SERIES 1000
ROAD PAVEMENTS - CONCRETE AND CEMENT BOUND MATERIALS

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ROAD PAVEMENTS - CONCRETE AND CEMENT BOUND MATERIALS

1001 (11/03) Strength Classes of Concrete and Constituent Materials for Pavement Layers

1 (11/04) 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 Appendix 7/1.

2 (11/04) Unless otherwise specified in Appendix 7/1 concrete shall conform with the requirements of draft prEN 13877-2:January 2002 and the requirements of this Series. The constituents of the concrete shall conform with BS EN 206-1 and BS 8500-1 and BS 8500-2 and draft prEN 13877-1:October 2003 and the requirements of this Series.

TABLE 10/1: (11/04) **Pavement Layers - Concrete Strength Classes**

Pavement Layer	BS EN 206-1, BS 8500-2, draft prEN 13877-2:January 2002			BS 8500-1 draft prEN 13877-1: October 2003	Clause
	Designed Concrete	Standardised Prescribed Concrete	Designated Concrete		
(i) Surface slabs: Unreinforced concrete (URC) Jointed reinforced concrete (JRC) Continuously reinforced concrete pavement (CRCP)	CC37			C32/40	))) 1001 to) 1034 and) 1044
(ii) Continuously reinforced concrete roadbase (CRCR)	CC37			C32/40	))
(iii) CRCP and CRCR ground beam anchorages	*			C25/30	)
(iv) Wet lean concrete 4) For bases or	CC18.5	ST4	GEN 3	C16/20	)
(v) Wet lean concrete 3) sub-bases	CC14	ST3	GEN 2	C12/15	) 1030
(vi) Wet lean concrete 2) as required in	CC9	ST2	GEN 1	C8/10	)
(vii) Wet lean concrete 1) Appendix 7/1	CC7	ST1	GEN 0	C6/8	)

NOTE: * Cores shall not be taken from ground beam anchorages

Cement

3 (05/01) The general term 'cement' in this Series means any of the materials in (i) or the combinations in (ii) below:

(i) (05/02) Cements — Complying with:

- (a) Portland cement CEM I — BS EN 197-1
- (b) Portland-slag cement CEM II/A-S and CEM II/B-S — BS EN 197-1
- (c) Blastfurnace cement CEM III/A and CEM III/B — BS EN 197-1
- (d) Portland-fly ash cement CEM II/A-V and CEM II/B-V — BS EN 197-1
- (e) Pozzolanic cement CEM IV/A — 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 6699
- (b) (11/04) Portland cement CEM I with pulverised-fuel ash (pfa) for use as a cementitious component in structural concrete — BS EN 197-1; BS 3892 Part 1

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Alternatively, in concrete class C16/20 and below, the pfa may be in accordance with BS 3892-2

(c) Portland cement CEM I with pozzolanic additive having a current BBA Certificate BS EN 197-1

(iii) (11/03) 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^3, and for < 20mm maximum size add 40 kg/m^3.

(iv) (11/03) When used, the proportion of silica fume to CEM I shall be 10 ± 1%.

TABLE 10/2: (11/04) **Minimum Cement or Combination Contents with 40 mm Maximum Aggregate**

Class (BS 8500-1) **Class (draft prEN 13877-2:January 2002)** **Cement**	**C32/40** **CC37**	**C32/40** **CC37** **in at least the top 50 mm of surface slabs**	**C25/30** **CC28**	**C16/20** **CC18.5**	**C12/15** **CC14**	**C8/10** **CC9**	**C6/8** **CC7**
Min. Portland cement CEM I, BS EN 197-1 (kg/m^3)	320	320	280	(a) or 180	(a) or 160	(b) or 130	(b) or 120
Min. other cements or combinations permitted in sub-Clauses 3(i) and 3(ii) (kg/m^3)	340	340	300	(a) or 180	(a) or 160	(b) or 130	(b) or 120
For mixtures pre-blended or mixed on site							
Maximum proportion of ggbs (%)	50	35	65	65	65	65	65
Max/min. proportion of pfa (%)	35/15	25/15	35/15	35/15	50/0	50/0	50/0
Min. CEM I content (kg/m^3)	220	255	200	160	-	-	-

NOTES: (a) denotes maximum aggregate/cement ratio of 14:1 by mass.
(b) denotes maximum aggregate/cement ratio of 18:1 by mass.

Water

4 (11/03) 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 CC37, CC28, C32/40 and C25/30 and 0.60 for strength classes CC18.5, CC14, C16/20 and C12/15. The requirements for standardised prescribed concrete shall be in accordance with BS EN 206-1 and BS 8500-2.

Admixtures

5 (11/03) An air-entraining admixture complying with BS EN 934-2 shall be used in concrete in at least the top 50 mm of surface slabs 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) (05/01) for surface slabs of pavements which are to be overlaid by a 30 mm minimum thickness thin surface course system complying with Clause 942, air entraining shall not be required.

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

Aggregate

6 (11/04) Aggregates for all pavement concrete, including wet lean, 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_{50} or FI_{35} for concrete of classes CC18.5 to CC32 and over class CC32, respectively. PFA when used as part of the aggregate shall comply with BS 3892: Part 2 or 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) (11/04) the resistance to freezing and thawing complies with BS EN 12620 clause 5.7.1 for pavement and wet lean concrete;

and

(ii) (11/04) the resistance to fragmentation complies with category LA_{35} of BS EN 12620 clause 5.2 for concrete surface slabs and LA_{40} of BS EN 12620, clause 5.2 for concrete bases and wet lean concrete;

or

(iii) (11/03) evidence can be provided to the Overseeing Organisation of satisfactory use of aggregate from the source.

The water absorption (WA) of the coarse aggregate from the source determined in accordance with BS EN 1097-2 shall also be declared. Where recycled coarse aggregate or recycled concrete aggregate is used in this Series, they shall comply with the limits specified in Table 2 of BS 8500-2 and it shall have been tested in accordance with Clause 710.

7 (11/03) 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 (11/03) Sand (i.e. fine aggregate) containing more than 25% by mass of acid-soluble material as determined in accordance with BS EN 196-21 and BRE Special Digest 1, Part 2, Appendix 3, 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 (11/03) 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.

Tests shall be carried out on three samples taken at random from the source prior to use. Tests shall also be carried out during stockpiling or paving, once a week, or at a lesser rate when authorised by the Overseeing Organisation.

Source of Recycled Aggregates

10 (05/01) 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.

11 (05/01) In order to detect substances and chemicals harmful to the durability of concrete, appropriate tests based on current relevant advice shall be carried out on recycled coarse aggregate and recycled concrete aggregate, and the results reported to the Overseeing Organisation.

Chloride Content

12 (11/03) The chloride ion content of the aggregate to be used in concrete with embedded metal shall be determined in accordance with the Volhard reference method in BS EN 1744-1, or in the case of recycled coarse aggregate or recycled concrete aggregate in accordance with BS 1881: Part 124, and shall be as stated in BS EN 206-1. The chloride class of reinforced concrete or concrete containing embedded metal shall be Cl 0,40 and unreinforced concrete shall be class Cl 1,0.

Chemical Requirement

13 (11/04) **Acid-soluble sulfate**

Acid-soluble sulfate content of the aggregates and filler aggregates for concrete pavements, including wet lean, shall comply with BS EN 12620, clause 6.3.1 and shall be Category $AS_{1,0}$ for air-cooled blast furnace slag and for other aggregates Category $AS_{0,2}$.

14 (11/04) **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 Air Content

1 (11/03) The concrete shall meet the requirement for exposure class XF4 in BS EN 206-1. 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:

(11/03) **Table 10/3: Minimum air contents**

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

2 (11/03) 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 m² 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 m² 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 206-1 the Contractor shall remove the concrete from the Works.

