IRC:SP:49-2014

GUIDELINES FOR THE USE OF DRY LEAN CONCRETE AS SUB-BASE FOR RIGID PAVEMENT

(First Revision)

INDIAN ROADS CONGRESS
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GUIDELINES FOR THE USE OF DRY LEAN CONCRETE AS SUB-BASE FOR RIGID PAVEMENT

1 INTRODUCTION

IRC:SP:49 "Guidelines for the Use of Dry Lean Concrete as Sub-base for Rigid Pavement" was published in 1998. TheRigid Pavement (H-3) Committee decided to revise the IRC:SP:49 with lower 7-day compressive strength as per latest trend in other Countries e.g. Australia & other countries. The revised draft was also to include mineral admixtures i.e. flyash & GBFS. For this task, a sub-group under the convenor ship of Dr. S.C. Maiti including Dr. L.R. Kadiyali, Shri P.L. Bongirwar, Shri M.C. Venkatesha, Shri Ashutosh Gautam & Shri J.B. Sengupta as Members was formed in the meeting of H-3 Committee held on 16th April, 2012.

The draft was prepared based on tests carried out at CRRI on DLC using OPC, PPC and PSC, for the desired 7-day compressive strength of concrete. The Rigid Pavement Committee (H-3) discussed the draft which was prepared by the sub-group in series of meetings. The Rigid Pavement Committee (H-3) approved the final draft in its meeting held on 7th December, 2013 for placing before the HSS Committee. The Highways Specifications and Standards Committee (HSS) approved this document in its meeting held on 7th January, 2014. The Executive Committee in its meeting held on 9th January, 2014 approved this document for placing before the IRC Council for approval. The IRC Council in its meeting held at Guwahati (Assam) on 19th January, 2014 approved the draft revision of IRC:SP:49 "Guidelines for the Use of Dry Lean Concrete as Sub-base for Rigid Pavement" for publishing.

The composition of the Rigid Pavement Committee (H-3) is given below:

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Kumar, Ashok	Venkatesh, M.C.
Kurian, Jose	Rep. of CMA
Maiti, Dr. S.C.	Rep. E-in-C Branch

2 WIDTH AND THICKNESS OF DLC SUB-BASE

The DLC Sub-base shall extend beyond the pavement edges by 500 mm to facilitate further construction operations and provide an adequate support for the concrete slab. The extra width facilitates the movement of paver tracks on the extended DLC. The off-set will be 200 mm in case of semi mechanized or manual construction.

Although the actual thickness will be governed by the design considerations, a thickness of minimum 150 mm is recommended for all major projects of State Highways and National Highways. When DLC is adopted as sub base in case of roads other than the above roads its thickness of 100 mm is recommended. For further details, IRC:62 'Guidelines for Design and Construction of Low Volume Roads', may be referred, where in different combinations of constructing other type of sub bases involving cement treated bases have also been provided.

3 MATERIALS

3.1 Cement

Any of the following types of cement may be used with the approval of the Engineer.

i)	Ordinary Portland Cement (OPC)	IS:8112, IS:12269
ii)	Portland Pozzolana Cement ((PPC)	IS:1489 (part 1)
iii)	Portland Slag Cement (PSC)	IS:455

If the subgrade soil contains soluble sulphates in a concentration more than 0.5 percent, the cement used shall be sulphate resisting portland cement conforming to IS:12330 or Portland slag cement with slag content upto 50 percent.

3.2 Aggregates

Aggregates for dry lean concrete shall be natural aggregate complying with IS:383. The aggregates shall not be alkali-reactive. The deleterious materials content shall not exceed the limits as per IS:383. In case the aggregates are not free from dirt, the same may be washed and water drained out at least 72 hours before batching.

Coarse aggregate shall consist of clean, hard, strong, dense and non-porous pieces of crushed stone or gravel and shall not consist of disintegrated stone, soft, flaky, elongated,

very angular or splintery pieces. The maximum size of the coarse aggregate shall be 26.5 mm. The water absorption of the aggregates shall not exceed 3 percent.

The fine aggregate shall consist of clean, natural sand or crushed stone sand or a combination of the two and shall conform to IS:383.

The fine aggregate shall be free from soft particles, clay, sea shell, loam, cemented particles, mica, organic and other foreign matter in accordance with IS:383. Aggregates which have water absorption of more than 3 percent, shall not be used.

3.2.1 *Grading of aggregates*

The grading of fine aggregate shall conform to grading zones I, II, III or IV as given in IRC:15 or IS:383. The grading of combined aggregate shall conform to **Table 1**.

