

Study of Defects in Flexible Pavement and Its Maintenance

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Abstract— A well-developed transportation infrastructure is essential for economic, industrial, social and cultural development of a country. Due to this need, human being has developed three modes of transport, i.e., by land, by water and by air. The road network has expanded from 4 lakh km in 1947 to 20 lakh km in 1993 and almost 55 lakh kms as on 31 March, 2015. India has less than 3.8 kms of road per 1000 people; including all its paved and unpaved roads. In terms of quality, all season, four or more lane highways; India has less than 0.07 kms of highway per 1000 people as of 2010. Inadequate maintenance of roads accounts to an act of disinvestment and sacrifice of past investment in roads. Roads have been receiving decreasing share of total Five Year Plan expenditure (decreasing from 6.7% in first plan to 3% in second plan). The Vehicle Operating Cost increases at a rapid rate as the condition of existing pavements starts deteriorating. The loss due to bad conditions of the main road network would be around Rs.12000 crore per annum. The purpose of the proposed study is to identify the defects in flexible pavements in highway system. For this study some test sections were identified on SH-4,(now upgraded as NH 205-A) in Punjab from Kharar to Landran, District S.A.S Nagar (Mohali). The parameters influencing the performance of flexible pavements will also be identified. For efficient maintenance of road pavements, the deficiencies in our existing highway system need to be clearly understood. All type of distresses/defects needs to be classified with causes and treatment as per different severity level.

Keywords: Defects, Flexible Pavement, Maintenance, Rutting, Paved Roads

I. INTRODUCTION

Maintenance of a road network involves a variety of operations, i.e., identification of deficiencies and planning, programming and scheduling for actual implementation in the field and monitoring. The essential objective should be to keep the road surface and appurtenances in good condition and to extend the life of the road assets to its design life. Broadly, the activities include identification of defects and the possible cause there off, determination of appropriate remedial measures; implement these in the field and monitoring of the results. This will involve several subsystems of identification, evaluation, planning, scheduling, management of men, material and machinery and then performance evaluation.

The objectives of the study are as follows:

- To identify type and classification of common defects in flexible pavements.
- To identify the causes of these defects and suggest remedial measures.
- To identify the defects in existing pavement maintenance practices.
- To rectify the identified defects for smooth movement of traffic flow.

II. IDENTIFICATION OF DEFECTS

By way of physical inspection of affected highway stretches deteriorated, the maintenance activities were categorized under three operations viz, Routine Maintenance, Periodic Maintenance and Special Repairs. During the inspection the defects in existing flexible road pavement were generally classified into the following groups:

- Road stretches which are structurally deficient where distress and failures of the pavements occurs at frequent intervals be identified. Unless the structural deficiency is made up by appropriate strengthening measures/overlay construction, rapid rate of failure would continue to occur in these stretches.
- Road stretches which have poor pavement surface condition and are badly undulated resulting in poor riding quality.
- Road stretches which have satisfactory structural and surface condition of pavement, but with localized failures; these localized pavement failures develop in the form of depression, large cracks, pot holes, etc. Such failures often propagate to larger areas resulting in overall failure of the entire stretch.

III. DEVELOPMENT OF METHODOLOGY FOR MAINTENANCE

A. Quality Assurance:

The quality assurance system should cover all aspects of road project starting from design, supply of maintenance right through the extreme process of construction and maintenance. It is suggested to observe the following:

- Bitumen and aggregates should be checked to assess the properties and behavior.
- Appropriate grade of bitumen depending on traffic intensity/climatic conditions should be used.
- Aggregates should be clean and dry.
- Bitumen and aggregates should be heated to the specified temperature under controlled conditions.
- After necessary correction, the surface to be paved should be cleaned thoroughly.
- Mechanized system should be preferred over the manual method of construction/maintenance.
- Laying and rolling temperature should be controlled.

B. Inspection of roads and assessment of maintenance:

Frequent inspection of the road is essential to identify the defects and their causes, determine priorities and take appropriate remedial measures.

