IMPLEMENTATION SPECIFICATION FOR ROAD WORKS

SERIES IM/1000 (IMPLEMENTATION)
ROAD PAVEMENTS – CONCRETE MATERIALS

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

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Contents

1000 ROAD PAVEMENTS - CONCRETE MATERIALS

General

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

2 The Contractor shall undertake the testing of concrete pavements as detailed in the Clauses of this Series unless detailed otherwise in contract specific Appendices 1/5, 1/6 or 7/1.

1001 Strength Classes of Concrete and Constituent Materials for Pavement Layers

1 Concrete in rigid or rigid composite pavements shall be one of the classes given in Table 1000-1, in accordance with the pavement design alternatives permitted in contract specific IM Appendix 7/1.

2 Unless otherwise specified in contract specific IM Appendix 7/1 concrete shall conform with the requirements of MSA EN 13877-2 and the requirements of this Series. The constituents of the concrete shall conform with MSA EN 206 and BS 8500-1 and BS 8500-2 and MSA EN 13877-1 and the requirements of this Series.

Table 1000-1: Pavement Layers — Concrete Strength Classes

Pavement Layer			MSA EN 206, BS 8500-2, MSA EN 13877-2			BS 8500-1 BS EN 13877-1	Clause
			Designed Concrete	Standardised Prescribed Concrete	Designated Concrete		
(i)	Surface slabs: Unreinforced concrete (URC) Jointed reinforced concrete (JRC) Continuously reinforced concrete pavement (CRCP)		C40/50**			C32/40**	1001 to 1031 and 1033
(ii)	Continuously reinforced concrete base (CRCB)		C40/50**			C32/40**	
(iii)	CRCP and CRCB ground beam anchorages		*			C25/30	
(iv)	Lower Strength concrete 4)	For bases or sub-bases as required in contract specific IM Appendix 7/1		ST4	GEN 3	C16/20	1029
(v)	Lower Strength concrete 3)			ST3	GEN 2	C12/15	

(vi)	Lower Strength concrete 2)			ST2	GEN 1	C8/10	
(vii)	Lower Strength concrete 1)			ST1	GEN 0	C6/8	
NOTE: * Cores shall not be taken from ground beam anchorages. ** Minimum permitted concrete class.							

Cement

3 The general term 'cement' in this Series means any of the materials in (a) or the combinations in (b) below:

a)	Cements		Complying with:
	i)	Portland cement CEM I	MSA EN 197-1
	ii)	Portland-slag cement CEM II/A-S and CEM II/B-S	MSA EN 197-1
	iii)	Blastfurnace cement CEM III/A and CEM III/B	MSA EN 197-1
	iv)	Portland-fly ash cement CEM II/A-V and CEM II/B-V	MSA EN 197-1
	v)	Pozzolanic cement CEM IV/A	MSA EN 197-1
b)	Combinations		Complying with:
	vi)	Portland cement CEM I with ground granulated blastfurnace slag (ggbs) for use with Portland cement CEM I	MSA EN 197-1 MSA EN 15167-1 MSA EN 15167-2
	vii)	Portland cement CEM I with fly ash (fa) for use as a cementitious component in structural concrete	MSA EN 197-1
	viii)	Portland cement CEM I with pozzolanic additive when approved by the Overseeing Organisation.	MSA EN 450-1 MSA EN 450-2 MSA EN 197-1

c) In each cubic metre of fully compacted concrete the cement content shall be in accordance with Table 1000-2. For 20 mm maximum size aggregate add 20 kg/m^3, and for < 20mm maximum size add 40 kg/m^3.

d) When used, the proportion of silica fume to CEM I shall be 10 ± 1%.

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

Table 1000-2: Minimum Cement or Combination Contents with 40mm Maximum Aggregate

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

Water

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

Admixtures

5 Concrete in at least the top 50 mm of surface slabs shall incorporate an air-entraining admixture complying with MSA EN 934-2, except:

a) for pavements with an exposed aggregate concrete surface constructed to Clause 1033 where at least the top 40 mm of the surface slab shall be air entrained;
or

b) for surface slabs of pavements with at least a class C40/50 concrete;

c) for surface slabs of pavements with a class C32/40 concrete which are to be overlaid by a 30 mm minimum thickness thin surface course system complying with Series 900.

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

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

Aggregate

6 Aggregates for all pavement concrete, including Lower Strength, shall comply with MSA EN 12620. Crushed concrete, which complies with the quality and grading requirements of MSA EN 12620 and Table 2 of BS 8500-2, may also be used in all pavement concretes except aggregate concrete surface complying with Clause 1033. 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:

a) the resistance to freezing and thawing complies with MSA EN 12620 clause 5.7.1 for pavement and Lower Strength concrete; and

b) the resistance to fragmentation complies with category LA_{35} of MSA EN 12620 clause 5.2 for concrete surface slabs and LA_{40} of MSA EN 12620, clause 5.2 for concrete bases and Lower Strength concrete.

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

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

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.

