



Indian Roads Congress
Special Publication 17

RECOMMENDATIONS ABOUT OVERLAYS ON CEMENT CONCRETE PAVEMENTS

NEW DELHI 1977

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35. The Director <i>(Prof. G.M. Andavan)</i>	Highways Research Station, Madras

1. INTRODUCTION

1.1. Subsequent to 1963, when the first I.R.C. recommendations on overlays were issued, a fair amount of experimental and other regular overlay construction of flexible and rigid type has been done in different parts of the country. Major overlays on roads have been laid in Maharashtra, U.P., Andhra Pradesh, Tamil Nadu, Karnataka and Kerala. Some overlay works have also been done in Gujarat on roads and by C.P.W.D. and M.E.S. on airfields. Therefore, the Cement Concrete Road Surfacing Committee of I.R.C. in their third meeting held at Madras in December 1970 set up a Working Group on Overlays on Cement Concrete Pavements, with the following personnel, for the purpose of collecting construction and performance data of overlay works on all-India basis, making assessment of typical overlay works and preparing a report thereon, to suggest revision, if any, of the earlier recommendations on overlays made by the *Ad hoc Committee of the Indian Roads Congress on overlays* set up in November, 1963:

A.R. Satyanarayana Rao	... <i>Convenor</i>
Dr. R.K. Ghosh	... <i>Member-Secretary</i>
C.L.N. Iyengar	... <i>Member</i>
M.D. Kale	... "
Mahabir Prasad	... "
M.R. Malya	... "
R.P. Sikka	... "

1.2. As overlays of similar specifications in different parts of the country were known to have behaved differently, the Working Group selectively inspected overlay works in Andhra Pradesh, U. P., and Maharashtra and assessed their performance. In assessing the performance and proposing revision of the existing recommendations, besides the specifications and mode of construction adopted for the overlay, the effect of existing slab condition, traffic, rainfall, drainage, temperature variation, sub-soil, base and sub-base conditions, and shoulder treatment was kept in view. The assessment was made by visual observation of the stretches and noting the surface condition of the overlay (cracks, patches, ruts and other depressions, spalling, ravelling, tendency to skidding, etc.). Repairs, if already carried out on the overlay, and their frequency were also noted.

1.3. The report including the recommendations was approved and recommended for publication as an I.R.C. document by the Cement Concrete Road Surfacing Committee (personnel given below):

K.K. Nambiar	... <i>Convenor</i>
Dr. R.K. Ghosh	... <i>Member-Secretary</i>

MEMBERS

D.C. Chaturvedi	K.C. Mittal
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Dr. S.K. Khanna	Director General (Road Dev.)

The report was processed by the Specifications & Standards Committee in their meeting held on the 22nd August, 1976 subject to certain modifications which on the authorisation of the Committee, were carried out jointly by Dr. R.K. Ghosh, Dr. M.P. Dhir and Shri R.P. Sikka. This report was subsequently approved by the Executive Committee in their meeting held on the 18th November 1976 and the Council in their 88th meeting held at Bhopal on the 4th December 1976 for being brought out as a Special Publication of the Indian Roads Congress.

1.4. The following abbreviations have been used in this report to designate the different types of flexible layers used in overlay construction, either singly or in conjunction with one another:

W.B.M.	:	Water Bound Macadam
B.U.S.G.	:	Built-Up Spray Grout
B.M.	:	Bituminous Macadam
A.C.	:	Asphaltic Concrete
P.S.C.	:	Premix with Seal Coat

Wherever these, and other pavement layers are referred to in the recommendations of the Working Group given in para 4 for adoption in overlay work, these should comply with the relevant IRC Specifications

2. INFORMATION ABOUT OVERLAY WORKS ON CEMENT CONCRETE PAVEMENTS IN INDIA

2.1. A questionnaire on overlays to include the different aspects of information was issued to State PWDs., C.P.W.D., Research Institutes, Border Roads Organisation, selected Municipal Corporations and M.E.S. The response to the questionnaire was very encouraging.

2.2. Information on overlay works (excluding those inspected by the Working Group) received from the different States, Union Territories and Organisations, is summarised in *Annexure 1*. This covers Gujarat, Kerala, Karnataka and Tamil Nadu and partly U.P. and Maharashtra. 'Nil' reports were received from Punjab, Bihar, Himachal Pradesh, Orissa, J. & K., West Bengal, Rajasthan, Meghalaya, Union Territories of Goa, Daman & Diu, Delhi, Chandigarh and Arunachal Pradesh and Border Roads Organisation.

2.3. The salient points emanating from the reports of Gujarat, Kerala, Karnataka, Tamil Nadu and Maharashtra are:

(1) In case of Gujarat, only 2 cm premix carpet was tried as a maintenance measure for distressed cement concrete pavements of 10-11 cm thickness with a view to improving their riding quality. This treatment was found to be unsatisfactory. Where the subgrade was black cotton soil, the life of such carpet was found to be very short and premix needed replacement every 2 years. The Gujarat P.W.D. felt that the correct specification for flexible overlay would be 7.5 cm B.M. under 4 cm A.C. surfacing.

(2) In Kerala also, 2 cm premix carpet was tried over thickened edge cement concrete pavement of 10 cm—7.5 cm—10 cm thickness on N.H. 47. As this measure did not serve the desired purpose, and very soon there was widespread reflection cracking, a subsequent treatment of 5 cm Shelcrete with seal coat was adopted. Performance of the second treatment (about 1½ years old at the time of gathering the information) was reported to be satisfactory.

(3) Karnataka adopted flexible overlay of 7.5—11 cm thickness consisting of Shelmacadam and Shelcrete, over the distressed 163 km cement concrete stretch of Karwar-Hubli road. The thickness of the concrete pavement was 10 cm and it was laid in 1953-54. The overlay performance was reported to be satisfactory after 6 years of service.

(4) In case of Tamil Nadu, 5—7.5 cm thick flexible overlays of either bitumen coated macadam or asphaltic concrete were adopted on about 48 km of old cement concrete pavement in varying degrees of distress. The performance was reported to be good. The age of the overlays was 2-6 years.

(5) In Bombay, many of the city roads had lean cement concrete bases which were given either flexible or rigid overlays. For example, on Annie Besant road, the first flexible overlay of 9 cm asphaltic concrete was laid in 1948-50. This performed satisfactorily for about 10 years. The second overlay of 10 cm B.M. (2 layers) + 4 cm A.C. was laid in 1971. Similarly, on Matine Drive, Jacob Circle, Crawford Market Junction, King's Circle etc. fully and partially bonded rigid overlays of 6-20 cm thickness with and without reinforcement were laid 6-10 years back. The performance of all these overlays was reported to be fair to good.

On some roads in other parts of Maharashtra, because of very heavy rainfall, weak subgrade, unfavourable drainage condition and delay in adopting suitable strengthening measures, the concrete pavement of inadequate thickness was very badly cracked and had rocking. In such cases, the residual strength of the concrete pavement could not be utilised by providing overlay thereon and the slabs were broken up fully.

3. INSPECTION OF SELECTED OVERLAY WORKS BY THE I.R.C. WORKING GROUP

3.1. During 1971, the Working Group inspected the following overlay works of both flexible and rigid type in Andhra Pradesh, U.P. and Maharashtra.

(I) Andhra Pradesh

N.H. 7

On N.H. 7, Hyderabad—Nagpur road section, different all-bituminous experimental overlays as well as granular layers under bituminous wearing courses were laid in km 18—18.8 over 10 cm thick old cement concrete pavement. The overlays were about 8 years old. The traffic intensity was reported to be about 1250 commercial vehicles per day. The rainfall in the area was about 50 cm annually. The sub-grade was sandy soil and there was good natural

drainage in the area. The annual air temperature variation was high, being of the order of 25°C. In general, the overlays of different specifications were in fair to very good condition. It was reported that no repairs were conducted on the overlays. Detailed particulars are given in *Annexure 2*.

The Working Group findings (limited to this inspection) were:

- (i) A minimum thickness of 10 cm was necessary for all-bituminous flexible overlays.
- (ii) For flexible overlay composed of granular layer under thin bituminous wearing course, a minimum of 15 cm for the granular layer was necessary.
- (iii) If 2 cm premix with seal coat was adopted as wearing course, the renewal of the seal coat should be done at least every 5 years.
- (iv) 4 cm asphaltic concrete was found to have performed better than 2 cm premix with seal coat as wearing course.
- (v) Meticulous sealing of cracks, and filling of depressions in the existing cement concrete pavement before laying an overlay improved the overlay performance.

