COMPARATIVE ANALYSIS OF DEFECT OCCURING IN BITUMINOUS PAVEMENT

A Project Submitted

In Partial fulflllment of the Requirements of

for the Degree of

BACHELOR OF TECHNOLOGY

In

Civil Engineering

by

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Under the Guidance

Of

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BBD UNIVERSITY

BABU BANARASI DAS UNIVERSITY

LUCKNOW

Session:- 2020-2021

A project report on

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CERTIFICATE

Certified that **Akhilesh Kumar Yadav (1170431006), Jaydeep Kumar (1170431021), Sameer Mishra (2170431008), Shubham Kumar Maurya (1170431034), Vikrant Singh (1170431041) has** carried out the research work presented in this Project entitled **"Comparative Analysis of Defect Occuring in Bituminous Pavement"** for the award of **Bachelor of Technology in Civil Engineering** from Babu Banarasi Das University, Lucknow under our supervision. The Project embodies results of original work, and studies are carried out by the student himself and the contents of the Project do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

Signature	**Signature**
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DECLARATION

We hereby declare that the project entitled "**DESIGN OF WATER TREATMENT PLANT"** submitted by us in the fulfillment of the requirements for the award of the Degree of **Bachelor of Technology in Civil Engineering,** to the **Babu Banarasi Das University, Lucknow,** is record of our own work carried under our supervision and guidance of **Ms. Neeti Mishra** (Assistant Professor) of Department of Civil Engineering, Babu Banarasi Das University, Lucknow. We further declare that the work reported in this project has not been submitted either in part or in full, for the award of any other degree or diploma in this university or any other institute or university

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ABSTRACT

According to the research, the flexible pavement defects and its causes are defined in terms of decrease in serviceability which was caused by the development of different types of deteriorations like cracks, surface defects, disintegration etc. on the flexible pavement. Before we going into the maintenance part, we will try to focus on the various defects and its causes. There are so many reasons for bituminous pavement failures. The level of correction in the existing surface will extend the life of maintenance works and strengthening the layer as well. According to my study, there are mainly 2 parameters i have figured out which are: - pavement cracking and surface defects on the pavement. While other distresses have been excluded including these parameters while stepping for maintenance part. With the study of maintenance techniques, there are various methods we are going to adopting for pavement protection which will help to increasing the life of the pavement and failure delay. The motive of this study was to analyse and evaluate the various causes of pavement defects, and provision of remedies to improve the various failures of the surface. Based on the past researches of researchers, various techniques has been studied with their measures which are helpful for increasing the life of serviceability. This case study attempts to identify the various parameters that affect the performance of the flexible pavement and by rid off this problem by applying the remedial measures over the particular stretch. It is a pursuit towards a study of the road condition with respect to varying soil, traffic and climatic conditions, periodic performance evaluation of selected roads of representative types and development of distress prediction models for roads . To achieve this aim, we have studied some research paper and on the basis of that , we further proceed. By taking the measurement of each part, we measured the various type of defects, corresponding to that we found out pavement condition Index (PCI). A PCI is a numerical index which tells us about the condition of the road as per its range that is 0 to 100 which was coming out to be very poor. Testing was done to know the reason of the pavement

failures and we found out that the most of the pavement was damaged by alligator cracks by repetitive heavily loading of the vehicles and surface defects. Pavement also damaged due to poor drainage and inadequate designing and poor quality of material

ACKNOWLEDGEMENT

We would like to express our gratitude to all the people behind the screen who helped us to transform an idea into a real application.

We owe immense intellectual debt to **Mr. Omprakash Netula** , Head of Department of Civil Engineering, Babu Banarasi Das University, Lucknow who kindly consented to supervise the present project work and guided it to completion. For his invaluable help and guidance we express our deep sense of gratitude.

We would like to express our profound sense of deepest gratitude to our project guide and motivator **Mr. Faraz Khan** (Assistant Professor), Department of Civil Engineering, Babu Banarasi Das University, Lucknow for her valuable guidance, sympathy and co-operation for providing necessary facilities and sources during the entire period of this project.

We wish to convey our sincere gratitude to all the faculties of Civil Engineering Department who have enlightened us during our studies. The facilities and co-operation received from the technical staff of Civil Engineering Department is thankfully acknowledged.

We express our thanks to all those who helped us in one way or other.

The blessings of our parents have been continuous source of encouragement for us throughout the project.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Pavement is anything which is being covered or paved, that is the covering of solid material like floor laid so that is to make a comfortable and hard surface for travel. Road pavement is a durable material for surface which is resting on an area design to sustain vehicular traffic or walk traffic, such as a road or pedestrian. Pavement is generally classified as

i. Flexible pavement

ii. Rigid Pavement

iii. Semi-Rigid pavement

iv. Composite pavement

FLEXIBLE PAVEMENT

The pavement which constructed with different number of layers of granular materials and covering of one or more of the waterproofing asphalt layer is considered as flexible. The flexible pavement will deflect under the load of the wheels. The purpose of this design of a flexible pavement is to prevent the excessive bending of any layer of the pavement structure, An over stressing may done if it fails in the design of the layer, which will cause the pavement directly to fail. In these flexible pavements, due to the strength of each layer is different; the load distribution pattern changes from one layer to another. The strongest material is to be provided on the top layer and the weakest layer is to be provided to the bottom layer.

Types of Flexible Pavements

The following are major types of flexible pavement,

1. Conventional layered flexible pavement,
2. Full-depth asphalt pavement, and
3. Contained rock asphalt mat (CRAM)

1. Conventional Flexible Pavements

Conventional flexible pavement uses the layered system. In which high-quality materials are placed at the top of the pavement layer to resist maximum stress and low-quality cheap materials are placed in lower layers.

2. Full-depth Asphalt Pavements

It is constructed by placing bituminous layers directly on the soil sub-grade. These types of pavement most suitable when there is high traffic and local materials are not available.

3. Contained Rock Asphalt Mats

It is constructed by placing dense/open-graded aggregate layers in between two asphalt layers. Properly designed asphalt concrete is placed above the sub-grade. This asphalt concrete will reduce the vertical compressive strain on soil sub-grade and protect from surface water.

1.2 PROBLEM DEFINING

An highway which is either flexible or rigid can get deteriorated in its level of serviceability due to various causes.

These factors are

1. Traffic loading

2. Environmental Factors

3. Quality of the material

4. Drainage

According to IRC, a pavement is designed for its design period of 10 years. After its design period pavement is likely to fail and needs maintenance operations to extend its life further. But sometimes it may fail earlier to its design period because of low quality of material or may by other factors. So the possible causes which arises has mentioned below

Road maintenance is one of the significant components of the complete road system. Even if the highways are designed and constructed in a good way, they may still require maintenance, the range that will depend on several factors which include the type of pavement [3]. A flexible pavement consists from several layers of granular materials covered with bituminous material (waterproof), and as its name mean, it is considered to be flexible. The flexible pavement will bend (flex) under the applied load of the tyre. The objective of designing a flexible pavement is to avoid extreme flexing of any of the layers, failure or un-ability to achieve its cause over stressing of a layer, which finally will cause the failure of the pavement. In the flexible pavements, the distribution pattern of load changes from one pavement layer to another, because the strength of each pavement layer is different. The least flexible and strongest material is in the top layer and the most flexible and weakest material is in the lowest layer. The reason for that is at the surface the wheel load is applied over small area, the result will be high stress level, and deeper down in flexible pavement, the load will be applied over a pavement.

