STRENGTHENING AND WIDENING OF FLEXIBLE PAVEMENT: A CASE STUDY OF KAITHAL RAJASTHAN BORDER SECTION (NH-152/65)

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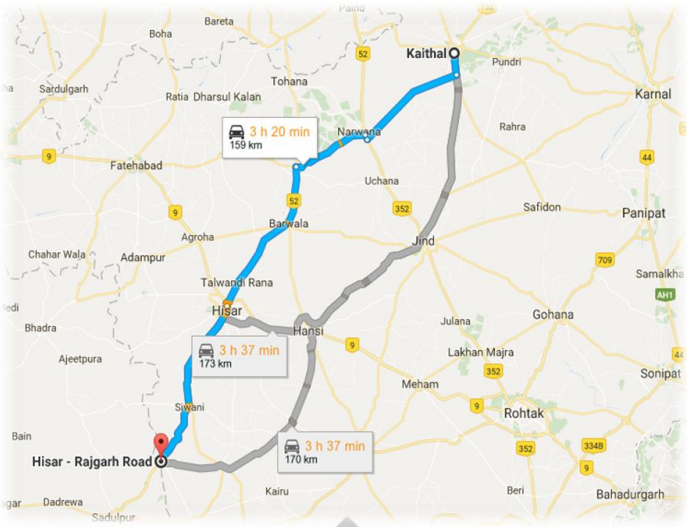
***Abstract* – Grossly, In India different types of pavement design have been observed, Most of the highways are having the flexible pavement. All types of pavements are designed to support the wheel load imposed on it from traffic moving over it. Additional stresses are also imposed by change in the climate. Pavement should be strong enough to resist the stresses and to distribute the external load. The study highlights the need of pavement evaluation and pavement evaluation measures for the road pavements of Kaithal – Rajasthan Border NH-152/65 for the stretch of 7.5 km. For structural evaluation the existing pavement condition has carried out by BBD technique and overlay design has carried out as per IRC: 81-1997 guidelines on Kaithal – Rajasthan Border NH-152/65 for the selected stretch of 7.5 km..**

***Keywords*: Strengthening and widening of flexible pavement**

1. INTRODUCTION

Government of India through Ministry of Road Transport and Highways has launched National Highway Development Program for improvement of National Highways network in the Country. In this program such roads are proposed for development which needs immediate capacity augmentation for safe and efficient movement of vehicles. This program is to be carried out in phases. The Project Corridor Four Laning of Kaithal-Rajasthan Border section of NH-152/65 from part of Phase IV B of NHDP program. This project highway is proposed for up graduation as per the traffic requirements through Public Private Partnership (PPP) basis.
The project road starts at Km 33+250 (Design Km 0.520) in Kaithal and ends at Km 241+580 (Design Km 165.759) of NH-152/65 in Rajasthan Borders. The project corridor is located in the State of Haryana and passes through four districts namely Kaithal, Jind, Hisar and Bhiwani. The nodal town on the stretches is Kalayat, Narwana, Barwala, Hisar, Barwa and Siwani. There is no major river crossed by the project road. The project road is not passing through any sensitive area live wildlife sanctuary, national park etc.
The project road being situated on the Yamuna-Ghagger plain, the terrain for the entire street is plain with the soil composition being alluvial type. The land use pattern in the project section is generally agriculture, with scattered stretches of urban/semi urban/ rural development. The percentage distribution of land use is 15.6%, 21.9% and 62.6% for semi Built up, Built up and agriculture respectively. The climate of Haryana is similar to other states of India lying in the northern plains is continental with extremes of heat in summer. The temperature falls in the minimum of 3˚C in January and reaches up to 50˚C during the months of May and June.
The existing highway geometry is very good and no major realignment to improve the horizontal geometry is envisaged. The terrain is absolutely plain and hence the vertical profile also needs very minimum improvement to achieve the required sight distance with respect to the design speed.
NHAI has appointed M/s Consulting Engineers Group Limited in association with SHRI KUSHALSURI Engineering Service Private Limited Jaipur to act independent engineer for this project.



2. LITERATURE REVIEW

Kunal P. Bhagat, Chetan P. Hadial, Ujjval J. Solanki (2015), "Mechanistic design of overlay based on Benkelman beam deflection technique," in this literature flexible pavement overlay design was carried out as per IRC: 81- 1997 -Guidelines for Flexible Road Pavement Strengthening using Benkelman beam deflection (BBD) technique. The design thickness as per evaluated of Benkelman beam deflection is 85 mm bituminous layer. They have done overlay design as per IRC 37 2012 base on fatigue and rutting failure criteria. The various inputs required for the design is computed through deflection & existing pavement layer thickness as per IRC guidelines. The computed fatigue & rutting strain is 0.0837 micron and 169 micron due to material which is lower than strain due to traffic so the overlay design found safe in both criteria

Mahendrakar Kiran Kumar, D. Gouse Peea, Konge Praveen Kumar (2015), "A study on overlay designs of repeatedly deteriorating flexible pavement," in this research they have studied on a factor, in India there is very high and very low pavement temperature in some parts of the country. Under this condition, flexible pavement tends to become soft in summer and brittle in winter. Further increase in road traffic during the last one decade with an unduly low level of maintenance has contributed to accelerated deterioration of road surfacing. To prevent this deterioration process, several types of measures may be adopted effectively such as improved design use of high performance material and effective construction technology.

