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Distress Measurement : A case study of SH-158-stretch between Waghodiya Intersections to Parul University

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ABSTRACT

It is necessary to provide good road network for the development of country. India has second largest highway and roadway networks system in the world. Due to unexpected economic development in the any region, the traffic loads on the road may increase at a rapid rate. The pavements also undergo higher distress due to increased wheel loads and load repetitions. There is great need for the effective and efficient management and maintenance of the road network. For the maintenance work pavement evaluation is crucial. In the present work, an attempt is made to evaluate the structural and functional condition of the existing flexible pavements. A network of 11 km coming under Vadodara District was selected and extensive field, laboratory investigation, pavement analysis were carried out based on the maintenance priority. The field work consists of road inventory, traffic studies, and Bump Integrator studies. PCI was computed based on the selected distress parameters i.e. patch, pothole, cracks, hungry surface, area of deflection etc. In addition, IRI and characteristic pavement deflections were computed from Bump Integrator. Based on PCI, IRI and deflection values suggestions given for remedial measures for particular distress.
Keywords: Pavement evaluation, PCI, IRI.

I. INTRODUCTION

Road building needs huge infrastructure. In case of developing countries, there is a shortage of funds required for new infrastructure projects- both for constructing them and more significantly towards their maintenance and repairs. Most of the existing pavements are flexible in nature having bituminous wearing course. These bituminous pavements, in general, have a problem that they get deteriorated with time. Most of the roads in India exhibit in general, deficiencies like rutting, cracking, potholes etc. Hence before going in for an appropriate rehabilitation, performance evaluation of the existing roads is an absolute necessity.

There are main two types of failure which are generally shown on pavement are functional failure and structural failure. Functional failure is the failure where the pavement is not in condition to carry traffic without causing discomfort to the road user. Structural failure shows a breakdown of more than one pavement components, making it incapable of sustaining the loads imposed upon its service life. Structural distresses are cracks, potholes, rutting, deflection etc.

In the present study a network of 11km of SH-158 showing signs of distress, coming under Vadodara district was selected and a detailed pavement condition evaluation was carried out based on the priority for the maintenance work. Roads were evaluated both functionally and structurally. Pavement condition is computed based on selected distress parameters like patch, pothole and cracks, deflection. In addition, ride quality measurements using MERLIN Machine for Evaluating Roughness using Low Cost Instrumentation and characteristics pavement deflection data is collected using Benkelman beam device.

II. DATA COLLECTION AND ANALISIS

A. General Data

The general data consists of geometric details of the roads which are collected visually walking along the entire stretch. All of these data will remain constant until the pavement undergoes maintenance or repair. General data like,

- Length of pavement:10 Km
- Width of pavement:3.5 m per lane
- Type of surface: Flexible pavement
- Number of lanes: 4
- Type of shoulder: unpaved
- Shoulder width: 1.5 m
- Pavement surface drainage condition: poor
- Road side drainage: surface drainage
- Side Drainage width:2.7 m
- Land use pattern: Industrial/Educational
- Terrain: Plain

B. Existing Crust Details

For the evaluating the condition of existing pavements, it is necessary to know the design features such as the thickness of the pavement component layers. The existing flexible pavements crust thickness were measured by excavating trail pits at the pavement-shoulder interface extending through the pavement layers and up to the level of sub grade.

As per secondary data existing pavement layers thicknesses at the time of the construction are as below
Semi Dense Bituminous Concrete= 25 mm
Bituminous Macadam = 50 mm
Bituminous Mix Macadam = 75 mm
Wet Mix Macadam = 150 mm
Water Bound Macadam = 150 mm
Granular Sub Base = 150 mm

C. Traffic Volume Count

Traffic census is carried out to analyse the traffic characteristic. For the present study the classified traffic volume study was carried out. A 12 hour traffic volume count for 3 consecutive days was carried out on selected roads referring to IRC: 106-1990. Trucks with more than two rear axle were considered as Multi-axle vehicles. Vehicles like two wheelers, three wheelers and cars will also counted but they are omitted from the count since they are not considered to be commercial vehicles, which affect the design process. The different vehicle classes were converted to PCU (Passenger Car Unit). Present traffic intensities are expressed in commercial vehicle per day (cvpd).

From the 3 days traffic volume count it is found that morning 9:00-10:00 am and evening 5:00-6:00 pm are peak hours.

Total commercial vehicles per day are 4348.
two wheelers, three wheelers and cars are not consider as commercial vehicles but its amount is very high for particular road because many activities are there like educational, industrial, construction etc. like, Parul University, Sumandeep collage, Apollo company, GIDC and also road site construction work.

D. Pavement Condition Survey

Pavement condition survey was carried out for the chainages as shown in the tables. it was observed a different type of distresses on the part of the project length like cracks, potholes, patch work, rutting, deflection, which need repair now and then The details of different identified distress analysis is shown separately in this report. The chainage wise different defects as measured (in the area) on the site are also tabulated. It seems that majority of failure on the road is in cracks forms, settlement, and rutting. Lots of patches work was also overserved. This shows that the action was taken against any defect etc.