Various types of failures are:

1) Alligator Cracking or Fatigue Cracking

2) Block Cracking

3) Hungry Surface

4) Formation of Corrugations

5) Depressions

6) Fatty surface or Bleeding

7) Formation of Potholes

8) Loss of Aggregates

9) Stripping

10) Reflection Crack

CHAPTER 2

LITERATURE REVIEW

2.1 FLEXIBLE PAVEMENT DETERIORATION AND ITS CAUSES

Sharad. S. Adlinge, Professor AK Gupta

IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)

ISSN: 2278-1684, PP: 09-15

In this research the failure of pavement was defined in terms of decreasing the serviceability caused by development of cracks and formation of ruts. Before going into maintenance part, it is better to interpret the causes of failure. Failures of bituminous pavements are caused due to a lot of reasons or combination of one with the other. Application of correct measure in existing surface will increase the overall life of pavement and will increase its supporting power. Three parameters were considered during this research that is unevenness index, rutting and pavement cracking. The purpose of this study was to evaluate the causes of pavement failure and discuss the particular remedies which can be adopted to improve the pavement performance.

CONCLUSION

The causes of deterioration were summed up as follows:

a) Impact load of traffic, especially of new roads on where the road is designed for comparatively for less traffic.

b) When a new road is constructed with better facilities the traffic from other roads also gets diverted to this new facility causes fatigue to newly constructed pavement.

c) Temperature fluctuations were considered to be prime cause of bleeding and cracking.

d) When shoulders provided were not adequate, it lead to edge failures.

e) If the provided subgrade was of poor clay, corrugations were resulted.

2.2 APPLICATION OF WASTE PLASTICAS AN EFFECTIVE CONSTRUCTION MATERIAL IN THE FLEXIBLE PAVEMENT

SasaneNeha .B. Gaikwad .Harish , Dr. J R Patil, Dr. S.D. Khandekar

International Research Journal of Engineering and Technology (IRJET)

Volume: 02, Issue: 03/June-2015

To preserve a particular road so that it behaves well in future for design period, it needs a systematic and pre-planned approach. It will reduce its maintenance operations and will increase its service life. Nowadays a pavement is subjected to various types of loading and which increases rapidly at an alarming rate causing failure of a pavement before it is expected to fail. So there is need of an alternative advanced material to be used while construction of a pavement, so that it behaves well during its service life. Use of plastic waste becomes handy in that matter. The paper included various laboratory tests bitumen, aggregate and bitumen-aggregate plastic mix. After performing various tests like penetration test, marshal stability test and ductility test on bitumen with addition of waste plastic it was been observed that with the increase in quantity of waste plastic in bitumen, the properties of bitumen were enhanced When waste plastic was used in newly constructed flexible pavements they showed good results when compared to existing ones . It was concluded that the optimum use of plastic can be done up to 10% based on marshal stability test . This method of using plastic waste in pavement construction emerged as an alternative for eco-friendly disposal of plastic . When aggregates were coated with polymers, their performance under wheel loads emerged to be better.

2.3 DESIGN APPROACH FOR GEOCELL REINFORCED FLEXIBLE PAVEMENTS Chandan Basu & Jitendra Kumar Soni

Highway Research Journal Indian Road Congress

Volume 6, No: 2, July-December 2013

Geocell is a recent development in civil industry. It has a unique three dimensional structure which makes it more important when compared to other geosynthetics. When the local soil is confined with a geosynthetic material like geocell, it shows better structural properties. When the geocells are incorporated in the pavement layers, it facilitates better load distribution and reduces the vertical stresses that are transmitted to the underlying layers. Use of geocells reduces pavement thickness and allows it to give adequate support for moving loads.

Geocell when used properly in flexible pavement depending upon the requirement, it can yield significant reduction in bituminous layers and reduces the overall cost of pavement. However this technology needs skilled and experienced installation. Besides cost saving it also reduces the overall construction time and increases the service life of a particular pavement.

2.4 ANALYSIS OF THE INFLUENCE OF SOFT SOIL DEPTH ON SUBGRADE CAPACITY FOR FLEXIBLE PAVEMENTS

Carvajal E & Romana M.

Proceeding of Int. conference on soil mechanics and Geotech. Paris 2013 Flexible pavement structure is analyzed on soft soil subgrade, through the finite element modeling of a multilayered system, with objective to evaluate the effect of soft soil on the pavement depth. The analysis also includes iterative procedure to evaluate 8 influence of small strains on stiffness of the soil sample. A simple static load imposed by a heavy truck was considered to evaluate the pavement response. The results so obtained were co-related with the empirical one, so as to estimate rutting failure intensity.

It was concluded that deep ground treatments are needed to be applied for achieving an allowable capacity of soft soil up to a minimum depth of 6m, otherwise maintenance cost will increase. The theoretical procedure done by finite element modeling system depicted that soft soil may be significant for long term behavior of flexible pavement, especially in case when shallow treatment of subgrade would be uneconomic. The application of deep treatment was good to achieve allowable capacity of soft soil.

2.5 CONSIDERATION OF THE DETERIORATION OF STABLISED SUBGRADE SOIL IN ANALYTICAL ROAD PAVEMENT DESIGN

Jabar M. Rasul, Michael P.N. Burrow, Gurmel S. Ghataora

Transportation Geotechnics(2016), vol.9:96-109

The stabilization of road subgrade soil may improve its mechanical properties considerably, however under the combined effect of cumulative traffic load and weathering these materials deteriorate over time and lose performance. However, current road design procedures neglect such deterioration of stabilised soils and consequently their use may result in the under design of road pavements and as a result unplanned maintenance and /or premature road failure. To address this, this research presents the results of a research program marrying experimental, analytical and numerical work which was used to develop a methodology which can be used for the first time to design accurately road pavements incorporating stabilized subgrade soils. An extensive experimental program was carried out consisting of laboratory durability tests to determine the mechanical behavior of stabilized subgrade soil in terms of permanent deformation and resilient modulus, under cycles of wetting and drying Results of the durability tests were used to validate an analytical predictive equation which considers the changes that take place to the material after cycles of wetting and drying. The experimental results show a 9 decrease in the resilient modulus after 25 cycles of wetting and drying cycles for 3 types of fine grained subgrade soils stabilized with varying amounts of lime-cement. In order to adequately replicate the stress dependency of the performance of the stabilised subgrades for analytical pavement design, two equations were developed that relate the resilient modulus of a stabilised soil with unconfined compressive strength (UCS). The developed equations were utilized with a numerical finite element model of a road pavement to determine the most appropriate road pavement designs, on an engineering basis, for a variety of stabilised soils. A novel relationship which can predict the deteriorated resilient modulus values for different stabilizer contents and types from a deteriorated resilient modulus value of one specified stabilizer content which was tested for durability. Two correlation equations derived from permanent deformation and unconfined compressive strength tests. The equations predict with an adequate accuracy the resilient modulus from the unconfined compressive strength and the stress state, for three soil types at four different stabilizer contents. The correlation equations can be used to determine a set of resilient modulus values for a series of different stress states. A procedure to take into account the nonlinearity of the stress dependency of the resilient modulus values of stabilized and unstablized subgrade soils. A performance model for stabilized subgrade soils which can predict with a satisfactory degree of accuracy the incremental accumulation of permanent deformation.

