SERIES NG 1000
ROAD PAVEMENTS – CONCRETE MATERIALS

Contents

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NG 1000 (02/16) General

1 (02/16) Advice on the design, construction and maintenance of concrete roads and for concrete mix design is published in Standards and Advice Notes and

Design:	The Design Manual for Roads and Bridges (DMRB), Volume 7
Construction:	Mechanical Construction of Concrete Pavements and Ancillary Works, Concrete Society, Technical Report No. 45
Mix Design:	Design of Concrete Mixes, SO, 1988
Remedial Works:	Concrete Pavement Maintenance Manual published by the Concrete Society

2 (02/16) The pavement design requirements for concrete pavements should be based on the Design Manual for Roads and Bridges Volume 7 and shown in contract specific Appendices 7/1 and 10/1.

3 (02/16) The philosophy for compliance has now changed to that of an end performance requirement of the finished pavement with cores being taken and assessed for density and compressive strength as specified in BS EN 13877-2. This is supplemented by determination of the air voids in the concrete, minimum cement content, control of the water cement ratio and use of suitable materials for durability purposes. There is no assessment of concrete cubes for compliance, however, the Contractor may wish to operate an early age cube testing regime for concrete control purposes.

4 (02/16) With the use end performance specifications, subject to meeting the requirements of the specification, the choice of construction methods and consistence should solely be that of the Contractor. However, the exception to this would be for the final regulation of concrete surface slabs where the use of a longitudinal oscillating float is required to provide necessary evenness prior to macro texture being applied. The requirements for pavement construction details and location of joints should be accordance with this Series.

5 (02/16) For small contracts, and with the agreement of the Overseeing Organisation, the requirements of BS EN 13877-1 may be employed with a recipe specification, compliance by cube testing and density complying with Clause 1003. With a recipe specification the method of construction should comply with the requirements of this Series.

6 (01/20) For new construction and major maintenance the end performance specification should be used. The pavement should meet the requirements of BS EN 13877-2 and Clauses 1001 to 1004 are the appropriate Clauses for assessment of the pavement quality and Lower Strength concretes.

7 (01/20) There are a range of flexural strength options in HD26 and there is a need to establish a flexural to compressive strength relationship for each pavement quality concrete mix.

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

1 (02/16) Clauses 1001 and 1002 give the requirements for constituent materials and limits for designed concrete in the form required in BS EN 206-1, BS EN 13877-1, BS EN 13877-2, BS 8500-1 and BS 8500-2.

2 (01/20) Seven strength classes of concrete are included to meet the needs of sub-bases, bases with flexible surfacing, continuously reinforced concrete bases with flexible surfacing and slabs in the pavement surface.

3 (02/16) The strength classes for pavement surface concrete has been selected to provide greater durability for increasingly heavy traffic.

4 (02/16) The minimum cement or combination content is given in BS 8500-1 Table A18 and is dependent on the maximum aggregate size in the concrete.

5 (01/20) In addition to Portland cement CEM I, the term ‘cement’ includes other hydraulic binders such as combinations of CEM I and ground granulated blastfurnace slag (ggbs) and pozzolanic cements such as blends of CEM I and fuel ash (fa), whether they are blended on site or manufactured by blending or intergrinding. These include Portland blastfurnace cement, Portland CEM II/B-V cement and pozzolanic fa cement.

6 (02/16) Portland limestone cement should not be used in the top 50 mm of the road surface, as this would increase the fine calcium carbonate content and lead to slipperiness. Microsilica may be used with CEM I to obtain high early strength concrete.

7 (02/16) For durability it is necessary to have a water/cement ratio below 0.45 for pavement surface slabs. The water/cement ratio is defined as the ratio of free water to total cementitious content of the concrete.

8 (02/16) High early strength Portland cements should only be used where rapid construction is required. In such cases, insulation blankets will be required over the concrete to provide suitable curing conditions which will reduce the risk of thermal cracking of the concrete.

9 (02/16) High early strength cements, high cement contents and low water/cementitious ratios may be used when there is a need to open a section of concrete pavement to traffic early. Prescribed concretes of fixed proportions may be used in rapid construction for high early strength concrete. The proportions of ingredients to be used should be decided by trial concrete mixes which when tested provide the quality, consistence and strength development required for the particular application.

10 (01/20) Both CEM I /fa and CEM I /ggbs concrete have a long term increase in strength greater than CEM I concretes for the same 28 day strength and provide greater durability and resistance to chemical attack. However, there is evidence that all but the strongest concretes in the top 50 mm of a road pavement which contain more than 25% fa or 35% ggbs are more likely to suffer from damage under freeze/thaw conditions, and is the reason the amount of fa and slag is limited to these values. If fa is included in the concrete it permits lower water/cement ratios for a required consistence, so providing denser concrete of lower permeability and greater durability.

(02/16) Admixtures

11 (02/16) Air entraining agents are essential in all but the strongest pavement surface slabs to reduce freeze/thaw damage. Asphalt material provides some protection to concrete slabs and air entraining agents are not necessary unless the concrete is to be exposed to freeze/thaw cycling before the surfacing is applied or before the concrete has gained sufficient strength. A small loss in strength is to be expected with air entrained concrete compared with plain concrete with the same mix proportions.

12 (01/20) Plasticisers can be used to reduce water in the concrete, increase strength and maintain consistence at the required level. They can be beneficial in concretes with blends of CEM I with ggbs or fa, as the water reduction partially compensates for the loss of early strength.

13 (02/16) Where low water/cement ratios are used to obtain CC37 or C32/40 strength, retarders can be used in high summer temperatures, to ensure that the finishing processes can be completed in time.

(02/16) Aggregates

14 (02/16) The maximum size of aggregate allowed is 40 mm, but the Contractor’s choice of size will depend on construction methods, and his ability to achieve surface regularity, properly constructed joints and correct alignment of dowels. Larger aggregate provides an advantage in producing a more stable concrete in the lower layer, while 20 mm aggregate is preferable in the top course for forming joints and achieving a good finish.

15 (02/16) Popouts can occur in the surface of the concrete slab when freeze/thaw susceptible particles are included in the aggregate. If there is a sufficient proportion of such particles this can lead to ‘D’ cracking which is a form of cracking caused by expansion due to freeze/thaw, close to transverse and longitudinal joints. The particles which can cause popouts with flint gravel aggregates are clay or chalk impurities or white flint particles.

16 (02/16) The white flints consist of nodules of cortex or harder flints covered in cortex which is weathered flint and is porous. Research has shown that all flint aggregates are porous but to varying degrees. Black flint is of very low porosity. Brown flints are three times more porous than black, and white flints are about four times more porous than brown flints. The overall porosity of an aggregate will depend on the proportion of white flints. Smaller particles tend to have higher absorption than larger aggregate sizes. In addition to freeze/thaw damage due to absorption of water there is a higher risk of alkali silica reaction in the presence of moisture in the porous aggregates.