3 (11/03) 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 206-1, to ensure uniform distribution of the agent throughout the batch during mixing.

1003 Density

1 (11/03) 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.

2 (11/03) The density of the concrete pavement shall be determined in accordance with draft prEN 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.

3 (11/03) The core shall have an average diameter of at least four times the nominal maximum aggregate size, and in any case at least 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.

4 (11/04) Cores shall be taken at the rate given in Clause 1028 for trial bays and according to Category 2 in Table 7 of draft prEN 13877-2:January 2002 for the main slab. 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.

5 (11/03) In calculating the density, allowance shall be made for any steel in the cores.

6 (11/03) 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 (11/03) Pavement Concrete Strength

1 (11/04) 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 draft prEN 13877-2:January 2002 on cores cut from the full depth of the slab. No correction for maturity shall be applied to the 7 day or 28 day strength.

2 (11/04) Concrete cores of the appropriate size shall be taken, cured and tested in accordance with BS EN 12504-1 with the exception that the core shall be cured under water at 20°C ±2°C from as soon as practically possible. The sampling rate shall be as designated in draft prEN 13877-2:January 2002 for Category 2, three cores shall be taken from areas of concrete of up to 3000 m² and one additional core for every further 1000 m² of concrete laid.

3 (11/03) An exception to the above sampling rate is that in the trial slab at least six cores shall be taken, three to be tested at 7 days and three at 28 days.

4 (11/03) 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.

5 (11/03) If during the construction of the trial length the average corrected core compressive strength, from the three cores, falls below the 7 day corrected core compressive strength given in Table 10/4. Then either the cement content of the concrete shall be increased by 5% by mass, or, a further trial slab shall be constructed using an improved compaction technique and/or an increased cement content. The increased cement content shall be maintained at least until the three corresponding 28-day core strength tests have been assessed. If the cement content is increased, the concrete shall be adjusted to maintain the required consistence.

TABLE 10/4: (11/03) **7 Day Corrected Core Compressive Strengths**

Class of concrete	CEM I concretes N/mm²	CEM I with pfa or ggbs concretes N/mm²
CC37	32	26.5
CC28	25	20
CC18.5	16.5	13
CC14	12	10
CC9	7.5	6.5
CC7	5	4

6 (11/04) Overlapping groups of four consecutive 28 day corrected core strengths shall be used for assessing the pavement for compliance with the criteria in Table A.1 of draft prEN 13877-2:January 2002. The pavement shall be accepted if both the criteria in Table A.1 are satisfied for four results derived from strength tests on cores taken from the constructed pavement. Conformity control of the concrete will be the responsibility of Contractor.

7 (11/04) For small jobs constructed to draft prEN 13877-1:October 2003 cubes shall be used for compliance.

8 (11/03) To assess the time for use of a concrete slab by traffic, the strength development rate may be predetermined by cubes stored at 20°C made from trial concrete mixes and maturity meters placed in the pavement. Alternatively pairs of cubes may be made for each 600 m² 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 Appendix 7/1. Tests for compliance with the specified strength shall be made in the normal way.

1005 (11/03) Consistence (Workability)

1 (11/03) 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 12 of BS EN 206-1. 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 206-1.

2 (11/03) 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 (11/03) Not Used

1007 (05/01) Separation and Waterproof Membranes

1 A separation membrane shall be used between jointed reinforced concrete surface slabs or unreinforced concrete surface slabs and the sub-base.

2 Separation membranes shall be impermeable plastic sheeting 125 microns thick laid flat without creases. Where an overlap of plastic sheets is necessary, this shall be at least 300 mm. There shall be no standing water on or under the membrane when the concrete is placed upon it.

3 Under CRCP and CRCR a waterproof membrane shall be provided, which shall be a bituminous spray in accordance with Clause 920 before concreting. Where a bituminous spray has been used to cure cement-bound material or wet lean concrete then only those areas, which have been damaged, shall be resprayed after making good.

1008 Steel Reinforcement

General

1 Reinforcement shall comply with any of the following standards and be in prefabricated sheets or cages, or bars assembled on site and shall be free from oil, dirt, loose rust and scale:

(i) (Carbon steel bars for the reinforcement of concrete) BS 4449.

(ii) (Cold-reduced steel wire for the reinforcement of concrete) BS 4482.

(iii) (Steel fabric for the reinforcement of concrete) BS 4483.

2 When deformed bars are used they shall conform to Type 2 bond classification of BS 4449.

3 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 CRCR), 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. Alternatively the reinforcement may be butt welded in accordance with Clause 1717.

4 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 (05/01) If the reinforcement is positioned prior to concreting, it shall be fixed on supports 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 Alternatively, when a reinforced concrete slab (JRC, CRCP or CRCR) 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 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.

Jointed Reinforced Concrete Slabs

8 The reinforcement shall be so placed that after compaction of the concrete, the cover below the finished surface of the slab is 50 ± 10 mm for slabs less than 200 mm thick, 60 ± 10 mm for slabs 200 mm or more but less than 270 mm thick, 70 ± 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 ± 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 mm ± 50 mm from any transverse joint, excluding emergency construction joints.

Continuously Reinforced Concrete Slabs (CRCP or CRCR)

9 The reinforcement shall be Grade 460 deformed steel bars with the diameters and spacings as described in Appendix 7/1.

10 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 (05/01) 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 ±25 mm. No longitudinal bar shall lie within 100 mm of a longitudinal joint. In reinforcement assembled on site, 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 ± 25 mm from the edges of the slab and longitudinal joints where tie bars as in Clause 1012 are used.

1009 Transverse Joints

General

1 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 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 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 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 ± 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 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 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 Transverse joints shall have a sealing groove which shall be sealed in compliance with Clause 1016.

Contraction Joints

7 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.

Expansion Joints

8 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 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.

Warping Joints

10 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.

Construction Joints

11 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 Emergency joints in unreinforced concrete slabs shall be contraction joints not less than 2.5 m from the preceding or succeeding joint position.

13 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.

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14 Construction joints in continuously reinforced concrete slabs (CRCP and CRCR) 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 Longitudinal Joints

General

1 (05/02) 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 CRCR between lanes or at the centre of lanes, within a tolerance of ± 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 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 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 ± 13 mm;

(ii) the joint groove shall be located vertically above the bottom crack inducers within a horizontal tolerance of ± 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 Sawn longitudinal joints shall consist of joint grooves complying with Clause 1013.

5 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.

Longitudinal Construction Joints

6 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 roadbases. Where the edge of the concrete slab is damaged it shall be made good before the adjacent slab is constructed.

1011 Dowel Bars

1 (11/03) Dowel bars shall be Grade 250 steel complying with BS 4449 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 or cropped cleanly with no protrusions outside the normal diameter of the bar. The dimensions of the dowel bars shall comply with draft prEN 13877-3 (October 2002). For expansion joints, dowel bars shall be 25 mm diameter at 300 mm spacing, 600 mm long for slabs up to 239 mm thick and 32 mm diameter for slabs 240 mm thick or more. For contraction joints, dowels shall be 25 mm diameter at 300 mm spacing 500 mm long.

2 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 Dowel bars shall be positioned at mid-depth from the surface level of the slab ± 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:

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(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 ± 3 mm per 300 mm length of bar;

(b) two thirds of the bars shall be within ± 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 Cradles supporting dowel bars shall not extend across the line of the joint.

5 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 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 (11/03) 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) (11/03) 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 12390-1. 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 0.14 N/mm².

8 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 Tie Bars

1 (11/03) Tie bars in transverse or longitudinal joints shall be Grade 250 steel or Grade 460 deformed steel bars complying with BS 4449, in accordance with the requirements given below and Table 10/5. Deformed

bars shall have Type 2 bond classification. Tie bars shall be free from oil, dirt, loose rust and scale. Tie bars which are to be cranked and later straightened shall be Grade 250.

