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FLEXIBLE PAVEMENT REHABILITATION SH177 (CH: 0.00 TO CH: 9.00) VYARA JUNCTION TO ANUMALA JUNCTION

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Abstract— The evaluation of a functional behavior or performance analysis, information is needed on the history of riding quality of the pavement stretch. In condition survey, pavement surface condition is measured and which types of the distress is observed. For the subgrade evaluation soil sample is taken at required locations on road stretch. In the structural evaluation of flexible pavement the pavement deflection is measured by the Benkelman Beam. It is possible to measure the rebound and residual deflections of the pavement structure. While the rebound deflection is one related to pavement performance, the residual deflection may be due to non-recoverable deflection of the pavement or because of the influence of the deflection bowl on the front legs of the beam. Rebound deflection is used for overlay design. A detailed pavement condition survey is done on State Highway 177 (Vyara Junction to Anumala Junction) and the road condition is evaluated structurally. The present study is evaluates the overlay thickness for State Highway 177 Vyara Junction to Anumala Junction.

Keywords— pavement, subgrade

I. LITERATURE SEARCH

Elena Romeoa,*, Antonio Montepara(2012) The primary benefit of the reinforcement is to significantly reduce tensile stresses in the surface layer shifting the maximum tensile and shear stress from the bottom of the surface layer to the bottom of the interlayer itself, thus reducing the fracture potential in the surface. Fiberglass C and steel reinforcements perform best due to the high bond strength developing between the grids and the surrounding asphalt mixture. It was observed that specimen geometry influences only the cracking behavior of steel-reinforced system. Steel net consists in a double-twist 80x100 mm hexagonal mesh, transversally reinforced with steel wires at regular intervals of 160 mm, thus a 100 mm width specimen results not adequate for investigating the bidirectional contribution of the interlayer. Conversely, a 500x500 mm specimen allows the reinforcement to act in both x and y directions optimizing load transfer and shear resistance and providing better aggregate interlocking.

P. Babashamsi, N.I. MdYusoff, H. Ceylan, N.G. Md Nor, H. SalarzadehJenatabadi(2016)in this paper cost of road construction consists of design expenses, material extraction, construction equipment, maintenance and rehabilitation strategies, and operations over the entire service life. An economic analysis process known as Life-Cycle Cost Analysis (LCCA) is used to evaluate the cost-efficiency of alternatives based on the Net Present Value (NPV) concept. It is essential to evaluate the above-mentioned cost aspects in order to obtain optimum pavement life-cycle costs. However, pavement managers are often unable to consider each important element that may be required for performing future maintenance tasks. Over the last few decades, several approaches have been developed by agencies and institutions for pavement life-cycle cost analysis (LCCA).

Vinay Kumar V1 and SireeshSaride(2016)in this paper reinforcement can be used effectively to improve the performance of the un surfaced rural pavements by reducing the rutting. The improvement against rutting in unpaved roads is shown in terms of performance factors namely TBR and RDR. The TBR and RDR for the granular aggregate base shows a good improvement with the increase in settlement ratio and number of load repetitions respectively with a TBR value of 1.87 at a settlement ratio of 15%. As high as 22% RDR was achieved with aggregate Rutting Behavior of Geo cell Reinforced Base Layer over Weak Sand Subgrade.

PriyankaSarker, ErolTutumluer , and Scott Lackey(2016)in this paper the ease in use and simplicity, such an empirical approach is outdated and lacking in many aspects to characterize recycled and/or nontraditional construction materials nowadays more commonly used in pavements. As far as the rehabilitation of low volume roads is concerned, the lack of testing for evaluating the structural condition of existing, in-service pavements often results in uneconomical and unreliable practices. This paper presents a mechanistic-empirical approach for overlay thickness designs of low volume pavements through a combination of nondestructive deflection testing and reestablished pavement damage models.

SA Kristiawan(2013)in this paper there are many parameters affecting the magnitude of shrinkage stress. Any criteria used to assess cracking tendency of concrete overlay caused by differential shrinkage should take into account all of the parameters involved in building up shrinkage stress. Assessment of shrinkage cracking behavior of concrete overlay could be classified into qualitative and quantitative method.

Dr.H.C.Mehndiratta, Dr.Praveen Kumar &M.SateeshKumar(2013)in this paper Empirical approach is acceptable only if crack initiation is considered and not where crack propagation is considered. Especially in the design of overlays over existing cracked pavements, fracture mechanics principles may be used to take into account the detrimental effects of stress concentration around the crack.

Shivangi Gupta &A.Veeraragavan(2009)in this paper present work is to study the benefit of SBS (Styrene Butadiene Styrene) polymer modified bituminous mixes on fatigue performance. The physical and mechanical properties of polymer modified and conventional binder mixes are evaluated. Mixes are compacted using both Marshall and Superpave Gyratory Compactor (SGC) and a comparison between the two is established in terms of the resilient modulus and fatigue life. Repeated load indirect tensile test equipment is used to evaluate the life to crack initiation and resilient modulus of the bituminous mixes. Retained Marshall stability and indirect tensile strength ratio tests were conducted. The improvement in fatigue life of polymer-modified mixes over the conventional mixes is reported. The research paper also describes the application of LEFM (linear elastic fracture mechanics) to characterize crack propagation using Indirect Tensile Fatigue Test (ITFT).

N.H.Jalkotr&A.S.Khaire, Superintending Engineer(2008)in this paper he has done the box return at Parga on Bridge on S.H. 62 across Bhima River in Pune District failure of the weir due to the flooding and by the use of the box return rehabilitation lifted by hydraulic jack treatment arrangement is done and also show how this rehabilitation is use in cost benefit.

Prithvi Singh Kandhal*, V. K. Sinha& A. Veeraragavan(2008)in this there is a proliferation of bituminous paving mixes in India. MORTH Specifications broadly provides 4 mixes for base courses, 6 mixes for binder courses and 4 mixes for wearing courses. Further two grading, each of BM, DBM, SDBC and BC are specified in the MORTH specifications. Too many options for a specific bituminous course have created confusion in mix selection and are mainly responsible to a considerable extent for the poor performance of flexible pavements in India. A case has been made out on technical grounds to have only 5 dense graded mixes of different nominal maximum aggregate size (NMAS) in the specifications, as is the case in most developed countries of the world.