17 (02/16) Porous flint aggregates have been found to be widely spread in the South of England, including certain marine sources. However, where local knowledge or experience of a particular source is satisfactory and the material properties are constant, the need for testing may be reduced.

18 (02/16) When dissimilar aggregates are used in two layer construction the effect of different thermal coefficients should be assessed. More easily-sawn aggregates may be preferred so that joint grooves can be made, but if used in the top layer above flint gravel for example, the effects of different thermal coefficients should be considered. The time for sawing joints will be dictated by the thermal characteristics of the flint gravel aggregate in the lower layer and not by the other aggregates.

19 (02/16) Although cracking due to alkali silica reaction (ASR) is rare in concrete pavements, identical requirements to those for structural concrete are specified. (See also NG 1704.)

20 (02/16) Where the magnesium sulfate (MS) test is used as a means of confirming source suitability, a certificate from a testing laboratory accredited in accordance with EN 45002 by an appropriate organisation accredited in accordance with sub-Clause 105.4 for those tests, showing a value no higher than the minimum specified and dated not more than 6 months previous to the start of the contract, should be provided.

For those sources seeking suitability based on historical evidence of satisfactory use, the following should be provided:

(i) Dated certification showing supply of materials conforming with all other aspects of Clause 1001.6.

(ii) Copies of dated delivery tickets showing materials, source and site supplied.

(iii) Documentary evidence of material source, site and tonnage supplied.

Evidence should be provided for at least two major sites.

Routine water absorption (WA) tests should be made on the delivered material. If any result from these tests exceeds the declared value (d) by more than 0.5 ie, > (d + 0.5) %, further investigation will be required.

21 (02/16) When recycled coarse aggregate or recycled concrete aggregate is used as an aggregate, grading variations and quality should be carefully monitored to ensure the requirements of BS EN 12620 and Table 2 of BS 8500-2 are achieved. Material quality should also be controlled by determining the resistance to fragmentation by the Los Angeles (LA) test method in BS EN 1097-2. When flint coarse aggregate containing white flints is present in the crushed concrete, the requirements of sub-Clause 1001.9 should be taken into account.

22 (02/16) The test procedure for identifying and quantifying constituent materials in recycled aggregates is described in Clause 710.

23 (02/16) When recycled coarse aggregate or recycled concrete aggregate is used, the maximum allowable proportion as part of the coarse aggregate should be determined from trial mixes.

24 (02/16) The method of test for chloride ion content in recycled coarse aggregate and recycled concrete aggregate should differ from that for natural and artificial aggregates due to the potential chloride content within any adhering cement fractions which needs to be taken into account.

25 (02/16) The acid soluble content of the fine aggregate is determined using BS EN 196-21 to assess the carbon dioxide conent (in %) and then multiplying this by the conversion factor of 100/44 from BRE Special Digest 1 to obtain the acid soluble carbonate content.

26 (02/16) To ensure adequate resistance to fragmentation of the aggregate, the aggregate should be Category LA_{35}. LA_{40} would be acceptable for the lower layer in two layer construction, and also for CRCB pavements.

NG 1002 (02/16) Air Content

1 (02/16) See sub-Clause NG1001.11.

NG 1003 (02/16) Density

1 (01/20) Density is required to be measured at regular intervals during paving as well as the trial length. The non-destructive method chosen by the Contractor must be calibrated back to cores taken from a trial.

2 (01/20) The minimum volume of the core, or any part of it, to be tested should not be less than one litre or ($50 \times D_{MAX}^3$), where D_{MAX} is the nominal maximum size of the course aggregate in mm.

3 (01/20) The minimum number of cores that should be tested in the trial area is six. However, for small areas, Category 0 in BS EN 13877-2 may be specified by the Overseeing Organisation, which does not require density testing.

4 (02/16) The water-displacement method is recommended as this is the most precise technique for determining the volume of the core.

5 (02/16) Where cores contain tie bars or other reinforcement, allowance for the amount of steel should be made in any calculation of the density of the concrete.

6 (02/16) As a rough rule for assessment of strength, a 1% reduction in density equates to a 5% loss of strength of concrete.

7 (02/16) When two radically different concretes are used in the slab in two-layer construction, the density assessment should be carried out on the two concretes separately.

8 (02/16) The same cores can be used for the density and strength testing.

9 (01/20) Further information is available in the Britpave Guide to Non-Destructive Density Testing of Concrete Pavements.

NG 1004 (02/16) Pavement Concrete Strength

1 (01/20) Concrete strength shall be monitored using the compressive strength of cubes. A trial shall be carried out to determine the relationship between flexural strength & compressive strength of the mix.

2 (02/16) The average diameter of the core should be at least 4 times the maximum aggregate size and not less than 100 mm. A correction factor for h/d ratios greater than one is given in Table 1 of BS EN 13877-2. The core should be tested in a saturated condition and no allowance should be made for any steel in the core.

3 (02/16) The core dimensions, the shape and the flatness tolerance of the ground surface should conform to the requirements of BS EN 12390-1. The top and bottom faces of the core should be ground as this gives more consistent results and eliminates the health and safety problems associated with other end preparation techniques.

4 (02/16) The tested specimen should be representative of the concrete from the full depth of the pavement. The whole core should be tested as taken, but where the core is tested in two parts, the lower corrected strength should be taken as representative of the concrete strength at that location.

5 (01/20) The use of corrected core strength should be avoided but if it is used then Correceted core Strength = 0.85 x Cube strength

6 (01/20) The 28 day acceptance criteria specified in BS EN 13877-2 for corrected core compressive strength in N/mm^2 are:

(i) The mean value of any four consecutive results $\geq f_{ck,core} + 4$

(ii) Any individual value $\geq f_{ck,core} - 4$

Where $f_{ck,core}$ is the specified characteristic core strength.

7 (01/20) The average value of 4 results represents 4000 m² of work at the specified rate of testing. If the Contractor wishes to reduce the area of pavement at risk he may wish to arrange for a higher rate of testing.

8 (01/20) In the event of the pavement concrete failing to meet the compliance criteria the amount of substandard pavement should be determined. This is achieved by taking cores in an area deemed acceptable and determining the mean value of four cores. Additional cores should be taken at either end of the area that does not comply until the running mean of four, at each end, is at least equal to the mean of the four cores from the acceptable area.

9 (01/20) When two radically different concretes are used in the slab in two-layer construction, the statistical check on strength results should be carried out on the concretes separately.

10 (01/20) In the trial length the same cores can be used for the strength and density testing.

11 (01/20) When working to BS EN 13877-1 and BS 8500-1 the average value of any four consecutive 7 day results should not fall below the strengths in Table NG 10/1.

TABLE NG 10/1: (01/20) **7 Day Cube Compressive Strengths**

Class of concrete	CEM I concretes N/mm²	CEM I with fa or ggbs concretes N/mm²
C32/40	35	29
C25/30	27	22
C16/20	18	14
C12/15	13	11
C8/10	8	7
C6/8	5.5	4.5

NG 1005 (02/16) Consistence (Workability)

1 (02/16) The consistence of the concrete at the point of placing should enable the concrete to be fully compacted and finished without undue flow. The optimum consistence for concrete to suit the paving plant being used should be determined by the Contractor.

