Performance Evaluation of Pala - Ettumanoor Road SH-32

Mini M.I1 Rema Devi M2 Laju Kottalil3 Basil Eldhose4

1Professor, Civil Engineering Dept. M.A.collegeof Engineering, Kothamangalam, Kerala, India
2Professor, Civil Engineering Dept. M.A.collegeof Engineering, Kothamangalam, Kerala, India
3Professor, Civil Engineering Dept. M.A.collegeof Engineering, Kothamangalam, Kerala, India
4B.Tech student, Civil Engineering Dept. M.A.collegeof Engineering, Kothamangalam, Kerala, India

Abstract— Pavements are complicated physical structures responding in a complex way to the influence of many variables such as loading, environment, material properties and variability, construction quality, maintenance etc. Pavement performance is a function of its relative ability to serve traffic over a period of time. Originally a pavement's relative ability to serve traffic was determined by visual inspection and experience. Evaluations of these influences are of great interests to pavement engineers. The objective of the present study is to carry out the various studies to evaluate the performance of State Highway at Pala-Ettumanoor. A detailed pavement evaluation study is done at two 1km stretches of State Highway and the road condition is evaluated.

Index Terms—Pala, Ettumanoor, Traffic, Travel, Highway

1. INTRODUCTION

The performance of the flexible pavement is influenced by many factors. These include gross load, tire pressure, repetition of load, thickness and durability of the various pavement components, and the elastic-plastic properties of the pavement. Pavement distress may be influenced by a combination of the above factors. Pavement failure may result from excessive shear stresses, consolidation of one or more of the pavement components, lateral shoving, bending or a combination of these. Pavement evaluation involves a thorough study of various factors such as sub grade support, pavement composition and its thickness, traffic loading and environmental conditions. The primary objective of pavement condition evaluation is to assess as to whether and to what extent the pavement fulfills the intended requirements so that the maintenance and strengthening jobs could be planned in time. There are various approaches and methods of pavement evaluations. The various methods may be classified into two groups:

1. Structural evaluation of pavements
2. Evaluation of pavement surface condition

The objective of the study was to carry out various investigations to evaluate the performance of the flexible pavement of State Highway connecting Ettumanoor and Pala (SH 32). It includes both functional and structural evaluation pavement. A detailed pavement condition survey has to be done for the assessment of pavement surface condition. Two representative study stretches each of 1 km length was intended to be evaluated for this study. These study stretches are named as Homogenous Sections I and II (HS I and HS II). The study includes both the laboratory studies and field surveys. This paper is organized as follows: Section I includes the introduction. Section II describes the study area. The methodology adopted is the subject matter of section III. Section IV explains the procedure of evaluation. Section V concludes the paper followed by references.

2. DESCRIPTION OF STUDY AREA

In this pavement performance study on SH 32 two stretches were taken between Kattachira and Kidangoor. (FIG1)
The details of each section as follows:

**PALA – ETTUMANNOOR (HS 1)**
1. Length of the section of the road: 1 km
2. Type of pavement: Bituminous
3. No. of lanes: 2 lanes
4. Divided/ Undivided: Divided
5. Type of shoulder: Earthen shoulder
6. Drainage system: Transverse drainage
7. Surrounding environment: Rural
8. Type of traffic: Mixed traffic
10. Details of existing crust:
   - Bituminous Macadam (BM): 100mm thick
   - Water Bound Macadam (WBM) grade 1: 100mm thick
   - Water Bound Macadam (WBM) grade 2: 150mm thick
   - Wearing coat MSS type: 20mm thick
   - Loosened & compacted soil: 200mm thick
   - Overlay of BC 40mm

**PALA – ETTUMANNOOR (HS 2)**
1. Length of the section of the road: 1 km
2. Type of pavement: Bituminous
3. No. of lanes: 2 lanes
4. Divided/ Undivided: Divided
5. Type of shoulder: Earthen shoulder
6. Drainage system: Transverse drainage
7. Surrounding environment: Rural
8. Type of traffic: Mixed traffic
10. Details of existing crust:
   - Year of completion: 30-7-2005
   - BM: 100mm thick
   - WBM grade 1: 100mm thick
   - WBM grade 2: 150mm thick
3. METHODOLOGY

Keeping in mind the broad objectives of the study, a detailed methodology for the study was framed which consist of a set of tasks involving various field studies and laboratory investigations. Various engineering studies and measurements essential for the pavement evaluation and performance assessment have been carried out along with the study roads conforming to standard Specifications. The pavement constructed or overlaid with bitumen is evaluated functionally by conducting detailed condition survey, measurement of roughness using MERLIN apparatus, measurement of skid resistance etc and structural evaluation of pavement is done by deflection studies using Benkelman Beam.

