture must be placed using a paver with a high compaction screed used in accordance with the method demonstrated on the Trial Length. The paver must be capable of attaining the thickness, lines and grades indicated on the plan, and produce consistent compaction and compliance with surface level tolerance.

- 5 (01/20) Laying shall be carried out in a way that avoids segregation and drying of the surface. Curing shall be undertaken in accordance with sub-Clause 1054.19 as soon as practicable, and the curing compound shall be applied prior to drying of the surface.
- 6 (01/20) Compaction of RCC shall be carried out by rollers to achieve the design compaction as demonstrated in the installation trial.
- 7 (01/20) The minimum compacted thickness shall be 150 mm.
- 8 (01/20) Making-up of level after initial compaction is not permitted.
- 9 (01/20) The edge of hardened RCC material shall be vertical and straight before fresh RCC material is laid against it within the permitted construction period in sub-Clauses 1054.2 and 1054.3. To ensure adequate bond between wet joints compaction shall be completed before drying and within the permitted construction period in sub-Clauses 1054.2 and 1054.3.
- 10 (01/20) Compaction of RCC layers by a method proven in the Trial Length (or by previous satisfactory experience on similar projects) to provide the required density and finished profile shall be completed without drying out and before setting of any part of the layer. Testing, controls and checking of RCC shall be carried out in accordance with the requirements in Clause 1059.
- 11 (01/20) On completion of compaction the surface shall be closed, free from ridges, cracks, loose material, visible voids, ruts, shear planes and other defects.
- 12 (01/20) Reworking and re-compaction of the layer to achieve the required surface finish shall only be permitted within the construction period set out in sub-Clauses 1054.2 and 1054.3 and only when the water content requirements of the reworked material are maintained within the limits stated in the method statement. 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 machine laid and compacted. The minimum length of full depth replacement shall be 15m and full width of a traffic lane.
- 13 (01/20) The exposed uncompacted edges of the longitudinal and transverse day joints shall be cut back to a minimum 1.5 times the layer thickness.
- 14 (01/20) Transverse and longitudinal day joints shall be formed before commencing further work by sawing vertically to the full depth.
- 15 (01/20) Unless otherwise specified in contract specific Appendix 7/1, all longitudinal joints shall be formed outside wheel path zones.
- 16 (01/20) Longitudinal day joints shall be subject to density testing procedures 300mm from the edge. The density shall be within 95% of that measured for the relevant test section.
- 17 (01/20) During cold weather:
- (i) the temperature of RCC shall not be less than 5°C at the time of laying;
  - (ii) RCC shall not be laid on a frozen surface;
  - (iii) laying of RCC shall cease when the air temperature falls below 3°C, and laying shall not be resumed until the rising air temperature reaches 3°C.
- 18 (01/20) In the case of heavy or persistent rain, production shall cease and any laid material shall be compacted immediately. The above also applies for light rain that results in any roller pick up and/or ponding of water on the uncompacted RCC.

(01/20) **Curing, Protection and Use of Surfaces by Traffic and Construction Plant**

- 19** (01/20) On completion of compaction the layer shall be cured to prevent loss of water by the following.
- (i) Application of a bitumen emulsion spray complying with Class C40B4, as specified in the National Foreword to BS EN 13808 to produce an even and complete coverage of at least 0.2 kg/m<sup>2</sup> 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 overlying layer.
  - (ii) Application shall be by metered mechanical spraying equipment, spray tanker or spraying device to ensure consistent and adequate cover rate. The machine spread rate shall be calibrated using the method in BS 594987. The spraying equipment used shall not cause permanent deformation in the surface. For small or inaccessible areas, application may be by hand held sprayer.
- 20** (01/20) RCC shall not be trafficked within 7 days of laying unless test specimens made at the time of construction as required in Clause 1059 and cured under the same conditions as the in-situ RCC achieve 20 N/mm<sup>2</sup>.
- 21** (01/20) Should the RCC when trafficked exhibit signs of damage, trafficking shall cease immediately and shall only resume once the layer has gained sufficient stability to resist damage.
- 22** (01/20) Surface contamination shall be avoided as far as is practicable and any unavoidable contamination shall be removed prior to overlaying.