2 (01/20) The Degree of Compactibility (Compaction Index or CI) test is a suitable consistence test for most of the stiff concretes required for machine paving. The CI test or the Vebe test should be used on trials of cohesive concretes, eg. when ggbs or fa are used, to measure the effect of vibration for a range of CI values.

3 (02/16) The optimum CI at the paver will need to be reassessed at intervals depending on the climatic conditions.

4 (02/16) Consistence should be constant. A useful check on whether the consistence is constant can be obtained by noting the power input to the mixer. If necessary, plasticising or retarding admixtures should be used to suit local or weather conditions.

5 (02/16) The target values for the Compaction Index will vary with the concretes and materials used and with the weather. Preliminary work indicated that:

Compaction Index = 2.676 – 1.633 x Compacting Factor

Giving approximate values of:

(i) single layer construction 1.37 – 1.29

(ii) two layer construction

top layer 1.37 – 1.32

bottom layer 1.45 – 1.40

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Low consistence is required in the concrete to ensure that inserted dowel bars are retained in position. Higher consistence is necessary to allow the texturing and finishing to be completed satisfactorily within the time available. In practice a compromise is required depending on the method of construction. However, it is likely that all concretes will be in Compaction Class C1.

6 (02/16) As uniform consistence is of prime importance for the slab to meet the requirements of the specification, it is in the Contractor's interest to control it by frequent testing at the batcher so that adjustments can be made quickly before too much concrete is transported to the paver. Tests at the paver are also required to ensure that the concrete placed in the paver is within specified limits.

7 (02/16) For small scale works where ready mixed concrete is used, no water other than any amount required to produce the specified consistence, should be added to the truck mixer drum before discharge. No additional water should be permitted in concrete which has been in transit for more than two hours.

8 (02/16) Although no precision data is available for the Compaction Index test it is suggested that a similar tolerance should be achievable to that formerly required for the Compacting Factor test.

NG 1007 (02/16) Separation and Waterproof Membranes

1 (01/20) A plastic sheeting separation membrane is not required on a bound or unbound sub-base.

NG 1008 (02/16) Steel Reinforcement

1 (01/20) Supports for reinforcement should be sufficiently numerous and rigid so that the reinforcement will comply with BS7973-2, specifically Table 1 and Section 8.1.

2 (02/16) When fixed height supports are used, eg. rings of standard mesh reinforcement, it is necessary to ensure a good surface regularity to the sub-base or base on which the reinforcement is laid.

3 (02/16) When prefabricated sheets are laid in two layer construction it is permissible to lay alternate sheets along the pavement with transverse steel uppermost. This allows the transverse lap to be made by placing one transverse bar of one sheet within the first mesh of the next sheet. This requirement will not apply if flying ends are provided in the prefabricated sheets at the position of the laps.

NG 1009 (02/16) Transverse Joints

1 (02/16) Transverse joints are normally contraction joints. Warping joints are retained in Clause 1009 for special cases, eg. for extra joints at manhole positions or when unreinforced slabs are alongside reinforced slabs, or in long narrow or tapered URC slabs between normal joint positions, to reduce the length/width ratio of the slabs to 2 or less, and in other similar situations. Alternatively, instead of extra joints, slabs with an aspect ratio greater than 2 may be reinforced. The spacing of transverse joints should be described in contract specific Appendix 7/1.

2 (02/16) Structures within the pavement depth should be isolated by at least 5 m of hot rolled asphalt or dense bitumen macadam base.

3 (02/16) At buried structures the concrete slabs and sub-base should be continued over the structure. The sub-base should be isolated from the structure by not less than 150 mm of granular fill. Composite bases should not be permitted to abut the structure.

4 (02/16) At the ends of CRCP, jointed reinforced slabs with expansion joints should be constructed between the anchorages and any other form of pavement. At the ends of CRCB, a jointed unreinforced slab with an expansion joint should be constructed between the anchorages and any other form of pavement. Between anchorages the only joints will be construction joints.

5 (02/16) Where an unreinforced carriageway is constructed in more than one width and transverse cracking occurs before concreting the adjacent width, repair of the cracks should be carried out before the laying of adjoining slabs to reduce the risk of sympathetic cracking. If extra joints are put in as part of the repair, they should be matched in adjacent subsequently laid slabs.

NG 1010 (02/16) Longitudinal Joints

1 (02/16) Longitudinal joints are required at such a spacing as will reduce the combination of thermal warping stresses and loading stresses to a minimum and reduce the risk of longitudinal random cracking. The maximum bay width is therefore set at 4.2 m, except when reinforced pavements are constructed in widths up to 6.0 m (or 5.0 m and 7.6 m respectively with limestone aggregate).

2 (02/16) Joints may be situated at or near lane lines or in the centre of a lane, whichever is the most economical for the Contractor's method of construction, but they should not be near the wheel track especially in heavily trafficked lanes.

NG 1011, NG 1012, NG 1019 (02/16) Placing and Inspection of Dowel Bars and Tie Bars

1 (02/16) When dowel and tie bars are to be inserted vertically into fresh concrete the concrete should be fully compacted over them. Tie bars may be inserted into the side of a slab provided the method ensures a good bond to the concrete.

2 (01/20) The fixings for dowel bar assemblies should be tested for strength in the trial length.

3 (02/16) To check the alignment of dowel bars it is necessary to remove the fresh concrete carefully to expose the top half of each end of each bar across the whole width of the slab under construction. The position of the ends of the bars can be measured relative to the side forms or wires by means of steel tapes stretched between the forms or wires, using a vertical spirit level placed alongside the bars.

The alignment for level can be measured from nylon lines pulled taut across the forms or measured using a gauge incorporating a spirit level with legs 300 mm apart with forks at the ends for placing over the bars. The legs can include rules to measure the position of the bar ends below the steel tapes.

4 (01/20) As the measurement of all the bars in any one joint is time consuming it will not be possible to complete the measurement, re-compact and finish the concrete within the normal time allowed in Table 10/7. It will be necessary to reinstate with a 1 m long reinforced slab as a full depth repair. Alternatively, the penultimate joint in the trial length could be selected for the dowel alignment check. The remaining concrete in the last slab is then discarded before work starts again.

5 (02/16) Dowel bars, tie bars and transverse reinforcement across a longitudinal joint need to be protected from corrosion. Suitable bituminous protective paint is allowed for reinforcement. Tie bars and dowel bars should be protected by bonded polymeric corrosion resistant coatings.