Functional evaluation of pavements

- Roughness measurement using MERLIN Apparatus - Roughness or Unevenness is a functional parameter, which affects the riding quality of pavements. The standard measure of the road roughness is the International Roughness Index (IRI).
- Condition survey (cracks, raveling, potholes, rutting, corrugation, edge break etc)
- Skid resistance using Portable Skid Resistance – skid resistance is the resistance offered by the pavement surface against skidding of vehicles. The portable skid resistance tester is used for the study
- Texture depth using sand patch method-To measure the pavement macro texture. Geometrical disposition of the individual aggregates in the surface characterizes its macro texture. Coarser texture results in quick drainage of water and less pavement slipperiness.

Structural evaluation of the pavements

Benkelman Beam Deflection technique is used for the structural evaluation of flexible pavements. The strength of a road pavement is inversely related to its maximum deflection under a known dynamic load. The equipment used for measuring the deflection is Benkelman Beam, which meets the requirement of IRC 81-1997.

4. RESULTS AND DISCUSSIONS

A Road inventory survey:

Pavement surface condition was evaluated by visual evaluation of pavement surface and shoulder by inventory survey. Detailed inventory survey was carried out taking a representative section of 1km length from each of the study area. And these study stretches of 1km were again divided into sections of 50m each and evaluated for surface and shoulder conditions in these sections. The shoulder dimension of the pavement was evaluated along with its condition.

During the survey, the following items of distress were visually recorded for every 50m in terms of percentage of the pavement surface area.

- Cracking
- Raveling
- Pot holes
- Edge break

From the condition survey conducted, the pavement had very little number of cracks and ruts in it. But at most of the sections, shoulder condition was below par.
B Texture depth

Texture Depth studies using Sand Patch Method as per BS 598 Part 105 (1990) was carried out on the study roads which gave an account of the macro texture of surface on study stretches. The ability of bituminous surfacing to provide the required skid resistance is governed by its micro texture and macro texture. The macro texture of the surfacing, as measured by its texture depth, contributes particularly to wet skidding resistance at high speeds by providing drainage routes for water between tyre and road surfaces. The surface condition should include a qualitative assessment of texture in the wheel paths so that it can be used to trigger quantitative testing if required.

The texture depth obtained is 0.314mm on HS I and 0.377mm on HS II (Table 1). Hence the pavement surface of the study road has got comparatively smooth surface texture and hence this may contribute to poor skid resistance of the surface in wet condition and more skidding at higher speeds. Also the surface texture study results reveals that because of the smooth texture there is less chance for draining of water between the tyre and road surface.

<table>
<thead>
<tr>
<th>NAME OF THE ROAD</th>
<th>SECTION</th>
<th>AVERAGE TEXTURE DEPTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVERAGE TEXTURE DEPTH</td>
<td>HS 1</td>
<td>0.314</td>
</tr>
<tr>
<td></td>
<td>HS 2</td>
<td>0.377</td>
</tr>
</tbody>
</table>

C Skid resistance test

The hardness and roughness of a road surface affects the cost of vehicle operation, comfort and safety. Although, the type of binding agent, the gradation, and the openness of the surface have some effect upon the rate at which polishing progress, the ultimate state of slipperiness is directly related to the resistance to polishing of the surface aggregate. If highways are to be built, which posses adequate anti-skid characteristics for a reasonable period of wear under the ever-increasing polishing effect of traffic, consideration must be given to the slipness potential of highway material of which paving mixtures are composed and adequate skid resistance may be included as design parameter. Skid resistance of a pavement is the frictional force developed at the tyre pavement interface, when the tyre is prevented from rotating skids along the pavement surface. Skid occurs when the wheels sliding without revolving or when the wheels partially revolve, i.e. when the path revolved along the road surface is more than circumferential than the corresponding longitudinal movement along the roads. Hence, skid is the inability of the driver to exercise control.

The resistance of wet road surfaces to skidding can be checked by means of a Portable Skid – resistance Tester (Portable Pendulum Tester). This apparatus developed at the Road Research Laboratory is used to measure the frictional resistance between a rubber slider (mounted on the end of a pendulum arm) and the road surface. This method provides a measure of frictional property, micro texture of surfaces, either in the field or in the laboratory.
Table 2 AVERAGE SKID NUMBER IN PALA-ETTUMANOOR ROAD

<table>
<thead>
<tr>
<th>NAME OF THE ROAD</th>
<th>SECTION</th>
<th>SKID NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS 1</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>HS 2</td>
<td>42</td>
<td></td>
</tr>
</tbody>
</table>

As per BS 812: 1967, the minimum value of skid number required for pavements of the study road should be 45. The obtained values for both stretches are lower than this value. Therefore, the pavement has inferior skid resistance.