(01/20) **Rectification**

- 23** (01/20) Before overlaying the finished pavement, high spots shall be removed by fine milling, grinding or bump cutting. Milling, grinding or bump cutting shall only be carried out after 7 days or when the material has achieved a strength of 20 N/mm<sup>2</sup>. No visible damage shall be evident to the upper section of the layer. Damage can include delamination, cracking and/or spalling of the surface.
- 24** (01/20) Depressions which exceed the permitted level tolerances under Clause 702 shall be removed and replaced to the full depth of the layer. Any loose material shall be removed and replaced to the full depth of the layer. The minimum length of the full depth replacement shall be 15m and full width of a traffic lane.

(01/20) **Daily Records**

- 25** (01/20) Daily record sheets shall be included in the Health and Safety file at the completion of the works and shall include the following information:
- (i) suppliers' details including name/company name and address;
  - (ii) mixing plant production batch record results (to include: date of production, aggregate content, cement content, added water, time of completion of mixing, vehicle identification);
  - (iii) records that demonstrate that the constructed layer is within the permitted tolerances;
  - (iv) density test measurements;
  - (v) sample and test locations;
  - (vi) site construction period records showing the time(s) of arrival, vehicle identification, time(s) of completion of compaction and time(s) of application of curing membrane;
  - (vii) construction period calculated in accordance with sub-Clauses 1054.2 and 1054.3;
  - (viii) weather records at point of laying.

### 1055 (01/20) Production of Roller Compacted Concrete Mixtures

- 1 (01/20) The RCC shall be produced in a static mixing plant that batches by mass and mixes in a forced-action mixer, to produce a homogenous mixture.
- 2 (01/20) The mixing plant shall have an automated recording and data collection system.
- 3 (01/20) A minimum of two aggregate fractions shall be used each with a separate feed hopper.
- 4 (01/20) RCC shall be transported directly to the point where it is to be laid. RCC shall be protected from the weather during transit and whilst awaiting tipping.
- 5 (01/20) Results of routine compressive strength testing and moisture content of aggregate, during normal production shall be used by the Contractor to make any necessary prudent adjustments to the mix design. The Contractor shall inform the Overseeing Organisation of any changes made to the mix design when the change is implemented.

### 1056 (01/20) Method Statement and Trial Length

#### (01/20) Method Statement

- 1 (01/20) At least 10 days prior to constructing the trial length specified in sub-Clauses 1056.4 to 1056.6 and when a trafficking trial is required sub-Clauses 1056.8 to 1056.10, the Contractor shall provide a full method statement to the Overseeing Organisation. The statement shall detail the operatives, plant, materials and procedures for the construction of the trial length(s) and of the works. The statement shall also include procedures for induced cracking, and the procedures to be applied during inclement weather, plant breakdowns and other unscheduled events.
- 2 (01/20) The method statement shall include the intended mixture proportions with supporting data from trial mix results carried out in accordance with Clause 1060 and/or historic records to justify the proportions.
- 3 (01/20) The method statement shall include a sample record sheet for the submission of the data required by sub-Clause 1054.25

#### (01/20) Trial length

- 4 (01/20) Prior to the commencement of the main works, the Contractor shall construct a trial length of at least 800 m<sup>2</sup> conforming to the submitted method statement. The trial length shall include a longitudinal joint, transverse end-of-day joint and a trafficking trial included should immediate trafficking be required. The trial length may be accepted into the permanent works where the work meets the specified requirements. 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 trial length.
- 5 (01/20) The trial length shall include crack induction at the spacing specified in Clause 1057.1. The effectiveness of the crack induction procedure used shall be checked within 28 days of construction, by recovering four evenly spaced 150 mm diameter cores from the line of the induced cracks and assessing each core for compliance with Clause 1057.1.
- 6 (01/20) The depth of the crack induction shall be measured versus the requirements of Clause 1057.2. Should the average depth of the induced cracks be less than the specified depth, then a further demonstration shall be completed with a revised method to verify compliant full width sections of RCC. Non-compliant sections shall be removed.
- 7 (01/20) The mixture constituents, proportions, laying and compaction plant and construction procedures used for the trial length shall not be changed unless the Contractor lays a further trial length or the changes are agreed by the Overseeing Organisation.
- 8 (01/20) The method statement shall include the proposed method by which the density compliance shall be achieved.

