GUIDELINES FOR CONSTRUCTION OF ROLLER COMPACTED CONCRETE PAVEMENTS

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

THE INDIAN ROADS CONGRESS
2005

GUIDELINES FOR CONSTRUCTION OF ROLLER COMPACTED CONCRETE PAVEMENTS

Published by

INDIAN ROADS CONGRESS
Kama Koti Marg,
Sector 6, R.K. Puram,
New Delhi – 110 022
2005

Price Rs. 160/–
(Packing & Postage Extra)

IRC:SP:68-2005

First Published : September, 2005
Reprinted : July, 2008
Reprinted : March, 2016

(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)

Printed at Aravali Printers & Publishers, New Delhi-110020
(500 copies)

CONTENTS

PERSONNEL OF THE HIGHWAYS SPECIFICATIONS AND STANDARDS COMMITTEE

(As on 29-04-2005)

1.	Velayutham, V. *(Convenor)*	Addl. Director General, Ministry of Shipping, Road Transport & Highways, New Delhi
2.	Sharan, G. *(Co-Convenor)*	Member (Tech), NHAI, New Delhi
3.	Dhodapkar, A.N. Chief Engineer (R) S&R *(Member-Secretary)*	Ministry of Shipping, Road Transport & Highways, New Delhi
		Members
4.	Bahadur, A.P.	Chief Engineer, Ministry of Shipping, Road Transport & Highways, New Delhi
5.	Chakarabarty, P.K.	Chief Engineer, Ministry of Shipping, Road Transport & Highways, New Delhi
6.	Dutta, P.K.	Executive Director, Consulting Engg. Services (I) Pvt. Ltd., New Delhi
7.	Desai, J.P.	Sr. Vice-President (Tech. Ser.), Gujarat Ambuja Cements Ltd., Ahmedabad
8.	Dhingra, S.L., Dr.	Professor, Indian Institute of Technology, Mumbai
9.	Gupta, D.P.	DG (RD) & AS, MOST (Retd.), New Delhi
10.	Gupta, S.K.	Chief Engineer, Uttaranchal PWD, Almora
11.	Jain, R.K.	Chief Engineer (Retd.), Sonepat
12.	Jain, S.S., Dr.	Professor & Coordinator (COTE), Indian Institute of Technology, Roorkee
13.	Kadiyali, L.R., Dr.	Chief Executive, L.R. Kadiyali & Associates, New Delhi
14.	Katare, Prabha Kant	Joint Director, National Rural Roads Dev. Agency, New Delhi
15.	Mathur, J.B.	Chief Engineer (Retd.), MSRTH, Noida
16.	Meena, H.L.	Chief Engineer-cum-Addl. Secy. to the Govt. of Rajasthan, PWD, Jaipur
17.	Momin, S.S.	Secretary (Works), Maharashtra PWD, Mumbai
18.	Pawar, A.B.	Secretary (Works) (Retd.), Pune
19.	Ranjan, Gopal, Dr.	Director, College of Engg., Roorkee
20.	Rathore, S.S.	Secretary to the Govt. of Gujarat, R&B Department, Gandhinagar
21.	Saha, Arghya Pradip	Sr. Consultant, New Delhi
22.	Sharma, S.C.	DG (RD) & AS, MORT&H (Retd.), New Delhi
23.	Nanda, P.K., Dr.	Director, Central Road Research Institute, New Delhi
24.	Singh, C.K., Dr.	Engineer-in-Chief-cum-Addl. Comm-cum-Spl Secy. (Retd.), Ranchi
25.	Singh, Nirmal Jit	Member (Tech.), National Highways Authority of India, New Delhi