2 (11/03) Tie bars for use across joints shall have corrosion protection in the form of a flexible polymeric corrosion resistant coating, bonded centrally onto 150 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 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 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 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 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 ± 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 (11/03) 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 ± 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: (11/03) **Tie Bar Details**

Joints	Diameter mm	Grade of Steel	Length mm	Spacing mm
Transverse construction joints in continuously reinforced concrete	As for main reinforcement	460	1500	Twice the spacing of main reinforcement
Emergency construction joints in jointed reinforced concrete slabs other than at contraction or expansion joints	12	250 or 460 deformed	1000 750	600 600
Warping joints	12	250 or 460 deformed	1000 750	300 600
Longitudinal All joints, except where Transverse reinforcement is permitted in lieu	12	250 or 460 deformed	1000 750	600 600
	or 16	460 deformed	600	600
	or 20	460 deformed	500	600
Transition from rigid to flexible construction	20	460 deformed	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 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 Joint Grooves

General

1 Transverse contraction or warping joint grooves shall be sawn in the hardened concrete.

2 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.

Sawn Transverse and Longitudinal Joint Grooves

3 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.

Wet-formed Longitudinal Joint Grooves

4 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.

Construction Joint Grooves in Surface Slabs

5 (11/03) 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 Groove Formers and Bottom Crack Inducers

General

1 Except where joint grooves are sawn, a bottom crack inducer shall be provided at each longitudinal joint position.

2 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 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.

Longitudinal Joints

4 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^3, 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.

CRCP Universal Beam Anchorage Transverse Joint

5 (05/01) 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 Joint Filler Board

1 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 ± 1.5 mm. It shall be a self-expanding cork seal or a firm compressible material or a bonded combination of compressible and rigid materials of sufficient rigidity to

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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 (11/03) 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 ± 2.5 mm, shall be placed in a ventilated drying oven maintained at a temperature of 55°C ± 5°C for 7 days, after which they shall immediately be immersed in water at room temperature of between 16°C and 21°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°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°C to 38°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) (11/03) Two of the specimens which pass the weathering test, and two new specimens, each trimmed to 100 mm square ± 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 mm², 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 0.07 N/mm² nor more than 10 N/mm² for material to be used in pavements and not less than 0.07 N/mm² and not more than 0.4 N/mm² 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 ± 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.

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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.

(iv) Immersion Test for Cork Filler Board

(a) Two specimens each 115 mm x 115 mm ± 2.5 mm shall be prepared and the thickness of each specimen shall be determined to the nearest 25 microns before the specimens are immersed in boiling water for one hour. After removal from the water the specimens shall be allowed to cool to room temperature and after 15 minutes at this temperature their thickness shall be remeasured to the nearest 25 microns.

(b) The material shall be deemed to have passed the test if both specimens have a thickness of not less than 140% of their thickness before immersion.

(v) Acid Test for Cork Filler Board

(a) Two specimens each 115 mm x 115 mm ± 2.5 mm shall be immersed in hydrochloric acid of a specific gravity of 1.18 at room temperature which is then brought to the boil and maintained thus for one hour when the specimens shall be removed and rinsed in water.

(b) The material shall be deemed to have passed the test when, after examination, the specimens show no evidence of serious disintegration, friability or lack of resilience. Discolouration or minor swelling shall not be considered as failure.

1016 Preparation and Sealing of Joint Grooves

General

1 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.

Preparation of Joint Grooves for Sealing

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

3 (11/03) 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 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° 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° 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 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/mm². When compression seals are used, the sides of the groove may be ground or wire brushed.

6 (11/03) 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 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 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: (11/03) **Dimensions of Applied Joint Seals**

Type and Spacing of Joints (m)	Minimum Width	Minimum Depth of Seal (Note 1)		Impregnated Foam Compression Strips	Depth of Seal Below the Concrete Surface
		Cold Applied	Hot Applied		
	mm	mm	mm	mm	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.

Sealing with Applied Sealants

9 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 Hot-applied sealants shall be heated in and applied from a thermostatically controlled, indirectly heated dispenser with a recirculating pump. The sealant shall not be heated to a temperature higher than the safe heating temperature nor for a period longer than the safe heating period, both as specified by the manufacturer. The dispenser shall be cleaned out at the end of each day and reheated material shall not be used.

11 (11/03) The components of cold-applied sealants shall be thoroughly mixed in the correct proportions in accordance with the manufacturer's instructions using an automatic metering and mixing dispenser or, for hand application, using a power operated paddle mixer for sufficient time to produce a homogenous concrete without entrapped air. 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.

Testing of Applied Sealants

12 (11/03) Test certificates shall be supplied from an appropriate organisation accredited in accordance with sub-Clauses 105.3 and 105.4 for testing sealants stating that the sealant complies with the relevant standard in Clause 1017. Site testing of cold-applied sealants shall be in accordance with BS 5212 : Part 2. Site testing of hot applied sealants shall be in accordance with BS 2499 : Part 2. Samples of hot applied sealants shall be taken and tested for initial penetration and resilience in accordance with clauses 8 and 23 respectively of BS 2499 : Part 3 : 1993 and shall comply with the requirements of BS 2499 : Part 1.

Sealing with Compression Seals

13 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 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 Joint Seals

1 (05/01) Joint seals shall consist of hot or cold applied sealants or compression seals or self expanding cork seals complying with this Clause. The colour of the joint seal material shall comply with the requirements of Appendix 7/2.

Hot-applied Sealants

2 Hot-applied sealants shall be Type N1 or Type F1 complying with BS 2499.

3 For joints between concrete surface slabs and bituminous surfacing, hot applied Type N1 sealants complying with BS 2499 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.

Cold-applied Sealants

4 Cold-applied sealants shall be Type N complying with BS 5212 : Part 1 except that Type F shall be used for lay-bys and hardstandings.

5 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.

Compression Seals

6 (11/03) Compression seals shall be pre-compressed neoprene impregnated expanding foam sealing strip having a current BBA certificate or rubber seals made of polychloroprene elastomers complying with BS 2752 and conforming with the requirements of ASTM Standard D2628-91 (1998). 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 (1998) 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 fuels and heat ageing when tested in accordance with BS 4443 : Part 4, Method 10 and BS EN ISO 2440 respectively. 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 903 : Part A16 or BS ISO 1817, the volume change shall not be greater than 5%.

7 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.

Self Expanding Cork Seal

8 Cork seals may be used in longitudinal joints, joints for manhole and gully slabs and for transverse joints in short lengths of individual slabs or for replaced slabs.

9 Self expanding cork seal for concrete pavements shall comply with the requirements of the Department

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of Housing and Construction, Commonwealth of Australia, Standard Specification RA SS 106 "Preformed Self Expanding Cork Joint Sealer" when tested in accordance with the same authority's Method of Test MT RA 100 - Tests for Preformed Self Expanding Cork Joint Sealer. The self expanding cork seal shall be stored dry in the manufacturer's wrapping until required for use.

10 Bonding seals to an existing slab shall be carried out up to 100 m in advance of the paver.

11 Individual lengths of cork seal may be joined using scarf joints. A contact adhesive approved by the supplier of the cork seal shall be used to secure the joint.

12 Following the completion of the finishing by machine the top of the cork seal shall be exposed. The protective tape on the top edge of the cork seal shall be removed as soon as possible after the concrete has hardened, normally within 24 hours.

1018 Joints at Manhole and Gully Slabs

1 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 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 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 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 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 (11/03) Reinforcement as shown on the Drawings shall be placed in the gully or manhole slab and concrete Class C32/C40 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 A sealing groove shall be made directly above the joint filler board and sealed in compliance with Clause 1016.