Table 1 Grading of Aggregates

Sieve Designation	Percentage Passing (by Weight)
26.50 mm	100
19.00 mm	75 – 95
9.50 mm	50 – 70
4.75 mm	30 – 55
2.36 mm	17 – 42
600 micron	8 – 22
300 micron	7 – 17
150 micron	2 –12
75 micron	0 – 10

3.3 Water

Water used for mixing and curing of concrete shall be clean and free from injurious amounts of oil, salt, acid, alkali, sugar, vegetable matter or other substances harmful to concrete. Water shall meet the requirements of IS:456. Potable water is generally considered satisfactory for mixing and curing. The pH value of water for mixing and curing upto 9 shall be permitted.

3.4 Mineral Admixtures

Flyash, 15-30 percent or Ground Granulated Blast Furnace Slag (GBFS), 25-50 percent by weight of cementitious material may be used in concrete as part replacement of Ordinary Portland cement, and in such case, the Ordinary Portland cement content shall not be less than 100 kg/m^3 of concrete. The flyash shall conform to IS:3812 (Part 1), and granulated blast furnace slag shall conform to IS:12089. Site mixing of flyash or GBFS shall be permitted only after ensuring availability of the equipments at site for uniform blending through a specific mechanized facility with automated process control like batching and mixing plant.

All materials shall be stored in proper places so as to prevent their deterioration or contamination by foreign matter to ensure their satisfactory quality and fitness for use in the work.

4 CONCRETE COMPRESSIVE STRENGTH AND CONCRETE MIX PROPORTIONING

4.1 Concrete Compressive Strength

The average compressive strength of each consecutive group of 5 concrete cubes shall not be less than 7 MPa at 7 days. In addition, the compressive strength of any individual concrete cube shall not be less than 5.5 MPa at 7 days. The design mix complying with these requirements shall be worked out before start of work.

4.2 Concrete Mix Proportions

The concrete mix shall be proportioned with a maximum aggregate cement ratio of 14:1 where OPC is used and 12:1 where PPC or PSC is used. The minimum cementItious materials content shall not be less than 140 kg/cum of concrete. If this minimum cementitious materials content is not sufficient to produce the concrete of the specified strength, it shall be increased as necessary. The flyash or GBFS content shall be 15-30 percent or 25-50 percent by weight of cementitious materials respectively, as given in Clause 3.4. The concrete mix proportions are based on Central Road Research Institute (CRRI) test results (**Annexure-B**).

The optimum water content shall be decided so as to ensure full compaction under rolling. Too much water will cause the concrete to be heaving up before the wheels and to be picked up on the wheels of the roller. Too little water will lead to inadequate compaction and segregation, a low in-situ strength and an open textured surface. Trial mixes of dry lean concrete shall be prepared with water content of 5.0, 5.5, 6.0, 6.5 and 7.0 percent of the total weight of material. Optimum moisture and density shall be established by preparing cubes with varying moisture contents, and moisture-density curve shall be drawn. Special vibratory hammer shall be used for compacting the specimens. While laying sub-base in main carriageway; the DLC may have 1 percent higher moisture content, to compensate evaporation loss during transport.

5 DRAINAGE LAYER

To facilitate quick disposal of water that is likely to enter the subgrade, a drainage layer (GSB) shall be provided below the sub-base throughout the road width. For further details on the drainage layer, IRC:58 may be consulted.

6 SUBGRADE

The subgrade shall conform to the grades and cross-sections on the drawings and shall be uniformly compacted to the modified Proctor density not less than 97 percent, that is normally specified. Reference may be made to IS:2720 (Part 8) for this. The lean concrete sub-base shall not be laid on a subgrade softened by rain after its final preparation. surface trenches and soft spots, if any, must be properly back-filled and compacted to avoid any weak spot. As far as possible, the construction traffic shall be avoided on the prepared subgrade. A day before placing of the sub-base, the subgrade surface shall be given a fine spray of water and rolled with one or two passes of a smooth wheeled roller after a lapse of 2-3 hours in order to stabilise loose surface. If found necessary, another fine spray of water may be applied just before placing the sub-base.

7 CONSTRUCTION

7.1 Trial Mixes

Trial mixes of dry lean concrete shall be prepared with moisture contents of 5.0, 5.5, 6.0, 6.5 and 7.0 percent using cement content requirement of aggregate-cement ratio specified in para 4.2. Optimum moisture and density shall be established by preparing cubes with varying moisture contents. Compaction of the mix shall be done in three layers with vibratory hammer fitted with a square or rectangular foot. After establishing the optimum moisture, a set of six cubes shall be cast at that moisture for the determination of compressive strength at 3 and 7 days. Trial mixes shall be repeated if the strength is not satisfactory either by increasing cement content or using higher grade of cement. After the mix design is approved, a trial section shall be constructed in accordance with para 7.9.