26.	Sinha, A.V.	Chief General Manager, National Highways Authority of India, New Delhi
27.	Sinha, N.K.	DG (RD)&SS, MOSRT& H (Retd.), New Delhi
28.	Sinha, V.K.	Chief Engineer, Ministry of Shipping, Road Transport & Highways, New Delhi
29.	Sarin, K.K.	DG (RD) & AS, MOST (Retd.), New Delhi
30.	Velayudhan, T.P.	Addl. D.G., Directorate General Border Roads, New Delhi
31.	Verma, V.C., Maj.	Executive Director, Marketing, Oriental Structural Engrs. Pvt. Ltd, New Delhi
32.	The Chief Engineer (NH)	R&B Department, Hyderabad
33.	The Chief Engineer (Plg.)	(S.B. Basu), Ministry of Shipping, Road Transport & Highways, New Delhi
34.	The Chief Engineer (Mech)	(V.K. Sachdev), Ministry of Shipping, Road Transport & Highways, New Delhi
35.	The Chief Engineer (Mech)	PWD, Kolkata
36.	The Chief Engineer (NH)	Sachivalaya Marg, Bhubaneshwar
37.	The Engineer-in-Chief	(Tribhuvan Ram) U.P. PWD, Lucknow
38.	The Chief Engineer	National Highways, PWD, Bangalore

Ex-Officio Members

39.	President Indian Roads Congress	(V.B. Borge), Secretary (Roads), Mumbai
40.	Director General (Road Development)	(Indu Prakash), Ministry of Shipping, Road Transport & Highways, New Delhi
41.	Secretary Indian Roads Congress	(R.S. Sharma), Indian Roads Congress, New Delhi

Corresponding Members

1.	Agarwal, M.K.	Engineer-in-Chief, Haryana PWD (Retd.), Panchkula
2.	Justo, C.E.G., Dr.	Emeritus Fellow, Bangalore University, Bangalore
3.	Khattar, M.D.	Executive Director, Hindustan Construction Co. Ltd., Mumbai
4.	Madhathil, Sunny C.	Director (Project), Bhagheeratha Engg. Ltd., Kochi
5.	Merani, N.V.	Principal Secretary, Maharashtra PWD (Retd.), Mumbai

GUIDELINES FOR CONSTRUCTION OF ROLLER COMPACTED CONCRETE PAVEMENTS

1. INTRODUCTION

1.1 The initial draft on 'Construction of Roller Compacted Concrete Pavements' was prepared by Dr. L.R. Kadiyali (Convenor, Rigid Pavement Committee) as the guidelines on this subject are quite useful for construction of low volume roads. The draft guidelines were considered and discussed by the Rigid Pavement Committee (H-5) (personnel given below) in their meeting held on 8th March, 2004 and approved with certain modifications.

Kadiyali, L.R., Dr. ... *Convenor*
CE(R)S&R, MOSRTH ... *Co-Convenor*
Venkatesha, M.C. ... *Member-Secretary*

Members

Chahal, H.S.
Chary, M.L.N.
Indoria, R.P.
Jain, R.K.
Kulkarni, P.D.
Kumar Stander
Mahajan, P.K.
Pandey, B.B., Dr.
Phull, Y.R.
Rastogi, S.P.
Sabnis, S.M.
Sharma, S.C.
Singh, Brajendra
Sinha, V.K.
Vasan, R.M., Dr.
Wasan, R.C.
Director, H.R.S., Chennai

Corresponding Members

Bhaumik, Kanti Bhushan
De, D.C.
Rao, K.V. Krishna, Prof.
Ravi Shankar, A.U.
Tare, Vandana, Dr. (Mrs.)

Ex-officio Members

President, IRC
(Momin, S.S.)
DG(RD) MOSRTH
(Prakash, Indu)
Secretary, IRC
(Sharma, R.S.)

1.2 Thereafter, the modified draft guidelines were considered by the Highways Specification and Standards Committee in their meeting held on 29th April, 2005. The Committee approved the draft guidelines with slight modifications for further consideration by the Executive Committee and Council. The Executive Committee approved the guidelines in their meeting held on 4th May, 2005 and the draft guidelines were discussed at the 175th Council meeting held at Shillong on 22nd May, 2005. After the deliberations, the Council accorded approval to the document with certain modifications suggested by the members. The document was modified by the Covenor, Dr. L.R. Kadiyali as per suggestions made.