IV. CLASSIFICATION OF DEFECTS WITH CAUSES AND TREATMENT

A. Types of Defects

The classification of the defects (shown in photographs) with unit of measure, causes and treatment is discussed in following order:-

1) Cracks:

- Alligator Cracking
- Longitudinal Cracking
- Block Cracking
- Edge Cracking
- Centre Cracking

2) Rutting and Shoving:

- Rutting Classification
- Shoving

3) Pot Holes and Patching:

- Pot Holes
- Patch Deterioration and Repairs

V. CLASSIFICATION OF CRACKS

A. Alligator cracking:

1) General Description:

These are the interconnected cracks which resembles the skin of an alligator shown in photographs. The above have been identified as follows:-

- Series of interconnected cracks.
- Many sided, sharp angled, usually longest side < 1 feet.
- Initially appears a longitudinal crack.

2) Unit of Measurement:-

- Sq.m of surface area at different severity levels. Rate entire area at highest severity level whenever different severity levels exists.

3) Severity level/Classification:-

The classification has also been done as per TRRL (Transport and Road Research Laboratory), i.e., m/sq.m. The severity levels have been classified as below:-

- Low – Longitudinal disconnected hairline cracks running parallel to each other, cracks not spalled. Generally width is < 3mm. Surface still gives fairly good riding quality.
- Moderate – Cracks are lightly spalled and form a pattern of articulated pieces. Cracks of width 3mm to 6mm are seen.
- High – Cracks are severely spalled and wider than 6mm. these are clearly visible while driving on road and give very poor riding quality.



Photograph showing Alligator Cracking

4) Causes:

The causes of the above cracking are as follows:

- Ageing of binder or initial over heating leads to brittleness of binder.
- Inadequate pavement thickness or excessive overloading or both.
- Unstable subgrade or lower layers, leading to excessive deflection of the surface particularly in the wheel tracks. Unstable conditions in subgrade or lower layers of the pavement might arise from saturation due to poor drainage conditions.

5) Treatment:

The treatment of the alligator cracking is discussed as follows:-

The treatment for all types of cracks depends on pavement remains structurally sound or has become distorted or unsound. Where the pavement is structurally sound, cracks should be filled with low viscosity binder. Slurry seal or sand bituminous premix patching can be used to fill wide cracks. If the cracks are fine and extend over large areas a light cut-back or an emulsified bitumen or fog seal can be boomed into the cracks and lightly filled with sand to prevent the picking up of the binder by the traffic. The extensive alligator cracking in wheel path will lead to rutting and hence the pavement will become structurally unsound. The unsound cracked pavements will need strengthening or rehabilitation treatment.

B. Longitudinal cracking:

1) General Description:

These cracks are relatively parallel to pavement center line, may appear either at the joint between the pavement and the shoulder or at the joint between two paving lanes.

2) Units of Measurement:-

- Linear measurement at each severity level.

3) Severity Level or Classification:-

- Low – Cracks with width less than 3mm with material in good condition.
- Moderate – Cracks with width from 3mm to 6mm and with random cracking along the longitudinal crack, sealant material is not in good condition.
- High – Cracks with width more than 6mm and extensive cracking along the crack. Generally accompanied by raveling etc. and can be easily seen while driving.

4) Causes:

The causes of the above cracking have been summarized as below:-

- Alternate wetting and drying beneath the shoulder surface owing to poor drainage and also due to variation in temperature.
- A weak joint between adjoining spreads in the layers of the pavement gives rise to lane joint cracks.
- Different frost heave condition



Photograph showing Longitudinal Cracking.

5) Treatment:

Treatment depends on whether pavement remains structurally sound or not, if structurally sound then treatment may be done as under:

- Fill cracks with bituminous binder.
- A slurry seal or sand bituminous premix patching for wide cracks.
- A fog-seal if the cracks are fine and extended over large area.

C. Block Cracking:

1) General Description:

These cracks appear as interconnected cracks forming blocks of square or rectangular shape on pavement surface. The size of the block cracking varies from 1000 sq.cm to 10000 sq.cm (1 sq.ft. to 10 sq.ft.). Block cracking is shown in photographs below.

