Ijesm
Consulting, help, relaxation
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES
&
MANAGEMENT

PAVEMENT SHOULDER INTERACTION ON NH-59A (KM 61-KM 136): A CASE STUDY

H.S. Goliya[*1], Kundan Meshram[2], Parul Mukherjee[3]
[*1]S.G.S.I.T.S., Indore.
[2]K.C.B.T.A, Indore.
[3]S.V.I.T.S. Indore

Abstract

In present case study done for NH-59A Indore – Ahemadabad National Highway, INDIA. The length of section taken 75 Km (Km 61to Km 136) between Dhar to Jhabua. Detailed surveys have been carried out. Road Inventory survey includes general details and condition of pavement & shoulder for some selected chainage. There are four categories of condition of pavement & shoulder viz.1) Pavement-Poor, Shoulder- Poor 2) Pavement- Good, Shoulder-Poor 3) Pavement-Fair, Shoulder-Good 4) Pavement-Good, Shoulder-Good. In section condition data for pavement cracking area, patch (%), no. of potholes per Km, depth of potholes (m), reveled area (%) and settled area (%) have been measured. Laboratory testing has been done for soil sample of selected chainage and check properties of soil like OMC, MDD, LL, PL, CBR and % of Gravel, Sand, Silt & clay for shoulder material, selected soil & subgrade soil.

Introduction

The shoulders are an important component of a highway system, particularly for highways that experience an appreciable volume of traffic. These are provided along the road edges to serve as an emergency lane for the vehicles compelled to be taken out of pavement or roadway. Shoulders act as safety strips for emergency use or for temporary parking of vehicles. They provide lateral support to the pavements and protect their edges from raveling, undermining or breaking. They provide a safe haven for the disabled vehicles and highway maintenance operations. They act as safety buffer between traveling vehicles and roadside obstacles (e.g. ditches, guardrails, signs etc.) and aid in the preservation of mainline pavement structure through lateral support and facilitation of drainage. Shoulder width is the distance from the edge of traveled way to the edge of roadway. Shoulder widths vary depending upon traffic volumes, terrain and cost of added width to the roadway sections. The materials used to construct shoulders are variable and include concrete, asphalt, grass, gravel and bituminous surfaces. Shoulders are particularly important for single lane roads and 80% of the state roads in India are still single lane carrying 35%-40% of the total road traffic. Hence these should be stable enough to support the normal traffic loadings and their surfaces should be adequately sloped to provide quick removal of storm water from the roadway into the drainage system.

Objectives of the study:

1. To investigate the factors that cause poor performance of shoulders adjacent to pavements and to identify the changes that will lead to substantially improved shoulder performance.
2. To evaluate the effectiveness of adding shoulders to the pavements at variable locations carrying mixed traffic.
3. To determine the effect of shoulder on pavements.

Data Collection

Road Inventory Survey Data

*** Corresponding Author**
E. mail:

Table1:General details	
Name of Road	Indore- Ahmadabad
Category of Road	National Highway
Section Name	NH59A, Dhar-Jhabua,India
Section Length	75 km(km 61 to km 136)

Table 2: Condition of Pavement & Shoulder

Section (chainage)	Pavement Condition	Shoulder condition
Km81/6,Km120/2, Km132/4	Poor	Poor
Km80/10,Km 99/6,Km129/2	Good	Poor
Km 74/6,Km 95/4, Km 124/2	Fair	Good
Km 86/2, Km 104/6,Km128/4	Good	Good