7 Sand (i.e. fine aggregate) containing more than 25% by mass of acid-soluble material as determined in accordance with MSA EN 196-2, in either the fraction retained on, or the fraction passing the 0.500 mm sieve, shall not be used in the top 50 mm of surface slabs. This requirement will not apply for pavements with an exposed aggregate concrete surface constructed to Clause 1033 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.

8 The water absorption of flint coarse aggregate containing white flints for use in concrete surface slabs, when determined in accordance with MSA EN 1097-6 shall not exceed:

a) 3.5% for any separate nominal size fraction;

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

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

Source of Recycled Aggregates

9 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.

Chloride Content

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

Chemical Requirement

Acid-soluble sulfate

11 Acid-soluble sulfate content of the aggregates and filler aggregates for concrete pavements, including Lower Strength, shall comply with MSA EN 12620, clause 6.3.1 and for other aggregates Category AS0,8.

Total sulfur

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

1002 Air Content

1 In the top 50mm concrete requiring air entrainment to satisfy Clause 1001.5 shall meet the requirement for exposure class XF4 in MSA EN 206. With the exception of concrete class C40/50 as defined in BS8500 this shall be achieved by the use of an air-entraining agent. The minimum quantity of air in air-entrained concrete as a percentage of the volume of the concrete shall be as in Table 1000-3.

Table 1000-3:Minimum Air Contents

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

2 The air content shall be determined at the point of delivery to the paving plant by the pressure gauge method in accordance with MSA 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 MSA EN 206 the Contractor shall remove the concrete from the works.

3 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 MSA EN 206, to ensure uniform distribution of the agent throughout the batch during mixing.

1003 Density

The Permanent Works

1 With the exception of the trial length, the density shall be measured by non-destructive methods.

2 A correlation shall be established for each mix and each measuring device and shall be established from the trial length where cores have been taken. The correlation established shall be provided to the Overseeing Organisation before commencement of the permanent works. The device chosen shall achieve a repeatability of at least 90%.

3 The concrete density measured by the device shall not be less than 95% of the average density of at least six fully compacted saturated moulded specimens made from the same mix in the trail area and tested at the same age.

4 The density shall be measured routinely at a distance of 0.8 to 1.2m from the edge of the slab and at the rate shown in Table 1000-8.

5 If a non-compliance in an area is indicated then cores shall be taken as required in the trial area. Density measurements shall be taken at the locations at which material is placed that has been sampled for cube testing.

The Trial Length

6 In the trial length the density of a saturated core cut from the full depth of the concrete pavement shall not be less than 95% of the average density of at least six fully compacted saturated moulded specimens made from the same concrete and tested at the same age.

7 The density of the concrete pavement shall be determined in accordance with MSA EN 13877-2. The density of a saturated core cut from the full depth of the concrete pavement shall be determined in accordance with MSA EN 12390-7. The determination of the saturated density of the fully compacted moulded specimens shall be in accordance with MSA EN 12350-1, MSA EN 12390-1 and MSA EN 12390-2.

8 The core shall have an average diameter of at least four times the nominal maximum aggregate size, and in any case not less than 100 mm diameter. Where different concrete mixes are used in separate layers, the density of each layer shall be separately determined by splitting or cutting the cores between the layers.

9 Cores shall be taken. If the density of any core is below the minimum required, the concrete across the whole width of the slab constructed at the time relating to that core shall be removed. In unreinforced concrete the whole slab length between joints shall be removed. For reinforced slabs, in order to determine the limit of the defective area of concrete which shall be removed, additional cores shall be taken at 5 m intervals on each side of any defective core until concrete of satisfactory density is found. Defective areas shall be made good with new material in accordance with the specification.

10 In calculating the density, allowance shall be made for any steel in the cores.

11 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 Pavement Concrete Strength

1 Concrete cores of 150mm diameter shall be taken from the trial length, cured and tested in accordance with MSA 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. A minimum of 9 cubes and 6 cores taken and at a minimum of 3 locations shall be taken from the trial length. For each set of 6 cores, three shall be tested at 7 days and three at 28 days

2 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.

3 The ratio of core density to non-destructive density measurement taken within 1m of the core location shall be determined from the trial length as described in Clause 1003.

4 If multi-layer construction is being used the cores shall be tested for adequacy of bond between layer in accordance with MSA EN 13877-2 with fv=1mPa at 7 days.

5 Once a satisfactory trial construction has been achieved strength monitoring of the main construction will be by the use of cubes cast at the rate of a set of 3 cubes for every 400 m^2 of concrete laid. A minimum of 6 sets of cubes shall be taken each day with each set being from a different delivery of concrete.

6 If the 7-day cube strength fails to conform with the requirements of MSA EN 206 table B1 sampling and testing for, and compliance with the specified characteristic core strength of designed concretes shall be undertaken by compressive strength testing in accordance with MSA EN 13877-2 on cores cut from the full depth of the slab.

7 The strength of the concrete slab shall be evaluated in accordance with MSA EN 206 (Annex B – Identity Testing: Table B.1).