### 1057 (01/20) Induced Cracking of RCC

- 1 (01/20) Transverse cracks shall be induced at 2.5 m longitudinal spacing with a tolerance of  $\pm 300$  mm.
- 2 (01/20) 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 quarter and one third 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 C40, as specified in the National Annexes to BS EN 13808. During final compaction of the mixture, the surface of the groove shall be fully closed throughout its full length. The bitumen in the groove shall be fully encased and remain continuous. The plant and methodology shall be approved as part of the Method Statement and Methodology trial under Clause 1056.
- 3 (01/20) The depth of bitumen emulsion membrane in the compacted layer shall be sufficient to reduce the effective cross-sectional area of the layer by between one quarter and one third, and shall be a minimum depth specified in the method statement based on the requirements of sub-Clause 1057.2. The effectiveness of the procedure shall be checked as part of the trial length as described in Clause 1056.
- 4 (01/20) Longitudinal cracks shall be induced, using the procedure specified in sub-Clause 1057.2, under each lane line and the edge line between the nearside lane and a hard shoulder. A longitudinal induced crack is not required between the nearside lane and a 1 metre hard strip. Unless otherwise specified in contract specific Appendix 7/1, longitudinal joints in all layers shall be situated outside wheel track zones.
- 5 (01/20) Saw cutting of the hardened RCC as an alternative to induced cracking is not permitted.

### 1058 (01/20) Roller Compacted Concrete Mixtures

- 1 (01/20) With the exception of mixture grading RCC mixtures shall comply with BS EN 14227-1, and have binder constituent proportions complying with the requirements of Clause 1052.
- 2 (01/20) Aggregates shall comply with the requirements of Clause 1052 and shall have a grading that complies with a grading envelope in Table 10/15 for a 0/14 or 0/20 aggregate mixture. The aggregate gradings in Table 10/15 exclude the binder constituent proportion.

**Table 10/15: (01/20) Aggregate Grading for RCC Mixtures (Excluding binders)**

Sieve mm	Percentage passing by mass					
	minimum	0/14	maximum	minimum	0/20	maximum
31.5	100		100	100		100
20	100		100	90		100
14	86		100	78		94
10	72		95	62		86
8	68		90	56		80
4	52		74	38		59
2	41		61	28		48
1	30		50	19		39
0.5	20		37	15		31
0.25	11		26	9		23
0.125	6		15	6		15
0.063	2		10	2		10

- 3 (01/20) The mixture 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 1060.
- 4 (01/20) The method of construction shall be in accordance with Clause 1054.
- 5 (01/20) The laboratory performance of the mix shall comply with the requirement of contract specific Appendix 7/1, when sampled and tested in accordance with Clause 1059.

### 1059 (01/20) Testing, Control and Checking of RCC

#### (01/20) General

1 (01/20) Tests, controls and checks shall be carried out in accordance with the requirements in Table 10/16 and the following sub-Clauses at locations stated in contract specific Appendix 1/5. Testing shall be carried out in compliance with the requirements of Clause 1055 and be undertaken by an organisation accredited in accordance with BS EN ISO/IEC 17025 for the test method.

#### (01/20) Sampling

2 (01/20) Sampling shall be in accordance with BS 1924-1. Where a bulk sample of RCC 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.

#### (01/20) Measurement of In-situ Wet Density

- 3 (01/20) With the exception of a trial length the normal method for determining density shall be by non-destructive methods.
- 4 (01/20) A correlation shall be established for each mix and each measuring device from the trial length.
- 5 (01/20) The density shall be measured routinely at a distance of 0.8 to 1.2m from the edge of the slab if a spot measurement process is chosen with a minimum frequency of one reading per laid area of 1000 m<sup>2</sup>.
- 6 (01/20) Density measurements shall be taken at the locations at which material is placed that has been sampled for cube testing.
- 7 (01/20) The average in-situ wet density of an area 1000 m<sup>2</sup> specified in sub-Clause 1059.6 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.
- 8 (01/20) The result of each single determination of in-situ wet density shall be not less than 92% of the wet density of the RCC cube made with the sample from the same location.

