Chapter 7: Paper 52

Case Studies on Failure of Bituminous Pavements

Praveen Kumar
Professor, Transportation Engineering Group, Civil Engineering Department, Indian Institute of Technology Roorkee, India

Ankit Gupta
Research Scholar, Transportation Engineering Group, Civil Engineering Department, Indian Institute of Technology Roorkee, India

Abstract

Pavement failure is defined in terms of decreasing serviceability caused by the development of cracks and ruts. Before going into the maintenance strategies, we must look into the causes of failure of bituminous pavements. Failures of bituminous pavements are caused due to many reasons or combination of reasons. Application of correction in the existing surface will enhance the life of maintenance works as well as that of strengthening layer. It has been seen that only 3 parameters i.e. unevenness index, pavement cracking and rutting are considered while other distresses have been omitted while going for maintenance operations. Along with the maintenance techniques there are various methods for pavement preservation which will help in enhancing the life of pavement and delaying of its failure. The purpose of this study was to evaluate the possible causes of pavement distresses, and to recommend remedies to minimize distress of the pavement. The paper describes lessons learnt from pavement failures and problems experienced during the last few years on a number of projects in India. Based on the past experiences various pavement preservation techniques and measures are also discussed which will be helpful in increasing the serviceable life of pavement.

Introduction

A number of portions of the National Highways by NHAI (National Highway Authority of India) and Rural roads under PMGSY (Pradhan Mantri Gram Sadak Yojna – A special scheme to connect the rural areas of India to all weather roads by Ministry of Rural Development) around the country are being strengthened and simultaneously being widened. But with the passage of time, the traffic intensity increased on these roads and the pavements started showing distress in the form of minor cracks. Some sections developed cracks after being overlaid with bituminous surfacing. However, the cracks on the bituminous surfacing included cracks, which appeared as reflective cracks or in the form of raveling that requires frequent repair treatment. The rehabilitation of cracked roads by simply overlaying with a layer of bitumen is rarely a durable solution. The cracks gradually propagate through the new overlay. It is a matter of fact that newly overlaid bituminous layer
does not possess the inherent property to prevent the propagation of cracks. The phenomenon referred to as reflective cracking is prevalent over many countries around the world. With the current financial crunch the departments involved in road construction are forced to use solutions with a balanced cost benefit objective.

The formation of cracks in the top layer of a pavement causes numerous problems such as discomfort to the users, reduction of safety, etc. In addition to the above, intrusion of water causing reduction of the strength in lower layers as well as lowering of bearing capacity of subgrade soil by pumping of soil particles through the cracks is also a major problem associated with the pavements. This leads to the progressive degradation of the road pavement structure in the neighborhood of the cracks (Sikdar, Jain, Bose and Kumar, 1999).

The origin of cracks differs by their shapes, configuration, amplitude of loading, movement of traffic and rate of deformation. A number of remedial measures have been recommended in the past and are still in experimental stages.

**PAVEMENT PRESERVATION**

Very little research has been conducted regarding pavement preservation practices used in India. Most of the maintenance techniques have evolved through the shared experience of practitioners. In contrast, a tremendous amount of research expenditures in the past 50 years has been spent on pavement materials characterization, construction practices, and pavement management techniques. In India, this is due in part because of the needs associated with the planning and execution of the Expressway, National Highway and Rural Roads System. Recently, organizations have begun to invest research and development funds into new preservation techniques and practices. This has been spurred by several surveys indicating lack of customer satisfaction with pavement conditions, safety, and congestion.

Studies have indicated that the funding needed to keep the current Highway System in good condition amounts far more as compared to whatever allotted. With this shortfall and the likelihood of significant increases not very good, it’s obvious that new and improved treatments and techniques are required if we expect to keep the system in an acceptable condition. By wisely spending resources on research to improve practices and techniques for pavement preservation, we hopefully can close the gap between needs and condition in order to better serve the traveling public.

Considerable effort was devoted to identify the potential research, development, and implementation topics. The pavement preservation techniques are grouped under the following broad topics.