B.N. SINHA(2007)has applied different methods of slope stability analysis of earth embankment have been discussed. The mathematical equations and the methodology for calculating the factor of safety of earth slope of any specified(chosen) slip circle by various methods has been given. By repeating the process for different slip circles, the minimum factor of safety can be calculated and critical slip circle obtained. For the purpose of direct comparison and easy explanation the critical circles were first established by the computer software by various methods of analysis and to illustrate the method only these circles were analyzed through independent mathematical equations and computations using Microsoft Excel program for the iterating process. It could be seen that without the use of computer for the analysis, particularly the iterating process, it would have been very cumbersome and time consuming to do the same by manual calculations. But it is possible to do complete analysis by Excel as explained in this paper. Graphical method can be used for marking the circle and various slices as is the normal practice for slope stability analysis. Graphical method of analysis can be used to draw force polygon to obtain various forces and computing factor of safety, but this paper has dealt with mathematical equations only for the analysis part. Since the main emphasis is on explaining and demonstrating the various methods, set of minimum forces.

Manik Barman &B.B.Pandey(2008)this paper is presenting a new methodology for the structural evaluation of rigid pavement using FWD, Details of the development of a back calculation program call back rigid for the structural evaluation of rigid pavement is described, Method computation of residual strength concrete is also given. The output of the developed model can provide the input for the mechanistic design of overlay for the rehabilitation of rigid pavement of highway.

A.U.Ravi Shankar, Harsha Kumar Rai, &RemeshaMithanthaya L.(2009)in this paper he has order to improve its properties the soil is blended with sand at different proportions unless until it satisfies the Atterberg's Limits for sub-base course. In recent past many Bio-Enzymes have come to the market which can be used as stabilizing agent. One such stabilizing agent is TerraZy me, which is used in the present investigation to further stabilize blended soil. The effect of enzyme on soil and blended soil in terms of Unconfined Compressive Strength (UCC), California Bearing Ratio (CBR), Compaction and permeability are studied. It has been observed that the enzyme treated soil showed significant improvement in terms of UCC, CBR with longer curing period.

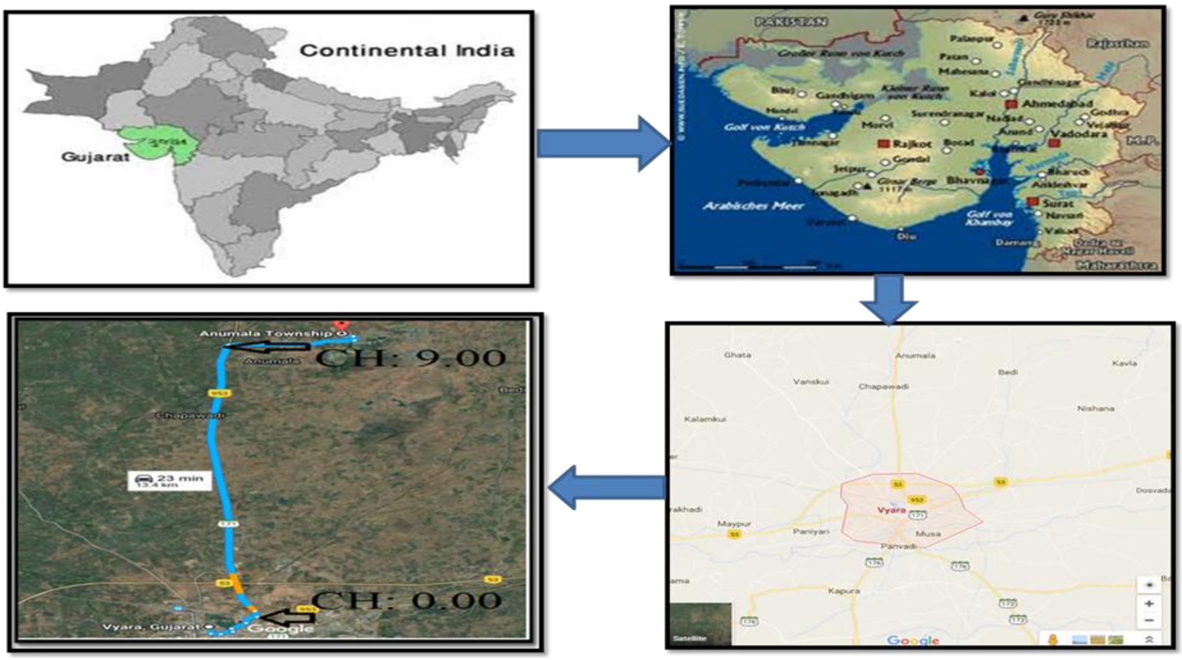
Atakilti Gidyelew Bezabih &Sathish Chandra(2009)in this paper he has flexible pavements use soil sub-grade strength in terms of California Bearing Ratio (CBR) and traffic loading in terms of million standard axles (msa). For the design of rigid pavements, IRC: 58-2002 uses the same parameters in terms of modulus of sub-grade reaction, k, and axle load distribution (ALD). To compare the cost of two types of pavements, it is necessary to ensure that they are designed for the same traffic loading. Therefore, a study was done to convert the traffic load given in msa into ALD and vice-versa. Mathematical models are developed to estimate the ALD from individual vehicle Courts.

A. Veeraragavan* & Lt. Col. Shailendra Grover(2010) he has Forensic investigation to ascertain the cause for the failure was carried out by testing the different pavement layers in the field and through laboratory tests on core samples of various pavement component layer materials. The contributing factors for the pre-mature failure were identified as inadequate compaction of subgrade/ embankment, excess fines and high plasticity index in the Granular Sub-Base (GSB) layers, low binder content in the bituminous layers, etc. The laboratory tests on GSB layer materials and permeability tests indicate that the dramatic pavement failures may be attributable to poor sub-surface drainage and also due to the heavy commercial traffic allowed on the dense bituminous macadam layers.

II Study Area

India has a vast road network of 4.24 million kilometers of which the State Highways account for 154,522 km and as per statics Gujarat has a 973 km state highway. Indian democracy is a federal form of government. State Governments, thus have the authority and responsibility to build road networks and state highways. Independent of the national highways and NHDP program, several state governments have been implementing a number of state highway projects since 2000.By 2010, state highway projects worth 937 crore had been completed, and an additional63 hundred crore worth of projects were under implementation**.** The State Highways provide linkages with the National Highways, District headquarters, important towns, Tourist centers and Minor ports and carry the traffic along major centers within the state. The Ministry of State for Surface Transport in India administers the National highway system, and state highways and other state roads are maintained by State public works departments. The central and state governments share responsibilities for road building and maintaining Indian roads. The Ministry of Shipping, Road Transport & Highways is primarily responsible for the construction and maintenance of National Highways (NHs).