2.6 FATIGUE AND RUTTING LIVES IN FLEXIBLE PAVEMENT

Ahmed Ebrahim Abu El-MaatyBehiry Ain Sham

Engineering journal (2012) 3,367-374

In this research, the flexible pavement is designed based on climatic conditions and axle load limits. According to the Egyptian code has specified certain load limits that should not be exceeded. The heavily loaded vehicles like overweight trucks cause many type of deterioration to 10 the pavement and thus reduce its life. The motive of the study is studying the effect of axle load increase, and the variation in pavement modulus on the overall pavement life. This research used the BISAR software and the Egyptian environmental materials conditions of pavement to evaluate the tensile strains which are occurring on the asphalt concrete (AC) layer and the compressive strains above the subgrade surface. The results revealed that tensile and compressive strain increased with increasing axle loads and decreased with increasing asphalt layer modulus thus the excessive trucks should be prohibited when their weights exceed the limits. Base thickness and subgrade resilient modulus were the key elements which control the equilibrium between fatigue and rutting lives.

Tensile and compressive strain increased with increasing axle loads and decreased with increasing asphalt layer elastic modulus. Furthermore, fatigue and rutting lives decrease dramatically with increasing the axle load, especially after the axle load exceeds 150 kN for fatigue life and 120 kN for rutting life. The fatigue damage basically increases in a higher rate with increasing the axle load while the rutting damage rate increases with a converging rate. Furthermore with increasing asphalt layer elastic modulus the fatigue and rutting damage decrease. Fatigue life has no sensitivity with the variation of base thickness compared with rutting life, which is high sensitive. While both fatigue and rutting lives have a good sensitivity with the variation of surface thickness specially at base thickness thicker than 300 mm. The increase of elastic modulus of asphalt or base layers has not obvious effect on the rutting life at base thickness thinner than 300 mm, thicker thickness lead to obvious increase in Rutting life. With respect to fatigue life, it has no sensitivity with the variation of base thickness while has a good sensitivity with the variation of surface modulus or base modulus at all values of base thickness. The optimum axle load causing both fatigue and rutting failures at the same time is about 135 kN. Thus, the maximum allowable axle load should not exceed 135kN because it will cause a fast deterioration rate to the pavement especially in summer season. Moreover, base thickness d2 and subgrade elastic modulus E3 are the key elements which control the equilibrium between 11 rutting and fatigue life. The pavement design life is governed by fatigue failure with smaller axle loads that is less than 150 kN and by rutting failure with greater axle loads.

2.7 SURVEY AND EVALUATION OF FLEXIBLE PAVEMENT FAILURES

Magdi M.E. Zumrawi

International Journal of science and research (IJSR), 2013

The paper is focusing on evaluate the different flexible pavement failures for maintenance planning. It is quite important to examine and to identify the various causes of the distressed pavement by selecting the proper treatment action. Based on previous study, using literature reviews of literatures, systematic guidelines for evaluation of damaged pavement have been proposed to provide useful information for maintenance work. The study consisted of two tasks: the first covered the visual inspection of the existing pavement failures and the second investigated the actual causes of these failures. According to this study, Obeid Khatim road in Khartoum was selected for investigation. An intensive field work was carried out on the existing pavement condition of this road. It was found that most of the pavement failures in the sections suffered from severe cracking and rutting failures. These failures might be been caused by fatigue failure on pavement structure due to the movement of heavily loaded truck-trailers. The damage could also be attributed to poor drainage, improper design and improper pavement materials used.This study has been undertaken to investigate the pavement failures and propose a method for inspection and evaluation of failed pavement. The results and the conclusions drawn. The method developed in this research has been based on previous experiences. The observation is on establishing a systematic, and yet simple and easy to understand guidelines that is flexible enough for use in a variety of situations. The method was developed in this research is pavement failure investigation. The method, combined with the experience of the highway engineer and adequate materials investigation, will help to ensure that the cause of a pavement failure can be reliably determined. The method developed for inspection and evaluation was trialed in pavement failures of Obeid Khatim road, to evaluate the effectiveness of the method for real use. It was found that the method was good as a general guide, particularly for junior highway engineers.

CHAPTER 3

METHODOLOGY

3.1. Alligator (fatigue) cracking

A series of interconnected cracks caused by fatigue failure of the HMA surface under repeated traffic loading. As the number and magnitude of loads becomes too great, longitudinal cracks begin to form (usually in the wheelpaths). After repeated loading, these longitudinal cracks connect forming many-sided sharp-angled pieces that develop into a pattern resembling the back of an alligator or crocodile.

Problem: Roughness, indicator of structural failure, cracks allow moisture infiltration into the base and subgrade, eventually results in potholes and pavement disintegration if not treated.

Possible Causes: Inadequate structural support for the given loading, which can be caused by a myriad of things. A few of the more common ones are:

- Decrease in pavement load supporting characteristics.
- Probably the most common reason is a loss of base, subbase or subgrade support from poor drainage. Water under a pavement will generally cause the underlying materials to become weak.
- Stripping on the bottom of the HMA layer. The stripped depth contributes little to pavement strength so the effective HMA thickness decreases.
- Increase in loading (i.e., the pavement is being loaded more heavily than anticipated in design)

Repair: A fatigue cracked pavement should be investigated to determine the root cause of failure. Any investigation should involve digging a pit or coring the pavement to determine the pavement’s structural makeup as well as determining whether or not subsurface moisture is a contributing factor. Once the characteristic alligator pattern is apparent, repair by crack sealing is generally ineffective. Fatigue crack repair generally falls into one of two categories:

- Small, localized fatigue cracking indicative of a loss of subgrade support. Remove the cracked pavement area then dig out and replace the area of poor subgrade and improve the drainage of that area if necessary. Patch over the repaired subgrade.

- Large fatigue cracked areas indicative of general structural failure. Place an HMA overlay over the entire pavement surface. This overlay must be strong enough structurally to carry the anticipated loading because the underlying fatigue cracked pavement most likely contributes little or no strength

Figure 3.1 Alligator Cracks

3.2. Bleeding

A film of asphalt binder on the pavement surface. It usually creates a shiny, glass-like reflecting surface that can become sticky when dry and slippery when wet.