NG 1013 (02/16) Joint Grooves

1 (01/20) Sawn grooves are preferred for transverse contraction and warping joints as they avoid disturbance to the surface of the plastic concrete. The timing of sawing the hardened concrete is critical. If sawn too soon the aggregate will be plucked out, if too late, the concrete will have cracked already. With flint gravel aggregates in normal strength concrete, cracking may occur before sawing can begin. With high early strength concrete there is a better opportunity for sawing flint gravel concrete. In two course construction, with flint gravel in the bottom layer, the time for sawing before cracking will be governed by the flint gravel, as it has the highest coefficient of expansion. If a crack forms before or during sawing, it should be left without sawing alongside it until the time comes to seal it. If the crack cannot be encompassed within a 40 mm wide joint, the slab should be repaired. In slabs constructed in more than one pass of the paver (one rip) cracks may occur earlier in the second pass under the influence of joint movement of the first pass unless sawing is carried out as soon as possible.

2 (02/16) Narrow crack-inducing grooves should be sawn first and widened for sealing later. In order to meet the requirements for high paving speeds with an economical number of saws and still reduce the risk of random cracking, it is common practice for approximately every third joint to be sawn as early as possible; the intermediate joints being sawn within the next few hours.

3 (02/16) Wet-formed joint grooves with bottom crack inducers will be allowed for winter work to ensure cracks appear at joint positions. In such cases it is important that the concrete is fully recompacted around the former or cork seal. As the joint groove former is placed just below the surface of the concrete, it is important to ensure that the surface of the concrete is a straight plane between the forms at wet-formed joints. Otherwise if the surface level is bowed by excess concrete the former will be tilted by the diagonal finisher when planing off the excess concrete. The depth of the top layers should be considerably greater than the depth of the joint former so that the positions of the formers are not influenced by the stiffness of the bottom layer.

4 (02/16) It is not good practice to set the formers low and pull them up again after the diagonal finisher. It is likely to cause lack of compaction of the concrete adjacent to the former and may lead to separation of the removable part of the former and bridging by mortar under it, which may cause horizontal cracking. However, it may be necessary on occasions to adjust the depth of former in which case the whole former must be raised in a vertical plane only using suitable tools. If excess concrete is not cleaned off above the former, concrete or mortar will bridge over the joint and will cause spalling of the arrises before sealing.

5 (02/16) The joint groove must form a complete discontinuity across the slab, so that the concrete will crack along the joint position. It is necessary to ensure that the groove is continued across the longitudinal joint and to the edge of the slab by sawing when forms have been removed.

6 (02/16) In normal summer work in URC only about one joint in four will crack initially. These joints tend to have greater movement at first until the other joints crack later with seasonal temperature changes or under traffic. In pavements constructed in two or more slabs the movement of joints in one slab will influence the cracking of uncracked joints in the adjacent slab from the longitudinal construction joint to the outer edge. A lack of discontinuity along the joint or dowel restraint may result in a crack appearing off line. This can be avoided by cleaning the top of the joint formers, using bottom crack inducers, and ensuring dowel alignment is satisfactory.

NG 1015 (02/16) Joint Filler Board

1 (02/16) Expansion joint filler board should have a pointed ridge as shown in the HCD, drawing number C2. The top of the ridge should be below the surface of the concrete but just within the depth of the sealing groove. It acts as a crack inducer initially and the sealing groove is sawn out later. Any other method of forming the sealing groove should be demonstrated in a trial.

NG 1016, NG 1017 (02/16) Preparation and Sealing of Joint Grooves

1 (02/16) One of the main causes of compression failures and damage to joints is the ingress and build up of solids or water-borne silt in the joint over a long period preventing or limiting proper movement at the joint. The requirements of a pavement joint sealant are:

(i) It should prevent the ingress of any solid matter into the joint.

(ii) It should form a waterproof seal and prevent most of the surface water from entering the joint crack.

(iii) It should be robust, have high extensibility, be resilient, be resistant to tearing, have a good bond to concrete and be unaffected by ageing and weathering.

2 (02/16) Preparation of the sealing groove is most important. In order to remove any laitance from the groove sides and to provide a good key for applied seals, the joint sides must be grit blasted. Grinding may be permitted to clean small lengths of groove where grit blasting is impracticable. Wire brushes may be used to remove filler board prior to grit blasting, and for preparing grooves for compression seals.

3 (02/16) Cracks will appear at transverse joints sporadically in new unreinforced concrete construction. Those that crack the earliest tend to have greater movement than would be expected if all the joints cracked evenly. This means that the groove width in winter may be wider than originally constructed, and allowance for future compression of the sealant should be made when sealing in cooler periods and the joint grooves should not be overfilled. Because of the extra movement in new URC pavement joints, cork and compression seal widths need to be greater to maintain them in compression.

4 (02/16) For compression seals the width of the seal required is governed by the calculated movement to ensure that the seal remains always in compression.

5 (01/20) With all sealants it is important to keep the top of the sealant below the surface at transverse joints to prevent damage by traffic when the joints are compressed in summer. When sealing in colder periods the level of the seal should be lower than in summer to allow for the compression of the seal upwards in warm periods. When longitudinal joints are sealed, the seal should be just below the surface.

6 (02/16) There are two grades of two part cold-applied sealing compounds to BS EN ISO 11600, used in structures and kerbs, etc; one for horizontal joints and the other for vertical joints. The grade offered by the Contractor should be suitable for the particular joint.

7 (02/16) Although the British Standards refer to two part sealants some types have three parts. These sealants may also be permitted as it is often advantageous to vary the quantity of retarder (within limits set by the manufacturer) according to the temperature conditions at the time of sealing, rather than include it in the hardener. In cooler weather cold applied sealants take longer to cure.

8 (02/16) In circumstances where longitudinal joints may not be on line with road markings, consideration should be given to the avoidance of contrasting colours of joint sealant and pavement. The requirements for joint sealant colour should be included in contract specific Appendix 7/2.

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

1 (02/16) Wherever possible, manholes and gullies should be sited outside the pavement, but if they occur in the pavement they should either straddle or be adjacent to a transverse joint in jointed concrete pavement. If the joint spacings are such that a manhole or gully position is in the middle of the slab, an extra joint is necessary which should be a tied warping joint.

2 (02/16) Details of the reinforcement required in the main slab and in CRC slabs around manhole or gully slabs are given in the HCD.

3 (02/16) Gully and manhole slabs should have square corners as in the HCD, on the sides that are not adjacent to a joint to avoid a proliferation of cracks induced from oblique corners.

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

1 (02/16) In order to avoid adverse effects on the riding quality it is most important to check that all the sensors on any wire-guided machine are functioning within the correct tolerances during all paving, especially if the machine has been standing overnight in wet conditions.

2 (02/16) The sub-base or any bedding for forms should be of sufficient strength to carry the train or paver without vertical movement and where necessary to carry any construction traffic. Cement bound bedding should have sufficient time to reach the necessary strength before paving begins. Precautions should be taken to prevent any construction traffic from damaging the subgrade next to the rails or paver tracks and so altering the levels after they have been set. Bedding other than the sub-base itself should be broken out after any section of pavement has been constructed and before any adjacent concrete is laid alongside, so that drainage of the sub-base and pavement is not impaired.