1019 Inspection of Dowel Bars

1 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 (05/01) 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.

3 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 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.

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1020 Side Forms, Rails and Guide Wires

Side Forms and Rails

1 All side forms and rails shall be made of steel 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 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 (11/03) 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 ± 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 ± 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 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.

Guide Wires

5 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 ± 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 ± 10 mm.

6 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 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 (11/03) Not Used

1022 (11/03) Not Used

1023 Transport and Delivery

1 (11/03) 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 Construction by Machine

1 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 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 50 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.

Construction by Fixed Form Paving Machines

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

4 (11/03) 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

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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.

5 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 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 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 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 (11/02) 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 CRCR 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 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 A minimum length of 500 mm of longitudinal oscillating float shall be within the length of the machine tracks or wheels.

12 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.

Construction by Slip-form Paving Machine

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

14 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 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 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 Slipform 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 Except for CRCR 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 slipform paver or alternatively it shall be attached to a slipform 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 (11/02) 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 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.

TABLE 10/7: (11/03) **Maximum Working Times**

Temperature of concrete at discharge from the delivery vehicle	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	3 hours	half hour	3 hours	1.5 hours
Exceeding 25°C but not exceeding 30°C	2 hours	half hour	2 hours	1 hour
Exceeding 30°C	Unacceptable for paving	-	Unacceptable for paving	-

General

21 (11/04) While the concrete is still plastic its surface shall be brushed to comply with the macrotexture requirements specified in Clause 1026. The surface and edges of surface slabs and CRC roadbases shall be cured in compliance with Clause 1027. Wet lean concrete bases and subbases shall be cured in compliance with Clause 1030.

22 (11/03) 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.

23 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 Construction by Small Paving Machines or Hand Guided Methods

1 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 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.

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2 The concrete shall be spread uniformly without segregation or varying degrees 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 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 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 (11/02) 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 The surface shall be brush-textured as described in Clause 1026.

7 (11/03) The surface shall be cured in compliance with Clause 1027, within the time to completion given in Table 10/7.

1026 Finished Surface Requirements

(11/02) Macrotexture of Running Surfaces

1 (05/01) 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.

2 (11/03) 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.

3 (11/02) 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.

4 (11/03) Macrotexture depths shall be as required in Table 10/8.

5 (11/03) 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: (11/03) **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
(ii) Not later than 6 weeks before the road is opened to public traffic	An average of 10 measurements	1.00	+0.25 -0.35

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(05/02) **Texture of Concrete Bases**

6 (05/02) The surface of wet-laid concrete bases shall be roughened before the application of any curing compound by brushing with a wire brush or stiff broom.

1027 Curing

1 (05/01) Immediately after the surface treatment described in Clause 1026, the surface and exposed edges of surface slabs shall be cured for a minimum period of 7 days, by the application of an approved resin based aluminised curing compound, or polythene sheeting or an approved 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 which is compatible with the bond coat specified on the British Board of Agrément HAPAS Roads and Bridges Certificate for the thin surfacing.

2 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 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 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 1/m². 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 1/m². The rate of spread shall be checked during construction of each trial length and for each 1000 m² of treated slab.

5 The mechanical sprayer shall incorporate an efficient mechanical device for continuous agitation and mixing of the compound in its container during spraying.

6 (11/04) Continuously reinforced concrete roadbases 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/m² to 0.55 l/m².

7 (05/01) To achieve high early strength for early use by vehicles, insulation blankets as described in Clause 1045 shall be used for accelerated curing.

1028 Trial Length

General

1 (11/03) Except in rapid construction projects and unless otherwise described in Appendix 7/1, at least three months prior to the construction of the trial length of surface slabs or CRCR the Contractor shall submit a detailed description of the proposed constituent materials, concrete proportions, plant, equipment and construction methods. 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 (11/03) Unless otherwise described in 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 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 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 CRCR.

Assessment

5 (11/03) The trial length shall comply for strength and density with the Specification in all respects, with the following additions and exceptions:

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.

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) (11/03) 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 Appendix 7/1.

(v) (11/03) 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.

Position of Reinforcement and Tie Bars

(vi) (11/03) 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.

Completion of Trial

6 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 (11/03) 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.

Rejection and Further Trials

8 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 Texturing of Hardened Concrete

1 (11/02) 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.

2 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 ± 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 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.

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(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 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 Wet Lean Concrete

Grades and Constituents

1 (11/03) The strength for wet lean 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.

(11/03) Consistence (Workability)

2 (11/03) Consistence shall comply with Clause 1005.

Placing

3 (11/03) Wet lean 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.

Compaction

4 (11/03) The spread wet lean 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 10/9.

Joints

5 (11/03) 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 (11/03) Longitudinal joints in wet lean 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.

Curing

7 (11/04) Curing of wet lean concrete shall comply with clause 4.2.6 of BS 1925-2 or BS EN 12390-1 as appropriate.

Sampling for Testing

8 (11/03) Sampling shall be as specified in Clause 1003.

Density

9 (11/03) The density shall be determined as required in Clause 1003.

Strength

10 (11/03) The strength shall be determined as in Clause 1004.

(11/03) Trial Concrete Mixes

11 (11/03) 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.

Trial Length

12 (11/03) At least 10 days before the start of the main wet lean concrete works a trial length of at least 400 m² 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 (11/03) 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.

Surface Finish

14 (11/03) The surface of the wet lean concrete after compaction and finishing and before overlaying shall be free from ridges, loose material, pot holes, ruts or other defects. The surface macrotexture shall comply with sub-Clause 1026.6.

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1031 (11/03) Measurement of Macrotexture Depth - Volumetric Patch Technique

1 (11/03) The macrotexture depth of the road surface will be determined using the method descibed and the equipment specified in BS EN 13036-1.

1032 Thin Bonded Repairs

Materials

1 Cement mortar shall be used for depths less than 20 mm and fine concrete for greater depths. Resin mortar may only be used for small patch repairs less than 1 metre long and less than 30 mm in depth and where insufficient time for adequate curing of a cementitious cement mortar exists.

2 (11/03) 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 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/mm² in less than 48 hours. For thin bonded repairs using high early strength concrete less than 30 mm depth, air entrainment is not required.

Procedure

4 Mark out the area to be rectified parallel and perpendicular to the axis of the road. Cut a groove around the perimeter at least 10 mm deep without over-cutting into the adjacent slab. Carefully cut out the concrete to the required depth, with a vertical face without undercutting the adjacent slab.

5 If a joint is included in the area to be rectified, fix a groove former or corkseal along the line of the joint by chasing out a groove. For joints on the perimeter fix the groove former or corkseal by adhesive to the adjacent slab.

6 For cementitious repairs, wet the area of the patch. Keep it wet until the repair material is ready to be placed. Remove excess water, prime the surfaces with cement grout or bonding agent, spread the repair material immediately before the primed surface is dry, with sufficient surcharge. Thoroughly compact it by vibration ensuring full compaction at the edges and corners.

7 Retexture the surface to match the surrounding concrete and cure in accordance with Clause 1027.

8 For resin mortar repairs, ensure the area is dry before application of the primer. Place the repair material within the time allowed by the manufacturer for the primer, and compact it well into the edges to the patch. Apply a brush texture to match the original.

1033 Full Depth Repairs and Reinstatements

General

1 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, which 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 The area of concrete to be removed shall be marked out perpendicular to and parallel to the axis of the road.

For continuously reinforced concrete slabs (CRCP or CRCR) 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.

Part Width Repairs

3 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.

Full Width Repairs

4 For full width repairs the following criteria shall apply unless otherwise specified in 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.