Problem: Loss of skid resistance when wet, unsightly

Possible Causes: Bleeding occurs when asphalt binder fills the aggregate voids during hot weather or traffic compaction, and then expands onto the pavement surface. Since bleeding is not reversible during cold weather or periods of low loading, asphalt binder will accumulate on the pavement surface over time. Likely causes are:

- Excessive asphalt binder in the HMA (either due to a poor mix design or manufacturing problems)
- Excessive application of asphalt binder during BST application
- Low HMA air void content (e.g., not enough void space for the asphalt to occupy), likely a mix design problem

Repair: The following repair measures may eliminate or reduce the asphalt binder film on the pavement's surface but may not correct the underlying problem that caused the bleeding:

- Minor bleeding can often be corrected by applying coarse sand to blot up the excess asphalt binder.
- Major bleeding can be corrected by cutting off excess asphalt with a motor grader or removing it with a heater planer. If the resulting surface is excessively rough, resurfacing may be necessary

Figure 3.2 Bleeding

3.3. Block cracking

Description: Interconnected cracks that divide the pavement up into rectangular pieces. Blocks range in size from approximately 1 ft^2 to 100 ft^2. Larger blocks are generally classified as longitudinal and transverse cracking. Block cracking normally occurs over a large portion of pavement area but sometimes will occur only in non-traffic areas.

Problem: Allows moisture infiltration, roughness

Possible Causes: HMA shrinkage and daily temperature cycling. Typically caused by an inability of asphalt binder to expand and contract with temperature cycles because of:

- Asphalt binder aging
- Poor choice of asphalt binder in the mix design

Repair: Strategies depend upon the severity and extent of the block cracking:

- Low severity cracks (< 1/2 inch wide). Crack seal to prevent (1) entry of moisture into the subgrade through the cracks and (2) further raveling of the crack edges. HMA can provide years of satisfactory service after developing small cracks if they are kept sealed (Roberts et. al., 1996[1]). If looks are important, or cracking is extensive, a slurry seal can be placed over the sealed cracks.
- High severity cracks (> 1/2 inch wide and cracks with raveled edges). Remove and replace the cracked pavement layer with an overlay.

Figure 3.3 Block Cracking

3.4. Shoving and Corrugation

A form of plastic movement typified by ripples (corrugation) or an abrupt wave (shoving) across the pavement surface. The distortion is perpendicular to the traffic direction. Usually occurs at points where traffic starts and stops (corrugation) or areas where HMA abuts a rigid object (shoving).

Problem: Roughness

Possible Causes: Usually caused by traffic action (starting and stopping) combined with:

- An unstable (i.e. low stiffness) HMA layer (caused by mix contamination, poor mix design, poor HMA manufacturing, or lack of aeration of liquid asphalt emulsions)

Repair: A heavily corrugated or shoved pavement should be investigated to determine the root cause of failure. Repair strategies generally fall into one of two categories:

- Small, localized areas of corrugation or shoving. Remove the distorted pavement and patch.
- Large corrugated or shoved areas indicative of general HMA failure. Remove the damaged pavement and overlay.

Figure 3.4 Shoving

3.5. Depression

Localized pavement surface areas with slightly lower elevations than the surrounding pavement.

Problem: Roughness, depressions filled with substantial water can cause vehicle hydroplaning

Possible Causes: Subgrade settlement resulting from inadequate compaction during construction.

Repair: By definition, depressions are small localized areas. A pavement depression should be investigated to determine the root cause of failure. Depressions should be repaired by removing the affected pavement then digging out and replacing the area of poor subgrade. Patch over the repaired subgrade.

Figure 1.5 Depression

3.6. Joint reflection cracking

Cracks in a flexible overlay of a rigid pavement. The cracks occur directly over the underlying rigid pavement joints. Joint reflection cracking does not include reflection cracks that occur away from an underlying joint or from any other type of base (e.g., cement or lime stabilized).

Problem: Allows moisture infiltration, roughness

Possible Causes: Movement of the rigid pavement slab beneath the HMA surface because of thermal and moisture changes. Generally not load initiated, however loading can hasten deterioration.

Repair: Strategies depend upon the severity and extent of the cracking:

- Low severity cracks (< 1/2 inch wide and infrequent cracks). Crack seal to prevent (1) entry of moisture into the subgrade through the cracks and (2) further raveling of the crack edges. In general, rigid pavement joints will eventually reflect through an HMA overlay without proper surface preparation.
- High severity cracks (> 1/2 inch wide and numerous cracks). Remove and replace the cracked pavement layer with an overlay after proper preparation of the underlying rigid pavement.

Figure 3.6 Joint Reflection Cracking

3.7. Longitudinal cracking

Cracks parallel to the pavement's centerline or laydown direction. Usually a type of fatigue cracking.

Problem: Allows moisture infiltration, roughness, indicates possible onset of fatigue cracking and structural failure.

Possible Causes:

- Poor joint construction or location. Joints are generally the least dense areas of a pavement. Therefore, they should be constructed outside of the wheelpath so that they are only infrequently loaded. Joints in the wheelpath will general fail prematurely.

- A reflective crack from an underlying layer (not including joint reflection cracking)
- HMA fatigue (indicates the onset of future fatigue cracking)
- Top-down cracking

Repair: Strategies depend upon the severity and extent of the cracking:

- Low severity cracks (< 1/2 inch wide and infrequent cracks). Crack seal to prevent (1) entry of moisture into the subgrade through the cracks and (2) further raveling of the crack edges. HMA can provide years of satisfactory service after developing small cracks if they are kept sealed (Roberts et. al., 1996[1]).
- High severity cracks (> 1/2 inch wide and numerous cracks). Remove and replace the cracked pavement layer with an overlay.

Figure 3.7 Longitudinal cracking

3.8 Patching

An area of pavement that has been replaced with new material to repair the existing pavement. A patch is considered a defect no matter how well it performs.

Problem:

Roughness

Possible Causes:

- Previous localized pavement deterioration that has been removed and patched
- Utility cuts

Repair: Patches are themselves a repair action. The only way they can be removed from a pavement's surface is by either a structural or non-structural overlay.

Figure 3.8 Patching

3.9. Polished aggregrate

Areas of HMA pavement where the portion of aggregate extending above the asphalt binder is either very small or there are no rough or angular aggregate particles.

Problem: Decreased skid resistance

Possible Causes: Repeated traffic applications. Generally, as a pavement ages the protruding rough, angular particles become polished. This can occur quicker if the aggregate is susceptible to abrasion.

Repair: Apply a skid-resistant slurry seal, BST or non-structural overlay.

Figure 3.9 Polished aggregate

3.10 Potholes

Small, bowl-shaped depressions in the pavement surface that penetrate all the way through the HMA layer down to the base course. They generally have sharp edges and vertical sides near the top of the hole. Potholes are most likely to occur on roads with thin HMA surfaces (1 to 2 inches) and seldom occur on roads with 4 inch or deeper HMA surfaces (Roberts et al., 1996[1]).

