UTILIZATION OF WASTE MATERIALS AS A PARTIAL REPLACEMENT OF BITUMEN

A

PROJECT REPORT

Submitted in partial fulfilment of the requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision

of

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STUDENT DECLARATION

We hereby declare that the work presented in the Project report entitled **"UTILIZATION OF WASTE MATERIALS AS A PARTIAL REPLACEMENT OF BITUMEN"** submitted for the partial fulfilment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of our work carried out under the supervision of **Amardeep.** This work has not been submitted elsewhere for the reward of any other degree/diploma. We are fully responsible for the contents of our project report.

Signature of Student	Signature of Student
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Date

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"UTILIZATION OF WASTE MATERIALS AS A PARTIAL REPLACEMENT OF BITUMEN"** in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the department of Civil Engineering , **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Akhil sharma (151657) and Tarun sharma (151690)** during a period from August, 2018 to May, 2019 under the supervision of **Amardeep** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date:

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ABSTRACT

In today's world conservation of environment from the different waste generated and the excessive use of the non-renewable resources has led to the way to find the new material either a waste or a renewable resource, which also don't harm the environment and which can also be utilize to partially replace the bitumen used in the road construction work. Therefore, use of waste engine oil obtained from vehicle and pine resin generated by trees could answer that demand. They can be used in order to meet the demand of the bitumen required in road paving without compromising there properties which is essential for construction or paving work. The pine resins can be used as an admixture .Bitumen mixtures were tested by means of different tests like softening point, penetration value, specific gravity and ductility. It was concluded that the waste motor oil when added it increases the value of penetration and improves ductility.

Keywords: - Bitumen, Waste engine oil, Modified bitumen, Pine resin, Waste material, Waste motor oil.

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LIST OF ABBREVIATIONS

GPPS	**General Purpose Polystyrene**
HIPS	**High Impact Polystyrene**
PS	**Polystyrene**
HDPE	**High-Density Polyethylene**
NCP	**Nanoceramic Powder**
XRF	**X-ray fluorescence**
PP	**Polypropylene**
DBM	**Dense Bitumen Macadam**
PCB	**Pyrolysis Carbon Black**
NA	**Natural Aging**
PAV	**Pressurized Aging Vessel**
TFOT	**Thin Film Oven Test**
TGA	**Thermo-Gravimetric analysis**

CHAPTER 1

INTRODUCTION

1.1 General

In this study, the main aim of this is to partially or fully replace bitumen by waste materials such as waste motor oil and pine resin as an additive. In today's time the government has banned the extraction of bitumen so, it was proposed to replace bitumen and use some waste products as replacement. This is done to reduce the use of natural resources in road pavement. Using waste motor oil results in lower viscosity that results in lower mixing and compaction temperatures. Bitumen has been broadly utilized in pavement construction because of its unique viscoelastic attributes and brilliant execution.

In the bitumen pavement because of the blend of traffic loading and indigenous habitat distress happens, for example, permanent deformation (rutting), fatigue cracking, thermal cracking and water harm. In this way bitumen alteration is a standout amongst the most broadly utilized techniques to improve the execution and diminish the distress in the bitumen asphalt.

1.2 Introduction

Right now, there is a developing worry to reuse waste materials and to monitor or limit the utilization of natural assets in road paving. In this manner, numerous investigations have as of late risen in which these issues, or some portion of them, are talked about.

For prevention and construction of road infrastructures the road paving industries utilize a high amount of natural and finite resources, such as bitumen and aggregates.

Bitumen plants are considered as significant sources of pollution as it has very excess amount of greenhouse gas emissions. Bitumen is a non-renewable resource so we have to use it suitably as it is generated after many years and the extraction of bitumen is not very eco-friendly and environment friendly. In India the production of bitumen have been limited and only some time period of year it can be extracted and only in limited amount.

Waste Engine oil

Used engine oil is a profitable asset. Hydrocarbon stock base which is obtained from crude oil of the nature being heavier and thicker is utilized to manufacture and improve the characteristic of motor oil and also some additive substances are utilized for incrementing specific properties of motor oil. The greater portion of an average motor oil consist of some hydrocarbons, ranging somewhere in between of 18 and 34 C (carbon) particles for each atom. Viscosity of the motor oil is one of its most exceptional characteristics as for the propelling parts it can uphold a lubricating film in between. Viscosity is the property of fluid to oppose the flow and can be said as the thickness of liquid. Motor oil's viscosity should be such that it is viscous enough to keep up film of lubrication in the propelling parts and also should be such that it flows through each and every part. Motor oil viscosity changes due to temperature variations are determined utilizing viscosity profile. In order for the sustainable construction of road pavements and also to find a replacement of bitumen in order to decrease the pollution caused by the manufacturing of bitumen. Alternate materials which can be used for partial replacement of bitumen in road paving were tested to solve the issues stated above. Due to its lower viscosity of waste motor oil its incorporation in asphalt mixtures is a being tested to prevent aging, which results in lower compaction and mixing temperatures. This solution is also environment friendly as waste motor oil is not totally reusable. However, the addition of waste motor oil has displayed problems like increase in rutting and low recovery for elasticity.

Pine resin

Pine resin is the hydrocarbon secretion of many plants, generally of coniferous tree like pine etc. pine resins from centuries is valued for its chemical worth and also for valuable uses such as producing adhesives, varnishes and even food glazing agents. There are different types of trees which have resins such as cedars, Douglas-firs, cypresses, hemlocks Waste Engine Oil is the oil used once in any engine widely collected from the service station of HRTC workshop at taradevi at Shimla**.**

The engine oil is not fully recyclable that's why we have used it, as using it is environment friendly. The pine resin was collected from waste of trees which is very helpful in our study. It was collected from the forest of Shoghi (near Shimla). Resin is a viscous substance obtained from natural resources like plants and trees or synthetically from treatment of polymers.

In this research various compositions of engine oil is being added i.e. starting from 1% and then check at 3% and after that for 5%   and so on up to 13% bitumen replacement by weight. The pine resin is also added in small amount to increase the binding properties as pine resin acts as the adhesive. As pine resin shows the adhesive properties so it is used as admixture.

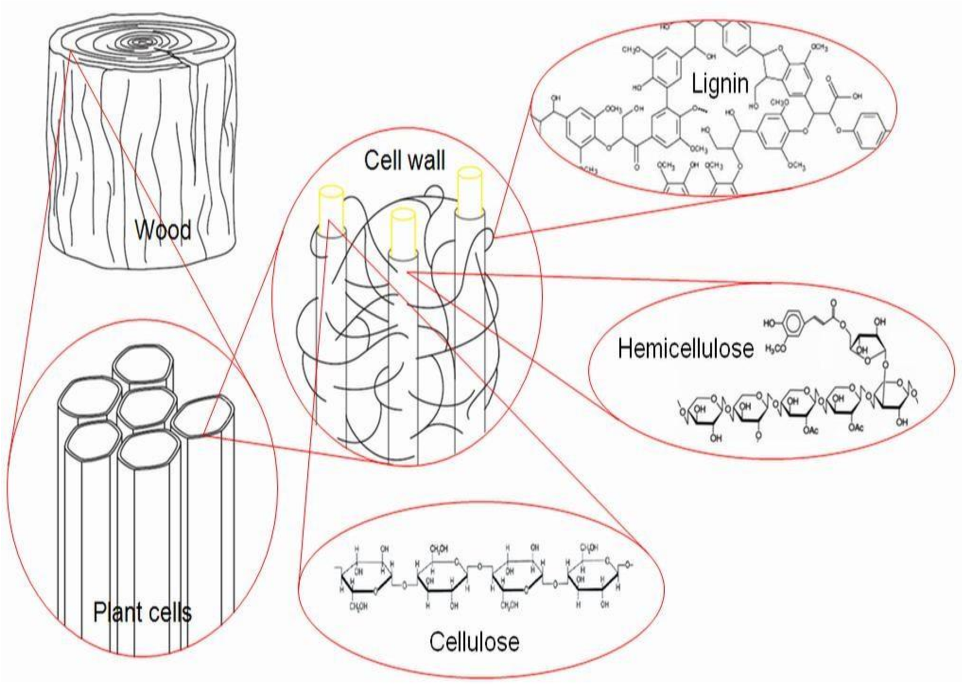


Fig 1.1 Cross linking of phenolic group
In pine resin structure

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

The following literatures were investigated and it was concluded that due to growing concern of using eco-friendly materials and conserving the environment, waste materials are a very promising substitute for bitumen in order to decrease the utilisation of natural resources in construction of road pavements. So, waste motor oil was majorly investigated to be used as an alternate in place of bitumen by partial replacement. Different waste materials have been i.e. lignin, various polymers, waste cooking oil, tyre rubber, palm oil fuel ash, steel slag etc.

Out of these we have selected two waste materials i.e. waste motor oil and pine resin. Pine resin was selected because, research on pine resin as a substitute has never been conducted. Pine resin is the hydrocarbon secretion of many plants, generally of coniferous tree like pine etc. pine resins from centuries is valued for its chemical worth and also for valuable uses such as producing adhesives, varnishes and even food glazing agents.

2.2 LITERATURE REVIEW

Fernandes et al. (2018) utilised the waste engine oil and recycled engine oil bottoms (EOB) mixed with polymers (i.e. waste polyethylene, crumb rubber and styrene butadiene.) in order to signify their usefulness as the alternative (i.e. partial or fully replacement) of bitumen in flexible pavement construction. Penetration and softening point, rolling thin-film oven test were conducted to identify the physical properties and rheological test were conducted which were viscosity test and the dynamic shear rheometer test to find out the flow. Final viscosity will be reduced when addition of EOB is done to bitumen will certainly facilitate the process of mixing production.

To determine chemical properties of bitumen mix the Fourier Transform Infrared Spectroscopy (FTIR) is done which is a helpful test. The quantified and heavy metals present in engine oil are predicted by plasma spectroscopy. As a result, 10% EO or 15%

RB and 6% HDPE, those improved with 10% EO or 12.5% RB and 5% SBS and lastly those replaced with 7.5% EO or 15% RB and 20% CR can replace the bitumen partially.

Cortavitarte et al. (2018) has conducted the study to examine the General Purpose Polystyrene (GPPS) usually called as crystal polystyrene; High Impact Polystyrene (HIPS) and Polystyrene from Hangers (HPS) were substituted to modify bitumen. Sieve analysis is conducted and particle size < 75 mm was maintained. There was decrease in plastic deformations and a significant increase in void content, whereas different properties were remained in the same way of conventional values when each and every sample was tested alone for comparison purposes. The addition of PS (not heated) slightly varies for the experimental mixtures, whose some portion of bitumen is replaced by PS.