If during the construction of the trial length, the optimum moisture content determined as above is unsatisfactory, suitable changes may be made in the moisture content to achieve a satisfactory mix. The cube specimens prepared with the changed moisture content should satisfy the strength requirement. Before production of the mix, natural moisture content of the aggregate should be determined on a day-to-day basis, so that the moisture content could be adjusted. The mix finally designed should neither stick to the rollers nor become too dry resulting in ravelling of surface.

7.2 General

The pace and programme of the lean concrete sub-base construction shall be matching suitably with the programme of construction of the cement concrete pavement over it. The sub-base shall be overlaid with Paving Quality Concrete (PQC) pavement not before 7 days after the sub-base construction.

7.3 Batching and Mixing

The batching plant shall be capable of separately proportioning each type of material by weight. The capacity of batching and mixing plant shall be at least 25 percent higher than the proposed capacity for the laying arrangements. The batching and mixing shall be carried out preferably in a forced action central batching and mixing plant having necessary automatic controls to ensure accurate proportioning and mixing. Calibration of the batching and mixing plant shall be carried out at regular intervals, normally every month. Other types of mixers shall be permitted subject to demonstration of their satisfactory performance during the trial length construction.

7.4 Transporting

Plant mixed lean concrete shall be discharged immediately from the mixer, transported directly to the point where it is to be laid and protected from the weather by covering with tarpaulin during transit. The concrete shall be transported by tipping trucks, sufficient in number to ensure a continuous supply of material to feed the laying equipment to work at a uniform speed and in an uninterrupted manner. The lead of the batching plant to the paving site shall be such that the travel time available from mixing to paving as specified in a para 7.6.2 will be adhered to.

7.5 Placing

Lean concrete shall be laid by a hydrostatic paver. The equipment shall be capable of laying the material in one layer in an even manner without segregation, so that, after compaction the total thickness achieved is as specified. The paving machine shall have high amplitude ramping bars to give good initial compaction to the sub-base. For more details, IRC:SP:86 'Guidelines for Selection, Operation, and Maintenance of Paver Finishers' may be referred.

The laying of the two-lane road sub-base shall be done in full width. For a pavement more than two-lanes, the operation may be carried out by two pavers in echelon separated by appropriate distance (15-20 m). Transverse and longitudinal construction joints shall be staggered by 500-1000 mm and 200-400 mm respectively from the corresponding joints in the overlaying joints in the overlaying concrete slabs.

7.6 Compaction

7.6.1 The compaction shall be carried out immediately after the material is laid and levelled. In order to ensure thorough compaction, rolling shall be continued on the full width till there is no further visible movement under the roller and the surface is closed. The dry density obtained (from the average of density obtained from three density holes of 200 mm dia.) shall not be less than 97 percent of that achieved during the trial length construction. The densities achieved at the edges i.e. 0.5 m from the edge shall not be less than 95 percent of that achieved during the trial construction as per para 7.9. Rolling shall commence on the lower edge of camber/one side slope and proceed towards centre/outer edge.

7.6.2 The spreading, compacting and finishing of the lean concrete shall be carried out as rapidly as possible and the operation shall be arranged so as to ensure that the time between mixing of the first batch of concrete in any transverse section of the layer and the compaction and final finishing of the same shall not exceed 90 minutes, when the concrete temperature is between 25 and 30°C and 120 minutes, if less than 25°C. This period may be reviewed in the light of the results of the trial length but, in no case shall it exceed 2 hours. Work shall not proceed when the temperature of the concrete exceeds 30°C. If necessary, chilled water or addition of ice may be resorted to for bringing down the temperature. It is desirable to stop concreting when the ambient temperature is above 35°C. After compaction has been completed, roller shall not stand on the compacted surface for the duration of the curing period except during commencement of next day's work near the location where work was terminated the previous day.

7.6.3 Double Drum smooth-wheeled vibratory rollers of minimum 80 to 100 KN static weight are considered to be suitable for rolling dry lean concrete. In case, any other roller is proposed, the same will be used after establishing its performance. The number of passes required to obtain maximum compaction depends on the thickness of the lean concrete, compactibility of the mix, and the weight and type of the roller etc. and the same as well as the total requirement of rollers for the job shall be determined during trial run by measuring the in-situ density and the scale of the work to be undertaken.