- Construction Practices
- Materials Selection and Mixture Design
- Treatment Strategies and Selection
- Performance Evaluation
- Training
- Policy
- Others

**Construction**

As the demands on our national highway network continue to grow, so does the need for construction and maintenance practices that will help extend the life of pavements. State highway agencies are increasingly using a variety of pavement preventive maintenance treatments to keep pavements in good condition longer, including slurry seal and micro-surfacing applications. To ensure that these treatments are used to their
maximum effectiveness, however, further research is needed on standardizing such practices as field sampling methods and quality control/quality assurance procedures. Standardization of field sampling methods, for example, will help agencies verify that a field mix is consistent with the laboratory mix design. Standard test methods for such procedures as using an ignition oven in preparing slurry, micro-surfacing and other emulsion mixes, meanwhile, would be a valuable quality control tool. Standardization will also help to encourage highway agencies to adopt comprehensive pavement preventive maintenance programs.

**Materials Selection and Mix Design**

The materials selection and mix design of a pavement preventive maintenance treatment are crucial to the success of that treatment. For example, an improperly applied chip seal can result in the early failure of the pavement and costly corrective maintenance. In other cases, such as the use of asphalt emulsion treated mixes, the lack of a standard design method can make it difficult to determine how a mix design will perform. Determining best practice materials selection and mix design procedures for these and other treatments must be a high priority if we are to achieve ultimate effectiveness for pavement preventive maintenance. This information will help highway agencies make informed, cost-effective decisions about preventive maintenance.

**Treatments and Selection Strategy**

To be effective, preventive maintenance treatments must be implemented at the right time. Unlike routine maintenance, which is usually performed when the pavement is failing, preventive maintenance treatments must be applied when the pavement is still in good condition, with no structural damage. In order to minimize costs, it is also important that highway agencies choose the right treatment for the right road, taking into account such variables as climate, traffic levels, and traffic delays. In making these pavement preservation decisions, highway agencies use a broad spectrum of data that often exists in many disparate databases, such as ones for pavement and maintenance management systems, traffic volumes, and construction and materials quality assurance records. Integrating or linking these databases is increasingly critical to making informed pavement preservation decisions.

**Performance**

As pavement preventive maintenance treatments become more widely used, it is important to evaluate their performance. However, the evolutionary nature of new treatments that have been introduced means that performance measures and criteria are often lacking. Research is needed into developing guidelines and criteria for maintenance treatment performance evaluations. These guidelines should include procedures for collecting pavement data. Such procedures and guidelines are essential to the continued successful implementation of pavement preservation initiatives nationwide.

**Training**

A well-trained workforce is a more efficient and effective workforce. As highway agencies place more emphasis on using preventive maintenance treatments, it has become evident that training is needed on the design and construction of these treatments. Training courses should be modular in nature, so that highway agencies can select the modules of interest to them. This training will provide a first introduction to those unfamiliar with the new preventive maintenance techniques, as well as serve as a refresher for those who would like to improve the performance of their maintenance treatments. Ultimately, training will improve the over-
all construction quality of treatments, helping to ensure that they perform for the length of or beyond their expected life span.

**Policy**

For pavement preservation programs to succeed, they must be sustained efforts with support and funding from all involved stakeholders. Loss of support or legislative priorities can result in the loss of the accumulated benefits of pavement preservation. To ensure the continued support of stakeholders, research efforts must identify and address their needs. Another policy area that can affect the success of pavement preservation programs is specifications for preventive maintenance applications. Traditional rigid specifications can stifle the innovative approaches that often produce a better finished product. Specifications for some pavement preventative applications, therefore, need to be more flexible.

**Other**

An additional area of preventive maintenance research that should be considered is the effectiveness of retrofit edge drains. These have been used by many highway agencies to reduce or prevent pumping and associated faulting in Portland Cement Concrete pavements. However, some questions have been raised about the need for this technique, as well as its cost effectiveness over time. Recycling of failed roads is also a thrust area where we can economize the budgets also. Base recycling offers savings over conventional reconstruction. By contrast, conventional reconstruction involves excavation and removal of existing material, transport of the material to city-owned or private asphalt plants, and then importation, placement, and compaction of new base materials and new asphalt concrete, with accompanying prolonged lane closures and excessive truck traffic.