Penetration and softening point, rolling thin-film oven test were done to determine the physical properties and rheological test were conducted which were viscosity test and the dynamic shear rheometer test to identify the flow. These mixtures were mixed after coarse aggregates and added during 30s with the aggregates before the start of the process. Cylindrical Marshall Specimens, rotatory compactor sample, rutting slabs and prismatic specimens found from 80 mm height slabs were 4 various types of samples that were prepared for the study. As a result 1% mixture of bitumen was replaced by PS gives the best results whereas 2% usage was not comes into account due to reduced cohesion properties shown by it.

Rahman et al. (2017) conducted the this study with the main aim to research on the waste products like waste cooking oil, tire rubber powder; palm oil fuel ash when used as a replacement of bitumen. The bitumen used was Bitumen having penetration value 60/70. Sieve analysis is conducted and particle size < 75 mm was maintained. For 5hrs reflux was performed at 170◦C temperature. Penetration and softening point, rolling thin-film oven test were performed to identify the physical properties and rheological test were conducted which were viscosity test and the dynamic shear rheometer test to find the flow. Mixing methods were suitably used.

As a result it was concluded that mix having 5% cooking oil of bitumen is the perfect ratio among all the mixes. They got success up to 15% of replacement done by the modifiers. As a result the viscosity got increased when tire rubber and POFA is added.

Fernandes et al. (2017) the study was conducted to examine the replacement done with waste motor oil in asphalt binder and elastomer modifiers in bitumen. In this study two types of products of waste engine were used one is waste engine oil (EO) which is untreated from light motor vehicles and another one is recycled engine oil bottoms (RB) which is higher in viscosity as the large part of small compounds is removed. Bitumen taken for experiment was B35/50. 10% wt. waste motor oil and 5 %wt. SBS were added to the bitumen (B35/50). Penetration value, softening point and dynamic shear rheometer tests were conducted to examine physical and rheological properties of the specimens.

The rheological properties were tested mechanically. Brookfield Rotational Viscometer was used to check the dynamic viscosity of both the products of waste engine oil. Their durability can be guaranteed and these mixtures are not sensitive to moisture. It also becomes the fact that the modified mixture having waste engine oil and SBS as replacement gives good results than the conventional bitumen B35/50.

Hussein et al. (2017) conducted the study with the basic aim is to replace the bitumen with inorganic Nanoceramic Powder (NCP) extracted from the ceramic wastes. Penetration value, ductility, softening point, and dynamic shear rheometer tests were performed to examine physical and rheological properties of the specimens. Bitumen having grade 60/70 is used in this study. The chemical compositions of the NCPs were determined by XRF analysis is used to examine the shape and size of nanoparticles of the NCPs and morphology was determined using a transmission electron microscope. The Fourier Transform Infrared Spectroscopy (FTIR) is a helpful tool used to find out the materials macromolecules, as it identify the various chemical organic compounds present in any solid, liquid. The penetration value and the softening point of NCP-modified bitumen gets improved.

Boomika et al. (2017) conducted the study with the main focus being is that the partial replacement of bitumen is done with lignin and plastic. Different proportion of lignin and plastic are added i.e.5&10%, 10&15%, 15&20%, 20&25% respectively. For the determination of rheological properties different tests were conducted like penetration, ductility, viscosity, softening point. The binding properties of bitumen get improved as Lignin possesses some binding properties. Ligno sulphonate is used as binder and is mixed by heating plastic, lignin and asphalt to about 110 to 180 degree Celsius on a hot plate and mixing then with spatula for several minutes. As a result the penetration value, ductility, stability value comes out to be maximum for 15&20%proportion, softening point and viscosity comes out to be maximum for 20%&25%proportion.By conducting research it was observed that the properties are enhanced by modifying bitumen.

Appiah et al. (2016) utilized different plastic waste thermoplastic polymers, namely High density polyethylene (HDPE) and Polypropylene (PP) were added in conventional AC-20 graded bitumen. At temperature range of 160˚C–170 ˚C the plastics were shrinked and blended with the bitumen 'in-situ', with a shear mixer. To determine the physical properties and to check flow of bitumen the rheological parameters such as penetration ring, ball softening point and viscosity tests were employed. From penetration test it was found that modified bitumen shows sharp decrease in penetration value.

For softening point, as compared to base bitumen there was a linear increase in the softening temperature for HDPE PMBs up to 3% concentration of polymer in bitumen. Viscosity test shows with the increment in concentration of polymer there is an increase in viscosity .It was recognised that polypropylene polymer, revealed profound effect on homogeneity and compatibility with slight linear increase in the viscosity, softening and penetration values and relatively high changes for HDPE modified bitumen.

Magadi et al. (2016) the steel slag was used as a substitute material for coarse aggregate of different sizes for different bitumen mix i.e. 37.5mm, 20mm, 12.5mm down at various percentages. The DBM (Dense Bitumen Macadam) grade 2 is used. Steel slag is reused up to 40% in bituminous clearing blends. Here blend plan, compaction tests, permanent deformation tests, stiffness modulus tests at different temperatures, fatigue tests and indirect tensile strength tests were done.

Materials involved are aggregates, steel slag and bitumen. Aggregates are tested for their strength, toughness, hardness, and shape and water absorption. The temperature at which it is mixed was 140-160ºC and compaction is done at the temperature 120-140°C. As a result it is found that the optimum bitumen content was decreased when 12.5mm down steel slag was utilised.

Feng et al. (2016) utilized the waste material with the aim to change street bitumen (SK70# and SK90#) through liquefy mixing two kinds of Pyrolysis Carbon Blacks (PCBs) produced using waste tires were chosen. Thin Film Oven Test (TFOT), Pressurized Aging Vessel (PAV) and Natural Aging (NA) were led to assess the warm and photo-oxidative maturing of the PCB altered bitumen. In the wake of including PCBs the warm and photo-oxidative maturing of bitumen were improved altogether.

In the event that the PCB content isn't over 10% the capacity security of the PCB changed bitumen meets the criteria required by polymer adjusted bitumen. In the event that 15%PCB is utilized the low temperature properties are observed to be antagonistically influenced while the high-temperature properties of bitumen are clearly upgraded by PCB change.

Menaria et al. (2015) conducted the study with the main objective was to add plastic waste in the bituminous mix for getting required strength. The different test for getting conservative outcomes and the ideal usage of plastic waste. Bitumen-VG-30 penetration grade bitumen was utilized. Penetration test, ductility test, softening point test, specific gravity test, viscosity test, flash and fire point test, Float test, Water content test, misfortune on warming test, marshal stability test and different tests were finished.

The tests were directed for three distinctive rate for example 4.25, 4.50, 4.75 bitumen content and the plastic substance shifts from 8 to 14 in the hole of 2.As an outcome, 8% as ideal plastic substance that can be utilized and can utilize it in max of 50 degrees of temp streets squander plastic improves the official and quality in the bitumen blend.

Naskar et al. (2010) conducted the study with the main objective is to modify bituminous binders prepared using different plastic contents 0–7wt% by weight of bitumen) and were replaced with bitumen. Thermogravimetric analysis (TGA) information is utilized by utilizing Kissinger and the Flynn– Wall– Ozawa techniques to decide the enactment energies. The most astounding warm stability was observed to be in changed bitumen (WPMB5) with 5 wt% plastic contrasted with different binders. TGA and DSC tests were led for inspecting the warm stability of the binders. At lower wt% WP content swelling happens so 5% is the ideal substance. In light of the nearness of increasingly unstable substance in bitumen the TGA/DTG results demonstrated that bitumen deteriorates more effectively than altered bitumen.

CHAPTER 3

MATERIALS AND METHOD

3.1 General

The motivation behind this region is to demonstrate the examination techniques utilized in this examination. Descriptions about the materials used are discussed in this chapter. As we know, specimen details and testing methods are essentials for an experimental investigation. Hence they are also described in detail in the following sections.

The test technique for this examination was separated into three sections:

- Section one essentially managed the assurance of properties of regular bitumen.
- Section two decides the properties of halfway replaced regular bitumen with waste motor oil.
- Section three managed deciding the ideal level of waste motor oil to be replaced with the regular bitumen.

3.2 Material properties

Materials required for this examination are Aggregates, Bitumen and Waste engine oil. A detail discussion regarding the required material type and their properties has been made below.

3.2.1 Aggregates

Pavement structure are one of the most important construction and the function of pavements is to bear heavy moving traffic loading and pavement structure mainly constitutes of aggregates. So, in order to utilize aggregates it's very important steady its characteristic and performance. The aggregates must have the property of resisting wearing due to the friction created between the tyres and pavement surface, durability from breaking down under various environmental changes and from very heavy duty moving wheel loadings. Bituminous concrete mixes are created utilizing a large number of different mineral aggregates. Different test have been conducted in the laboratories to check the performance and characteristics of the aggregates to be used in the construction. The tests are as follows

- Crushing Test According to IS: 2386 (Part)-IV
- Los Angeles Abrasion Test According to IS: 2386 (Part)-IV
- Impact Test According to IS: 2386 (Part)-IV
- Soundness Test According to IS: 2386 (Part)-V
- Shape Test According to IS: 2386 (Part)-I
- Water Absorption and Specific Gravity According to IS: 2386 (Part)-III

3.2.1 Bitumen

Bitumen is majorly used in pavement construction in the form of a binder. The process for obtaining bitumen is that crude petroleum is fractionally distilled to get it. Bitumen material is a form of hydrocarbon. Bitumen is a substance which can be easily dissolved CCl_4 (carbon tetrachloride) and in CS_2 (carbon disulphide). As, stated before bitumen has high tendency of binding and is used as a material for water proofing of pavement structures. The determination of using the type of bitumen depends upon the construction that is taking place according to the necessity. Bitumen under room temperature remains solid, non-volatile for all purposes. In situ bitumen vapour pressure is beneath the motive of regulation of acknowledgement for typical composition. The property of viscosity is used for grading different types of bitumen. The grade of bitumen that was used for experimentation in this study is VG 10. Following test were conducted to evaluate performance and characteristics of bitumen.

- Softening Point Test According to IS: 1205-1978
- IS: 1203 1978 guidelines were used i.e. Indian standard way for testing of bituminous materials: determination of penetration (First review) bitumen used is of grade 80/100.

- As directed by IS: 1208 1978, Indian standard way for testing of bituminous materials: determination of Ductility (First revision) bitumen used is VG 10.

- Specific Gravity test According to IS: 1202-1978

3.2.3 Waste engine oil

Used engine oil is a profitable asset. Hydrocarbon stock base which is obtained from crude oil of the nature being heavier and thicker is utilized to manufacture and improve the characteristic of motor oil and also some additive substances are utilized for incrementing specific properties of motor oil. The greater portion of an average motor oil consist of some hydrocarbons, ranging somewhere in between of 18 and 34 C (carbon) particles for each atom. Viscosity of the motor oil is one of its most exceptional characteristics as for the propelling parts it can uphold a lubricating film in between. Viscosity is the property of fluid to oppose the flow and can be said as the thickness of liquid. Motor oil's viscosity should be such that it is viscous enough to keep up film of lubrication in the propelling parts and also should be such that it flows through each and every part. Motor oil viscosity changes due to temperature variations are determined utilizing viscosity profile. In order for the sustainable construction of road pavements and also to find a replacement of bitumen in order to decrease the pollution caused by the manufacturing of bitumen. Alternate materials which can be used for partial replacement of bitumen in road paving were tested to solve the issues stated above. Due to its lower viscosity of waste motor oil its incorporation in asphalt mixtures is a being tested to prevent aging, which results in lower compaction and mixing temperatures. This solution is also environment friendly as waste motor oil is not totally reusable. However, the addition of waste motor oil has displayed problems like increase in rutting and low recovery for elasticity.