8 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 400 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 contract specific IM Appendix 7/1.

1005 Consistence (Workability)

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

2 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 Separation and Waterproof Membranes

1 Over a bound sub-base a waterproof membrane shall be provided, which shall be a bituminous spray in accordance with Clause 913. Where a bituminous spray has been used to cure cement-bound material or low strength concrete then only those areas, which have been damaged or degraded, shall be resprayed after making good.

1007 Steel Reinforcement

General

1 Reinforcement shall comply with any of the following standards and shall be cut and bent in accordance with BS 8666. The reinforcement materials shall be obtained from an organisation which has current, valid product acceptance scheme certification, such as CARES

certification, in accordance with Clause 104. Re-bending of carbon steel bars and fabric reinforcement on site shall not be permitted:

Hot Rolled and Cold Worked Carbon Steel Bars.

a) MSA EN 10080 and BS 4449 (Grade B500B or B500C).

Steel Wires

b) MSA EN 10080 and BS 4482 (Ribbed Grade B500).

Steel Fabric

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

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

3 Spacing of bars shall not be less than twice the maximum size of aggregate used. Laps in longitudinal bars shall be not less than 35 bar diameters or 450 mm whichever is greater. In continuously reinforced concrete slabs (CRCP or CRCB), only one third of the laps may be in any one transverse section, except in single bay width construction where half the laps may be in any one transverse section. There shall be a minimum of 1.2 m longitudinally between groups of transverse laps or laps in prefabricated reinforcement sheets.

4 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 (i.e. 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 If the reinforcement is positioned prior to concreting, it shall be fixed on chairs conforming with the requirements of BS 7973 and retained in position at the required depth below the finished surface and distance from the edge of the slab so as to ensure that the required cover is achieved. Reinforcement assembled on site shall be tied, or firmly fixed, at sufficient intersections to provide sufficient rigidity to ensure that the reinforcement remains in the correct position during construction of the slab.

6 Alternatively, when a reinforced concrete slab (JRC, CRCP or CRCB) is constructed in two layers, the reinforcement in the form of prefabricated sheets may be placed on or into the bottom layer which shall be spread and compacted to such a level that it will support the reinforcement without distortion at the required position in the slab. The sheets shall be tied together at overlaps and after the second layer has been spread and compacted, the reinforcement shall have the required cover.

7 When a reinforced concrete slab is constructed at maximum width as in Clause 1009 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 1011 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 CRCB)

9 The reinforcement shall be Grade B500B or B500C deformed steel bars with the diameters and spacings as described in contract specific IM 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 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. Reinforcement longitudinal bars shall be placed immediately above any transverse bars, which shall be at right angles to the longitudinal axis of the carriageway. Any transverse reinforcement shall terminate 125 ± 25 mm from the edges of the slab and longitudinal joints where tie bars as in Clause 1011 are used.

1008 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 contract specific IM 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.

a) deviations of the filler board or bottom crack inducer from the intended line of the joint shall be not greater than ± 10 mm;

b) 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;

c) 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 1017.

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 1015.

Contraction Joints

7 Contraction joints shall consist of:

a) a sawn joint groove complying with Clause 1012;

b) dowel bars complying with Clause 1010;

c) a sealing groove complying with Clause 1015.

Expansion Joints

8 Expansion joints shall consist of:

a) a joint filler board complying with Clause 1014;
b) dowel bars complying with Clause 1010;
c) 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:
a) a sawn joint groove complying with Clause 1012;
b) tie bars complying with Clause 1011;
c) a sealing groove complying with Clause 1015.

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.

14 Construction joints in continuously reinforced concrete slabs (CRCP and CRCB) at end of day or in an emergency shall not be constructed within 1.5 m of any lap in the longitudinal reinforcement. The stop end formwork shall be sufficiently rigid to ensure that the longitudinal reinforcement and the tie bars as required in sub-Clause 1011.7 which project through the joint are held in the correct position.

1009 Longitudinal Joints

General

1 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 1007.7. Longitudinal joints shall be provided in CRCB 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 1012, a bottom crack inducer complying with Clause 1013 and tie bars complying with Clause 1011, except where transverse reinforcement is permitted in lieu.

3 Longitudinal joints shall be constructed within the following tolerances:

a) 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;

b) the joint groove shall be located vertically above the bottom crack inducers within a horizontal tolerance of ± 25 mm;

c) the best fit line along the constructed joint groove, shall be not more than 25 mm from the intended line of the joint;

d) 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 1012.

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 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 1011 with a joint groove as in Clause 1012. Alternatively, if split forms are used, the transverse reinforcement, if 12 mm diameter or more, may be continued across the joint for a minimum of 500 mm or 30 times the diameter of the transverse reinforcement bars, whichever is the greater. The transverse reinforcement in these circumstances shall be protected by suitable

bituminous paint or equivalent coating for a distance of at least 75 mm either side of the joint. A joint sealing groove is not required in construction joints in continuously reinforced concrete bases. Where the edge of the concrete slab is damaged it shall be made good before the adjacent slab is constructed.