2) Units of Measurement:-

- Square feet or square metre of surface area at each severity level.

3) Severity Level or Classification:-

- Low – Blocks defined by unspalled cracks with a mean width of 3mm and sealant being in good condition. The blocks are generally of larger size at low severity level.
- Moderate – Moderately spalled cracks and mean width between 3 to 6mm.
- High – Blocks well defined by cracks that are severely spalled and the mean width greater than 6mm. The size of the block is reduced as compared to low and moderate severity levels.



Photograph showing Block Cracking

4) Causes:

The possible causes are summarized as below:-

- Inadequate pavement thickness and unstable condition of subgrade and lower layers.
- Shrinkage of bituminous layer itself with age.
- Ageing and brittleness of binder.

5) Treatment:

The block cracking should be repaired by laying a interface treatment followed by giving surface layer as per original existing surface.

D. Edge Cracking:

1) General Description:

These are fairly continuous cracks, parallel to and usually upto 0.5m from the edge of pavement. Edge cracks if not repaired in time lead to edge breaking and lane to shoulder drop off and separation occurs. (ii) Units of Measurement:-

- Linear, measurement at each severity level.

2) Classification or Severity Level:-

The severity levels have been classified as below:-

- Low – Cracks with no break-up or raveling with mean width upto 3mm.
- Moderate – Cracks with some break-up or raveling and mean width between 3mm to 6mm.
- High – Cracks with considerable break-up or raveling along edge and the width is more than 6mm.

3) Causes:

The causes are summarized as below:-

- Lack of lateral support from shoulder.
- Poor drainage and frost heavy condition.
- Inadequate pavement width forcing traffic to move too close to the edge of the pavement.
- Settlement or yielding of the underlying materials.
- Non provision of extra width of pavement on curves.

4) Treatment:

The possible treatment has been summarized below:-

- Improve the shoulder condition and give lateral support to pavement.
- Seal the cracks with either of these depending on severity level and width of cracks as follows:
 - Low viscosity binder.
 - A slurry seal.
 - Fog seal.

E. Center Cracking:

1) General Description:

The cracking pattern appears all along the centre line of pavement. These are similar to longitudinal cracks and are not commonly seen. The centre cracking are shown in photograph.

2) Unit of Measurement:-

- Length in meters as per each severity level.

3) Classification or Severity Levels:

The classification is as under:-

- Low – Cracks with sealant material in good condition and mean width upto 3mm.
- Moderate – Cracks with some break-up or raveling and mean width between 3mm to 6mm.
- High – Cracks with considerable break-up or raveling along center line of the pavement and width is more than 6mm. It can be easily noticed while driving on the road.



Photograph showing Centre Cracking

4) *Causes:*

The root cause for centre line cracking is summarized as below:-

- Improper or weak joint between adjoining, spreads all along the centre line of the pavement.
- Different moisture conditions on both sides of the pavement.
- Different frost heave conditions along the centre line.
- Improper design of pavement with reference to camber.

5) *Treatment:*

It is better to take full precautions while constructing a pavement. The general treatment method for cracks explained earlier can also be used. This can be rectified by sealing the cracks with slurry seal and or fog seal depending on width of the cracks.

While inspection of cracks on site, cracks with width $\frac{1}{2}$ inch to $\frac{3}{4}$ inch were cleaned first and then sealed. The sealing material used was Asphalt Emulsion Slurry Seal (crack filler/seal master).

After filling the cracks the selected stretch was allowed to dry for 24 hours and no traffic was allowed to move on that stretch for 24 hours. After 24 hours the traffic was allowed to move on that stretch. The inspections were made after every week for a month to see the status of that road stretch.

While inspection, it was clearly seen that no further deterioration found for the selected stretch. The bond between the two cracks was also good and the riding quality seemed to be good also.

VI. RUTTING AND SHOING

A. *Rut Depth Classification:*

1) *General Description:*

Rutting is a longitudinal surface depression or groove in the wheel path. If the rutting is accompanied by adjacent bulging, it may be sign of subgrade movement. This phenomenon takes place when either pavement thickness is inadequate or there is heavy channelized traffic.