(2) Uttar Pradesh

(a) G.T. Road (around Kanpur)

On km 1005-1007 km 996-999 and km 995-997 of G.T. road, both flexible and rigid overlays were laid. Old cement concrete slabs were 10 cm thick in km 1006-1007 and km 996-998 and 7.5-6.5-7.5 cm in km 998-999. The slabs were 25-34 years old. The traffic intensity was 800-1000 commercial vehicles per day. In total, 27 overlay specifications, mostly of the flexible type, were tried out. In the flexible type, both all-bituminous overlays as well as granular layers under bituminous wearing course were adopted. The rigid overlay was of fully bonded type and the bonding medium used was epoxy resin formulation in one case and cement sand slurry in the other. The age of the overlays varied between 2 and 5½ years. These overlays were laid as experimental lengths and their performance was fair to very good.

(b) Kanpur-Hamirpur Road

Experimental flexible overlays were also laid in km 12-16 of Kanpur-Hamirpur road over 9 cm thick cement concrete slabs

25—27 years old. Twenty one specifications were tried out. The traffic intensity was about 340 commercial vehicles per day. The overlays were 3-4 years old and the performance ranged from good to very good.

(c) *G.T. Road (Ghaziabad-Bulandshahar Section)*

Km 1310—1392 of G.T. Road between Ghaziabad and Bulandshahar were overlaid with different flexible specifications of W.B.M. (with stone ballast), W.B.M. (with brick ballast), built-up spray grout (B.U.S.G.) and B.M. under 2-2.5 cm premix carpet. The overlay thickness varied between 9 and 26 cm. In some of the stretches, the top course was provided after a gap of 9—11 years. The slab thickness was 11 cm. The age of the top course varied from 1 to 7 years in case of overlays having more than 15 cm thickness. In one length, there was 7.5—9 cm thick W.B.M. with surface dressing at the top. This length, laid some 12 years back, failed badly. Sections having overlay thickness of 15 cm or more performed very well under traffic of 1000—1500 commercial vehicles per day.

(d) *N.H. 24 (Hapur-Garhmukteshwar Section)*

On Hapur-Garhmukteshwar Section of N.H. 24, there was an experimental rigid overlay (km 67.9—68.1) of fully bonded type. The old cement concrete pavement was 7.5—9 cm thick and was either sound or showed initial cracking near slab corners and edges. The concrete slabs were washed with detergent solution, treated with dilute HCl and subsequently flushed clean with water. Cement sand slurry was used as bonding medium. The thickness of cement concrete overlay was 10 cm. In one portion, about 3.5 kg per sq. m. of mild steel reinforcement was provided. The traffic was about 700—1000 commercial vehicles per day. The overlay was more than 10 years old. At this stage, the condition of the overlay was such that some portion had cracked moderately, while the rest was sound. Cracking in the overlay by and large related to the condition of the existing concrete pavement. Mild steel reinforcement was found to have a salutary effect on prevention of crack-widening.

(e) *G.T. Road (km 1300-1301 near Aligarh)*

The Section was visited by two members of the Working

Group, subsequent to the main inspection in U.P. The single-lane 3.6 m wide old concrete pavement of 7.5 cm thickness, laid in 1944-45 was overlaid with different experimental specifications of flexible overlay in 1965. At the time of overlaying, concrete slabs were in varying degree of distress, including some apparently sound slabs as well.

The overlay specifications used were of three broad types :

- (i) *All granular* Consisting of WBM with two coat surface dressing (SD) or premix with seal coat (PSC).
- (ii) *Composite* Consisting of partly WBM and partly (a) bituminous macadam (BM) with PSC/ashaltic concrete (AC) or (b) AC.
- (iii) *All bituminous* Consisting of BM and/or AC.

The overall thickness of different specifications ranged from about 5 to 22.5 cm. A tack coat was given over the existing concrete slabs before overlaying—at the rate of 9.1 kg per 10 m² in case of WBM and 6.8 kg per 10 m² in case of BM or AC, as the first layer immediately above the slab. In case of all-bituminous overlays, use of expanded metal mesh at the rate of about 5.0 kg per m² was also tried on a few slabs. The overlays with two coat surface dressing were given a renewal coat in 1968 after about 3 years of construction.

The test track carried a daily traffic of about 1000 commercial vehicles in 1966, which rose to about 1400 commercial vehicles per day by 1971.

At the time of the visit, the different sections of the test track were in different conditions, some having stood quite well, while the others showed such distress as reflection cracking, ravelling, pot holes etc.

The subgrade in all the lengths had low plasticity soil with PI ranging between 4-14. Drainage was good and there was no evidence of mud pumping anywhere. The water table was at a depth of more than 3 m. The annual rainfall was about 80 cm and air temperature variation very high, being around 40°C. The particulars are given in *Annexure 2*.

The Working Group findings (limited to this inspection) were :

(i) A minimum of 15 cm granular layer under thin bituminous wearing course such as 2 cm premix with seal coat or 10 cm all-bituminous layer was necessary for flexible overlays in areas where the soil was of low plasticity, base course satisfactory, drainage condition satisfactory and rainfall of medium intensity (40–125 cm annually).

(ii) The following was generally agreed to in respect of flexible overlay :

(I) Slabs moderately to badly cracked

Where the traffic was 1000 commercial vehicles per day and above, 7.5 cm B.M. + 2.5 cm A.C., or 15 cm granular layer + 2.5 cm A.C. was required. Where traffic was less than 1000 commercial vehicles per day, 7.5 cm B.M. + 2 cm premix with seal coat, or 15 cm granular layer + 2 cm premix with seal coat was necessary.

Note : (a) 15 cm granular layer could be either wholly W.B.M., 7.5 cm W.B.M. + 7.5 cm B.U.S.G., or wholly B.U.S.G.

(b) The seal coat for the premix should be renewed at least every 5 years.

(II) Slabs very badly cracked (alligator type of cracking)

Steps should first be taken to prevent rocking, if any, by mud-jacking or other means. All cracks should be sealed properly with suitable bituminous materials.

This should be followed by placement of coated macadam (about 2.5 to 3 per cent bitumen) of required thickness with 5 cm as levelling course. The overlay specifications to be adopted over the levelling course should be the same as those for (I).

(III) Unless subgrade was poor, where there was pumping of the base course under the slabs and/or the slabs were rocking and could not be treated to prevent rocking, the slabs should not be broken into pieces but their residual strength utilised to the fullest extent by overlaying them.

(IV) Where W.B.M. as granular overlay was directly laid over the existing concrete slabs, either a bituminous tack coat or 1 cm layer of non-plastic soil should be incorporated in between to enable rolling and proper compaction of the W.B.M.

(iii) The following was generally agreed to in respect of rigid overlay :

(I) Fully bonded rigid overlay with conventional acid-etching treatment and cement-sand slurry as bonding medium might be adopted where the existing cement concrete pavement was almost sound.

(II) On slabs in different degrees of cracking, if rigid overlay was to be adopted, it should be either partially bonded or unbonded and designed accordingly. Partially bonded rigid overlay came in

question only when the slabs were not cracked beyond moderate level.

(3) Maharashtra

(a) N.H. 3 (Bombay-Agra Section)

This section (km 38—181) was composed of 12.5 cm thick cement concrete slabs laid some 23-31 years back and performed well for many years. Because of phenomenal increase in traffic (traffic intensity in 1971 being upto 4000 commercial vehicles per day), inadequate slab thickness, heavy rainfall and poor sub-soil conditions, they suffered distress and needed strengthening. The different measures adopted for strengthening were :

- (i) Removing and breaking badly cracked concrete slabs into pieces (in about 25 per cent of the area) and filling the gap with broken cement concrete upto a depth of about 5 cm, the remaining depth of 7.5 cm being filled with pre-coated metal using bitumen at the rate of 56 kg per cubic metre of metal, followed by a bituminous seal using 9.8 kg of binder per 10 sq.m. The entire surface was then overlaid with 6.25 cm B.M. and 3.75 cms thick asphaltic concrete. A portion of this length from km 50.6 to 52.2 was reported to have been opened to traffic without laying the A.C. wearing coat. This was damaged in monsoon and subsequently was covered with an additional layer of 5 cm B.M. before laying the final 3.75 cm A.C. wearing coat, making a total thickness of 11.25 cm B.M. and 3.75 cm A.C. in this portion. This portion of the road had behaved quite satisfactorily. The remaining portion viz. with 6.25 cm B.M. and 3.75 cm A.C. showed signs of distress and needed to be repaired.
- (ii) Removing concrete slab completely, breaking it into pieces, laying the concrete pieces in layer of 7.5 cm to 12.5 cm, followed by rolling and grouting with asphalt at the rate of 29.3 kg per 10 sq.m. Some 32 km portion of the road was done as per this specification completely. In some portions, extra stone metal layer was added to make up for the additional crust thickness required for CBR values of subgrade, before grouting with bitumen and finally covering with 7.5 cm B.M. and 3.75 A.C. This had given satisfactory performance.