NG 1024 (02/16) Construction by Machine

1 (01/20) Descriptions of two main types of pavers (fixed form and slip-form) are given in the Concrete Society Technical Report 45.With either type of machine the slab may be laid in one or two layers. However, there are more restrictions on single course paving.

2 (02/16) With fixed form paving, the control of surface levels is mainly governed by the spreader being able to spread the concrete evenly to the correct surcharge. It is bad practice to rely on subsequent regulating beams and the diagonal finisher to achieve the correct levels by a major planing operation. If the first regulating beam in the compactor/finisher has too big a roll of concrete anywhere along the beam the setting of the spreader should be changed. The roll in front of the regulating beam or diagonal finisher should be between 100 mm and 150 mm evenly distributed along the beam. If the roll is too great then adjustment should be made at the spreader. If segregation occurs in the roll, adjustments to the consistence of the concrete may be necessary.

3 (02/16) With slip-form pavers there is a tendency for edge slump in the concrete immediately after leaving the paver. If the slump is out of tolerance for level fixed side forms are required where concrete being placed has to be matched to another section of pavement, eg. at slip road tapers or when construction is in two or more strips. In other work it is advisable for transverse finishing operations to be made against the crossfall to reduce the effect of flow towards the low side. Similarly on steep longitudinal gradients construction should preferably be up the gradient.

4 (02/16) Joint groove formers should be cleaned prior to and after texturing to prevent concrete or mortar bridging over them, which would later cause spalling of the joint arrises.

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

1 (02/16) If sufficient internal vibration is provided and truss type finishing screeds with multi-vibration points are used together with scraping straight edge and bull floats where necessary, a well compacted slab with a satisfactory level and finish can be achieved. There is no technical restriction on the lengths of pavement which can be constructed in this manner, which is suitable for short bypasses, urban areas, widening or slip roads. More even distribution of the concrete is obtained if auger spreaders are fitted to the screeds.

2 (02/16) Slip road tapers adjacent to a concrete pavement should always be of a similar construction for the full length of the taper, which is adjoining the concrete slab, in order to keep the same depth of construction across the whole pavement width. If the remainder of the junction or roundabout is of flexible construction, a standard transverse transition slab should be included at the end of the taper after the slip road has diverged and is separate from the carriageway. The slip road taper slab should not be tied longitudinally to the main carriageway after the point where the traffic lanes of the slip road leave the main carriageway, as this is the point at which changes in level and direction of movement of the slabs can occur. Joints in that part of the slip road taper which is tied to the carriageway and constructed at the same time can be normal to the axis of the main carriageway and in the same line of the main carriageway joint.

NG 1026 (02/16) Finished Surface Requirements

1 (01/20) The brush finished texture is only permitted when maintaining or widening an existing pavement. All new exposed concrete pavements need to include a performance surface which is demonstrated in a System Installation Performance Trial (SIPT). It is important that a uniform finish is achieved both along and across the slab. Care should be taken to minimise variations which may occur with differences in ambient conditions and the consistence of the concrete.

(02/16) **Brushed Concrete Surface Finish**

2 (02/16) From experience a suitable macrotexture can be obtained by using a wire brush made of 32 gauge tape wires grouped together in tufts and initially 100 mm long. The brush should have two rows of tufts. The rows should be 20 mm apart and the tufts in one row should be opposite the centre of the gap between tufts in the other row. The brush should be replaced when the shortest tuft wears down to 90 mm long.

3 (02/16) If the macrotexture depth is over 1.25 mm it will produce unacceptable tyre noise. Trial lengths should be closely monitored and if the macrotexture depth is outside the limits, adjustments should be made to the consistence of the concrete, or to the pressure on the brush, or to the time when brushing is carried out after compaction, or the type of brush changed. Thereafter spot checks should be made on the concrete surface as necessary.

4 (02/16) Where the surface macrotexture from the average of ten results has been found to be deficient or excessive the areas to be rectified can be assessed from the individual measurements. If necessary, additional measurements can be made in a particular lane to decide the limit of treatment. If four or more successive individual measurements are deficient or excessive, the area relating to those measurements should be treated across the full lane (or lanes) width.

5 (02/16) Isolated areas less than 6 m in length need not be treated unless the macrotexture has been omitted altogether or riding quality is impaired. If such areas are close or occur in a regular pattern or chain, they should not be left untreated.

6 (02/16) Measurements should be carried out in sufficient time before opening to general traffic to allow the Contractor to complete remedial works, taking into account the effect of wear of heavy construction traffic.

7 (02/16) The depth of grooved texture (hardened concrete) should be measured by means of a tyre tread gauge.

NG 1027 (02/16) Curing

1 (02/16) Curing is essential to provide adequate protection from evaporation and against heat loss or gain by radiation and so permit the concrete to achieve its designed strength. The retention of moisture is particularly important with cement or cement blends which have a slow rate of increase in strength. Without moisture the hydration process cannot be completed. Without adequate curing the concrete strength could be half the strength of the corresponding cubes cured in water in the laboratory.

2 (01/20) The best form of curing is to keep the concrete constantly damp. This can be achieved by covering the concrete with plastic sheeting, or by a sprayed plastic material which hardens into a plastic sheet, which can be removed by traffic, or by an aluminised curing compound. For small bays or patches, wet hessian covered by plastic sheeting is satisfactory. For concrete slabs and bases a waterproof bituminous spray is normally sufficient.

3 (02/16) Plastic sheeting or sprayed plastic film will avoid the risk of damage by rainfall and the consequent cost of rectification by surface grinding, retexturing or relaying. The use of tentage will also reduce the risk of rain damage but unless closed at sides and ends it could cause a wind-tunnel effect which would reduce the curing. Where tentage is used measures should be taken to prevent drips falling on to unhardened concrete. Tentage covers should overlap by a minimum of 500 mm. Remedial works leave a generally patchy, aesthetically unpleasant surface. The rate of progress of fixed form paving plant makes the provision of tentage feasible, but with the higher output of slip form pavers tentage is generally uneconomical, and without rails there could be damage to the sides of the pavement. Sprayed plastic film allows paving to continue in wet weather, except in heavy storms.

4 (02/16) Thermal insulation blankets provide accelerated curing and an increased rate of strength development.

NG 1028 (02/16) Trial Lengths

1 (02/16) Trials to prove new or modified machinery should be carried out off site or below pavement level. The Contractor is permitted to choose whether he lays the trial as part of the pavement or elsewhere, but if the former, he is not allowed to proceed with other trials or further paving at pavement surface level until any defective trial lengths have been removed, or rectified to comply with the specification.

NG 1029 (01/20) Texturing of Hardened Concrete by Transverse Grooves

1 (02/16) Experience has shown that grooving, with the grooves at an irregular spacing and of average size 3 mm wide by 4 mm deep as required, produces less tyre noise than surface dressing. It is the only acceptable method of retexturing the surface of concrete pavements as it will provide a long life texture.