Repair Work

5 A groove of 40 mm nominal depth but less than the depth of any reinforcement shall be sawn around the perimeter. For jointed slabs, the saw-cut shall be full depth to provide the face for a new joint. There shall be no over-cutting into the adjacent slab. Additional cuts within the repair area may be made to ease removal of the redundant portion of the slab. At internal corners full depth holes across the corners at the limits of the saw cuts shall be drilled prior to breaking out.

The line of cut shall not vary by more than ±25 mm throughout its length from the set out line. All sawn edges shall be perpendicular or parallel to the sides and surfaces of the slab.

When sawing operations have been completed, and before any other operations are commenced, the surface of the carriageway shall be thoroughly cleaned of the slurry produced by sawing and of any other detritus.

6 The concrete shall be carefully broken out without undercutting the slab or damaging adjoining slabs. If reinforcement has to be removed sufficient shall be left for a lap length, except where a dowelled joint is being made. Reinforcement shall not be bent and subsequently straightened. Slurry from sawing, slab breaking, repair materials and other debris shall be prevented from entering joints and grooves in adjacent areas.

7 When a new joint is required holes shall be drilled of the appropriate size and depth for dowels or tie bars according to the type of joint. These holes shall be thoroughly cleaned of debris and dust. This shall include but not be limited to the use of oil-free compressed air at a pressure of not less than 0.5 N/mm^2.

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.

The holes shall be filled with epoxy mortar, the mortar being injected to the rear of the hole to avoid air entrapment. The dowel bars shall be inserted into the holes before the initial set of the mortar. If cartridges of epoxy mortar are used they shall be inserted into each hole, the dowel bar inserted through the cartridges and rotated for 1 minute to ensure that the epoxy mortar is well mixed. After insertion the dowels and tie bars shall be within the specified tolerances for alignment.

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.

Where Appendix 7/1 or the drawings so require, full bay replacement shall be made and this may require an expansion joint or a contraction joint to be provided at the ends of the replaced bay.

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8 Expansion joint filler shall be fixed to one of the transverse joints. In the other transverse joint, contraction joint groove forming strips or cork seal shall be fixed to the edges of the adjacent concrete.

If the repair is adjacent to another slab, bond between the two slabs shall be prevented by providing full depth 5 mm thick compressible foam strips to Clause 1014 along the longitudinal joint between them.

9 The sub-base layer and any separation membrane shall be reinstated as necessary to comply with Series 800 and Clause 1007 respectively.

Defective sub-base material shall be removed and the sub-base reinstated to the correct level with the material described in Appendix 7/2. Reinstatement of the sub-base shall be completed before new dowel and tie bars are fixed at the joints.

10 New reinforcement shall be lapped and welded or tied. The length of tied laps shall be 35 bar diameters or 450 mm whichever is the greater for longitudinal bars and 300 mm for transverse bars. Welded laps shall be 150 mm minimum length unless a butt-weld process has been permitted in Appendix 7/1.

11 The reinstated concrete shall be placed, spread, compacted and finished as specified in Clause 1025. Particular care shall be taken to ensure full compaction at the edges. The concrete shall be normal or high early strength pavement concrete, complying with Clauses 1001 to 1005 and shall achieve the required characteristic strength prior to opening to traffic.

Crack Repairs

12 Stitched crack repairs shall be either

Type 1 - Staple Tie Bar Repair
Type 2 - Diagonal Tie Bar Repair

as described in Appendix 7/2 and compliant with sub-Clauses 13 and 14 of this Clause.

The extent of crack repairs shall be determined by inspection after the surface has been cleaned.

13 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.

Holes of 25 mm - 30 mm diameter by 50 mm deep shall be drilled at each end of the slot and the slots cleaned out using oil free compressed air.

When in a dry state the slots shall be primed and the staple tie bars placed into beds of epoxy mortar and covered to a minimum depth of 30 mm with the same material.

The sides of the slots shall be cleaned of loose material and the slots filled with thoroughly compacted epoxy or cementitious mortar as described in Appendix 7/2.

After curing a groove shall be sawn along the line of the crack and sealed in accordance with Clause 1016.

14 (11/03) For Type 2 crack repairs drilling points shall be marked out 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.

Holes of 16 mm minimum diameter shall be drilled at right angles to the crack and at approximately 26° to the surface of the slab to a depth which allows 50 mm cover at the bottom of the slab. These holes shall be thoroughly cleaned of debris and dust.

12 mm diameter Grade 460 deformed steel tie bars shall be notched at a point which will ultimately be 50 mm below the slab surface when the bars are fully inserted into the hole.

Each hole shall be filled with epoxy mortar and its quantity adjusted to ensure that when the tie bar is fully inserted the level of the mortar is up to a point which is 25 mm below the notch on the tie bar. Such adjustment of the epoxy mortar and the final insertion of the tie bar shall be done rapidly to ensure its completion before the initial set of the mortar. After the epoxy mortar has set, the length of tie bar above the notch shall be broken off. Once all these bars have been broken off, the tops of all these holes shall be filled with epoxy mortar.

If cartridges of epoxy mortar are used the bars shall be inserted through the cartridges and rotated for 1 minute to ensure that the adhesive is well mixed.

Joint Grooves and Seals

15 Longitudinal joint grooves shall be recut where directed in Appendix 7/2 using the following procedure.

The longitudinal joint shall be saw cut to a nominal width of 10 mm to encompass the existing joint and to sufficient depth to remove the existing sealant approximately 25 mm deep. Where existing sealant or traces thereof cannot be removed within the 10 mm saw cuts the groove shall be widened to enable all existing sealant to be removed.

The groove sides shall be vertical, and the horizontal alignment of the groove shall be straight and parallel to the edge of the slab.

The concrete and sealant shall be removed between the saw cuts without damaging the sides of the groove.

The base of the groove shall be formed to a uniform profile suitable for the application of debonding tape or caulking material.

Any residual traces of sealant or detritus shall be removed from the groove and the groove prepared for sealing in accordance with Clause 1016.

16 (11/03) Transverse joint grooves shall be recut where directed in Appendix 7/2 using the following procedure.

The transverse joint shall be saw cut to form a groove to satisfy the dimension of applied joint seals as specified in Table 10/6 allowing for debonding tape or any necessary caulking material of at least 5 mm uncompacted depth and to encompass the existing joint.

The groove sides shall be vertical, and the horizontal alignment of the groove shall be straight and parallel to the line of the joint.

The concrete and sealant shall be removed between the saw cuts without damaging the sides of the groove.

The base of the groove shall be formed in accordance with Clause 1017.

Any residual traces of sealant or detritus shall be removed from the groove and the groove prepared for sealing in accordance with Clause 1016.

17 Unless cork sealants complying with Clause 1017 have been used, the joints shall be sealed in accordance with Clause 1016.

1034 Summary of Rates for Sampling and Testing Concrete for Pavement Layers

1 (11/04) Unless otherwise stated in Appendix 1/5, Table 10/9 summarises the minimum rates of sampling and testing of specimens to the Specification.

2 Samples for testing shall be taken at the point of placing or from the relevant pavement layer.

TABLE 10/9: (11/03) **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 m² or 6 per day
		b) Slabs less than 300 m²	1 per 20 m length or 3 per day
1003	Density	a) Main slab and trial length	A minimum of 3 cores at a rate of 1 core per 1000 m²
1004	Strength	a) Main slab	3 cores for areas up to 3000 m² and 1 additional core per further 1000 m²
		b) Trial length	At least 6 cores, half to be tested 7 days and half at 28 days
1005	Consistence	a) Main Slab - Initial 50 m³ - Subsequently	3 samples 1 per 150 m³ or 1 per production day
		b) Slabs less than 150 m³	3 samples in the first 50 m³ then 1 more
1016	Hot or cold applied joint sealants	Penetration test	One sample per 1000 m joint or at least one per day
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	Macrotexture 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	Wet lean concrete	As in Clause 1003 and 1004	
	In situ density		A minimum of 3 cores at a rate of 1 core per 1000 m²
	Strength	a) Main slab	3 cores for areas up to 3000 m² and 1 additional core per further 1000 m²
		b) Trial length	At least 6 cores, half to be tested at 7 days and half at 28 days

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1035 to 1042 (11/04) Not Used

1043 Foamed Concrete

1 (05/02) 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 (11/03) 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/mm² at an age of 7 days.