All roads, other than National Highway in States, fall within the jurisdiction of respective state governments. The development and maintenance of National Highways are being doneon agency basis. The National Highways Authority of India (NHAI), State Public Works Departments (PWDs) and the Border Road Organization (BRO) are the main agencies.



Study Area Corridor Vyara junction CH: 0.00 km to Anumala junction CH: 9.00 km

III Data Collection

(a) Moisture Content:

Field moisture content of sub grade soil samples was determined by oven-drying method as per IS:2720 (Part-2) at every test pit location for calculating field dry density (FDD), from bulk density determined at site by sand replacement / core cutter method.

(b) Grain size Analysis:

Grain size analysis test was carried out for each soil sample by wet sieve method as per IS: 2720 (part -4) -1985.

(c) Atterberg's Limits:

The plasticity indices i.e., liquid and plastic limits of sub grade soil were determined using Casagrandes liquid limit device as per IS: 2720 (part-5).
Based on grain-size analysis and Atterberg"s Limits the sub grade soil has been classified according to the IS System of Soil Classification using IS: 1498 - 1987.

(d) Modified Proctor Test:

The sub grade soil samples were tested by modified proctor compaction method for determining maximum dry density (MDD) and optimum moisture content (OMC) from the moisture-density relationship as per IS: 2720 (Part-8).

(e) CBR Test:
For the determination of CBR values of existing soil sub grade, three compaction energy levels were employed, using dynamic compaction by applying 18 blows, 35 blows and 55 blows to the CBR test specimen with a rammer of 4.89-kg in weight. The test specimens were remolded at OMC. Penetration test was conducted on test specimens, using CBR testing machine with rate of loading 1.25mm/min. The test specimens were immersed in water for a period of 4 days. A surcharge weight of 2.5 kg was kept on the specimen throughout the testing period. CBR values were determined corresponding to 2.5 mm and 5.0-mm penetrations. The testing was done as per IS 2720 (Part 16). The test results of embankment soil pertaining to different corridors for sieve analysis, moisture content, index properties, and their classification are enclosed here.

4.5 Deflection Approach
The structural strength of pavement is assessed by measuring surface deflections under a standard axle load. Larger pavement deflections imply weaker pavement and subgrade. The overlay must be thick enough to reduce the deflection to a tolerable amount. Rebound deflections are measured with the help of a Benkelman Beam. Benkelman beam survey is for measurement the pavement deflection. As shown in Figure Benkelman beam consists of a slender beam 3.66 m long pivoted at a distance of 2.44 m from the tip. By suitably placing the probe between the dual wheels of a loaded truck, it is possible to measure the rebound and residual deflections of the pavement structure. While the rebound deflection is one related to pavement performance, the residual deflection may be due to non - recoverable deflection of the pavement or because of the influence of the deflection bowl on the front legs of the beam. Rebound deflection is used for overlay design.

Steps in Design of Overlays

- Measurement and estimation of the strength of the existing pavement.
- Design life of overlaid pavement.
- Estimation of the traffic to be carried by the overlaid pavement.
- Determination of the thickness and the type of overlay

Specifications for Measurement

- Condition survey and deflection data are used to establish sections of uniform performance.
- At least 10 deflection measurements should be made for each section per lane subject to a minimum of 20 measurements per km.
- If the highest or the lowest deflection values for the section differ from the mean by more than one-third of the mean, then extra deflection measurement should be made at 25 m on either side of point where high or low values are observed.
- As per IRC: 81-1997, Data collection for measurement of deflection during survey shall be recorded as per the given in Annexure I. In case of pavement shows severe distress or signs of premature failure further investigations would be necessary to ascertain t1he causes and design remedial measures.

IV Data Analysis

A visual survey shall be used to evaluate the surface condition of segments of pavement at SH:177 Vyara to Anumala

Junction. On moving from starting to CH:0/00 km to CH:9/00 km the surface was observed. The pavement condition evaluation was focus on these measures of pavement quality:

1. The distress types generally resulting from environmental factors in conjunction with traffic: Random or block cracking or transverse cracking.
2. Load associated distress manifestations: alligator cracking, shear failure or pot holes, patching. The condition survey observations are coded as Surface defects: A, Crack types: B, Deformation: C and Disintegration: D, are provided in Table 5.1 and observations of conditions are recorded in Table 5.2 as given below.

Table5.1: Measurement for Condition

Surface Defects (A)	Crack type (B)	Deformation (C)	Disintegration (D)
1. Smooth Surface	1. Hairline Crack	1. Ruts	1. Ravelling
2. Hungry Surface	2. Alligator Crack	2. Settlements	2. Pot Holes
	3. Longitudinal Crack		
	4. Edge Crack		
	5. Shrinkage Crack		
	6. Transvaal Crack		

Table 5.2: Pavement Condition survey on SH: 177 (Vyara to Anumala Junction)

Chainage(m)	Defects	Condition
500	B2,B3,D1	Fair
1000	B2,B3,B4,C1	Fair
1500	A2,B1,B4,B6	Fair
2000	A2,B5,B6,D2,D1	Very poor
2500	A2,B2,B4,B5,B6,D2,D1	Very poor
3000	A2,B5,B6,D2,D1	Fair
3500	A1,B4,B5	Poor
4000	A2,B2,B3,C1,C2	Poor
5000	A2,B1,C1,C2,D2	Fair
5500	B2,B4,B5,B6	Poor
6000	B2,B5,B6,C2,D2	Fair
6500	B4,B5,D1	Fair
7000	B2,B3,B4.C2	Fair
7500	B1,B4,D1	Fair
8500	B2,B6,D2	Fair
9000	B2,B4,D2	Fair

A. Cracking: Visual distresses in the form of cracks have been recorded on every 500 m interval, with the % area. The cracks generally alligator to block cracks in the first section for majority of the length. In many of the locations both the lanes have been repaired either with crack seal or patching. The figure 5.2 shows the variation of cracking.

B. Raveling:

Raveling which indicates the hungriness of surface has been notice at very isolated locations. The figure 5.4 shows the variations of Raveling

The locations where it has been recorded in some of the batches between 3 to 3.5 km, 4to 4.5 and 7.5 to 8.