- Softening Point Test as per IS 1205 1978
- Penetration Test as per IS 1203 1978
- Ductility Test as per IS 1208 1978
- Specific Gravity Test IS 1202 1978

3.3 Tests on Bitumen and Modified Bitumen

3.3.1 Softening point test

Conforming to the Indian Standards code IS: 1205 1978, this test was performed. This testing was done to measure the softening point of bitumen which can be explained as the point at which the bitumen due to temperature variations softens to a certain degree in accordance to the test specifications. Ring and Ball is the apparatus that is utilized in this test. At a certain temperature the samples made for testing of bitumen were placed in the brass rings which were then submerged in a liquid (glycerin or water). The heating of the liquid in which the test sample is placed is done at a rate of 5 degree Celsius per minute and a steel ball was then placed atop of the bitumen sample. The temperature at which the bitumen softens after the necessary heating and the steel balls touch the bottom of metal plate at a measured length is known as softening point. The material with higher softening point is referred as to have lower vulnerability to the temperature rise and is favoured to be used in hot weathers. This test helps us to determine the temperature for which the bitumen should be heated for its preparation as a construction material in road pavements. 35°C - 70°C is the variation of bitumen's softening point.

Apparatus

1. Ring and ball device
2. Thermometer : Low Range: -2˚ to 80˚C, Graduation 0.2˚C: High Range : 30˚ to 200˚C,
3. Scaling 0.5˚C

Procedure

1. Apparatuses, are to be firstly gathered to carry out the testing namely laboratory thermometer, steel balls and brass rings are used.
2. At a temperature of 5˚ ± 0.5˚C the beaker should be filled with heated refined liquid each minute.
3. At a temperature of 5˚ ± 0.5˚C the liquid should be heated and stirred properly with assistance of a stirrer every minute.

4. The test samples should be heated until the point that the steel balls pass through brass rings due to softening of bitumen samples. As shown in figure 3.2(b)
5. Hence, the temperature at which the material softens and the balls touch bottom of metal plate is noted as the softening point.

(a) Placing of sample

(b) Ring and ball device

Fig 3.2 Softening point setup

3.3.2 Penetration Test

The testing was carried out in accordance with Indian standard code IS: 1203 1978.The degree of stability is calculated through the penetration test of bituminous material. The value ranges from 80-100 for a bitumen graded at 80/100.The distance measured when the steel needle penetrates through the bituminous material under planned definite loading and temperature is known as penetration value. Bitumen's consistency is measured through penetration test. The needle is let to penetrate the bitumen sample for a time period of 5 seconds. Up to 3 to 5 samples were prepared for measuring penetration value by penetrating at a separation distance of 10mm apart. 100 gram is the weight of needle utilized. Pouring of bitumen into the sample mould in order to safeguard the test specimen against dirt and it is then cooled at temperatures ranging in the middle of 15°C to 30°C for a time period of 30 min and is then placed into a hot water tub for a time period of 60 mins at a temperature of about 25° ± 0.1 °C.

Apparatus

1. Penetration Device
2. Needle(Pointer)
3. Vessel

4. Water tub
5. Thermometer for Water tub
6. Stop wristwatch

Procedure

1. The needle of the dial gauge is set to measure the first reading or for reading zero value.
2. The needle is properly penetrated for 5 seconds. As shown in fig3.3.
3. Regulate the penetration device to measure the downward distance penetrated.
4. Readings at minimum three different points at the surface of specimen are marked at a distance of at least l0 mm to the side of the bowl. After that the average of the sample reading is taken for every sample made and final reading is noted.

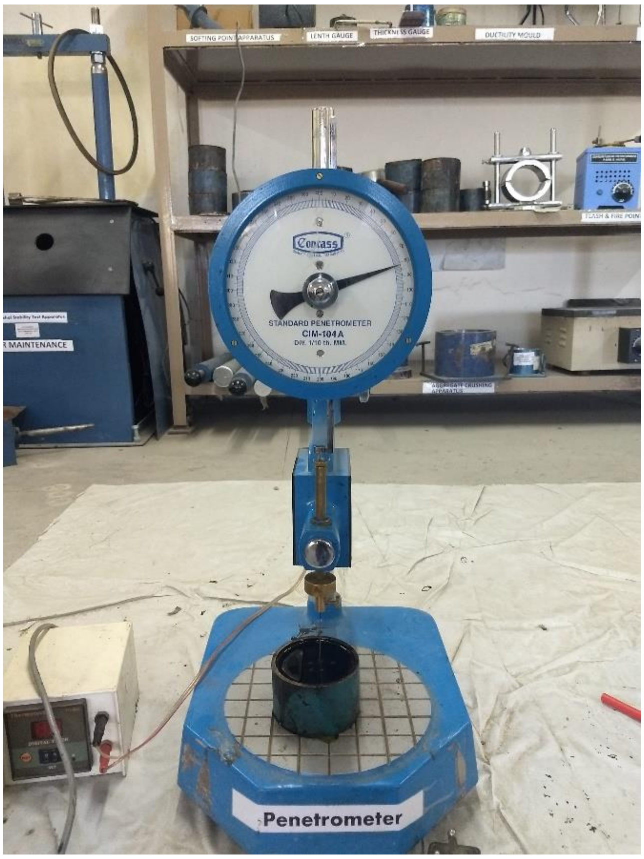


Fig 3.3 Penetration test setup

3.3.3 Ductility Test

This test was conducted according to the Indian standard code IS: 1208 1978. Under heavy loading from the traffic the bitumens ductility is a property which helps the pavements to outspread. The distance up to which the bitumen elongates before failure is measured using this test on samples of bitumen. The ductility testing gives an extent of bonding or adhesive nature of bitumen's capacity of expansion. The binder that is used in construction must have the characteristic of holding a thin ductile film in flexible pavement plan over the aggregates in order to enhance the bonding within aggregate. Material used as binder which has inadequate ductility characteristic detach from exposure to frequently moving loads i.e. traffic, delivering porous roadway surface. The distance measured in centimetres before the bituminous material gets broken when the sample is drawn away from each other, using specified temperature and speed conforming to the standards give us the value of bituminous materials ductility. Ductility values varies from 0 to 150 dependent on the type of bitumen.

Apparatus

1. Briquette device
2. Scales
3. Water tub
4. Thermometer for Water tub
5. Ductility machine as per IS : 1208

Procedure

1. The sample of bitumen is heated to bring it in liquid state and dispensed in the briquette assemblage and positioned on a brass plate. As shown in fig 3.4.
2. The entire assemblage get together incorporating bitumen briquette alongside metal plate is permitted to cool in air.
3. 80 to 90 minutes is the time limit for which the whole assemblance is placed in hot water tub maintaining a temperature of 27° C.

4. Different bitumen grades have different ductility ranging from 5-100 cm. for the purpose of necessary performance the ductility of sample must be at least 50 cm

(a) Sample preparation

(b) Ductility test apparatus

Fig 3.4 Ductility test setup

3.3.4 Specific Gravity Test

This specific gravity test is performed according to the Indian standard code IS: 1202 1978. The specific gravity of semi-solid bituminous material, asphalt cement, and soft tar pitches is stated as the ratio of the mass of a specified volume of the material at 25°C to that of an equivalent volume of water at the same temperature.

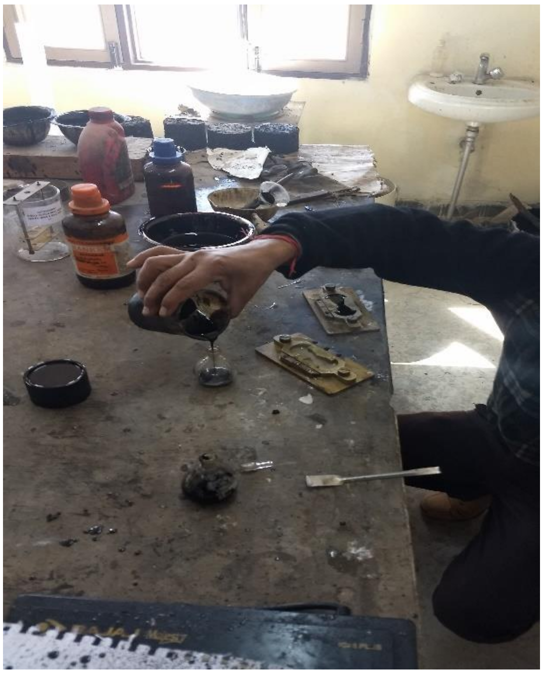
Apparatus

1. Utilizing a 50ml specific gravity bottle, regular container having a diameter of 6mm and also using 25 mm diameter's wide tube type bottle with the diameter.
2. Weighing machine having least count of 1g.
3. Thermometer
4. Water tub

Procedure

1. Specific gravity bottle is firstly cleansed and dried before weighing. (Weight 'A').
2. The distilled water is poured into the specific gravity bottle and is then plugged with immovable cap in order to weigh. (Weight 'B'). As shown in fig 3.5.
3. Specific gravity bottle is then half filled with the bitumen and weigh it (Weight 'C').
4. The specific gravity bottle is then filled equally in two halves of bitumen and distilled water and then it is weighed. (Weight 'D').

Specific gravity= ((C-A)/ (B-A)-(D-C))



(a) Placing of sample

(b) Specific gravity device

Fig 3.5 Specific gravity test

3.3.5 Marshall Stability Test

The "Marshall Stability" of the bituminous blend example is characterized as a most extreme burden conveyed in kg at the typical test temperature of 60°C when load is connected under determined test condition. The “Flow Value" is a total distortion, which goes to the maximum load of a Marshall Test sample, which is expressed in mm units. This test set attempts to obtain optimal bonding material for mixture type and traffic intensity.

Apparatus

1. Mould Assembly: mould which is cylindrical in shape of 10 cm diameter and 7.5 cm height containing of a base plate and collar extension
2. Sample Extractor: for extracting the compacted sample from the mould
3. Compaction platform and hammer.
4. Breaking hammer
5. Loading apparatus
6. Flowmeter, water tub, thermometers

Procedure

1. 60°±1 °C is the temperature that is maintained for heating the tests samples for 2 hours in the oven or for just about 30-35 minutes in hot water tub.
2. Samples are then extracted from oven and hot water tub in the bottom part of the breaking head. The upper section of breaking head of the sample is kept in the position and the entire assembly is placed in position on the test machine as shown in figure 3.6 (a).
3. The flowmeter is attuned to the value of zero after placing it on one of the posts.
4. Loading rate of 50 mm per minute is applied until the failure loading readings are received.
5. Flowmeter is used to measure the flow of sample in millimetres and the ultimate loading is measured in Newton.