Problem: Roughness (serious vehicular damage can result from driving across potholes at higher speeds), moisture infiltration

Possible Causes: Generally, potholes are the end result of fatigue cracking. As fatigue cracking becomes severe, the interconnected cracks create small chunks of pavement, which can be dislodged as vehicles drive over them. The remaining hole after the pavement chunk is dislodged is called a pothole.

Repair: In accordance with patching techniques.

- Small, localized areas of raveling. Remove the raveled pavement and patch. If the pavement is still structurally sound, the raveling can be fixed with a fog seal or slurry seal.
- Large raveled areas indicative of general HMA failure. Remove the damaged pavement and overlay.

Figure 3.10 Potholes

3.11 Ravelling

The progressive disintegration of an HMA layer from the surface downward as a result of the dislodgement of aggregate particles.
Problem: Loose debris on the pavement, roughness, water collecting in the raveled locations resulting in vehicle hydroplaning, loss of skid resistance

Possible Causes:

- Loss of bond between aggregate particles and the asphalt binder as a result of:
- Asphalt binder aging. Aging is generally associated with asphalt binder oxidation as it gets older. As the asphalt binder gets older, oxygen reacts with its constituent molecules resulting in a stiffer, more viscous material that is more likely to lose aggregates on the pavement surface as they are pulled away by traffic.
- A dust coating on the aggregate particles that forces the asphalt binder to bond with the dust rather than the aggregate
- Aggregate segregation. If fine particles are missing from the aggregate matrix, then the asphalt binder is only able to bind the remaining coarse particles at their relatively few contact points.
- Inadequate compaction during construction. High density is required to develop sufficient cohesion within the HMA. Often, inadequate compaction

will also result in rutting because once the pavement is opened to traffic, it will continue to compact in the wheelpaths under traffic loading.

- Mechanical dislodging by certain types of traffic (studded tires, snowplow blades or tracked vehicles).

Repair: A raveled pavement should be investigated to determine the root cause of failure. Repair strategies generally fall into one of two categories:

- Small, localized areas of raveling. Remove the raveled pavement and patch. If the pavement is still structurally sound, the raveling can be fixed with a fog seal or slurry seal.
- Large raveled areas indicative of general HMA failure. Remove the damaged pavement and overlay.

Figure 3.11 Ravelling

3.12 Rutting

Surface depression in the wheelpath. Pavement uplift (shearing) may occur along the sides of the rut. Ruts are particularly evident after a rain when they are filled with water. There are two basic types of rutting: mix rutting and subgrade rutting. Mix rutting occurs when the subgrade does not rut yet the pavement surface exhibits wheelpath depressions as a result of compaction/mix design problems. Subgrade rutting occurs when the subgrade exhibits wheelpath depressions due to loading. In this case, the pavement settles into the subgrade ruts causing surface depressions in the wheelpath.

Problem: Ruts filled with water can cause vehicle hydroplaning, can be hazardous because ruts tend to pull a vehicle towards the rut path as it is steered across the rut.

Possible Causes: Permanent deformation in any of a pavement's layers or subgrade usually caused by consolidation or lateral movement of the materials due to traffic loading. Specific causes of rutting can be:

- Insufficient compaction of HMA layers during construction. If it is not compacted enough initially, HMA pavement may continue to densify under traffic loads.
- Subgrade rutting (e.g., as a result of inadequate pavement structure)
- Improper mix design or manufacture (e.g., excessively high asphalt content, excessive mineral filler, insufficient amount of angular aggregate particles)

Repair: A heavily rutted pavement should be investigated to determine the root cause of failure (e.g. insufficient compaction, subgrade rutting, poor mix design or studded tire wear). Slight ruts (< 1/3 inch deep) can generally be left untreated. Pavement with deeper ruts should be leveled and overlayed.

Figure 3.12 Rutting

3.13 Slippage

Crescent or half-moon shaped cracks generally having two ends pointed into the direction of traffic.

Problem: Allows moisture infiltration, roughness

Possible Causes: Braking or turning wheels cause the pavement surface to slide and deform. The resulting sliding and deformation is caused by a low-strength surface mix or poor bonding between the surface HMA layer and the next underlying layer in the pavement structure.

Repair: Removal and replacement of affected area.

Figure 3.13 Slippage

Severity level of distress

Distresses	Severity level
Longitudinal cracks	Moderate
Alligator Cracks	Heavy
Potholes	Low
Patches	Moderate
Transverse Cracks	Low
Edge cracking	Low
Block Cracking	Moderate
Slippage Cracking	Low
Weathering and Raveling	Low

3.4 FACTORS AFFECTING THE PERFORMANCE OF THE FLEXIBLE PAVEMENT

These are the various factors which affects the performance of the pavement:

a) Subgrade

b) Traffic

c) Moisture content

d) Quality of material

e) Maintenance

a) SUBGRADE

Subgrade is the underlying soil which supports the overall load of the traffic and transmits into it. Properties of subgrade material are important in determining the thickness of pavement. When subgrade stability is low, the thickness of pavement require is greater to protect it from wheel loads.

b) TRAFFIC

Traffic is the primary factor to which affecting the performance of the flexible pavement. The performance of the pavement is mainly affected by its magnitude and frequency of loading, number of repetitions and configuration of the load by heavily vehicles. Primarily, the thickness of the pavement depends upon design wheel load. When the wheel load is higher, the thickness of pavement required is greater.

Design wheel load is further dependent on various factors such as:

- Gross wheel load
- Contact pressure
- Dual or multiple wheel loads and Equivalent single wheel load
- Repetition of loads

c) MOISTURE CONTENT

Moisture content significantly weakens the soil strength of the subgrade. It may be form at any coarse of the pavement. Moisture content variations are dependent upon climatic conditions, type of soil, drainage conditions, type of pavement and ground water level.

d) QUALITY OF MATERIAL

The material provides on the pavement is mainly supports of the whole pavement. Better quality of material withstands the whole pavement for a longer period. While the poor quality of materials leads to failure on the pavement. Quality of material indicates the required compaction, control of moisture content and use of skilled labor when a pavement is being constructed.

e) MANTANENCE

It is the most important parameter of the pavement system. The maintenance operations involve the assessment of road conditions, diagnosis of the related problem and adopting the appropriate measures. Several types of failures are ranging from minor to major does takes place on roads even on well constructed highways, so they need a periodic maintenance to increase their service life. Quality of material indicates the required compaction, control of moisture content and use of skilled labor when a pavement is being constructed.