Table: 3 Section Condition Data for Pavement

Section (Km.) NH-59A	Cracking Area %	Patch %	No. of Potholes Per m.	Depth of Potholes (cm)	Raveled Area %	Settled Area %
Km.61	18	45	5	15	20	11
Km.62	21	37	7	12	18	12
Km.63	26	33	5	15	25	11
Km.64	25	32	6	14	21	10
Km.65	19	35	8	13	19	9
Km.66	21	30	5	15	20	12
Km.67	18	36	9	12	18	9
Km.68	28	34	9	14	22	10
Km.69	20	32	5	15	17	11
Km.70	22	30	7	15	25	10
Km.71	27	39	5	13	19	12
Km.72	24	35	5	14	12	10
Km.73	10	26	4	10	14	8
Km.74	1	-	2	2	-	1
Km.75	11	25	4	9	11	8
Km.76	15	21	4	11	13	7
Km.77	10	22	4	10	15	7
Km.78	16	27	3	11	12	6
Km.79	14	26	2	9	9	5
Km.80	-	-	-	-	1	-
Km.81	15	23	3	10	15	8
Km.82	12	25	3	11	10	6
Km.83	16	28	2	9	14	5
Km.84	13	26	2	10	10	7
Km.85	-	-	-	-	-	-
Km.86	-	-	-	-	-	-
Km.87	-	-	-	-	-	-
Km.88	11	23	2	12	11	5
Km.89	17	27	3	11	9	6
Km.90	13	24	2	9	15	7
Km.91	10	21	2	11	14	8

Km.92	12	23	4	10	9	5
Km.93	14	28	4	11	10	8
Km.94	15	21	2	11	13	7
Km.95	-	1	-	-	1	-
Km.96	-	-	-	-	4	-
Km.97	-	-	-	-	2	-
Km.98	1	-	-	-	1	-
Km.99	1	2	-	-	3	-
Km.100	-	-	1	2	-	-
Km.101	-	-	-	-	-	-
Km.102	2	2	-	-	1	-
Km.103	-	-	-	-	1	-
Km.104	-	-	-	-	-	-
Km.105	12	26	8	8	11	6
Km.106	9	22	8	7	10	4
Km.107	11	24	7	10	12	6
Km.108	13	21	6	9	15	4
Km.109	17	23	8	7	13	5
Km.110	15	30	6	9	14	6
Km.111	14	31	6	8	10	6
Km.112	11	27	7	10	9	4
Km.113	10	25	8	7	14	5
Km.114	9	26	6	9	12	4
Km.115	12	22	8	7	11	4
Km.116	14	21	7	8	15	6
Km.117	13	22	5	10	10	5
Km.118	11	25	7	7	9	4
Km.119	16	22	5	9	13	6
Km.120	29	20	8	7	12	4
Km.121	1	-	-	-	-	-
Km.122	-	-	-	-	-	-
Km.123	1	-	-	-	-	-
Km.124	-	1	-	-	-	-
Km.125	-	-	1	8	2	-
Km.126	-	-	1	7	-	-
Km.127	-	-	-	7	1	-

Km.128	-	-	-	-	-	-
Km.129	3	-	2	-	-	-
Km.130	30	47	8	22	15	16
Km.131	28	38	7	15	17	15
Km.132	15	2	2	4	10	1
Km.133	16	-	3	4	11	3
Km.134	14	3	2	5	9	-
Km.135	12	1	4	3	7	2
Km.136	11	1	4	6	8	-

Test Result

CASE 1 (A1) Chainage Km 81/6

Shoulder-Poor **Pavement -Poor**

Depth of sample	OMC %	MDD Gm/cc	Gravel %	Sand %	Silt %	Clay %	LL %	PI %	CBR %	Remark	Pavement condition
Standard values	12-15	1.8-1.91	50-55	20-25	12-15	4-6	25-28	5-6	12-14	-	Poor
Top 20 cm.	18	1.74	11.92	30.1	55.6	2.32	29.3	9.94	4.23	Shoulder material	
20-60 cm.	16	1.66	-	-	-	-	29.4	9.10	3.56	Selected soil	
60 cm. and below	19	1.61	10.5	6.0	72.6	10.8	32.7	15.7	2.03	Sub grade soil	