(a) Placing of sample

(b) Marshall Stability apparatus

Fig 3.6 Marshall test setup

3.4 Tests on Aggregates

3.4.1 Crushing value test

In conformance to the Indian standard code IS: 2386 (Part-IV) - 1963. Crushing check is employed to work out the crushing check of coarse aggregates and to assess the quality of aggregates to be used in several kinds of road pavement. The total crushing value tells the resistance of an aggregate to crushing under a moderate compressive load. Crushing value is generally a measure of the strength of the aggregates. The aggregates thus ought to have least crushing worth.

Procedure

1. Place the mould in position on the bottom plate and weigh it (W)
2. Place the sample in three layers, each layer being tamped to twenty five strokes exploitation the tamping rod. Care should be taken in the case of weak materials so the particles do not break and weigh it (W1).
3. Flatten the surface of aggregate rigorously and put the plunger so it rests sideways on surface. Care should be taken to confirm that the plunger doesn't stick within the cylinder.
4. In compression testing machine cylinder is placed with plunger on loading platform. As shown in the figure 3.7.
5. A load at a uniform rate is applied to complete a load of forty tonnes in ten minutes.
6. After this the material is taken away from the cylinder.
7. Sieving is done with a 2.36mm IS sieve, care should be taken to avoid loss of fines.
8. Now weigh the material which has passed through the sieve (W2).

Fig 3.7 Crushing value setup

3.4.2 Aggregate Impact value test

In conformance to the Indian standard code IS: 2386 Part-IV 1963. This test is done to check the aggregate impact value for coarse aggregate. Toughness of the material can be defined as the characteristic to resist an impact. The aggregates tend to break down into small fragments due to heavy loading from moving traffic. As, the aggregates are subjected to such heavy loading so in order to oppose the fragmentation of aggregates into smaller particles they should have high toughness value. Hence, impact value test is utilized to measure this characteristic. Oppose to sudden impact or shock by the aggregates is known as aggregate impact value.

Procedure

1. Using the IS sieve the aggregates retained on 10 mm sieve and passing through 12.5 mm are chosen for the testing. Variation of temperature is kept in between 100° C -105°C for oven drying the aggregates.
2. The cylinders used for testing are filled with aggregates about one third of its dimension. Tamping rod is used to tamp the aggregates about 25 times with the round edge.
3. Now again fill the cylinder with aggregates in two different layers and with the help of tamping rod they should be tamped 25 times each with the round edge.

4. In the cylindrical measure, the overflow rod of the set is cut off, it is used on a straight edge.
5. Whole of the sample is weighed to 0.01 gram using a measuring cylinder.
6. Aggregates are then shifted to a cup which is properly positioned to be tamped 25 times on the base plate of machine.
7. Hammer is now lifted to a height of 38 centimetres above the aggregates surface, in order to let the hammer hit the surface by allowing it to free fall. The total of such 15 blows are given, each of which blow is done at no intervals of less than 1 second. The aggregate sample is to be sieved using a 2.36mm sieve after it is taken out of the cup until no notable passage amount.
8. W_1 grams is denoted as the weight of oven dried sample and samples which have passed through 2.36 mm sieve be W_2 grams. So, the aggregates impact value can be defined as the fines percentage formed in terms of the sample's total weight.

Table 3.1 Classification of aggregates based on aggregate impact value

Aggregate impact value (%)	Quality of Aggregate
<10	Exceptionally Strong
10-20	Strong
21-30	Satisfactory for road surfacing
>35	Weak for road surfacing

3.4.3 Specific gravity and Water absorption

This test is performed according to the Indian standard code IS: 2386 (Part-III) 1963. This test is regulated to determine the water absorption of the given set of aggregates. Water absorption of aggregate gives an idea of strength of aggregate. Aggregates which are generally porous in nature have more water absorption and are considered unsuitable until or if they are found to be sustainable based on strength, impact and hardness tests conducted.

Procedure

1. The total of 2 kg of aggregate sample is taken and then it is washed thoroughly so that all the fines are removed, all the aggregates are then poured into a wire basket

of depth 50mm and the basket is completely submerged into distilled water which has a temperature variation ranging from 22°C- 32°C.

2. Now drop the basket 25 mm over head the base of the tank for the entrapped air to be released from the wire basket. For about 25 times dropping of basket is done at a rate of 1 drop per second.

3. The aggregates which are present in the basket should be immersed for the total period in water for 24 ± 0.5 hours. They must be immersed completely.

4. The weight of the sample and aggregate should be taken while suspended in water, which is kept at a temperature of about 22°C to 32°C. If the sample/basket has to be taken to the different tank for weight. Shaking of the aggregates should be done about 25 times in order to take out the entrapped air as mentioned in earlier steps.

5. While suspended in water weight in grams is noted as W1. The aggregates are then taken out of water and kept in place for some time so that the excess surface water can dry off by itself and then aggregates are placed to the dry absorbent cloth. The empty basket now again jolted for 25 times and weight is taken in waster as W2 grams. As shown in fig 3.8.

6. The absorption process of aggregates should be done further until it is satisfied that by cloth no more water can be removed. The aggregates are further dried by adsorbent having single layer of cloth and then aggregates are further concede to dry off for at least 12 minutes until they are almost surface dry, more time of about 10 to 20 minutes may be required.

7. Process of surface drying must not include any of external source of heating like direct sunlight or atmospheric exposure.

8. To increase the drying of the surface of aggregates, a mild stream of hot air can be used during the first 10 minutes.

9. The weight of the dry surface of the aggregate is noted as W3 in grams. For about 24 hours the aggregates are placed on a tray in order to let them dry under the temperature ranging from 105°C to 110°C.

10. The sample is taken out of oven and weight of dry aggregate is noted as W4 in grams. There should be at least 2 trials, but not simultaneously.

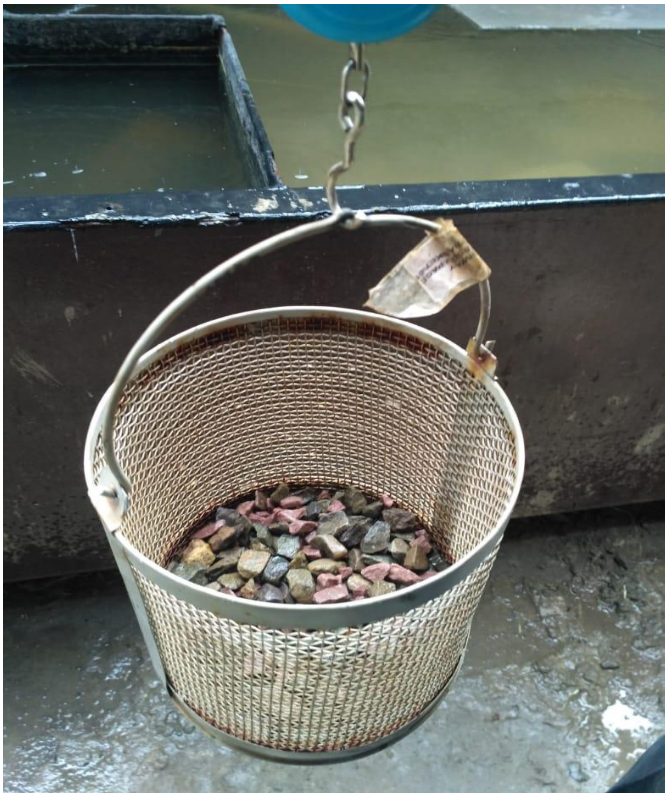


Fig 3.8 Water Absorption test

3.4.4 Flakiness Index and Elongation Index

This test is performed by the Indian standard code IS: 2386 Part-I 1963. The state of particle is controlled by the percent of flaky particles and by the extended particles contained in it. If there should arise an occurrence of rock it is controlled by its Angularity Number. The shape of the aggregates is governed by doing flakiness and elongation tests. Aggregates which are flaky in nature or extended are destructive to increased workability and the soundness of blends. If these particles are present in abundance then they are not favourable to great interlocking and henceforth the blends having this, it will be difficult to compact it to the favourable degree. The presence of excess of prolonged and flaky particles considered unwanted in base coarse and bituminous development and bond solid sorts, as it may cause natural defect with possibilities of separating under astounding burdens. The workability of cement is increased when rounded aggregates are used in concrete road construction.

By better interlocking exact state of particles are attractive for granular base coarse as due to expanded stability got as the shape of aggregates goes amiss more from the round shape, as due to the angular, flaky and lengthened aggregates, the void content in an aggregate of any earlier size increments and hence consequently the grain size distribution of the graded aggregates must be appropriately adjusted so as to get least voids in the dry blend or the most noteworthy dry density.

Procedure

1. Take the sample and allow it to pass through Indian standard sieve.
2. Total of 200 pieces are taken out and weighed as W1 gram.
3. The flaky material need to be separated. Thereafter measurement is done for thickness check.
4. Now take the weight of flaky material that has passed the gauge with the accuracy of at least 0.1% of the sample.
5. The weight of flaky material that has passed through the gauge is W1 gram. Also the weight of fraction that has passed and retained on the standard sieve be W1, W2, W3 and total weight is the sum of all the above weights. Similarly take the weights of the sample that has passed through each of the predefined thickness gauges. Also take the total load of the sample that has passed the individual thickness gauges.
6. Now the flakiness index is determined as the total weight of the flaky sample that has passed the individual thickness gauges linked as the level of the absolute weight of the sample that has been gauged.
7. Similarly take the weight of the samples from every division that is held on the stated length of gauge.
8. The weight of the samples that are retained on individual length gauges is known as elongation index. This is articulated as the percentage of total weight of the material.

Fig 3.9 Shape test

3.4.5 Los-Angeles Abrasion value test

The test is performed according to the Indian standard code IS: 2386 Part-IV 1963. This test is performed to decide Los Angeles abrasion value and to discover the similarity of aggregates for its utilization in the pavement construction. From wear or hardness protection proportion is abrasion. It is a pivotal property for road aggregates the most part when utilized in wearing course surface. Because of the substantial traffic development, the aggregates utilized in the surface course are exposed to wearing activity at the top. At the point when vehicles precedes onward the street the fine particles like residue, soil or even water which divides the wheels of vehicle and road surface causes abrasion on road wearing surface. Then this rule is done to identify the abrasion activity with the utilization of standard steel balls which are put into a drum with aggregates and then rotated for a fixed number of revolution gives there impact on aggregates. The wear of the aggregates because of scouring with steel balls is noted and is known as Los Angeles Abrasion Value.