**MAIN REASONS FOR DISTRESSES**

(i) Sudden increase in traffic loading especially on new roads where the design is based on lesser traffic is a major cause of cracking. After construction of good road, traffic of other roads also shifts to that road. This accelerates the fatigue failure (Alligator Cracking).

(ii) Temperature variation ranging from 50º C to below zero conditions in the plain areas of North and Central India leads to bleeding and cracking.

(iii) Provision of poor shoulders leads to edge failures.

(iv) Provision of poor clayey subgrade results in corrugation at the surface and increase in unevenness.

(v) Poor drainage conditions especially during rainy seasons, force the water to enter the pavement from the sides as well as from the top surface. In case of open graded bituminous layer, this phenomenon becomes more dangerous and the top layer gets detached from the lower layers.

(vi) If the temperature of bitumen/bituminous mixes is not maintained properly, then it also leads to pavement failure. Over heating of bitumen reduces the binding property of bitumen. If the temperature of bituminous mix has been lowered down then the compaction will not be proper leading to longitudinal corrugations.

(vii) If the modified bitumen, especially Crumb Rubber Modified Bitumen (CRMB) has been used, then stirring during transportation is must otherwise crumb rubber will be separated out.

The different forms of deformation, cracking and edge defects and possible causes are given in Table 1, 2 & 3 respectively.
### Table 1. Deformation

<table>
<thead>
<tr>
<th>Form of Distress</th>
<th>Possible Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rutting</td>
<td>Inadequate pavement thickness. Post construction compaction. Instability of base of surfacing.</td>
</tr>
<tr>
<td>Shoving</td>
<td>Poor bond between layers. Lack of edge containment. Inadequate pavement thickness.</td>
</tr>
<tr>
<td>Depression</td>
<td>Settlement of service trench or embankment. Isolated consolidation. Volume change of subgrade.</td>
</tr>
<tr>
<td>Corrugations</td>
<td>Instability of AC (Asphaltic Concrete) or base course.</td>
</tr>
</tbody>
</table>

### Table 2. Forms of cracking

<table>
<thead>
<tr>
<th>Form of Distress</th>
<th>Possible Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse</td>
<td>Reflection of shrinkage cracking. Construction joints.</td>
</tr>
<tr>
<td>Diagonal</td>
<td>As for meandering.</td>
</tr>
<tr>
<td>Block</td>
<td>Reflection of joints or shrink cracking in underlying concrete or cemented pavement. Thermal cycling in AC.</td>
</tr>
<tr>
<td>Crocodile (Crazing)</td>
<td>Fatigue failure due to flexible/brittle base. Inadequate thickness.</td>
</tr>
<tr>
<td>Crescent (Shear)</td>
<td>Poor bond between wearing and base courses. Flexible base. Thin wearing course. High horizontal stress due to braking, etc.</td>
</tr>
<tr>
<td>Environmental cracking</td>
<td>Reactive subgrade (often cracks centered on trees).</td>
</tr>
<tr>
<td>(Diagonal, Long)</td>
<td></td>
</tr>
<tr>
<td>Pumping of fines through crack</td>
<td>Traffic forces water in and out from the cracks extending full depth of surfacing leads to washing out of fines from granular material or subgrade.</td>
</tr>
</tbody>
</table>
Table 3. Edge defects

<table>
<thead>
<tr>
<th>Form of Distress</th>
<th>Possible Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edge drop</td>
<td>Inadequate pavement width.</td>
</tr>
<tr>
<td></td>
<td>Erodible shoulder material (lack of plasticity).</td>
</tr>
<tr>
<td>Edge break</td>
<td>Inadequate pavement width.</td>
</tr>
<tr>
<td></td>
<td>Inadequate edge support.</td>
</tr>
<tr>
<td></td>
<td>Traffic travelling on shoulder edge drop.</td>
</tr>
<tr>
<td></td>
<td>Weak seal coat/loss of adhesion.</td>
</tr>
</tbody>
</table>