CASE 1 (A2) Chainage Km 120/2

Shoulder- Poor **Pavement- Poor**

Depth of sample	OMC %	MDD Gm/cc	Gravel %	Sand %	Silt %	Clay %	LL %	PI %	CBR %	Remark	Pavement condition
Standard values	12-15	1.8-1.91	50-55	20-25	12-15	4-6	25-28	5-6	12-14	-	Poor
Top 25 cm	16	1.64	30.1	49.48	14.45	5.9	39.8	19.1	3.69	Shoulder material	
25-50cm	15	1.62	25.22	36.66	32.02	6.10	26.9	12.5	3.60	Selected soil	
50cm &below	16	1.63	16.14	26.82	50.77	6.27	31.1	15.9	2.90	Sub grade soil	

CASE 1 (A3) Chainage Km 132/4

Shoulder- Poor **Pavement- Poor**

Depth of sample	OMC %	MDD Gm/cc	Gravel %	Sand %	Silt %	Clay %	LL %	PI %	CBR %	Remark	Pavement condition
Standard values	12-15	1.8-1.91	50-55	20-25	12-15	4-6	25-28	5-6	12-14	-	Poor
Top 45 cm	15	1.76	24.1	40.6	32.1	3.1	48.2	22.9	3.3	Shoulder material	
45-90cm	16	1.61	20.3	37.5	32.9	9.2	49.5	29.7	3.2	Selected soil	
90cm and below	19	1.57	20.1	36.8	33.1	9.1	50.4	25	3.1	Sub grade soil	

CASE 2 (B1) Chainage Km 80/10

Shoulder- Poor Pavement-Good

Depth of sample	OMC %	MDD gm/cc	Gravel %	Sand %	Silt %	Clay %	LL %	PI %	CBR %	Remark	Pavement condition
Standard values	12-15	1.8-1.91	50-55	20-25	12-15	4-6	25-28	5-6	12-14	-	
Top 25 cm.	18	1.75	17.70	29.9	47.6	3.5	4.7	31.8	3.9	Shoulder material	
25-50 cm.	13	1.64	21.23	46.9	28.3	3.50	33.9	23.6	3.1	Selected soil	**Good**
50 cm. and below	15	1.62	17.8	36.8	32.4	13.5	38.1	22.7	3.0	Sub grade soil	

CASE 2 (B2) Chainage Km 99/6

Shoulder- Poor Pavement-Good

Depth of sample	OMC %	MDD gm/cc	Gravel %	Sand %	Silt %	Clay %	LL %	PI %	CBR (S) %	Remark	Pavement condition
Standard values	12-15	1.8-1.91	50-55	20-25	12-15	4-6	25-28	5-6	12-14	-	
Top 17 cm	19	1.78	24.1	40.6	32.0	3.1	33.1	14.6	3.65	Shoulder material	
17-65	18	1.79	23.5	50.1	18.7	7.6	33.4	16.2	3.37	Selected soil	**Good**
65cm and below	19	1.72	13.61	13.1	51.9	21.2	34.2	18.6	2.97	Sub grade soil	

CASE 2 (B3) Chainage Km 129/2

Shoulder- Poor Pavement-Good

Depth of sample	OMC %	MDD Gm/cc	Gravel %	Sand %	Silt %	Clay %	LL %	PI %	CBR %	Remark	Pavement condition
Standard values	12-15	1.8-1.91	50-55	20-25	12-15	4-6	25-28	5-6	12-14	-	
Top 20cm	12	1.82	35.87	29.4	24.6	10.1	31.79	13.1	3.82	Shoulder material	
20-60 cm	13	1.79	21.2	46.9	28.3	3.5	37.5	16.3	3.12	Selected Soil	**Good**
60 cm and below	15	1.68	-	-	-	-	37.1	20.5	2.78	Sub grade soil	