(b) N.H. 4 (Bombay-Poona Section)

On this road (section between km 36-173) also, thickness of the concrete slab was 12.5 cm and was laid 27 to 31 years back. When the cracks started appearing on the rigid pavement, the repairs were first reported to have been carried out with 2 cm to 3.75 cm premix carpet, some time in the year 1955. It was reported that these did not stand well. (Traffic intensity in 1971 was about 4000 commercial

vehicles per day). The measures that were tried out thereafter were as under:

- (i) Experimental stretches : Between km 66 to 66.4 and km 72.2 to 76.4 overlaid in 1962; and in kms 135.2, 135.6, 135.8, 139.4, 141.0, 142.6 and 161.8 overlaid in 1967. It was reported that out of the various experiments conducted in 1962, the specification found to be satisfactory consisted of 7.5 cm thick bitumen coated metal, grouted with bitumen at the rate of 39 kg per 10 tq. m., and covered with 2.5 cm asphaltic concrete.
- (ii) In a length of about 18.4 km, treatment had been done between the years 1965 and 1968:

Removing the badly cracked slabs in about 25 per cent of total area, re-filling these portions with broken pieces of concrete in about 5 cm thickness and remaining 7.5 cm thickness filled with bituminous premixed metal, covering the full area with 6.25 cm B.M. and 4 cm A.C. (similar to the specifications followed on Agra-Bombay Road).

- (iii) Having regard to the excessive deterioration of concrete slabs in the remaining kilometres, the following specification was followed:

Breaking the concrete slab completely in pieces, relaying the same, grouting it with 29.3 kg asphalt per 10 sq.m. covering it with 7.5 cm B.M. and 4 cm A.C. wearing coat.

Additional metal layer was reported to have been provided in some lengths before grouting to compensate for deficiencies in crust thickness wherever necessary as per C.B.R. requirement.

- (iv) In km 135.2 with distressed concrete slabs, the following specification was adopted:

Providing 10 cm metalling with 32 kg per 10 sq.m. bituminous grout and 4 cm bituminous carpet followed by another layer of 4 cm asphaltic concrete laid after monsoon.

The performance of this specification beyond the ghats towards Poona laid some 5 years back was very satisfactory. The annual rain-fall here was 225-250 cm and drainage good.

(c) Bombay City Roads

On Dr. Ambedkar Road and at King's Circle, fully bonded rigid overlays of 1:1½:3 concrete and 6-9 cm thickness were adopted. M.S. reinforcement at the rate of 30 kg per 10 sq.m. was provided in the overlay. The existing concrete pavement was 15 cm thick and of 1:2:4 mix. At the time of overlaying, the condition of the existing slabs was reported to be good. The condition of the overlay in 1917

under very heavy traffic and high rainfall (about 200 cm annually) was fair to good after 6.9 years of service.

In Poibavdi junction, partially bonded rigid overlay was ad-opted over existing lean concrete base, which was of good quality, after removing the flexible crust. The overlay was of a total thickness of 12.5 cm out of which 7.5 cm was of 1:2:4 mix and top 5 cm of 1:11:3 mix. M.S. reinforcement of 30 kg per 10 sq.m. was provided in the overlay. The overlay was about 10 years old and its performance under very heavy traffic good.

The particulars of the roads inspected in Maharashtra given in *Anneeuire* 2 show that in contrast to the conditions to which the overlays were subjected to in Andhra Pradesh and U.P. those in Maharashtra were more severe, namely annual rainfall was of the order of 200-400 cm; subgrade was weak in most of the areas varying from black-cotton soil to marine clay to soft moorum having high P.I. values; pavement shoulder was either inadequate or completely absent in many portions; and drainage in many areas was unfavourable. in addition to these, the traffic on the overlaid sections was very heavy with 2000-7000 commercial vehicles per day. Considering these aspects, the general findings (limited to this inspection) were :

- (i) Where traffic was heavy, but rainfall not very high (less than 200 cm annually), existing concrete pavement slightly to moderately cracked, and drainage satisfactory, 11.5 cm all-bituminous overlay was necessary. This might comprise 7.5 cm B.M. under 4 cm A.C.
- (ii) Where rainfall was very high (250—400 cm annually) and drainage not very satisfactory, a minimum thickness of 16.5 cm composed of coated macadam (about 2.5-3 per cent bitumen) of not less than 5 cm + 7.5 cm B.M. + 4 cm A.C. might be provided for heavy traffic condition.
- (iii) Under all circumstances, the locations of the rocking slabs and the slabs through which mud-pumping had occurred, should first be identified and the same rectified using appropriate means. If rectification could not be economically carried out, they should be removed, broken to pieces and used as macadam layer with bituminous grouting at the rate of 30 kg per 10 sq.m. Alternatively, the slabs could be removed and grouted macadam layer laid with new stone metal. All cracks were to be sealed properly before the overlay was laid.
- (iv) For sections under heavy traffic and/or high rainfall, the surface course of the flexible overlay should at least be 4 cm A.C.

- (v) Suitable hard shoulders and adequate drainage should be provided, if not already present, on both the sides of the overlaid sections.
- (vi) For slabs in sound or slightly cracked condition, either fully bonded or partially bonded rigid overlay might be adopted.
- (vii) For slabs in fairly to moderately cracked condition, partially bonded rigid overlay might be considered.
- (viii) For slabs in moderately to badly cracked condition, unbonded rigid overlay with at least 5 cm of bituminous separation layer might be considered.

4. RECOMMENDATIONS ABOUT OVERLAYS ON CEMENT CONCRETE PAVEMENTS

4.1. The recommendations made herein are based on the comprehensive information collected from different parts of the country and inspection of typical road sections in the States of Andhra Pradesh, Uttar Pradesh and Maharashtra. Since these pertained to roads with slab thicknesses mostly in the range of 75-125 mm, even though some of the roads in the State of Maharashtra had thickness in the range of 150-200 mm, these recommendations may at this stage be deemed on a conservative basis to apply particularly to existing slabs in the thickness range of 75-125 mm.

4.2. Classification of Traffic and Rainfall for Overlay Design

4.2.1. Traffic

For the purpose of these recommendations, the following classifications of traffic and rainfall intensities have been adopted:

<i>Traffic (Commercial vehicles per day having laden weight exceeding 3 tonnes)</i>	<i>Category</i>
0— 150	light
151— 450	medium heavy
451—1500	heavy
Exceeding 1500	very heavy

4.2.2. Rainfall Intensity

<i>Annual rainfall (cm)</i>	<i>Category</i>
0 to 40	low
Exceeding 40 upto 125	medium
Exceeding 125 upto 200	high
Exceeding 200	very high

4.3.. Condition of Existing Pavement

4.3.1. For the purpose of strengthening of concrete pavement with an overlay, the condition of the concrete pavement may be categorised in terms of total length of crack per unit area of the pavement. For this purpose, the following criteria may be used for guidance:

<i>Length of crack in m per 10 sq. m.</i>	<i>Category</i>
(i) 0 to 1.0	sound
(ii) Exceeding 1.0 upto 2.5	slightly cracked
(iii) Exceeding 2.5 upto 5.5	fairly cracked
(iv) Exceeding 5.5 upto 8.5	moderately cracked
(v) Exceeding 8.5 upto 12.0	badly cracked
(vi) Exceeding 12.0	very badly cracked

- Notes :* (a) Based on the above criteria, workable lengths with similar slab condition should be identified for arriving at the overlay measures needed. This classification should be done carefully to see that limited portions with exceptional degree of distress do not result in heavy overlays.
- (b) 'Badly' cracked and 'very badly' cracked slabs which are rocking should be sorted out and removed. The removed slab material may be broken and the resulting aggregate used as base with bituminous grouting at the rate of 30 kg per 10 m² or alternatively utilised as granular material for sub-base in the widening portion or for shoulders.