Grooving across joints should be avoided as this could lead to minor spalling and damage to the seal. In order to obtain the minimum depth of 3 mm the setting of the machine should take into account the transverse irregularity of the surface. Isolated areas of substandard texture less than 1 m in length along the carriageway would be unlikely to require treatment except in special circumstances.

NG 1030 (01/20) Lower Strength Concrete

1 (01/20) Lower Strength concrete is the term describing lower strength concretes which, using present pavement design, are suitable only for sub-bases. Four classes of Lower Strength concrete have been selected. These provide a range of strengths sufficient to enable the Contractor to choose a concrete stronger than the minimum specified to permit early access onto a sub-base after laying.

The inclusion of Lower Strength concrete in the specification allows the Contractor to choose alternative methods of laying the sub-base most suited to the size and location of the contract; as a workable concrete via paving plant or by hand guided methods.

NG 1043 (02/16) Foamed Concrete

1 (02/16) Foamed concrete is a lightweight material produced by incorporating a preformed foam or an air entraining agent into a base mix of cement paste or mortar, using standard or proprietary mixing plant.

2 (02/16) Foamed concrete is normally prepared on site, either from basic constituents, or using ready-mixed base mortar delivered to site. However, subject to experience gained by prior development that the material is suitable for transport by road, it may be delivered to site entirely ready-mixed.

3 (02/16) Foamed concrete should be prepared in accordance with a mix formulation proven, by prior development testing, to yield a compressive strength within the required range. The wet density corresponding to the specified strength should be determined in the development testing.

4 (02/16) The wet density of the foamed concrete should be checked prior to and during placement or as agreed.

5 (02/16) On any site presenting special drainage or groundwater problems, the foamed concrete should be formulated to have a permeability not less than that of the surrounding ground. Alternatively a backfill layer of pea gravel, of 100 mm minimum thickness and surrounded by a geotextile filter fabric where appropriate, may be considered to offer an equivalent drainage potential.

6 (02/16) Foamed concrete flows very easily and may infiltrate, and block, any damaged drainage or ducting existing within, or immediately adjacent to, the excavation. Unguarded reinstatements can represent a drowning hazard for children.

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

1 (02/16) Guidance to the requirements specified in Clause 1044 is contained in Chapter 3 of HD 38 (DMRB 7.5.3).

2 (02/16) Methods and construction requirements for this type of surface should be based on the general requirements of Series 1000.

3 (02/16) The PSV and AAV requirements of the coarse aggregate in the surface layer concrete are dependent on the traffic category and should be specified in contract specific Appendix 7/1. Guidance on the PSV and AAV requirements is given in Chapter 2 of HD 36 (DMRB 7.5.1).

4 (02/16) Attention is drawn to the flakiness index requirement in Clause 1044 for the coarse aggregate in the top layer concrete. This is Flakiness Index category FI_{15}, rather than the more common FI_{20}.

5 (02/16) Sub-Clause 1044.5.(iv) specifies that at least 60% of the concrete (total mass of the constituents excluding water) should consist of the coarse aggregate specified in contract specific Appendix 7/1. This is to ensure that sufficient coarse aggregate is presented at the surface after brushing the laitance to expose the aggregate.

6 (02/16) Hardness and durability of the coarse aggregate should be as described in sub-Clause 901.2.

7 (02/16) The compiler should specify in contract specific Appendix 7/1, coarse aggregate size and appropriate macrotexture depth requirements using Table NG 10/2. A high speed road has an 85 percentile speed of traffic exceeding 90 km/h (55 miles/hour). The compiler should assess if the in-use traffic speed of the road is anticipated to be above this level.

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8 (02/16) The Contractor should be required to submit at the time of tender a completed contract specific Appendix 10/1, containing details of his proposed plant and equipment to achieve the required surface.

9 (02/16) The Contractor is required to submit to the Overseeing Organisation for their consent a detailed method statement one month prior to the commencement of site trials. In the UK trials have been successfully concluded using conventional rail mounted paving equipment, but in the rest of Europe and elsewhere contractors have normally chosen to use slipform paving equipment.

TABLE NG 10/2 (01/20) **Grading and Macrotexture Depth Requirements**

CATEGORY OF ROAD	COARSE AGGREGATE SIZE (mm)	MACROTEXTURE DEPTH REQUIREMENTS		
		AVERAGE	MAXIMUM	MINIMUM
High Speed Roads				
(> 90 km/h)	6.3/10	1.2 mm ± 0.25 mm	1.60 mm	1.10 mm
Low Speed Roads				
(< 90 km/h)	4/8	1.0 mm ± 0.20 mm	1.5.0 mm	0.75 mm

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

1 (02/16) Thermal insulation blankets laid on the finished concrete can enhance the rapidity of curing by the retention of heat. This is of benefit not only in cold weather, but also at other periods to accelerate the curing of the concrete slab.

NG 1048 (02/16) Use of surfaces by Traffic and Construction Plant

1 (02/16) Where there is a need to open a section of concrete pavement or base to traffic early after placing the concrete, high strength concretes may be used. To estimate the time when the required strength may be achieved trial mixes should be tested at various early periods to establish a rate of strength development. These times can be confirmed by testing cubes which were placed alongside the pavement in moulds insulated around the sides. However, such results can only be used as an expedient for the purpose and not for compliance with the specification.

(01/20) Roller Compacted Concrete Mixtures

NG1051 (01/20) Roller Compacted Concrete General Requirements

1 (01/20) Advice on design and construction of Roller compacted Concrete (RCC) is published in the Design Manual for Roads and Bridges (DMRB) Volume 7 and is also available in the Britpave Guide to Roller Compacted Concrete Pavements, BP/55. The clauses (for RCC mixtures) in Series 1000 refer to BS EN 14227-1, Hydraulically bound mixtures. BS EN 14227 requires aggregates to conform to BS EN 13242 which apply to aggregates obtained by processing natural or manufactured or recycled materials. Manufactured and Recycled aggregate materials are not permitted for use in the manufacture of RCC mixtures.

2 (01/20) The term ‘mixtures’ is used in preference to ‘materials’ to conform to BS EN 14227 Hydraulically bound mixtures, Specifications. The Parts of BS EN 14227 provide specifications for mixture composition and laboratory mechanical performance but do not cover production and construction methods. Series 1000 provides a mixture specification to suit design requirements and provides a specification for the construction of the pavement layers.

3 (01/20) Thickness design curves for RCC in HD 26 (DMRB 7.2.3) are based on the specification requirements in Series 1000 which link to design performance. Any Departure from the Series 1000 specification shall require review in context of any design assumptions; including the use of RCC over an unbound subbase, which is not a permitted option in HD 26 (DMRB 7.2.3).

(01/20) **Grading Characteristics**

4 (01/20) The grading of RCC is defined for the aggregate alone, excluding the binder constituent proportion.