C. Rutting:

Rutting has been recorded in between 2 to 2.5, 3 to 3.5, and 7.5 to 8. The figure 5.5 shows the variations of Rutting.

D. Stripping :
Stripping has been recorded in between 2.5, 3 to 3.5, and 6.5 to 8. The figure 5.6 shows the variations of Raveling**.**

Pavement damage includes cracks, pot-holes, settlement and disintegration as given in above table and visually it can be shown by pictures given at below. It is thus concluded that the damage is mostly due to heavy traffic and subsurface exploration revealing that the subgrade have clayey sand and that the main deficiency is the aggregate base, which in some cases are much less than the original pavement recommendations. The pavement deterioration probably starts when moisture migrates into the clay subgrade.

Table 5.3: Possible surface Maintenance Measures for some Pavement

Type of distress	**Maintenance measures**
Block Cracking	Application of new bituminous coat recycling
Bleeding Sand blinding	Bleeding Sand blinding
Corrugation	Scarification of elevated part by mechanical blades and rolling
Depression	Application of profile corrective course
Fatty surfaces	Application of hot, dry, small aggregates, and rolling
Hungry surfaces	Application of fog seal, slurry seal
Loss of aggregates	Application of seal coat, fog coat, surface dressing
Polished st0one	Surface dressing or other suitable form of wearing coat
Pot holes	Patching and partial reconstruction
Ravelling	Seal coat, fog coat, or laying of renewal coat
Rutting failure	Milling of protruded portion, profile corrective course Recycling
Slippage	Replacement of top wearing coat with proper tack or prime coat
Smooth surfaces	Resurfacing with premix carpet
Stripping	Replacement of affected layer with fresh mix
Swell and blow up	Milling of protruded portion, construction of drainage

5.2 Traffic data analysis:
Traffic volume count is carried out on stretch at Rampura location. We have the peak hour 4 to 5, where the vehicle intensity is high which is shown in figure 5.4 and Table 5.5.

Table 5.4: Traffic count data (In to Vyara)

In to Vyara							
Time Duration	Two Wheeler	Three Wheeler	Four Wheeler	Bus	Truck	Bullock	Cycle
7:30 to8:00	34	22	42	32	5	1	1
8:00 to 8:30	48	38	48	58	3	1	2
8:30 to 9:00	20	30	30	48	7	1	2
9:00 to 9:30	13	27	43	23	2	0	1
9:30 to 10:00	23	45	17	43	2	0	1
10:00 to 10:30	35	27	37	38	3	0	1
10:30 to 11:00	28	45	58	47	3	0	2
11:00 to 11:30	30	32	17	25	1	0	1
11:30 to 12:00	33	28	33	23	5	0	0
12:00 to 12:30	23	17	17	11	2	0	1
12:30 to 1:00	11	8	6	7	0	0	2
1:00 to 1:30	5	6	8	8	1	0	2
1:30 to 2:00	7	7	13	13	1	0	1
2:00 to 2:30	8	7	6	2	0	0	3
2:30 to 3:00	8	12	6	1	1	0	1

3:00 to 3:30	3	6	2	1	0	0	2
3:30 to 4:00	22	7	17	12	2	0	1
4:00 to 4:30	17	7	12	6	0	0	0
4:30 to 5:00	23	7	28	7	0	1	2
5:00 to 5:30	38	32	33	12	2	0	1
5:30 to 6:00	22	32	33	22	3	2	0
6:00 to 6:30	68	28	40	28	0	0	1
6:30 to 7:00	58	33	47	28	3	0	1
Sub Total	776	619	805	566	70	6	33
PCU value	**0.5**	**1.0**	**1.0**	**3**	**3**	**6**	**0.5**
PCU	388	619	805	1698	210	36	16.5
Total PCU	**3772.5**						

Table 5.5: Traffic count data (Out to Vyara)

Out to VYARA							
Time Duration	Two Wheeler	Three Wheeler	Four Wheeler	Bus	Truck	Bullock	Cycle
7:30 to8:00	37	27	63	27	6	1	5
8:00 to 8:30	44	42	58	47	9	0	4
8:30 to 9:00	18	34	33	47	6	1	4
9:00 to 9:30	17	28	47	32	2	0	2
9:30 to 10:00	28	55	32	40	2	1	3
10:00 to 10:30	37	37	40	53	3	0	1
10:30 to 11:00	30	37	52	48	3	0	2
11:00 to 11:30	37	17	22	22	1	0	6
11:30 to 12:00	22	27	33	28	5	1	4
12:00 to 12:30	18	17	17	11	1	1	2
12:30 to 1:00	11	6	6	13	0	0	0
1:00 to 1:30	6	5	6	7	0	0	1
1:30 to 2:00	8	8	12	7	2	0	1
2:00 to 2:30	11	8	2	1	0	0	0
2:30 to 3:00	11	12	5	1	0	0	1
3:00 to 3:30	5	6	3	2	0	0	1
3:30 to 4:00	27	12	22	8	3	0	0
4:00 to 4:30	22	7	17	7	3	0	0
4:30 to 5:00	30	13	33	12	1	0	1
5:00 to 5:30	32	47	37	12	2	0	0
5:30 to 6:00	22	32	32	17	3	1	0
6:00 to 6:30	53	29	63	32	1	0	1
6:30 to 7:00	72	48	43	37	3	0	0
Sub Total	846	685	858	606	69	6	40
PCU Value	**0.5**	**1.0**	**1.0**	**3**	**3**	**6**	**0.5**
PCU	423	685	858	1818	207	36	20
Total PCU	**4047**						

5.3 Benkelman Beam Deflection Survey

The Benkelman beam survey for CH: 0/00 km to CH:9/00 km is carried out to check structural stability of pavement based on rebound deflection of pavement. The actual survey was carried out as describe below.