Fig 3.10 Los-Angeles test setup

Los Angeles abrasion test values has been standardized by the ASTM (American society for testing and materials), AASHO (American Association of state highway and Transportation Officials) and also by the IS: 2386 part IV 1963. Standard specification of Los Angeles abrasion values is available for various types of pavement constructions.

Table-3.2:Los-Angeles values (IS: 2386 Part IV 1963)

Sr. No.	Types of pavement	Los-Angeles abrasion value, Maximum %
1	Water bound macadam(WBM), sub-base course	60
2	a) WBM base course with bituminous surfacing b) Bituminous macadam base course c) Built-up spray grout base course	50
3	a) WBM surfacing course b) Bituminous macadam binder course c) Bituminous penetration macadam d) Built-up spray grout binder course	40
4	a) Bituminous carpet surface course b) Bituminous surface dressing, using single or two coats c) Bituminous surface dressing, using precoated aggregates d) Cement concrete surface course	35
5	a) Bituminous asphaltic concrete surface course b) Cement concrete pavement surface course	30

CHAPTER 4
RESULTS AND DISCUSSION

4.1 General

From the various tests that were conducted on bitumen samples are discussed below in this chapter. So, bitumen samples that were tested along with modified bitumen for penetration value, softening point value, ductility value, specific gravity test and Marshall Stability test. Bitumen is modified utilizing the material know as waste motor oil in order to substitute and lessen the utilization of bitumen. Pine resin is also added as an admixture for further enhancement of properties.

4.2 Properties of Bitumen

The properties of conventional bitumen such as penetration, softening point, Ductility, Specific gravity and Marshall Stability tests values were observed by various tests in highway laboratory lab of the Civil Engineering Department of Jaypee University of Information Technology, Waknaghat (H.P). The results are analysed and discussed as under.

Table 4.1 Results of conducted test on bitumen

Sr. no	**Characteristic**	**Value**	**Remark(IS:73:2013)**
1	Penetration(0.1mm)	86	80-100
2	Softening point(°C)	48	40(Min.)
3	Ductility(cm)	84	75(Min.)
4	Specific gravity	1.02	0.98(Min.)
5	Marshall stability(KN)	5.5	≥3.4

From the above table 4.1 it was conclude that the bitumen (i.e. VG 10) is meeting the required standard of every test conducted. Now in the following section we will discuss and compare the results of conventional and waste engine oil modified bitumen with varying percentage of waste engine oil in details.

4.2.1 Properties of bitumen on adding waste engine oil

As studied earlier we have conducted that penetration test is used to examine the consistency of the sample of bitumen. So, in laboratory we have performed the penetration test once to check the purity of conventional bitumen and bitumen with different percentage of waste engine oil and got the following penetration values as result.

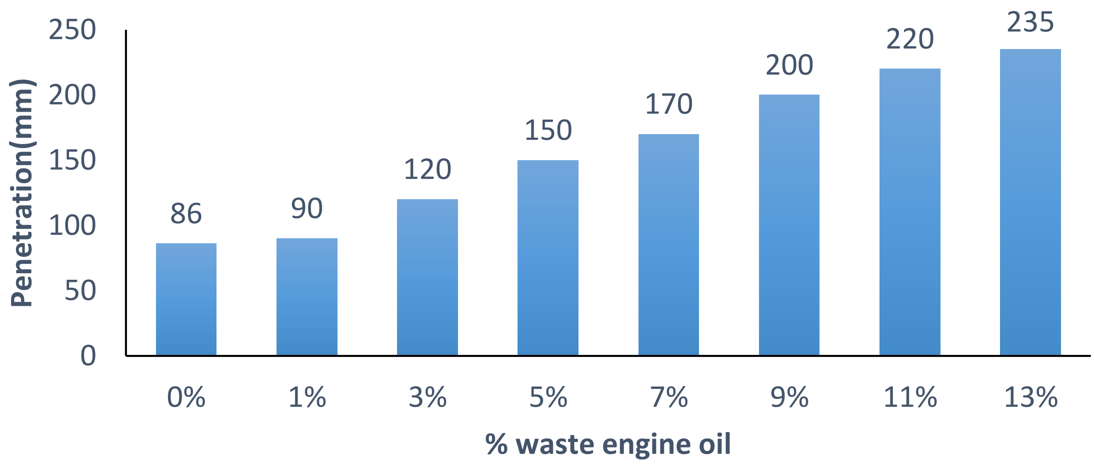


Fig 4.1. Penetration vs Percentage waste engine oil

As we can see in above fig 4.1 that as the value percentage of waste engine oil increases the penetration value goes on increasing. As it can be seen that addition of waste engine oil has strong effect on increasing the penetration value by increasing the elasticity of waste engine oil modified bitumen binder, thus making it more temperature susceptible and which makes it suitable for only low weather condition where temperature is near zero degree Celsius. Test results are shown in table in appendix A.

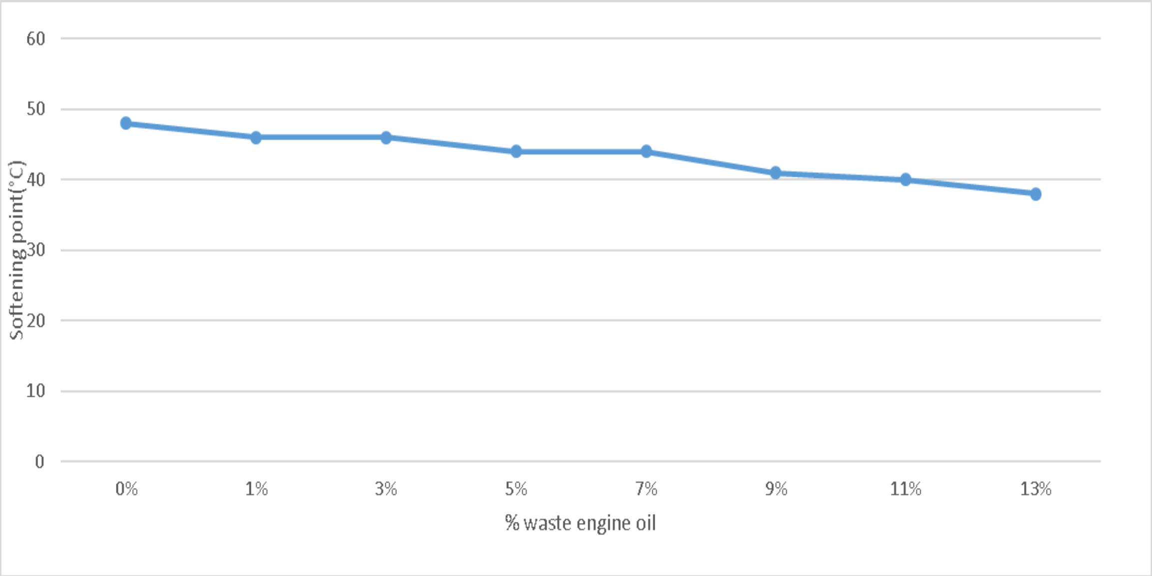


Fig 4.2: Softening point vs percentage waste engine oil

Above fig 4.2 shows that as the percentage of waste engine oil in bitumen increases the value of softening point decreases also it indicates that modified bitumen with waste engine oil can only be used in sub-zero temperature conditions. Test results of this are shown in appendix B.

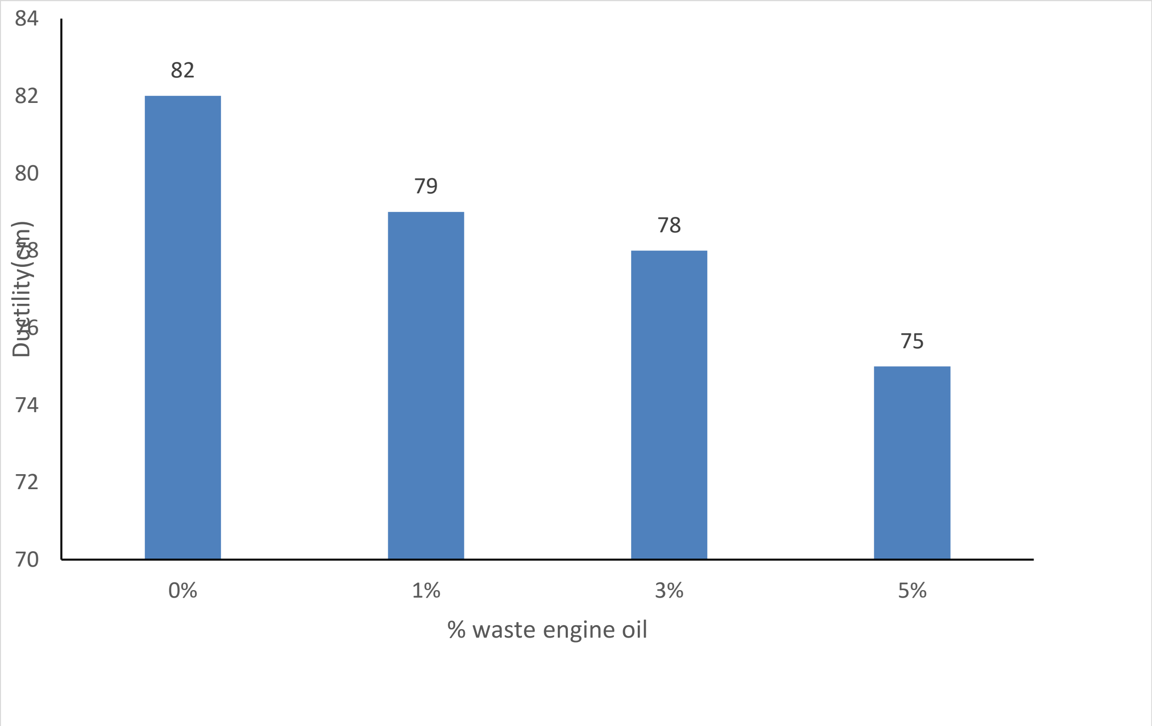


Fig 4.3 Ductility vs percentage waste engine oil

Table 4.2 Specific gravity result

Sr. No.	Sample	W1(gm)	W2(gm)	W3(gm)	W4(gm)	Specific Gravity
1.	VG-10 (conventional bitumen)	26	70	45	71	1.01
2.	1% of Replacement with waste engine oil	20	64	41	65	1.05
3.	3% of Replacement with waste engine oil	26	81	50	81	1
4.	5% of Replacement with waste engine oil	20	64	40	64	1
5	7% of Replacement with waste engine oil	27	71	46	72	1.01
6	9% of Replacement with waste engine oil	27	64	44	72	1.03
7	11% of Replacement with waste engine oil	20	64	40	64	1
8	13% of Replacement with waste engine oil	20	64	41	64	1.04

Specific gravity= ((W3-W1)/ (W2-W1)-(W4-W3))

As from the above table 4.2 it is clear that the specific gravity of the conventional bitumen as well as modified bitumen with waste engine oil lies within the permissible limit as specified by the Indian standard code IS: 1202 1978. Hence this is suitable for testing.

