# “STRUCTURAL EVALUATION OF RURAL HILLY ROADS”

## A PROJECT

***Submitted in partial fulfillment of the requirements for the award of the degree of***

**BACHELOR OF TECHNOLOGY**

**IN**

**CIVIL ENGINEERING**

Under the supervision of

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**to**

**JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY**

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**HIMACHAL PRADESH, INDIA**

**MAY-2018**

# CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"STURCTURAL EVALUATION OF RURAL HILLY ROADS"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology,Waknaghat is an authentic record of work carried out by **Shivam Sharma (141691) and Somil Jain (141689)** during a period from July 2017 to June 2018 under the supervision of **Mr. Aakash Gupta (Assistant Professor)**, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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# ABSTRACT

Structural evaluation of a pavement focuses on the analysis of pavement to find out whether it is structurally stable enough to withstand daily routine traffic loading due to repetitive action of vehicles. The present study focuses on the Benkelman beam analysis of 12 stretches each of 2.5 kms on rural roads selected in vicinity of NH22. The characteristic deflection of each road is predicted for a future value to get the cost of future overlay on the given segment. The cost is then used to compare with the cost of regular maintenance, thus giving us the more economical option of the two methods. CBR value of subgrade soil is calculated to check the strength of the subgrade and it is also used in deflection prediction model to get the future deflection. This analysis gives us the better method for the maintenance of a flexible pavement. The analysis also requires the VDF value which is dependent on the different weight classes of the vehicles that are used daily on the pavement. The CSA value thus calculated using the VDF is used to calculate the required overlay that is needed for each of 12 selected roads using IRC81-1997.

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# CHAPTER-1

## 1.1 Structural Evaluation of Pavement

It is important to maintain accurate and latest information about the current condition and remaining time in service life of pavements .It is fundamental for the efficient maintenance. It also provides the required information for planning networksand taking forward the work program for pavement rehabilitation or reconstruction. From a management perspective, it is desired to obtain pavement structural data of the pavement to provide a firm basis for informed decisions.

## 1.2 Need of Structural Evaluation

The Repetitive action of vehicular loads results in consequent deterioration of pavement. Heavy vehicles and repetitive action leads to many structural defects and deformities.Structural evaluation is required to inspect the working condition of pavement to determine the need of timely maintenance and overlay in case of immensely deteriorated pavements.Thus structural evaluation is vital for determination of serviceability of roads.

Pavements fall apart with age and activity stacking. Assessment of in benefit pavements is extremely fundamental for keeping them in great serviceable condition. To get an entire thought of the current state of any asphalt both basic and useful assessment are vital. The most essential Parameter of Structural Evaluation is Deflection (all the more regularly alluded to as BBD). Diversion is the auxiliary property of asphalt. Asphalt avoidance assessment is an imperative report. Shape and greatness of redirection is an element of auxiliary condition, temperature, dampness condition and movement write and volume influencing asphalt structure. Asphalt basic execution can be resolved through it surface condition, conduct under load, and material properties. A few viewpoints are promptly watched, (for example, surface condition), though subsurface data concerning the basecourse, subbase and subgrade is expensive to accumulate and decipher with dangerous testing; this is the reason non-ruinous techniques, especially avoidance testing with the Falling Weight Deflectometer (FWD), and the Benkleman Beam Deflection (BBD). BBD being the most efficient and simple to get is utilized everywhere throughout the world for avoidance estimation.

## 1.3 Parameters of structural evaluation:

### 1.3.1 Benkelman Beam Deflection

The Benkelman Beam,which was produced at the Western Association of State Highway Organization (WASHO) Road Test in 1952, is an effortlessly worked machine which depends on the lever arm standard principle.The Benkelman Beam is used with a loaded truck – typically 8.2 tonnes on the rear single axle with dual tires fully inflated to a standard value be 480 to 550 kPa (70 to 80 psi).The measurement is made by placing the tip of the benkleman beam also called probe, in between the dual tyres and the measurement of the pavement surface deflection is carried out. The Benkelman Beam is low cost but is also slow, labour intensive but is most widely all over the world for deflection measurement because of economical and principle attributes.

Standard Benkelman Beam tests are described in:

- AASHTO T 256: Pavement Deflection Measurements
- ASTM D 4695: General Pavement Deflection Measurements
- IRC 81

Figure 1.1: Benkelman Beam

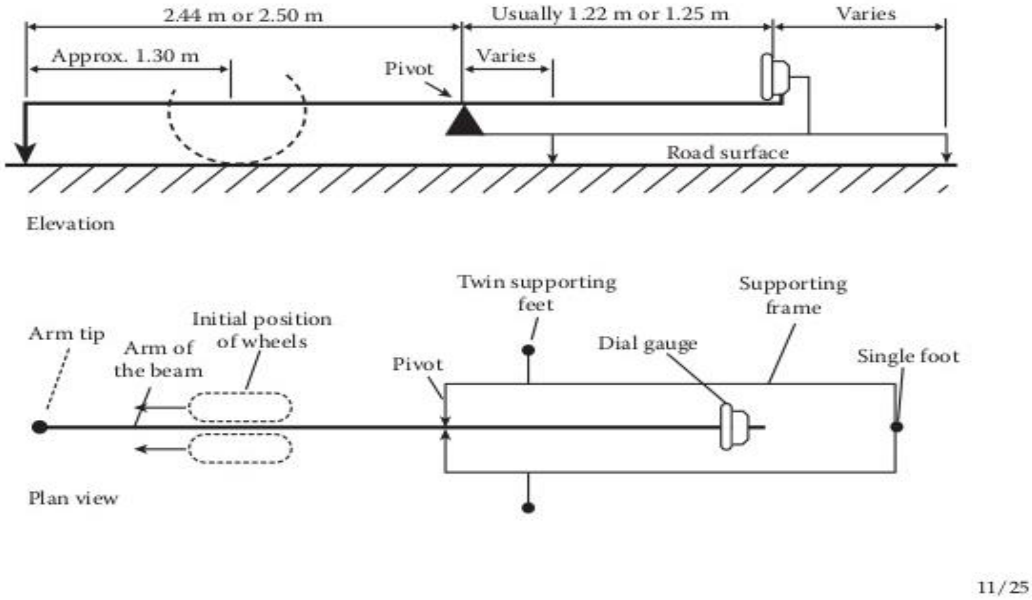


Figure 1.2: Benkelman Beam Assembly

Figure 1.3: Placing of the benkelman beam

## Temperature Correction

Standard temperature is 35℃ Correction for temperature variation on deflection values measured at pavement temperature other than 35℃ should be 0.01mm for each degree change from the standard temperature.

## Moisture Content Correction

Correction for seasonal variation depends on type of soil subgrade. Deflection depends upon the change in the climate. Worst climate (after monsoon)-considered for design. Standard curves for variation of soil and rainfall are given in IRC 81.

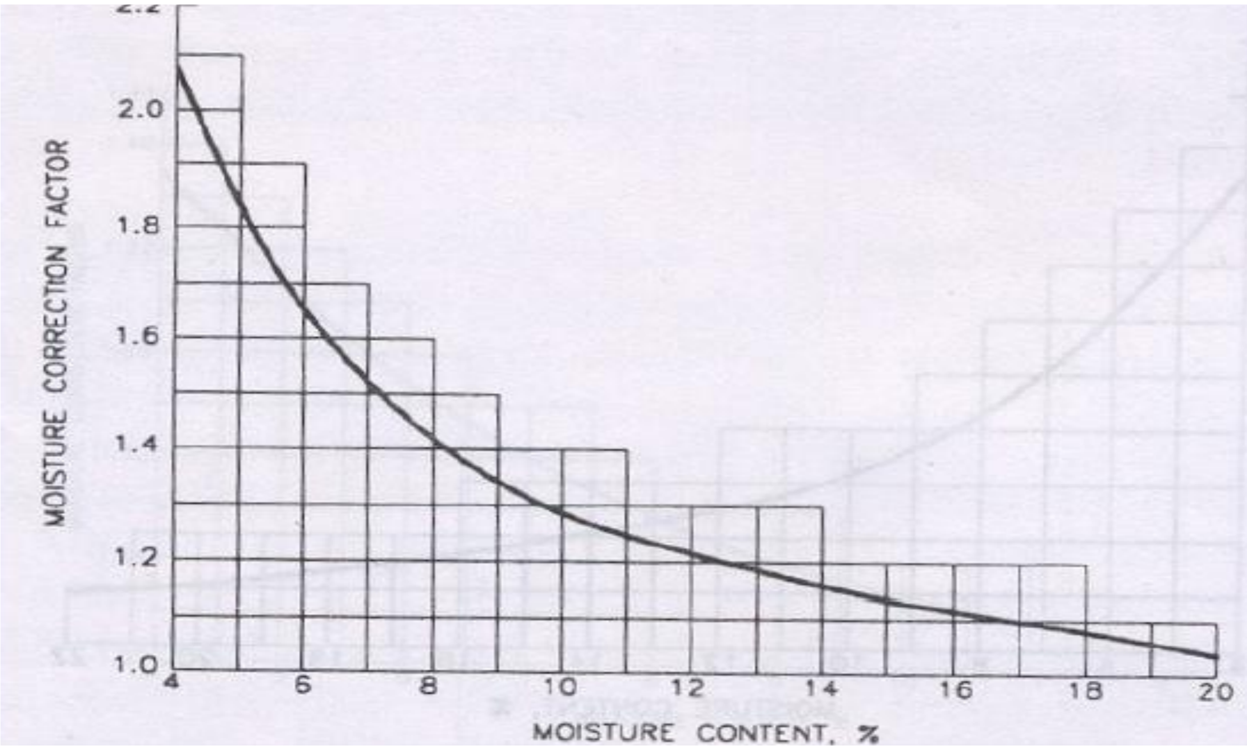


Figure 1.4: Moisture correction factor

### 1.3.2 Falling Weight Deflectometer

All sudden load delivering mechanisms produces a sudden impulsive load to the road top surface. The consequent pavement response of the road surface (deflection) is measured by a series of highly sensitive sensors. The most commonly used method for deflection measurement is the use of an efficient but costly instrument called the falling weight deflectometer (FWD). The FWD can either be mounted in a vehicle or on a trailer and is furnished with a weight and a few speed transducer sensors. To play out a test, the vehicle is ceased and the stacking plate (weight) is situated over the coveted area. The sensors are then brought down to the asphalt surface and the weight is dropped. Numerous tests can be performed on a similar area utilizing distinctive weight drop statures (ASTM, 2000[1]).There are many advantages of using FWD. The advantage of an suddenly applie load inpact measuring device over a steady state deflection measuring device is that it is very rapid, the implusive load can be provided with an easy variation and it more precisely provides the simulation the transient loading of the vehilces moving over the surface of the road . Results from FWD tests are often referred to as using the FWD AREA Parameter.

Figure 1.5: Falling Weight Deflectometer

### 1.3.3 California Bearing Ratio ( CBR Test)

The **California bearing ratio** (**CBR**) is a penetration test which is used for evaluation and analysis of the mechanical strength and stablity of natural ground surfaced having sil and rocks, subgrades and basecourses below the newly constructed carriageways. It was firstdeveloped by the California Department of Transportation before World War II. It is used commonly since then.

The California bearing proportion (CBR) is an entrance test for assessment of the mechanical quality of normal ground, subgrades and basecourses underneath new carriageway development. It was created by the California Department of Transportation before World War II.The fundamental site test is performed by estimating the weight required to avoid soil or total with a plunger of standard region. The deliberate weight is then separated by the weight required to accomplish an equivalent infiltration on a standard pounded shake material. The CBR test is portrayed in ASTM Standards D1883-05 (for research center arranged examples) (for soils set up in field), and AASHTO T173. The CBR test is completely depicted in BS 1367 : Soils for structural building purposes. It is received in IRC 35 to check the quality of subgrade and for additionally plan of asphalt.

The CBR rating was created for estimating the heap bearing limit of soils utilized for building streets. The CBR can likewise be utilized for estimating the heap bearing limit of unchanged airstrips or for soils under cleared airstrips. The harder the surface, the higher the CBR rating. A CBR of 3 compares to worked farmland, a CBR of 4.75 likens to turf or wet mud, while damp sand may have a CBR of 10. Astounding pulverized shake has a CBR more than 80. The standard material for this test is smashed limestone which has an estimated CBR value of almost 100, implying that it isn't very surprising to see CBR estimations of values higher than 100 in very much compacted regions. The CBR data is included in “Annexure II”.


Figure 1.6: CBR testing machine

### 1.3.4 Traffic Volume Studies

The design traffic is considered in terms of the cumulative number of standard axles. The cumulative number of Standard Axles to be catered for in the design. The traffic data is included on the “Annexure-III”.