Photographs of different type of pavement distresses like pot hole, ravelling, edge failure, hill debris over the road, alligator cracking (fatigue), longitudinal cracking, polished aggregate and patching are given below:

![Figure 1. Pot Hole](image1)

![Figure 2. Ravelling](image2)
CHAPTER 7: PAPER 52

Figure 3. Edge Failure

Figure 4. Hill Debris Doming Over the Road

Figure 5. Alligator Cracking (Fatigue)
Figure 6. Longitudinal Cracking

Figure 7. Polished aggregate

Figure 8. Patching
EFFECT OF CHARACTERISTICS OF BITUMINOUS MIXES

The existing pavement design methods can be used to quantify the influence of variation in the characteristics of bituminous binder and mix properties in terms of either layer thickness for a given pavement life or vice versa. Percent air voids, bitumen content and grade of bitumen were studied and were observed to have an influence on the design of the pavement.

In India extensive use of granular materials have been resorted due to its comparatively low cost of construction, but its effect on high modulus layers of dense asphalt mixes have never been examined or taken into consideration during design of flexible pavements. After failure of some sections, analytical aids using the design methods available abroad have been resorted to by assigning higher values to granular layers and ignoring the fact of very low modulus values should be assigned to granular layers especially under high modulus layers of thick asphalt concrete mixes. These important aspects have been discussed in the paper.

Fatigue of bituminous mixes based on controlled stress is an important parameter which should not be neglected despite the fact that it is time consuming, leads to data which contributes towards the forecasting of predictive behavior and subsequent development of cracks. The development of cracks at site depends on the location of the pavement layer and is difficult to predict. Test results indicate that the relationship between tensile strain and service life depends on the volumetric proportions of the binder in the mix and its softening point. Test results also indicate that the fatigue life of a surfacing is a function of stiffness of the mix.

PAVEMENT FAILURE RELATED CASE STUDIES

Study of Cracks Occurrence on a Portion of NH-1 (Alligator Cracking)

Cracks have been observed on the NH-1 (National Highway) between the stretch km 238 to 241 on the widened and strengthened portion. The team from IIT Roorkee visited the section for a detailed study. The study stretches show various types of failure and the details are given below:

The portion between km 238 to 239 shows alligator cracks of width about 5 mm and settlements of about 10 mm in the centerline. The stretch shows deep deformation of DBM (Dense Bituminous Macadam) and sporadic cracks. It seems that the deterioration of the above stretch was not caused by inadequate design thickness of the pavement but it is due to underestimation of the volume of traffic. The portion between km 239 - 240 shows minor deformations and few cracks. The deformation is found to increase with increase in settlement. From the site visit and visual inspection, it is concluded that:

(i) Lack of bond between DBM and existing surface. This might be the reason for the occurrence of cracks.
(ii) Inadequate interlocking may be due to less adhesion and it requires a study of chemical composition of the bitumen used.
(iii) The differential settlement occurred at the joints of the newly laid surface widened portion.
(iv) Inadequate crust thickness to meet the requirement of number and higher axle loads of commercial vehicles.

Study of Cracked Surface to Rao Pitampur Toll Road (Failure Due to Poor Base and Unstable Subgrade)

A project was referred to CRRI (Central Roads Research Institute) namely the Rao Pitampur Toll Road near Indore, Madhya Pradesh (CRRI, 2004). This road was constructed over a black cotton subgrade. The existing bituminous surface was observed to have extensive undulations. The other type of distress was in the form of settlement of the road pavement which might be attributed to the intrusion of sub base material into the soft
black cotton subgrade soil, thereby adversely affecting the riding quality of the pavement. A general condition survey of the pavement surface was conducted to assess the type of distress. Special emphasis was laid on the drainage aspect and other relevant data were collected during the course of detailed investigation. The study indicated the failure of the surfacing, ravelling, extensive potholes, depressions, map cracks, edge failure and settlement of the surfacing accompanied by shoving of the surface layer. Considering the extent and severity of distress, the road was not expected to perform its intended function unless suitable remedial measures were suggested. The details of the suggestions are as under:

(i) Geofabrics were recommended at only those portions, which required full depth reconstruction because of extensive failures caused by poor drainage and absence of a sand cushion layer over the existing subgrade.