1010 Dowel Bars

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

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

2 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:

a) 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:
   i) all bars in a joint shall be within ± 3 mm per 300 mm length of bar;
   ii) two thirds of the bars shall be within ± 2 mm per 300 mm length of bar;
   iii) 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;

b) for all bars, after construction of the slab:
   i) twice the tolerances for alignment as in (a) above;
   ii) 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:

a) two thirds of the number of bars of any assembly tested shall not deflect more than 2 mm per 300 mm length of bar;

b) 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:

a) 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.

b) 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.

c) 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.

d) 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 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 MSA 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:

a) 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 MSA EN 12390-2. At 7 days a tensile load shall be applied to achieve a movement of the bar of at least 0.25 mm. The average bond stress to achieve this movement shall be not greater than 0.89 N/mm^2.

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.

1011 Tie Bars

1 Tie bars in transverse or longitudinal joints shall conform to Clause 1007, in accordance with the requirements given below and Table 1000-4.

2 Tie bars for use across joints shall have corrosion protection in the form of a flexible polymeric corrosion resistant coating, bonded centrally onto 200 mm of the previously cleaned centre section of the bars.

Where tie bars are to be cranked for construction joints and later straightened, the coating shall be shown to be capable of being straightened through 90 degrees without cracking.

The coating for both straight and cranked bars after straightening shall be able to withstand 250 hours immersion in a salt fog cabinet complying with MSA 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 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 mm for a sufficient number of concrete batches to complete that section of pavement.

Table 1000-4:Tie Bar Details

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

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

8 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.

1012 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 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 1000-5 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 1015.

1013 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 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.

1014 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 firm compressible material or a bonded combination of compressible and rigid materials of sufficient rigidity to resist deformation during the passage of the concrete paving plant. The depth of the joint filler board for manhole and gully slabs shall be the full depth of the slab less the depth of the sealing groove. In expansion joints, the filler board shall have a ridged top as shown on the drawings, except where a sealing groove former is indicated on the drawings. Holes for dowel bars shall be accurately bored or punched out to form a sliding fit for the sheathed dowel bar.

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

a) Weathering Test

i) 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.

ii) 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.

iii) The material shall be deemed to have passed the weathering test if the specimens show no signs of disintegration or shrinkage.

b) Compression and Recovery Test

i) 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 MSA EN ISO 7500-1, with auxiliary platens 100 mm^2, minimum 13 mm thick. During each application of load each specimen shall be compressed to 50% of its original thickness at a rate of strain of 1.3 mm per minute. The load required to achieve this amount of compression shall be:

- not less than 0.7 N/mm^2 nor more than 10 N/mm^2 for material to be used in pavements; and
- not less than 0.7 N/mm^2 and not more than 0.4 N/mm^2 for material to be used in bridge joints.

ii) 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.

iii) 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.

iv) 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%.

c) Extrusion Test

i) 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.

ii) The extrusion mould shall be 100 mm x 100 mm (+ 0.5 mm, - 0) internally, of sufficient depth to test the sample as received, open on one side only and fixed rigidly to a base plate. The mould shall be provided with a closely fitting pressure plate which shall fit without binding, and with an accurate horizontal measuring dial gauge or measuring device accurate to 25 microns. The specimen shall be mounted in the extrusion mould and loaded once as described in the compression and recovery test. The extrusion at the open side of the mould shall be measured with the gauge when the specimen is compressed to 50% of its original thickness and before release of the load.

iii) The material shall be deemed to have passed the test if the extrusion of the free edge does not exceed 6 mm.

1015 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 1016. 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 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 1000-5, 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 1000-5, 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 1028.

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 N/mm². When compression seals are used, the sides of the groove may be ground or wire brushed.

6 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 1000-5, 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 1000-5:Dimensions of Applied Joint Seals

Type and Spacing of Joints (m)	Minimum Width mm	Minimum Depth of Seal (Note 1)		Impregnated Foam Compression Strips mm	Depth of Seal Below the Concrete Surface mm
		Cold Applied mm	Hot Applied mm		
Contraction					
15 and under	13 (Note 2)	13	15	30	5 ± 2
Over 15 to 20	20	15	30	30	5 ± 2

Over 20 to 25	30	20	25	40	5 ± 2
Expansion	30	20	25	40	7 ± 2
Transverse Warping	10	10	13	30	5 ± 2
Longitudinal Joints (if sealed)	10	10	13	30	0 to 5
Gully and Manhole Slabs	20	15	20	30	0 to 3

NOTE (1): The depth of seal is that part in contact with the vertical face of the joint groove. The depth of seal below the surface shall be taken at the centre of an applied seal relative to a short straight edge, 150 mm long, placed centrally across the joint within 7 days of sealing.
NOTE (2): For cork seals other than in construction joints, grooves shall be 20 mm width, 50 mm depth.

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 prepared and applied in accordance with the manufacturer's instructions.