4.3.2. As far as possible, existing cement concrete pavements requiring strengthening should be overlaid at first signs of distress, while the condition of the slab is still 'slightly cracked'.

4.4. Choice of the Type of Treatment

Two alternative treatments, viz., rigid overlays and flexible overlays are possible for strengthening existing cement concrete pavements. In some cases, complete removal of slab and reconstruction might be found warranted. Different alternatives are available for each of the two main overlay types, viz., fully bonded, partially bonded and unbonded in case of rigid overlays; and all bituminous and composite (i.e. partly granular and partly bituminous) in case of flexible overlays. Before making a choice in each case, relative economics of the various alternatives should be studied in detail taking into account their total costs i.e. the initial as well as the recurring maintenance costs over the design life.

4.5. Rigid Overlays

4.5.1. For existing concrete pavement slabs in 'sound' and 'slightly' cracked condition, fully bonded and partially bonded rigid overlay respectively may be adopted.

4.5.2. For slabs in 'fairly' to 'moderately' cracked condition, partially bonded rigid overlay may be adopted.

4.5.3. For slabs in 'moderately' to 'badly' cracked condition, unbonded overlay with at least 5 cm of bituminous separation layer (B.M.) may be adopted.

Note : In all cases, before the overlay work is undertaken, the locations of the rocking slabs and slabs affected by mud-pumping should first be identified and the same rectified using appropriate means. If rectification cannot be carried out, they should be removed, the exposed sub-base properly compacted and the gap filled with coated bituminous macadam having 2.5–3 per cent binder content or aggregate derived from the broken slab compacted as WBM and grouted with bitumen at the rate of 30 kg per 10 m².

4.5.4. Partially bonded and unbonded rigid overlays may be designed as follows:

(i) Partially bonded overlay

$$h_o = (h_m 1.4 - Ch_e^{1.4})^{1/1.4}$$

(ii) Unbonded Overlay

$$h_o = (h_m^* - Ch_e^*)^{1/2}$$

where h_o —thickness of overlay, h —thickness required for the monolithic slab, h_e —thickness of the existing concrete pavement and C —pavement condition factor, the values of which might be taken as follows:

Category of existing pavement	Value of C
slightly cracked	1.00
fairly cracked	0.75
moderately cracked	0.55
badly cracked	0.35

4.5.5. In case of unbonded overlay, a separation layer as stated in para 4.5.3 is required to be provided after cracks are cleaned and sealed properly with bituminous materials. For partially bonded overlay, the concrete pavement should be generally cleaned of any loose or extraneous matter, given a detergent wash

locally (using powdered soap at the rate of 1 kg per 10 m² of the pavement surface) along with scrubbing with wire brushes to remove oily and greasy material and subsequently the whole surface flushed with water to remove all traces of the solution and other dust particles.

4.5.6. In case of fully bonded rigid overlay, the thickness of the overlay may be taken as that required to make up the difference between the monolithic thickness of cement concrete pavement needed for the present day traffic and the existing pavement thickness. The monolithic thickness may be designed as per IRC : 58-1974 "Guidelines for the Design of Rigid Pavements for Highways". During construction, adequate care should be taken to ensure good bond between the overlay and the existing pavement. For this purpose besides the treatment specified for partially bonded over-lays in para 4.5.5, all bond-preventing materials such as joint sealing compound, bituminous materials used for repair of cracks, paint markings, greasy and oily marks, etc., should be meticulously re-moved. Wherever necessary, light chiselling to scarify the surface for effective bond and to remove loose material at the surface should be done. These treatments should be followed by acid-etching (1:1 dilute HC1 at the rate of 4 kg per 10 m² of surface) in two applications. The surface should be finally flushed with water to remove all traces of acid. On the saturated surface-dry-slabs, bonded rigid overlay should be laid immediately after applying a thin layer (about 1 mm thick) of 1:1 cement sand slurry as bonding medium.

4.5.7. In high rainfall areas, particularly where the drainage is not satisfactory and/or on pavements carrying very heavy traffic of more than 1500 commercial vehicles per day, mild steel reinforcement at the rate of 3 kg per m² should be provided in fully bonded and partially bonded overlays. Mild steel reinforcement mesh at the rate of 3 kg per m² should also be provided in the overlay across cracks in the existing pavement, the width of the mesh being determined from consideration of bond length required on either side of the crack. Such reinforcement may be provided as a general practice for fully bonded and partially bonded rigid overlay irrespective of rainfall, subgrade and climatic conditions.

4.5.8. Joints in the fully bonded and partially bonded overlays

should be matched with those in the existing cement concrete pavement both in regard to location and type.

4.6. Flexible Overlay

4.6.1. The following specifications may be adopted in areas where the annual rainfall is of medium intensity (exceeding 40 upto 125 cm) drainage condition favourable, and subgrade soil of low plasticity (P.I. not exceeding 14).

- (i) **For very heavy traffic (exceeding 1500 commercial vehicles per day)**
 - (1) 7.5 cm B.M. under 4 cm A.C.
or
 - (2) 15 cm granular layer under 4 cm A.C.
- (ii) **For heavy and medium heavy traffic (151-1500 commercial vehicles per day)**
 - (1) 7.5 cm B.M. under 2 cm premix with seal coat
or
 - (2) 7.5 cm B.U.S.G. under 2 cm premix with seal coat (for medium heavy traffic only)
or
 - (3) 15 cm granular layer under 2 cm premix with seal coat or
 - (4) 7.5 cm granular layer under 4 cm A.C.

- Notes:*
- (a) In case of very heavy traffic of more than 1500 commercial vehicles per day, the 15 cm granular layer should comprise 7.5 cm W.B.M. (lower layer)-4- 7.5 cm built-up spray grout (B.U.S.G.). Instead of B.U.S.G., coated macadam consisting of more or less 40 mm single-size aggregate mixed with 2.5-3 per cent bitumen may also be used.
 - (b) Where W.B.M. is directly laid over the existing concrete slabs, either a bituminous tack coat or 1 cm layer of non-plastic soil may be provided in between so as to enable rolling and proper compaction of W.B.M.
 - (c) In all cases, before the overlay work is undertaken, the locations of the rocking slabs and slabs affected by mud-pumping should first be identified and the same rectified using appropriate means. If rectification cannot be carried out, the treatment should be as indicated in the Note under para 4.5.31
 - (d) The cracks in the existing cement concrete pavement should be cleaned and sealed properly with bituminous materials before the flexible over-lay is laid.

4.6.2. The following specifications may be adopted in areas where the annual rainfall is of high intensity (exceeding 125 upto 200 cm), drainage condition unfavourable, and subgrade of high plasticity (P.I. 20 and above):

- (i) For very heavy traffic (exceeding 1500 commercial vehicles per day)
10 cm B.M. under 4 cm A.C.
- (ii) For heavy and medium heavy traffic (151 – 1500 commercial vehicles per day)
7.5 cm B.M. under 4 cm A.C.

Note: Notes (c) and (d) under para 4.6.1 apply as regards treatment to existing slabs prior to overlaying.

4.6.3. The following specifications may be adopted for very heavy traffic (exceeding 1500 commercial vehicles per day) in areas where the rainfall is of very high intensity (exceeding 200 cm annually), drainage condition unfavourable, and subgrade of high plasticity:

- (i) 5 cm coated macadam consisting of more or less 40 mm single size aggregate mixed with 2.5-3 per cent bitumen under 7.5 cm B.M. with 4 cm A.C. as wearing course.
or
- (ii) 11 cm B.M. with 4 cm A.C. as wearing course.

Notes: (a) Where the existing cement concrete pavement is in 'sound' to 'fairly cracked' condition, the base course thickness of the overlay may be reduced but limited to the values stipulated in para 4.6.2.

- (b) Notes (c) and (d) under para 4.6.1 apply as regards treatment to existing slabs prior to overlaying.

4.6.4. For conditions other than those stipulated in 4.6.1, 4.6.2 and 4.6.3, suitable intermediate or next higher specification may be adopted at the discretion of the Engineer-in-Charge.

4.7. Drainage

The strengthened cement concrete pavement should be provided with adequate drainage facilities for successful performance.

5. SUGGESTIONS FOR FURTHER WORK

- 5.1. It is suggested that experimental stretches of overlays of

both flexible and rigid type might be laid taking into consideration the recommendations made herein.

5.2. It is further suggested that experiments with continuously reinforced concrete and fibrous concrete as rigid overlay might also be conducted similarly.