7.6.4 In addition to the number of passes required for compaction there shall be a preliminary pass without vibration to bed the lean concrete down and again a final pass without vibration to remove roller marks and to smoothen the surface.

Special care shall be exercised during compaction near joints, kerbs, channels, side forms and around gullies and manholes. In case adequate compaction is not achieved by the roller at these points, use of plate vibrator will be permitted.

7.6.5 The final lean concrete surface on completion of compaction and immediately before overlaying, shall be well closed, free from movement under roller and free from ridges, cracks, loose material, pot holes, ruts or other defects. The final surface shall be inspected immediately on completion and all loose, segregated or defective areas shall be corrected by using fresh lean concrete material laid and compacted. For repairing honeycombed surface, fresh concrete of the grade of parent concrete, with aggregates of size 10 mm and below, shall be spread and compacted. It is necessary to check the level of the rolled surface for compliance. Any level deficiency should be corrected after applying concrete with aggregate of size 10 mm and below, after roughening the surface, when the concrete is still green. Similarly, the surface regularity also should be checked with 3 m straight edge. The deficiency should be made up with concrete with aggregates of size 10 mm and below. At the end of the day's work/stoppage of work due to breakdown of any machinery, in the chain, the work shall be finished straight by placing a channel at the end and placing concrete in slope beyond the channel. On the next day the channel is removed and minor cutting to obtain vertical face as per para 7.7 may be needed.

7.6.6 Segregation of concrete in the dumpers shall be controlled by moving the dumper back and forth while discharging the mix into it and by other means. Even paving operation shall be such that the mix does not segregate.

7.7 Joints

Day's work shall be stopped by vertical joints. The edge of the compacted material shall be cut back to a vertical face, when work starts next day.

7.8 Curing

As soon as the lean concrete surface is completed, curing shall commence.

a) Curing shall be done by covering the surface by hessian cloth in two layers which shall be kept continuously moist for 7 days by sprinkling water.

b) If water-curing is not possible, the curing shall be done by spraying with liquid curing compound. The curing compound shall be white pigmented type with water retention index of minimum 90 percent, when tested in accordance with the test method given in **Annexure-A**. To check the efficiency of the curing compound, the supplier shall be required to provide the test certificate from a recognized laboratory. Curing compound shall be sprayed immediately after rolling is complete. As soon as the curing compound has lost its tackiness, the surface shall be covered with wet hessian for three days.

7.9 Trial Length Construction

7.9.1 The trial length shall be constructed (in two days), at least 14 days in advance of the proposed date of commencement of work. The length of trial construction shall be a minimum of 60 m length and for full width of the pavement. The trial length shall contain the

construction of at least one transverse construction joint involving hardened concrete and sub-base to be laid subsequently, so as to demonstrate the soundness of the procedure. In one day trial length of not more than 30 m shall be laid.

7.9.2 In order to determine and demonstrate the optimum moisture content which results in the maximum dry density of the mix compacted by the rolling equipment and the minimum cement content that is necessary to achieve the strength stipulated, trial mixes shall be prepared as per para 7.1.

7.9.3 After the construction of the trial length, the in-situ density of the freshly laid material shall be determined by sand replacement method (as per IS:2720 part-8) with 200 mm dia density hole. Three density holes shall be made at locations equally spaced along a diagonal that bisect the trial length; average of these densities shall be determined. These main density holes shall not be made in the strip 500 mm from the edge. The average density obtained from the three samples collected shall be the reference density and is considered as 100 percent. The field density of regular work will be compared with this reference density in accordance with para 7.6.1. A few cores may be cut so as to check segregation or any other deficiency and also to ascertain strength.

7.9.4 The hardened concrete shall be cut over 3 m width and reversed to inspect the bottom surface for any segregation taking place. The trial length shall be constructed after making necessary changes in the grading of aggregates and the mix to eliminate any segregation of the mix. The lower surface shall not have honey-combing and the aggregates shall not be held loosely at the edges.

7.9.5 The trial length shall be outside the main works. After the approval of the trial length construction has been given, the materials, mix proportions, moisture content, mixing, laying, compaction, plant, construction procedures shall not be changed.

7.10 Control of Thickness, Density and Strength

The tolerances for thickness shall be ± 10 mm. The dry density of the laid material shall be determined from density holes at locations equally spaced along a diagonal that bisects each 2000 sq.m or part thereof, of material laid each day. The control of strength shall be exercised by taking samples of dry lean concrete for making cubes at the rate of 3 samples for each 1000 sq.m or part thereof laid each day. The cube samples shall be compacted, cured and tested in accordance with IS:516.