It was also noticed that even some of the patches were also repaired twice to thrice. This implies that there may be some structural discrepancy in the road. Looking to that of 56,000 sq. m. the total area under the investigation, the distress area is 26,360 sq. m. identified in the investigation, which means 47.07 % of the area is under defects.

Figure 2. Rutting on Road of SH-158

Figure 3. Pothole on Road of SH-158

Figure 4. Patching on Road of SH-158

Figure 5. Alligator Cracks on Road of SH-158

Figure 6. Hungry Surface on Road of SH-158

E. Roughness Measurements

Roughness of pavement is an indication of its riding quality and level of service. The fifth wheel bump integrator was used for the roughness measurement .the vehicle was driven through the test selection and bump were measured. With the fifth wheel bump integrator the value obtained is in mm/km. the data obtained from fifth wheel bump integrator is converted to standard roughness value (IRI in m/km) using calibration equation.

The roughness data was converted into Unevenness Index (UI) in mm/km by using the following formula:

$$UI = \frac{BI\ Counter\ Reading(cm) * 10 * Diatance\ Counter\ Reading\ per\ Km}{Distance\ Counter\ Reading\ in\ Test\ Lenght}$$

For Dipstick, roughness was observed in terms of IRI (m/km). IRI was converted into reference UI using the following standard equation, as recommended by the World Bank.

Reference UI (mm/km)=630 $(IRI)^{1.12}$

Based on the roughness observed through ARUR-UI (mm/km) and reference roughness in terms of UI (mm/km), the following calibration equation, to determine the corrected/ calibrated roughness, was developed.

Y= (1.448*X) – 1877
R^2 (regression coefficient) = .998
Where,
Y= Calibrated roughness, mm/km
X = Observed roughness with ARUR, Steco-283 mm/km.

Two lane of Parul University to Waghodiya Intersection the average value of roughness index was 3198.25 mm/km and two lane of Waghodiya Intersection to Parul university was 3524 mm/km which are high as per IRC:SP:16-2004. So road section is poor in condition.

F. Laboratory Investigation

The laboratory results would help in knowing the properties of materials used in the field at the time of construction. The data collected from the laboratory tests would help in providing proper rehabilitation for the in-service pavements.

As per IRC: 2720 (part-5), Liquid limit is 42.1 and plastic limit is 19.94 and plasticity index is 22.26. From the A-line diagram soil is CI (Clay with Intermediate Plasticity). Free Swelling is 55.56. From the Mechanical analysis test Sand is 49.58%, 50.42% of silt/clay and 0% of gravel. Specific gravity is 2.575. Maximum dry density is 1.74 g/cm^2 and optimum moisture content is 18.73 %. Soaked CBR value for 96 hours is 3.20% at 2.5mm penetration.

G. Deflection Measurements

The structural adequacy of pavements is ascertained by carrying out deflection testing. For the present study, deflection measurements were done as per IRC: 81-1997. For the design purpose characteristic deflection shall be taken as given in following equations:

Mean Deflection, $X = \frac{\in x}{N}$

Standard Deviation, $\sigma = \frac{\sqrt{\in (x-X)^2}}{n-1}$

Characteristic Deflection,

(i) $D_c = X + 2\sigma$
For major arterial roads (NH & SH)

Where,
x = Individual deflection, mm
X = Mean deflection, mm
n - Number of deflection measurements
σ = Standard deviation, mm
Dc = Characteristic deflection, mm

The characteristic deflection (Dc) value and cumulative number of standard axle are used for the overlay design. Cumulative number of standard axle is determining by using following formulas:

$$N = \frac{365*A*[(1+r)^n-1]*F*D}{r}$$

Where,
N = the cumulative number of standard axles to be catered for in the design in terms of msa.

A= Initial traffic, in the year of completion of construction, in terms of the number of commercial vehicles per day duly modified to account for lane distribution

r = Annual growth rate of commercial vehicles
n = Design life in years
F = Vehicle damage factor
$A = P (1 + r)^x$

Where,
P = Number of commercial vehicles as per last count.
X = Number of year between the last count and the year of completion of construction.

The thickness deduced from the overlay thickness design curves is the overlay thickness in terms of bituminous macadam construction. In case other compositions are to be laid for strengthening, the equivalent overlay thickness to be provided may be determined using appropriate equivalency factors as suggested below:

1 cm of Bituminous macadam = 1 .5 cm of WBM/Wet Mix Macadam/BUSG
1 cm of Bituminous macadam = 0.7 cm of DBM/AC/SDC.

By using all above equation according to my data for all 4 km of road of L.H.S and R.H.S, Characteristic deflection is 1.54mm and overlay requirement in terms of BM is 187.25mm.

III. CONCLUSION

From the actual study it is found that Roughness index is exceeding the limits. From the PCI survey it is found that the 47.07% are of pavement is under the distress. PCU per day is also exceeding the limits. Characteristic deflection is 1.54mm. So all distress found in the highway were exceeding their maximum limits. Frequency and interval of pavement distresses is too much and also exceeded the standard limits. Therefore, immediate repair and maintenance is required either overlay or resurfacing.

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