SOIL

Soil is the main material of construction of fill or embankment and the subgrade of roadways. Soil is also used in other pavement layers usually as stabilized soil in sub-base and base course. The pavement layers are laid above the soil subgrade which provides the stability and support to the pavement. The design performance of a pavement particularly flexible one depends upon the type of subgrade and its properties. Soil compaction is an important parameter in construction of a road. Compaction of soil subgrade improves the load supporting capacity of the pavement, which in turn results in decreased pavement thickness. There are various tests to be performed for evaluation of strength of soil subgrade and important one is CBR-California Bearing Ratio Test which is to be carried out in the laboratory

AGGREGATES

Aggregates bear the load stresses occurring on the road and runway pavements and they also abrasive action of traffic under dry and wet conditions, when used in wearing course. As compared to fine aggregates, coarse aggregate shave greater importance in pavement construction. Aggregates are used in construction flexible pavement layers and also as sub-base course in rigid pavement construction.

There are various tests to be performed to check the desirable properties of aggregates e.g Aggregate Impact Test, Toughness Test or resistance to Impact test etc.

The required properties of aggregates may be summarized as follows:

1) Resistance against Impact loading.

2) Resistance to abrasive action due to wheel loads.

3) Resistance against getting polished due to moving traffic.

4) Crushing strength must be adequate.

5) Shape and gradation.

6) Soundness or resistance against weathering action.

7) Good adhesion with bitumen.

8) Resistance against getting slippery surface.

BITUMINOUS MATERIALS

Bitumen is binder used in pavement construction which includes both bitumen and tar. Bitumen is a petroleum product obtained by distillation of crude petroleum but the road tar is formed from destructive distillation of charcoal, coal or wood. Both bitumen and tar have same appearance but they differ in properties. Tar is rarely used in pavement construction because of its undesirable properties such as susceptible to temperature etc.

The bitumen is brought to sufficient fluidity or viscosity before using it in the pavement construction by any one of the following methods:

- Heating in the form of hot bituminous binder
- Dissolving in light oils, in the form of cutback
- Dispersion in bituminous water, in the form of bituminous emulsion

Bituminous binders are commonly used in surface course of pavement and may be also used as a base course in flexible pavement to withstand relatively adverse conditions of traffic and climate. These materials are also used in soil bitumen stabilization and to prepare sealer materials for filling and fixing the joints in cement concrete pavements. Bitumen is available in variety of types and grades depending upon its use. Paving grade bitumen is used in construction of roads and for water proofing of structures industrial grades are used. There are a number of tests to be performed to assess the quality of bitumen being used in construction e.g. viscosity test, penetration test etc.

TEST ON THE MATERIALS

A pavement is designed against a particular design period and is expected to give satisfactory service for the period of its design life. The recommended design life for 31 National Highways and State Highways is 15 years and for Expressways or Freeways is 20 years as per IRC: 37-2001, when we talk about flexible pavements and for rigid pavements it can be taken 20-40 years. After the expiry of its design period, the pavement starts to fail structurally and therefore it needs renewal to extend its life. Even during service life of pavement the wearing course gets deteriorated due to wheel loads and needs routine maintenance.

According to "Code of practice for maintenance of bituminous surfaces of highway" IRC:82, the defects of bituminous surfacing can be summarized as following:

a) CRACKS: For example, alligator cracks, longitudinal cracks, transverse cracks, shrinkage cracks, edge cracks, reflection cracks etc.

b) DEFORMATIONS: For example, rutting, corrugations, settlement, heaving etc.

c) SURFACE DEFECTS: For example, fatty surfaces, hungry surfaces, smooth surfaces etc.

d) DISINTEGRATIONS: For example, stripping, loss of aggregates, formation of potholes, weathering and ravellings etc. Defects can be occurs in the various layers of the pavements. So, for all these defects measurements, we are going conduct the various type of tests:

3.6.1 **AGGREGATE CRUSHING VALUE TEST**

The test is performed on the aggregates for checking the mechanical properties of the material that is aggregate. It helps us to know

a) Satisfactory resistance to crushing under the roller during construction of pavement and under application of heavy wheel loads on the pavement.

b) Sufficient resistance to impact loads

c) Adequate resistance to abrasive action and getting polished under traffic movements. The test on the stone aggregates is carried out on Compression Testing Machine. The coarse aggregates which are used for pavement construction should be strong enough to resist the crushing under the load of the rollers during compaction. If the aggregates are weak, the stability and performance of the pavement is liable to be negatively affected. The resistance to crushing of the coarse aggregates under the progressively applied compressive loads is articulated in terms of Aggregate Crushing Value.

A low aggregate crushing value indicates higher resistance to getting crushed under the application of specific load, hence aggregate crushing value should be low to achieve high quality pavement.

APPRATUS

a) Steel cylinder with central diameter 150 mm including an appropriate plunger and a piston

b) Steel tamping rod having diameter of 16mm and length of 450-600mm

c) Balance of capacity 3kg at least

d) A Compressive Testing Machine (CTM) which is capable of applying load 50 tones at a uniform rate of 4-5 tones per minute

e) IS sieves of having sizes 2.36mm, 10mm, 12.5mm

f) Cylindrical measure having dimensions of internal diameter of 115mm and height 180mm

PREPARATION OF THE TEST SAMPLE

The sample of coarse aggregate which are passing from standard 12.5mm IS sieve and getting retained over 10mm IS sieve is to be taken. If the sample of aggregates is not dry it should be oven-dried by heating at a temperature of 100-110 degrees for 4 hours and 33 then allowed them to cool at a room-temperature. The sample is filled in the cylindrical measure in 3 layers and tamped 25 times with tamping rod, the depth of each layer being approximately equal. Then the aggregates at the top layer are leveled and the sample is weighed.

PROCEDURE

It consists of the aggregates passing from 12.5mm sieve and retained on 10mm sieve. The aggregate should be oven-dried by heating at 100-110°C.

1) Sieve out the material through 12.5mm and 10mm from IS sieve. The test material should be passed from 12.5mm of sieve and retained on 10mm.

2) The cylinder of the test shall be put in position on the base plate and the sample should be added in 3 layers and each layer will subjected to 25 strokes with tempered rod.

3) The aggregate should be leveled properly after tempering.

4) A plunger is inserted in such a way that it laid horizontally at its surface. Proper care must be taken as to make assure that it doesn't jam in the cylinder.

5) Put the material under the compaction testing machine.

6) The load is applied gradually as the total load is reached in 10 minutes. The total load shall be 40 tones.

7) Now, release the load and crushed material is to be collected from cylinder.

8) Crushed material is now sieved out by 2.36mm IS Sieve.

9) The material passing the sieve will be weighed and recorded.

Aggregate crushing Value = W2/W1*100 in percentage

W1 = Total weight of dry sample in gms

W2 = Weight of portion passing 2.36 mm sieve.

3.6.2 AGGREGATE IMPACT VALUE TEST

This experiment is done on the aggregates to check the toughness of the materials. Due to the heavy vehicular movement on the road, the aggregates are subjected to the sudden 34 load as a result, break down takes place. The aggregate should have sufficient toughness to resist the disintegration from the impact of wheels of the vehicles. Therefore, this characteristic is measured by Impact value test in terms of testing of the materials.