#### (01/20) Laboratory Mechanical Performance

- 9 (01/20) A bulk sample of RCC shall be taken from each location specified for the determination of in-situ wet density, as sub-Clause 1059.5
- 10 (01/20) For conformity assessment the 28 day strength shall be determined in accordance with BS EN 13286-41 on specimens made from each bulk sample in accordance with BS EN 13286-51, using vibratory compaction. The minimum-mean average strength of RCC shall be C40/50, which shall be
- 40 MPa as determined from 150mm diameter 2:1 cylinder specimens, or
  - 50 MPa where determined for either 150mm cubes or 150mm diameter 1:1 cylinder
- 11 (01/20) The requirement specified in contract specific Appendix 7/1 shall be deemed to be satisfied if the average compressive strength of the group of specimens is equal to or greater than C40/50 and no individual test result is less than C27/34N/mm<sup>2</sup>.

**TABLE 10/16: (01/20) Requirements for Testing, Control and Checking of RCC**

Test/control/check	Test frequency	Test reference
Constituents	<p>Aggregates – BS EN 13242 Declaration of performance to be submitted for each aggregate used prior to the commencement of RCC work.</p> <p>Cement – Declaration of performance to be submitted prior to the commencement of RCC work.</p> <p>Slag – Certificates to be provided weekly to confirm the declared values required by BS EN 14227-2, Clause 5.</p> <p>Fly ash – Certificates to be provided weekly to confirm compliance with the requirements of BS EN 14227-4.</p> <p>Other constituents (that do not fall under the scope of the Construction Products Regulation) – certificates to be provided weekly to confirm compliance with the specification agreed as part of the factory production control system for the mixture.</p>	–
Batching records for 'mix-in-plant' method of construction using batching by mass	Continuously using the automated surveillance and data collection system	–
Aggregate grading	Not less than 2 per day	BS EN 933-1
Water content at final compaction	Not less than 2 per day	BS 1924-2, Clause 1.3
In-situ wet density	1 per 1000 m <sup>2</sup> or part thereof laid each day (measured at the locations detailed in sub-Clause 1059.5)	Sub-Clause 1059.5
Laboratory mechanical performance	1 per 1000 m <sup>2</sup> or part thereof laid each day (with test specimens prepared from a bulk sample taken from each of the locations detailed in sub-Clause 1059.5)	As required by Table 10/17
Strength after immersion in water	Laboratory mixture design procedure	Sub-Clause 1060.7

**Table 10/17: (01/20) Laboratory Mechanical Performance Testing Requirements for RCC**

Clause	Mixture	Curing regime	Curing temperature	Test method	Age at test
1059.5	RCC	BS EN 12390 Water at 20°C	20°C	R <sub>c</sub> – BS EN 13286-41	28 days or other age agreed by the Overseeing Organisation (see Note)

**NOTE:**

For site control purposes, RCC 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** (01/20) Compliance of the area specified in sub-Clause 1059.5 shall be assessed using the results for test specimens that are cured and tested in accordance with Table 10/17 using compression testing to the class of mechanical performance specified in contract specific Appendix 7/1.

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

**1060 (01/20) Laboratory Mixture Design Procedure**

**1** (01/20) 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 RCC, based on the mixture design procedure described in this Clause.

**2** (01/20) The mixture design procedure shall determine the properties of the RCC at a minimum of 3 values of binder contents, and a minimum of 2 values of water content for each value of binder content.

**3** (01/20) The optimum water content (owc) and maximum bulk density of the mixture shall be determined using the vibrating hammer method detailed in BS EN 13286-4.

**4** (01/20) RCC mixtures shall be classified in accordance with BS EN 14227-1 by compressive strength with specimens manufactured in accordance with EN 13286-41, at the age of 28 days.

**5** (01/20) In order to establish strength development characteristics, compressive strength shall be reported at 7 and 28 days.

**6** (01/20) The strength after immersion in water shall be assessed in accordance with sub-Clause 1060.7. The test temperature shall be  $(20 \pm 2)$  °C.

**(01/20) Resistance to Water – Strength After Immersion**

**7** (01/20) 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 a sealed condition for 28 days at the same test temperature; and then removed from their moulds and immersed in aerated water for 14 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.

**8** (01/20) The test temperature shall be  $(20 \pm 2)$  °C.