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The Working Group further wishes to record the assistance of the State P.W.Ds. in readily supplying the data on overlay work done by them.

DETAILS OF OVERLAY WORKS COLLECTED (OTHER THAN THOSE INSPECTED) BY THE WORKING GROUP DURING THE YEAR 1971

Location	Details of old concrete pavement			Years of useful service	Distress, type and degree	Sub-base course under old cement concrete pavement	Drainage	Rainfall cm	Temperature Variation °C	Type of overlay & year of overlaying	Design consideration, if any	Details of overlay & pre-treatment, if any	Condition of overlay and age at the time of reporting	Traffic intensity in 24 hours (No. of Comm. Vehicles)	Condition of shoulders	Maximum wheel load, kg	Period or age after constn. upto which overlay performed satisfactorily without any major treatment	Subsequent treatment, if any, given to overlay	Any other details
	(a) Year of construction	(b) Thickness, cm	(c) Slab width, m																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

GUJARAT

1. (a) Ahmedabad-Viramgam road (b) 10 (c) 3.66	1. (a) 1955 (b) — (c) 3.66	—	Undowelled exp. jt. (e) 37 m	1:2:4 by vol.	—	Wide cracks	Average 25 cm granular sub-base	Good	75 to 80	About 40	Flexible	Nil	2 cm premix with seal coat as a maintenance measure	Not satisfactory	1. (b) 399 2. (b) 292 3. (b) 425 4. (b) 416	Good	4080	—	—
2. (a) Ahmedabad-Dhandhuka Gondal Porbandar road (c) 28.40	2. —	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3. (a) Nadiad Dakor Indore Jabalpur road (c) 17.60	3. (a) 1948-49 (b) — (c) —	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4. (a) Nadiad-Kapadwanj-Bibipura road (c) 48.0	4. (a) 1955 (b) — (c) —	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5. (a) Nadiad-Kapadwanj Modasa road (c) 45.40	5. —	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6. (a) Harsol-Dhansura road (c) 30.40	6. —	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7. (a) Ankleshwar-Hansol-Sahol road (b) km 5.8 to 69.6 (c) about 48 (d) 3.66	7. (a) 1955 (b) 10 (c) 3.66	—	—	10	Cracking	Black cotton soil sub grade	—	75	—	Flexible 1965-66 & 1967-68	Nil	—do—	—do—	(b) 203	—	—	—	—	—
8. (a) Baroda-Khandewadi road (c) 30 (d) 6.30	8. (a) 1953-55 (b) 11.25 (c) 3.66	—	—	5	Cracking & rocking of slabs	—do—	—	75	—	Flexible 1960-65	Nil	—do—	Not satisfactory, extensive cracking	(b) 1020	Good	—	About 2 yrs. Renewal 1967-70	—	—

(Contd.)

Annexure I (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
9. (a) Godhra-Halol-Bodeli road (b) km 0 to 38.4 (c) 40 (d) 3.66	9. (a) 1954-55 (b) 10 (c) 3.66	—	—	8	Cracking of slabs	-do-	—	78-100	—	Flexible 1962	Nil	2 cm thick premix with seal coat	Not satisfactory, extensive cracking	(b) 350	—	—	About 2 yrs.	Renewal after about 2 years	—
10. (a) Halol-Khandewadi road (b) km 33.8 to 41.6 (c) 8 (d) 3.66	10. (a) 1954-55 (b) 10 (c) 3.66	—	—	8	-do-	-do-	—	-do-	—	Flexible 1963	Nil	-do-	-do-	(b) 725	—	—	-do-	-do-	
11. (a) Sevalia-Godhra-Dohad road (b) km 115.0 to 164.8 (c) 52 (d) 3.66	11. (a) 1954-55 (b) 10 (c) 3.66	—	—	8	Cracking	Black cotton soil subgrade	—	—	—	-do-	Nil	2 cm premix	Not satisfactory	(b) 375	—	—	-do-	—	
12. (a) Sevalia-Godhra-Dohad road (b) km 164.5 to 208.0 (c) 43 (d) 3.66	12. (a) 1952-54 (b) 10 (c) 3.66	—	—	Slight cracking	Moorum	—	80	—	Flexible 1964-65	Nil	2 cm premix	Satisfactory	(b) 318	—	—	—	—	—	
KERALA																			
(a) Trivandrum-Nagercoil road (NH 47) (b) km 570 to 578 & 594 to 599 (c) 13 (d) 4.3	(a) 1939-41 (b) 10-7.5-10 (c) 4.3	Exp. jt. undowelled butt type @ 10.1 m	1:2.4 by vol.	23	Fairly cracked	Sandy-gravel subgrade. 15 cm soling 15-45 cm WBM	Satisfactory except at cut portions	112 to 150	20 to 42	Flexible 1964-66, 1969-70	Nil	2 cm premix 1964-66 (km 570-578), 5 cm A.C. with seal coat 1969-70 (km 594-599)	Km 570-576, not satisfactory, needed replacement in 5 yrs. Km 576-578, reflection cracking after 6 yrs. km 594-599 satisfactory after 1½ yrs.	(a) 1125 (b) 1212	0.9 m wide shoulders with 15 cm WBM and 1 cm premix	4080	5 cm A.C. satisfactory after 1½ yrs. of service	Km 570-576, given occasional patch renewal followed by 2 cm premix & finally covered with 5 cm A.C. in 1969	—

(Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
KARNATAKA																			
(a) Karwar-Hubli road (b) km 0 to 163.2 (c) 163.2 (d) 6.10	(a) 1953-54 (b) 10 (c) 3.66	Exp. jt. undowalled butt type @ 6.10 m	—	10	Badly cracked	Varying	—	75 to 375 (varying)	—	Flexible	—	For entire length 3.75 cm shelcrete. Addl. thickness in some portions; (a) 3.75 cm shelmacadam (b) 7.5 cm shelmacadam + seal coat	Satisfactory. 6 yrs.	(b) 393	—	—	—	—	—
TAMIL NADU																			
1. (a) Tenkasi-Madurai road (b) km 53.4 to 54.0, 54.4 to 54.6, 55.4 to 55.6, 56.0 to 56.4, 59.6 to 60.4, 61.8 to 62.4. (c) 2.813 (d) 5.46	(a) 1953-54 (b) 10 (c) 5.46	Exp. jt. @ 10.1 m	1:2:4 (0.5 w/c)	12	Badly cracked with rocking slabs	15 cm WBM over black cotton soil	Fair	84	—	Flexible 1965-66	Nil	7.5 cm coated macadam + 3.5 cm bit. wearing coat	Smooth in general; wheel tracks have started forming in some sections. 4 years.	(b) 470 to 600	Fair; no treatment	5400	Nil	—	—
2. (a) Tenkasi-Madurai road (b) km 59.0 to 59.6, 60.4 to 60.8, 61.4 to 62.2, (b) 10 68.2 to 68.4, 68.8 to 69.2 (c) 2.210 (d) 5.46 to 7.3	(a) 1953-54 (b) 10 (c) 5.46 to 7.3	-do-	-do-	13	-do-	-do-	-do-	-do-	—	Flexible 1966-67	Nil	7.5 cm A.C.	-do-	(b) 1300 to 1500	Good; no treatment	-do-	Nil	—	—
3. (a) Grand Southern Trunk road (NH-45) (b) km 304.2 to 311.8 (c) 7.6 (d) 6.8	(a) 1951 (b) 10 (c) 6.8	-do-	-do-	12	-do-	15 cm WBM over stiff clay	Good	88	—	Flexible 1963	Nil	6.25 cm A.C.	Smooth in general; some pot holes. 8 years	(b) 1300 to 4200	Fair; no treatment	-do-	Nil	—	—

(Contd.)