1. The point on the pavement to be tested is selected and marked. For highways, the point should be located 60 cm from the pavement edge if the lane width is less than 3.5 m and 90 cm from the pavement edge for wider lanes. For divided four lane highway, the measurement points should be 1.5 m from the pavement edge.
2. The dual wheels of the truck are cantered above the selected point.
3. The probe of the Benkelman beam is inserted between the duals and placed on the Point.
4. The locking pin is removed from the beam and the legs are adjusted so that the plunger of the beam is in contact with the stem of the dial gauge. The beam pivot arms are checked for free movement.
5. The dial gauge is set at approximately 1 cm. The initial reading is recorded when the rate of deformation of the pavement is equal or less than 0.025 mm per minute.
6. The truck is slowly driven a distance of 2.7 m and stopped.
7. An intermediate reading is recorded when the rate of recovery of the pavement is equal to or less than 0.025 mm per minute.
8. The truck is driven forward a further 9 m.
9. The final reading recorded when rate of recovery of pavement is equal to or less then 0.025mm per minute.
10. Pavement temperature is recorded at least once every hour inserting thermometer in the standard hole and filling up the hole with glycerol.
11. The tyre pressure is checked at two or three hour intervals during day and adjusted to the standard, if necessary.

5.3.1 CALCULATIONS

1) Subtract the final dial reading from the initial dial reading. Also subtract the intermediate reading from the initial reading.
2) If the differential readings obtained compare within 0.025 m the actual pavement deflection is twice the final differential reading.
3) If the differential readings obtained do not compare to 0.025 mm, twice the final differential dial reading represents apparent pavement deflection.
4) Apparent deflections are corrected by means of following formula:

$$XT = XA + 2.91\ Y$$

Where,
XT = True pavement deflection
XA = Apparent pavement deflection
Y = Vertical movement of the front legs.
5) The rebound deflection (%) shall be the twice of the XT value.

5.4 COMPUTATION OF DESIGN TRAFFIC

The design traffic is considered in terms of the cumulative number of standard axles to be carried during the design life of the road. Its computation involves the estimates of the initial volume of commercial vehicles per day, lateral distribution of traffic, the growth rate, and the design life in years and the vehicle damage factor to convert commercial vehicle in standard axel The following equation may be used to make the required calculation.

$$\mathbf{NS = \{365*A[(1+r)n-1]*F\}/ r}$$

Ns= The cumulative number of standard axles
A = Initial traffic in the year of completion of construction, in terms of the commercial vehicles per day
r = Annual growth rate of commercial vehicles
x = Design life in years
F = Vehicle damage factor
The reading of BBD test are provided in Annexure II, BBD Test result graph is given in Fig 5.11. As per IRC: 81-1997 “Guidelines for Strengthening of Flexible road pavements

using Benkelman beam deflection technique” the characteristic deflection determined by

Benkelman beam deflection survey, is not more than 0.5mm.While it is clearly seen from the reading that the corrected deflection is more than 0.5mm. .And the characteristic deflection depends upon corrected deflection. From graph of Figure 5.11 to5.17, we may observe that from CH:0.00 km to CH:9.00 km the corrected characteristic deflection is vary up to 0.71 mm and further it increases up to 2.65 mm.. For overcame of this result we may provide strengthening and improved riding surface, as rehabilitation of pavement.

The type of material to be used in overlay construction will depend on several factors such as the importance of the road, the design traffic, the thickness and the condition of the existing bituminous surfacing, construction convenience and relative economics. Before implementing the overlay, the existing surface shall be corrected and brought to proper profile by filling the cracks, pot holes, ruts and undulations. No part of the overlay design thickness shall be used for correcting the surface irregularities From the result of Benkelman beam deflection survey the average of characteristic deflection is varies from 0.72 to 2.66 mm so from this we may suggest an overlay with an average thickness. And for need of continuity in construction and better understanding we provide an equal average thickness of 25mm of Semi Dense Bituminous Concrete (SDBC) as a surface course throughout the CH: 0.00 km to CH.9.00 km.

Overlay Thicknesses Provided Per km

Chainage(km)	Characteristic Deflection(mm)	Bituminous Macadam(mm) (BT)	Overlay adopted (SDBC+ BUSG)
0 to 1	2.27	200	25+200
1 to 2	0.72	120	25+150
2 to 3	2.66	210	25+200
3 to 4	1.43	160	25+150
4 to 5	0.92	140	25+150
5 to 6	2.62	210	25+200
6 to 7	2.45	200	25+200
7 to 8	1.21	110	25+150
8 to 9	1.30	130	25+150

SOIL INVESTIGATION:

(a) Moisture Content:

Field moisture content of sub grade soil samples was determined by oven-drying method as per IS:2720 (Part-2) at every test pit location for calculating field dry density (FDD), from bulk density determined at site by sand replacement / core cutter method.

(b) Grain size Analysis:

Grain size analysis test was carried out for each soil sample by wet sieve method as per IS:
2720 (part -4) –1985.

(c) Atterberg's Limits:

The plasticity indices i.e., liquid and plastic limits of sub grade soil were determined using
Casagrande's liquid limit device as per IS: 2720 (part–5). Based on grain-size analysis and Atterberg's Limits the sub grade soil has been classified according to the IS System of Soil Classification using IS: 1498 – 1987.

(d) Modified Proctor Test:

The sub grade soil samples were tested by modified proctor compaction method for determining maximum dry density (MDD) and optimum moisture content (OMC) from the moisture-density relationship as per IS: 2720 (Part-8).

(e) CBR Test:

For the determination of CBR values of existing soil sub grade, three compaction energy levels were employed, using dynamic compaction by applying 18 blows, 35 blows and 55 blows to the CBR test specimen with a rammer of 4.89-kg in weight. The test specimens were remolded at OMC. Penetration test was conducted on test specimens, using CBR testing machine with rate of loading 1.25mm/min. The test specimens were immersed in water for a period of 4 days. A surcharge weight of 2.5 kg was kept on the specimen throughout the testing period. CBR values were determined corresponding to 2.5 mm and 5.0-mm penetrations. The testing was done as per IS 2720 (Part 16). The test results of embankment soil pertaining to different corridors for sieve analysis, moisture content, index properties, and their classification are enclosed here.