4.2.2 Properties of bitumen on addition of pine resin

4.2.2.1 Penetration test:

Table 4.3 Penetration test results

Sr. No.	**Sample**	**Penetration value**			**Mean Value of penetration (mm)**
		1(mm)	**2(mm)**	**3(mm)**	
1.	VG-10 (conventional bitumen)	86	84	90	86
2.	Bitumen with 1% replacement of pine resin	13	13	10	12
3.	Bitumen with 3% replacement of pine resin	9	9	12	10
4.	Bitumen with 5% replacement of pine resin	8	8	9	8.33

As from the above table 4.3, that as the percentage of pine resin increases the penetration value decreases significantly. It is clear that the addition of pine resin has a strong effect on bitumen mix as its makes the bitumen very hard in nature.

4.2.2.2 Softening point test:

On the basis of the results it was observed that the percentage of pine resin in bitumen increases the value of softening point also increases as shown in Table 4.3. Therefore, it was concluded that bitumen modified with pine resin has a good potential at hot climates regions where temperature rises to more than 50°C.

Table 4.4 Softening point test results

Sr. No.	Sample	Temperature (°C)		Mean value of softening point (°C)
		Ball(1)	Ball(2)	
1.	VG-10 (conventional bitumen)	48	48	48
2.	Bitumen with 1% replacement of pine resin	63	63	63
3.	Bitumen with 3% replacement of pine resin	67	67	67
4.	Bitumen with 5% by weight replacement of pine resin	69	71	70

We also observe that as the percentage of pine resin increases, value of Softening Point keep on increasing due to the fact that penetration also decreases and it becomes brittle.

4.2.2.3 Ductility test

Table 4.5 Ductility test results

Sr. no.	Sample	Ductility in cm
1.	VG-10 (conventional bitumen)	86
2.	Bitumen with 1% replacement of pine resin(by weight)	4
3.	Bitumen with 3% replacement of pine resin(by weight)	0(sample failed)
4.	Bitumen with 5% replacement of pine resin(by weight)	0(sample failed)

From above table 4.5 we observed that as the percentage of pine resin increases the value of ductility has drop down significantly. This can also be inferred that as the softening point value increases and penetration value decreases with increase in the percentage of pine resin as a result of which it is becoming brittle and hence we see the failure.

4.3 Marshall stability test

Bituminous concrete mixing is routinely employed by Marshall Law. This test is widely used in regular testing programs for the construction of paving jobs. The dependence of the mixture is characterized as the most extreme burden expressed by a narrow example at a standard test temperature of 60 degree Celsius. This test set attempts to obtain optimal bonding material for mixture type and traffic intensity. Marshall Stability and Flow Testing provide the predictive measurement of performance for the Marshal Mix design method. To check stability of the test which determines the maximum load supported by the test load when a loading rate of 50.8 mm per minute. The load is applied to the sample until it fails, and the maximum load is named as the stability. During loading, due to dial gauge which is attached provides loading, the plastic flows of the sample (distortion) measure. The value of the flow is recorded at 0.25 mm (0.01 in) increase at the same time when the maximum load is recorded.

4.3.1 Specification for Marshall stability test

- Replacement of Bitumen with waste engine oil and pine resin
- Grading according to IRC:37-2002 for VG 10 type bitumen

Table 4.6 IRC-Grading

Gradation of DBM Mixes

Sieve Size mm	Cumulative % passing	Specified Grading
37.5	100	100
26.5	95	90-100
19	83	71-95
13.2	68	56-80
4.75	46	38-54
2.36	35	25-42
0.3	14	21-42
0.075	5	2-8

Fig 4.4 Grading for VG 10

Fig 4.5 Sample at 4 % waste engine oil and 1% of pine resin

4.3.2 Analysis of Data

Especially three examples with fluctuating bitumen content from 3-5% were set up in the Highway Engineering Lab and Stability Test was performed by us in the Highway Engineering Lab of Civil Engineering Department of Jaypee University of Information Technology, Waknaghat (H.P). The outcomes are investigated and talked about as under.

Fig 4.6 Sample failed at 3% replacement of Waste engine oil

Fig 4.7 Sample at 5 % waste engine oil and 2% of pine resin

Table 4.7 Marshall Stability Value

Sr. No.	Bitumen Content (In %)	Conventional Bitumen(KN)	Stability of mix having 3% waste engine oil (KN)	Stability of mix having 4% waste engine oil + 1 % pine resin (KN)	Stability of mix having 5% waste engine oil + 2 % pine resin(KN)
1	3	5.1	-	5.8	5.5
2	4	6.6	-	7.6	7.2
3	5	5.9	-	6.9	6.2

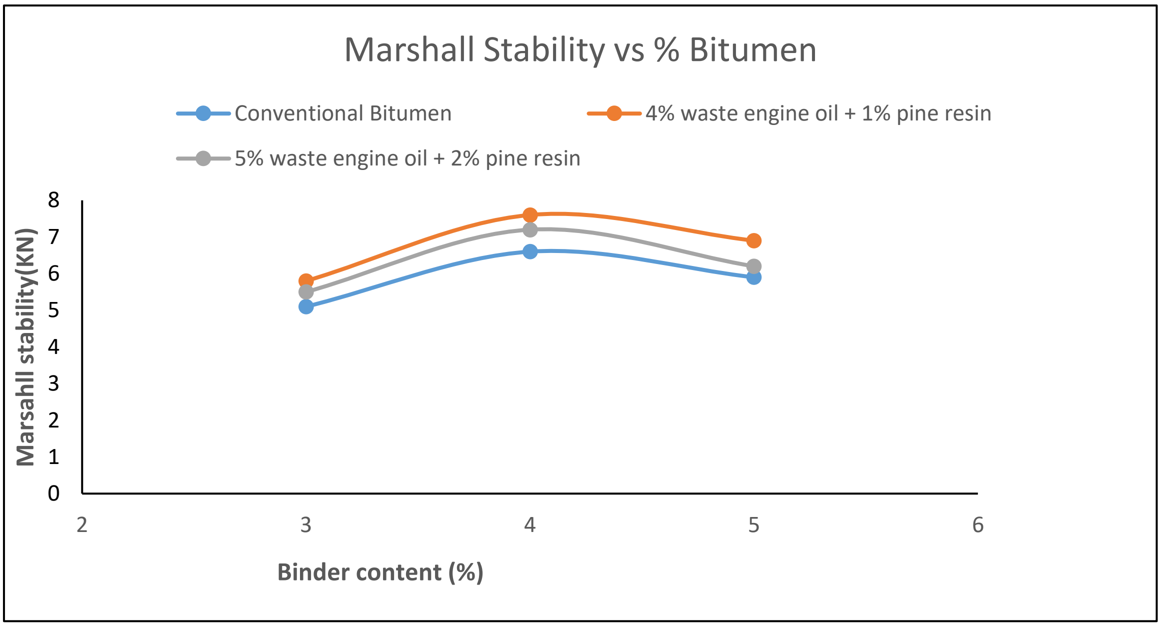


Fig 4.8 Bitumen content vs Marshall Stability

Form the above fig 4.8 it is clear that stability value for bitumen modified with waste engine oil and pine resin is added as an admixture is more than that of normal bituminous mix throughout the varying percentage of bitumen content. The maximum stability is achieved at 4% bitumen content in the case of modified bitumen with waste engine oil and pine resin as an admixture.

Table 4.8 Marshall Flow value

Sr. No.	Bitumen Content (In %)	Flow value conventional Bitumen(mm)	Flow value of mix having 3% waste engine oil (mm)	Flow value of mix having 4% waste engine oil + 1 % pine resin (mm)	Flow value of mix having 5% waste engine oil + 2 % pine resin(mm)
1	3	2.03	-	2.33	2.6
2	4	2.67	-	3.23	3.53
3	5	3.56	-	4.25	4.54

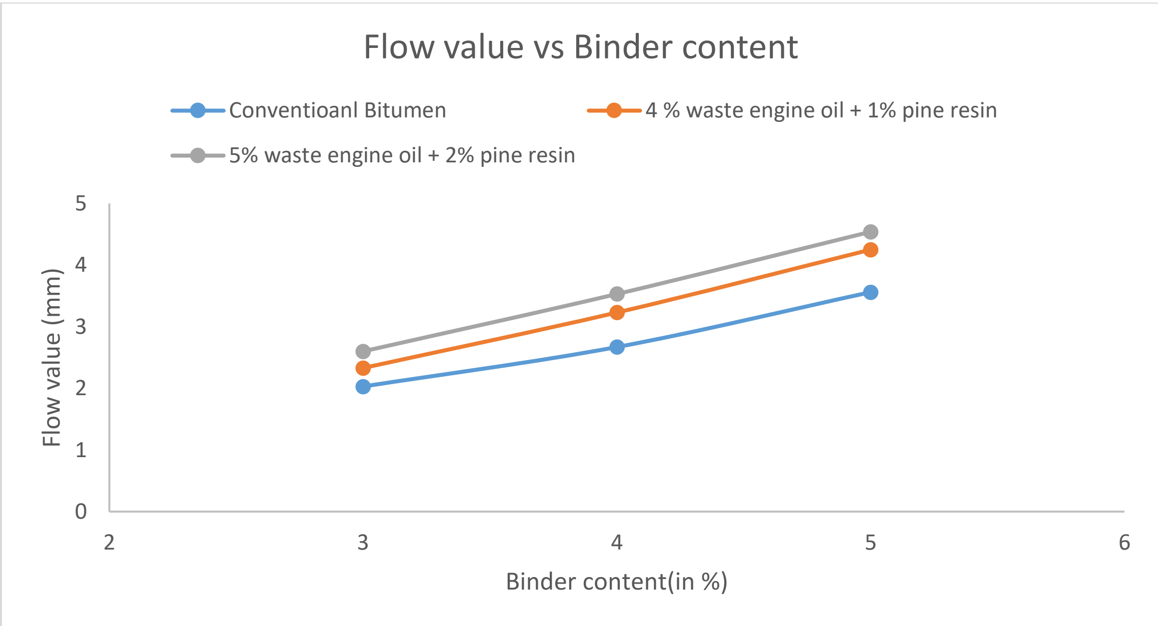


Fig 4.9 Flow value vs Binder content

From Figure 4.9 it is clear that the flow values keep on increasing both in the cases of Normal Bituminous Mix and modified bitumen with waste engine oil and pine resin as the percentages of bitumen keeps on increasing.