A. A. Patel, Dhaval V. Lad (2015)**,** "Pavement evaluation by Benkelman beam of state highway section (Waghodiya crossing to Limda)" In this structural evaluation of flexible pavement deflection by the Benkelman Beam is measured. Rebound deflection is used for overlay design. A detailed pavement condition survey is done on State Highway 158 (Waghodiya crossing to Limda) and the road condition is evaluated structurally. Their present study is evaluates the overlay thickness for State Highway 158 Waghodiya crossing to Limda.

Breeten Singh Konthoujam, Dr. M. R. Rajashekar (2015), they analyzed the traffic flow in most cities of India is a mixed traffic characteristics and also the traffic congestion is the common problem in most major cities in India. In Bangalore city, most of the roads are congested and operate in level of service E or F. the objective of the present study is to improve the performance operation of the urban read network by proposing the proper alternatives to enhance the traffic capacity. To achieve this objective, a complete methodology for analyzing the mixed traffic flow in 2 km long stretch from Koli Farm Fate to Jalli Machine Bus stop in Bangalore city, along the Bannerghatta road, is selected and analyzed. The present investigation concludes that the Gottigere to Kolli Farm Gate of Bannerghatta road has a LOS of 'D' & Kolli Farm Gate to Gottigere has also LOS of 'D'. Kolli Farm Gate to AMC College has a LOS 'C' & AMC College to Kolli Farm Gate has also LOS 'C'. AMC College to Jalli Machine Bus stop has LOC 'B' &Jalli Machine Bus stop to AMC College has a LOC 'A'.

3. OBJECTIVES OF THE PROPOSED WORK

The objectives of the work would be:

(i) To study the existing traffic situation for the selected road stretch. Highway infrastructure projects would also require substantial up-scaling if the sector is to be developed for broader objective of achieving socio-economic development of the country and maintain the targeted growth trajectory.

(ii) To carry out traffic volume survey of stretch.

(iii) To study on need of road widening and justify the activities such as Road Safety, pilot schemes to test the efficacy of new / emerging technologies and materials, etc.

4. PAVEMENT SURFACE CONDITION SURVEY

The functional evaluation survey is conducted on NH - 152, from Km 33+250 (Design Km 0.520) of flexible pavement. In this phase of operation visual observations supplemented by simple measurements for Rut-depth, block crack, patching, hairline crack, alligator crack, longitudinal crack, transverse cracks, pot holes etc. distresses using a 3 meter straight edge.

S. No.	Chainage	Average area of cracks in m^2 (C)	Average area of patching in m^2 (P)	Average rut depth in mm (RD)	Pavement classification section
1	33+250 – 32+750	182.90	310.59	18.288	Fair
2	25+300 – 24+600	150.90	142.90	15.24	Fair
3	1+500 – 0+000	157.85	135.40	20.066	Poor
4	121+400 – 121+850	63.01	66.76	6.35	Good
5	121+850 – 122+530	70.41	67.45	7.874	Good
6	122+530 – 123+540	72.11	82.26	18.288	Good
7	124+000 – 124+400	161.32	81.31	21.59	Fair
8	130+650 – 131+050	59.94	146.32	20.574	Poor
9	156+300 – 157+200	36.56	220.80	23.114	Poor
10	167+80 – 169+000	182.69	185.45	22.23	poor

Table 1 - Distress measurement during visual condition survey

5. SUB-GRADE SOIL TESTS

The materials were obtained from the nearby borrow areas, where plenty amount of material is available for the construction purpose. The material which is collected for testing is different in location every kilometer between stretched, so that the material was separately tested in the laboratory so as to design the soil sub grade.

5.1 Atterberg Limits Test

The Liquid and Plastic Limits (Atterberg Limits) of soil indicate the water contents at which certain changes in the physical behavior of soil can be observed. From Atterberg limits, it is possible to estimate the engineering properties of fine-grained soils. Plasticity is the property that enables a material to undergo deformation without noticeable elastic recovery and without cracking or crumbling.