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

Testing of Applied Sealants

12 No additional testing of sealants is required provided a declaration of performance for cold-applied sealants in accordance with MSA EN 14188-2 or for. MSA EN 14188-1 has been provided to the Overseeing Organisation.

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.

1016 Joint Seals

1 Joint seals shall consist of hot or cold applied sealants or compression seals complying with this Clause. The colour of the joint seal material shall comply with the requirements of contract specific IM Appendix 7/2. For hot-applied and cold applied sealants the Contractor shall submit the declaration of performance for each sealant to the Overseeing Organisation prior to the incorporation of the sealant into the works. The declaration of performance shall demonstrate that the sealant meets the specification requirements.

Hot-applied Sealants

2 Hot-applied sealants shall be Type N1 or Type F1 or Type F2, as stated in contract specific IM Appendix 7/1, and conforming to MSA EN 14188-1.

3 For joints between concrete surface slabs and bituminous surfacing, hot applied Type N1 sealants conforming to MSA EN 14188-1 shall be used. Alternatively polymer modified bitumen sealing strips may be used and shall be applied in accordance with the

manufacturer's instructions. Hot-applied Type N1 sealants may be used in joints in asphalt kerbs laid on concrete pavements.

Cold-applied Sealants

4 Cold-applied sealants shall be Type N conforming to MSA EN 14188-2 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 Compression seals shall be pre-compressed neoprene impregnated expanding foam sealing strip having current product acceptance scheme certification in accordance with sub-Clauses 104.25 and 104.26 such as HAPAS certification, or rubber seals made of polychloroprene elastomers complying with BS 2752 and conforming with the requirements of ASTM Standard D2628-91. Seals of butadiene-acrylonitrile or other synthetic rubbers may be used if certificates are produced to show that they conform to the performance requirements of ASTM Standard D2628-91 for oven ageing, oil and ozone resistance, low temperature stiffening and recovery. Seals made of ethylene vinyl acetate in microcellular form and other synthetic materials may be used in longitudinal joints and in structures if test certificates are produced to show adequate resistance to heat ageing when tested in accordance with MSA EN ISO 2440 and resistance to fuel oils. The compression set of any seal shall not be greater than 15% when the specimen is subjected to a 25% compression in accordance with MSA EN ISO 1856. When immersed in standard oils for 48 hours at 25°C in accordance with BS ISO 1817, the volume change shall not be greater than 5%.

7 Compression seals shall be shaped so that they will remain compressed at all times in accordance with Clause 1015 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.

1017 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 1014 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 Reinforcement as shown on the drawings shall be placed in the gully or manhole slab and concrete Class C32/40 shall be placed by hand in the space between the main slab and the manhole frame. The concrete shall be fully compacted and finished in compliance with Clause 1022.

7 A sealing groove shall be made directly above the joint filler board and sealed in compliance with Clause 1015.

1018 Inspection of Dowel Bars

1 Compliance with Clause 1010 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 When the slab has been constructed, the position and alignment of dowel bars and any filler board shall be measured after carefully exposing them across the whole width of the slab. When the joint is an expansion joint the top of the filler board shall first be exposed sufficiently in the plastic concrete to permit measurement of any lateral or vertical displacement of the board. During the course of normal working these measurements shall be carried out at a rate of one joint per 1500 m length of slab or one per 5 days whichever occurs the sooner. For small areas the rate shall be one joint for up to each 100 joints. For trial lengths measurements shall be carried out at two consecutive joints.

3 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.

1019 Side Forms, Rails and Guide Wires

1 All side forms and rails shall be made of steel or timber and be sufficiently robust and rigid to support the weight and pressure caused by the paving equipment. Side forms for use with wheeled paving machines shall incorporate metal rails firmly fixed at a constant height below the top of the forms.

2 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 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 Unless a laser or electronically controlled level system capable of meeting the vertical and horizontal tolerances stated below is used, a guide wire shall be provided along each side of the slab to be constructed by slip form paving plant. Each guide wire shall be at a constant height above and parallel to the required edges of the slab as shown on the drawings, within

a vertical tolerance of ± 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.

1020 Transport and Delivery

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

1021 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 1022.

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 40 mm or twice the maximum size of the coarse aggregate, whichever is the greater, and shall be at least 15 mm thicker than the depth of the groove former, if used.

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 Concrete shall be discharged without segregation into a hopper spreader which is equipped with the means of controlling its rate of deposition on to the sub-base or on to the lower layer. The concrete shall be spread in each layer without segregation and to a uniform uncompacted density over the whole area of the slab. The deposited concrete shall be struck off to the necessary level by the underside of the hopper as it is traversed across the spreading machine. The machine shall be capable of being rapidly adjusted for changes in average and

differential surcharge necessitated by changes in slab thickness or crossfall. When the slab is constructed in two layers, the spreading of the concrete in the top layer shall follow the completion of the bottom layer within the times given in Table 1000-6.