5.5.1 Soil sampling and testing

Table: 5.7 Grain Size Analysis

SR. NO.	Chainage (km)	Sieve analysis % by Weight		
		Gravel > 4.75 mm(%)	Sand (4.75 -0.075) mm(%)	Silt Clay < 0.075 mm(%)
1	1.00	0.00	8.63	91.37
2	2.00	0.00	10.60	89.34
3	3.00	0.20	16.10	83.69
4	4.00	0.15	15.43	84.42
5	5.00	0.00	21.29	78.71
6	6.00	0.00	17.28	82.72
7	7.00	0.00	20.15	79.85
8	8.00	0.00	18.70	81.30
9	9.00	0.00	18.94	81.06

Table: 5.8 Attemberg Limit

SR. NO.	Chainage (km)	Atterberg's Limit		
		Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)
1	1.00	64.11	21.84	42.27
2	2.00	64.87	23.28	41.58
3	3.00	64.97	23.40	41.56
4	4.00	60.81	23.80	35.00
5	5.00	64.62	22.84	41.78
6	6.00	66.06	23.92	42.14
7	7.00	64.31	26.36	37.94
8	8.00	63.47	25.77	37.69
9	9.00	63.80	22.89	40.90

Table: 5.9 Maximum Dry Density & Optimum Moisture Content

SR. NO.	Chainage (km)	MDD	OMC
1	1.00	1.73	17.04
2	2.00	1.69	15.78
3	3.00	1.78	15.97
4	4.00	1.79	14.66
5	5.00	1.78	13.67
6	6.00	1.79	14.84
7	7.00	1.75	14.65
8	8.00	1.72	15.21
9	9.00	1.71	15.87

Table: 5.10 California Bearing Ratio

SR. NO.	Chainage (km)	CBR with 4 day Soaking
1	1.0	1.17
2	2.0	1.52
3	3.0	1.48
4	4.0	1.71
5	5.0	1.80
6	6.0	1.60
7	7.0	1.64
8	8.0	1.87
9	9.0	1.64

5.6 EXISTING PAVEMENT COMPOSITION

By conducting a pavement composition survey by excavating the surface up to the bottom of the subgrade. The thickness is measured every 500m alternate side on whole stretch. The data at every km is shown in Table.

Table 5.11: Existing Pavement Composition

SR. NO.	Chainage(m)	BC/DBM (mm)	WMM (mm)	GSB (mm)	Total Thickness (mm)
1	1000 RHS	100	240	220	560
2	2000 LHS	100	250	150	500
3	3000 RHS	100	270	200	570
4	4000 LHS	110	180	200	490
5	5000 RHS	120	320	200	640
6	6000 LHS	100	250	300	650
7	7000 RHS	70	250	220	540
8	8000 LHS	120	230	150	500
9	9000 RHS	100	300	320	720

5.7 DESIGN OF CC OVERLAY OVER FLEXIBLEPAVEMENT

Cement Concrete overlay constructed on the top of an existing bituminous pavement is known as White topping. White topping is thus cement concrete overlay as Rehabilitation or

Structural strengthening alternative on bituminous pavement. There are three types of White topping, Conventional White topping, Thin White topping (TWT), and Ultra-Thin White topping (UTWT).

(I) Conventional White Topping(CWT)

It consists of a PCC overlay of thickness 200mm or more (on the existing bituminous layer) which is designed and constructed without consideration of any bond between the concrete overlay and underlying bituminous layer. Conventional White topping is designed like a new rigid pavement without assuming any composite action. Conventional White topping treats the existing bituminous surface as a sub-base like Dry Lean Concrete (DLC) and to this extent the condition of bituminous surface does not matter.

(II) Thin White Topping (TWT)

PCC overlay of thickness greater than 100 mm and less than 200mm is classified in Thin

White topping. The bond between the overlaid PCC and underlying bituminous layer is often a consideration but it is not mandatory. The bonding consideration may be ignored in the design. High strength concrete with fibres is commonly used.

(III) Ultra-Thin White Topping(UTWT)

PCC overlay of thickness equal to or less than 100 mm is classified as ultra-thin White topping. Bonding between underlying bituminous layer and overlaid PCC layer is mandatory in case of Ultra-Thin White topping. Milling the existing bituminous surface to an average depth of 25 mm is normally used to provide the bonding the interface between the existing bituminous surface and PCC overlay. Fibres and high strength concrete are normally provided.

Advantages of White Topping

1. Long life, low maintenance, low life cycle cost, improved safety and environmental benefits.
2. Bituminous overlay exhibits a more rapid loss of serviceability as compared to concrete white topping.
3. Deformation like rutting and cracking predominant in case of bituminous pavement which is normally absent with concrete surfaces of white topping.
4. Conventional White Topping improves structural capacity of existing bituminous pavement, if built on strong base course, and it impedes structural distresses.
5. White Topping exhibits better reflectance, reduction in heat island effect, reduction in

street light requirements.
6. White Topping is quite cost effective to tackle annual budget constraints and high traffic levels.

5.8 THICKNESS DESIGN FOR CONVENTIONAL WHITETOPPING

The design principal adopted for conventional White topping is similar to those of normal concrete pavements as provided in IRC:58-2002 "Guidelines for the Design of plain jointed Rigid Pavements for Highways" and IRC:15-2002 "Standard specification and code practice for construction of concrete roads"
The graphical method given in Appendix V, IRC: SP: 76-2008, can be used to for determining the "k" value with respect to characteristic deflection of BBD test as per IRC: 81-1997 "Guidelines for strengthening of flexible pavements using Benkelman Beam Deflection Technique". The rest of the design can be done with the help of existing IRC: 58-2002 by using the "K" values.

DESIGN OF CONVENTIONAL WHITETOPPING

Flexural Strength	41.41	Kg/cm2	As per IRC 58,appendix-5 for M35 mix,page – 65
Say	41.00	Kg/cm2	
Effective K Value over DLC	27.7	Kg/cm2/cm	As per IRC-58, Table 2, page - 10, & table-4,page-11
Modulus of Elasticity of Concrete	300000		As per IRC-58, Para 4.7.2- page 13,
Poison's ratio (μ)	0.15		As per IRC-58, Para 4.7.2- page 13
Design Period (n)	20		Given Data
Thermal coefficient of concrete(α)	0.00001	per °C	As per IRC-58, Para 4.7.3,page-13
Traffic grow rate (r)	0.075		Given Data
CV Per Day (A)	3126		Given Data
Cumulative nos. of Repetition	64204820		As per IRC-58,Equation-1, page-6
Design traffic 25% of cumulative repetition	16051205		
Factor of Safety	1.2		As per IRC-58, Para 4.2, page 5
Spacing of Transverse/ Contraction Joint (L)	450	Cm	As per IRC-15-2002, Appendix: B
Width of Pavement (B)	350	Cm	Given data
Trial Thickness (h)	28	Cm	Assume
Temperature Differential	14.9	per °C	As per IRC-58, table 1, page – 8