5 (01/20) RCC may be required to carry site traffic and in-service traffic before having developed its strength. This means that the mixture should have good initial mechanical stability to prevent rutting and to allow the formation of cementitious bonds.

6 (01/20) RCC cubes with a minimum mean strength of 50N/mm^2 have been shown to have a min flexural strength of 5N/mm^2, which is the basis for design thickness of the RCC layer.

NG 1052 (01/20) RCC Constituents

1 (01/20) The binder shall be in accordance with Table 10/13. Other binder types are not permitted.

(01/20) **Aggregates**

2 (01/20) Table 10/14 gives requirements for aggregates using the Categories from BS EN 13242.

3 (01/20) A Category for the proportion of crushed or broken particles in coarse aggregate is specified. This is because crushed rock aggregate will support construction and in-service traffic better than rounded aggregate with the same grading curve. The specification for the mixtures requires Category $C_{100/0}$.

4 (01/20) The Los Angeles coefficient of coarse aggregate is a measure of its resistance to fragmentation and an indicator of mechanical strength. A lower value indicates greater resistance. The selection of Category LA_{35} is specified for RCC layers.

NG 1053 (01/20) Storage of Constituents

1 (01/20) The moisture content of aggregates stored at the production facility should be continuously monitored.

2 (01/20) Wet (conditioned) FA shall have no agglomerations greater than 10mm size to ensure a homogenous RCC product. The absence of agglomerations greater than 10mm size should be determined by sieving samples through a 10 mm size test sieve using not more than 10 seconds of gentle agitation by hand. Wet (conditioned) FA shall be stored at the source or at the production location for at least 72 hours before use, and have a minimum water content of 10%.

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

(01/20) **Production**

1 (01/20) In-plant mixing with batching by mass should be used to manufacture the RCC mixture. Continuous mixing plants, where the mass of the aggregate and binder are constantly recorded using load cells or similar devices, are considered to be mass batching plants.

2 (01/20) The plant should operate a quality management system which follows the guidance in BS EN 14227-1 Annex B. The objective of production control is to give assurance that the mixture conforms to the specification.

(01/20) **Layer Construction**

3 (01/20) The values of construction period in sub-Clauses 1054.2 and 1054.3 allow for the variation in the rate of hydration of different blends of cement binder with temperature. Until further research indicates otherwise, no hydration is assumed at temperatures below 3ºC; this is an established figure for cement.

4 (01/20) High-compaction paving equipment provides better compaction through the paving machine and requires less post placement rolling to achieve the required compaction than conventional asphalt paving machines equipped with only a vibratory screed. The less rolling required, the better the final surface regularity.

5 (01/20) Multi-layer lifts of RCC are not permitted and the HD 26 (DMRB 7.2.3) designs for RCC do not account for any scenario other than a single layer monolith installed on a bound foundation.

6 (01/20) The Contractor is responsible for protecting the works from weather damage. To protect RCC from drying or wetting during transport, it is normally necessary to sheet delivery vehicles. The process of sheeting should not cause undue delay to the delivery process.

7 (01/20) Segregation can be seen as zones of coarse aggregate without enough fine aggregate to fill the gaps between the larger particles. This should be avoided because it leads to an increase in the proportion of air voids. Large air voids can fill with water, giving rise to a large reduction in strength of the mixture and destruction of local inter-layer bond. Coarse and rounded aggregates and non-cohesive mixtures are prone to segregation. Rounded or crushed gravels are not permitted.

8 (01/20) Segregation often occurs in all-in aggregate stockpiles prior to mixing. This can result in variable and poorly graded mixtures. Segregation at the mixing stage can be avoided by using a number of aggregate fractions. A minimum of two aggregate fractions should be used each with a separate aggregate feed hopper.

9 (01/20) To assure layer integrity, the surface must be free of surface shearing, when a thin plate of compacted mixture becomes detached from the top surface. Surface shearing can be mitigated by using a combination of vibratory compaction followed by a pneumatic tyred roller (PTR). However, with some mixtures, the surface can be covered with fine surface cracking, which rolling (even with a PTR) will not remove. Such cracks are very shallow and are not detrimental to the RCC performance. The surface of RCC pavement more closely resembles rolled asphalt than a conventional concrete, may include minor surface tearing and be open-textured but should not exhibit segregation.

10 (01/20) The water content in the top part of the layer can be adversely affected by high temperatures and/or low humidity, particularly when associated with a high wind speed. This makes compaction difficult and can prevent setting and hardening in the top part of the layer. In order to maintain the water content, it may be necessary to spray water on the surface during compaction and start the curing stage immediately on completion of compaction.

11 (01/20) Compaction of the longitudinal joints within the permitted construction period in accordance with sub-Clauses 1054.2 and 1054.3 is a requirement to optimise load transfer across the joint. However, they will always be a relative point of weakness in the pavement, hence the requirement to locate them outside wheelpath zones.

12 (01/20) Compaction of RCC shall be carried out by vibrating roller(s). A pneumatic-tyred roller (PTR) may also be used as part of the compaction process. The suitability of the laying and compaction plant and construction procedures will be demonstrated during construction of the trial length.

13 (01/20) Longitudinal joints should present the same appearance and texture as the remainder of the surface and the accuracy of surface across the joints should meet the criteria specified.

14 (01/20) Early trafficking of the pavement may be permitted, if the traffic is well controlled. It should be noted that:

(i) RCC mixtures made with crushed hard aggregate should be suitable for immediate trafficking without demonstration;

(ii) Provided the IBI is greater than 50, the constructed layer should be suitable for immediate trafficking for the purposes of constructing subsequent layers.

(iii) Where there is a need to overlay the RCC with a bituminous surfacing immediately after placing and open the pavement to traffic early the stability of the constructed layer should be closely monitored. Early assessment of the times required to achieve early in-situ strength can be assessed by testing cubes made and cured in accordance with sub-Clause 1054.20 and placed alongside the pavement in moulds insulated around the sides during the trial period. These times can be confirmed by further testing during construction. However, such results can only be used as an expedient for the purpose and not for compliance with the specification.

(01/20) **Cold and Wet Weather Working**

15 (01/20) The rate of hydration of cement binders slows down at low temperatures and hydration can stop if the mixture temperature falls to close to 3°C. If freezing occurs in a mixture which has yet to attain full strength it may disrupt the bond between the binder and the aggregate. The formation of ice lenses can displace aggregate from RCC mixtures. The RCC mixture chosen by the Contractor should develop sufficient tensile strength to resist internal freezing, if it is likely to be subject to temperatures close to 3°C. Strength develops relatively quickly in a RCC mixture with minimum cement contents given in Table 10/13, so it is unlikely to be affected by low temperatures. The Contractor should use a risk assessment approach to evaluate and define appropriate weather and construction time criteria for RCC by considering:

(i) the depth of cover provided by the overlying layers;

(ii) the type and durability of the aggregates used in the mixture;

(iii) the likely strength gain of the mixture prior to overlay;

(iv) the site location (TRL Report RR 45 provides guidance on the influence of location);

(v) the likely construction date;

(vi) timely application of the curing membrane to prevent ingress of water.