(ii) The drainage system is inadequate and should be improved by constructing side drains using geofabrics on either side of the road wherever required.

**Study of Non-Permissible Cracking and Undulation Distress on NH-7 (Undulations and Failure of Bituminous Surfacing)**

The study was undertaken by Infra Techno Consultants Australia and Singapore. The details of the study are as under:

(i) **Current Distress Modes**

The following distress modes have been observed by all concerned within a year of completion of stretches of the highway:

- Minor hair cracks.
- Hair cracks up to the BC (Bituminous Concrete) thickness less than 35 mm.
- Hair cracks up to the BC thickness more than 35 mm.
- Alligator cracks up to full BC and DBM thickness, and
- Riding surface undulations beyond permissible limits.

(ii) **Current Rectification in Progress**

The following have been in progress for some time, respectively, for each of the above:

- Sealing with emulsion and covering with coarse sand grit.
- Removal of full-depth BC min 2 m (width) x 5 m (length) and BC reinstatement plus 25 mm overlay.
- Same as above with 40 mm overlay.
- Removal of full-depth BC+DBM and reinstatement of both, plus hard shoulders.
- Same as second point above, min 3.5 m (width) x 5 m (length).

(iii) **Prognosis & Observations**

- Earlier similar treatment has not rectified distress.
- Similar distress has appeared in other National Highways having similar pavement configurations.
- Alternative surface renewal treatments to varying depths are being considered by MoRTH (Ministry of Roads Transport and Highways), some in consultation with CRRI.

(iv) **WMM (Wet Mix Macadam) & Asphalt Course Realities**

- The unbound crushed rock layers have a tendency to change shape under repetitive loading beam action.
- These crushed rock layers lack required stiffness. There are exhaustive evidences that a stiffer base course (Resilient Modulus 450-700 MPa) has a direct relationship to subgrade rutting life in terms of ESAs.
- The DBM layers function in the configuration appears to be more of a BC-WMM bond rather than significantly increasing pavement strength.
- Asphalt courses above certain thickness develop increased tensile fatigue.
Cracks Occurrence in Ramghat-Aligarh Road in U.P.

Advice was sought by PWD (Public Works Department) - Aligarh (Uttar Pradesh) regarding causes of cracks occurrence in Ramghat-Aligarh Road near Aligarh. A team from IIT Roorkee visited the site and found that the density of the different layers was in conformity to the average value given by the records of construction time and the workmanship was of good quality (Jain and Kumar, 1998). However, the cracks have appeared due to the following reason:

(i) The top surface layer Mix Seal Surfacing (MSS) was constructed on existing BM layer. The layer of BM was exposed to unexpected rain and water percolated into lower portion through BM layer. The longitudinal drainage was not proper along the road and cross drainage works were also missing at various locations and the entire pavement was in saturated condition. That is why the water which had percolated into the lower layers could not escape through the sides. At one or two locations water was observed in BM layer while taking the density of BM and MSS layers by sand replacement method.

(ii) The road was widened on one side so there was differential settlement. It disturbed the camber position and the total thickness of the pavement crust was not uniform along the pavement width. This also caused variation in strength as well as load distribution of the pavement along the road width and results in cracks.

(iii) MSS itself is semi dense coat and during heavy rains, water was stagnated on the pavement surface. Due to continued stagnation of water, MSS layer also allowed percolation of water into lower layers.

Cracks Occurrence on Meerut Bypass (NH-58)

IIT Roorkee was requested to estimate the overlay requirements of Meerut Bypass, which has recently been declared as a part of NH-58. It was found that there is a wide variation in overlay thickness requirement of this 18.2 km road section. It varies from 25 mm (in terms of BM) at 15-16 km to 185 mm at 0-1 and 8-9 km. Here it was seen that water was stagnating along the road at some sections and side slopes were eroded. This resulted in the entry of water into the embankments and cracks had appeared in the pavement. These cracked sections required more strengthening in terms of layer thickness (Jain and Kumar, 1998).