A = Initial Traffic in the year of completion of construction on design lane

r = Annual growth rate of commercial vehicles

n = Design life in years

F = Vehicle Damage Factor

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

Equation 1: Calculation of number of Standard axles

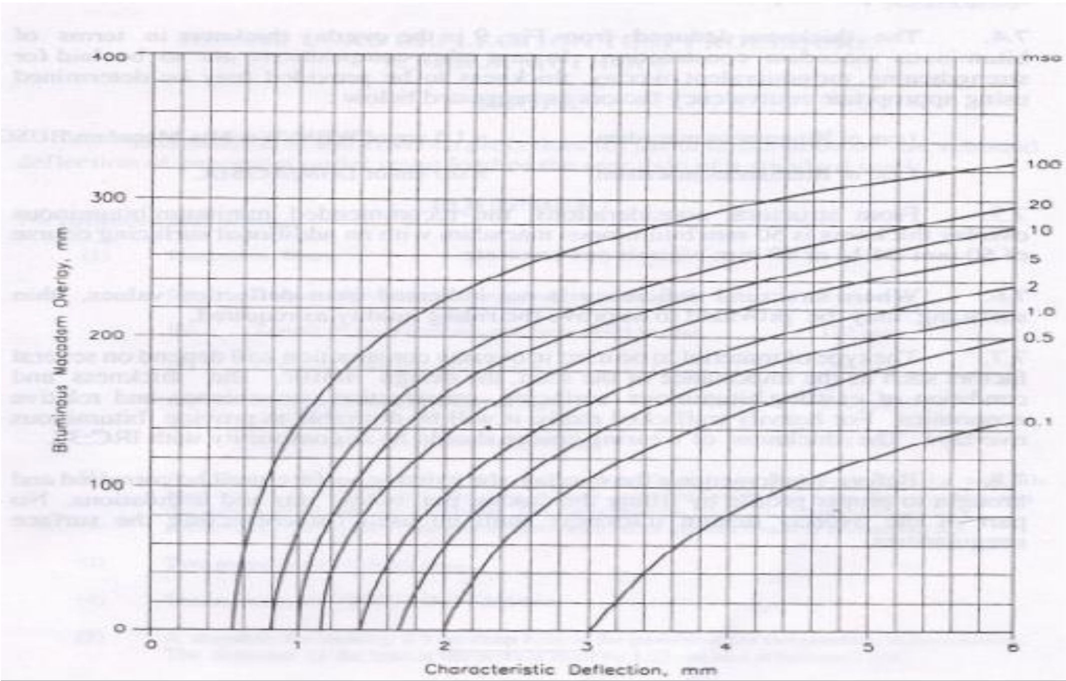


**Fig 1.7**: Use of traffic studies in design of pavement

### 1.3.5Vehicle Damage Factor

The multiplier for converting the number of commercial vehicles of different axle load an axle configuration to the number of standard axle-load repetition is termed as vehicle damage factor (VDF). VDF = Equivalent of standard axles / commercial vehicle The vehicle damage factor depend upon the axle configuration, Axle loading, terrain, Type of road and hence the vehicle damage factor varies with the axle configuration, type of load, axle loading, terrain from region to region. We have used IRC:SP 72-2015 for the calculation of VDF value by using the different vehicle classes and their consequent impact on the pavement surface.

## 1.4 Instruments used

**1.4.1** Benkleman Beam for Deflection Studies.

**1.4.2** CBR Machine for Subgrade Strength Evaluation.

**1.4.3** Glycerol and sensitive thermometer for temperature correction.

**1.4.4** Oven for moisture content

## 1.5 Literature Review

**Fontul Simona** (November 2004), conducted structural evaluation of Flexible pavement using Non-Destructive tests. The aim of his project is to improve the existing methodologies which were being used to evaluate a flexible pavement. He evaluated the Bearing Capacity of the pavement by measuring in-situ deflection, Pavement thickness and then established a Response model of the pavement. The analysis of his result showed the suitability and advantages of proposed methodology for structural evaluation of pavement.

**Subramaniam B.,** et al, (August, 2017) , conducted Functional and Structural evaluation of road pavement. He evaluated the condition of a selected section from Budalpur to Pudupatti on State Highway 99. Structural evaluation of pavement was carried out by Benkelman Beam to determine the capacity to withstand future traffic loading. From this data, overlay thickness required to maintain the pavement in serviceable condition.

**Deol Sunny**, (july,2017), conducted structural evaluation of pavements using non-destructive techniques in low volume road. Light Weight Deflectometer is used for structural evaluating the pavement layer moduli and overlay design. Due to the extremely expensive set, destruction and handling constraints in the FWD, the benkleman beam is still the most widely used instrument for the deflection finding works.

**Long Bing**, (Sept,2011), conducted structural evaluation of rigid pavement sections. It addresses the structural performance of experimental rigid pavements constructed in California. Falling Weight Deflectometer (FWD) was utilized to conduct deflection testing for backcalculation of layer moduli and subgrade reaction moduli (K-value), evaluation of joint load transfer capacity, and detection of voids under the slabs. In addition, pavement distress condition was also evaluated as it relates to the integrity of pavement structure.

**Umersalam**et al. (2015) have collected required filled data like existing pavement structure, soil subgrade data, pavement surface condition, traffic data and rebound deflection by using Benkelman Beam Deflection (BBD) technique. They were evaluated total existing pavement thickness for site 1 and site 2 and compared them with new overall pavement thickness and it was evident that site 1 fall short by 360 mm and site 2 fall short by 320 mm. The required overlay thickness for site 1 and site 2 was 95 mm and 60 mm respectively to strengthening them.

**Aghera V. Hardik ,**conducted a review on performance evaluation of Flexible pavement. structural evaluation of pavement by Benkelman Beam Deflection technique, evaluate pavement roughness and distress by Bump Integrator and visual observation at particular sections of the roads. Visual observation considers crack, patch, potholes, rutting and raveling. Roughness and visual distresses correlates each other. Regression model were developed between roughness and visual distress by using SPSS software.

**Abaza, k (2005)**

Pavement performance is evaluated using visual inspection. A performance curve is constructed, relating pavement performance to service time or equivalent single axle load of 80 KN. This further leads to the construction of flexible pavement overlay design models. An attempt is made to compensate for loss in pavement strength over service time. Relative strength are indicated by the structural number and gravel equivalent.

**Prasad, D. et al (2014)**

Performance evaluation of low volume roads is done to prioritize the maintenance order of the selected road stretches in Tumkur, Karnataka. Investigations were made regarding CBR of subgrade soil, Benkelman Beam deflection method, International Roughness Index (IRI). Roads were rated according to number of potholes, patching, rutting and cracking. A new parameter called as Modified Maintenance priority index(MMPI) is used to prioritize the roads.

**Chou, P. et al (1993)**

Pavement structural conditions are evaluated non-destructively to obtain pavement deflection. Pavement deflections are categorized by their elastic moduli from back-calculations of the surface deflections. It is a knowledge based system and Pavement Structural Evaluation System is developed. Thus it helps in improving the efficiency of interpreting Non Destructive Test Results.

**Hoffman, M. et al (1983)**

Different loading modes are used to collect Pavement deflection data. Various methods are static( Benkelman Beam) ,vibratory (Road Rater), impulse(Falling Weight Deflectometer). Performance of pavement is observed for different loading modes. Comparisons show that Falling Weight Deflectometer best stimulate the response of pavement under moving trucks. Benkelman Beam induces highest deflection in pavements.

**Nayak , R. et al (2012)**

Various factors that disrupt the road pavement conditions are analysed. The parameters used were road condition, traffic condition, environmental conditions that affect deflection values of pavement. Data is acquired from various sources and integrated to obtain useful information. The generated model shows the factors that affect or disrupt pavement deflection data.

### 1.5.1 Deflection model Selection on basis of Literature Review

The result of rigorous literature review, we have concluded the use of following deflection model for the prediction of deflection values. The following model is developed after 8 years of regular deflection data being collected and more importantly implied for low volume rural roads which is almost similar to our conditions.

$$Def_t = Def_i + 0.355(CSA{*}P_{age})^{Def} + SN^{-1.472}$$

Equation 1- Deflection Prediction Formula

$$\boldsymbol{SN} = 3.51(\log_{10} CBR) - 0.85(\log_{10} CBR)^2$$

Equation 2 Calculation of Structural Number

| |
|---|
| $Def._i$=Initial characteristic deflection (mm) at the beginning. |
| $Def_t$ = Characteristic deflection (mm) after time 't' where 't' is age of pavement. |
| CSA= Cumulative Standard Axles in billion |
| SN = Modified Structural Number |
| Page= Age of Pavement in years at the end of time interval 't' |

Table 1.1: Deflection prediction model of Rural hilly Roads

## 2.1 Objectives

- Literature review of Deflection Prediction Models.
- To predict the future overlay using present Benkelman Beam Deflection values for 12 selected rural stretches each of 2.5km with help of suitable prediction models using IRC81-1997.
- Comparing the cost estimation of future overlay and regular maintenance of pavement.

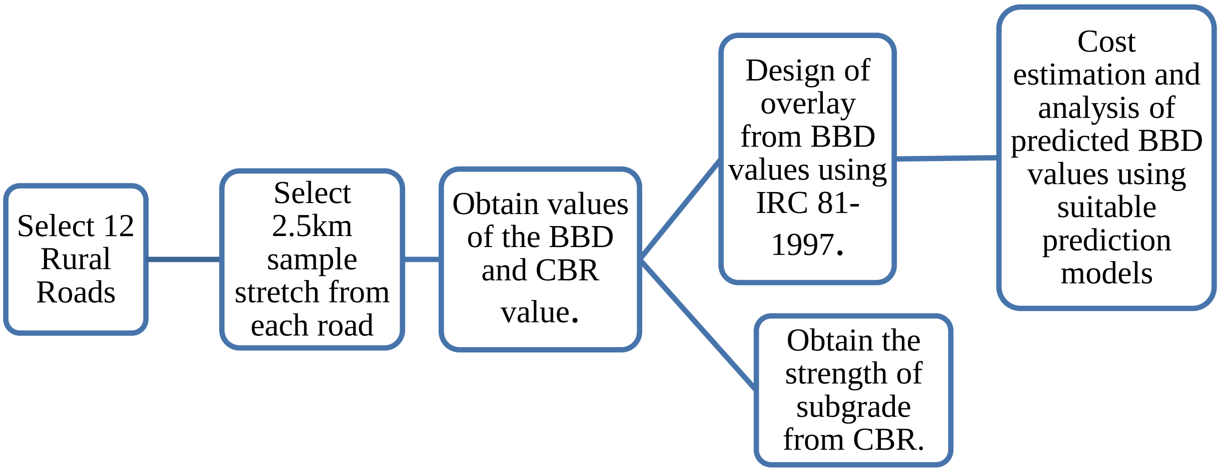


Figure 2.1: Flow chart representation of project work

## 2.2 Objectives achieved

**1.)** Calculation of CBR value of soil from 8 of selected 12 stretches.

**2.)** Learning the basics of Benkleman Beam and its practical application to calculate the pavement deflection values.

**3.)** Collection of Deflection data of selected roads.

**4.)** Cost estimation and proving cost effectiveness of regular maintenance

## 2.3 Selected rural road stretches:

Twelve roads are selected for the structural evaluation of pavement. All selected roads are important rural roads connected to NH. Criteria for selection of road:

i. All roads must be rural roads.

ii. Minimum length of road stretch is about 2-2.5 km.

On each stretch the BBD reading will be taken at an interval of 100m. Total of 25 readings will be taken on each of selected stretches.

### 2.3.1 List of Selected Rural Roads

Table 2.1: List of selected Rural Roads

| Road ID | Road Name | Road Width (m) | Road ID | Road Name | Road Width (m) |
|---|---|---|---|---|---|
| **RR-1** | Domehar-Waknaghat Road | 3.5 | **RR-7** | Shoghi Lagroo Road | 3.35 |
| **RR-2** | Salogra-Ashwini Khad Road | 3.35 | **RR-8** | Wakna link Road | 3.25 |
| **RR-3** | Kyari Bangla Road | 3.35 | **RR-9** | Saij Road | 3.35 |
| **RR-4** | Basha Road | 3.35 | **RR-10** | Chail Road | 3.4 |
| **RR-5** | Industrial Road | 3.5 | **RR-11** | Nain Basal Road | 3.35 |
| **RR-6** | Salana Road | 3.3 | **RR-12** | Dadhog Road | 3.3 |


Figure 2.2: Selected Rural Roads

## 2.4 Data collection:

The soil samples from 8 of the selected 12 stretches have been collected and CBR values of each of the samples have been calculated.  Atleast 5-6kg of soil is required from each of the selected stretches and CBR test is conducted.


Figure 2.3: Sample Collection


Figure 2.4: Sample Collection from RR 8

Figure 2.5: Mould filled with CBR sample

Figure 2.6: Testing on CBR sample

Figure 2.7: Soil sample failure after CBR test

# CHAPTER- 3

## 3.1 Benkelman Beam Deflection Data Collection

Benkelman Beam deflection readings for various selected flexible pavement roads was conducted by a loaded truck. The truck was loaded such that the rear axle load was 8.2 tonnes. Loading of truck took place in kyarighat (near waknaghat). The loaded truck was then used to get the deflection readings for various selected roads

.


Figure 3.1: Loading of truck to 8200kg


Figure 3.2: Placing of benkelman beam between the tyres at RR 7


Figure 3.3: Deflection reading when truck moves 2.7 metres from initial position


Figure 3.4: Truck is at 2.7 metres from initial point

Figure 3.5: Placing of probe of the benkelman beam

Figure3.6: Benkelman beam reading at RR 2

Figure 3.7:Deflection data when truck moves 9m from intermediate point

# Chapter-4

## Cost estimation:

The cost estimation is done on the basis of survey conducted by the PMGSY. The survey yielded the average for the annual maintenance and overlay of premix carpet. The cost estimation done by us proved the economic advantage of regular maintenance over complete overlay after few years.

## Conclusion:

The effective cost for regular annual maintenance is coming out to be much lower than cost of overlaying for most of the selected rural stretches. In accordance to study conducted by us overlaying after 4-5years is only suitable for roads with extremely low volume of daily traffic. The difference of cost effectiveness of maintenance is nearly half the cost of overlaying for some stretches with high traffic densities and relatively higher CSA value. Thus on the basis of our study we can conclude that the regular annual maintenance of low volume selected rural roads is more cost effective than the overlaying done after 4-5 years of daily use. The result can be justified by the following table and the same in "annexure VII".

| | Future Overlay in year 2021 | Age of pavement | Cost of regular maintenance (PMGSY) | Cost of Providing overlay(PMGSY) |
|---|---|---|---|---|
| RR1 | 120 mm | 7 yrs | 2.45lakhs | 4.25lakhs |
| RR2 | 150 mm | 5 yrs | 1.75lakhs | 5.087lakhs |
| RR3 | 150 mm | 7 yrs | 2.45lakhs | 5.087lakhs |
| RR4 | 60 mm | 6 yrs | 2.10lakhs | 2.03lakhs |
| RR5 | 220 mm | 6 yrs | 2.10lakhs | 7.79lakhs |
| RR6 | 200 mm | 7 yrs | 2.45lakhs | 6.65lakhs |
| RR7 | 100 mm | 5 yrs | 1.75lakhs | 3.39lakhs |
| RR8 | 70 mm | 6 yrs | 2.10lakhs | 2.30lakhs |
| RR9 | 150 mm | 7 yrs | 2.45lakhs | 5.08lakhs |
| RR10 | 200mm | 8yrs | 2.80lakhs | 6.88lakhs |
| RR11 | 160 mm | 6 yrs | 2.10lakhs | 5.42lakhs |
| RR12 | 130 mm | 7 yrs | 2.45lakhs | 4.35lakhs |

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# APPENDIX

# Annexure-I

# Benkleman Beam deflection data of rural roads

## RR 1: Domehar-Waknaghat Road

Table 2.1: Deflection data of RR 1(Domehar-Waknaghat Road)

| Do (mm) | Di (mm) | $D_f$ (mm) | 2*$D_i$ (mm) | 2*$D_f$(mm) |
|---|---|---|---|---|
| 0 | 0.352 | 0.355 | 0.704 | 0.71 |
| 0 | 0.217 | 0.219 | 0.434 | 0.438 |
| 0 | 0.41 | 0.413 | 0.82 | 0.826 |
| 0 | 0.401 | 0.403 | 0.802 | 0.806 |
| 0 | 0.302 | 0.304 | 0.604 | 0.608 |
| 0 | 0.269 | 0.272 | 0.538 | 0.544 |
| 0 | 0.215 | 0.217 | 0.43 | 0.434 |
| 0 | 0.188 | 0.191 | 0.376 | 0.382 |
| 0 | 0.361 | 0.364 | 0.722 | 0.728 |
| 0 | 0.201 | 0.204 | 0.402 | 0.408 |
| 0 | 0.415 | 0.417 | 0.83 | 0.834 |
| 0 | 0.334 | 0.337 | 0.668 | 0.674 |
| 0 | 0.381 | 0.384 | 0.762 | 0.768 |
| 0 | 0.341 | 0.343 | 0.682 | 0.686 |
| 0 | 0.271 | 0.274 | 0.542 | 0.548 |
| 0 | 0.225 | 0.227 | 0.45 | 0.454 |
| 0 | 0.358 | 0.361 | 0.716 | 0.722 |
| 0 | 0.381 | 0.383 | 0.762 | 0.766 |
| 0 | 0.396 | 0.399 | 0.792 | 0.798 |
| 0 | 0.425 | 0.427 | 0.85 | 0.854 |
| 0 | 0.332 | 0.335 | 0.664 | 0.67 |
| 0 | 0.282 | 0.285 | 0.564 | 0.57 |
| 0 | 0.303 | 0.306 | 0.606 | 0.612 |
| 0 | 0.339 | 0.346 | 0.678 | 0.692 |
| 0 | 0.297 | 0.299 | 0.594 | 0.598 |

## RR 3: Kyari Bangla Road

Table 3.2 : Deflection data of RR 3(Kyari Bangla Road)

| Do(mm) | Di(mm) | Df(mm) | Di*2(mm) | Df*2(mm) |
|---|---|---|---|---|
| 0 | 0.252 | 0.255 | 0.504 | 0.51 |
| 0 | 0.274 | 0.277 | 0.548 | 0.554 |
| 0 | 0.187 | 0.19 | 0.374 | 0.38 |
| 0 | 0.219 | 0.222 | 0.438 | 0.444 |
| 0 | 0.392 | 0.396 | 0.784 | 0.792 |
| 0 | 0.321 | 0.325 | 0.642 | 0.65 |
| 0 | 0.204 | 0.208 | 0.408 | 0.416 |
| 0 | 0.291 | 0.294 | 0.582 | 0.588 |
| 0 | 0.225 | 0.229 | 0.45 | 0.458 |
| 0 | 0.162 | 0.165 | 0.324 | 0.33 |
| 0 | 0.329 | 0.334 | 0.658 | 0.668 |
| 0 | 0.205 | 0.206 | 0.41 | 0.412 |
| 0 | 0.313 | 0.315 | 0.626 | 0.63 |
| 0 | 0.301 | 0.303 | 0.602 | 0.606 |
| 0 | 0.412 | 0.414 | 0.824 | 0.828 |
| 0 | 0.209 | 0.213 | 0.418 | 0.426 |
| 0 | 0.215 | 0.218 | 0.43 | 0.436 |
| 0 | 0.325 | 0.327 | 0.65 | 0.654 |
| 0 | 0.225 | 0.228 | 0.45 | 0.456 |
| 0 | 0.261 | 0.263 | 0.522 | 0.526 |
| 0 | 0.401 | 0.404 | 0.802 | 0.808 |
| 0 | 0.264 | 0.265 | 0.528 | 0.53 |
| 0 | 0.182 | 0.184 | 0.364 | 0.368 |
| 0 | 0.31 | 0.313 | 0.62 | 0.626 |
| 0 | 0.286 | 0.288 | 0.572 | 0.576 |

## RR 5: Industrial Road

Table 3.3: Deflection data of RR 5(Industrial Road)

| Do(mm) | Di(mm) | Df(mm) | $D_i$*2(mm) | $D_f$*2(mm) |
|---|---|---|---|---|
| 0 | 0.512 | 0.514 | 1.024 | 1.028 |
| 0 | 0.413 | 0.415 | 0.826 | 0.83 |
| 0 | 0.404 | 0.407 | 0.808 | 0.814 |
| 0 | 0.359 | 0.362 | 0.718 | 0.724 |
| 0 | 0.342 | 0.345 | 0.684 | 0.69 |
| 0 | 0.362 | 0.365 | 0.724 | 0.73 |
| 0 | 0.516 | 0.518 | 1.032 | 1.036 |
| 0 | 0.558 | 0.563 | 1.116 | 1.126 |
| 0 | 0.311 | 0.315 | 0.622 | 0.63 |
| 0 | 0.269 | 0.272 | 0.538 | 0.544 |
| 0 | 0.408 | 0.412 | 0.816 | 0.824 |
| 0 | 0.192 | 0.195 | 0.384 | 0.39 |
| 0 | 0.212 | 0.216 | 0.424 | 0.432 |
| 0 | 0.234 | 0.237 | 0.468 | 0.474 |
| 0 | 0.257 | 0.259 | 0.514 | 0.518 |
| 0 | 0.318 | 0.321 | 0.636 | 0.642 |
| 0 | 0.364 | 0.368 | 0.728 | 0.736 |
| 0 | 0.252 | 0.255 | 0.504 | 0.51 |
| 0 | 0.182 | 0.184 | 0.364 | 0.368 |
| 0 | 0.152 | 0.155 | 0.304 | 0.31 |
| 0 | 0.202 | 0.204 | 0.404 | 0.408 |
| 0 | 0.162 | 0.163 | 0.324 | 0.326 |
| 0 | 0.189 | 0.193 | 0.378 | 0.386 |
| 0 | 0.195 | 0.197 | 0.39 | 0.394 |
| 0 | 0.227 | 0.229 | 0.454 | 0.458 |

## RR 7: Lagroo Road

Table 3.4: Deflection data of Lagroo Road

| Do(mm) | $D_i$(mm) | $D_f$(mm) | $D_i$*2(mm) | $D_f$*2(mm) |
|---|---|---|---|---|
| 0 | 0.312 | 0.314 | 0.624 | 0.628 |
| 0 | 0.321 | 0.324 | 0.642 | 0.648 |
| 0 | 0.401 | 0.404 | 0.802 | 0.808 |
| 0 | 0.376 | 0.379 | 0.752 | 0.758 |
| 0 | 0.381 | 0.385 | 0.762 | 0.77 |
| 0 | 0.266 | 0.271 | 0.532 | 0.542 |
| 0 | 0.251 | 0.257 | 0.502 | 0.514 |
| 0 | 0.421 | 0.423 | 0.842 | 0.846 |
| 0 | 0.439 | 0.443 | 0.878 | 0.886 |
| 0 | 0.369 | 0.373 | 0.738 | 0.746 |
| 0 | 0.26 | 0.263 | 0.52 | 0.526 |
| 0 | 0.257 | 0.259 | 0.514 | 0.518 |
| 0 | 0.328 | 0.333 | 0.656 | 0.666 |
| 0 | 0.412 | 0.415 | 0.824 | 0.83 |
| 0 | 0.352 | 0.355 | 0.704 | 0.71 |
| 0 | 0.394 | 0.396 | 0.788 | 0.792 |
| 0 | 0.315 | 0.319 | 0.63 | 0.638 |
| 0 | 0.26 | 0.264 | 0.52 | 0.528 |
| 0 | 0.193 | 0.197 | 0.386 | 0.394 |
| 0 | 0.232 | 0.235 | 0.464 | 0.47 |
| 0 | 0.334 | 0.336 | 0.668 | 0.672 |
| 0 | 0.228 | 0.242 | 0.456 | 0.484 |
| 0 | 0.257 | 0.259 | 0.514 | 0.518 |
| 0 | 0.318 | 0.321 | 0.636 | 0.642 |
| 0 | 0.413 | 0.417 | 0.826 | 0.834 |

## RR 4: Basha Road

Table 3.5: Deflection data of RR 4(Basha Road)

| $D_o$(mm) | $D_i$(mm) | $D_f$(mm) | $D_i$*2(mm) | $D_f$*2(mm) |
|---|---|---|---|---|
| 0 | 0.152 | 0.155 | 0.304 | 0.31 |
| 0 | 0.182 | 0.184 | 0.364 | 0.368 |
| 0 | 0.19 | 0.191 | 0.38 | 0.382 |
| 0 | 0.212 | 0.214 | 0.424 | 0.428 |
| 0 | 0.23 | 0.232 | 0.46 | 0.464 |
| 0 | 0.162 | 0.165 | 0.324 | 0.33 |
| 0 | 0.204 | 0.208 | 0.408 | 0.416 |
| 0 | 0.178 | 0.182 | 0.356 | 0.364 |
| 0 | 0.218 | 0.221 | 0.436 | 0.442 |
| 0 | 0.251 | 0.253 | 0.502 | 0.506 |
| 0 | 0.168 | 0.171 | 0.336 | 0.342 |
| 0 | 0.139 | 0.141 | 0.278 | 0.282 |
| 0 | 0.149 | 0.153 | 0.298 | 0.306 |
| 0 | 0.229 | 0.233 | 0.458 | 0.466 |
| 0 | 0.293 | 0.295 | 0.586 | 0.59 |
| 0 | 0.146 | 0.149 | 0.292 | 0.298 |
| 0 | 0.191 | 0.195 | 0.382 | 0.39 |
| 0 | 0.211 | 0.214 | 0.422 | 0.428 |
| 0 | 0.233 | 0.234 | 0.466 | 0.468 |
| 0 | 0.161 | 0.165 | 0.322 | 0.33 |
| 0 | 0.201 | 0.203 | 0.402 | 0.406 |
| 0 | 0.218 | 0.22 | 0.436 | 0.44 |
| 0 | 0.17 | 0.173 | 0.34 | 0.346 |
| 0 | 0.245 | 0.249 | 0.49 | 0.498 |
| 0 | 0.162 | 0.168 | 0.324 | 0.336 |

## RR 6: Salana Road

Table 3.6: Deflection data of RR 6(Salana Road)

| $D_o$(mm) | $D_i$(mm) | $D_f$(mm) | $D_i$*2(mm) | $D_f$*2(mm) |
|---|---|---|---|---|
| 0 | 0.413 | 0.418 | 0.826 | 0.836 |
| 0 | 0.162 | 0.167 | 0.324 | 0.334 |
| 0 | 0.208 | 0.213 | 0.416 | 0.426 |
| 0 | 0.316 | 0.32 | 0.632 | 0.64 |
| 0 | 0.18 | 0.181 | 0.36 | 0.362 |
| 0 | 0.263 | 0.267 | 0.526 | 0.534 |
| 0 | 0.144 | 0.15 | 0.288 | 0.3 |
| 0 | 0.409 | 0.415 | 0.818 | 0.83 |
| 0 | 0.315 | 0.317 | 0.63 | 0.634 |
| 0 | 0.219 | 0.221 | 0.438 | 0.442 |
| 0 | 0.243 | 0.244 | 0.486 | 0.488 |
| 0 | 0.194 | 0.199 | 0.388 | 0.398 |
| 0 | 0.318 | 0.321 | 0.636 | 0.642 |
| 0 | 0.404 | 0.412 | 0.808 | 0.824 |
| 0 | 0.161 | 0.164 | 0.322 | 0.328 |
| 0 | 0.352 | 0.354 | 0.704 | 0.708 |
| 0 | 0.234 | 0.238 | 0.468 | 0.476 |
| 0 | 0.29 | 0.292 | 0.58 | 0.584 |
| 0 | 0.338 | 0.34 | 0.676 | 0.68 |
| 0 | 0.355 | 0.358 | 0.71 | 0.716 |
| 0 | 0.225 | 0.227 | 0.45 | 0.454 |
| 0 | 0.321 | 0.324 | 0.642 | 0.648 |
| 0 | 0.36 | 0.363 | 0.72 | 0.726 |
| 0 | 0.236 | 0.238 | 0.472 | 0.476 |
| 0 | 0.174 | 0.177 | 0.348 | 0.354 |

## RR 8:Vakna Road

Table 3.7: Deflection data of RR 8(Vakna Road)

| $D_o$(mm) | $D_i$(mm) | $D_f$(mm) | Di*2(mm) | $D_f$*2(mm) |
|---|---|---|---|---|
| 0 | 0.417 | 0.418 | 0.834 | 0.836 |
| 0 | 0.304 | 0.307 | 0.608 | 0.614 |
| 0 | 0.329 | 0.336 | 0.658 | 0.672 |
| 0 | 0.269 | 0.271 | 0.538 | 0.542 |
| 0 | 0.146 | 0.15 | 0.292 | 0.3 |
| 0 | 0.186 | 0.189 | 0.372 | 0.378 |
| 0 | 0.207 | 0.209 | 0.414 | 0.418 |
| 0 | 0.242 | 0.245 | 0.484 | 0.49 |
| 0 | 0.315 | 0.318 | 0.63 | 0.636 |
| 0 | 0.202 | 0.205 | 0.404 | 0.41 |
| 0 | 0.158 | 0.163 | 0.316 | 0.326 |
| 0 | 0.167 | 0.169 | 0.334 | 0.338 |
| 0 | 0.365 | 0.37 | 0.73 | 0.74 |
| 0 | 0.154 | 0.16 | 0.308 | 0.32 |
| 0 | 0.214 | 0.218 | 0.428 | 0.436 |
| 0 | 0.404 | 0.408 | 0.808 | 0.816 |
| 0 | 0.316 | 0.321 | 0.632 | 0.642 |
| 0 | 0.172 | 0.176 | 0.344 | 0.352 |
| 0 | 0.241 | 0.245 | 0.482 | 0.49 |
| 0 | 0.343 | 0.349 | 0.686 | 0.698 |
| 0 | 0.211 | 0.214 | 0.422 | 0.428 |
| 0 | 0.183 | 0.187 | 0.366 | 0.374 |
| 0 | 0.261 | 0.264 | 0.522 | 0.528 |
| 0 | 0.337 | 0.341 | 0.674 | 0.682 |
| 0 | 0.301 | 0.305 | 0.602 | 0.61 |

## RR 9: Saij Road

Table 3.8: Deflection data of RR 9(Saij Road)

| $D_o$(mm) | $D_i$(mm) | $D_f$(mm) | $D_i$*2(mm) | $D_f$*2(mm) |
|---|---|---|---|---|
| | | | | |
| 0 | 0.414 | 0.417 | 0.828 | 0.834 |
| 0 | 0.432 | 0.438 | 0.864 | 0.876 |
| 0 | 0.389 | 0.397 | 0.778 | 0.794 |
| 0 | 0.332 | 0.335 | 0.664 | 0.67 |
| 0 | 0.357 | 0.36 | 0.714 | 0.72 |
| 0 | 0.434 | 0.438 | 0.868 | 0.876 |
| 0 | 0.407 | 0.41 | 0.814 | 0.82 |
| 0 | 0.359 | 0.36 | 0.718 | 0.72 |
| 0 | 0.377 | 0.381 | 0.754 | 0.762 |
| 0 | 0.418 | 0.42 | 0.836 | 0.84 |
| 0 | 0.447 | 0.45 | 0.894 | 0.9 |
| 0 | 0.424 | 0.427 | 0.848 | 0.854 |
| 0 | 0.511 | 0.516 | 1.022 | 1.032 |
| 0 | 0.591 | 0.595 | 1.182 | 1.19 |
| 0 | 0.417 | 0.419 | 0.834 | 0.838 |
| 0 | 0.503 | 0.505 | 1.006 | 1.01 |
| 0 | 0.466 | 0.467 | 0.932 | 0.934 |
| 0 | 0.481 | 0.483 | 0.962 | 0.966 |
| 0 | 0.36 | 0.369 | 0.72 | 0.738 |
| 0 | 0.381 | 0.383 | 0.762 | 0.766 |
| 0 | 0.401 | 0.402 | 0.802 | 0.804 |
| 0 | 0.319 | 0.322 | 0.638 | 0.644 |
| 0 | 0.378 | 0.38 | 0.756 | 0.76 |
| 0 | 0.399 | 0.403 | 0.798 | 0.806 |
| 0 | 0.313 | 0.315 | 0.626 | 0.63 |

## RR 10: Chail Road

Table 3.9: Deflection Data of RR 1(Chail Road)

| Do(mm) | $D_i$(mm) | $D_f$(mm) | Di*2(mm) | $D_f$*2(mm) |
|---|---|---|---|---|
| 0 | 0.321 | 0.323 | 0.642 | 0.646 |
| 0 | 0.325 | 0.327 | 0.65 | 0.654 |
| 0 | 0.285 | 0.285 | 0.57 | 0.57 |
| 0 | 0.261 | 0.263 | 0.522 | 0.526 |
| 0 | 0.208 | 0.209 | 0.416 | 0.418 |
| 0 | 0.255 | 0.258 | 0.51 | 0.516 |
| 0 | 0.322 | 0.325 | 0.644 | 0.65 |
| 0 | 0.303 | 0.306 | 0.606 | 0.612 |
| 0 | 0.289 | 0.291 | 0.578 | 0.582 |
| 0 | 0.207 | 0.21 | 0.414 | 0.42 |
| 0 | 0.281 | 0.282 | 0.562 | 0.564 |
| 0 | 0.352 | 0.351 | 0.704 | 0.702 |
| 0 | 0.391 | 0.393 | 0.782 | 0.786 |
| 0 | 0.252 | 0.254 | 0.504 | 0.508 |
| 0 | 0.268 | 0.27 | 0.536 | 0.54 |
| 0 | 0.297 | 0.299 | 0.594 | 0.598 |
| 0 | 0.315 | 0.317 | 0.63 | 0.634 |
| 0 | 0.269 | 0.271 | 0.538 | 0.542 |
| 0 | 0.297 | 0.298 | 0.594 | 0.596 |
| 0 | 0.286 | 0.287 | 0.572 | 0.574 |
| 0 | 0.271 | 0.276 | 0.542 | 0.552 |
| 0 | 0.309 | 0.31 | 0.618 | 0.62 |
| 0 | 0.321 | 0.232 | 0.642 | 0.464 |
| 0 | 0.339 | 0.341 | 0.678 | 0.682 |
| 0 | 0.207 | 0.209 | 0.414 | 0.418 |

## RR 11:Nain Road

Table 3.10: Deflection data of RR 11(Nain Road)

| $D_o$(mm) | $D_i$(mm) | $D_f$(mm) | Di*2(mm) | Df*2(mm) |
|---|---|---|---|---|
| 0 | 0.521 | 0.524 | 1.042 | 1.048 |
| 0 | 0.563 | 0.567 | 1.126 | 1.134 |
| 0 | 0.582 | 0.586 | 1.164 | 1.172 |
| 0 | 0.501 | 0.504 | 1.002 | 1.008 |
| 0 | 0.483 | 0.485 | 0.966 | 0.97 |
| 0 | 0.612 | 0.613 | 1.224 | 1.226 |
| 0 | 0.552 | 0.554 | 1.104 | 1.108 |
| 0 | 0.556 | 0.558 | 1.112 | 1.116 |
| 0 | 0.421 | 0.424 | 0.842 | 0.848 |
| 0 | 0.489 | 0.492 | 0.978 | 0.984 |
| 0 | 0.561 | 0.563 | 1.122 | 1.126 |
| 0 | 0.512 | 0.515 | 1.024 | 1.03 |
| 0 | 0.525 | 0.527 | 1.05 | 1.054 |
| 0 | 0.533 | 0.536 | 1.066 | 1.072 |
| 0 | 0.53 | 0.532 | 1.06 | 1.064 |
| 0 | 0.545 | 0.546 | 1.09 | 1.092 |
| 0 | 0.549 | 0.551 | 1.098 | 1.102 |
| 0 | 0.487 | 0.489 | 0.974 | 0.978 |
| 0 | 0.561 | 0.564 | 1.122 | 1.128 |
| 0 | 0.497 | 0.5 | 0.994 | 1 |
| 0 | 0.449 | 0.452 | 0.898 | 0.904 |
| 0 | 0.503 | 0.506 | 1.006 | 1.012 |
| 0 | 0.602 | 0.604 | 1.204 | 1.208 |
| 0 | 0.561 | 0.562 | 1.122 | 1.124 |
| 0 | 0.532 | 0.534 | 1.064 | 1.068 |

## RR 12:Dadhog Road

Table 3.11: Deflection Data of RR 12(Dadhog Road)

| Do(mm) | $D_i$(mm) | $D_f$(mm) | $D_i$*2(mm) | $D_f$*2(mm) |
|---|---|---|---|---|
| 0 | 0.352 | 0.354 | 0.704 | 0.708 |
| 0 | 0.212 | 0.214 | 0.424 | 0.428 |
| 0 | 0.189 | 0.192 | 0.378 | 0.384 |
| 0 | 0.144 | 0.147 | 0.288 | 0.294 |
| 0 | 0.232 | 0.237 | 0.464 | 0.474 |
| 0 | 0.201 | 0.203 | 0.402 | 0.406 |
| 0 | 0.26 | 0.263 | 0.52 | 0.526 |
| 0 | 0.142 | 0.145 | 0.284 | 0.29 |
| 0 | 0.305 | 0.306 | 0.61 | 0.612 |
| 0 | 0.128 | 0.131 | 0.256 | 0.262 |
| 0 | 0.207 | 0.21 | 0.414 | 0.42 |
| 0 | 0.198 | 0.201 | 0.396 | 0.402 |
| 0 | 0.169 | 0.171 | 0.338 | 0.342 |
| 0 | 0.246 | 0.247 | 0.492 | 0.494 |
| 0 | 0.252 | 0.254 | 0.504 | 0.508 |
| 0 | 0.313 | 0.316 | 0.626 | 0.632 |
| 0 | 0.144 | 0.147 | 0.288 | 0.294 |
| 0 | 0.153 | 0.157 | 0.306 | 0.314 |
| 0 | 0.223 | 0.226 | 0.446 | 0.452 |
| 0 | 0.219 | 0.222 | 0.438 | 0.444 |
| 0 | 0.205 | 0.207 | 0.41 | 0.414 |
| 0 | 0.231 | 0.234 | 0.462 | 0.468 |
| 0 | 0.19 | 0.193 | 0.38 | 0.386 |
| 0 | 0.311 | 0.312 | 0.622 | 0.624 |
| 0 | 0.168 | 0.171 | 0.336 | 0.342 |

## RR 2: Ashwanikhad Road

Table 3.12: Deflection Data of RR 2(Ashwini khad Road)

| **Do(mm)** | **$D_i$(mm)** | **$D_f$(mm)** | **$D_i$*2** | **$D_f$*2** |
|---|---|---|---|---|
| 0 | 0.178 | 0.181 | 0.356 | 0.362 |
| 0 | 0.242 | 0.251 | 0.484 | 0.502 |
| 0 | 0.277 | 0.279 | 0.554 | 0.558 |
| 0 | 0.153 | 0.163 | 0.306 | 0.326 |
| 0 | 0.189 | 0.191 | 0.378 | 0.382 |
| 0 | 0.221 | 0.223 | 0.442 | 0.446 |
| 0 | 0.118 | 0.119 | 0.236 | 0.238 |
| 0 | 0.221 | 0.224 | 0.442 | 0.448 |
| 0 | 0.118 | 0.121 | 0.236 | 0.242 |
| 0 | 0.185 | 0.189 | 0.37 | 0.378 |
| 0 | 0.133 | 0.135 | 0.266 | 0.27 |
| 0 | 0.232 | 0.233 | 0.464 | 0.466 |
| 0 | 0.211 | 0.215 | 0.422 | 0.43 |
| 0 | 0.176 | 0.178 | 0.352 | 0.356 |
| 0 | 0.155 | 0.159 | 0.31 | 0.318 |
| 0 | 0.123 | 0.125 | 0.246 | 0.25 |
| 0 | 0.171 | 0.173 | 0.342 | 0.346 |
| 0 | 0.188 | 0.19 | 0.376 | 0.38 |
| 0 | 0.134 | 0.137 | 0.268 | 0.274 |
| 0 | 0.165 | 0.169 | 0.33 | 0.338 |
| 0 | 0.113 | 0.116 | 0.226 | 0.232 |
| 0 | 0.175 | 0.176 | 0.35 | 0.352 |
| 0 | 0.212 | 0.216 | 0.424 | 0.432 |
| 0 | 0.161 | 0.163 | 0.322 | 0.326 |
| 0 | 0.178 | 0.18 | 0.356 | 0.36 |

# Annexure-II

## CBR Calibration Factor

Table 4.1 CBR Calibration Factor

| Applied Force (Kg) | Standard proving Ring Reading(Divisions) |
|---|---|
| 25 | 83.4 |
| 50 | 162.5 |
| 75 | 245.5 |
| 100 | 333.9 |
| 125 | 417.1 |
| 150 | 500.2 |
| 175 | 585.3 |
| 200 | 671.5 |
| 225 | 758.5 |
| 250 | 845.8 |

**Proving Ring Constant- 3.164**

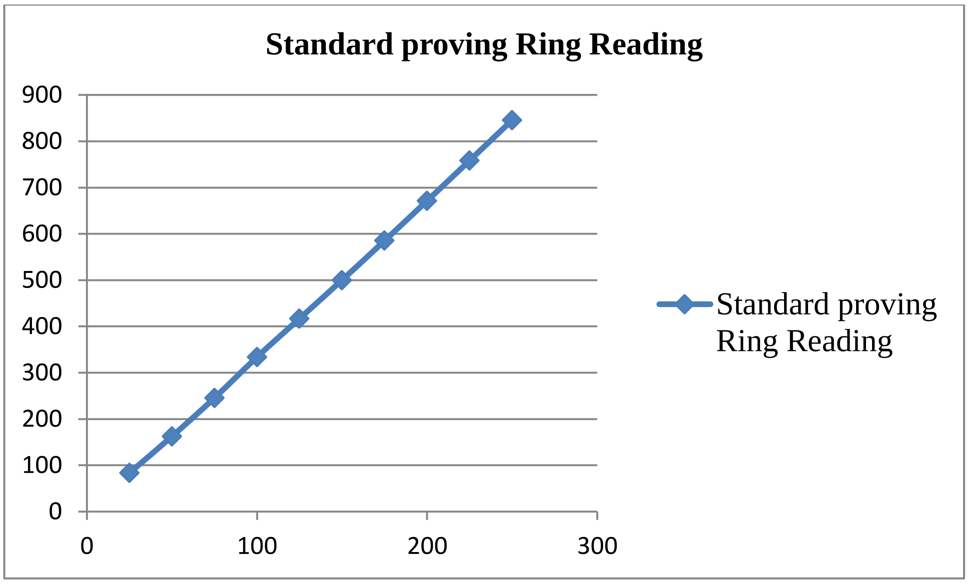


Figure 4.1: Standard Calibration Curve

# CBR data of selected road stretches

Table 4.2 CBR data RR1

| Deflection(mm) | Load | Proving Ring Reading |
|---|---|---|
| 0.5 | 78.4672 | 24.8 |
| 1 | 169.5904 | 53.6 |
| 1.5 | 252.4872 | 79.8 |
| 2 | 325.2592 | 102.8 |
| 2.5 | 399.9296 | 126.4 |
| 3 | 470.1704 | 148.6 |
| 3.5 | 536.6144 | 169.6 |
| 4 | 587.2384 | 185.6 |
| 4.5 | 632.1672 | 199.8 |
| 5 | 670.768 | 212 |
| 5.5 | 713.7984 | 225.6 |
| 6 | 755.5632 | 238.8 |
| 6.5 | 796.0624 | 251.6 |
| 7 | 832.132 | 263 |
| 7.5 | 861.8736 | 272.4 |
| 8 | 891.6152 | 281.8 |
| 8.5 | 920.0912 | 290.8 |
| 9 | 944.7704 | 298.6 |
| 9.5 | 972.6136 | 307.4 |
| 10 | 989.6992 | 312.8 |

**California Bearing Ratio- 28.45%**

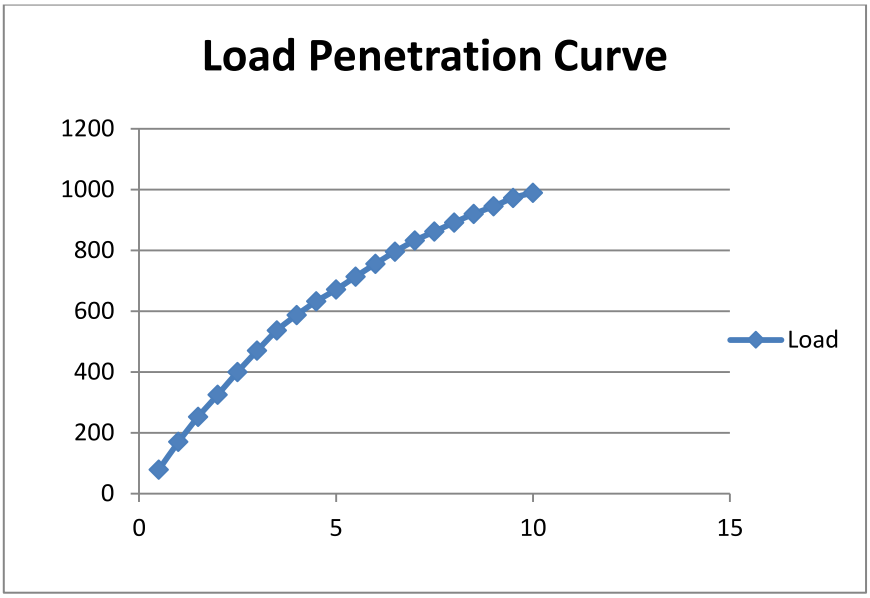


Figure 4.2: Load Penetration Curve of RR1

Table 4.3 CBR data RR2

| Deflection(mm) | load | Proving Ring Reading |
|---|---|---|
| 0.5 | 103.7792 | 32.8 |
| 1 | 216.4176 | 68.4 |
| 1.5 | 307.5408 | 97.2 |
| 2 | 362.5944 | 114.6 |
| 2.5 | 435.11328 | 137.52 |
| 3 | 505.6072 | 159.8 |
| 3.5 | 558.7624 | 176.6 |
| 4 | 609.3864 | 192.6 |
| 4.5 | 658.7448 | 208.2 |
| 5 | 692.916 | 219 |
| 5.5 | 721.392 | 228 |
| 6 | 749.868 | 237 |
| 6.5 | 779.6096 | 246.4 |
| 7 | 802.3904 | 253.6 |
| 7.5 | 828.968 | 262 |
| 8 | 861.8736 | 272.4 |
| 8.5 | 895.412 | 283 |
| 9 | 923.888 | 292 |
| 9.5 | 952.364 | 301 |
| 10 | 980.84 | 310 |

**California Bearing Ratio-29.62%**

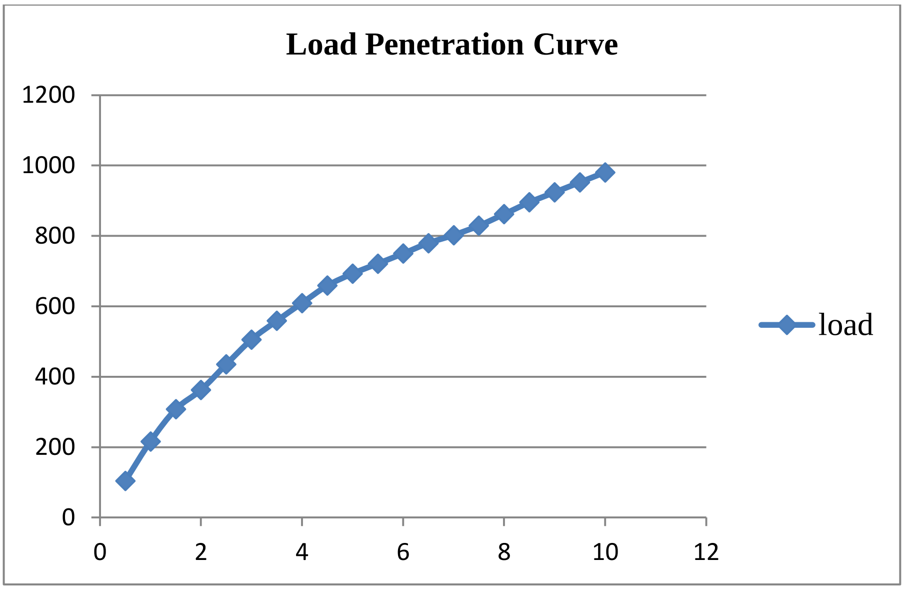


Figure 4.3: Load Penetration Curve of RR2

Table 4.4 CBR data RR3

| **Deflection(mm)** | **load** | **Proving Ring Reading** |
|---|---|---|
| 0.5 | 88.592 | 28 |
| 1 | 164.528 | 52 |
| 1.5 | 246.792 | 78 |
| 2 | 294.252 | 93 |
| 2.5 | 376.516 | 119 |
| 3 | 435.9992 | 137.8 |
| 3.5 | 485.9904 | 153.6 |
| 4 | 540.4112 | 170.8 |
| 4.5 | 583.4416 | 184.4 |
| 5 | 620.7768 | 196.2 |
| 5.5 | 658.112 | 208 |
| 6 | 700.5096 | 221.4 |
| 6.5 | 736.5792 | 232.8 |
| 7 | 767.5864 | 242.6 |
| 7.5 | 797.328 | 252 |
| 8 | 831.4992 | 262.8 |
| 8.5 | 862.5064 | 272.6 |
| 9 | 895.412 | 283 |
| 9.5 | 920.724 | 291 |
| 10 | 946.036 | 299 |

**California Bearing Ratio-26.73%**

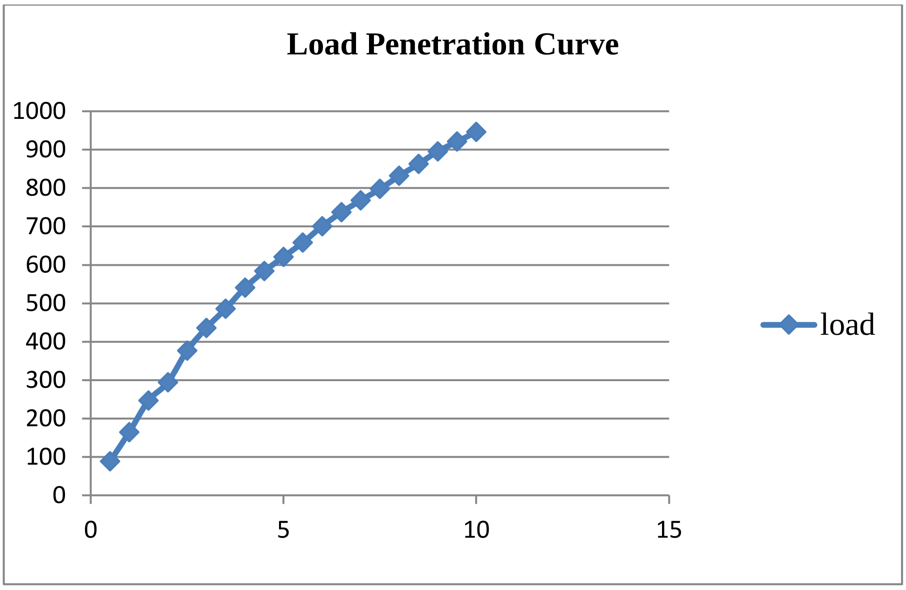


Figure 4.4: Load Penetration Curve of RR3

Table 4.5 CBR data RR4

| Deflection(mm) | Load (Kg) | Proving Ring Reading |
|---|---|---|
| 0.5 | 129.724 | 41 |
| 1 | 227.808 | 72 |
| 1.5 | 308.8064 | 97.6 |
| 2 | 375.8832 | 118.8 |
| 2.5 | 451.8192 | 142.8 |
| 3 | 514.4664 | 162.6 |
| 3.5 | 563.192 | 178 |
| 4 | 597.996 | 189 |
| 4.5 | 626.472 | 198 |
| 5 | 658.112 | 208 |
| 5.5 | 692.916 | 219 |
| 6 | 721.392 | 228 |
| 6.5 | 749.868 | 237 |
| 7 | 784.672 | 248 |
| 7.5 | 813.148 | 257 |
| 8 | 847.952 | 268 |
| 8.5 | 873.264 | 276 |
| 9 | 901.74 | 285 |
| 9.5 | 936.544 | 296 |
| 10 | 965.02 | 305 |

**California Bearing Ratio-30.76%**

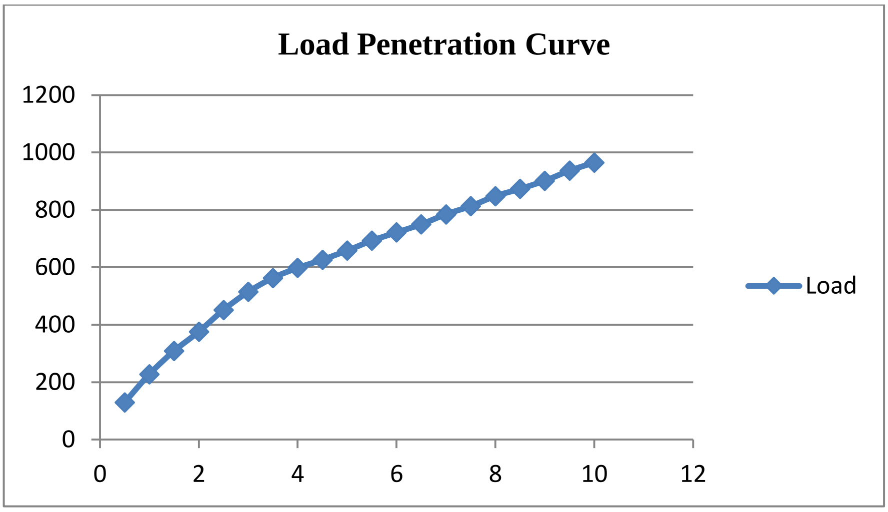


Figure 4.5: Load Penetration Curve of RR4

Table 4.6 CBR data RR5

| Deflection(mm) | Load (Kg) | Proving Ring Reading |
|---|---|---|
| 0.5 | 66.444 | 21 |
| 1 | 142.38 | 45 |
| 1.5 | 219.5816 | 69.4 |
| 2 | 290.4552 | 91.8 |
| 2.5 | 350.5712 | 110.8 |
| 3 | 406.8904 | 128.6 |
| 3.5 | 460.0456 | 145.4 |
| 4 | 513.2008 | 162.2 |
| 4.5 | 563.192 | 178 |
| 5 | 608.1208 | 192.2 |
| 5.5 | 650.5184 | 205.6 |
| 6 | 689.1192 | 217.8 |
| 6.5 | 725.1888 | 229.2 |
| 7 | 758.0944 | 239.6 |
| 7.5 | 785.9376 | 248.4 |
| 8 | 813.148 | 257 |
| 8.5 | 838.46 | 265 |
| 9 | 863.772 | 273 |
| 9.5 | 889.084 | 281 |
| 10 | 911.232 | 288 |

## California Bearing Ratio-25.28%

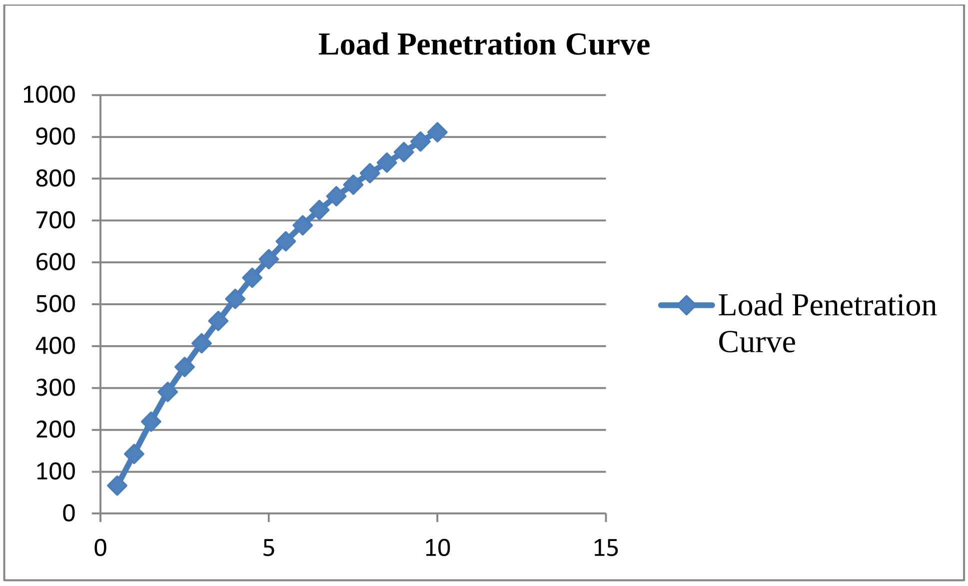


Figure 4.6: Load Penetration Curve of RR5

Table 4.7 CBR data RR6

| Deflection(mm) | Load(Kg) | Proving Ring Reading |
|---|---|---|
| 0.5 | 62.6472 | 19.8 |
| 1 | 122.1304 | 38.6 |
| 1.5 | 196.168 | 62 |
| 2 | 266.4088 | 84.2 |
| 2.5 | 333.4856 | 105.4 |
| 3 | 402.4608 | 127.2 |
| 3.5 | 459.4128 | 145.2 |
| 4 | 502.4432 | 158.8 |
| 4.5 | 541.044 | 171 |
| 5 | 578.3792 | 182.8 |
| 5.5 | 614.4488 | 194.2 |
| 6 | 654.948 | 207 |
| 6.5 | 698.9276 | 220.9 |
| 7 | 715.6968 | 226.2 |
| 7.5 | 759.36 | 240 |
| 8 | 798.5936 | 252.4 |
| 8.5 | 836.2452 | 264.3 |
| 9 | 870.1 | 275 |
| 9.5 | 904.904 | 286 |
| 10 | 927.052 | 293 |

**California Bearing Ratio: 23.56%**

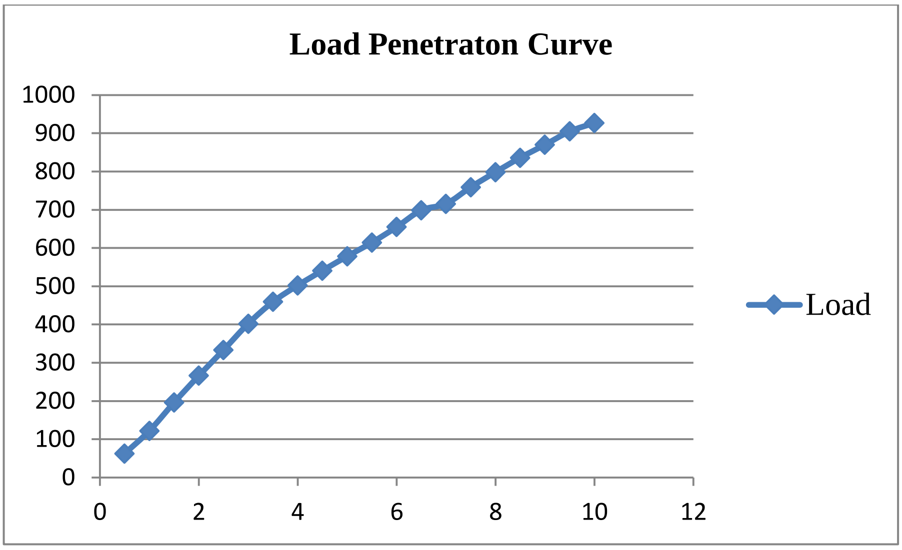


Figure 4.7: Load Penetration Curve of RR 6

Table 4.8 CBR data RR7

| Deflection(mm) | Load(Kg) | Proving Ring Reading |
|---|---|---|
| 0.5 | 85.428 | 27 |
| 1 | 161.364 | 51 |
| 1.5 | 237.3 | 75 |
| 2 | 297.416 | 94 |
| 2.5 | 341.712 | 108 |
| 3 | 373.352 | 118 |
| 3.5 | 423.976 | 134 |
| 4 | 461.944 | 146 |
| 4.5 | 499.912 | 158 |
| 5 | 534.716 | 169 |
| 5.5 | 575.848 | 182 |
| 6 | 618.8784 | 195.6 |
| 6.5 | 658.112 | 208 |
| 7 | 689.752 | 218 |
| 7.5 | 720.1264 | 227.6 |
| 8 | 747.6532 | 236.3 |
| 8.5 | 781.508 | 247 |
| 9 | 809.984 | 256 |
| 9.5 | 847.952 | 268 |
| 10 | 883.0724 | 279.1 |

**California Bearing Ratio: 24.62%**

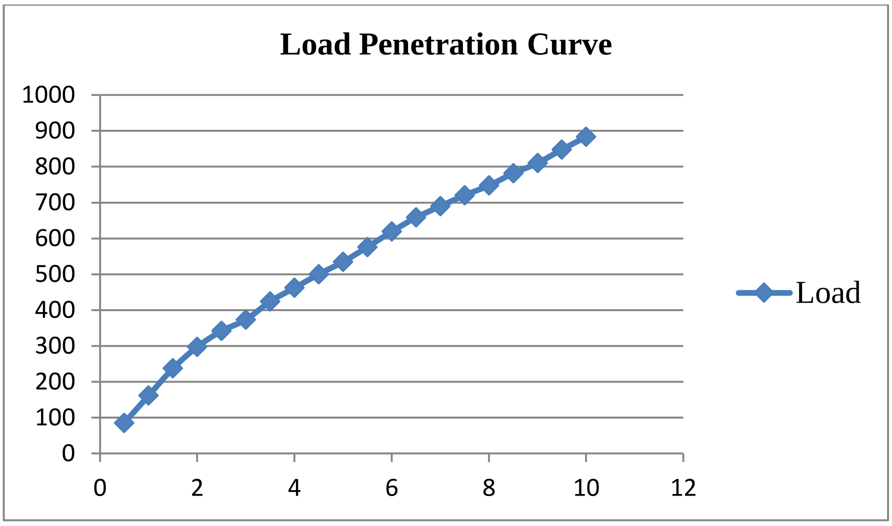


Figure 4.8: Load Penetration Curve of RR 7

Table 4.9 CBR data RR8

| Deflection(mm) | Load(Kg) | Proving Ring Reading |
|---|---|---|
| 0.5 | 87.9592 | 27.8 |
| 1 | 165.1608 | 52.2 |
| 1.5 | 248.6904 | 78.6 |
| 2 | 342.3448 | 108.2 |
| 2.5 | 409.4216 | 129.4 |
| 3 | 449.288 | 142 |
| 3.5 | 496.748 | 157 |
| 4 | 537.88 | 170 |
| 4.5 | 573.9496 | 181.4 |
| 5 | 603.0584 | 190.6 |
| 5.5 | 635.3312 | 200.8 |
| 6 | 663.1744 | 209.6 |
| 6.5 | 692.916 | 219 |
| 7 | 724.556 | 229 |
| 7.5 | 752.3992 | 237.8 |
| 8 | 777.0784 | 245.6 |
| 8.5 | 803.656 | 254 |
| 9 | 831.4992 | 262.8 |
| 9.5 | 857.444 | 271 |
| 10 | 893.1972 | 282.3 |

## California Bearing Ratio- 28.23%

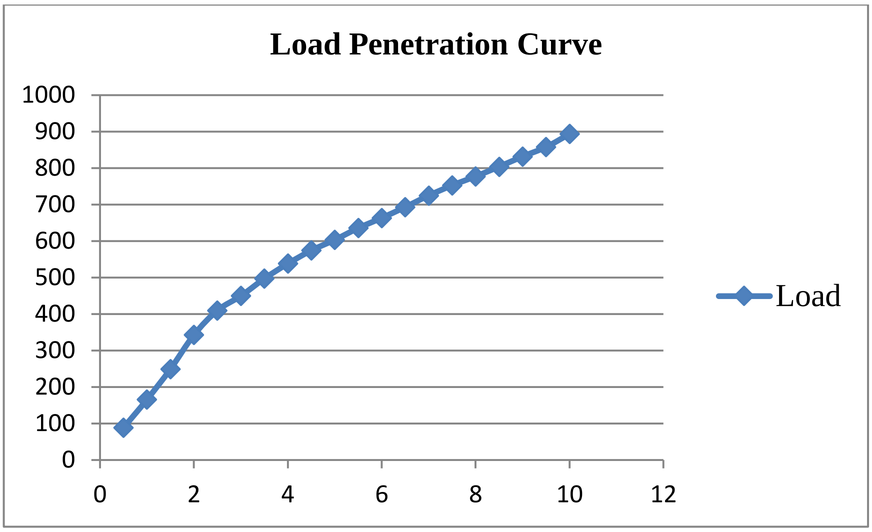


Figure 4.9: Load Penetration Curve of RR8

Table 4.10 CBR data RR9

| **Deflection(mm)** | **Load(Kg)** | **Proving Ring Reading** |
|---|---|---|
| 0.5 | 67.0768 | 21.2 |
| 1 | 151.2392 | 47.8 |
| 1.5 | 201.2304 | 63.6 |
| 2 | 248.0576 | 78.4 |
| 2.5 | 292.67 | 92.5 |
| 3 | 337.9152 | 106.8 |
| 3.5 | 359.7468 | 113.7 |
| 4 | 378.4144 | 119.6 |
| 4.5 | 396.7656 | 125.4 |
| 5 | 420.1792 | 132.8 |
| 5.5 | 436.632 | 138 |
| 6 | 463.8424 | 146.6 |
| 6.5 | 495.4824 | 156.6 |
| 7 | 530.9192 | 167.8 |
| 7.5 | 549.2704 | 173.6 |
| 8 | 568.8872 | 179.8 |
| 8.5 | 580.2776 | 183.4 |
| 9 | 599.8944 | 189.6 |
| 9.5 | 627.7376 | 198.4 |
| 10 | 652.4168 | 206.2 |

**California Bearing Ratio-21.37%**

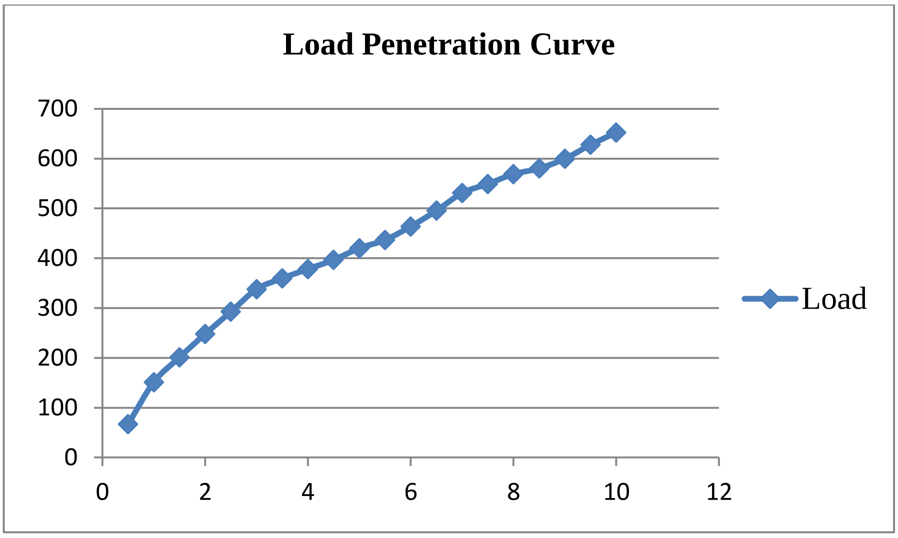


Figure 4.10: Load Penetration Curve of RR 9

Table 4.11 CBR data RR10

| Deflection(mm) | Load(Kg) | Proving Ring Reading(mm) |
|---|---|---|
| 0 | 87.9592 | 27.8 |
| 0.5 | 163.2624 | 51.6 |
| 1 | 213.2536 | 67.4 |
| 1.5 | 256.9168 | 81.2 |
| 2 | 296.1504 | 93.6 |
| 2.5 | 336.6496 | 106.4 |
| 3 | 374.6176 | 118.4 |
| 3.5 | 403.41 | 127.5 |
| 4 | 431.5696 | 136.4 |
| 4.5 | 460.362 | 145.5 |
| 5 | 485.9904 | 153.6 |
| 5.5 | 513.8336 | 162.4 |
| 6 | 541.6768 | 171.2 |
| 6.5 | 569.52 | 180 |
| 7 | 596.7304 | 188.6 |
| 7.5 | 623.308 | 197 |
| 8 | 645.456 | 204 |
| 8.5 | 669.5024 | 211.6 |
| 9 | 691.0176 | 218.4 |
| 9.5 | 710.6344 | 224.6 |
| 10 | 730.884 | 231 |

**California Bearing Ratio-24.56%**

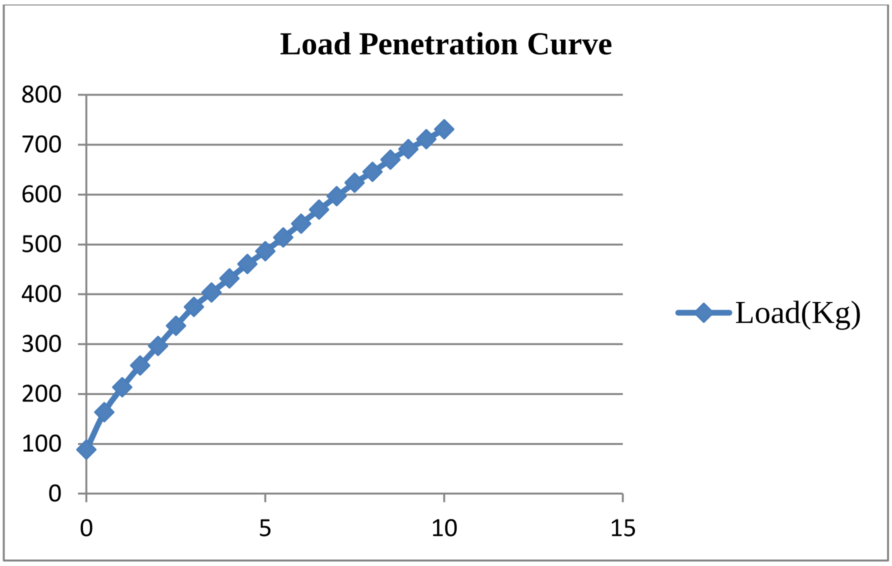


Figure 4.12: Load Penetration Curve of RR11

Table 4.12 CBR data RR11

| **Deflection(mm)** | **Load(Kg)** | **Proving Ring Reading** |
|---|---|---|
| 0.5 | 62.6472 | 19.8 |
| 1 | 103.1464 | 32.6 |
| 1.5 | 153.1376 | 48.4 |
| 2 | 197.4336 | 62.4 |
| 2.5 | 255.6512 | 80.8 |
| 3 | 284.1272 | 89.8 |
| 3.5 | 308.1736 | 97.4 |
| 4 | 330.9544 | 104.6 |
| 4.5 | 347.4072 | 109.8 |
| 5 | 360.696 | 114 |
| 5.5 | 378.4144 | 119.6 |
| 6 | 391.7032 | 123.8 |
| 6.5 | 403.7264 | 127.6 |
| 7 | 415.7496 | 131.4 |
| 7.5 | 429.6712 | 135.8 |
| 8 | 448.0224 | 141.6 |
| 8.5 | 460.0456 | 145.4 |
| 9 | 473.9672 | 149.8 |
| 9.5 | 484.7248 | 153.2 |
| 10 | 498.6464 | 157.6 |

**California Bearing Ratio- 18.67%**

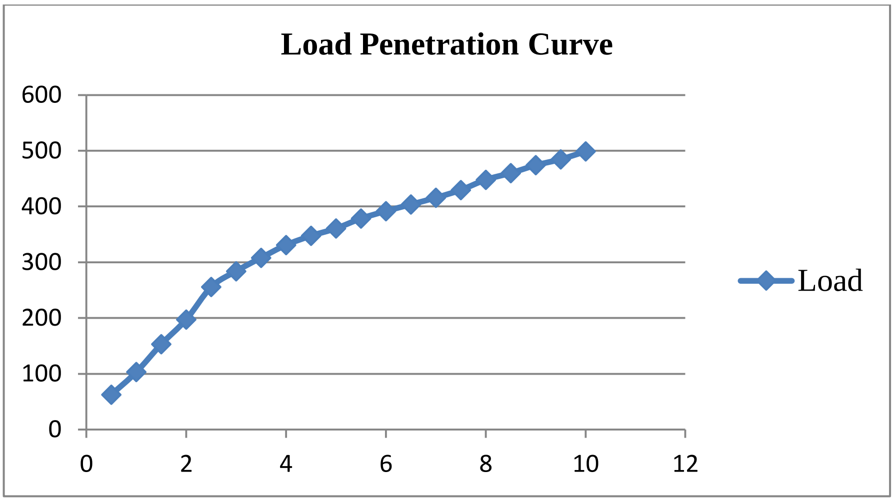


Figure 4.12: Load Penetration Curve of RR11

Table 4.13 CBR data RR12

| Deflection(mm) | Load(Kg) | Proving Ring Reading |
|---|---|---|
| 0.5 | 74.6704 | 23.6 |
| 1 | 150.6064 | 47.6 |
| 1.5 | 200.5976 | 63.4 |
| 2 | 253.7528 | 80.2 |
| 2.5 | 310.7048 | 98.2 |
| 3 | 343.6104 | 108.6 |
| 3.5 | 372.7192 | 117.8 |
| 4 | 399.9296 | 126.4 |
| 4.5 | 422.7104 | 133.6 |
| 5 | 444.8584 | 140.6 |
| 5.5 | 466.3736 | 147.4 |
| 6 | 486.6232 | 153.8 |
| 6.5 | 511.3024 | 161.6 |
| 7 | 529.6536 | 167.4 |
| 7.5 | 544.8408 | 172.2 |
| 8 | 562.5592 | 177.8 |
| 8.5 | 579.6448 | 183.2 |
| 9 | 597.996 | 189 |
| 9.5 | 612.5504 | 193.6 |
| 10 | 626.472 | 198 |

## California Bearing Ratio- 22.66%

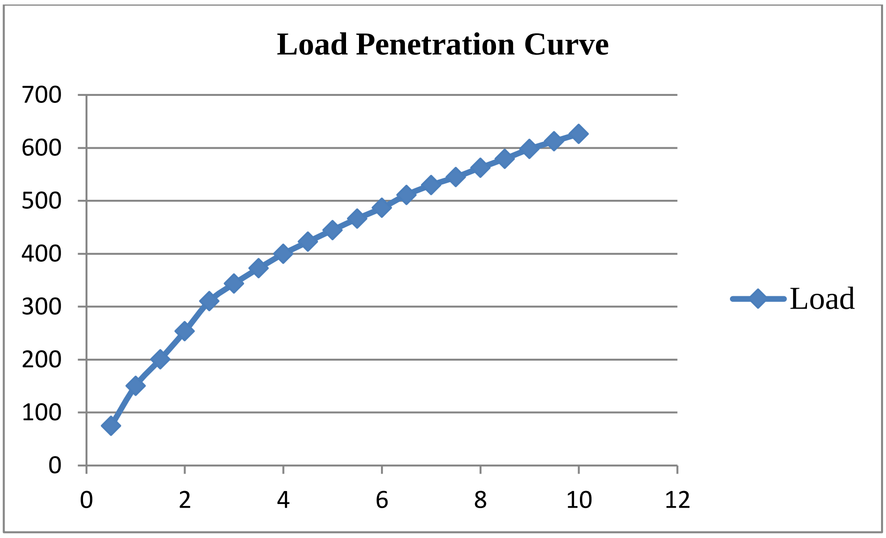


Figure 4.13: Load Penetration Curve of RR 12

# Annexure III

## Traffic data of Rural Roads

Table 5.1 : Traffic data RR1

| Time | | Day 1 | | Day 2 |
|---|---|---|---|---|
| Vehicles | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. |
| Cars | 18 | 11 | 13 | 16 |
| Buses | 3 | 5 | 4 | 5 |
| 2-Wheels | 29 | 31 | 30 | 24 |
| Pickups | 9 | 4 | 11 | 6 |
| Trucks | 13 | 11 | 9 | 10 |

Table 5.2 : Traffic data RR2

| Time | | Day 1 | | Day 2 |
|---|---|---|---|---|
| Vehicles | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. |
| Cars | 21 | 19 | 28 | 17 |
| Buses | 2 | 6 | 3 | 4 |
| 2-Wheels | 17 | 18 | 13 | 16 |
| Pickups | 3 | 7 | 10 | 9 |
| Trucks | 11 | 16 | 12 | 9 |

Table 5.3 : Traffic data RR3

| Time | | Day 1 | | Day 2 |
|---|---|---|---|---|
| Vehicles | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. |
| Cars | 19 | 16 | 21 | 12 |
| Buses | 3 | 2 | 3 | 2 |
| 2-Wheels | 12 | 16 | 14 | 11 |
| Pickups | 5 | 4 | 6 | 7 |
| Trucks | 5 | 6 | 7 | 8 |

Table 5.4 : Traffic data RR4

| Time | | Day 1 | | Day 2 |
|---|---|---|---|---|
| Vehicles | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. |
| Cars | 14 | 11 | 15 | 13 |
| Buses | 4 | 5 | 4 | 5 |
| 2-Wheels | 22 | 19 | 21 | 14 |
| Pickups | 6 | 9 | 8 | 5 |
| Trucks | 5 | 7 | 4 | 4 |

Table 5.5 : Traffic data RR5

| Time | | Day 1 | | Day 2 |
|---|---|---|---|---|
| Vehicles | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. |
| Cars | 17 | 19 | 21 | 15 |
| Buses | 3 | 4 | 3 | 4 |
| 2-Wheels | 15 | 17 | 13 | 18 |
| Pickups | 12 | 15 | 10 | 15 |
| Trucks | 28 | 24 | 31 | 21 |

Table 5.6 : Traffic data RR6

| Time | | Day 1 | | Day 2 |
|---|---|---|---|---|
| Vehicles | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. |
| Cars | 11 | 17 | 19 | 20 |
| Buses | 3 | 5 | 3 | 5 |
| 2-Wheels | 21 | 24 | 17 | 25 |
| Pickups | 6 | 8 | 9 | 4 |
| Trucks | 15 | 22 | 19 | 27 |

Table 5.7 : Traffic data RR7

| Time | | Day 1 | | Day 2 |
|---|---|---|---|---|
| Vehicles | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. |
| Cars | 17 | 19 | 15 | 18 |
| Buses | 5 | 4 | 5 | 4 |
| 2-Wheels | 18 | 11 | 16 | 14 |
| Pickups | 6 | 8 | 5 | 9 |
| Trucks | 7 | 4 | 11 | 5 |

Table 5.8 : Traffic data RR8

| Time | | Day 1 | | Day 2 |
|---|---|---|---|---|
| Vehicles | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. |
| Cars | 2 | 4 | 1 | 3 |
| Buses | 0 | 0 | 0 | 0 |
| 2-Wheels | 7 | 5 | 4 | 7 |
| Pickups | 0 | 0 | 1 | 1 |
| Trucks | 8 | 9 | 3 | 6 |

Table 5.9 : Traffic data RR9

| Time | | Day 1 | | Day 2 |
|---|---|---|---|---|
| Vehicles | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. |
| Cars | 13 | 9 | 10 | 11 |
| Buses | 0 | 0 | 0 | 0 |
| 2-Wheels | 11 | 15 | 16 | 12 |
| Pickups | 2 | 4 | 3 | 4 |
| Trucks | 7 | 6 | 4 | 6 |

Table 5.10 : Traffic data RR10

| Time | | Day 1 | | Day 2 |
|---|---|---|---|---|
| Vehicles | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. |
| Cars | 35 | 42 | 28 | 45 |
| Buses | 11 | 9 | 11 | 9 |
| 2-Wheels | 37 | 28 | 25 | 33 |
| Pickups | 9 | 11 | 13 | 10 |
| Trucks | 16 | 12 | 18 | 6 |

Table 5.11 : Traffic data RR11

| Time | | Day 1 | | Day 2 |
|---|---|---|---|---|
| Vehicles | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. |
| Cars | 28 | 19 | 21 | 14 |
| Buses | 5 | 2 | 5 | 2 |
| 2-Wheels | 28 | 34 | 19 | 24 |
| Pickups | 7 | 9 | 11 | 4 |
| Trucks | 5 | 2 | 3 | 2 |

Table 5.12 : Traffic data RR12

| | | Day 1 | | Day 2 |
|---|---|---|---|---|
| Vehicles | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. | 9 A.M. to 12 Noon | 2 P.M. to 5 P.M. |
| Cars | 7 | 11 | 13 | 9 |
| Buses | 0 | 0 | 0 | 0 |
| 2-Wheels | 8 | 7 | 11 | 4 |
| Pickups | 4 | 1 | 3 | 2 |
| Trucks | 5 | 4 | 3 | 6 |

# Annexure IV

# Characteristic Deflection and required present overlay

| | CSA(in msa) | Soil type | PI | Annual Rainfall | Moisture correction | Characterstic Deflec.(mm) | Reqd. Overlay |
|---|---|---|---|---|---|---|---|
| RR1 | 65.66MSA | Gravel | | 1518mm | 1.38 | 1.088mm | 100mm |
| RR2 | 70.2MSA | Clay | 13.6 | 1518mm | 1.85 | 0.825mm | 95mm |
| RR3 | 18.3MSA | Clay | 12.1 | 1518mm | 1.85 | 1.269mm | 105mm |
| RR4 | 17MSA | Gravel | | 1518mm | 1.38 | 0.66mm | 50mm |
| RR5 | 85.8MSA | Clay | 14.23 | 1518mm | 1.85 | 1.59mm | 180mm |
| RR6 | 105.36MSA | Gravel | | 1518mm | 1.38 | 0.99mm | 100mm |
| RR7 | 21.1MSA | Gravel | | 1518mm | 1.38 | 1.095mm | 160mm |
| RR8 | 10.4MSA | Gravel | | 1518mm | 1.38 | 0.9455mm | 30mm |
| RR9 | 12.6MSA | Gravel | | 1518mm | 1.38 | 1.323mm | 60mm |
| RR10 | 173.62MSA | Clay | 13.4 | 1518mm | 1.85 | 0.918mm | 200mm |
| RR11 | 18.6MSA | Gravel | | 1518mm | 1.38 | 1.59mm | 140mm |
| RR12 | 22MSA | Clay | 11.25 | 1518mm | 1.85 | 1.025mm | 50mm |

Table 6 : Characteristic deflection and present overlay

# Annexure V

# Predicted future characteristic deflection and overlay for year 2021

Table 7 : Characteristic deflection and overlay 2021

| Road | Characteristic Deflection | CBR | CSA | Structural Number | Future Deflection | Overlay | Pavement age |
|---|---|---|---|---|---|---|---|
| RR 1 | 1.088 | 28.45% | 65.66 msa | 3.3066 | 1.4037 mm | 125 mm | 7 yrs |
| RR 2 | 0.825 | 29.62% | 70.2 msa | 3.324 | 1.417 mm | 150 mm | 5 yrs |
| RR3 | 1.269 | 26.73% | 18.3 msa | 3.2778 | 1.4693 mm | 150 mm | 7 yrs |
| RR 4 | 0.66 | 30.76 | 17 msa | 3.3408 | 0.9165 mm | 60 mm | 6 yrs |
| RR 5 | 1.59 | 25.28% | 85.8 msa | 3.251 | 1.8898 mm | 220 mm | 6 yrs |
| RR 6 | 0.99 | 23.56% | 105.36 msa | 3.215 | 1.4318 mm | 200 mm | 7 yrs |
| RR 7 | 1.095 | 23.62% | 21.1 msa | 1.3177 | 3.2174 | 100 mm | 5 yrs |
| RR 8 | 0.9455 | 28.23% | 10.4 msa | 3.303 | 1.1435 mm | 70 mm | 6 yrs |
| RR 9 | 1.323 | 21.37% | 12.6 msa | 3.1644 | 1.5207 mm | 150 mm | 7 yrs |
| RR10 | 0.918 | 24.56% | 173.62msa | 3.236 | 1.52 | 250mm | 7years |
| RR 11 | 1.59 | 18.67% | 18.6 msa | 3.088 | 1.8107 mm | 160 mm | 6 yrs |
| RR 12 | 1.025 | 22.66% | 22 msa | 3.195 | 1.258 mm | 130 mm | 7 yrs |

# Annexure VI

# VDF value and vehicle class distribution in accordance to IRC:SP 72-2015

Table 8.1 Vehicle class distribution and VDF value for RR1

| **Class** | **VDF(ACC to IRC SP 72-2015)** |
|---|---|
| 9 laden HCV | 23.22 |
| 108 MCV | 33.48 |
| 50 partially laden HCV | 15.5 |
| | NET VDF= 72.2 |

Table 8.2 Vehicle class distribution and VDF value for RR2

| **Class** | **VDF** |
|---|---|
| 10 laden HCV | 25.8 |
| 102 partially laden HCV | 31.62 |
| 64 MCV | 19.84 |
| | NET VDF=77.26 |

Table 8.3 Vehicle class distribution and VDF value for RR3

| **Class** | **VDF** |
|---|---|
| 6 laden HCV | 15.48 |
| 39 Partially laden HCV | 12.09 |
| 42 MCV | 13.02 |
| | NET= 40.59 |

Table 8.4 Vehicle class distribution and VDF value for RR4

| **Class** | **VDF** |
| --- | --- |
| 4  Laden HCV | 10.32 |
| 30 for partially laden HCV | 9.3 |
| 57 MCV | 17.67 |
|  | NET=36.27 |

Table 8.5 Vehicle class distribution and VDF value for RR5

| **Class** | **VDF** |
| --- | --- |
| 15 laden HCV | 38.7 |
| 104 partially laden HCV | 32.24 |
| 64 MCV | 19.84 |
|  | NET VDF = 90.78 |

Table 8.6 Vehicle class distribution and VDF value for RR6

| **Class** | **VDF** |
| --- | --- |
| 18 Laden HCV | 46.44 |
| 110 Partially laden HCV | 34.1 |
| 71 MCV | 22 |
|  | NET VDF=102.54 |

Table 8.7 Vehicle class distribution and VDF value for RR7

| Class | VDF |
|---|---|
| 6 laden HCV | 15.48 |
| 45 Partially laden HCV | 13.95 |
| 44 MCV | 13.64 |
| | NET VDF=43.07 |

Table 8.8 Vehicle class distribution and VDF value for RR8

| Class | VDF |
|---|---|
| 5 Laden HCV | 12.9 |
| 40 Partially Laden HCV | 12.4 |
| 20 MCV | 6.2 |
| | NET VDF=31.5 |

Table 8.9 Vehicle class distribution and VDF value for RR9

| Class | VDF |
|---|---|
| 7 Laden HCV | 18.06 |
| 40 Partially Laden HCV | 12.4 |
| 20 MCV | 6.2 |
| | NET VDF=36.66 |

Table 8.10 Vehicle class distribution and VDF value for RR10

| Class | VDF |
|---|---|
| 20 Laden HCV | 51.6 |
| 148MCV | 46 |
| 96 Partiallly laden HCV | 29.76 |
| | NET VDF= 127.36 |

Table 8.11 Vehicle class distribution and VDF value for RR11

| Class | VDF |
|---|---|
| 5 Laden HCV | 12.9 |
| 29 partially laden HCV | 9 |
| 57 MCV | 17.67 |
| | NET VDF=39.57 |

Table 8.12 Vehicle class distribution and VDF value for RR12

| Class | VDF |
|---|---|
| 9 laden HCV | 23.22 |
| 41 Partially laden HCV | 12.76 |
| 42 MCV | 13.02 |
| | NET VDF=48.95 |

# Annexure VII

## Estimated cost comparison of regular maintenance of pavement and complete overlaying in year 2021 in accordance to PMGSY survey

Table 9 Cost Comparison of maintenance and overlay

| | Future Overlay in year 2021 | Age of pavement | Cost of regular maintenance (PMGSY) | Cost of Providing overlay(PMGSY) |
|---|---|---|---|---|
| RR1 | 125 mm | 7 yrs | 2.45lakhs | 4.45lakhs |
| RR2 | 150 mm | 5 yrs | 1.75lakhs | 5.087lakhs |
| RR3 | 150 mm | 7 yrs | 2.45lakhs | 5.087lakhs |
| RR4 | 60 mm | 6 yrs | 2.10lakhs | 2.03lakhs |
| RR5 | 220 mm | 6 yrs | 2.10lakhs | 7.79lakhs |
| RR6 | 200 mm | 7 yrs | 2.45lakhs | 6.65lakhs |
| RR7 | 100 mm | 5 yrs | 1.75lakhs | 3.39lakhs |
| RR8 | 70 mm | 6 yrs | 2.10lakhs | 2.30lakhs |
| RR9 | 150 mm | 7 yrs | 2.45lakhs | 5.08lakhs |
| RR10 | 250mm | 8yrs | 2.80lakhs | 6.88lakhs |
| RR11 | 160 mm | 6 yrs | 2.10lakhs | 5.42lakhs |
| RR12 | 130 mm | 7 yrs | 2.45lakhs | 4.35lakhs |