(ii) A maximum cube compressive strength of 10 N/mm² 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 12390-1 and tested for compressive strength in accordance with BS EN 12390-3.

3 (11/03) 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 (05/02) After placing, foamed concrete shall not be tamped, or otherwise compacted.

5 (05/02) 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 Pavements with an Exposed Aggregate Concrete Surface

General

1 Pavements with an exposed aggregate concrete surface shall comply with all the requirements of this Series except where otherwise specified in this Clause.

2 The Contractor shall complete Appendix 10/1 and submit this with his tender documents. If after acceptance the Contractor wishes to change the proposals contained in Appendix 10/1 this change shall only be with the consent of the Overseeing Organisation.

3 The concrete slab shall be laid in either a single layer or in two layers as stated in Appendix 10/1. If laid in two layers the surface layer shall be laid monolithically with the lower layer.

4 (11/03) 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.

Quality of Concrete in the Slab

5 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 Appendix 7/1.

(ii) (11/03) For 6.3/10 mm coarse aggregate or 4/8 mm coarse aggregate as required in 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) (11/03) 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) (11/03) 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 Appendix 7/1. The Category of flakiness index of the aggregate is FI_{15}.

(vi) Hardness and durability of the coarse aggregate shall be as described in sub-Clause 901.2.

(vii) (05/01) 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/m³ and the maximum free water/cement ratio shall be 0.40.

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(viii) (11/03) The air content, density and strength requirements shall be as required in Clauses 1002, 1003 and 1004 respectively.

General Construction Requirements

6 The concrete paving equipment shall comply with 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) (11/03) 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.

Finished Surface Requirements

7 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.

Production of an Exposed Aggregate Surface

8 (05/02) 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 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.

Retarder

9 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 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 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 The Contractor shall use the retarder which he has nominated in Appendix 10/1. This shall be of a type and composition to satisfy the requirements of this Clause.

Application of the Retarder

13 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 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 Back-up spraying equipment shall be available on the Site at all times for use in case of a breakdown of the spraying machine.

Protection of the Surface after the Application of the Retarder

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 Appendix 10/1. This protection shall be applied immediately after the application of the retarder.

17 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 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.

Exposing the Aggregate Surface

19 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 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 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.

Brushing System

22 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 (11/02) The brushing equipment nominated by the Contractor in 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 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 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.

Protection of the Surface Layer After Exposure of the Aggregate

26 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.

(11/02) **Surface Macrotexture Depth and Remedial Measures**

27 (11/02) 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 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 Appendix 7/1.

28 (11/03) 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 (11/02) 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 (11/02) 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.

Preliminary Trials

31 (11/03) 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 Appendix 7/1.

32 (11/02) 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 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 (11/02) 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 (11/02) 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 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.

Trial Length

37 (11/02) 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 (11/02) 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 (11/02) 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 (05/01) Weather Conditions for Laying of Cementitious Materials

1 Road pavement materials in a frozen condition shall not be incorporated in the Works but may be used, if acceptable, when thawed.

2 Road pavement materials shall not be laid on any surface which is frozen or covered with ice.

3 (11/04) The temperature of concrete in any pavement layer shall not be less than 5ºC at the point of delivery. These materials shall not be laid when the air temperature falls below 3ºC and laying shall not be resumed until the rising air temperature reach 3ºC 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 2ºC and shall be retained for a minimum of 3 days or until the concrete is assessed to have reached 50% of the specified characteristic compressive strength provided the air temperature is above 0ºC 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/mC (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 (05/01) Cold Recycled Cement Bound Material

Scope

1 Recycled cement bound material shall be designed and produced to form the foundation or main structural layer of a road pavement. The primary aggregate source shall be obtained by cold pulverisation of all or part of the existing road structure. The stabilising agent shall be hydraulic cement with Portland cement CEM I as the main component. The aggregate grading may be

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adjusted by the addition of a filler. Lime may also be used to modify any cohesive subgrade soil incorporated in the pulverised layer.

2 (11/03) Prior to commencing the pulverisation and stabilisation works, the Contractor shall demonstrate, to the satisfaction of the Overseeing Organisation, using the results of the concrete design procedures described in sub-Clauses 1046.43-1046.49 of this Clause, that the existing pavement materials in the sections of the works defined in Appendix 7/19, are capable of being recycled by pulverisation to form the primary aggregate component of a recycled cement bound material which can meet the specified end-product performance requirements.

Component Materials

Aggregates and Fillers

3 (11/04) The pulverised road material when mixed with any supplementary aggregate and/or filler shall normally be granular material with not less than 5% and not more than 20% passing the 0.063 mm sieve (Zone A graded material in accordance with Table 10/10). Approval for use of pulverised granular material containing up to 35% passing the 0.063 mm sieve (Zone B graded material in accordance with Table 10/10) shall require confirmation by the Overseeing Organisation, subject to the results of the mixture design procedures described insub-Clauses 43 to 49 of this Clause.

4 (11/03) The pulverised granular material shall contain not more than 2% of organic matter as determined in accordance with BS 1377 : Part 3 : clause 3.

TABLE 10/10: (11/04) **Particle Size Distribution of Granular Material for Recycling**

Sieve size (mm)	Percentage by mass passing	
	Zone A Graded Material	Zone B Graded Material
63	100	-
31.5	87 - 100	-
20	66 - 100	100
10	48 - 75	75 - 100
6.4 (or 4)	39 - 62 (31 - 52)	62 - 97 (52 - 90)
2.8 (or 2)	27 - 47 (23 - 40)	47 - 82 (40 - 73)
0.500	12 - 27	27 - 49
0.250	9 - 23	23 - 45
0.063	4 - 20	20 - 33

Note: (11/03) Aggregate grading shall have a coefficient of uniformity (C^u) exceeding 10.

Cement, Filler and Lime

5 (11/03) The constituents and required quality standards of hydraulic cement, filler and lime shall be certified by the supplier, whose manufacturing and delivery processes shall be implemented using quality management systems in accordance with the BS EN ISO 9001 series of standards and certified by an accredited body.

6 (11/03) The primary binder shall be Portland cement CEM I or Portland slag cement or Blastfurnace cement or Portland fly ash cement in accordance with sub-Clause 1001.3.

7 PFA shall be in accordance with BS 3892 : Part 1.

8 Lime for lime stabilisation (or as a modifier for plastic fines) shall be either quicklime or hydrated lime, as stated in Appendix 7/19, complying with sub-Clause 615.33.

Water

9 (11/03) Water for moisture content control of the pulverised granular material shall normally be obtained from a water company supply and used without testing. Water from an alternative source shall comply with BS EN 1008 and be approved by the Overseeing Organisation.

Pulverisation and Stabilisation

10 The Contractor shall satisfy the Overseeing Organisation that the plant used for pulverisation is capable of uniformly pulverising the existing road in a single pass, to a depth specified in Appendix 7/19. The plant used for stabilisation shall be capable of uniformly mixing controlled amounts of water and cementing agent(s) into the full depth of the pulverised layer. For either operation, the plant shall be equipped with a means of controlling the depth of processing to ±15 mm of the required depth.