CASE 3 (C1) Chainage Km 74/6

Shoulder-Good Pavement-Fair

Depth of sample	OMC %	MDD Gm/cc	Gravel %	Sand %	Silt %	Clay %	LL %	PI %	CBR %	Remark	Pavement condition
Standard values	12-15	1.8-1.91	50-55	20-25	12-15	4-6	25-30	5-6	12-14	-	
Top 25 cm	16	1.75	50.5	26.7	18.1	4.5	21.5	5.4	12.6	Shoulder material	
25-50 cm	19	1.73	49.62	29.7	17.9	2.6	22.4	6.0	7.72	Selected soil	**Fair**
50cm and below	18	1.72	32.8	10.6	46.9	9.7	25.5	4.8	3.52	Sub grade soil	

CASE 3 (C2) Chainage Km 95/4

Shoulder-Good **Pavement-Fair**

Depth of sample	OMC %	MDD Gm/cc	Gravel %	Sand %	Silt %	Clay %	LL %	PI %	CBR %	Remark	Pavement condition
Standard values	12-15	1.8-1.91	50-55	20-25	12-15	4-6	25-30	5-6	12-14	-	
Top 25 cm	15	1.79	51.2	29.4	15.4	3.8	20.1	8.3	12.14	Shoulder material	
25-50 cm	16	1.78	38.3	36.9	19.8	4.9	23.3	6.0	7.69	Selected soil	**Fair**
50cm and below	18	1.57	23.5	50.1	18.7	7.6	24.2	6.5	3.35	Sub grade soil	

CASE 3 (C3) Chainage Km 124/2

Shoulder-Good **Pavement- Fair**

Depth of sample	OMC %	MDD Gm/cc	Gravel %	Sand %	Silt %	Clay %	LL %	PI %	CBR %	Remark	Pavement condition
Standard values	12-15	1.8-1.91	50-55	20-25	12-15	4-6	25-30	5-6	12-14	-	
Top 20 cm	13	1.80	51.5	49.2	0.6	0.15	17.1	5.3	11.05	Shoulder material	
20-70cm	16	1.68	39.15	33.1	25.2	2.49	26.3	4.5	7.30	Selected soil	**Fair**
70cm and below	18	1.55	30.1	49.4	14.4	5.9	26.1	4.2	3.18	Sub grade soil	

CASE 4 (D1) Chainage Km 86/2

Shoulder-Good **Pavement- Good**

Depth of sample	OMC %	MDD Gm/cc	Gravel %	Sand %	Silt %	Clay %	LL %	PI %	CBR %	Remark	Pavement condition
Standard values	12-15	1.8-1.91	50-55	20-25	12-15	4-6	25-30	5-6	12-14	-	
Top 30 cm	18	1.88	69.8	15.9	6.5	7.6	20.04	5.0	12.7	Shoulder material	**Good**
30-65cm	15	1.70	49.6	29.6	18.0	2.7	28.26	5.3	8.78	Selected Soil	
65cm and below	19	1.55	39.5	34.6	20.6	5.1	27.44	5.1	3.50	Sub grade soil	

CASE 4(D2) Chainage Km 104/6

Shoulder-Good **Pavement-Good**

Depth of sample	OMC %	MDD Gm/cc	Gravel %	Sand %	Silt %	Clay %	LL %	PI %	CBR %	Remark	Pavement condition
Standard values	12-15	1.8-1.91	50-55	20-25	12-15	4-6	25-28	5-6	12-14	-	
Top 20 cm	16	1.88	52.1	23.1	22.4	2.2	19.9	6.0	12.28	Shoulder material	**Good**
20-60 cm	18	1.70	48.9	29.9	18.3	2.74	22.2	5.4	8.65	Selected Soil	
60cm and below	19	1.55	32.8	10.6	46.9	9.62	28.4	5.11	3.26	Sub grade soil	

CASE 4(D3) Chainage Km 128/4

Shoulder-Good Pavement- Good

Depth of sample	OMC %	MDD Gm/cc	Gravel %	Sand %	Silt %	Clay %	LL %	PI %	CBR %	Remark	Pavement condition
Standard values	12-15	1.8-1.91	50-55	20-25	12-15	4-6	25-28	5-6	12-14	-	
Top 25 cm	15	1.92	52.1	23.1	22.4	2.2	24.6	5.01	12.08	Shoulder material	**Good**
25-50cm	18	1.66	21.2	46.9	2.3	3.5	25.2	5.77	10.23	Selected Soil	
50cm and below	19	1.53	48.9	29.9	18.3	2.7	26.2	6.1	9.40	Sub grade soil	

Discussion

The following discussions have been made on the basis of research carried out during the work.