D Roughness measurement

Roughness of a road is a key functional characteristic—lower the roughness value better would be the riding quality. Increase in roughness also significantly increases the maintenance cost of both vehicles and pavement. As per IRC specifications (IRC-SP:16-2004), for bituminous concrete surface, roughness value of less than 2000 mm/Km is indicative of “good” condition of the road and for a value of 2000-3000 mm/Km, the condition of a road is considered to be “average”. Pavement roughness or unevenness is generally defined as an expression of irregularities in the pavement surface that adversely affect the ride quality of a vehicle (and thus the user). Roughness is an important pavement characteristic because it affects not only ride quality but also vehicle delay costs, fuel consumption and maintenance costs. In the objective measurement, the roughness is indicated in terms of cumulative measure of vertical displacements as recorded by a recording wheel due to the unevenness in the longitudinal profile of the road. This cumulative measure of ups and downs in road profile is termed as roughness index or unevenness index and is normally represented in m/km or mm/km. Unevenness could be measured using various equipments like Fifth wheel bump integrator and MERLIN. These values can be converted to the International Roughness Index (IRI) and compared with the standards as prescribed in IRC SP: 16-2004. Surface unevenness affects vehicle speed, comfort, vehicle operating cost and safety and hence needs to be given careful consideration during initial construction and subsequent maintenance.

Table 3 AVERAGE ROUGHNESS INDEX IN PALA-ETTUMANOOR ROAD

<table>
<thead>
<tr>
<th>STRETCH</th>
<th>AVERAGE INTERNATIONAL ROUGHNESS INDEX (IRI) m\km</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS 1</td>
<td>2.83</td>
</tr>
<tr>
<td>HS 2</td>
<td>2.45</td>
</tr>
</tbody>
</table>

As per IRC specifications (IRC-SP:16-2004), for bituminous concrete surface, roughness value of less than 2000 mm/Km is indicative of “good” condition of the road and for a value of 2000-3000 mm/Km, the condition of a road is considered to be “average”. Hence here the pavement surface belongs average category.

E Benkelman Beam

Benkelman Beam is a device, which can be conveniently used to measure the rebound deflection of a pavement due to a dual wheel load assembly or the design wheel load. Of the various equipment used for the purpose, Benkelman Beam is the most commonly used, as the measurements are simple, cheaper and easy. Benkelman Beam deflection measurements are preceded by a rating survey of the road condition so as to divide it into homogeneous sections of approximately similar serviceability.

The Benkelman Beam deflections were measured at 20 points in each kilometer, staggered at 50 meter interval in both directions with truck having rear axle load of 8.17 tones and tyre pressure of 5.6 kg/cm2. The measurements were taken as per CGRA procedure laid down in IRC: 81-1997.
Here most of the characteristic deflection values come in the range of 0.5 – 1 mm and hence the pavement is reasonably strong. For values in the range of 1 – 2 mm, the strength of the pavement is moderate. As per IRC 81-1997 the overlay design thickness obtained is 140mm BM, after 5 years projected traffic from the present year

F Subsoil investigations
Sub grade can be defined as a compacted layer, generally of naturally occurring local soil, just beneath the pavement crust, providing a suitable foundation for the pavement. The design of the pavement layers to be laid over sub grade soil starts off with the estimation of sub grade strength and the volume of traffic to be carried. Design of the various pavement layers are very much dependent on the strength of the sub grade soil over which they are going to be laid. Weaker sub grade demands thicker layers whereas stronger sub grade goes well along with thinner pavement layers. The Indian Road Congress encodes the exact design strategies of the pavement layers based upon the sub grade strength. Sub grade strength is mostly expressed in terms of CBR, the California Bearing Ratio. Hence, in all, the pavement and the sub grade together must sustain the traffic volume. Numbers of tests are required to be conducted on the sub grade soil in a highway project to assess the characteristics and engineering properties. In order to investigate the properties of sub grade soil, certain tests were conducted. Soil was collected from the sub grade level beneath the pavement surface by taking trial pits on the shoulder near to the carriageway edge. Following are the various tests done. In order to investigate the properties of sub grade soil, certain tests were

Subsoil investigations included standard proctor test, Atterberg limits, CBR tests, sieve analysis on the sub grade sample soil collected. The following is the summary of data obtained from these tests.