Table 4.9 Voids filled with Bitumen

Sr. No.	Bitumen Content (In %)	VFB in conventional Bitumen	VFB of mix having 3% waste engine oil	VFB of mix having 4% waste engine oil + 1 % pine resin	VFB of mix having 5% waste engine oil + 2 % pine resin
1	3	65	-	70	67
2	4	73	-	78	76
3	5	77	-	80	79

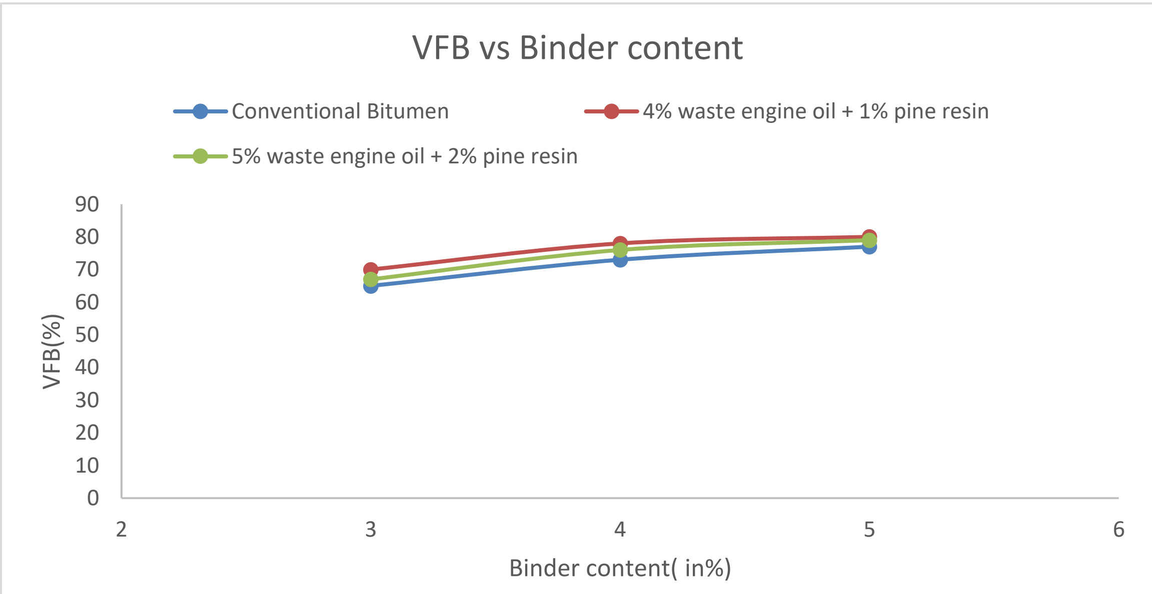


Fig 4.10 VFB vs Binder content

From fig 4.10 it is evident that the Voids filled with bitumen (VBF) keeps on increasing for the both in case of Normal bituminous mix and modified bitumen with waste engine oil and pine resin. The maximum value for both the mixes is achieved at 4% of bitumen content but the value of modified bitumen shows higher value of VFB. This is due to the fact that the binding is more efficient in modified bituminous mix.

Table 4.10 Density of Marshall Mix

Sr. No.	Bitumen Content (In %)	Density of conventional Bitumen	Density of mix having 3% waste engine oil	Density of mix having 4% waste engine oil + 1 % pine resin	Density of mix having 5% waste engine oil + 2 % pine resin
1	3	2.13	-	2.15	2.14
2	4	2.19	-	2.22	2.2
3	5	2.13	-	2.16	2.14

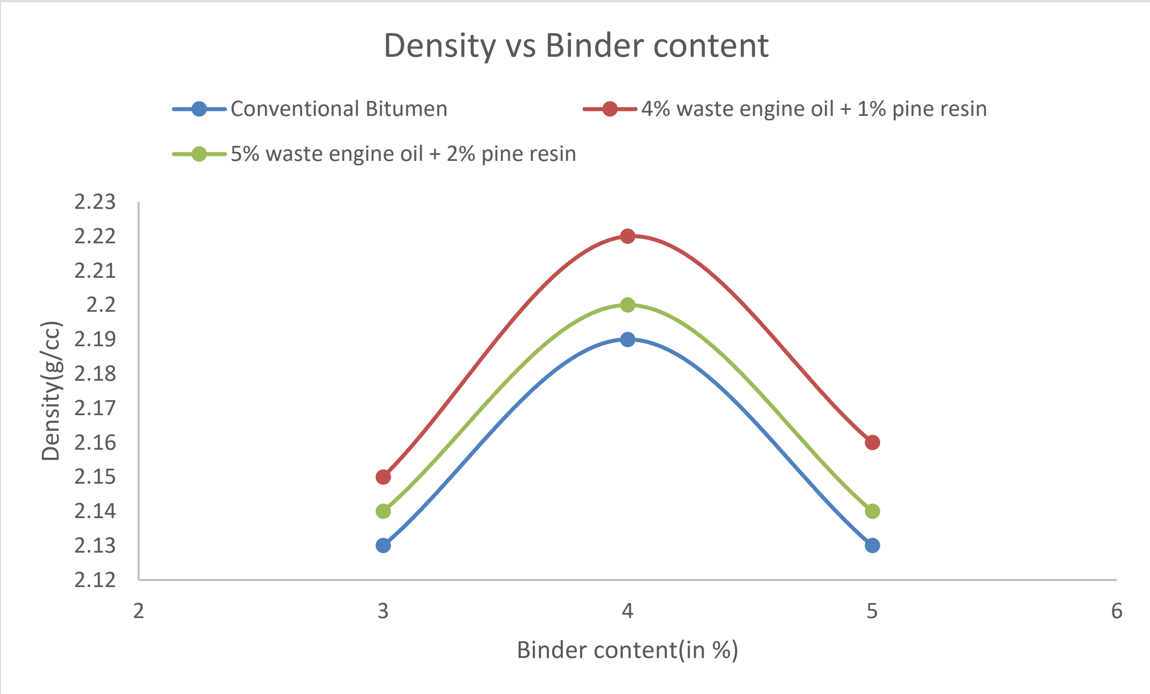


Fig 4.11 Density vs Binder content

From fig 4.11 it is clear that the maximum density for both the normal bituminous mix and the modified bitumen with waste engine oil and pine resin is attain at 4% bitumen content.

CHAPTER 5

CONCLUSION AND DISCUSSION

5.1 General

In this section, the results of all the test which were conducted is discussed. As for bitumen test which were performed were penetration value test for the conformation of purity of bitumen. After that the different compositions of waste motor oil with bitumen for motor oil in bitumen and then compared the tests result with the previous study of bitumen of grade VG-10.

5.1 Conclusion and Discussion

As the study conducted in this report has shown us that is it possible to partially replace the conventional bitumen with bio binders. As per the experimental work we have successful replaced the conventional bitumen with different proportions/percentages of waste engine oil and pine resin respectively. The experiments has shown us that replacing only waste engine oil with the conventional bitumen did not gave the expected results, after mixing the conventional bitumen with waste engine oil formed a soft mixture which has passed most of the tests like penetration test, ductility etc. But showing the uncertain results in softening point and Marshall Stability test. The over soft mixture can be explained as the waste engine oil is also a petroleum product which is more fluidic in nature and heating the mix between 120°C to 140°C, most of the hydrogen bonding of the waste engine getting vaporized.

The results differ when pine resin is replaced in different percentages in conventional bitumen. The addition of pine resin increased the rigidity of the mixture which has failed in all the tests conducted in the highway laboratory. The main reason behind the failure can be that most of the volatile may have vaporized resulting lesser water in the voids which is crucial/vital for making the bitumen soft thus mix has become more rigid than normal bituminous mix. From the above results obtained we concluded that pine resin has only 1 % optimum percentage as most of the test at this percentage was successful and in case of waste engine we found that it cannot be added alone as our Marshall Test specimen has failed when 3% replacement was made.

Thus after that we started the Marshall Stability test with Waste engine oil along with pine resin and they have given us favourable result after performing the test at different percentages, the optimum percentage we have concluded when 4% waste engine oil and 1% of pine resin is added respectively because at these percentages the desired results were obtained and some exceed the standard results.

From the point of future scope, study can be extended by increasing the percent utilisation of the waste materials (i.e. proposed in the present study) in the flexible pavement by making different combination with same or other waste materials by looking at their chemical compositions. Methodology presented in this study can be revalidate by implementing in the field (i.e. by constructing flexible pavement using these waste materials). Furthermore, other suitable waste materials (i.e. on the basis of their chemical composition) can be proposed for the same.

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APPENDIX I

Calculations of mix design	Tests performed – Impact test, Abrasion, Crushing, Soundness, Shape, Specific gravity	I

I.1 Aggregates test results

Table I.1 Aggregates Tests Result

Tests	Actual Value	Remark
Impact value of aggregates	19%	Impact value of aggregates
Los-Angeles Abrasion value	29.5%	Can be used as a wearing or Surface course
Crushing value	28.7%	Can be used as a wearing or Surface course
Soundness Value	0.1% and 0.3%	
Shape Test	21.6% and 19.5%	Less than 30%
Specific gravity	2.46	In between 2.5 to 3.0
Water absorption	1.95%	In between 0.1% to 2 %

I.2 Grading of Aggregates

Table I.2 Grading for Mix Design

Nominal size of aggregates	**13mm**
Size of sieve in mm	**Percentage passing by weight**
37.5	100
26.5	95
19	83
13.2	68
4.75	46
2.36	35
0.3	14
0.075	5

APPENDIX II

Modified results of bitumen	**Tests conducted –** Penetration, Softening point, Specific gravity, Ductility	**II**

II.1 Penetration Test Results

Table II.1 Penetration Test Results

Percentage of waste engine oil	**Penetration value in mm**
0	86
1	90
3	120
5	150
7	170
9	200
11	220
13	235

II.2 Softening Point results

Table II.2 Softening Point results

Percentage of waste engine oil	**Softening point in °C**
0	48
1	46
3	46
5	44
7	44
9	40
11	41
13	38

II.3 Ductility Test Results

Table II.3 Ductility test results

Percentage of waste engine oil	**Ductility value in cm**
0	82
1	79
3	78
5	75
7	No breakdown. (Distance from lowest Surface less than 1cm)
9	No breakdown. (Distance from lowest Surface less than 1cm)
11	No breakdown. (Distance from lowest Surface less than 1cm)
13	No breakdown. (Distance from lowest Surface less than 1cm)

II.4 Specific Gravity test results

Table II.4 Specific Gravity test results

Percentage waste engine oil	Specific Gravity
0	1.01
1	1.05
3	1
5	1
7	1.01
9	1.03
11	1
13	1.04

APPENDIX III

Marshall mix design	Marshall Stability test	III

III.1 Marshall Stability value

Table III.1 Marshall Stability test results (KN)

Bitumen Content (In %)	At 0% waste Engine oil	At 3% waste engine oil	At 4 % waste and 1 % pine resin	At 5% waste and 2 % pine resin
3	5.1	-	5.8	5.5
4	6.6	-	7.6	7.2
5	5.9	-	6.9	6.2