Table 1000-6: Maximum Working Times

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

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 1012. 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 The regulation and finishing of the surface of the slab shall be carried out by a machine which incorporates twin oblique oscillating finishing beams which shall be readily adjustable for both height and tilt. The beams shall weigh not less than 170 kg/m, be of rectangular section and span the full width of the slab. The leading beam shall be vibrated. The beams shall be supported on a carriage, the level of which shall be controlled by the average level of not less than four points evenly spaced over at least 3.5 m of the supporting rail, beam, or slab, on each side of the slab that is being constructed. Except for CRCB slabs, the final regulation of the surface of the slab shall be provided by a longitudinal oscillating float, travelling across

the slab. After the final regulation and before the macrotexture is applied, any excess concrete on top of the joint groove former, where present, shall be removed. Additionally the longitudinal oscillating float shall complete the traverse of the slab in both directions within the length of the float and shall have a total longitudinal stroke of 200 mm to 300 mm.

10 The longitudinal oscillating float shall have a minimum length of 3 m and a minimum constant width of 250mm 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 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 Slip-form paving machines shall have vibration of variable output, with a maximum energy output of not less than 2.5 kW per metre width of slab per 300 mm depth of slab for a laying speed of up to 1.5 m per minute or pro rata for higher speeds. The machines shall be of sufficient mass to provide adequate reaction on the traction units to maintain forward movements during the placing of concrete in all situations.

18 Except for CRCB slabs, the final regulation of the surface slab shall be provided by a longitudinal oscillating float travelling across the slab. The longitudinal float shall comply with the requirements of sub-Clauses 9, 10 and 11 of this Clause. Additionally, the longitudinal float shall either be a separate machine closely following a slip-form paver or alternatively it shall be attached to a slip-form paver in such a manner that it functions effectively and does not adversely affect the performance of the paver or the surface of the slab.

19 Joint grooves shall be constructed in compliance with Clause 1012. 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.

General

21 While the concrete is still plastic its surface shall be treated to comply with the macrotexture requirements specified in Clause 1023. The surface and edges of surface slabs and CRC bases shall be cured in compliance with Clause 1024. Lower Strength concrete bases and subbases shall be cured in compliance with Clause 1026.

22 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 1000-6. This working time is a function of degree hours.

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.

1022 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, roller beams or hand guided methods. Hand tamping beams may only be used for short lengths or infill bays or tapers. Reinforcement, dowel bars and tie bars shall be supported in position in accordance with Clauses 1007, 1010 and 1011 respectively, except where two layer construction is used and reinforcement is placed on the bottom layer.

2 The concrete shall be spread uniformly without segregation or varying amounts of pre-compaction, by conveyor, chute, blade or auger. The concrete shall be struck off by a screed or auger so that the average and differential surcharge is sufficient for the surface of the slab to be at the correct levels after compaction of the concrete.

3 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 Joint grooves shall be constructed in compliance with Clause 1012. 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 1023.

7 The surface shall be cured in compliance with Clause 1024, within the time to completion given in Table 1000-6.

1023 Finished Surface Requirements

Macrotexture of Running Surfaces

1 The macrotexture of running surfaces for pavement widening, partial reconstruction and repair shall comply with sub-Clauses 2 to 6 of this Clause, other pavements shall comply with sub-Clause 2 and sub-Clauses 7 to 8 of this Clause.

2 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.

Brush Finish Macrotexture

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

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

5 Macrotexture depths shall be as required in Table 1000-7.

6 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 the contract, by retexturing the hardened concrete surface as described in Clause 1025. 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 1000-7. The treatment shall not affect the requirements of Clause 702 in respect of surface levels or surface regularity.

Table 1000-7: Macrotexture Depths

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

Performance Characteristics of Concrete Road Surfaces

7 The surface macrotexture shall meet the performance requirements stated in Table 1000-7.

Texture of Concrete Bases

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

1024 Curing

1 Immediately after the surface treatment described in Clause 1023, the surface and exposed edges of the surface shall be cured, without disturbance, for a minimum period of 7 days, by the application of a resin based aluminised curing compound, or polythene sheeting or a sprayed plastic film which hardens into a peelable plastic sheet and which shall be removed before road marking and opening to traffic. Where the concrete is to receive a thin surfacing overlay, the surface and exposed edges shall be cured for a minimum of 7 days by the application of a curing agent. If the concrete is to be overlaid by bituminous surfacing the curing agent shall be compatible with the bond coat and installation requirements for the thin surfacing in accordance with Series 900.

2 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 Continuously reinforced concrete bases shall be cured in accordance with this Clause. Immediately prior to laying the bituminous surfacing or upper base, a cationic bituminous tack coat shall be applied in accordance with Clause 913 at a rate between 0.35 l/m² to 0.55 l/m².

7 To achieve high early strength for early use by vehicles, insulation blankets as described in Clause 1034 may be used for accelerated curing.

1025 Texturing of Hardened Concrete

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

2 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:

a) 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.

b) At each of the 10 locations the depth of 10 adjacent grooves shall be measured.

c) 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.

d) 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.