2. SCOPE

Roller Compacted Concrete Pavements (RCCP) are used where equipments like concrete pavers are readily available. The other equipments used for RCCP is the vibratory roller and mixers/batching plants which are now available at most road construction sites. The

final finished surface of RCCP is not as smooth as the conventional paver-laid pavement. This deficiency is generally overcome by providing a bituminous surfacing for roads where high speeds are expected. For roads where speed of vehicles is not an essential attribute, as in the case of low-volume Rural Roads, RCCP without bituminous surfacing is a good choice. RCCP has to support the weight of the vibratory roller, it has to be sufficiently dry.

3. MATERIALS

3.1. Cement

Any of the following type of cement may be used:

(i) Ordinary Portland Cement
IS 269:1989 - Specification for 33 grade ordinary Portland Cement (Fourth Revision)
IS 8112:1989 - Specification for 43 grade ordinary Portland Cement (First Revision)
IS 12269:1987 - Specification for 53 grade ordinary Portland Cement

(ii) Portland Slag Cement
IS 455:1989 - Specification for Portland Slag Cement (Fourth Revision)

(iii) Portland Pozzolana Cement
IS 1489:Part 1:1991 - Specification for Portland Pozzolona Cement Part 1 Fly Ash based (Third Revision)

If the pavement is likely to rest on a soil subgrade having soluble sulphates in a concentration more than 0.5 per cent cement used shall be sulphate resistant and shall conform to IS 12230. Cement may be obtained in bulk form or in bags. If paper bags are proposed to be used, there shall be bag splitters with the facility to separate pieces of paper bags and dispose them suitably. No paper pieces shall enter the concrete mix. Cement shall be transported, handled and stored on the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground in perfectly dry and water-tight sheds and shall be stacked not more than eight bags high. Wherever bulk storage containers are used, their capacity should be sufficient to cater to the requirement at site and they should be cleaned at least once in every 3 to 4 months.

Each consignment of cement shall be stored separately so that it is readily identifiable and the material can be used in the sequence in which it is delivered at site. Any consignment or part of a consignment of cement which has deteriorated in any way, during transportation and storage, shall not be used in the works.

3.2. Fly-ash

Fly-ash shall conform to Bureau of Indian Standards Specification, IS 3812–1981 (Grade I). The physical requirements shall conform to Table 1.

Table : 1 Physical Requirements of Fly-ash (As per IS 3812)

Sl. No.	Characteristics	Requirements
(i)	Fineness, Specific surface area in m^2/kg, by Blaine's permeability method, minimum	320
(ii)	Particles retained on 45 micron IS sieve, per cent maximum.	34
(iii)	Lime Reactivity, average compressive strength, N/mm^2.	4.5
(iv)	Soundness by autoclave test expansion of specimen in per cent maximum.	0.8
(v)	Drying shrinkage per cent, maximum.	0.15

Fly-ash shall be transported in covered trucks, and slightly sprinkled with water, to avoid dust nuisance. Excessive stock-piling of fly-ash at site shall be avoided, and its supply regulated to match with the consumption.

In case stock-piling becomes unavoidable, adequate precautions shall be taken to prevent dusting by spraying of water on stockpiles at regular intervals or covering the stockpiles with tarpaulin or plastic sheets.

The properties of fly-ash shall be tested at regular intervals. At least one set of tests prescribed in IS 3812 shall be carried out once a week.

3.3. Aggregates

3.3.1. Aggregates for RCCP shall be natural material complying with IS 383. The aggregates shall not be alkali-reactive. In case the aggregates are not found to be free from dirt, they may be washed and drained for at least 72 hours before batching.