Undulations in Army Area Roads

A study was assigned to IIT Roorkee to investigate the corrugations over the newly laid Semi Dense Bituminous Concrete (SDBC) in Army Area of Roorkee. The investigating team observed that although the quantity of bitumen, aggregate quality and proportioning were good but the compaction was done after the temperature of the mix had cooled down. As a remedy, the contractor was asked to provide a sand bitumen layer (Kumar, 2002).

ANTI REFLECTIVE CRACKING PRESERVATION MEASURES

Overlay Thickness

Overlay thickness is one of the prominent factors in minimizing the cracks. Increased overlay thickness of bituminous layer with or even without modified binder helps in preventing the reflecting cracks. The remedy may lie in placement of a Stress Absorbing Membrane (SAM) or Strain Absorbing Membrane Interlayer (SAMI), bituminous impregnated geotextile or geogrids adhering to the old structures and the new structure. It may be pertinent that, all solutions be checked involving pavement components, such as overlays inter layer and old pavement structure and the type of soil.
Interlayer Between the Old Surfaces and the New Overlay

The differential movement of the thermal origin may be absorbed by the interlayer and has an important stress release effect on the structure. The stress release should also effectively be transferred between the pavement layers. The interlayer developed should be based on polymer modified bitumen (for Indian condition) since the viscoelastic behavior of this material meets our specific requirements.

Water proofing is an important aspect in case of pavements with cracks and any ingress of water in the soil beneath the pavement must be prevented under any circumstances. The interlayer must possess this property of water barrier. Water proofing may be achieved by complete saturation of the interlayer mass. This is the reason why needle punched fabrics fulfils the requirements. Geocomposites (Bio geogrids fused with geofabrics) are available which fulfils the above requirements.

Bitumen is a desirable interlayer material. To improve the thermal susceptibility of interlayer modifications based on elastomers and plastomers are done. The use of Styrene-Butadiene-Styrene (SBS) copolymer modified bitumen permits better performance but is more expensive. The modified binder may be used in more difficult cases when there are crack movements.

The interlayer bitumen is mechanically stabilized by the addition of fibers acting as containers. These fibers may be used at site for repairing of the pavement structure. The mechanical effectiveness of the interlayer is highly dependent on the adhesion of the old pavement and the new overlay. The adhesion must be permanent and uniform.

It is very important to note that the interlayer is effective in containing reflection cracks as long as vertical movement of the crack edges is restricted. It is obvious that shear movements may not be prevented by a thin layer without severe damage to the overlay.

Modification of Overlay Characteristics

The effective way to prevent propagation of cracks is to inflict sufficient tensile resistance into the overlay system. This may be brought about by:

a. Use of short fibers spread in entire mass, and
b. Use of reinforcing elements located in the lower part of the overlay.

Bitumen even after modification remains susceptible to changes in temperature, but polymeric material, glass and steel are less susceptible to these parameters. Reinforcement of the overlay may be obtained by the use of reinforcing fabrics, composite geogrids and meshes in the lower part of the overlay. The placement condition is extremely important and no wrinkles should be allowed to exist. These reinforcing materials are generally placed under tension by nailing, pegging etc. Thus geosynthetics may also be used as a reinforcement of microsurfacing layer (i.e. Fabric Reinforced Chip seal).

PAVEMENT PRESERVATION MEASURES

Based on the available studies and experience gained, the following remedial measures have been suggested:

i. Use of Geo-fabric and Pavement Reinforcing Interlayer to Control Reflective Cracking in Bituminous Concrete Overlays: A project entitled ”Use of Geo-fabric as Pavement Reinforcing Interlayer to control Reflective Cracking in Bituminous Concrete Overlays” was sponsored by MOST (Ministry of Surface Transport). The test sections (two km distressed road) for field trials were selected on NH-2 between Kanpur and Varanasi over a sandy silty subgrade near Allahabad. Inventory data like distress data, Benkelman Beam deflection value, crust details, field density and traffic census data was collected for the proposed two
km test sections. Based on the inventory data analysis it was found that the pavement was badly cracked. To prevent the occurrence of such failure geo-fabric interlayer was provided over the exiting surfacing and covered with a 40 mm thick DAC (Dense Asphalt Concrete) layer. Along with it, a control section consisting of 40 mm thick DAC layer was laid over the cracked surfacing. It was observed that after three years the performance of the geo-fabric section was better than the control section.