Sample No.	Liquid Limit in %	Plastic Limit in %	Plasticity Index in %
1	39.9	35.909	3.991
2	48	44.358	3.462
3	42.6	39.2	3.4
4	47.6	43.3	4.3

Table 2 - Summary of Atterberg Limit Test

5.2 California Bearing Ratio Test

CBR value of soil sample is used to find out the thickness of pavement layers. CBR value is inversely proportional to thickness of the pavement layer. If the sub-grade is stronger, higher the CBR value, lesser thickness is required and vice-versa. California bearing ratio test conducts in laboratory as well as on field also.

Sample No.	Chainage	IS classification	CBR in %
1	33+250 – 32+750	GC	6.3
2	25+300 – 24+600	GC	6.2
3	1+500 – 0+000	GC	6.2
4	121+400 – 121+850	GC	6.3
5	121+850 – 122+530	GC	6.4
6	122+530 – 123+540	SM	5.1

7	124+000 – 124+400	SM	5.1
8	130+650 – 131+050	SM	5
9	156+300 – 157+200	ML	7.9
10	167+80 – 169+000	ML	7.8

Table 3 - Result of CBR test

6. Traffic Volume Data

Traffic volume survey carried out at NH 152 PCU/day for justification of capacity of road. Three day 12 hours survey has carried out for the wide and accurate justification of road capacity. Traffic volume study data for three days are tabulated below

	Total PCU/Day	Consider Maximum PCU/Day
Day – 1 (Saturday)	25664	25843
Day – 2 (Sunday)	21565	
Day – 3 (Monday)	25843	

Table 4 - Summary of traffic volume data

6.1 Traffic Survey of Commercial Vehicle Per Day (CVPD)

	HCV			Tractor			Bus		
	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
Average CVPD	1735			163.3333333			914.3333333		
Total CVPD	2812.666667								
Consider Total CVPD	2813								

Table 5 - Commercial vehicles per day

7. RESULTS AND ANALYSIS

7.1 Calculation of Million Standard Axels For Widening

The following equation may be used to make the required calculation

$$NS = \frac{365xA[\{1+r\}^{x}-1]}{r} \text{ x } F$$

Ns = the cumulative number of standard axles to be catered for in the design

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

x = Design life in years

F = Vehicle damage factor (number of standard axles per commercial vehicle)

Ns = 49.85029 msa. ≈ 50 msa.

7.2 Calculation of Million Standard Axels For Overlaying

Ns = 49.0234 msa

7.3 Design of Overlay Thickness

Calculation of Characteristic Deflection from the Analysis of the Test Data for Section Km 33+250 To Km 32+750

Mean deflection mm, $X = \frac{\sum X}{n}$ = 1.00233 mm

Standard deviation mm, $\sigma = \frac{\sqrt{(x-X)^2}}{n-1}$ = 0.0442 mm

Characteristic Deflection mm, Dc = X + 2σ = **1.0907 mm**

Calculation of Characteristic Deflection from the Analysis of the Test Data for Section Km 25+300 To Km 24+600

Mean deflection mm, $X = \frac{\sum X}{n}$ = 0.8763 mm

Standard deviation mm, $\sigma = \frac{\sqrt{(x-X)^2}}{n-1}$ = 0.0628 mm

Characteristic Deflection mm, Dc = X + 2σ = **1.0019 mm**

Calculation of Characteristic Deflection from the Analysis of the Test Data for Section Km 1+500 To Km 0+000

Mean deflection mm, X = $\frac{\sum X}{n}$ = 0.9418 mm

Standard deviation mm, σ = $\frac{\sqrt{(x-X)^2}}{n-1}$ = 0.0342 mm

Characteristic Deflection mm, Dc = X + 2σ = **1.01022 mm**

Calculation of Characteristic Deflection from the Analysis of the Test Data for Section Km 121+400 To Km 121+850

Mean deflection mm, X = $\frac{\sum X}{n}$ = 1.0099 mm

Standard deviation mm, σ = $\frac{\sqrt{(x-X)^2}}{n-1}$ = 0.0312 mm

Characteristic Deflection mm, Dc = X + 2σ = **1.0722 mm**

8. CONCLUSION

1. It is observed from data that average daily traffic (ADT) in PCU/day is more than the IRC recommended for capacity per day of 2 lanes for plain rural road.
2. Average daily traffic (ADT) on Kaithal – Rajasthan border section NH-152/65 is 25,843 PCU/day, it is more than 15,000 PCU/day of IRC recommended for capacity per day of 2 lane plain rural road from which it has been justified that widening is required on the selected stretch.
3. It has been found that 4 sections are having poor surfaces from the surface condition survey, and structural evaluation also has conducted using Benkelman beam deflection test at poor section within 4 km and found the characteristic deflection

9. FUTURE SCOPE

1. Structural evaluation of the pavement can be done by using falling weight deflectometer (FWD) and/or light weight deflectometer (LWD).
2. Estimation for the widening and overlay can be computed.
3. Other pavement design software can be used for evaluation.
4. Alternate material can be used in the pavement designing

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