3.3.2. Coarse aggregates : Coarse aggregates shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel or natural rounded gravel and shall be devoid of pieces of disintegrated stone, and soft, flaky, elongated, very angular or splintery pieces. The coarse aggregates shall not have a combined flakiness and elongation index more than 40 per cent. The maximum size of coarse aggregates shall not exceed 25 mm. No aggregate which has water absorption of more than 5 per cent be used. The aggregates shall be tested for soundness in accordance with IS 2386 (Part V). After 3 cycles of testing, the loss shall not be more than 12 per cent if sodium sulphate solution is used or 18 per cent if magnesium sulphate solution is used.

Coarse aggregates shall be delivered at site in two separate sizes. They shall be dumped and stacked over firm and levelled ground. The stackyard shall have adequate surface drainage arrangement so that water does not stagnate below the aggregates. Aggregates placed on the ground shall not be removed from the stockpile within 30 cm of the ground until the final cleaning up of the work. The aggregates from the bottom layer shall be permitted to be used after cleaning the aggregates by screening/washing as directed by the Engineer.

3.3.3. Fine aggregates : Fine aggregates shall consist of clean, natural sand or crushed stone sand or a combination of the two. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica, organic and other foreign matter. The fine aggregate shall not contain deleterious substances more than the following:

Clay lumps : 4.0 per cent

Coal and lignite : 1.0 per cent

Material passing

IS sieve No. 75 micron : 4.0 per cent in natural sand and 15.0 per cent in sand produced by crushing rock.

3.3.4. Blending of aggregates : The coarse and fine aggregates shall be blended so that the material after blending shall conform to the grading given in Table 2.

Table 2

Sieve Designation (mm)	Percentage passing the sieve by weight
26.5	100
19.0	80-100
9.5	55-80
4.75	35-60
600 micron	10-35
75 micron	0-8

3.3.5. Water

Water used for mixing and curing shall be clean and free from injurious amount of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS 456.

4. MIX DESIGN

4.1. Mix design for RCCP is totally different from the design of mix for a conventional cement concrete pavement as the Abrahm's water/ cement ratio law does not hold good. RCCP is a no-slump concrete.

The mix shall be proportioned by weight of all ingredients such that the desired target mean strength is achieved. The mix design shall be based on the flexural strength of concrete. The moisture content shall be selected so that the mix is dry enough to support the weight of a vibratory roller, and yet wet enough to permit adequate distribution of paste throughout the mass during mixing, laying and compaction operations. The water content by weight may be in the range of 4 – 7 per cent and shall be determined by trial mixes having water content changing at intervals of 0.5 per cent. The optimum moisture content which gives the maximum density shall be determined. The coarse aggregates by volume shall be in the range of 52 – 56 per cent, and the volume of sand shall be varied to optimize the strength by trials. The fly-ash/ cement ratio and the water/cementitious material (cement + fly ash) ratio shall be selected so as to achieve the required strength. Fly-ash quantity shall be so proportioned that it replaces cement to an extent of 20 – 50 per cent by weight.

Using the proportion of coarse aggregates, fine aggregates, water, cement and fly-ash so established, a trial length is constructed to demonstrate satisfactory performance of the mix and the construction equipment proposed to be used.

5. CONSTRUCTION

5.1. Trial Length

A trial length of at least 30 m shall be constructed officially outside the main works. The Contractor shall construct trial sections away from the carriageway for refining his construction methodology, suitability of his equipments etc. before requesting to construct officially a trial section after notifying to the Engineer. In case the Contractor fails to construct satisfactorily trial section, he shall repeat trials till he is able to construct a satisfactory trial section. The moisture content determined in the laboratory mix design shall be tried and the rolling equipment shall be employed to determine the number of passes required to achieve the maximum density. After the construction of the trial length, the in-situ density of the freshly laid material shall be determined by sand replacement method with 15 or 20 cm diameter density holes. Three density holes shall be made at locations equally spaced along a diagonal that bisects the trial length; the average of three densities shall be determined. These main density holes shall not be made in the strip 50 cm from the edges. The average density obtained from the three samples collected shall be the reference density and is considered as 100 per cent. The field density will be compared with this reference density.