Annexure I (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4. (a) Grand Southern Trunk road (NH-45) (b) km 303.8 to 304, 306.8 to 307, 307.0 to 307.8 (c) 1.2 (d) 6.8	(a) 1951 (b) 10 (c) 6.8	Exp. jt. @ 10.1 m	1:2:4 (0.5 w/c); 213 to 290	17	Badly cracked with rocking slabs	15 cm WBM over clayey subgrade	Good	88	—	Flexible 1968	Nil	6.25 cm coated macadam with tack coat	Smooth in general. 3 years	(b) 1300 to 4200	Fair; no treatment	5400	Nil	—	—
5. (a) Trichy-Salem road (N.H. 7) (b) km 121.4 to 122.8 (c) 1.6 (d) 6.8	(a) 1956 (b) 10 (c) 6.8	-do-	-do-	11	-do-	15 to 23 cm gravel + 12 to 20 cm WBM over clayey subgrade	-do-	84	—	Flexible 1967	Nil	5 cm A.C.	Some pot holes. 4 years	(b) 2500 to 4280	-do-	-do-	Nil	—	—
6. (a) Trichy-Salem road (N.H. 7) (b) km 120.8 to 121.2, 122.8 to 123.2, 125.8 (c) 1.6 (d) 5.5 to 6.8	(a) 1956 (b) 10 (c) 5.5 to 6.8	Exp. jt. @ 10.1 m	1:2:4 (0.5 w/c); 200 to 290	-do-	-do-	22 cm gravel + 12 to 20 cm WBM over clayey subgrade	-do-	-do-	—	-do-	Nil	7.5 cm coated macadam	Generally smooth; fine hair cracks on close observa- tion. 4 years	(b) 2500	-do-	5400	—	—	—
7. (a) Trichy-Salem road (N.H. 7) (b) km 126.8 to 128.4 (c) 1.6 (d) 5.5	(a) 1956 (b) 10 (c) 5.5	-do-	-do-	-do-	-do-	-do-	-do-	-do-	—	-do-	Nil	-do-	Smooth. 4 years	(b)	-do-	-do-	—	—	—
8. (a) Trichy-Salem road (N.H. 7) (b) km 128.4 to 130 & 120.0 to 120.8 (c) 2.8 (d) 6.8	(a) 1956 (b) 10 (c) 6.8	-do-	-do-	-do-	-do-	-do-	-do-	-do-	—	-do-	Nil	-do-	-do-	-do-	-do-	-do-	—	—	—

(Contd.)

Annexure I (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
9. (a) Varanasi-Cape Comorin road (N.H.7) (b) km 199.8 to 202.2 (c) 2.4 (d) 3.66	(a) 1956 (b) 10 (c) 3.66	Exp. jt. @ 10.1 m	1:2.4 (0.5 w/c); 200 to 290	13	Badly cracked with rocking of slabs	Sandy loam sub-grade under 15 cm gravel+15 cm W.B.M.	Fair	84	—	Flexible 1968-69	Nil	7.5 cm coated macadam	Smooth. 2-3 yrs.	(b) 2500	Fair; no treatment	5400	—	—	—
10. (a) Salem-Cochin-Cape Comorin road (N.H. 7) (b) km 50.2 to 63.6, 66.8 to 67.0, 68.8 to 69.0, 70.6 to 72.0 (c) 12.8 (d) 6.8	(a) 1940-41 (b) 10 (c) 4.25	-do-	-do-	25	-do-	Soil gravel subgrade under 15 cm stone soling+30 to 38 cm WBM	-do-	147	—	Flexible 1964-65 to 1967-68	Nil	5 cm A.C. with seal coat	Smooth; reflection cracking & rutting under wheel tracks. 5 yrs.	(b) 1200	-do-	-do-	—	—	Further overlay is needed
11. (a) Salem-Cochin-Cape Comorin road (N.H.7) (b) km 57.2 to 57.6, 58.6 to 58.8 & 59.0 to 59.2 (c) 0.8 (d) 6.8	-do-	-do-	-do-	-do-	-do-	-do-	-do-	—	—	Flexible 1967-68 and 1968-69	Nil	7.5 cm coated macadam	Smooth. 3 years.	(b)	-do-	-do-	-do-	—	—
UTTAR PRADESH																			
1. (a) Delhi-Mathura road (N.H. 2) near Farrah (b) km 1225.6 to 1227.2 (c) 0.4 (d) 6.10	(a) 1962-63 (b) 7.5 & 10 (c) 6.10	(a) Exp. jts. @ 30 m, (b) Cont. Jt. Dummy groove type @5.0 m	—	7	7.5 cm sections cracked extensively; 10 cm sections, corner & long. cracks only	—	Good	—	—	Flexible 1970	—	7.5 cm B.M. +3.75 cm A.C.	Very good. 1 year.	—	Good	4080	Till date	Nil	—
MAHARASHTRA																			
1. Bombay City roads (i) (a) Marine Drive (b) — (c) 1.8 (d) 11.0	(a) — (b) 15 to 17 (c) 11.0	—	Lean cement concrete	—	—	—	200 cm	—	Rigid 1962 (partially bonded)	—	16 cm rigid overlay with 1:2.4 mix.	Fair to good, 9 yrs.	Very high	—	-do-	Till date 9 years	—	28 days overlay conc. comp. str. 286 kg/sq. cm. 9 cm A.C. over lean c.c. laid earlier removed	

(Contd.)

Annexure I (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
MAHARASHTRA																			
(ii) (a) Annie Besant road	(a) 15 (b) 15 to 17 (c) —	—	Lean cement concrete	—	—	(a) Moorum of CBR 6 (b) no sub-base	—	200 cm	—	Flexible 1948-50	—	9 cm A.C.	Required maintenance from 1960 onwards. Very good after 2nd overlay in 1971	Very high	—	4080	10 years	2 layers of B.M. 5 cm each + 4 cm A.C. laid in 1971	—
(iii) (a) Jacob Circle	(a) 1930 (b) 15 (c) —	—	—do—	32	—	—	—	—do—	—	Rigid (partially bonded) 1962	—	20 cm cement concrete overlay consisting of 15 cm of 1:2:4 mix and top 5 cm with 1:1½:3 mix.	Fair to good after 9 years	—do—	—	—do—	Till date 9 years	—	Stone set overlay over lean c.c. removed
(iv) (a) Shivaji Park Junction (at places)	(a) 1927 (b) 20	—	—do—	—	—	—	—	—do—	—	Rigid (partially bonded) 1970-71	—	6.25-8.75 cm cement concrete overlay with 1:1½:3 mix; 30 kg/10 sq. m. mild steel reinforcement	—	—do—	—	—do—	—	—	9-12.5 cm A.C. overlay removed
(v) (a) Crawford Market Junction (at places)	(b) 15	—	—do—	—	—	Rubble soiling and metal layer about 30-36 cm as sub-base	—	—do—	—	Rigid (partially bonded) 1961	—	12.5 cm cement concrete overlay consisting of 7.5 cm of 1:2:4 mix and top 5 cm of 1:1½:3 mix; 30 kg/10 sq.m. mild steel reinforcement	Fair to good after 10 years	—do—	—	—do—	Till date 10 years	Nil	—

DETAILS OF OVERLAY WORKS INSPECTED BY THE WORKING GROUP DURING THE YEAR 1971

Location	Details of old concrete pavement					Sub-base course under old C.C. pav-ement	Drainage	Rainfall, cm	Temperature variation, °C	Type of overlay and year of overlaying	Design consideration, if any	Details of overlay and pretreatment, if any.	Condition of overlay and age at the time of reporting**	Traffic intensity in 24 hrs. (No. of comm. vehicles)	Condition of shoulders	Maximum wheel load, kg	Period or age after construction upto which overlay performed satisfactorily without any major treat-ment	Subsequent treatment if any, given to overlay	Any other details	
	(a) Name of the road (b) Km (c) Length of road, km (d) Width of road, m	(a) Year of construc-tion (b) Thickness, cm (c) Slab width m	Joint type and spacing, m	Mix proportions and compr. strength, kg/m³	Years of useful service															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
ANDHRA PRADESH																				
1. (a) Hyderabad-Nagpur road (N.H. 7) (b) Km 18 to 18.8 (c) 0.8 (d) 6.05	(a) 1950 (b) 10 (c) 6.05 with central long. joint	(a) Exp. jt., undowelled @ 10 m (b) Full depth contraction jt. @ 3.33 m	—	13	Slabs in diff. stages of failure with long. and trans. cracks and pot holes. Some settlements also	Sandy soil subgrade. Slabs laid on 15 cm granular sub-base over low embankment	Good	50	25	Flexible	1963	Nil	Each specification 38 m x 6.05 m laid over 'good' and 'bad' sections (1) 3.75 cm A.C. (Rs 31,700/km) (2) 7.5 cm A.C. (Rs 60,000/km) (3) 10 cm A.C. (Rs 96,000/km) (4) 12.5 cm A.C. (Rs 1,09200/km) (5) 7.5 cm B.M.+3.75 cm A.C. (Rs 72,300/km) (6) 7.5 cm B.M.+2 cm premix+seal coat (Rs 59,000/km) (7) 7.5 cm W.B.M.+2 cm premix+seal coat (Rs 39,600/km) (8) 7.5 cm W.B.M.+3.75 cm A.C. (Rs 52,900/km) (9) 15 cm W.B.M.+3.75 cm A.C. (Rs 71,900/km) (10) 15 cm W.B.M.+2 cm premix+seal coat (Rs 58,700/km)	Fair to good. Age 8 years	(a) 661 (b) 1505	—	4080	Till date about 8 yrs.	Nil	—

(Contd.)