11 The plant used for stabilisation shall be equipped with a spraybar system within the mixing chamber capable of uniformly distributing water at a monitored and controlled rate. Evidence confirming the capabilities of the plant and calibration of flow meters, shall be submitted to the Overseeing Organisation prior to the stabilisation works commencing.

12 The material shall be pulverised and stabilised in a single layer if the compacted thickness is 300 mm or less. If the compacted thickness is greater than 300 mm, the material shall be pulverised and stabilised in a minimum number of layers between 150 mm and 300 mm thick. Where more than one layer is required, the Contractor shall satisfy the Overseeing Organisation that the lower layer has achieved adequate stability in

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accordance with sub-Clause 27 of this Clause before proceeding with the overlying layer.

Pulverisation Process

13 Pulverisation of the existing road structure shall be carried out in a systematic pattern, to the required depth, to ensure that all parts of the existing road designated in Appendix 7/19 are included in the works. An overlap of at least 150mm shall be made between adjacent passes of the machine. Any material missed along hard edges or around obstructions shall be excavated and placed in the path of subsequent passes of the machine until a uniform fully pulverised aggregate is obtained. The pulverised material shall not be contaminated with material drawn in from the verge.

14 All longitudinal and transverse joints shall be clean cut and vertical. Where work continues adjacent to previously recycled material, transverse joints shall be reformed a minimum 0.5 m into the previously treated construction. Where a layer of material for stabilisation is placed over a layer previously stabilised, the depth of pulverisation/stabilisation of this layer shall be set to cut into the underlying stabilised layer by at least 20 mm.

15 Excess pulverised material shall be removed by the grader and/or excavator for use elsewhere on the site or transported to stockpile at locations given in Appendix 7/19. The surface of the layer shall be graded nominally to the required profile and provisionally compacted.

16 (11/04) Moisture content of the pulverised aggregate immediately prior to stabilisation shall be measured in accordance with BS EN 1097-5. The moisture content shall be uniform throughout the layer within the range 0% to +4% of the optimum moisture content for the unstabilised aggregate, including any designed proportion of filler, determined in accordance with clause 2.1 of BS 1924-2, using vibratory compaction.

17 If the moisture content of the unstabilised pulverised aggregate fails to meet the specified moisture content range, corrective action shall be taken either by aeration to reduce the moisture content or by controlled addition of water to increase the moisture content.

18 Aeration of the affected area shall be achieved by full depth passes of the recycling machine to disturb and loosen the material and assist the evaporation of excess moisture. The material shall be kept in a loose condition until subsequent moisture content tests show that the treated material has reached the required moisture content range. The layer shall be re-graded nominally to the required profile and provisionally compacted in preparation for stabilisation.

19 An increase in the moisture content of the affected area shall be achieved by the controlled addition of water through an adjustable spraybar system in conjunction with full depth passes of the recycling machine to achieve a uniform distribution of the water throughout the layer. Water shall be added in increments and mixed in until subsequent moisture content tests show that the material has reached the required moisture content range. The layer shall be re-graded nominally to the required profile and provisionally compacted in preparation for stabilisation.

Stabilisation Process

20 Stabilisation shall not be carried out during or after periods of rainfall where the duration and intensity are likely to cause the stabilised mixture to exceed the specified moisture content criteria and compromise the stability of the layer under compaction as described in Sub-Clause 27 of this Clause. Stabilisation of frozen materials shall not be permitted.

21 Prior to stabilisation, pulverised materials within 100 mm of restricted hard edges such as kerbs and channels, or around obstructions such as gullies, shall be removed and spread uniformly over the remaining full width of the pulverised material.

22 Cement binder, filler, hydrated lime or quicklime shall be spread full-width on the surface of the layer using a mechanical spreader capable of distributing the material(s) in a uniform manner. The rate of spread of these materials shall be calculated to achieve mixture composition determined in accordance with sub-Clauses 43 to 49 of this Clause and monitored as the spreading operation proceeds in accordance with sub-Clause 31 of this Clause.

23 The stabilisation shall be carried out to the required depth in a systematic pattern similar to that used for the pulverisation process, with an overlap of at least 150 mm between adjacent passes of the machine. Where necessary, additional water shall be introduced and distributed through the spraybar system, directly into the rotor and mixing box of the stabiliser.

24 The layer of stabilised material shall be graded to level and compacted within two hours of the final pass of the stabilising plant, unless a curing or “maturing” period of aeration is required. Any furrow formed by prior excavation of edge materials shall be re-filled by grading the adjacent stabilised material into the space using a minimum amount of re-working.

25 (11/04) The compaction of each layer shall be carried out using compaction plant approved by the Overseeing Organisation, until such time as the density complies with the minimum compaction field requirements specified in the Clause 816 and the

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stabilised layer provides a stable and dense surface. Any open or segregated surface area shall be re-mixed by machine during stabilisation.

26 Where specified in the Appendix 7/19 a system for inducing transverse cracks shall be installed into the fresh stabilised material in accordance with sub-Clauses 50 to 60 of this Clause. The installation shall be carried out after grading to level and application of initial compaction, then completed by final compaction.

27 The stability of the layer under compaction shall be deemed adequate if the finished surface does not move, rut or exhibit transverse cracking under the load of subsequent construction traffic.

28 Where required by the Overseeing Organisation, the stability of a layer in any area shall be assessed after a curing period of at least 24 hours by channelled trafficking using a rigid three-axle tipper truck loaded to a gross mass of 24 tonnes (assumed equivalent to three standard axles). The vertical deformation shall be measured in all wheeltracks at monitoring points on each of 5 transverse sections set 1m apart after 5, 15, 30 and 40 passes of the truck. The mean vertical deformations at the above trafficking increments shall be plotted against the respective number of truck passes and the mean vertical deformation corresponding to 100 standard axles shall be interpolated. The layer shall be deemed acceptable if the mean vertical deformation corresponding to 100 standard axles is less than 10 mm.

29 On completion of compaction the surface shall be sealed using a sprayed membrane of Class K1-40 bitumen emulsion complying with Clause 920. The bitumen emulsion shall be sprayed at the rate stated in Appendix 7/19. Where the surface is opened to traffic, the sealing membrane shall be blinded with fine aggregate or sand applied at a rate of 5.5 to 7.0 kg/m^2.

Process Control

30 (11/04) The sampling and testing of the recycled cement stabilised base shall be carried out as required for cement bound materials (CBM) in accordance with the relevant Clauses of Series 800.

31 The rate of spread of cement, filler, hydrated lime or quicklime shall be measured by weighing the amount of material retained on each of five trays or mats of known area laid in the path of the spreading machine. The trays shall be positioned approximately at points equally spaced along a diagonal bisecting the area of coverage. The mean rate of spread and percentage addition of the material shall be determined and recorded for each assessment area.

32 As directed by the Overseeing Organisation, where lime has been used to modify a cohesive soil component of the pulverised aggregate, the acceptability of the modified materials shall be tested in accordance with sub-Clause 615.13.

End Product Performance of Recycled Cement Bound Material

33 (11/04) The end-product performance of the recycled cement bound material shall be assessed on the basis of measurements and tests carried out on samples provided from five locations equally spaced along a diagonal that bisects each 800 m^2 or part thereof completed each working day.

34 Within 24 hours of completion, the as-installed performance of the stabilised layer shall be evaluated using a dynamic plate loading or penetrometer technique to determine values of elastic modulus at points on a nominal grid pattern, as described in Appendix 7/19. The elastic modulus at each point and the mean elastic modulus for the assessment area shall comply with the minimum standards stated in Appendix 7/19. Additionally, before proceeding with construction of the overlying pavement, the evaluation process shall be repeated to demonstrate that the elastic modulus value at all points and that of the mean value have increased over the respective as-installed values by not less than the percentage values stated in Appendix 7/19. Where these criteria are not met, the full extent of the non-compliant material shall be determined and appropriate remedial measures implemented. Remedial action shall comprise either a delay in construction to allow further curing and stiffening of the layer to occur or a repeat of all or part of the recycling process, followed by re-evaluation, until a compliant material is achieved.