After the approval of the trial length, the main work shall proceed with the materials, mix proportions, moisture content, mixing, laying and roller and construction procedures determined during the trial length.

5.2. Batching and Mixing

The batching and mixing shall be done in a batching plant capable of proportioning the materials by weight, each type of material being weighed separately. The capacity of the batching and mixing plant shall be at least 25 per cent higher

than the proposed capacity for laying the pavement. 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. For small jobs, concrete mixers of at least of 0.4/0.3 cum (14/10cft) capacity may be used, provided reliable weigh batching arrangement is provided. Pan mixers may also be used. The weighing balances shall be calibrated by weighing the aggregates, cement, fly-ash and water on a large weighing machine. The accuracy of the weighing scales of the batching plant shall be within ± 2 per cent in the case of aggregates and ± 1 per cent in the case of cement, fly ash and water. The batching plant shall be such that it can be shifted from place to place easily as the work progresses.

5.3. Transporting

Concrete shall be discharged from the mixer and transported directly to the point where it is to be laid by tipper trucks covered with tarpaulin or wheel-barrows. The capacity of the transport equipment shall match the production capacity of the batching plant and the laying equipment to ensure construction to go on at a uniform speed in an uninterrupted manner.

5.4. Laying

The concrete shall be laid by a paver, with electronic sensors. The paver shall be capable of laying the material in one layer in an even manner without segregation, so that after compaction, the total thickness is as specified.

The laying of the two-lane road may be done either in full width or lane by lane. If lane by lane paving is adopted, it is preferable if two paving machines are used in echelon one immediately behind the other so that the joint is well compacted when the mix is green and has not set. The concreting of the second lane should be done within 90 minutes of placing concrete in the first lane.

5.5. Compaction

Compaction shall be carried out immediately after the material is laid and levelled.

Rolling shall be done with a vibratory roller of the double drum smooth wheel type (80 – 100 kN). The number of passes required to obtain the maximum compaction shall be determined during the trial run by increasing the in-situ density.

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

The spreading, compacting and finishing of the concrete pavement shall be carried out as rapidly as possible and the operation shall be so arranged as to ensure that the time between the mixing of the first batch of concrete in any transverse section of the layer and the final finishing of the same shall not exceed 90 minutes when the concrete temperature is above 25°C and below 30°C, and 120 minutes if less than 25°C. This period may be reviewed in light of the results of the trial run, 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, the 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 the work was terminated the previous day.

If a high quality surface is desired, the primary compaction with a vibratory roller shall be followed by two or three passes with 200 kN pneumatic tyred roller, to close up any surface voids or cracks. The tyre pressure of the roller shall be a minimum of 0.56 N/mm^2.

If the RCCP is too wet or too dry for compaction upon laying, the water content shall be adjusted at the plant to correct this. Only minor changes in water content from the design mix should be made; otherwise a new mix design may be needed.

After making the initial static pass as mentioned earlier, the vibratory rolling should commence at the outer edge of the first paving lane, so that the rolling wheel extends over the edge of the pavement by 25 – 50 mm to confine the RCCP and prevent excessive lateral displacement of the concrete upon further rolling. Two passes are given in this position. The roller should then shift to within 300 – 450 mm of the interior edge and make two passes. The uncompacted material in the centre of the lane should then be compacted with two passes of the roller. The pattern shall be repeated once to make a total of four passes on the lane, or more if the specified density is not achieved. When the adjacent lane is placed, two passes should extend 25 – 50 mm over the outer edge, if the lane is to form an outer lane of the carriageway. If the second lane is not to form an outer lane (as in a carriageway of more than 2 lanes), the outer edge should leave 300 – 450 mm of the edge uncompacted. The joint between the first lane and the second lane is then compacted, as well as the remaining width of the lane in the same manner. The edges of the pavement are then trimmed to form a vertical face.