7.11 Opening to Traffic

No heavy commercial vehicles like trucks and buses shall be permitted on the lean concrete sub-base after its construction. Light vehicles if unavoidable may, however, be allowed after 7 days of its construction with prior approval of the Engineer.

Annexure-A

(Refer Clause 7.8)

Test on Curing Compound

The efficiency of the curing compounds in terms of the extent, to which they reduce the evaporation loss of water from the surface of a standard mortar slab, can be determined by test. The test method provides the information on the escape of moisture from the surface of the mortar specimen, which may lead to loss of strength, shrinkage or low abrasion resistance of the hardened dry lean concrete.

Test Procedure

The metal rectangular mould shall be non-absorbent, watertight and rigidly constructed. The size of the mould is 150 x 300 mm at the top, 145 x 295 mm at the bottom, and 50 mm deep measured on the inside. Ordinary portland cement and graded standard sand in the proportion 1:3 and a water-cement ratio of 0.40 to 0.44 (by weight) shall be used, to produce a flow of 35 ± 5 percent, in 10 drops of the flow table.

The mortar test slab specimen (3 No.) shall be made by placing mortar in two layers and tamping 50 times with the tamper, on each layer. The top surface of the test slabs will be finished with a float. On the dry surface of the specimens, within 1 hour of finishing, the curing compound shall be sprayed. The curing compound shall be of such character that, it hardens within 30 minutes after application. The specimens along with the moulds shall be weighed accurately to the nearest 1 gm, and shall be kept in the humidity cabinet (with exposure temperature of 38°C and a relative humidity of 35 percent) for 72 hours. After taking out from the humidity cabinet, the specimens along with the moulds shall be weighed accurately again to the nearest 1 gm. The average percentage retention of the mixing water shall be calculated.

Annexure-B

(Refer Clause 4.2)

DLC Test Results from CRRI

	PSC				OPC				PPC				PPC		
	PSC-1	PSC-2	PSC-3	PSC-4	OPC-1	OPC-2	OPC-3	OPC-4	PPC-1	PPC-3	PPC-2	PPC-4	PPC-5	PPC-6	PPC-7
Cement : Aggregate	1 : 12	1 : 13	1 : 14	1 : 15	1 : 12	1 : 13	1 : 14	1 : 15	1 : 12	1 : 13	1 : 14	1 : 15	1 : 16	1 : 17	1 : 18
Cement, Kg	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Water,% @	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Aggregate,Kg	1680	1820	1960	2100	1680	1820	1960	2100	1680	1820	1960	2100	2240	2380	2520
Sand @ 40%, Kg	672	728	784	840	672	728	784	840	672	728	784	840	896	952	1008
Coarse Aggregate, Kg	1008	1092	1176	1260	1008	1092	1176	1260	1008	1092	1176	1260	1344	1428	1512
20mm, Kg @ 50%	504	546	588	630	504	546	588	630	504	546	588	630	672	714	756
10mm, Kg@ 50%	504	546	588	630	504	546	588	630	504	546	588	630	672	714	756
Total Wt of concrete kg =	1820	1960	2100	2240	1820	1960	2100	2240	1820	1960	2100	2240	2380	2520	2660
Quantity for Cubes 5	28.35	28.35	28.35	28.35	28.35	28.35	28.35	28.35	28.35	28.35	28.35	28.35	28.35	28.35	28.35
≈	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Cement	2.31	2.14	2.00	1.88	2.31	2.14	2.00	1.88	2.31	2.14	2.00	1.88	1.76	1.67	1.58
Sand	11.08	11.14	11.20	11.25	11.08	11.14	11.20	11.25	11.08	11.14	11.20	11.25	11.29	11.33	11.37
20 mm	8.31	8.36	8.40	8.44	8.31	8.36	8.40	8.44	8.31	8.36	8.40	8.44	8.47	8.50	8.53
10 mm	8.31	8.36	8.40	8.44	8.31	8.36	8.40	8.44	8.31	8.36	8.40	8.44	8.47	8.50	8.53
Water	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95
Dry Density	2367	2384	2380	2337	2392	2418	2391	2340	2349	2332	2328	2330	2310	2320	2320
7 Day Avg. C/S in Mpa	**11.0**	**11.4**	**9.5**	**9.0**	**14.4**	**14.4**	**11.4**	**9.6**	**10.8**	**9.5**	**8.5**	**7.3**	**6.5**	**6.0**	**4.0**

(The Official amendments to this document would be published by the IRC in its periodical, 'Indian Highways' which shall be considered as effective and as part of the code/guidelines/manual, etc. from the date specified therein)