**Pertains to the year 1971

Annexure 2 (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2. (a) Hyderabad-Vijayawada road (N.H.9) (b) Km 14.4 to 16.0 (c) 1.6 (d) 6.05	(a) 1948-50 (b) 10 to 11.25 (c) 6.05 with central long. jt.	—	—	22	Slabs with long. cracks	(a) Sandy soil sub-grade (b) Granular sub-base 15-17 cm	Good	50	25	Flexible 1971	Nil	7.5 cm B.M. + 3.75 cm A.C.	Current	(b) 300 to 400	—	4080	—	—	—
UTTAR PRADESH																			
1. (a) Grand Trunk road in Kanpur Distt. (b) Km 995.2 to 996.8 (c) 1.3 (d) 6.0	(a) 1937 (b) 10 (c) 6 with central long. jt. (d) 6.0	(a) Exp. jt. undowelled @ 30 m (b) Contraction jt. @ 10 m	1:2:4	29	Badly cracked, but no rocking	(a) Soil type ML & CL. PI 4 to 14 (b) Sub-bases 10 cm WBM over 10 cm brick soling over 17-23 cm kankar	-do-	80	40	Flexible 1966	—	(1) 11 cm B.U.S.G. + 2.5 cm premix (2) 11 cm B.U.S.G. + 3.75 cm A.C. (3) 7.5 cm B.M. + 2.5 cm premix (4) 7.5 cm B.M. + seal coat (5) 7.5 cm A.C. + seal coat (6) 10 cm A.C. + seal coat (Cost Rs 12.50 to 16.40 per sq. m.)	Fair. Age 5 yrs.	750 1050	Brick on edge, Good	4500	Till date about 5 years	Nil	—
2. (a) Grand Trunk road in Kanpur Distt. (b) Km 996.8 to 998.4 (c) 1.6 (d) 6.0	(a) 1937 (b) 7.5-6.25-7.5 (c) 6.0 with long. jt. (Note: 2 kg/sq.m. reinforcement)	—do—	1:2:4	32	Moderately to badly cracked	(a) Soil type ML & CL. PI 4 to 14 (b) Sub-bases 22.5-27.5 cm WBM + kankar	Good	80	40	Flexible 1969-70	Select suitable specification for flexible overlay and also to determine its min. thickness	5.0 to 7.5 cm lean bit. premix levelling course Specifications: (1) 2.5 cm A.C. + 2.5 cm mastic asphalt (2) 3.75 cm A.C. + 2.0 cm mastic asphalt (3) 5.0 cm A.C. (4) 2.5 cm A.C. (5) 5.0 cm A.C.+seal coat (6) 5.0 cm B.M.+seal coat (Cost Rs 11.30 to 16.47 per sq. m.)	Very good. 1 to 2 years	(a) 1250 (b) 1375	Good	4500 kg	Till date	Nil	—

(Contd.)

Annexure 2 (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
3. (a) Grand Trunk road in Kanpur Distt. (b) Km 1005.8 to 1007.4 (c) 1.6 (d) 3.65	(a) 1944-46 (b) 10 (c) 3.65	-do-	-do-	21	Moderately cracked	(a) Soil type ML & CL. PI 4 to 14 (b) 10-15 cm WBM + 20-30 cm kankar sub-base	-do-	-do-	-do-	Rigid & Flexible 1965-66	Rigid Overlay 8.75 cm rigid overlay (joints matched) (a) acid etching treatment + cement slurry bonding media and (b) acid etching + epoxy resin as bonding media. Flexible Overlay (OBBA- overburnt brick ballast) (1) 7.5 cm B.M. + seal coat (2) 7.5 cm B.M. + 2.5 cm premix (3) 7.5 cm shell Macadam + seal coat (4) 7.5 cm shell Macadam + 2.5 cm premix (5) 7.5 cm full grout + 2.5 cm premix (6) 7.5 cm full grout + seal coat (7) 7.5 cm A.C. + seal coat (8) 15 cm WBM + 2 coat S.D. (9) 7.5 cm WBM (OBBA) + 7.5 cm WBM + 2 coat S.D. (10) Tack-coat + 15 cm WBM + 2 coat S.D. (11) 7.5 cm WBM + B.U.S.G. + 2 coat S.D. (12) Tack-coat + 7.5 cm WBM (OBBA) + WBM + 2 coat S.D. (13) 11 cm WBM + 2.0 cm premix (Cost Rs 11.1 to 22.6 per sq.m.)	Fair to very good	(a) 625 (b) 937	Brick on edge. Good	-do-	Till date 5 yrs.	Nil	Rigid overlay conc. strength at 28 days: comp. str. = 828 kg/sq. cm. Flex. str. = 35.4 kg/sq. cm.	

(Contd.)

Annexure 2 (Contd.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4.	(a) Kanpur-Hamirpur road (b) Km 12.8 to 14.4 (c) 1.6 (d) 3.65	(a) 1944-46 (b) 8.75 (c) 3.65	-do- Contraction jts. skewed at 70° to the centre line	-do-	23	Badly to very badly cracked	(a) Soil type ML & CL. (b) 8.75 to 15 cm WBM + 10 to 25 cm kankar sub-base	-do-	-do-	-do-	Flexible 1967-68	-do-	(1) 7.5 cm B.M. + seal coat (2) 7.5 cm B.M. + 2.5 cm A.C. (3) 2.5 cm A.C. (4) 2.5 cm premix (5) 7.5 cm B.U.S.G. + 2.5 cm A.C. (6) 7.5 cm B.U.S.G. + 2.0 cm premix (7) 7.5 cm B.C. + 2.5 cm A.C. (8) 7.5 cm B.C. + seal coat (9) 5.0 cm A.C. + 2.5 cm A.C. (10) 5.0 cm + seal coat (11) 5.0 cm B.M. + seal coat (12) 5.0 cm B.M. + 2.5 cm A.C. (Cost Rs 5.90 to 16.1 per sq.m.)	Good to very good	(a) 375 (b) 500	-	-do-	-do-	Nil	-
5.	(a) Kanpur-Hamirpur road (b) Km 14.4 to 16.0 (c) 1.6 (d) 3.05	(a) 1944-46 (b) 8.75 (c) 3.05	Exp. jt. @ 30 m. spacing	-do-	-do-	-do-	-do-	-do-	-do-	-do-	-do-	(1) 7.5 cm A.C. (2) 11.25 cm B.M. + seal coat (3) 11.25 cm A.C. + seal coat (4) 7.5 cm WBM + 7.5 cm B.M. + seal coat (5) 7.5 cm WBM + 7.5 cm A.C. + seal coat (6) 15 cm B.U.S.G. + 2.0 cm premix (7) 7.5 cm WBM + 7.5 cm B.U.S.G. + 2.0 cm premix (8) 7.5 cm WBM + 7.5 cm B.U.S.G. + 2 coat S.D. (9) 7.5 cm WBM + 7.5 cm B.U.S.G. + 2.5 cm A.C. (Cost Rs 15.9 to 19.0 per sq.m.)	Good. 3 to 4 yrs.	(a) 375 (b) 500	-	-do-	-do-	Nil	-	
6.	(a) Grand Trunk road near Bulandshahar (b) Km 1310.4 to 1392 (c) 82 (d) 3.65	(a) — (b) 11.25 (c) 3.65	—	—	—	(a) Subgrade silty soil with low plasticity (b) 15-20 cm kankar sub-base	Good in general (at places water- logging)	—	—	—	Flexible	—	Several flexible overlays specifications of diff. combinations of WBM (with stone ballast), WBM (with brick ballast), B.U.S.G. and BM under 2-2.5 cm premix carpet. The total overlay thickness varied between 9 and 26 cm. In most of the sections the overlay was laid in 2 instal- ments, the second overlay being laid after the first one of 7.5 to 8.5 cm thick granular material showed distress. The second overlay was 1 to 7 yrs. old	Condition of second overlay after 1-7 yrs. Good to very good	(b) 1000- 1200	Good in general (at places water- logging)	-do-	Second overlay satisfactory till date. 1-7 yrs.	Second overlay consisted of 17.5 cm WBM/ 7.5 cm B. U.S.G. under 2-2.5 cm premix.	—

(Contd.)