16 (01/20) Due to the large output for RCC paving works that are likely to be achieved versus those of concrete, additional practical considerations are require to be taken in to consideration to ensure that the RCC is correctly protected from cold and wet weather. For large paved areas, it is often impractical to apply insulation blankets and/or polythene foam sheets for the purpose of protecting the RCC for the necessary curing time. In addition, the porosity of the RCC surface is a consideration for potential early life frost damage prior to overlay with asphalt therefore the integrity of the bituminous curing membrane must be maintained to prevent possible ingress of surface water.

17 (01/20) Care should be taken to ensure a full coverage of the surface of RCC with bituminous curing emulsion at the specified rate, to prevent loss of water from the laid RCC. This is undertaken to mitigate the risk of the RCC differentially drying. Where this occurs it can result in reduced durability of the RCC surface and/or localised delamination of the upper layer.

18 (01/20) Rain can degrade RCC mixtures, particularly if the mixture has a high proportion of fine aggregate or if the mixture is to be trafficked soon after laying. Because of this, Clause 1056 requires the Contractor's method statement to clearly define the action to be taken to mitigate any adverse effects caused by rain. If the rain is light, it may be possible to continue laying by adjusting the amount of water added during production of the mixture.

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

1 (01/20) Forced action mixers should be used so that relatively small proportions of binder or activator are distributed and thoroughly mixed with the aggregates or soils. This forced action is normally produced by one of the following methods:

(i) a batch mix system using a vertical axis rotating pan mixer with fixed location vertical blades to force the flow to the centre of the pan and prevent the agglomeration of fine material at the pan wall;

(ii) a continuous mix system where horizontal pairs of counter rotating helical blades blend and then mix the constituents as they are fed into the mixer.

2 (01/20) The free flow of constituents into a continuous mixer is essential for the production of a mixture with consistent characteristics. With fine graded, constituents, it may be necessary to use hoppers with a number of design features that assist free flow, such as vibrators and friction reducing internal coatings.

3 (01/20) Further advice about the mix-in-plant construction method can be found in CCIP-009 available from the Concrete Centre (www.concretebookshop.com) and in the Material Production section of the Britpave Guide to Roller Compacted Concrete Pavements.

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

1 (01/20) The method statement prepared by the Contractor should describe the proposed method of working for the demonstration area and for the main works. It should contain a description of all stages of construction, including:

(i) facilities for storing of constituents;

(ii) plant to be used for mixing, transport and laying;

(iii) estimated time durations and intervals between the main stages of the work;

(iv) site preparation details prior to laying the RCC layer;

(v) mixing method, time of residence in mixer, output, etc;

(vi) transport, journey time, protection during transport etc;

(vii) compaction and levelling;

(viii) curing and protection;

(ix) action to be taken during inclement weather;

(x) production control checks including:

  (a) site preparation;

  (b) mixing

  (c) water addition;

  (d) batching and mixing records;

  (e) depth of finished layer;

  (f) compaction;

  (g) in-situ density measurement;

  (h) level control;

  (i) surface finish;

  (j) density measurement.

NG 1057 (01/20) Induced Cracking of RCC

1 (01/20) The need for inducing transverse and longitudinal cracks in RCC is determined by the design requirements. Further guidance is given in HD 26 (DMRB 7.2.3).

2 (01/20) The plant and methodology used for forming the grooves in the freshly laid material is to be approved as part of the Method Statement and Methodology trial under Clause 1056. Formation of grooves using plate compactors or small devices that result in differential compaction should be avoided as these can result in poor surface regularity of the compacted RCC layer.

3 (01/20) The depth of the formed groove should be within the range stated in the method statement. The object of forming a groove is to reduce the cross section depth of the finished pavement thickness between ¼ and ⅓ in order to induce cracking.

4 (01/20) The effectiveness of the procedure shall be checked as part of the demonstration area under Clause1056.

5 (01/20) Saw cutting of the hardened RCC as an alternative to induced cracking is not permitted due to the risk of natural micro cracking prior to sufficient strength being obtained which would be required to cleanly saw cut the RCC.

NG 1058 (01/20) Roller Compacted Concrete Mixtures

1 (01/20) The grading curves for the aggregates for RCC are specified using the mixture grading envelopes in Table 10/15. The specified grading envelopes allow a choice of 0/20 mm size and 0/14 mm size mixtures, each with a tightly controlled grading curve. The grading curve applies to the aggregate mixture, not including the binder.

2 (01/20) Compliance with the tightly controlled grading curve will usually require a mixing plant with a number of aggregate feed hoppers so that different aggregate sizes can be added to the mixer in a controlled way.

3 (01/20) In order to facilitate early life trafficking RCC, the RCC must have sufficient strength to avoid damage. This can be determined by testing specimens made at the same time as the specimens required in Clause 1059 but cured under the same conditions as the in-situ RCC having achieved an average strength of at least 20 N/mm^2.

NG 1059 (01/20) Testing, Control and Checking

1 (01/20) RCC specified using BS EN 14227 are tested using the test methods in the relevant Parts of BS EN 13286. The scope of the test methods is restricted to mixture tests and tests on specimens made from mixtures. Tests for water content and plasticity are found in BS 1924-1, grading in BS EN 933-1, and in-situ density in BS 1924-2.

NG 1060 (01/20) Laboratory Mixture Design Procedure

1 (01/20) A schedule of testing should be used for each combination of binder and water content. The mix design procedure should determine the properties of the RCC at a minimum of 3 values of binder content, each 30kg/m^3 apart and a minimum of 3 values for water content of 0.8 x OWC, OWC and 1.2 x OWC for each binder content.

2 (01/20) The Contractor should provide evidence of strength development over a minimum of 28 days. This information should be used by the Contractor to declare the age of testing for site control purposes. A minimum ten specimens is required for each test age. Specimens should be tested at 7 days and 28 days and at other ages to suit the requirements of the Contractor.

(02/16) NG SAMPLE CONTRACT SPECIFIC APPENDIX 10/1: PLANT AND EQUIPMENT FOR THE CONSTRUCTION OF EXPOSED AGGREGATE CONCRETE SURFACE

The Contractor shall insert details below of the methods, plant and equipment he intends to use in the Works to construct an exposed aggregate concrete road surface to Clause 1044 and **shall submit this contract specific Appendix with his Tender**.

No. of Layers *[1044.3]*	a) One b) Two		....
Paving Equipment *[1044.6]*	a) Fixed Form	i) Two Separate pavers ii) Two layer paver	....
	b) Slip Form	i) Two Separate pavers ii) Two layer paver	....
Retarder Type *[1044.12]*	a) Manufacturer b) Type reference		....
Brushing Details *[1044.8]*	a) Wet b) Dry		....
Brushing Equipment *[1044.23]*	a) On Slab b) Spanning Slab		....

Retarder Protection Method *[1044.16]* ....