Table 4 Sub Soil Properties

<table>
<thead>
<tr>
<th>SI No</th>
<th>Soil Sample Code</th>
<th>OM C (%)</th>
<th>MD D (g/cc)</th>
<th>CBR (%)</th>
<th>LL (%)</th>
<th>PL (%)</th>
<th>PI</th>
<th>Gravel %</th>
<th>Sand %</th>
<th>Silt &amp; Clay %</th>
<th>Soil Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HS 1</td>
<td>11.60</td>
<td>2.580</td>
<td>13.50</td>
<td>32.50</td>
<td>16.33</td>
<td>16.17</td>
<td>12.4</td>
<td>61.40</td>
<td>26.20</td>
<td>SC</td>
</tr>
<tr>
<td>2</td>
<td>HS 2</td>
<td>15.50</td>
<td>1.800</td>
<td>10.65</td>
<td>31.50</td>
<td>21.65</td>
<td>10.45</td>
<td>8.98</td>
<td>82.66</td>
<td>43.87</td>
<td>SC</td>
</tr>
</tbody>
</table>

Table 5 Pavement Details

<table>
<thead>
<tr>
<th>Design Life</th>
<th>Design Traffic in msa</th>
<th>Total Pavement Thickness</th>
<th>Design Sub Grade CBR = 10</th>
<th>Bituminous Surface</th>
<th>Granular Base</th>
<th>Granular Sub Base</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>BC</td>
<td>DBM</td>
<td></td>
</tr>
<tr>
<td>Current year (2013)</td>
<td>34</td>
<td>590 mm</td>
<td>40 mm</td>
<td>100 mm</td>
<td>250 mm</td>
<td>200 mm</td>
</tr>
<tr>
<td>After 5 years (2018)</td>
<td>96</td>
<td>640 mm</td>
<td>50 mm</td>
<td>140 mm</td>
<td>250 mm</td>
<td>200 mm</td>
</tr>
</tbody>
</table>

G Pavement redesign
Based on the present 24 hr traffic obtained from traffic survey, and the sub grade soil CBR, the required pavement thickness was obtained. The cumulative standard axle was calculated based on the following formula:
N= 365 * [(1+r)n -1] * A * F * V / r
Where, N= cumulative number of standard axles to be catered for in the design in terms of msa.
A = initial traffic in year of completion of construction in terms of commercial vehicles per day. D = lane distribution factor. F = vehicle damage factor. N = design life in years.
r = annual growth rate of commercial vehicles

5. CONCLUSIONS
From the condition survey conducted, it was found that most of the sections were having poor shoulder. Edge drops and edge breaks were visible at many locations. The major distresses like cracks, raveling etc were not seen on the study stretches. Based on visual evaluation, the pavement has good riding quality. Skid resistance of the pavement was obtained in terms of skid number. It was obtained as 40 and 42 for the stretches HS I and HS II respectively. As per the recommendations of BS: 812-1967, minimum value of skid number should be 45 for such roads. Therefore the pavement has insufficient skid resistance. Texture depth studies revealed the macro texture of pavement which is further related to skid resistance.

Texture depth obtained for HS I and HS II are 0.314mm and 0.377mm which lies in the range of 0 – 0.4mm. Hence as per the specifications of BS 598 Part 105(1990), the pavement surface has got a smooth texture. This has contributed to the inferior skid resistance of the pavement surface. Anti skid surface treatment materials and methods could be used and the wearing course composition should be selected in such a way that better skid resistance is achieved. As per IRC specifications (IRC-SP:16-2004), for bituminous concrete surface, roughness value in the range 2000-3000 mm/Km., the condition of a road is considered to be „average”

Hence here the pavement surface belongs to average category. Here most of the characteristic deflection values come in the range of 0.5 – 1 mm and hence the pavement is reasonably strong. For values in the range of 1 – 2 mm, the strength of the pavement is moderate. The design according to IRC 37: (2001), the present pavement thickness was found to be sufficient for the current year. The projected traffic after 5 years requires more pavement thickness which have to be provided in the next overlay.

From the functional and structural evaluation of the Pala-Ettumannoor SH, apart from skid resistance, the performance is found to be satisfactory. Therefore the pavement can be evaluated as having good riding quality functionally and moderate to reasonably strong structurally. But the pavement structure demands an overlay after a period of five years.

REFERENCES
[6], IRC: 81-1997, “Guidelines for strengthening of flexible road pavement using Benkelman beam deflection technique”.