ii. Paper Adhesion between Existing Road Surface and Strengthening Layer: Based on the experience and studies, the failure of the strengthening layer is due to improper adhesion and quality of bitumen. The chemical composition (chemistry) of the bitumen used is to be studied. The test like penetration test, specific gravity, water content in the bitumen, softening point, penetration, ductility, loss on heating, matter soluble in carbon disulphide, stripping test need to be carried out before the use of the bitumen for mixes as well as tack coat.

iii. Corrective Measures before Strengthening: It has been observed that if existing surfaces are not properly cleaned, and cracks are filled, the strengthening layer also exposed to cracking and leads to pavement failure. Therefore, there is a need to correct the existing surface by cleaning and filling the cracks adequately. It has also been observed that if existing surface are properly corrected then the provided overlay thickness led to its design life without much maintenance needs.

iv. Selection of Bituminous Layer for Base and Surface Course: It has been observed that DBM should not be laid on WMM and Water Bound Macadam (WBM). There is a need to provide at least a thickness of BM between WMM, WBM and DBM. Further, DBM surface should be covered with a thin layer of 50 mm BC. The DBM surface should not be exposed to rain water as in case of AC layer. Due to ingress of water and high traffic loads, DBM surface deteriorated and cracks occurred.

v. Study of Adjoining Lands before Widening and Strengthening: It has been observed that the adjoining lands of the existing roads be studied before widening and strengthening. Sometimes adjoining lands within the right of way is filled with rain water/crop water and bearing capacity of the portion is reduced. If the portion adjoining to this area is used for widening without proper treatment to subgrade soil and embankment foundation settlement occurs and leads to cracking. Therefore, it is suggested that the investigations should be carried out and embankment foundation and soil subgrade used for widening be improved by admixtures like lime.

vi. Avoidance of Differential Settlement at Jointed Portion: Differential settlement occurred at the joint of widened and strengthening of existing portion. This can be avoided by careful compaction of the subgrade and embankment of the widened portion. If this is done, then uniform distribution of traffic load will lead to the avoidance of cracks and failures at jointed portion.

CONCLUSIONS

Based on the review of literature, studies conducted in India and experiences of the authors, following conclusions are drawn:

1. Proper pavement preservation techniques, guidelines and policy should be implemented in implementing any highway design and construction project

2. Use of geofabric as pavement reinforcing inter layer be made to control reflective cracking in bituminous concrete overlay especially on heavy trafficked road sections. Polymer modified bitumen mixes be used to prevent reflective cracking.

3. Differential settlement at jointed portion of widened and existing pavements should be avoided. The jointed portion needs special consideration and treatment.
4. DBM as a bituminous surface on the WBM or WMM shall not be laid. The BM layer should be provided between WBM/WMM and DBM layers to avoid crack occurrence. Further, a thin layer of BC (say 50 mm) on the DBM surface should be provided.

5. Sealing of cracks may be done with rubberized bitumen. The rubber powder obtained from retreated or reclaimed old truck tires and lime stone dust powder should be mixed with bitumen to seal the cracks.

6. Longitudinal drainage and cross drainage works should be given top most priority. Without rectifying the improper longitudinal and transverse drainage, a good amount of overlay will be of no use.

7. Whenever a road is to be widened, it should be widened equally on both the sides. For new roads, subgrade should be prepared for the total width of the road including the shoulder width of about 2 m, so that there will be less chances of differential settlement in future widening.

8. Side slopes should be repaired immediately before the rains. As far as possible, in areas of moderate to heavy rains, the use of bituminous surfacing such as DBM, BM and MSS should be avoided as a top layer.

9. Recycling of failed roads is one of the major thrust area for pavement preservation.

REFERENCES