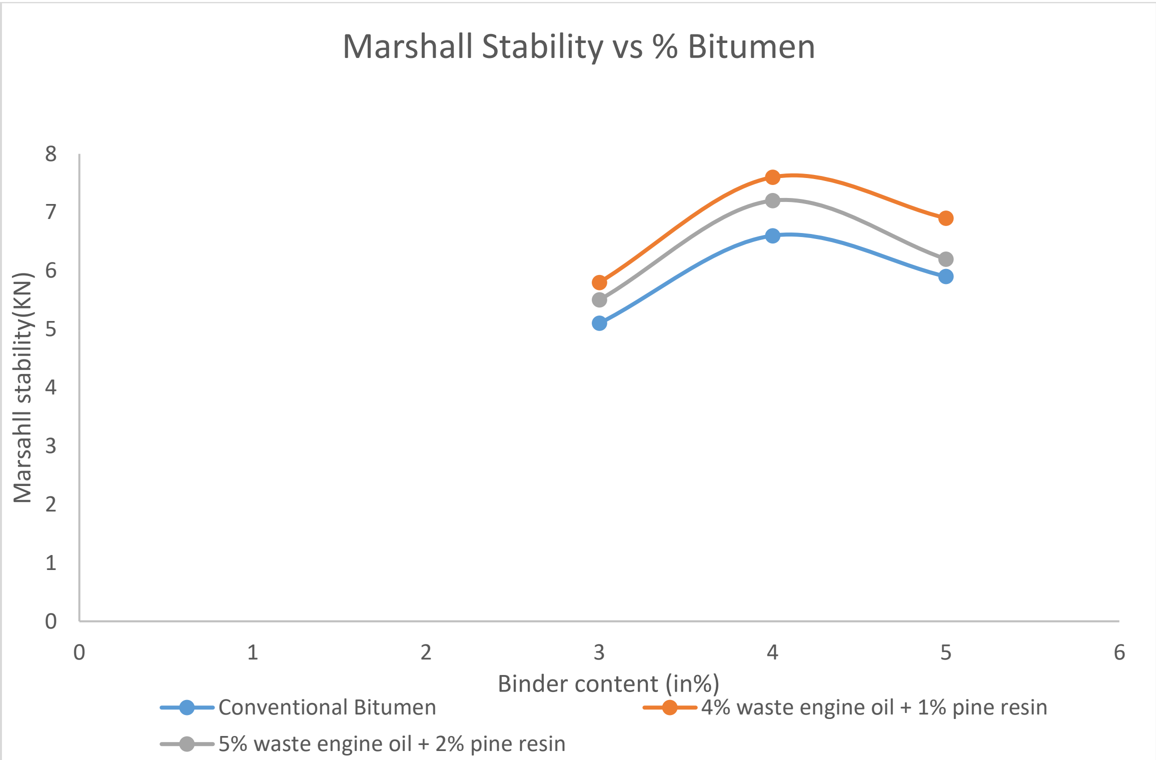

Fig III.1 Graph of Marshall Stability Vs Binder content

III.2 Flow value Vs Binder content

Table III.2 Flow value (0.25 mm units)

Bitumen Content (In %)	At 0 % waste engine oil	At 3% of waste engine oil	At 4% waste engine oil + 1% Pine resin	At 4% waste engine oil + 1% Pine resin
3	2.03	-	2.33	2.6
4	2.67	-	3.23	3.53
5	3.56	-	4.25	4.54

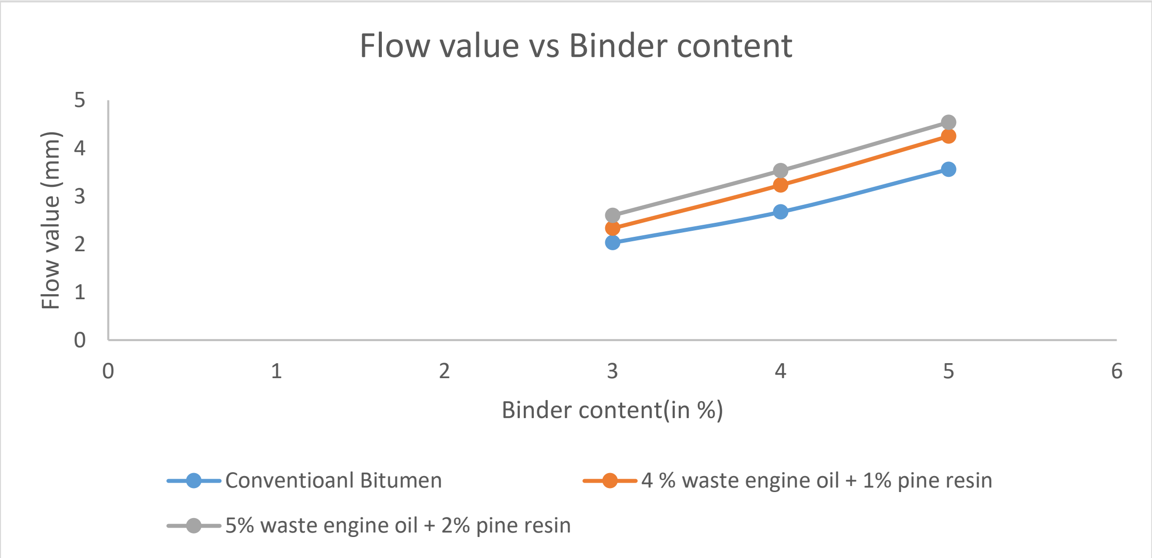

Fig III.2 Graph of flow value Vs Binder content

III.3 VFB Vs Binder content

Table III.3 Voids Filled with Bitumen (%)

Bitumen Content (In %)	At 0% waste engine oil	At 3% waste engine oil	At 4% waste engine oil + 1% pine resin	At 5% waste engine oil + 2% pine resin
3	65	-	70	67
4	73	-	78	76
5	77	-	80	79

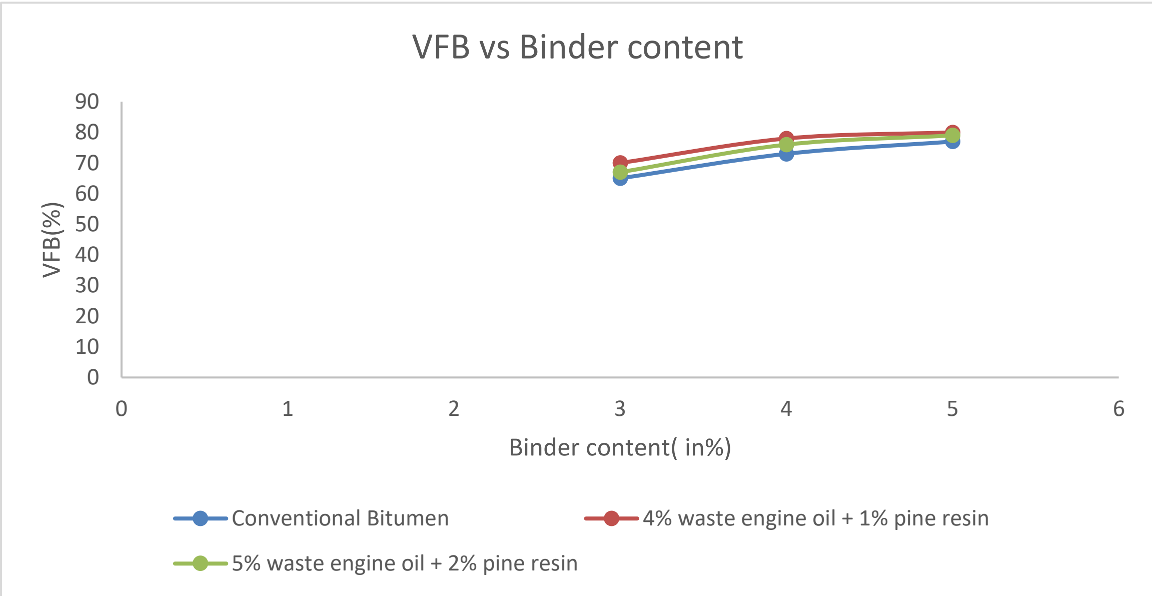

Fig III.3 Graph of VFB Vs Binder Content

III.4 Bulk unit weight Vs Binder content

Table III.4 Bulk unit weight results

Bitumen Content (In %)	**At 0% waste engine oil**	**At 3% waste engine oil**	**At 4% waste engine oil + 1% pine resin**	**At 5% waste engine oil + 2% pine resin**
3	2.13	-	2.15	2.14
4	2.19	-	2.22	2.2
5	2.13	-	2.16	2.14

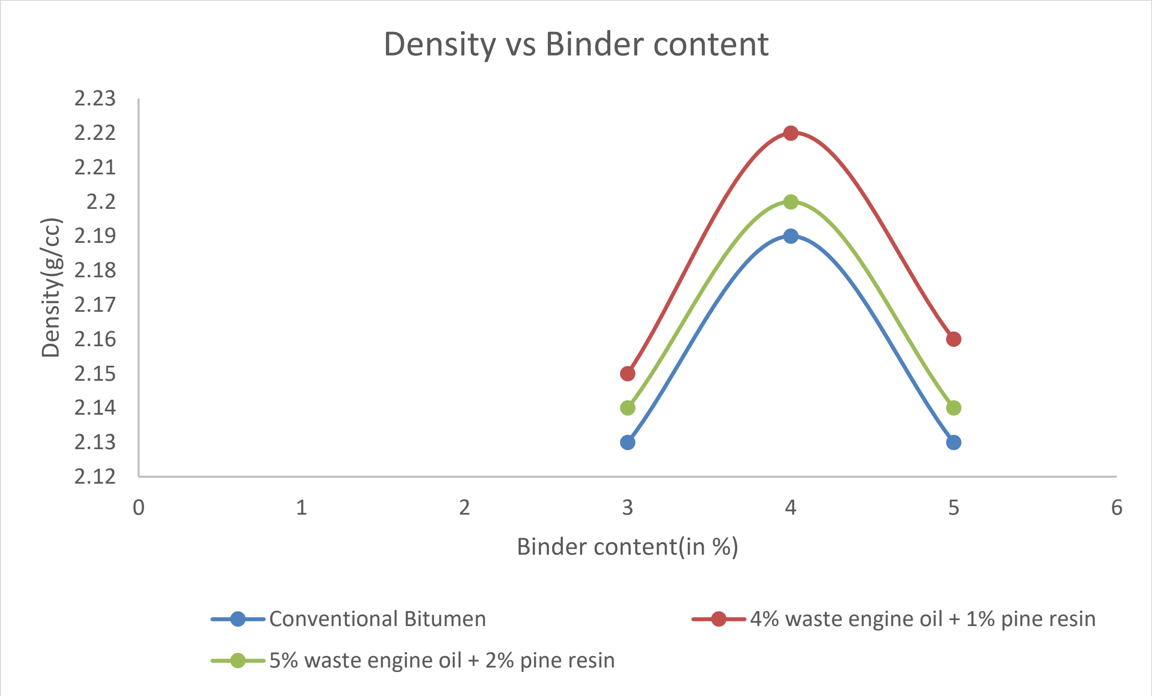

Fig III.4 Graph of Density Vs Binder content