APPARATUS:

- Steel cylinder with central diameter 150 mm including an appropriate plunger and a piston
- Steel tamping rod having diameter of 16mm and length of 450-600 mm
- Balance of capacity 3kg at least
- Impact Testing Machine having capacity 45 to 60 kg.
- IS sieves of sizes 2.36mm, 10mm, 12.5mm
- Cylindrical measure having dimensions of having internal diameter of 115mm and height 180mm

PROCEDURE:

a) The test sample having capacity size 10mm and 12.5mm are taken. The aggregates must be oven-dried by heating at 100-110°C for a period of 4 hours and allow them to cool.

b) Sieve out the test material through 12.5mm and 10.0mm from IS sieves. The aggregate passing from 12.5mm sieve and retained on 10mm sieve were taken.

c) Now, put the aggregates to the measuring cylinder as it filled about just 1/3 rd depth.

d) Then compact the material by giving 25 blows with the tamping rod.

e) We add 2 more layers of aggregate in the same way, so that cylinder will be full.

f) Now, strike the remaining aggregates.

g) Find out the total weight of the aggregates which is taken as W.

h) Put the impact machine on the level plate on the floor.

i) Put the sample in a mould and place under the machine and tempered it 25 times with temping rod.

j) Now, pull the hammer up at its lower end is 382mm above the aggregate sample in the mould and allow it to fall.

k) Remove the crushed aggregate from the mould and sieve it out from 2.36mm IS sieve.

l) Weigh the crushed sample passing the sieve carefully. Also, weigh the material which was retained in the sieve.

m) Now, calculate the aggregate impact value on the basis of their formulas.

Therefore, Aggregate Impact value= W2/W1*100 in percentage

W1 = Total weight of dry sample in gms

W2 = Weight of portion passing 2.36 mm sieve

3.6.3 LOS ANGELES ABRASION TEST

Due to the heavy vehicular movement, the surface coarse of the road pavement is subjected to the wearing and tearing action at the top surface. So the road aggregates used in the surface course should possess enough hardness or resistance to abrasive action. When the vehicular loads on the pavement surface moves at a greater speed, the soil particles present between the road surface and tyres causes abrasion to the road surface. Steel tyres of animal drawn vehicles cause noteworthy abrasion of road surface.

Los angeles abrasion test is used to determine the abrasion of the aggregate which are used in the construction. . In order to determine the hardness of aggregates IRC (Indian Road Congress) has suggested Los Angeles Abrasion test over the other tests. It determines the percentage wearing and tearing due to relative abrasion between the aggregates and the steel balls which we used as a charge while performing the test.

APPARATUS:

- Los Angeles Abrasion Testing machine
- 1.70 mm IS sieve
- abrasive charge depending on grade of aggregates
- balance
- oven

- tray

PROCEDURE:

a) Clean the aggregates that have been oven dried at a temperature of 105-110°C, to constant weight. The grade of the aggregate to be used in the test should be closest to those used in road construction.

b) Take the aggregate sample weighing 2.5kg and place them in the LA abrasion testing machine.

c) Add steel charge balls as per grading. Here we are using 8 balls.

d) Fix the cover of machine and tighten the bolts so that no material is lost during the test.

e) Now, allow the machine to rotate at a specified speed of 30-33 revolutions per min. and the specified number of revolution is 500 for the grade C.

f) If the revolutions are complete, the machine is stopped and the material is removed out and dust is taken care off.

g) The material is sieved out on 1.70 mm sieve and then washed and dried up.

Penetration test

Consistency of bituminous materials depends upon numerous factors such as its composition and temperature when temperature lies between 25-50 degrees. Most of the paving grade bitumen remains either in plastic or semi-solid state and have high viscosity because of which they cannot be mixed with aggregates. But there are certain grades of cutback bitumen and bituminous emulsion which possess low viscosity at this temperature and can be easily mixed at low temperatures without heating.

Penetration value we used to find the consistency of bituminous material and measure of hardness. It is the vertical distance penetrated by the needle point in to the bituminous material under the specific load condition, time and temperature. This distance is measured in one tenths (1/10th) of an mm. This test is used for finding out the consistency of bitumen.

APPARATUS:

- Container: A flat bottom, cylindrical metallic dish having dia. 55cm and 35mm of depth is required. If we get the penetration value is of the order of 225 or more, dish of having 70mm dia. and 45mm depth is to be taken.
- A Standard needle: A straight, good quality, conical end needle.
- Water Bath: It should maintain at 25±0.1°C to the sample to be immerged to the depth should not less than 100mm from top and supported on perforated shelf shouldn't be more than 50 mm.
- Penetration Apparatus or Penetrometer: It should allow the needle to penetrate with appreciable friction for desired time duration and should accurately give results in 1/10 of mm.
- Thermometer: It should be readable upto 0.2°C.

PROCEDURE:

(i) Test specimen preparation: - First of all, soften the bitumen to a pouring consistency at a temperature between 75° to 100°C above its temperature which soften the bitumen and stir the material thoroughly to make it homogeneous and should free from air bubbles and water. Pour the melt sample into the container at a depth at least 15mm in excess of the expected penetration. Now, allow it to cool at an a temperature between 15° to 30°C for 1 hour. Then place it with the transfer metallic dish in the water bath at 25° ± 0.1 °C. 39

(ii) Now, fill the metallic dish with water to a sufficient depth so that it completely covers the container. Place the sample under the needle of penetrometer and put this on the stand of the given apparatus.

(iii) Now, clean up the needle with benzene solution (C_6H_6), allow it to dry and then adjust it with the weight. The total moving load should be 100gms by including the weight of the needle, super-imposed weight and carrier.

(iv)Adjust the needle using the adjusting screws to make the contact with the surface of the given sample.

(v) Set the pointer on the penetrometer dial to read 0 and note down the initial reading.

(vi) Now, release the needle by pressing the knob for exactly 5.0 sec.

(vii) Note down the final reading by the adjustment of penetrometer for checking the penetration.

(viii) At least 3 readings at points after testing the sample should not be less than 100mm apart.

(ix) Clean the needle with benzene carefully and dried.

(ix) Now sample container is also transfer in the water bath before next testing is to be done so as to maintain the temperature 25°C at the constant rate. Penetration value will be calculated on the basis of their mean by taking the values of initial and final penetrations in considerations.

3.6.5 Softening point of the Bitumen

The softening point of the bitumen is that temperature at which the bituminous material gets soften. It consists of 2 steel balls having dia. 9.5 mm each which place between the two brass rings and heated up under water at a constant temperature. As the rings touches the ground, the temperature will be counted as softening point temperature.