1026 Lower Strength Concrete

Grades and Constituents

1 The strength for Lower Strength concrete shall be as described in Clause 1001 with the following constituents:

a) cements as described in sub-Clause 1001.3 and water/cement ratio as described in sub-Clause 1001.4;

b) aggregate shall be in accordance with sub-Clause 1001.6.

Consistence (Workability)

2 Consistence shall comply with Clause 1005.

Placing

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

Compaction

4 The spread Lower Strength concrete shall be compacted using internal or external vibration, or a combination of both to meet the required density. Compaction and finishing to level shall be completed within the times given in Table 1000-6.

Joints

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

Curing

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

Sampling for Testing

8 Sampling shall be as specified in Clause 1003.

Density

9 The density shall be determined as required in Clause 1003.

Strength

10 The strength shall be determined as in Clause 1004.

Trial Concrete Mixes

11 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 At least 10 days before the start of the main Lower Strength concrete works a trial length of at least 400 m^2 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 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 The surface of the Lower Strength concrete after compaction and finishing and before overlaying shall be free from ridges, loose material, pot holes, ruts or other defects.

1027 Measurement of Macrotexture Depth – Volumetric Patch Technique

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

1028 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 be used for patch repairs where insufficient time for adequate curing of a cementitious cement mortar exists.

2 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 MSA EN 12620. Coarse aggregate for fine concrete shall be (4/10) single sized aggregate complying with MSA 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/mm^2 before opening to traffic. For thin bonded repairs using high early strength concrete, air entrainment is not required.

1029 Full Depth Repairs

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, 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 For continuously reinforced concrete slabs (CRCP or CRCB) the edge of the repair shall be not less than 0.5 m from the nearest crack and not less than 3 m from a transverse construction joint at ground beam anchorages.

Where this and the provisions of sub-Clause 3 of this Clause would otherwise require a longitudinal repair joint within 1 m of the existing longitudinal joint or edge, the repair shall be extended to align with that longitudinal joint or edge.

3 High early strength concrete shall be able to achieve 25 N/mm^2 before opening to traffic. For full depth repairs using high early strength concrete, air entrainment is not required.

Part Width Repairs

4 Providing all the following criteria are met, part width repairs may be carried out in accordance with sub-Clause 4 of this Clause:

a) the transverse width of the repair shall not exceed 45% of the width of the slab under repair; and

b) the longitudinal joint which would be formed by the repair shall not occur within the wheeltrack; and

c) 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

5 For full width repairs the following criteria shall apply unless otherwise specified in contract specific IM Appendix 7/2:

a) 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.

b) 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.

c) 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

6 Any replacement dowels and tie bars shall comply with the requirements of Clauses 1010 and 1012 respectively. Epoxy mortar shall be to the manufacturer's recommendation for this specific application.
Where repairs straddle a movement joint with an adjacent slab, tie bars shall be omitted and the joint between the slabs debonded to ensure that movement patterns are not restricted.

Crack Repairs

7 Stitched crack repairs shall be either:

a) Type 1 – Staple Tie Bar Repair
b) Type 2 – Diagonal Tie Bar Repair

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

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

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

1030 Bay Replacement

1 Where individual bays are to be replaced they shall match the design thickness of the original concrete including reinforcement if originally included.

2 The replacement bay shall be connected to the surrounding concrete with new dowel and tie bars at transverse and longitudinal joints in accordance with Clause 1010.

3 Grooves shall be formed in accordance with Clause 1012.

4 A surface texture as specified in Clause 1023 shall be applied and a sprayed resin based, aluminized curing compound.

5 Joints surrounding the new bay shall be sealed specified in Clause 1015.

1031 Summary of Rates for Sampling and Testing Concrete for Pavement Layers

1 Unless otherwise stated in contract specific IM Appendix 1/5, Table 1000-8 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 1000-8: Rates for Sampling and Testing Concrete for Pavement Layers

Clause	Test	Rate (the greater number shall be used)	
1002	Air content	a) Main slab	1 per 300 m^2 or 6 per day
		b) Slabs less than 300 m^2	1 per 20 m length or 3 per day
1003	Density	a) Trial length	A minimum of 3 cores at a rate of 1 core per 1000 m^2 sets of
		b) Main Slab	3 cubes for every 400m^2 of concrete laid
1004	Strength	a) Main slab	3 cubes per 400m^2 not less than 6 sets per day. 1 to be tested at 7 days and 2 at 28 days.
		b) Trial length	At least 9 cubes, 3 to be tested 7 days and 6 at 28 days
1005	Consistence	a) Main Slab – Initial 50 m^3 – Subsequently	3 samples, 1 per 150 m^3 or 1 per production day
		b) Slabs less than 150 m^3	3 samples in the first 50 m^3 then 1 more
1018	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
1023	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.
1026	Lower Strength	As in Clause 1003 and 1004	A minimum of 3 cores at a rate of 1 core per 1000 m^2.