2) *Unit of Measurement:*

The rut depth can be measured in mm and width of rutting can be measured in meters.



3) *Causes:*

The causes are as under:-

- Weak pavement and heavy channelized traffic.
- Improper mix design and lack of stability.
- Inadequate compaction of the mix at the surface or in the underlying layers during construction.
- Intrusion subgrade clay into base course.

4) *Treatment:*

- Fill with premix open/dense graded material and compact to the desired levels after applying a tack coat.
- If rutting is due to subgrade failure then excavation and rectification of subgrade is done.

B. *Shoving:*

1) *General Description:*

It is a form of plastic movement resulting into localized bulging of surface. Shoving occurs characteristically at points where traffic starts or stops or at sharp curves. Shoving is shown in photographs.

2) *Unit of Measurement:*

It really cannot be measured in facts and figures but the effect can be seen or riding quality.

3) *Classification or Severity Levels:-*

- Low – When effect on riding quality is quite low.
- Moderate – When it is possible to drive with low speed only.
- High – When riding quality is very bad and extensive bumpy ride is experienced.



4) *Causes:*

- Lack of stability in mix (excessive binder, high proportion of fines, too soft binder) of surface or base course.
- Pushing action by wheels of heavy traffic at time of acceleration and de-acceleration.
- Lack of bond between bituminous surface and underlying layers.

5) *Treatment:*

- Filling the depression with premix materials after applying suitable tack coat.
- Remove the material in the affected area down to a firm base and laying a suitable premix patch.

VII. POT HOLES AND PATCHING

A. *Pot Holes:*

General Description:

These are bowl shaped holes of various sizes in the surface layer or extending into the base course. These are caused by localized disintegration of material and usually appear at water logged places or after rains.

1) *Unit of Measurement:-*

Depth in cm and area of pot hole in cm.sq.



2) *Causes:*

- Localized disintegration of materials.
- Ingress of water in the pavement through cracks in surface course.
- Poor bond between surface and base course layers.
- Less bitumen content in localized areas or too thin bituminous surface.

3) *Treatment:*

Treatment is done by patch work or patch repairs. To fill pot holes (after cleaning) with the premix open/dense graded patching or even penetration patching and followed by compaction.

B. *Patch Deterioration and Repairs:*

1) *General Description:*

This is the portion of the pavement surface that has been removed and replaced/repared. The damage to surface could be because of cracking, pot holes, etc. These are shown in photograph.

2) *Unit of Measurement:*

- Square metre of surface area and number of patches at each severity level.

3) *Classification or Severity Level:-*

- Low – Patch is in good condition or has low severity distress of any kind.
- Moderate – Patch has moderate severity distress of any type and patch repairs carried out as per type of distress.
- High – Patch has high severity distress of any type.

4) *Causes:*

Main causes of patch deterioration are as follows:-

- Poor mix design and obsolete (out of date) maintenance technique.
- Opening of road to traffic before repaired patch sets properly.
- When repairing of small defects are not done in time.

5) *Treatment:*

- To have proper mix design and choose aggregates and binders as per prevailing climatic conditions and specifications.
- The repaired patch should merge with the type of original surface and eradicate the cause of failure.

- Proper design, regular inspection and maintenance of drainage system is of utmost importance in preserving the investment made on highway system and in providing comfort and safety to the road user.
- The classifications of all types of distresses have been identified. The cause and treatment is different for different severity levels of each distress.
- The defects in existing highway system and in maintenance practices must be clearly understood and eradicated.
- The influencing parameters considered in this study are cracks and cracking pattern, roughness, rut depth, pot holes and deflections. The above parameters have been classified according to their severity levels.
- Maintenance decision can be taken based on the criteria of reaching any one or all of the influencing parameters to their maximum acceptable limits.
- The small distress (cracking, potholes, showing, rutting, etc.) must be repaired before any major maintenance (overlay, renewal coat) is done. Even reduced thickness of overlay will show better results if minor defects are repaired before overlays are done.

VIII. CONCLUSIONS

Following conclusions have been drawn based on the present study: