PAVEMENT EVALUATION AND DESIGN OF OVERLAY

Submitted in partial fulfilment of the requirements
for the degree of
Bachelor of Engineering

Mr. Dayatar Mohammad Sajid Aziz 15DCES66
Mr. Patel Saqib MohdHanif 15DCES80
Mr. Qureshi Mohd Subhan Mohd Miya 15DCES81

Under Guidance of
Prof. Tehsin Kazi

Department of Civil Engineering,
School of Engineering and Technology

Anjuman-I-Islam's Kalsekar Technical Campus
Plot No. 2 3, Sector – 16, Near Thana Naka, Khanda Gaon,
New-Panvel, Navi-Mumbai. 41026.

2017-2018

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CERTIFICATE

This is to certify that the project entitled *"***Pavement Evaluation And Design Of Overlay***"* is a bonafide work of "**Mr. Dayatar Mohammad Sajid Aziz (15DCES66), Mr. Patel Saqib MohdHanif (15DCES80), Mr. Qureshi Mohd Subhan Mohd Miya (15DCES81).**", submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of "Bachelor of Engineering" in Department of Civil Engineering.

(Prof. Tehsin Kazi)
Guide

(Dr. Rajendra Magar)
HOD

(Dr. Abdul Razak Honnutagi)
Director

PROJECT REPORT APPROVAL FOR B. E.

This project report entitled "**Pavement Evaluation And Design Of Overlay**" is a bonafide work of "**Mr. Dayatar Mohammad Sajid Aziz (15DCES66), Mr. Patel Saqib MohdHanif (15DCES80), Mr. Qureshi Mohd Subhan Mohd Miya (15DCES81).**"is approved for the degree of "**Bachelor of Engineering**" in "**Department of Civil Engineering**''

Examiners

1. …………………………

2. …………………………

Supervisors:

1. …………………………

2. …………………………

Date:

DECLARATION

I declare that this written submission represents my ideas in my own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Mr. Dayatar Mohammad Sajid Aziz (15DCES66)

Mr. Patel Saqib MohdHanif (15DCES80)

Mr. Qureshi Mohd Subhan Mohd Miya (15DCES81)

Date:

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We take this opportunity to thank all our professors and non-teaching staff who have directly or indirectly helped our project. We pay our respects and love to our parents and all other family members and friends for their love and encouragement throughout our career. Last but not the least we express our thanks to our friends for their cooperation and support.

ABSTRACT

In India, different types of pavement design have been observed. Most of the highways are having the flexible pavement. Pavement is designed to support the wheel load imposed on it from traffic moving over it. Additional stresses are also imposed by change in the climate. Pavement should be strong enough to resist the stresses and to distribute the external load. The study highlights the need of pavement evaluation and pavement evaluation measures for the road pavements of Road joining NH48 to NH548.

Present study also includes the collection of required field data like soil subgrade data, existing pavement structure, traffic data, pavement surface condition and rebound deflection by using BBD technique and laboratory investigations, and finally on the basis of data analysis, design of extra width of road and overlay thickness of the road pavement and strengthening of the pavement has been discussed for the same road stretch.

For road widening the existing traffic volume study carried out and compared with design standard volume as per IRC: 64-1990 guidelines and need of widening is justified. For structural evaluation the existing pavement condition has carried out by BBD technique and overlay design has carried out as per IRC: 81-1997 guidelines.

(**Keywords:** Pavement failure, Bituminous Roads, Traffic Study, Pavement Design, IRC 81)

TABLE OF CONTENTS

ANJUMAN - I - ISLAM'S KALSEKAR TECHNICAL CAMPUS, NEW PANVEL
ENGINEERING & TECHNOLOGY ARCHITECTURE PHARMACY
AIKTC
NAVI MUMBAI - INDIA

List of Figures

List of Tables

ANJUMAN - I - ISLAM'S KALSEKAR TECHNICAL CAMPUS, NEW PANVEL
ENGINEERING & TECHNOLOGY ARCHITECTURE PHARMACY
AIKTC
NAVI MUMBAI - INDIA

Chapter 1

Introduction

1.1 Background

Transportation infrastructure plays a lead role in economic growth and development of country. The road transport is the ancient and perhaps the most widely adopted mode of transport of mankind. The road transport witnessed a tremendous growth rate after independence of our country. Pavements are the key elements of infrastructure of the country, whose functions are to promote transport activities, economic activities and to improve the standard of living.

Flexible pavements are constructed of several layers of natural granular material covered with one or more waterproof bituminous surface layers, and as the name imply, is considered to be flexible. A flexible pavement will flex (bend) under the load of a tyre. The objective with the design of a flexible pavement is to avoid the excessive flexing of any layer, failure to achieve this will result in the over stressing of a layer, which ultimately will cause the pavement to fail. In flexible pavements, the load distribution pattern changes from one layer to another, because the strength of each layer is different. The strongest material (least flexible) is in the top layer and the weakest material (most flexible) is in the lowest layer. The reason for this is that at the surface the wheel load is applied to a small area, the result is high stress levels, deeper down in the pavement, the wheel load is applied to larger area, the result is lower stress levels thus enabling the use of weaker materials.

1.2 Pavement Functions

The primary functions of a pavement are to:

1. **Provide a reasonably smooth riding surface:** A smooth riding surface (Low Roughness) is essential for riding comfort, and over the years it has become the measure of how road users perceive a road.
2. **Provide adequate surface friction (skid resistance):** In addition to a riding comfort, the other road user requirement is that of safety. Safety, especially during wet conditions can be linked to a loss of surface friction between the tyre and the pavement surface. A pavement must therefore provide sufficient surface friction and texture to ensure road user safety under all conditions
3. **Protect the subgrade:** The pavement must have sufficient structural capacity (strength and thickness) to adequately reduce the actual stresses so that they do not exceed the strength of the subgrade.
4. **Provide waterproofing:** The pavement surfacing acts as a waterproofing surface that prevent the underlaying support layers including the subgrade from becoming saturated through moisture ingress.

1.3 Problem Statement

Flexible pavements undergo functional deterioration as well as structural deterioration simultaneously due to the combine effects of climate, environment and traffic loads. The functional deterioration is indicated by the changes in surface condition of the pavement in the form of deterioration in the riding quality, which can be measured by simple methods; it is also possible to restore the surface to original condition of the pavement by providing a profile correction course and a resurfacing layer.

The rate of structural deterioration of flexible pavement depends on several factors such as (a) the stability of the existing pavement structure and the component layers (b) magnitude and re-operation of traffic wheel loads (c) growth rate of traffic loads (d) effective functioning of pavement drainage system and severity of the climatic and environment factors.

1.3.1 Factors influencing the performance of a pavement

1. **Traffic:** Traffic is the most important factor influencing pavement performance. The performance of pavements is mostly influenced by the loading magnitude, configuration and the number of load repetitions by heavy vehicles. The damage caused per pass to a pavement by an axle is defined relative to the damage per pass of a standard axle load.
2. **Moisture (water):** Moisture can significantly weaken the support strength of natural gravel materials, especially the subgrade. Moisture can enter the pavement structure through cracks and holes in the surface, laterally through the subgrade, and from the underlying water table through capillary action. The result of moisture ingress is the lubrication of particles, loss of particle interlock and subsequent particle displacement resulting in pavement failure.
3. **Subgrade:** The subgrade is the underlying soil that supports the applied wheel loads. If the subgrade is too weak to support the wheel loads, the pavement will flex excessively which ultimately causes the pavement to fail. If natural variations in the composition of the subgrade are not adequately addressed by the pavement design, significant differences in pavement performance will be experienced.
4. **Construction quality:** Failure to obtain proper compaction, improper moisture conditions during construction, quality of materials, and accurate layer thickness (after compaction) all directly affect the performance of a pavement. These conditions stress the need for skilled staff, and the importance of good inspection and quality control procedures during construction.
5. **Maintenance:** Pavement performance depends on what, when, and how maintenance is performed. No matter how well the pavement is built, it will deteriorate over time based upon the mentioned factors. The timing of maintenance is very important, if a pavement is permitted to deteriorate to a very poor condition.

1.4 Needs of Study

1. Regular management and maintenance must be undertaken to enhance the quality of the road.
2. To evaluate the strength and resilience to distress that get developed with time due to increase in traffic volume and to give remedial measures to check their degradation by designing the required overlay thickness.
3. To provide a satisfactory riding quality to the road users.
4. To reduce number of accidents.
5. To ensure safe and efficient movement of traffic.

1.5 Objectives

The aim and objective of our project is to evaluate structural stability of the selected flexible pavement and to recommend suitable maintenance work required (evaluate the necessity of strengthening and overlay design). Provide a satisfactory riding quality to the road users, reduce accidents and ensure safe and efficient movement of traffic.

1.6 Scope of Study

1. To carry out traffic volume survey and data analysis to get information about PCU/day & widening of road.
2. To evaluate structural stability of the pavement with Benkelman beam test.
3. To obtain sub grade soil characteristics for design of proposed overlay pavement.

Chapter 2

Review of Literature

2.1 Introduction

For strengthening of flexible pavement researchers have found large literature over the world based on different techniques, methods, models, tests, IRC code standard, HCM manual, LOS, software etc. for different case studies. Few among them have studied on pavement deterioration, distresses, rehabilitation, maintenance, overlay, capacity of road, traffic flow characteristic, traffic congestion, etc. for strengthening & widening of flexible pavement.

2.2 Research studies

2.2.1 Sharad.S.Adlinge., and Prof.A.K.Gupta

"Pavement Deterioration and its Causes"

In this paper Pavement failure is defined in terms of decreasing serviceability caused by the development of cracks and ruts. The purpose of this study was to evaluate the possible causes of pavement distresses, and to recommend remedies to minimize distress of the pavement. The paper describes lessons learnt from pavement failures and problems experienced during the last few years on a number of projects in India. Based on the past experiences various pavement preservation techniques and measures are also discussed which will be helpful in increasing the serviceable life of pavement.

This research conclusion, the causes of pavement deterioration are: Sudden increase in traffic loading especially on new roads where the design is based on lesser traffic is a major cause of cracking. After construction of good road, traffic of other roads also shifts to that road. This accelerates the fatigue failure (Alligator Cracking). Temperature variation ranging from 50º C to below zero conditions in the plain areas of North and Central India leads to bleeding and cracking. Provision of poor shoulders leads to edge failures. Provision of poor clayey subgrade results in corrugation at the surface and increase in unevenness. Poor drainage conditions especially during rainy seasons, force the water to enter the pavement from the sides as well as from the top surface. In case of open graded bituminous layer, this phenomenon becomes more dangerous and the top layer gets detached from the lower layers. If the temperature of bitumen/bituminous mixes is not maintained properly, then it also leads to pavement failure. Overheating of bitumen reduces the binding property of bitumen. If the temperature of bituminous mix has been lowered down then the compaction will not be proper leading to longitudinal corrugations.

2.2.2 Vivek Pagey., A.K.Singhai and R.K.Yadav

"A Field Study on Causes of Failure of Bituminous Pavements (Jabalpur to Patan road)"

A detailed field study was conducted by the authors to find out the various causes of the failure of the road.

The study was carried out in following stages:

1. Preliminary Survey or Reconnaissance
2. Detailed Field Study and Sample Collection
3. Laboratory Tests

After the study the data was analyzed to find the causes of the failure of the study road. Conclusions were drawn based on the data obtained from the field study and laboratory tests and recommendations were put forward to prevent such types of failures.

The design was done as per the Indian Road Congress (IRC) standards. The code used was IRC: 37- 2001 for the design of the above mention pavement.

This research conclusion, The daily traffic volume has increased considerably on the study road. It has increased by more than 100% as per the traffic study done during the study in the year 2012. This increase in the traffic took place in a very short span of time. The increment in the design traffic is phenomenal in terms of commercial vehicles per day. Prior to the design of the road, the average traffic volume was around 270 commercial vehicles per day in the year 2003 which got increased to around 543 commercial vehicles per day. The road was not at all able to bear such a heavy traffic load which caused the failure of the study road.

There were some other reasons identified for the failure of the study road: The CBR values of the subgrade, determined in the laboratory were below the designed CBR value of 7 %. Low CBR values cause uneven settlement of the different pavement layers causes rutting and undulations on the top surface of the pavement. The width of the carriageway was kept 3.75 m in the study road with unpaved shoulders on both sides of the carriageway. The crossing of heavy vehicles became a big problem which further damage and scarify the sides of the bituminous layer. The soil below the subgrade was found to be the Black Cotton soil, which exhibits the characteristics of the excessive swelling in presence of moisture and shrinkage in the absence of moisture. The soil also exerted heavy swelling pressure on the subgrade and made it vulnerable and susceptible to failure. The shoulders were found not properly compacted due to whuch rain water started accumulating in the ruts created on the shoulders and the slowly entered the pavement layers caused damages to it. The relative compaction of various layers was also found less than 98 % in some cases which is not desirable from the point of view of road construction.

2.2.3 Rokade S., Agarwal P. K., and Shrivastava R. (2010)

"Study on Performance of Flexible Highway Pavements"

In this research they have studied on functional and structural evaluation at 4 National highways and 1 State highway, in the structural evaluation the pavement deflection was measured in flexible pavement by the Benkelman Beam technique. It is possible to measure the residual & rebound deflections of the pavement structure. While for pavement performance the rebound deflection is one related it, 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. For overlay design the rebound deflection is used. The present study objective is to carry out the various studies on at flexible National Highways and State Highway near Bhopal to evaluate the performance (in service behavior).

They have done performance data of existing pavement according to Benkelman beam deflection and also given the basic principles of method of deflection and technique of Benkelman beam deflection that how can perform a test according to standard specification.

This research concludes that the traffic volume study indicate that in case of NH 12, NH 69, NH 3, NH 86 and SH 23, the traffic is of very high intensity and also heavy axle load vehicles ply on the roads. The heavy axle loads on the road are leading to its premature failure and distresses like rutting, cracking, localized depressions etc. The drainage system both longitudinal and transverse are inefficient and is not working properly especially for NH 3 and NH 86 leading to failures pertaining to improper drainage system, namely Pot holes, Stripping etc. On all the five stretches, the Benkelman beam study was conducted and structural inadequacy was found in the sections of all the five stretches i.e. NH12, NH69, NH3, NH86& SH23.The Pavement Performance or evaluation Study will help in arriving at the most appropriate overlay &maintenance activity or remedial measures, suitable for a particular section of the road.

2.2.4 G. Bhatt Mayank, Amit Vankar, Dr L.B. Zala (2013)

"Structural Evaluation Using Benkelman Beam Deflection Technique And Rehabilitation of Flexible Pavement For State Highway 188 (Sarsa Junction to Vasad Junction)"

In this research they have studied on structural evaluation. 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 detail pavement condition survey is done on state highway 188 (sarsa junction to vasad junction) and the road condition is evaluated structurally. The present study is evaluates the overlay thickness for state highway 188 sarsa junction to vasa junction.

In this they have done pavement performance data like as visual survey data, structural evaluation of pavement by Benkelman beam, existing pavement composition and soil sampling & testing and finally given the overlay thickness design.

The conclusion of research, the visual observation for cracks, potholes, raveling and stripping can explain weak sports of pavement. The Benkelman beam study was conducted on all the selected section of SH: 188 from sarsa to vasad junction of the road and structural inadequacy were found in all the sections. There is needed to go for measures such as an overlay on all the sections of SH: 188 form sarsa to vasad junction. The overlay thicknesses in terms of bituminous macadam were found for all the stretches, it ranges from 110mm to 210mm. The visual observation and Benkelman beam deflection correlates each other.

2.2.5 A.A. Patel and Dhaval V. Lad (2015)

"Pavement Evaluation by Benkelman Beam of State Highway Section (Waghodiya Crossing To Limda)"

In this structural evaluation of flexible pavement deflection by the Benkelman Beam is measured. Rebound deflection is used for overlay design. A detailed pavement condition survey is done on State Highway 158 (Waghodiya crossing to Limda) and the road condition is evaluated structurally. Their present study is evaluates the overlay thickness for State Highway 158 Waghodiya crossing to Limda.

This studied method in they have carried out visual survey and structural survey. In visual survey find Rutting, Patching and Pothole. And in structural survey find deflection by Benkelman beam deflection test.

Finally conclusion based on visual observation for rutting, patch work, potholes and cracks are weak spots of pavement was given. Calculate the overlay thickness on existing flexible pavement in terms of bituminous macadam by BBD technique. The visual observation and Benkelman beam deflection correlates each other as per the IRC81 1997 guideline.

2.2.6 Umersalam, Alsana Bashir. Dr. Mohammad Shafi Mir and Tanzeer Rashid (2015)

"Evaluation and Strengthening of Reconstructed Roads Excavated for Utilities Using Benkelman Beam Deflection (BBD) Technique (A Case Study)"

In this research they have focus on need of pavement evaluation and pavement evaluation measures for the road pavements of urban areas in Kashmir. The collection of required field data such as subgrade data of soil, existing pavement structure, traffic data, surface condition of pavement and rebound deflection by using BBD technique, laboratory investigations and finally the design of the overall thickness of the road pavement and overlay whatsoever required to strengthen the road stretches. In this given compassion between newly propose thickness and existing pavement thickness.

The methodology of studied is divided in major two part first one is to collection of survey and traffic data and second one is data analysis and design. And overall methodology like as survey for the classification of pavement, evaluation of soil subgrade and existing pavement thickness, traffic survey, actual measurement of deflection using Benkelman beam, correction factors for temperature, design of required overlay thickness and evaluation of pavement.

Conclusion of research, on performing the pavement deflection survey it was found that site 1 & 2 require overlay thicknesses of 95 mm and 60 mm respectively for strengthen them. The pavement was not designed properly taking all the considerations & recommendations of IRC. Water affects the entire serviceability of a road. No proper camber is present.

2.3 IRC Code

2.3.1 IRC: 37-2012 "GUIDELINES FOR THE DESIGNING OF FLEXIBLE PAVEMENTS"

In IRC: 37-2012 the following guidelines or contents are there like Traffic Growth Rate, Design pavement Life, Vehicle Damage Facto, Distribution of Commercial Traffic Over the Carriageway, Computation of Design Traffic, Principles of pavement design, Pavement model, Different layers of a flexible pavement and location of strain, Methodology, Fatigue model, Rutting in pavement, Rutting model, Computation for performance criterion, Fatigue strain calculation, Rutting strain calculation, Determination of modulus of elasticity of three layers, Computation of granular layer modulus, Modulus of bituminous layer and Calculation procedure using IIT PAVE.

2.3.2 IRC: 64-1990 "GUIDELINES FOR CAPACITY OF ROADS IN RURAL AREAS"

In IRC: 64-1990 following information are there Speed-Flow Relationships, Level of Service (LOS), Capacity and Design Service Volume, Equivalency Factors, Recommended Design Service Volumes for Single Lane Roads, Recommended Design Service Volumes for Intermediate Lane Roads, Recommended Design Service Volumes for Two Lane Roads and Recommended Design Service Volume for Multi-Lane Roads.

2.3.3 IRC: 81-1997 "GUIDELINES FOR STRENGTHENING OF FLEXIBLE ROAD PAVEMENTS USING BENKELMAN BEAM DEFLECTION TECHNIQUE"

In the code following contents or guidelines are available as Basic principles of deflection method, Procedure for deflection survey, Pavement condition survey, Criteria for classification of pavement sections, Performa for recording field information collected during the pavement condition Survey, Criteria of standard size, loading and type of truck, Deflection measurements, Performa for recording pavement deflection data, Correction for temperature variations, Correction for seasonal variation, Moisture correction factor, Traffic growth rate, Design life, Computation of design traffic, Distribution of commercial traffic over the carriageway, Vehicle damage factor, Analysis of data for overlay design, Characteristic deflection, Design of overlay, Overlay thickness design curves, Static load deflection test procedure, Equipment and Deflections are corrected formula.

Chapter 3

Methodology

Methodology involves, Selecting Flexible Pavement with fail condition. (Road joining NH48 with NH548). Visual and traffic volume study survey for determination of deteriorations and surface failure. Laboratory tests for determination of sub-grade condition. Pavement deflection survey. Data analysis. Pavement design (New, Overlay). Result, conclusion and Recommendations.

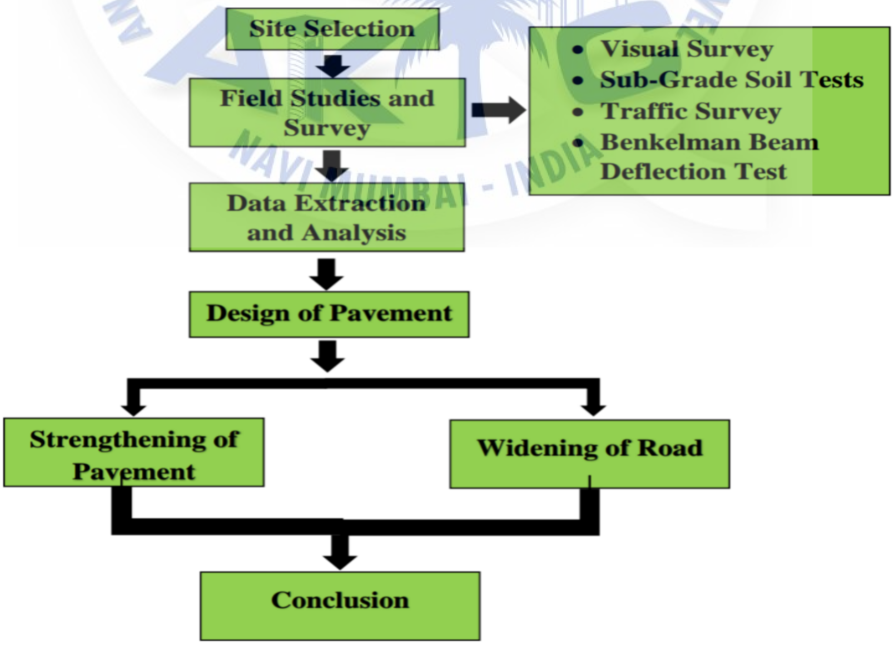

Fig 3.1: Methodology Chart

3.1 Site selection

We have selected the road pavement passing by our college and on which we daily use to travel for college. The pavement surface is flexible pavement with bad condition i.e disintegrations and even uneven settlements are seen on the surface. The road is not heavily traffic condition but in future it will be a tremendous increase in traffic due to institutes and development of nearby areas.

Fig 3.2: Site plan

The salient features of the Road Section are:

1. Length of the stretch: 650 m.
2. Type of Pavement: Bituminous.
3. Width of carriageway: 7 m.
4. No. of lanes: 2 lanes.
5. Divided/Undivided: Divided.
6. Type of Shoulder: Unpaved Shoulder.
7. Surrounding Environment: Rural.
8. Type of traffic: Mixed traffic.

3.2 Pavement Condition Survey

This phase of operation, which shall precede the actual deflection measurement, consists primarily of visual observations supplemented by simple using below Table 3.1. The length of the pavement was divided into section of 100 m and the inspection was carriod out for both way.

Sr. No.	Cracking (A)	Surface Deformation (B)	Disintegration (C)	Surface Defect (D)
1	Fatigue	Rutting	Potholes	Ravelling
2	Longitudinal	Corrugation	Patches	Bleeding
3	Transverse	Shoving		Polishing
4	Block	Depression		
5	Slippage	swell		
6	Reflective			
7	Edge			

Table 3.1: Reference table for identification of pavement deterioration

3.2.1 Types of pavement deterioration

The four major categories of common asphalt pavement surface distresses are:

A. Cracking.
B. Surface deformation.
C. Disintegration.
D. Surface defects.

A. Cracking

The most common types of cracking are:

1. **Fatigue cracking:** Fatigue cracking is commonly called alligator cracking. This is a series of interconnected cracks creating small, irregular shaped pieces of pavement. It is caused by failure of the surface layer or base due to repeated traffic loading (fatigue).

2. **Longitudinal cracking:** Longitudinal cracks are long cracks that run parallel to the center line of the roadway. These may be caused by frost heaving or joint failures, or they may be load induced.

3. **Transverse cracking:** Transverse cracks form at approximately right angles to the centerline of the roadway. They are regularly spaced and have some of the same causes as longitudinal cracks. Transverse cracks will initially be widely spaced (over 20 feet apart). They usually begin as hairline or very narrow cracks and widen with age.

4. **Block cracking:** Block cracking is an interconnected series of cracks that divides the pavement into irregular pieces. This is sometimes the result of transverse and longitudinal cracks intersecting. They can also be due to lack of compaction during construction.

5. **Slippage cracking:** Slippage cracks are half-moon shaped cracks with both ends pointed towards the oncoming vehicles. They are created by the horizontal forces from traffic. They are usually a result of poor bonding between the asphalt surface layer and the layer below.

6. **Reflective cracking:** Reflective cracking occurs when a pavement is overlaid with hot mix asphalt concrete and cracks reflect up through the new surface. It is called reflective cracking because it reflects the crack pattern of the pavement structure below.

7. **Edge cracking:** Edge cracks typically start as crescent shapes at the edge of the pavement. They will expand from the edge until they begin to resemble alligator cracking. This type of cracking results from lack of support of the shoulder due to weak material or excess moisture.

B. Surface deformation

Pavement deformation is the result of weakness in one or more layers of the pavement that has experienced movement after construction. The deformation may be accompanied by cracking. Surface distortions can be a traffic hazard.

The basic types of surface deformation are:

1. **Rutting:** Rutting is the displacement of pavement material that creates channels in the wheel path. Very severe rutting will actually hold water in the rut. Rutting is usually a failure in one or more layers in the pavement. The width of the rut is a sign of which layer has failed. A very narrow rut is usually a surface failure, while a wide one is indicative of a subgrade failure.

2. **Corrugation:** Corrugation is referred to as wash boarding because the pavement surface has become distorted like a washboard. The instability of the asphalt concrete surface course may be caused by too much asphalt cement, too much fine aggregate, or rounded or smooth textured coarse aggregate.

3. **Shoving:** Shoving is also a form of plastic movement in the asphalt concrete surface layer that creates a localized bulging of the pavement. Locations and causes of shoving are similar to those for corrugations.

4. **Depressions:** Depressions are small, localized bowl-shaped areas that may include cracking. Depressions cause roughness, are a hazard to motorists, and allow water to collect. Depressions are typically caused by localized consolidation or movement of the supporting layers beneath the surface course due to instability.

5. **Swell:** A swell is a localized upward bulge on the pavement surface. Swells are caused by an expansion of the supporting layers beneath the surface course or the subgrade. The expansion is typically caused by frost heaving or by moisture.

C. Disintegration

The progressive breaking up of the pavement into small, loose pieces is called disintegration.

The two most common types of disintegration are:

1. **Potholes:** Potholes are bowl-shaped holes similar to depressions. They are a progressive failure. First, small fragments of the top layer are dislodged. Over time, the distress will progress downward into the lower layers of the pavement. Potholes are often located in areas of poor drainage. Potholes are formed when the pavement disintegrates under traffic loading, due to inadequate strength in one or more layers of the pavement, usually accompanied by the presence of water.

2. **Patches:** A patch is defined as a portion of the pavement that has been removed and replaced. Patches are usually used to repair defects in a pavement or to cover a utility trench. Patch failure can lead to a more widespread failure of the surrounding pavement.

D. Surface defects

Surface defects are related to problems in the surface layer. The most common types of surface distress are:

1. **Ravelling:** Ravelling is the loss of material from the pavement surface. It is a result of insufficient adhesion between the asphalt cement and the aggregate. Initially, fine aggregate breaks loose and leaves small, rough patches in the surface of the pavement. As the disintegration continues, larger aggregate breaks loose, leaving rougher surfaces.

2. **Bleeding:** Bleeding is defined as the presence of excess asphalt on the road surface which creates patches of asphalt cement. Excessive asphalt cement reduces the skid-resistance of a pavement, and it can become very slippery when wet, creating a safety hazard. Bleeding occurs more often in hot weather when the asphalt cement is less viscous (more flowable) and the traffic forces the asphalt to the surface. Figure 13 shows an example of bleeding during hot weather.

3. **Polishing:** Polishing is the wearing of aggregate on the pavement surface due to traffic. It can result in a dangerous low friction surface. A thin wearing course will repair the surface.

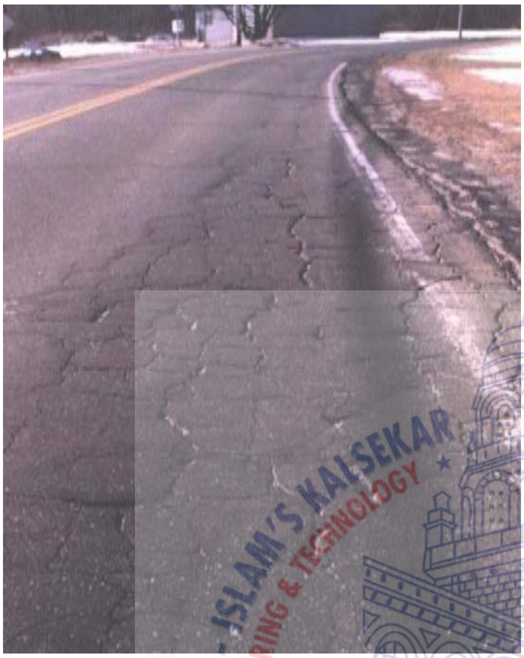

Fig 3.3: High Severity Alligator Cracking

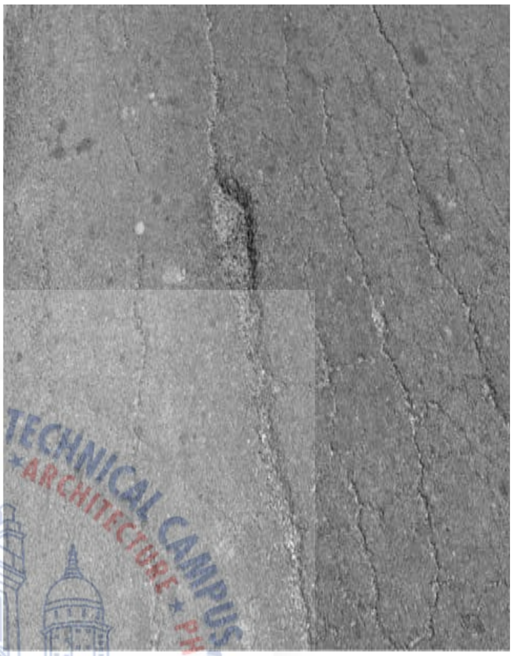

Fig 3.4: Longitudinal Cracking

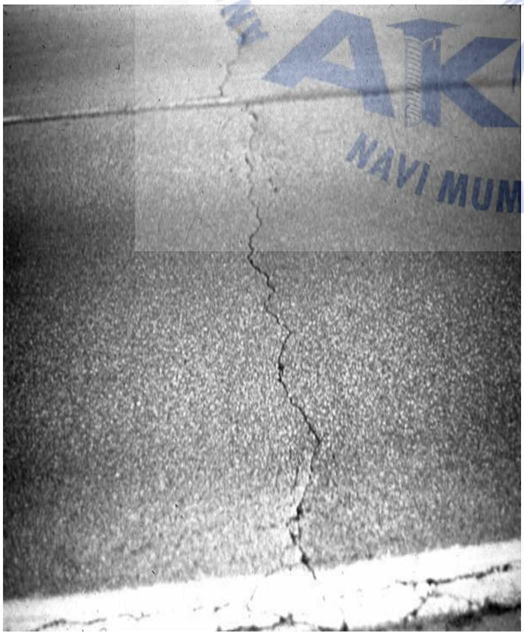

Fig 3.5: Low Severity Transverse Crack

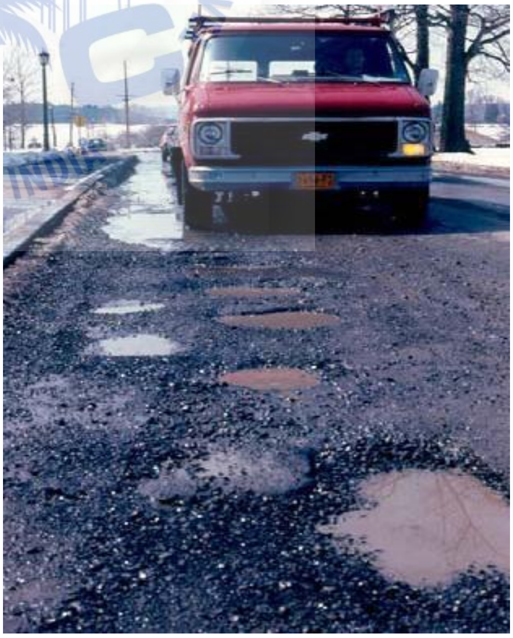

Fig 3.6: Potholes Caused by Poor Drainage

Fig 3.7: High Severity Ravelling Of Asphalt Surface

3.3 Traffic survey

Traffic in terms of million standard axle shall be considered for the design of overlay. If sufficient data are available at the stretch with respect to the wheel load distribution of commercial vehicles or the vehicle damage factor and their transverse placement, the cumulative standard axles may be worked out based on actual data, otherwise design traffic may be calculated as per the procedure given in IRC:37 and IRC: 81.

Estimate of the initial daily average traffic flow for any road should normally be based on 7-day 24-hours classified traffic counts. However, in exceptional cases where this information is not available 3-day count could be used.

3.3.1 Traffic growth rate

An estimate of likely growth rate can be obtained as follows:

a. By studying the past trend in traffic growth.
b. Elasticity of transport demand.
c. If adequate data is not available, it is recommended that an average value of 7.5 percent may be adopted for roads in rural routes.

3.3.2 Design life

It is recommended that the design life for strengthening of major roads should be at least 10 years. Less important roads may however be designed for a shorter design period but not less than 5 years in any case.

3.3.3 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 estimates of the initial volume of commercial vehicles per day, lateral distribution of traffic, the growth rate, the design life in years and the vehicle damage factor (number of standard axle per commercial vehicle) to convert commercial vehicles to standard axles.

The following equation may be used to make the required calculation.

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

Where,

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

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

r = Annual growth rate of commercial vehicles

n = Design life in years

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

3.3.4 Vehicle damage factor

The vehicle damage factor (VDF) is a multiplier for converting the number of commercial vehicles of different axle loads to the number of standard axle-load repetitions. The vehicle damage factor is arrived at from axle-load surveys on typical road sections so as to cover various influencing factors such as traffic mix, type of transportation, type of commodities carried, time of the year, terrain, road condition and degree of enforcement. The AASTHO axle load equivalence factors may be used for converting the axle load spectrum to an equivalent number of standard axles. For designing a strengthening layer on an existing road pavement, the vehicle damage factor should be arrived at carefully by using the relevant available data or carrying out specific axle load surveys depending upon importance of the project. The designer should take the exact value of VDF after conducting the axle load survey particularly in the case of major projects. Where sufficient information on axle load is not available, the tentative indicative values of vehicle damage factor as given in Table 3.2 may be used.

Initial traffic intensity in terms of number of commercial vehicles per day (Traffic range)	Terrain	
	Rolling/Plain	Hilly
0-150	1.5	0.5
150-1500	3.5	1.5
more than 1500	4.5	2.5

Table 3.2: Indicative VDF Values

3.4 Sub-Grade Soil Tests

The materials will be obtained from the nearby borrow areas, where plenty amount of material is available for the construction purpose. The material which is collected for testing will be different in location every 250 meters between stretched, so that the material was separately tested in the laboratory so as to design the soil sub grade.

3.4.1 Atterberg Limits Test (Is 2720- Part 5)

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

Standard Reference: IS 2720- PART 5 Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Equipment: Liquid limit device, Flat grooving tool with gage, Eight moisture cans, Balance, Glass plate, Spatula, Wash bottle filled with distilled water, Drying oven set at 105°C.

Test Procedure:

Liquid Limit:

1. Take roughly 3/4 of soil and place it into the mould. Assume that the soil was previously passed through a No. 40 sieve, air-dried, and then pulverized. Thoroughly mix the soil with a small amount of distilled water until it appears as a smooth uniform paste. Cover the dish with cellophane to prevent moisture from escaping.
2. Weigh four of the empty moisture cans with their lids, and record the respective weights and can numbers on the data sheet.

3. Adjust the liquid limit apparatus by checking the height of drop of the cup. The point on the cup that comes in contact with the base should rise to a height of 10 mm. The block on the end of the grooving tool is 10 mm high and should be used as a gage. Practice using the cup and determine the correct rate to rotate the crank so that the cup drops approximately two times per second.
4. Place a portion of the previously mixed soil into the cup of the liquid limit apparatus at the point where the cup rests on the base. Squeeze the soil down to eliminate air pockets and spread it into the cup to a depth of about 10 mm at its deepest point. The soil pat should form an approximately horizontal surface.
5. Use the grooving tool carefully cut a clean straight groove down the center of the cup. The tool should remain perpendicular to the surface of the cup as groove is being made. Use extreme care to prevent sliding the soil relative to the surface of the cup.
6. Make sure that the base of the apparatus below the cup and the underside of the cup is clean of soil. Turn the crank of the apparatus at a rate of approximately two drops per second and count the number of drops, N, it takes to make the two halves of the soil pat come into contact at the bottom of the groove along a distance of 13 mm (1/2 in.).
7. Take a sample, using the spatula, from edge to edge of the soil pat. The sample should include the soil on both sides of where the groove came into contact. Place the soil into a moisture can cover it. Immediately weigh the moisture can containing the soil, record its mass, remove the lid, and place the can into the oven. Leave the moisture can in the oven for at least 24 hours. Place the soil remaining in the cup into the porcelain dish. Clean and dry the cup on the apparatus and the grooving tool.
8. Remix the entire soil specimen in the porcelain dish. Add a small amount of distilled water to increase the water content so that the number of drops required closing the groove decrease.
9. Repeat steps six, seven, and eight for at least two additional trials producing successively lower numbers of drops to close the groove. One of the trials shall be for a closure requiring 25 to 35 drops, one for closure between 20 and 30 drops, and one trial for a closure requiring 15 to 25 drops. Determine the water content from each trial by using the same method used in the first laboratory. Remember to use the same balance for all weighing.

Plastic Limit:

1. Weigh the remaining empty moisture cans with their lids, and record the respective weights and can numbers on the data sheet.
2. Take the remaining 1/4 of the original soil sample and add distilled water until the soil is at a consistency where it can be rolled without sticking to the hands.
3. Form the soil into an ellipsoidal mass. Roll the mass between the palm or the fingers and the glass plate. Use sufficient pressure to roll the mass into a thread of uniform diameter by using about 90 strokes per minute. (A stroke is one complete motion of the hand forward and back to the starting position.) The thread shall be deformed so that its diameter reaches 3.2 mm (1/8 in.), taking no more than two minutes.

4. When the diameter of the thread reaches the correct diameter, break the thread into several pieces. Knead and reform the pieces into ellipsoidal masses and reroll them. Continue this alternate rolling, gathering together, kneading and rerolling until the thread crumbles under the pressure required for rolling and can no longer be rolled into a 3.2 mm diameter thread.
5. Gather the portions of the crumbled thread together and place the soil into moisture can, and then cover it. If the can does not contain at least 6 grams of soil, add soil to the can from the next trial (See Step 6). Immediately weigh the moisture can containing the soil, record its mass, remove the lid, and place the can into the oven. Leave the moisture can in the oven for at least 24 hours.
6. Repeat steps three, four, and five at least two more times. Determine the water content from each trial by using the same method used in the first laboratory. Remember to use the same balance for all weighing.

Analysis:

Liquid Limit:

1. Calculate the water content of each of the liquid limit moisture cans after they have been in the oven for at least 24 hours.
2. Plot the number of drops, N, (on the log scale) versus the water content (w). Draw the best-fit straight line through the plotted points and determine the liquid limit (LL) as the water content at 25 drops.

Plastic Limit:

1. Calculate the water content of each of the plastic limit moisture cans after they have been in the oven for at least 24 hours.
2. Compute the average of the water contents to determine the plastic limit, PL.
3. Calculate the plasticity index, PI=LL-PL.

Report the liquid limit, plastic limit, and plasticity index to the nearest whole number, omitting the percent designation.

Plastic Limit (PL) = Average of water content

Plasticity Index (Pl) = LL – PL

Fig 3.8: Atterberg Limit Test

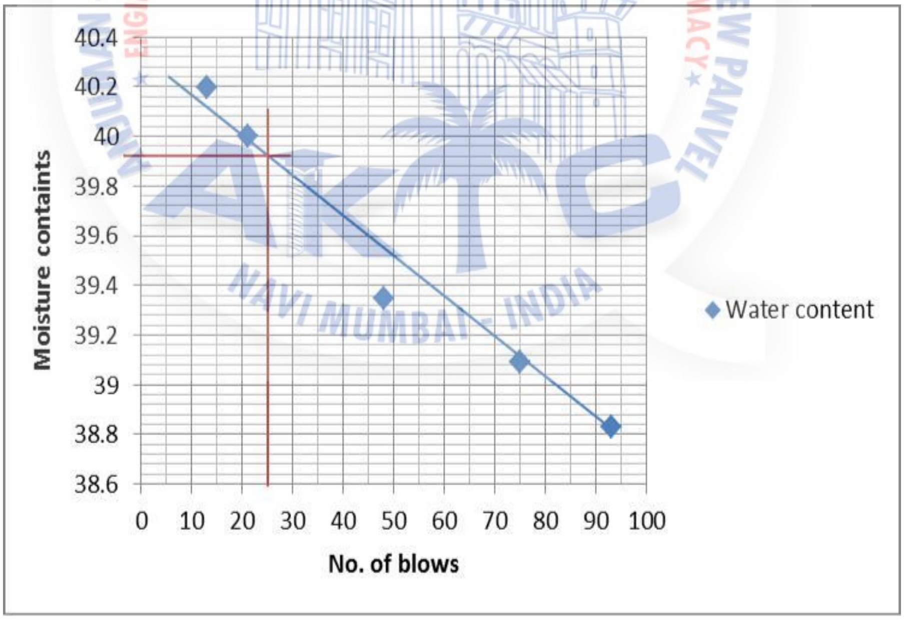

Fig 3.9: Typical Liquid limit test Curve

3.5 Structural Evaluation of Pavements by Benkelman Beam

3.5.1 Basic Principle of Deflection Method

Performance of flexible pavements is closely related to the elastic deflection of pavement under the wheel loads. The deformation or elastic deflection under a given load depends upon sub grade soil type, its moisture content and compaction, the thickness and quality of pavement courses, drainage conditions, pavement surface temperature etc. Pavement deflection is measured by the Benkelman Beam which consists of a slender beam 3.66m long pivoted at a distance of 2.44 m from the tip. By suitably placing the probe between the dual wheels of the 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 legs of the beam. Rebound deflection is used influence of the deflection bowl on the front for overlay design.

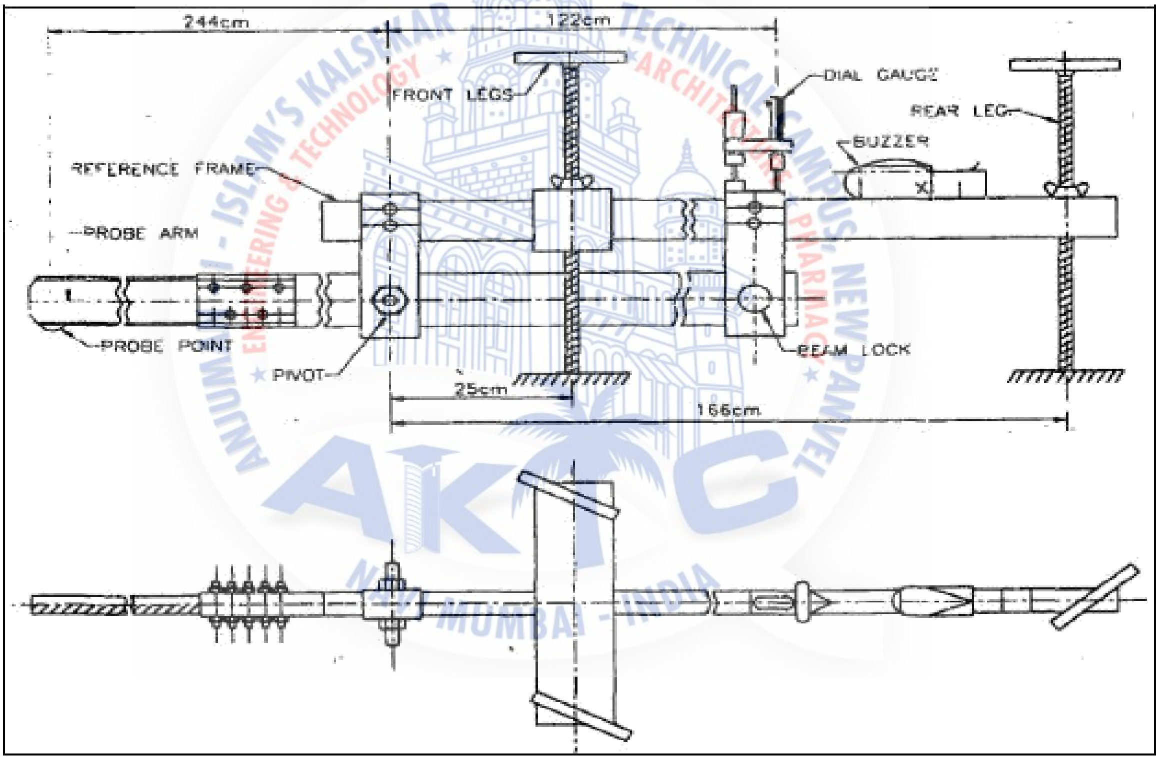

Fig 3.10: Benkelman Beam

3.5.2 Procedure of Structural Evaluation for Benkelman Beam Deflection

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 centered above the selected point.
3. The probe of the Benkelman beam is inserted between the duals and placed on the selected 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 270 cm 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 is recorded when the rate of recovery of pavement is equal to or less than 0.025 mm 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 the day and adjusted to the standard, if necessary.

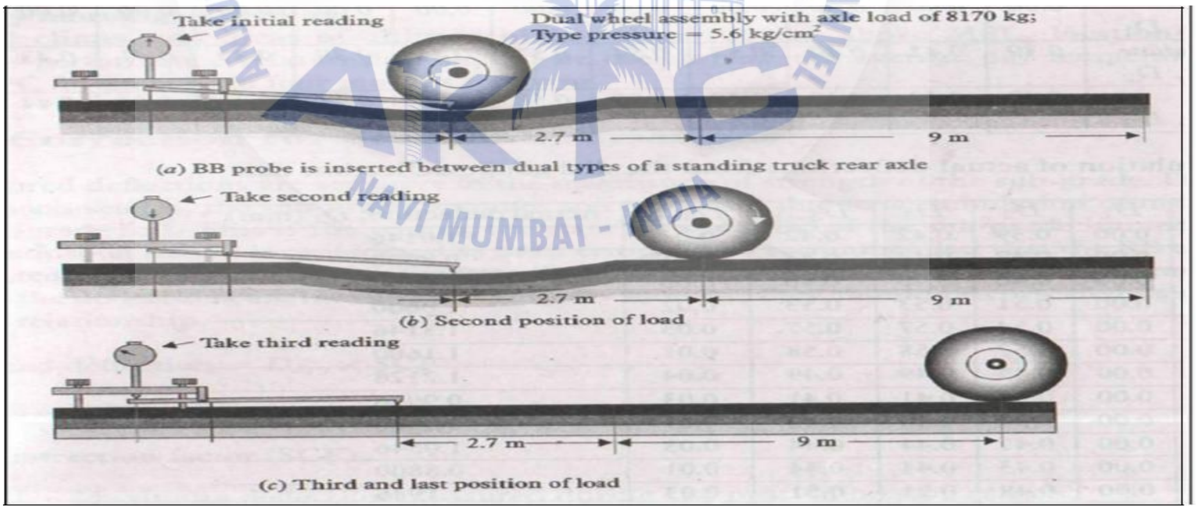

Fig 3.11: Position of Standard Loaded Truck During Deflection Measurement

3.6 Design of pavement thickness

The PCU/day will be calculated by traffic volume study and accordingly wether widening of existing road is required or not.

If widening is not required then from the Benkelman Deflection test readings and overlay curve from IRC 81 the overlay need to be designed.

Chapter 4

Data Collection and Analysis

4.1 Pavement Condition Survey

The following observation were recorded while performing visual inspection on the sections of pavement. The observation were recorded in the below Table 4.1 with ref to Table 3.1.

Fig 4.1: Potholes on selected pavement surface

Fig 4.2: Ravelling on selected pavement surface

Fig 4.3: Patching on selected pavement surface

Fig 4.4: Edge cracking on selected pavement surface

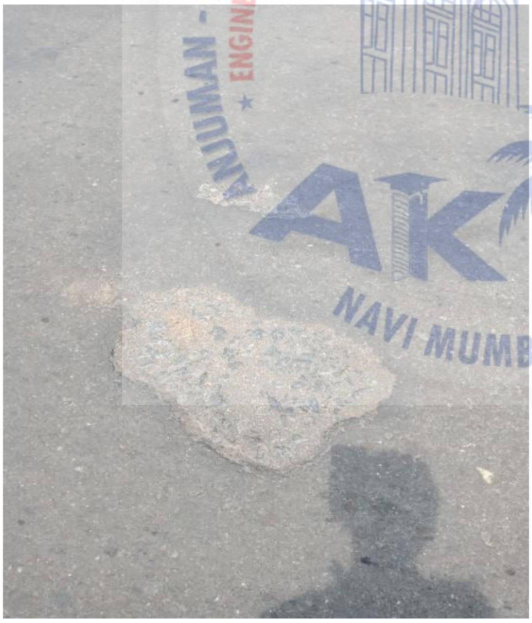

Fig 4.5: Depressions on selected pavement surface

Fig 4.6: Longitudinal cracking on selected pavement surface

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Fig 4.7: Performing pavement condition survey

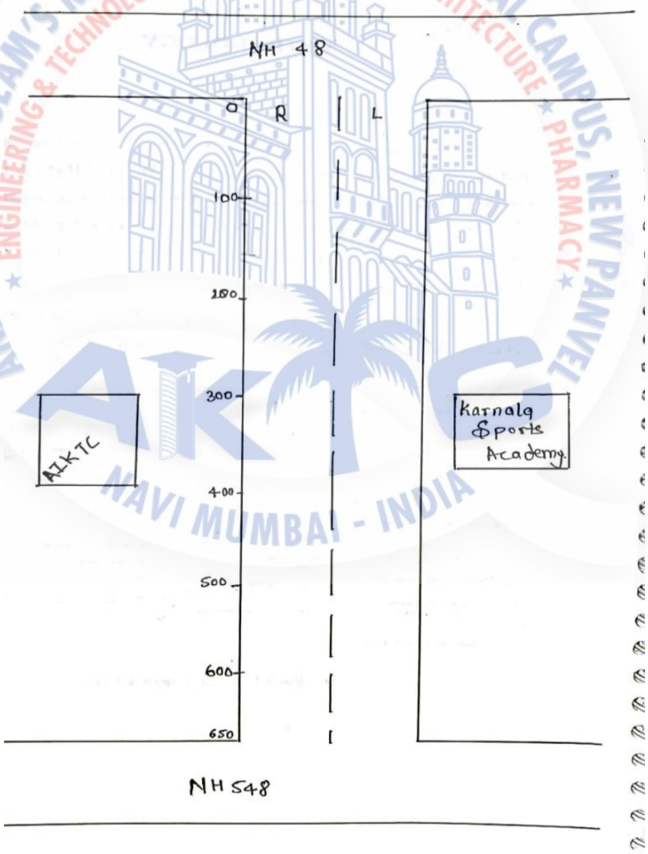

Fig 4.8: Layout of sections of pavement for pavement condition survey

Chainage	Defects	CD work detail	Condition
0-100R	A2, A5, A6, B1, B2, C1, C2, D1, D2	No	Poor
0-100L	A2, D1		Fair
100-200R	A2, A3, B2, B4, C1, C2, D1, D2		Poor
100-200L	A2, C2, D1, D3		Fair
200-300R	A6, A7, B2, B5, D2, D3		Poor
200-300L	B2, C2		Good
300-400R	A2, A6, A7, B2, B5, C1, C2		Fair
300-400L	A1, A2, B2, C1, D1		Fair
400-500R	A1, A2, A5, A6, B2, B4, B5, C1, C2, D1, D2, D3		Poor
400-500L	A2, B2, B4, B5, C1, C2, D3		Poor
500-600R	A2, A7, B2, D2		Good
500-600L	A2, B1, C1, D4		Fair
600-650R	A2, A7, B2, D2		Good
600-650L	A2, A3, A7, B2, B4, C1, C2, D1		Fair

Table 4.1: Observation table for pavement condition survey

It is observed from Table 4.1 that the most part of the pavement is poor and some are fair. Ultimately more that 50% of pavement is in bad condition which leds to discomfort for users and wear and tear to vehicles and thus this stretch of pavement needs to be repaired immediately.

4.2 Traffic survey

4.2.1 The capacity of rural road for two lane single carriage way

Traffic volume survey carried out at road in PCU/day for justification of capacity of road. Three days 24 hours survey has carried out for the wide and accurate justification of road capacity.

Traffic volume study data for three days are tabulated below:

For Day 1 (Saturday)

Sr. No.	Time	Fast Moving Vehicles					
		TW	Car	Auto	LCV	HCV	Bus
1.	8am-9am	71	65	67	12	5	4
2.	9am-10am	82	56	71	14	6	3
3.	10am-11am	85	79	89	16	8	6
4.	11am-12	123	89	45	21	6	5
5.	12-1pm	145	101	32	32	8	4
6.	1pm-2pm	120	99	23	31	10	6
7.	2pm-3pm	99	85	29	29	13	6
8.	3pm-4pm	103	78	45	21	12	7
9.	4pm-5pm	140	106	88	16	10	5
10.	5pm-6pm	123	114	76	15	18	4
11.	6pm-7pm	144	98	23	14	10	7
12.	7pm-8pm	111	72	16	10	6	4
13.	8pm-9pm	65	61	9	12	4	2
14.	9pm-10pm	43	42	8	6	3	3
15.	10pm-11pm	31	29	7	8	2	1
16.	11pm-12pm	12	12	7	6	0	2
17.	12-1am	8	9	2	3	0	1
18.	1am-2am	7	7	3	1	0	0
19.	2am-3am	5	4	1	0	0	0
20.	3am-4am	0	2	0	0	0	0
21.	4am-5am	0	1	3	4	3	0
22.	5am-6am	12	7	11	4	3	0
23.	6am-7am	23	17	14	6	2	2
24.	7am-8am	45	31	19	5	4	3
	Total	1597	1264	688	286	133	75
	PCU value	0.5	1	1	1.5	3	3
	PCU/day	799	1264	688	429	399	225
	Total PCU/day	3804					

Table 4.2: Traffic volume data in PCU/Day for day 1

For Day 2 (Sunday)

Sr. No.	Time	Fast Moving Vehicles					
		TW	Car	Auto	LCV	HCV	Bus
1.	8am-9am	55	42	10	11	6	5
2.	9am-10am	65	43	15	15	8	6
3.	10am-11am	59	51	8	18	6	3
4.	11am-12	71	68	6	19	7	5
5.	12-1pm	89	71	8	21	9	6
6.	1pm-2pm	99	89	10	31	11	7
7.	2pm-3pm	123	57	7	26	9	4
8.	3pm-4pm	119	98	11	31	5	8
9.	4pm-5pm	140	110	7	32	4	4
10.	5pm-6pm	145	102	8	12	6	5
11.	6pm-7pm	134	99	11	16	5	3
12.	7pm-8pm	132	86	5	8	6	5
13.	8pm-9pm	76	56	7	9	6	2
14.	9pm-10pm	42	45	8	7	4	1
15.	10pm-11pm	23	32	4	5	6	3
16.	11pm-12pm	22	18	3	4	3	1
17.	12-1am	21	10	0	0	3	0
18.	1am-2am	11	9	1	0	0	1
19.	2am-3am	9	4	0	0	1	0
20.	3am-4am	5	3	0	0	0	0
21.	4am-5am	3	2	1	0	0	0
22.	5am-6am	12	11	3	2	1	2
23.	6am-7am	23	28	6	4	3	4
24.	7am-8am	29	32	10	9	5	3
	Total	1507	1166	149	280	114	78
	PCU value	0.5	1	1	1.5	3	3
	PCU/day	754	1166	149	420	342	234
	Total PCU/day	3065					

Table 4.3: Traffic volume data in PCU/Day for day 2

For Day 3 (Monday)

Sr. No.	Time	Fast Moving Vehicles					
		TW	Car	Auto	LCV	HCV	Bus
1.	8am-9am	85	94	85	11	6	6
2.	9am-10am	99	112	92	12	7	4
3.	10am-11am	112	123	101	23	9	8
4.	11am-12	123	156	67	25	12	5
5.	12-1pm	145	160	55	12	13	8
6.	1pm-2pm	120	171	45	24	11	4
7.	2pm-3pm	135	145	47	15	14	5
8.	3pm-4pm	156	134	65	27	19	6
9.	4pm-5pm	166	145	80	31	10	3
10.	5pm-6pm	155	162	82	24	6	6
11.	6pm-7pm	165	171	34	26	7	5
12.	7pm-8pm	180	123	23	18	4	3
13.	8pm-9pm	121	112	21	10	7	3
14.	9pm-10pm	78	89	16	8	3	3
15.	10pm-11pm	52	56	10	5	7	2
16.	11pm-12pm	23	32	5	2	4	0
17.	12-1am	12	21	4	0	3	0
18.	1am-2am	9	12	0	0	5	0
19.	2am-3am	7	10	0	0	2	0
20.	3am-4am	8	9	0	1	0	0
21.	4am-5am	4	3	6	0	0	0
22.	5am-6am	16	6	12	1	4	2
23.	6am-7am	45	15	13	4	2	3
24.	7am-8am	61	45	23	9	4	0
	Total	2077	2106	886	288	159	76
	PCU value	0.5	1	1	1.5	3	3
	PCU/day	1039	2106	886	432	477	228
	Total PCU/day	5168					

Table 4.4: Traffic volume data in PCU/Day for day 3

Summary of above three day traffic volume data is given below:

	Total PCU/Day	Consider maximum PCU/Day
Day 1 (Saturday)	3804	**5168**
Day 2 (Sunday)	3065	
Day 3 (Monday)	5168	

Table 4.5: Summary of traffic volume data

The IRC recommended Design Service Volumes for Two Lane Roads for plain terrine and Curvature (Degrees per Kilometer 0-50) are 15,000 PCU/day. And the actual PCU/Day of selected stretch is 5168 PCU/Day. So that based on IRC recommendation and present PCU/Day Widening of road is not needed.

4.2.2 Design of Cumulative Standard Axle

Sr. No.	Time	HCV			Bus		
		Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
1.	8am-9am	5	6	6	4	5	6
2.	9am-10am	6	8	7	3	6	4
3.	10am-11am	8	6	9	6	3	8
4.	11am-12	6	7	12	5	5	5
5.	12-1pm	8	9	13	4	6	8
6.	1pm-2pm	10	11	11	6	7	4
7.	2pm-3pm	13	9	14	6	4	5
8.	3pm-4pm	12	5	19	7	8	6
9.	4pm-5pm	10	4	10	5	4	3
10.	5pm-6pm	18	6	6	4	5	6
11.	6pm-7pm	10	5	7	7	3	5
12.	7pm-8pm	6	6	4	4	5	3
13.	8pm-9pm	4	6	7	2	2	3
14.	9pm-10pm	3	4	3	3	1	3
15.	10pm-11pm	2	6	7	1	3	2
16.	11pm-12pm	0	3	4	2	1	0
17.	12-1am	0	3	3	1	0	0
18.	1am-2am	0	0	5	0	1	0
19.	2am-3am	0	1	2	0	0	0
20.	3am-4am	0	0	0	0	0	0
21.	4am-5am	3	0	0	0	0	0
22.	5am-6am	3	1	4	0	2	2
23.	6am-7am	2	3	2	2	4	3
24.	7am-8am	4	5	4	3	3	0
	Total	133	114	159	75	78	76
	Average CVPD	135.33			76.33		
	Total CVPD	211.66					
	Consider Total CVPD	212					

Table 4.6: Commercial Vehicle per day

The commercial traffic (greater 3 tonnes) 212 CV/Day has been reported on the stretch. The design traffic calculations for overlay design are presented below.

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 estimates of the initial volume of commercial vehicles per day, lateral distribution of traffic, the growth rate, the design life in years and the vehicle damage factor (number of standard axle per commercial vehicle) to convert commercial vehicles to standard axles.

The following equation may be used to make the required calculation:

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

Where,

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

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

r = Annual growth rate of commercial vehicles

n = Design life in years

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

Calculation of million standard axel for overlaying portion

Initial traffic on the stretch = 212 CV/Day

A = Initial traffic x Lane distribution factor

Lane distribution factor = 0.75 (as per IRC: 81-1997 for two lane single Carriage way roads)

Hence

A = 212 x 0.75 = 159

r = 7.5 % (assumed growth rate, as per IRC: 81-1997)

n = 10 year for state highway road as per IRC: 81-1997

F= 3.5 for plain roads carrying traffic between 150-1500 CV/day

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

$$= \frac{365*159*[(1+0.075)^{10}-1]}{0.075} * 3.5$$

Ns = 2.87 ≈ 3 (For overlaying portion)

4.3 Sub-Grade Soil Tests

Soil sample was been collected from poor surface condition. Calculation of LL, PL, & PI of sample is same as procedure in chapter 3 (3.4) and results of the sample are as given below in Table 4.7.

Fig 4.9: Obtaining Sub-Grade Soil for testing

Fig 4.10: Sub-Grade Soil

Sample No.	LL%	PL%	PI%
1.	58	38	20

Table 4.7: Results of Atterberg limit test

4.4 Structural Evaluation of Pavement by Benkelman Beam

This method is used to know the deflection of the pavement which is in turn used in determining the overlay thickness for an existing flexible pavement.

Procedure of structural evaluation for Benkelman beam deflection is mention in chapter 3 (3.5).

Deflections measured by the Benkelman Beam arc influenced by the pavement temperature. For design purposes, therefore, all deflection values should be related to a common temperature. Measurements made when the pavement temperature is different than standard temperature would need to be corrected. The standard temperature and the procedure for correction are discussed below.

Pavement deflections are also affected by seasonal variations in climate. For the purpose of applying these guidelines, it is intended that the pavement deflections should pertain to the period when the subgrade is at its weakest condition. In India, this period occurs during the recession of monsoon. It is, therefore, desirable to conduct deflection measurements during this period. Where the same is not feasible, a correction factor should be applied.

Correction for Temperature Variations

The standard temperature recommended by IRC 81:1997 is 35°C. Correction for temperature variation on deflection values measured at pavement temperature other than 35°C should be 0.01 mm for each degree centigrade change from the standard temperature of 35°C. The correction will be positive for pavement temperature lower than 35°C and negative for pavement temperature higher than 35°C.temperature of pavement and atmosphere is measured at interval of every 1 hour. Correction for temperature is carried out for the study.

Fig 4.11: Recording Pavement Temperature

Seasonal Correction

Correction for seasonal variation shall depend on type of subgrade soil, its field moisture content (at the time of deflection survey) and average annual rainfall in the area. For this purpose, subgrade soils have been divided into three broad categories, namely sandy/gravelly, clayey with low plasticity (PI < 15) and clayey with high plasticity (PI>15). Similarly, rainfall has been divided into two categories, namely low rainfall (annual rainfall < 1300 mm) and high rainfall (annual rainfall >1300 mm). Moisture correction factors (or seasonal correction factors) shall be obtained from IRC: 81-1997 chart for given field moisture content, type of subgrade soil and annual rainfall. Seasonal correction is incorporated in the study.

Evaluation by Benkelman beam

Benkelman Beam Deflection survey is carried out in total 650 m chainage of flexible pavement at 50 m interval and alternate lane as shown in Fig. This method of test covers a procedure for the determination of the rebound deflection of pavement under static load of the rear axle of a standard truck. There are three dial gauge readings are observed at every test point, initial (0.0 m), intermediate (2.70m), and final (9m). Data collected during Benkelman Beam Deflection technique, dial gauge reading, calculation of rebound deflection, seasonal correction, temperature correction, characteristics deflection are given in below Table 4.9.

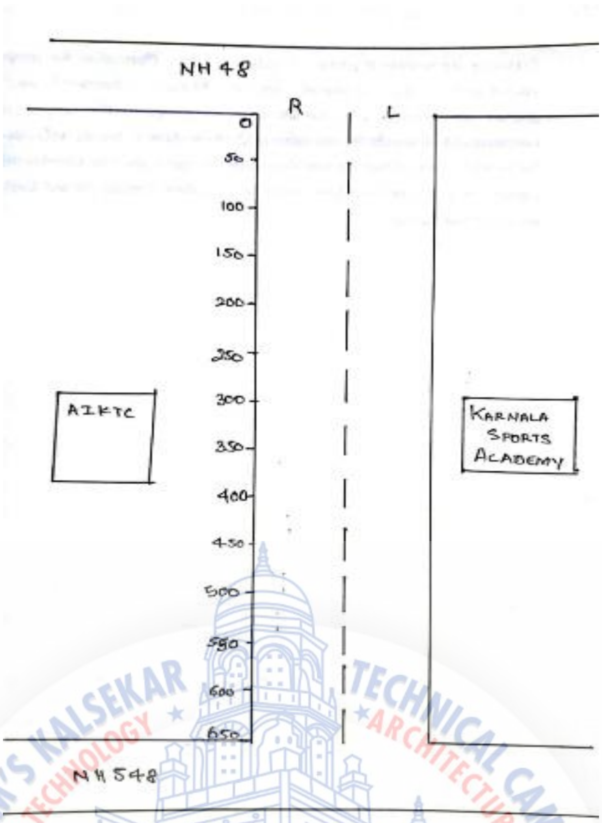

Fig 4.12: Layout of sections of pavement for Structural Evaluation of Pavement

Fig 4.13: Setting of Benkelman Beam

Fig 4.14: Positioning of pivot

Fig 4.15: Recording of Benkelman Beam deflection reading

Preformat for Recording Pavement Deflection Data	
Road name:	City road joining NH48 and NH548.
No. of traffic lanes:	2
Date and time of observation:	22/03/2018
Air temperature, °c:	28 To 34
Annual rainfall, mm:	> 1300
Climate conditions(hot/humid/cold):	Hot
Whether temperature correction is to be applied:	Yes
Whether correction for seasonal variation is to be applied:	Yes

Table 4.8: Preformat for Recording Pavement Deflection Data

Sr. No.	Location of test point & Identification of Lane.	Pavement Temperature ^{0}C	Type of soil & PI	Moisture Content %	Dial gauge Reading mm			Rebound deflection mm	Correction for Temp. mm	Correction for season	Corrected deflection mm
					Initial	Intermediate	Final				
1	0L	40	Silt & Clay (MH) 20%	9.27	7.23	7.13	7.09	0.513	-0.05	1.3	0.602
2	50R				8.19	8.09	7.90	1.686			2.130
3	100L				5.09	4.91	4.85	0.829			1.013
4	150R				1.10	0.98	0.82	1.491			1.873
5	200L				5.41	5.37	5.25	1.020			1.261
6	250R				3.29	3.23	3.18	0.511			0.599
7	300L				5.86	5.82	5.74	0.705			0.851
8	350R				7.11	7.06	6.96	0.882			1.082
9	400L				6.58	6.51	6.30	1.782			2.251
10	450R				1.57	1.49	1.30	1.646			2.075
11	500L				4.39	4.28	4.24	0.533			0.627
12	550R				6.78	6.72	6.68	0.433			0.498
13	600L				7.66	7.59	7.46	1.156			1.438
14	650R				1.89	1.83	1.78	0.511			0.599

Mean Deflection mm, X = $\frac{\Sigma x}{n}$ = 1.210 mm

Standard Deviation mm, σ = $\frac{\sqrt{\Sigma(x-X)^2}}{n-1}$ = 0.177 mm

Characteristic Deflection mm, Dc = X + σ = 1.387 mm

Table 4.9: Calculation for Rebound Deflection and Characteristics Deflection

The procedure of calculation of rebound deflection is given in below chart where, D1, D2, and D3 are initial, intermediate, and final dial gauge readings respectively.

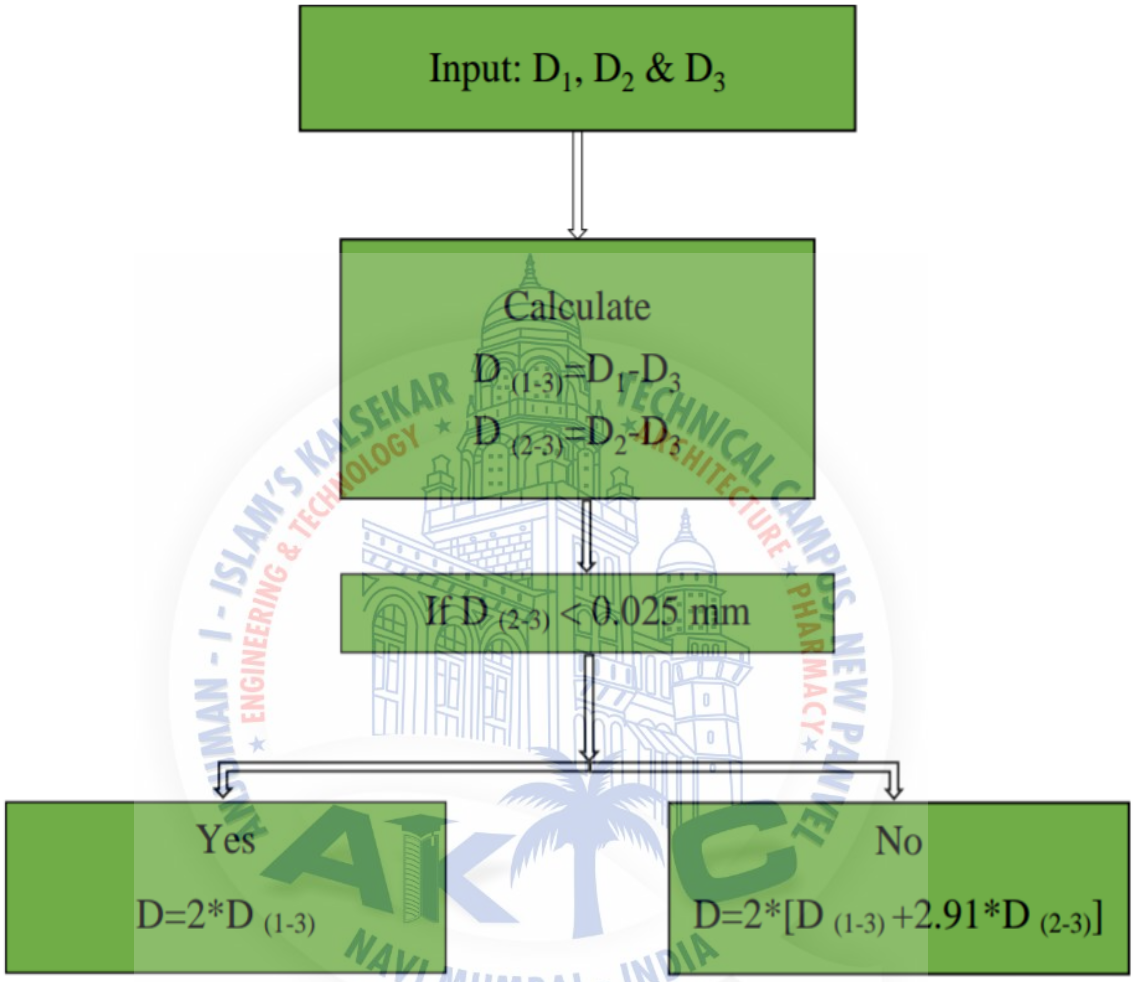

Fig 4.16: Procedure for Calculation of Rebound Deflection

4.5 Design of Overlay Thickness

From the overlay thickness design curve based on characteristic deflection and design traffic, detail overlay design is given below:

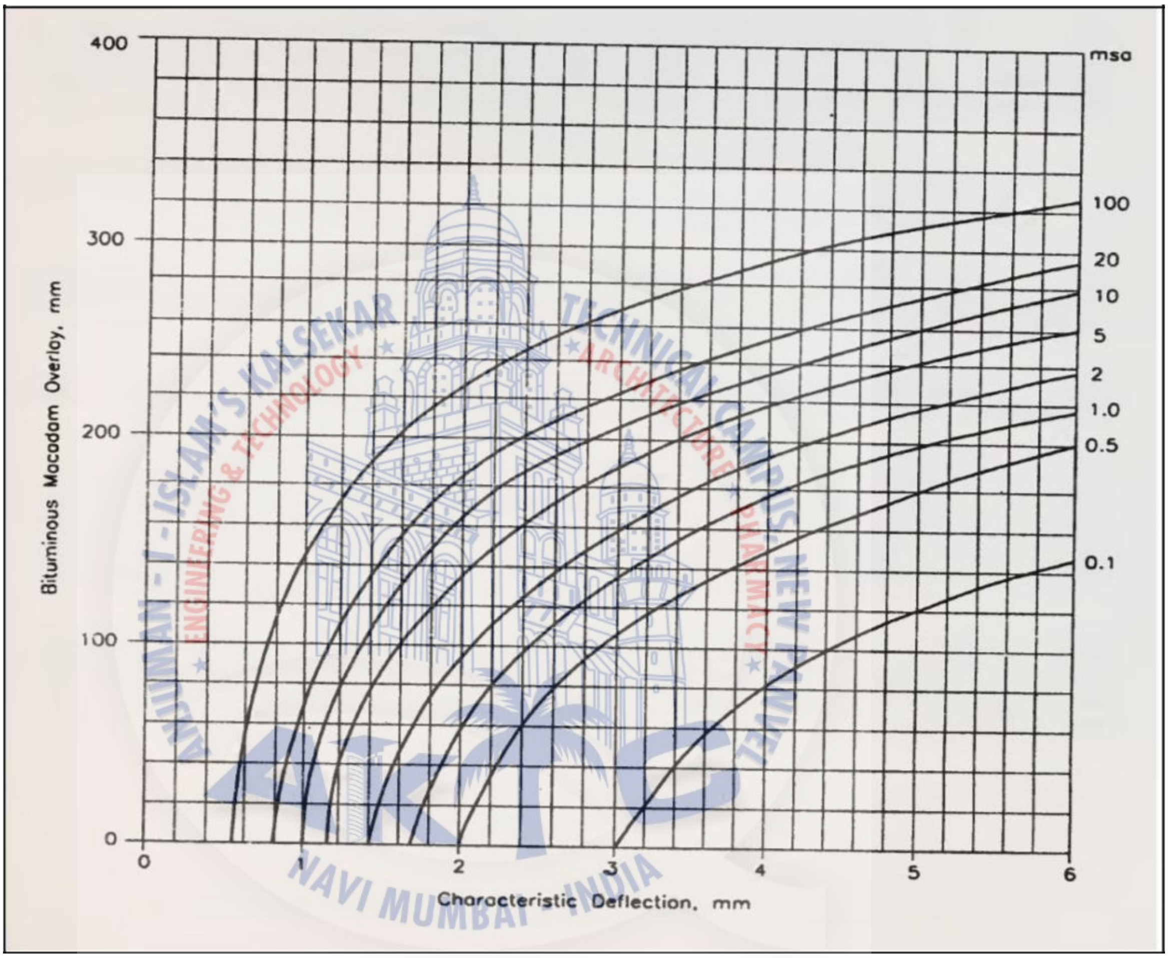

Fig 4.17: Overlay Thickness Design Curve

Characteristic Deflection mm, Dc = 1.387 mm

Design of Cumulative Standard Axle = 3 msa

From the above data and with reference to overlay design thickness curve shown in fig 4.17 the overlay thickness is found as given below and accordingly the alternate for different material is also recommended as per IRC 81.

Alternative 1: Provide bituminous concrete (BC) of 40 mm thickness over a DBM course of 50 mm thickness.

Alternative 2: Provide a DBM thickness of 35 mm.

Alternative 3: Provide a Bituminous Macadam of 50 mm thickness.

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 condition of existing bituminous surfacing, construction convenience and relative economics.

Before implementing the overlay, the existing surface shall be corrected and bought 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.

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AIKTC
NAVI MUMBAI - INDIA

Conclusion

1. From Pavement Condition Survey (Visual Inspection) it is been found that the major part of the road is been damaged and having almost all types of failure seen i.e pot holes, rutting, swelling, patching etc. Ultimately more that 50% of pavement is in bad condition which leds to discomfort for users and wear and tear to vehicles and thus this stretch of pavement needs to be repaired immediately.

2. From Traffic survey it is been found that the widening of pavement is not required from. The CVPD of the pavement was been found to be 212. The road is not heavily traffic condition. The cumulative number of standard axles was calculated to be 3 msa.

3. From Sub-Grade Soil Tests the LL was found to be 58% and PL was found to be 38%. Based on this the PI was calculated to be 20%. From the above data and Atterberg plasticity chart the soil was been classified as silt and clay with high plasticity(MH).

4. From Structural Evaluation of Pavement by Benkelman Beam it is been found that the characteristic deflection of the pavement stretch is 1.387 mm, based on this and the cumulative number of standard axles i.e 3 msa, with reference to the overlay thickness design curve based on characteristic deflection and design traffic from IRC 81 the overlay thickness for the pavement was found to be 50 mm of Bituminous Macadam (BM). The alternates for this as per IRC 81 is as given below:

   Alternative 1: Provide bituminous concrete (BC) of 40 mm thickness over a DBM course of 50 mm thickness.

   Alternative 2: Provide a DBM thickness of 35 mm.

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