	Concrete In situ density Strength	a) Main slab	3 cubes per 600m^2 not less than 6 sets per day. At least 6 cubes, half to be tested 7 days and half at 28 days
		b) Trial length	3 cubes per 600m^2 not less than 6 sets per day. At least 6 cubes, half to be tested 7 days and half at 28 days

1032 Foamed Concrete

1 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 Foamed concrete used for backfilling excavations, including trench reinstatement, under road pavements shall have the following compressive strengths:

a) A minimum cube compressive strength of 4 N/mm^2 at an age of 7 days.

b) A maximum cube compressive strength of 10 N/mm^2 at an age of 7 days.

(The compressive strength shall be determined by testing foamed concrete cubes which have been made in accordance with MSA 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 MSA EN 12390-2 and tested for compressive strength in accordance with MSA EN 12390-3.

3 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 MSA EN 12620. Larger size aggregate may be used provided it can be shown to be practicable.

4 After placing, foamed concrete shall not be tamped, or otherwise compacted.

5 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.

1033 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 Clause 1023 and where otherwise specified in this Clause.

2 The Contractor shall complete contract specific IM Appendix 10/1 and submit this with his tender documents. If after acceptance the Contractor wishes to change the proposals contained in contract specific IM 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 contract specific IM Appendix 10/1. If laid in two layers the surface layer shall be laid monolithically with the lower layer.

4 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:

a) The surface layer shall be not less than 40 mm thick. The coarse aggregate shall comply with the size requirements of contract specific IM Appendix 7/1.

b) For 6.3/10 mm coarse aggregate or 4/8 mm coarse aggregate as required in contract specific IM 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.

c) The fine aggregate grading shall comply with the 0/2 (FP) or 0/1 (FP) grading in MSA EN 12620 except that not less than 99% of the mass of the material shall pass the 2 mm sieve.

d) The coarse aggregate shall comprise at least 60% by mass of the oven dry constituents of the concrete.

e) The polished stone value (PSV) and the aggregate abrasion value (AAV) of the coarse aggregate determined in accordance with MSA EN 1097-8 shall be as specified in contract specific IM Appendix 7/1. The Category of flakiness index of the aggregate is FI15.

f) Hardness and durability of the coarse aggregate shall be as described in sub-Clause 902.2.

g) The type of cement used in the concrete shall be limited to Class 42.5N/42.5R Portland cement CEM I complying with MSA EN 197-1. The minimum cement content of the concrete shall be 375 kg/m^3 and the maximum free water/cement ratio shall be 0.40 due to the requirement to brush and expose the surface.

h) 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 contract specific IM 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:

a) 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.

b) 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.

c) 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.

d) 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.

e) 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 1021, travelling across the slab before the application of a retarder complying with MSA 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 1029 to the extent required to obtain compliance with the specification.

Production of an Exposed Aggregate Surface

8 In order to obtain a suitable exposed aggregate surface the main requirement shall be the removal of the surface mortar from the top of the slab to produce an exposed aggregate finish. This objective may be achieved by the application of a suitable cement set retarder which is sprayed on the surface of the fresh concrete immediately after it has been levelled and finished. Retarded mortar shall be removed by wet or dry brushing as stated in contract specific IM 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 contract specific IM 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 contract specific IM 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 The brushing equipment nominated by the Contractor in contract specific IM 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 1024. 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.

Surface Macrotexture Depth and Remedial Measures

27 The texture depth of the surface of the concrete shall be measured using a volumetric patch technique described in MSA EN 13036-1. The average macrotexture depth of each 1000 m section of carriageway lane, or each carriageway lane where less than 1000 m, shall comply with the requirements of contract specific IM Appendix 7/1.

Any individual result shall be neither greater than the maximum, nor be less than the minimum value of macrotexture depth stated in contract specific IM Appendix 7/1.

28 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 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 1025 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.

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

32 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 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 MSA EN 13036-1.

35 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 The macrotexture depth shall be tested for compliance in accordance with sub-Clauses 38 and 39 of this Clause.

38 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 MSA EN 13036-1.

39 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.

1034 Weather Conditions for Laying of Cementitious Materials

1 Road pavement materials in a frozen condition shall not be incorporated in the works.

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

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

1035 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 Concrete slabs may be used by traffic when the cube compressive strength is assessed to have reached 25 N/mm^2 for pavement surface slabs, or 20 N/mm^2 for bases with asphalt surfacing. The method of assessing the time when this strength is reached shall be as described in Clause 1004.

3 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.

1731 Price Reductions

1 The Overseeing Organisation may carry out price reductions for non-conforming concrete and for the following characteristics in lieu of remedial work:

a) Compressive strength for pavement concrete

b) Thickness

c) Surface regularity

These shall be according to the formulae in the Series 150 - Price Reductions for Non-Conforming Materials. If the defects are for more than a single characteristic the price reductions are added unless stated otherwise.

2 The Overseeing Organisation shall not be under any contractual obligation to apply price reductions for non-conforming and/or defective works.