35 (11/04) Within 270 days of completion of the surfacing works, a Falling Weight Deflectometer survey shall be carried out and analysed in general accordance with HD 29 (DMRB 7.3.2). In particular, the measurements shall be taken on the finished road surface in the nearside wheelpath, at a uniform and maximum spacing of 10 m. The survey shall be carried out during a period when the pavement temperature at a depth of 50 mm is within the range 15°C to 25ºC. The FWD results shall be analysed using a linear elastic FWD back-analysis computer program, with the pavement modelled as a two layer system. Layer 1 shall represent the combined design thickness of the bound materials (ie the combined recycled material and overlying surfacing materials) and layer 2 shall represent the unbound foundation layer of infinite depth. End-product performance shall be defined in terms of the calculated stiffness of layer 1, uncorrected for temperature. Compliance shall be achieved when the rolling mean of 10 results is not less than the figure specified in Appendix 7/19 and no individual result is less than 85% of the figure specified.

36 In the event that the layer 1 stiffness requirements of sub-Clause 35 of this Clause are not met, the full extent of the non-compliant material shall be determined by further investigation involving coring and laboratory testing. For each area of non-compliance, cores shall be extracted through the full depth of the stabilised layer at locations directed by the Overseeing Organisation, at a minimum rate of one x 150 mm diameter core per 75 m^2.

37 The Contractor shall be responsible for extraction of the cores with the minimum of force or disruption. Air flush coring shall be allowed for materials that are disturbed by water flush coring. After extraction, each core shall be labelled and photographed and, prior to testing, shall be stored in sealed polythene bags, in a uniformly supported position, at a temperature of 20ºC ± 5ºC. The thickness of the recycled layer shall be measured and recorded.

38 Reinstatement of all core holes shall be completed before opening the area to traffic. All backfill materials shall comply with sub-Clause 903.19.

39 If, at any of the prescribed core locations, it is not possible to extract an intact core of suitable size or condition for the end-product performance testing, using a maximum of three attempts in an area of 1.5 m radius, the material in the vicinity shall be deemed not to comply with the end-product performance specification.

40 (11/04) In the laboratory, each core extracted successfully shall be trimmed to remove surfacing materials and any underlying material prior to the measurement of core density and air voids content in accordance with the standards listed in Table 10/11.

41 (11/04) Following the measurement of density and air voids content, each core shall be prepared and tested to determine the compressive strength of the core, in accordance with the procedures and standards given in Table 10/12.

42 (11/04) The results obtained shall be used to judge the expected performance of the recycled stabilised material in the works in relation to the performance of equivalent hydraulically bound materials. The recycled stabilised material in the assessment area shall be deemed acceptable if the compliance criteria described in Table 10/13 are met.

TABLE 10/11: (11/04) **Procedures and Standards to be Used to Determine the Density of Core Samples of Recycled Cement Bound Material**

Procedure	Procedure Stage	Standard to be Used
Core preparation for density testing	Measurement of core dimensions and accuracy of measurement Methods of trimming core to length	BS EN 12504-1
	Test specimen type, shape and moisture condition	BS EN 12390-7
Core testing for density	Apparatus specification Measurement of volume dimensions Volume by water displacement Measurement of mass Equations for density Accuracy and units of density	BS EN 12390-7
	Core density as a proportion of theoretical density	Clause 1003

TABLE 10/12: (11/04) **Procedures and Standards to be Used to Determine the Compressive Strength of Core Samples of Recycled Cement Bound Material**

Procedure	Procedure Stage	Standard to be Used
Core preparation for density testing	Measurement of core dimensions and accuracy of measurement Assessment of voids Maximum and minimum dimensions for strength testing	BS EN 12504-1
	Methods of capping core	BS EN 12390-3 Annex A
	Suitability of core for strength testing Storage of cores before capping	BS EN 12504-1
Core testing for strength	Type of strength test Minimum period of testing after end-preparation Method of curing core prior to testing Measurement of core test specimen dimensions and accuracy Equation for calculating core strength	BS EN 12504-1
	Testing machine specifications Rate of loading	BS EN 12390-4 BS EN 12390-3
	Correction for length/diameter ratio	Draft prEN 13877-2 (January 2002)

TABLE 10/13: (11/04) **Compliance Criteria for Recycled Cement Bound Material Based on Results of Tests on Cores Extracted from the Works**

Property	Individual cores	Mean from cores in each surveyed area
Core density relative to refusal density	93%	95% minimum
Excess voidage *	3.0%	2.0% maximum
Layer thickness [from core measurement]	+ 25 mm	+ 15 mm of specified
Equivalent cube compressive strength	**CBM equivalence	**CBM equivalence

* Excess voidage of a core is defined as the amount by which the actual air voids content exceeds the air voids content of the fully compacted moulded cube of the same cement bound material.

** Compliance criteria is quoted in relation to the design 7 day cube compressive strength appropriate to the equivalent CBM classification of the recycled material.

Mixture Design and Characterisation

43 (11/03) Mixture design characterisation of recycled cement bound material for each site, or section of site, including details of the cementing agent and/or stabilising agent(s) and their quantities, shall be submitted to the Overseeing Organisation at least one week prior to commencement of the recycling works. Where the site investigation has identified significant variation of existing pavement materials between different sections of the site, a CBM design shall be submitted for each section of the site. The proposed plan area and depth of the different sections, covered by each mixture design, shall be approved by the Overseeing Organisation.

44 (11/04) The mixture design for recycled cement bound material shall use the same method of mixture design as that used for plant mixed CBM specified in Clauses 816. The permitted alternatives and equivalent recycled mixture designs for each part of the Works shall be as described in Appendix 7/19.

45 The laboratory crushed and processed aggregate with a particle (or "lump") sized distribution complying with sub-Clause 3 of this Clause shall be thoroughly mixed with measured proportions of the cement to produce trial mixtures with different cement contents. The type and grade of the cement used in the trial mixtures shall be the same as that used in the finished works.

46 If lime is required for stabilisation and/or modification of clay included from pulverisation of the upper subgrade layer, the same proportion of lime shall be added into the trial mixture.

47 (11/04) The cement content of the recycled cement bound mixture shall be determined in the same manner as the cement content for plant mixed CBM. The minimum cement content shall be 3% by weight.

48 The mixture design process shall be repeated until an acceptable mixture design is achieved. To achieve this the target composition of the mixture shall be systematically adjusted and the mixture design tests repeated.

49 (11/04) In addition to the other requirements, the average compressive strength determined after 7 days immersion in water of five test specimens of the target composition mixture, prepared in accordance with sub- Clause 3 of this Clause, shall be not less than 80% of the average compressive strength of five control specimens when subjected to the test procedure described in BS 1924-2: clause 4.3. After 7 days immersion, the specimens shall not show any signs of cracking or swelling.

Induced Cracks

50 (11/04) Recycled cement bound material shall have cracks induced during construction as described in Clause 818 and in Appendix 7/1.

1047 (11/04) Not Used

1048 (05/01) Use of Surfaces by Traffic and Construction Plant

1 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 (11/03) Concrete slabs may be used by traffic when the cube compressive strength is assessed to have reached 25 N/mm² for pavement surface slabs, or 20 N/mm² for bases with asphalt surfacing. The method of assessing the time when this strength is reached shall be as described in Clause 1004.

3 (11/03) 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 0ºC or below.

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