Case-1

1. The section of road in km 81/6 is found to be damaged with 200m to 300 m patches repaired with BUSG. The cracking area is found to be 15-16%. In this section, the shoulder material is found to be eroded.
2. The stretch of road in km 120/2 has 7 no. of potholes of sizes varying from 0.5 sq m to 2 sq m. In this region the settlement of shoulder material is observed along the left side of road. The bulging of road edges is also marked.
3. 15 % cracks along the edges are observed in km 132/4 along with 4% raveling area. The shoulder material is also completely eroded.

Case-2

4. In km 129/2 the pavement is in good condition as the cracks and potholes are not found. The shoulders in this section are found to be in bad condition.
5. In km 99/6 only 1% cracking is seen and no ruts and cracks are observed. The shoulder material is found to be settled by 25 cm. on left side of pavement.
6. In km 80/10, the pavement is of ridable quality. The shoulders are partly eroded for 400 m in this section.

Case-3

7. In km 74/6, transverse cracking and alligator cracking is observed on the pavement surface, while no settlement of shoulder material is seen.
8. In km 124/2, 20% rutting is seen and the depth of ruts varies between 3.5 cm - 10cm. The shoulders are found to be in good condition.
9. In km 95/4, 25% rutting along with 10% cracking is observed. The shoulders are observed to be in good condition.

Case-4

10. In km 86/2, 104/6, 128/4 the pavement is in good condition and there are no distresses. The shoulders are in good condition. ‘

Conclusion

Based on the study following conclusions have been drawn:

1. Due to the removal of shoulder material, longitudinal cracks and potholes are observed on the road surface along the pavement. Due to lack of maintenance, the wearing coat is removed and the base course is damaged resulting in a jungle of raveling and cracking.
2. The shoulders are found to be settled thereby causing damage to the pavement edges due to the horizontal thrust of tyres. The percolation of water also destroys the bituminous top surface of the pavement.
3. Rutting is observed due to traffic effect and repetitive load condition.
4. Wherever good quality material is used in the shoulders, the pavement is found to be in good condition.
5. The shoulders should be constructed of the same material as the mainline pavement because both of them are interdependent and to maintain a longer

life of pavement continuous monitoring and intermittent maintenance of shoulders should be done.

References

1. Thomas O. Willet, "Technical Advisory-Paved Shoulders" U.S. Department of Transportation, Federal Highway Association 1990.
2. Polus A., "Analysis of Flow, Safety and Warrants for Paved Shoulders on Two Lane Rural Highway", Road and Transport Research Manual 1999.
3. Geni Bahar, "Synthesis for best practices for the Implementation of centre line and shoulder Rumble strips", proceedings of Canadian road safety conference, June 2001.
4. Mehndiratta H.C. and Chandra Satish, "Effect of shoulder on life of Flexible Pavements", Highway Research Bulletin No.67, 2002, pp 61-66.
5. Mehndiratta H.C., Chandra Satish and Kumar Manoj, "Effect of Shoulder Condition on space, Placement and Capacity of Road." Indian Highways, volume 33, No.8, 2005, pp 21-33.
6. David J.White, Charles Jahren, Mohd. Sulemann, "Effective shoulder design and maintenance" Journal of Iowa highway research board, vol. 217, 2007, pp 54-59.
7. Khabiri Mohd.M and Kargaran Bafqi Mohd.R., "Effect of pavement boundaries depths on structural strength of roadway" Journal of applied science Research, vol.4, 2008, p p103- 109.