Apparatus:

i. Two steel balls having dia 9.5 mm each

ii. Two brass ring members to support the balls in between, having dia from top to bottom 17.5 mm and 15.9 mm respectively.

iii. One support- beaker- so it can hold the rings in position.

iv. Thermometre

Procedure:

i. Take two steel balls having dia 9.5 mm each and should have weight 0.05 gms.Also, take two members of brass rings having depth of 6.4 mm and having dia. from top 17.5 mm and from 15.9 mm respectively.

ii. Now, assemble the apparatus with the rings and put thermometer in position.

iii. Fill the beaker with water at a height of 50 mm from the upper surface of rings and it should be at temperature of 5°C. 41

Note:- we can use glycerin as well only if we want the softening point above than 80°C and initial temperature must be at 35°C.

iv. Now, apply heat to the beaker and stir the liquid so it can maintain the constant temperature 5±0.5°C.

v. As the temperature increases, the balls start getting soften and sink through the ring along with some portion of bitumen.

vi. Note down the readings as the balls touches the surface of the beaker.

vii. Record the temperature when both balls touch the base. And by taking the average of both, it will be the softening point of the bitumen.

3.6.6 Ductility test of the bitumen

Apparatus: - standard briquette mould, Ductility testing machine, water bath, thermometer having range 0 to 44°C

Procedure: - Heat the bitumen at a temperature more than 100°C till become liquid.

a. Assemble the moulds on the brass plate.

b. Get the mould oily internally with glycerin and dextrin to prevent it from sticking while pouring the bitumen into the moulds.

c. Now, pour the bitumen into the briquette moulds until it get level full.

d. Allow it to cool at room temperature for 30-35 minutes and then put the moulds into the water bath to make it specific temperature for 30 minutes.

e. Remove the excess bitumen with the help of sharp blade or knife

f. Put the brass plate and mould with briquette specimen for one and half hour.

g. After that, remove the briquette from the plate and detach the side pieces.

h. Now, clamp the sample with rings at each end of the testing machine. i. Adjust the reading of the machine at 0.

j. Now, start the machine and pull clips at a constant speed 50 mm per minute.

k. As it moves, the bitumen tends to elongate. The point where it thread of the bitumen breaks, note down the reading.

l. Take such 3 reading and compute the ductility of the material.

CHAPTER 4

RESULT AND ANALYSIS

4.1. Causes of the defects

1. Temperature Changes: The temperature in the Punjab ranges from 1°C to 45°C or more. Since, the region is plain. So due to the temperature changes, defects were found.
2. Vehicular Loading : Since, the road is exposed of heavy vehicular movements resulting in fatigue failure so this is the main reason of distresses. The probable defect is coming out to be Alligator cracks.
3. Poor quality of material From the performed tests, we've found out that the quality of the material is poor. It was just due to materials which was laid on the ground was defected.
4. Poor quality control and method of construction Due to improper method of construction and poor quality control, distresses took place. It might because of the temperature maintenance on which mix is prepared which is either bituminous mix or aggregate was not properly maintained which leads to the pavement distresses.
5. Due to the provision of the poor shoulders, it leads to edge cracking.
6. Environmental factors such as heavy rainfall, due to water-logging pavement duw to poor drainage conditions leads to failure which are either in the shape of potholes or patches.
7. Poor paving lane joins and inadequate construction joints leads to longitudinal and transverse cracks.

4.2. Selection of the best maintenance option

From the graph of severity level, alligator cracks are the main reason of pavement defects. So for Alligator cracks, rehabilitation is required on the top layer and a proper additional surface coarse is needed with a fresh layer of the bitumen as per design and quality standards. This may be economical then by providing the overlay for whole pavement.

For potholes, it can be covered by premix material after cleaning and painted with bituminous binder.

Patches are the one kind of improvement for the pavement. A entire damaged area is selected and covered/filled with fresh layer of bitumen. So it can be economical as compared to by demolishing the whole pavement ground.

Block cracking also can be improved by surface treatment or by providing a thin overlay on the surface coarse.

Edge cracks are improved either by the improvement of drainage or a also we can fill the cracks by making the slurry of bituminous emulsion or emulsified bituminous crack seal.

Longitudinal and transverse cracks also have the same techniques as edge cracking. By improvement of drainage by clearing off the source that collects water on the pavement and also by bituminous slurry to fill the cracks on the joints. Making the side drainage is also a good idea for this.

Slippage cracking can be maintained by making a full depth patch by selecting the entire area of the crack.

Weathering is raveling is improved by any surface treatment or a thin coat of the bitumen.

CHAPTER 5

CONCLUSION

Pavement deterioration is the process by which distress (defects) develop in the pavement under the combined effects of traffic loading and environmental conditions. Some Causes of Road Cracks and Deterioration are Defects caused during construction due to poor construction quality, Structural failure of base, poor highway facilities, Poor maintenance policy, Poor supervision and others.

Pavement deterioration process starts very slowly so that it may not be noticeable, and over time it accelerates at faster rates, they must be implementation of the proper maintenance and repair work in suitable time; which will maintain the pavement in a safe and acceptable operational condition and helps to save cost of maintenance. Road maintenance is one of the important components of the entire road system. Even if the roads are well designed and constructed, they may require maintenance. Repair and maintenance procedures cannot overcome bad design problems but can help prevent these problems resulting from degradation.

The possible causes of deterioration on road are firstly during implementation of road; Failure in the layers of the road (failure in Subgrade or other layers), the asphalt mixture arrival in the site is cold, the wrong way in the casting and compaction of asphalt and others. Secondly after implementation; Heat shrinkage of asphalt materials (change in temperatures and climate), High stress (Heavy traffic volume or increase vehicle weight), Lack of water drainage system and many more.

Early detection and repair of road defects are important to maintain the permanence of road. The Suggested maintenance for the cracks and defects in road are Crack seal (fill the crack) to prevent moisture entering into subgrade through the cracks, Improve (construct) drainage system, Reconstruction of the edge and support the edge with paving stones and patching.

5.1. RECOMMENDATION AND FUTURE WORK

The importance of governorate of roads maintenance to maintain the level of road performance and ensuring safety for its users, Where there is so many of paved roads is subject to regular maintenance and preventive. To reduce road defects in general, during the construction or maintenance of the road, the municipality must ensure that the construction work are performed as properly and required. Also to construct the roads that have high traffic volume must be increase the thickness of the asphalt layer must be increased more than 70 mm (To avoid defects that are due to high traffic volume) and the level of the asphalt layer should be at the same level of the soil beside the road. It is recommended to use the soil derived from rock breakage as an alternative to wadi soil that was used for road.

To reduce the spread of further defects and cracks on road the following measures are suggested:

- Continuous periodic inspection of roads.
- Fill the cracks and repair minor defects on the road surface.
- Construct the shoulders and Repair Edge Cracking of the road.
- Construct a water drainage system.
- Reconstruct some parts of the road.
- Periodic cleaning of the road

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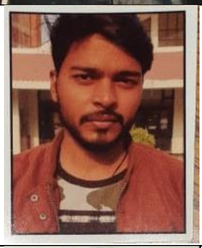	Name: Akhilesh Kumar Yadav Roll no: 1170431006 Add: Lodhan Purwa , Ayodhya Email Id: ay2625@bbdu.ac.in Phone no: 8429418750
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