Annexure 2 (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
7. (a) Hapur-Garh road N.H. 24 (b) Km 62-62.2 (c) 0.2 (d) 3.65	(a) 1947-52 (b) 7.5 (c) 3.65	(a) No exp. jt. (b) Plain butt joints @ 10 m	1:2:4	12	Sound to slight cracking	(a) Silty soil with low plasticity (b) 12.5-15 cm kankar + 15 cm WBM sub-base	Good	80	40	Rigid 1961	—	10 cm fully bonded rigid over- lay (4 kg./sq. m. reinforce- ment in one section) after acid-etching treatment using cement sand slurry as bond- ing medium.	Good in general after 10 yrs. Sound for overlay over sound slabs and fairly to moderately cracked for overlay over slightly cracked slabs. Rein- forced sec- tion fairly cracked but cracks held tight by rein- forcement	(a) 250 (b) 1375	Carriageway widened on both the sides of the overlaid sec- tions	-do-	Till date about 10 years	Nil	Overlay con- crete strength at 28 days; compr. str. =306-511 kg/ cm ² Flex. str.=40.63 kg/cm ²
8. (a) Lucknow-Gorakhpur road, N.H 28 (b) Km 9-10 (c) 1 (d) 6.05	(a) 1941 (b) 9 (c) 6.05	—	—	29	Extensive cracking	(a) Silty soil with low plasticity (b) 17.5 to 32.5 cm kankar sub-base	Good in general (at places water- logging)	80	40	Flexible 1971	—	(1) 7.5 cm B.M. + seal coat (2) 7.5 cm B.U.S.G. + 7.5 cm B.M. + seal coat	Current	(b) 1250	—	-do-	—	—	
9. (a) G.T. Road near Aligarh (b) Km 1300-1301 (c) 1 (d) 3.65	(a) 1944-45 (b) 7.5 (c) 3.65	Plain butt joint @ 10 m	-do-	21	Sound and fairly to badly cracked	—	-do-	—	—	Flexible 1965	—	(1) 6 to 10 cm A.C. (2) 7.5 to 15 cm WBM + 7.5 to 15 cm B.M. + premix with seal coat (3.75 cm A.C. (3) 7.5 to 15 cm B.M. + pre- mix with seal coat (3.75 cm A.C. (4) 7.5 to 22.5 cm WBM + 2 coat S.D. premix with seal coat (3.75 cm A.C.	Fair to very good. 5 years	(a) 1000 (b) 1375	—	4030 kg	Till date 5 yrs.	Nil	Total no. of specifications =46
MAHARASHTRA																			
1. (a) Bombay-Agra Road, N.H. 3 (b) Km 38.4 to 180.8 (c) 142 (d) 6.05	(a) 1940-47 (b) 12.5 to 15 (c) 6.05 (with central long. jt.)	(a) Exp. jt. @ 36.6 m and contraction jt. @ 9.15 m	1:2:4 160 kg/cm ²	20 to 25	Badly cracked	(a) Clayey soil and moorum with CBR from 2 to 12 (b) 22.5 cm soling, 7.5 cm metall- ing, 2.5 cm 1:4:8 lean concrete	Fair to poor	225 to 400	27	Flexible or re- moval of c.c. slabs and recon- struction of the road as flexible pavement, 1959-71	To investigate the efficacy of different flexi- ble overlays	Overlay: Removing badly cracked c.c. slab in 25 per cent of the area, filling the excavated gap with pre-coated material covered with 5-11.25 cm BM and 3.75 cm AC. Reconstruction: Removing completely existing c.c. slab and breaking to 5 cm—7.5 cm size pieces which were spread in two layers and consolidated. Additional metal, where neces- sary, to make up for the crust thickness required from CBR consideration. Grouting with bitumen @ 293 kg per 100 sq. m. covered with 7.5 cm BM and 3.75 cm AC.	Fairly satis- factory to very good. 2-5 yrs. for overlay re- construction	(a) 125 to 2750 (b) Varying, 1250 to 7625	Moorum shoulders, Fair	5000 kg.	Till date 2-5 yrs	The following treatment pro- posed on over- laid sections: Breaking and removing badly cracked c.c. slab in 40 per cent area, re- laying the broken slab pieces and extra metal, as necessary, grouting with bitumen @ 293 kg per sq.m., covered with 5 cm BM and 4 cm AC. No treatment proposed on reconstructed sections.	—

(Contd.)

Annexure 2 (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
(2) (a) Bombay-Poona road, N.H. 4 (b) Km 36.8 to 172.8 (c) 136 (d) 7.0	(a) 1940-44 (b) 12.5 (c) 6.10 (with central long. jt.)	Exp. jt. @ 36.6 m and contrac-tion jt. @ 9.15 m	1:2:4	14	Badly cracked	(a) Subgrade of moorum with CBR 2 to 9 and B.C. soil (b) 15 to 30 cm WBM sub-base	Satisfactory to Good	250 to 400	27	-do-	-do-	* (See note below)	Fairly satis-factory to very good after 2 to 8 years of second overlay	(b) 6250	—	5000	Till date 1-7 years.	-do-	—
(3) Bombay City Road i) (a) Poibavdi Junction	(b) 15	—	Lean conc.	—	Good	Rubble soling +WBM of about 30-35 cm	Gets flooded during rains	200	—	Rigid (partially bonded) 1960	—	12.5 cm overlay consisting of 7.5 cm of 1:2:4 mix and 5 cm of 1:1½:3 mix (30 kg/10 sq. m. of m.s. reinforcement)	Good after 10 years	Very high	—	4080	Till date 10 years.	—	—
ii) (a) King's circle (at places)	(b) 15	—	1:2:4	—	—	—	—	-do-	—	Rigid (fully bonded) 1962	—	6.25-8.75 cm of rigid overlay with 1:1½:3 mix (30 kg 10 sq.m. of m.s. reinforcement)	Fair to good after 9 years	Very high	—	-do-	Till date 9 years.	Nil	—
iii) (a) Dr. Ambedkar road between Sion and King's Circle Bridge (at places)	(b) 15	—	1:2:4	—	Slab in good condition	Subgrade of CBR 4 to 6	—	-do-	—	Rigid (fully bonded) 1962	—	6 to 9 cm of fully bonded rigid overlay of 1:1½:3 mix (30 kg 10 sq. m. of m.s. reinforcement)	Fair to good after 6-9 yrs.	Very high	—	-do-	Till date 6-9 years.	Nil	—

*Note:

Overlay:

(i) Experimental Sections:

Following specifications adopted:

1. — Concrete slab broken to pieces not exceeding 10 cm.
— Broken concrete covered with 4.5 cu.m. per 100 sq.m. of 4 cm size metal
— Grouted with 6 kg/sq.m. of 60/70 bitumen.
— Cover coat of 0.9 cu.m. per 100 sq.m. of 1.25 cm size chippings
— 2.5 cm AC.
2. — Same as 1 excepting covered with 4 cm AC.
3. — 7.5 cm thick BM with 0.37 kg/sq.m. tack coat
— 2.5 cm A.C. with 0.37 kg/sq.m. tack coat
4. — 0.37 kg/sq.m. tack coat
— 7.5 cm thick bitumen coated 4 cm size metal
— 3 kg/sq.m. bitumen grout
— cover coat of 0.9 cu.m. per 100 sq.m. of 1.25 cm size chippings

- 0.37 kg/sq.m. tack coat
- 2.5 cm AC.

5. — Same as 4 excepting bitumen grout @ 2.5 kg/sq.m.

6. — Same as 4 excepting bitumen grout @ 2.5 kg/sq.m.

7. — 7.5 cm bitumen coated 4 cm size metal
— 4 kg/sq.m. bitumen grout
— 2.5 cm AC.

8. — 7.5 cm premixed waterbound machine laid macadam
— 1.25 kg/sq.m. priming coat of cutback
— 4 cm AC.

9. — 7.5 cm premixed waterbound machine laid macadam
— 2.5 kg/sq.m. bitumen seal
— 1.8 cu.m./100 sq.m. of 1.6 cm size chippings
— 2.5 cm AC.

(ii) Breaking the concrete in 25 per cent area and following the same specification as adopted on Bombay-Agra Road.

Reconstruction:

Same as adopted on Bombay Agra Road.