DESIGN FOR FATIGUE LIFE

SPECTRUM (%)	Axle Load	Stress (Appdix-1)	Stress Ratio stress/ flexural strength	Expected Repitions (n) (spectrum x design traffic)	Fatigue Life (N) 0.45 < SR < 0.55	Fatigue Life (N) SR > 0.55	Fatigue Life (N)	Fatigue Life Consumed (n / N)
	Single							
10	14	16.8	17.31	0.422	1605120.5	INFINITY	INFINITY	0
10	12	15.31	15.31	0.373	1605120.5	INFINITY	INFINITY	0
10	10	12	13.31	0.324	1605120.5	INFINITY	INFINITY	0
10	8	9.6	11.73	0.286	1605120.5	INFINITY	INFINITY	0
25	6	7.2	9.3	0.227	4012801.2	INFINITY	INFINITY	0
25	4	4.8	7.58	0.185	4012801.2	INFINITY	INFINITY	0
5	2	2.4	7.58	0.184	802560.2	INFINITY	INFINITY	0
	Tandem							
0.3	36	43.2	17.46	0.425	48153.6	INFINITY	INFINITY	0
0.3	28	33.6	14.88	0.363	48153.6	INFINITY	INFINITY	0
0.5	20	24	10.73	0.262	80256.0	INFINITY	INFINITY	0
0.5	16	19.2	8.46	0.206	80256.0	INFINITY	INFINITY	0
3.4	12	14.4	7.58	0.185	545741.0	INFINITY	INFINITY	0
Design Axle Load Stress			17.46					
							should <1 Hence SAFE	

Check for Temperature Stresses			
Radius of Relative Stiffness (l)	67.10	Cm	As per IRC-58,Para 5.2.1 (b),page-20
L/1	6.71	-	As per calculation from L and l value
B/1	5.22	-	As per IRC-58, From Fig-2, page-21
Coefficient C	0.764	-	As per IRC-58, From Fig-2, page-21
Edge Warping Stress	17.08	Kg/cm^2	As per IRC-58,Para 5.2.1 (b), page-19
Total Stress = Axle Load Stress	34.54	Kg/cm^2	Should < 41 Kg/cm2

Check for Corner Stresses			
Tyre Pressure (q)	8	Kg/cm^2	As per IRC-58, Para4.2 page 5
Max Wheel Load (Tandem Axle)	24000	Kg	As per IRC-58, Para4.2 page 4
Load / Wheel (P)	8000	Kg	
C/C dist. between Two Dual Wheel	31	cm	
Radius of Area of Tyre Contact Single Axle Dual Wheel (a) =	26.52	Kg/cm^2	As per IRC-58,Equation page-57

Corner Stress(Sc)	15.38	Kg/cm^2	As per IRC-58, Para5.2.2 page-20
Design of Dowel Bars			
Design wheel load = 98 percentile axle load is 16 tons. The wheel load therefore, is 8000 kg.(dual wheel load)			
Percentage of load transfer	40		As per IRC-58, Para 6.2.2.
Slab thickness, h	28	Cm	As per IRC-58, Para 6.2.2.
Joint width, z	2	Cm	
Radius of relative stiffness	67.10	Cm	As per IRC-58,Para 5.2.1 (b), page-20

Design of tie bars

Details of Dowel bar as per IRC:15-2002, Table no-7 For Slab Thickness 28 cm				
Diameter	3.2		Cm	Assumed
Length	50		Cm	Assumed
Space	18		Cm	Assumed
Fb=	255.75		Kg/cm^2	
First dowel bar is placed @ distance = 15 cm from the pavement edge				
No. of Dowel bars = 1 + l/spacing =		4.73	4.73	
	Say nos. of dowels		5	
Assuming that the load transferred by the first dowel is Pt and assuming that the load on dowel bar at a distance of l from the first dowel to be zero, the total load transferred by dowel bar system .				
			2.39	Pt.
Load carried by the outer dowel bar, Pt = (8000*0.4/2.39)		1338.69	Kg.	
Check for bearing stress				
Moment of inertia of dowel bar = (ת x b4)/64=		5.14	cm4	
Relative stiffness of dowel bar embedded in concrete ß = (k x b/ 4*EI)1/4				
ß =	0.24			
Bearing stress in dowel bar = (Pt x k) x (2 + ß * z)/ (4*ß3 EI)				
	246.94		**Should be < Fb =**	255.75
			Hence	**SAFE**

Design Parameters			
Slab thickness	28	Cm	
Lane width, b	7	M	
Coefficient of friction, f	1.5		
Density of concrete	2400	Kg/m^3	
Allowable tensile stress in plain bars	1250	Kg/cm^2	As per IRC: 21-2000
Allowable tensile stress in deformed bars	2000	Kg/cm^2	As per IRC: 21-2000
Allowable bond stress in plain tie bars	17.5	Kg/cm^2	
Allowable bond stress for deformed bars	24.6	Kg/cm^2	
Diameter of tie bar, d	12	MM	
Details of tie bar as per IRC:15-2002 for 28 cm slab thickness			
Diameter	12	Mm	
Max. Spacing - Plain bar	37	Cm	
Max. Spacing - Deformed bar	60	Cm	
Minimum length - Plain Bars	63	Cm	
Minimum length - Deformed bars	69	Cm	
Design Calculation			
For Plain tie bar			
Area of steel bar per metre width of joint to resist the frictional force at slab bottom			
As = bfW/s =	5.64	cm2/m	
Cross-sectional area of bar , A= 3.14 x d2/4	1.13	Sq. cm	
Perimeter of tie bar, P = 3.14 x d	3.77	Cm	
Spacing of tie bars = A/As =	20.03	Cm	
Provide tie bar @ spacing of 20 cm c/c			
Length of tie bar =(2xSxA)/(BxP) =	42.86	Cm	
Increase length by 10 cm for loss of bond due to painting and another 5 cm for tolerance in placement. Therefore the length is =42.86 + 10 + 5 = 57.82 cm=58cm			

5.9 DESIGN RESULTS

Slab Thickness	28	Cm
Width of Slab	350	Cm
Contraction Joints @ every	450	Cm
Diameter of Dowel Bars	3.2	Cm
Length of Dowel Bars	50	Cm
Spacing of Dowel	18	Cm
Diameter of Tie Bar	1.2	Cm