5.6. Joints

At the end of the day's work, the roller shall roll off the end of the lane, rounding off the end of the lane in the process. This rounded end shall be trimmed to form a vertical face through the entire depth of the pavement. When the work is resumed the next day, the vertical face is moistened and the paver is backed into place, and set to proper direction by using shims sitting on top of the hardened used concrete. After the paver lays the next day's work, a static pass is made in the transverse direction across the first width of the pavement, and the joint carefully rolled to produce a smooth surface across the joint.

If the concreting of the adjacent lane is delayed due to some reasons, a cold longitudinal joint results between the two lanes. In that case, the edge of the first lane shall be trimmed back to sound concrete to form a vertical face. The vertical face is dampened before laying concrete in the adjacent lane. The height of the screed shall be set to an elevation approximately 25 per cent higher than the desired thickness of the compacted concrete. The screed shall overlap the hardened concrete by 50 – 75 mm. The excess fresh concrete shall be pushed back to the edge of the fresh concrete lane with rakes so that a minimal amount of fresh material is left on the surface of the hardened concrete. The edge of the fresh lane shall be rolled first in the static mode with about 300 mm of the roller on the fresh concrete to form a smooth longitudinal joint.

There is no need for cutting transverse joints in RCCP, as cracks are allowed to form naturally. It is also not necessary to provide dowels for load transfer.

5.7. Curing

In view of the low water content in RCCP, curing shall receive the highest attention. Soon after the compaction is over, depending upon weather, wind velocity and humidity, curing shall start within one hour to two hours after laying by covering the pavement with wet hessian in two-three layers for the first 24 hours. After the first

day's curing, small earthen rectangles/dykes about 50 mm high transversely and used longitudinally shall be made and shall be filled with water for atleast 16 more days.

As soon as the curing compound has lost its tackiness, the surface shall be covered with wet hessian/gunny bags which shall be kept continuously moist for 7 days by sprinkling water.

5.8. Opening to Traffic

All vehicular traffic shall be kept off the RCCP for at least 14 days. Traffic may be allowed selectively after this period till 28 days, controlling the load of vehicles.

6. QUALITY CONTROL

Adequate quality control shall be exercised in respect of strength of concrete. At least two beam and two cube specimens, one each for 7 days and 28 days strength testing shall be cast for every 150 cum (or part there of) of concrete placed during construction. On each day's work, not less than three pairs of beams and cubes shall be made for each type of mix from the concrete delivered at site. Each pair shall be from a different delivery of concrete. Groups of four consecutive results from single specimens tested at 28 days shall be used for assessing the strength for compliance with the requirements. The flexural strength test results shall prevail over compressive strength tests for compliance. A quality control chart indicating the strength value of individual specimens shall be maintained for continuous quality assurance. Where the requirements are not met with, or where the quality of the concrete or its compaction is suspect, the actual strength of the concrete in the slab shall be ascertained by carrying out tests on cores cut from the concrete at such locations. The cores shall be cut at the rate of 2 cores for every 150 cum of concrete. The crushing strength of the cylindrical cores shall be converted to cube strength by using the following formula.

Core strength = 0.8 cube strength

This formula applies for cores with a height to diameter ratio of 2. For ratios in the range of 1 to 2, the crushing strength of cores may be corrected by using the following formula:

$$f = 0.11\,n + 0.78$$

Where f = correction factor to be applied to the core strength of specimens
n = height to diameter ratio of the core

The concrete in the pavement represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is at least equal to 85 per cent of the 28 day characteristic cube strength specified.

The in-situ density of concrete shall be determined from three density holes at locations equally spaced along a diagonal that bisects each 2000 sqm or part thereof of the pavement laid each day. The field density obtained shall be 97 per cent of that achieved during the trial length construction.

The surface regularity of the finished pavement shall be checked by taking levels. The tolerance in surface levels shall be + 5 mm and – 6 mm. The maximum allowable difference between the road surface and the underside of a 3 m straight edge when placed parallel with, or at right angles to the centre line of the road shall be 6 mm.