Spacing of Tie bar-plain	20	Cm
Length of Tie Bar	58	Cm

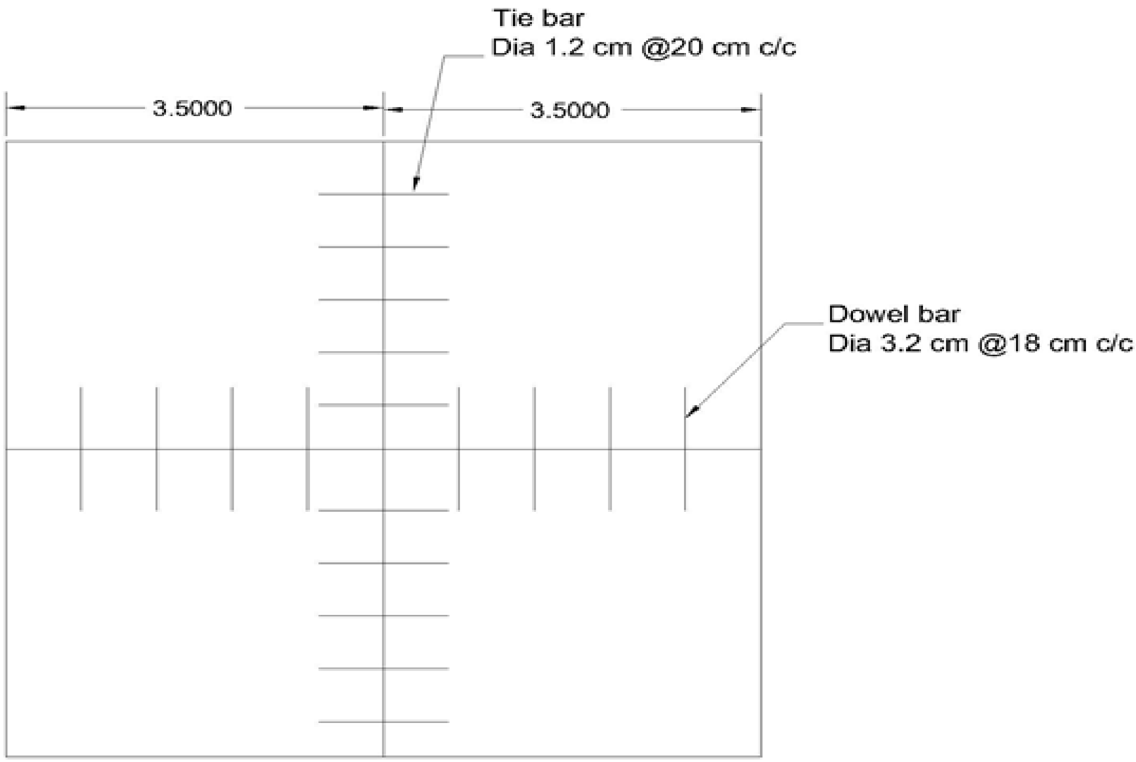


Figure 5.21 Slab design Detail.

5.10 ESTIMATE COST FOR OVERLAY

The purpose of Strengthening, improve riding surface and repair rehabilitation of existing pavement on CH: 0.00 to CH: 9.00. We may provide 2 alternatives as rehabilitation treatments of it. To compare 3 alternative we have to estimating both alternatives. Table given below provide abstract for estimate of asphalt overlay over asphalt pavement. And table 5.9 provide abstract for estimate of CC overlay over asphalt pavement. Here the Rate is taken from S.O.R. National Highway 2009-2010.

Table 5.12 Abstract for Asphalt overlay over asphalt pavement

Qty	Description of Item	Rate	Unit	Amount
52500	Providing, laying and rolling of built up- spray grout of layer over prepared base consisting of a two layer composite construction of compacted crushed aggregate using mortar grader for aggregates. Key stone chips spreader may be used with application at rate of15kg/10sqmt for each layer, and with key aggregates placed on top of the second layer to serve as a Base confirming to the line, grades and cross-section specified, the compacted layer thickness being Av.75mm incl. cost of tack coat emulsion at a rate of 2.00 kg/10sqmt	184*2	Sq mt	19320000

Qty	ITEM NO:2 SDBC	Rate	Unit	Amount
3018.75	Providing and laying 25vmm thick semi dense bituminous concrete with 100-120 TPH batch type HMP / Drum mix with 60-90 THP producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with 5.00% bituminous binder of 60-70 grade of mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No.508 complete in all respects.	2450	MT	7395937.5
TOTAL				26715937
Add 1% Quality control charges				267159.375
Total				26983096.5

Table 5.13: Abstract for CC overlay over asphalt pavement

Qty	ITEM NO:2 SDBC	Rate	Unit	Amount
	ITEM NO 1			
14700	CEMENT CONCRETE PAVEMENT Construction of unreinforced, dowel jointed plain cement concrete pavement over a prepared sub base with 43 grade cement @400 kg per cum, coarse and Fine aggregate conforming to IS 383, maximum size of coarse aggregate should not exceeding 25mm, mixed in batching and mixing plants as per approved mix design, transported to site, laid with a fixed form or slip form paver, spread, compacted and finished in a continues operation including joints, joints filler, separation membrane, sealant primer, joint sealant, dowel bar, tie rod, Admixtures as approved, curing compound, finishing to lines and grades as per drawing)	5413	Cum	79571100
	ITEM NO 2			
121.55	Supplying, Fitting and Placing uncoated TMT 3.2cm Dia bar Reinforcement in Slab of Cement Concrete pavement complete as per drawing and technical specification.	45505	Tonne	5531132.75

Qty	ITEM NO 3	Rate	Unit	Amount
97.39	Supplying, Fitting and Placing un- Coated TMT 1.2cm Dia bar Reinforcement in Slab of Cement Concrete pavement complete as per drawing and technical specification.	47505	Tonne	4626511.95
Total				85564844.7
Add 1% Quality control charges				855648.447
Total				86420494

v. Conclusion

1. The visual observation for Cracks ,Potholes, Raveling, Stripping can explain weak sports of pavements
2. The Benkelman beam study was conducted on all the selected sections of SH: 188 from Sarsa to Vasad Junction of the road and structural inadequacy were found in all the sections.
3. There is a need to go for measures such as an overlay on all the sections of SH: 188 from Sarsa To Vasad Junction. The overlay thicknesses in terms of Bituminous Macadam were found for all the stretches, it ranges from 110mm to 210mm.
4. The visual observation and Benkelman beam deflection correlates each other.

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