RERPLACEMENT OF BITUMEN WITH PINE RESIN

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

Mr. Chandra Pal Gautam
Asst. Professor

by

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173234

HIMACHAL PRADESH, INDIA

MAY, 2019

STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled **"Replacement of bitumen with Pine resin"** submitted for 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 my work carried out under the supervision of **Mr. Chandra Pal Gautam**. This work has not been submitted elsewhere for the reward of anyanother degree/diploma. I am fully responsible for the contents of my project report.

Tarun Verma | Harshit Chauhan

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Department of Civil Engineering

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6 May, 2019

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Replacement of bitumen with Pine resin"** submitted in 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 work carried out by **Tarun Verma (151623) & Harshit Chauhan (151675)** under the supervision of **Mr. Chandra Pal Gautam, Assistant Professor,** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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

6 May, 2019

Mr. Chandra Pal Gautam	Dr. Ashok Kumar Gupta	Signature of external examiner
Assistant Professor	Professor and Head	External Examiner
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JUIT, Waknaghat	JUIT, Waknaghat	

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Thank you.

Harshit Chauhan

Tarun Verma

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LIST OF ACRONYMS AND ABBREVIATIONS

HL	Hydrated Lime
OGFC	Open Grade Friction Concrete
PAV	Pressure Aging Vessel
RA	Reclaimed Asphalt
RTFO	Rolling Thin-Film Oven
SMA	Stone Mastic Asphalt
UPR	Unsaturated polyester resin

ABSTRACT

In the construction world, most flexible pavement constructions use synthetic asphalt made from crude oil and well-known as conventional asphalt. Therefore, to find more environmentally friendly construction people around the world are very interested in finding a bioasphalt. Natural asphalt (bio asphalt) is an alternative asphalt that is extracted from non-petroleum based renewable resources. Some of the sources of bio asphalt are resin, sugar, molasses, lignin, rice, vegetable oil, waste cooking oil, waste engine oil, coconut waste, cellulose, palm oil waste, rubber, starches of corn and potato. Bio asphalt has the ability to replace the conventional asphalt.

The bioasphalt is used because of several reasons, such as asphalt mixtures derived from plants and trees could replace petroleum-based mixtures. One of bioasphalt which can be used as an alternative material of conventional asphalt is resin (damar). Pine resin is present in huge amounts in Himachal Pradesh.

The first phase of this research focuses on the replacement of conventional bitumen with different percentages of natural resin in the conventional asphalt 80/100 pen and to obtain the optimum resin content. Then tests are being carried on the replaced bitumen and the properties are compared to the conventional bitumen with no replacement.

[*Keywords*: bioasphalt; flexible pavement; resin gum]

CHAPTER 1
INTRODUCTION

Natural asphalt (bio asphalt) is an alternative asphalt that is extracted from non-petroleum based renewable resources. Some of the sources of bio asphalt are resin, sugar, molasses, lignin, rice, vegetable oil, waste cooking oil, waste engine oil, coconut waste, cellulose, palm oil waste, rubber, starches of corn and potato. Bio asphalt has the ability to replace the conventional asphalt.

One of the alternative way to make bitumen is from waste vacuum tower bottoms which is produced in the process of cleaning used motor oils, which are normally burned or dumped into landfills. Resin is a sticky, gelatinous or synthetic natural compound. In its initial state it is highly viscous and it hardens as its treatment process is done. It is readily soluble in alcohol , but due to lignin present in it, solubility in water is zero. Pine resin is a compound which is classified in many different ways according to its uses and consumption criteria. It also has many different applications depending on its availability and consumer requirements (on daily basis). The places where its availability is more than enough it is used for medicinal purposes and as an alternate bio asphalt.

Plants are the only source of resin. Pine sap is a classic example of its natural presence having a characteristic sharp odor of terpene compounds found naturally. For thousands of years humans have been using resin produced from different verity of plants. Some plants leave out similar substances known as gum or gum resin that does not interact with water. This gum is more softer and more malleable. Resin that is obtained from plants can be dark brown in color, it varies in hardness and depicts an opaque nature. As this resin contains unstable compounds thus are extremely volatile.

The asphalt mix needs to be modified by adding additives to the conventional bitumen or asphalt mix as it has been proven in some previous cases that it helps in improving the performance of asphalt pavement by enhancing its efficiencies. Fibers and Polymers have gained much greater attention among all the modifiers of asphalt due to their excellent improvement effect. In many asphalt mixtures like Stone Mastic Asphalt (SMA), Open Grade Friction Concrete (OGFC), Asphalt Concrete and Hot rolled asphalt modifiers like Various fiber and polymer modifiers, such as cellulose fiber, polyester fiber resin, epoxy resin, rock wool, fibrin and short asbestos and mineral fiber have been used. The influence of fiber and polymers had been an interesting topic for researchers to improve conventional asphalt properties.

The use of polyester resin for reinforcing flexible pavements was made by Haoran et al considering different possibilities for utilizing it. Under the studies of tensile reinforcement method the application of a thin-layer coating with a polymer, unsaturated polyester resin (UPR) on the surface of a laboratory-prepared unmodified asphalt concrete mixture was studied. For the very cause of increasing the bitumen ductility an attempt to use 100% of resin as a filler has been conducted for better results.

For identifying the chemical properties of bio asphalt the researchers are trying to use animal waste product of swine manure as an alternative. The results obtained from tests performed on this bio asphalt alternative were noted and compared with the unmodified asphalt concrete mixture and a series of modified asphalt mixtures. Marshall stability, tensile strength, compressive strength and permeability of asphalt concrete were seen to be improved by the use of modified resin.

CHAPTER 2

LITERATURE REVIEW

2.1 General

Various previous studies has shown that Pine resin can replace the conventional asphalt and be used as an alternate binder for pavement construction. Pine resin has the ability to replace conventional asphalt as it contains complex organic polymers. Some of these researches that has shown how the conventional asphalt can be replaced by the bio binders is discussed in this chapter.

2.2.Properties and design of renewable bioasphalt for flexible pavement.

Mujb Adel Dami Mohammed Fachi Ary Sateyawan (2016)

2.2.1. Research Method

All the tests were carried at the laboratory of Sebelas Maret University of Surakarta, Indonesia. This study was carried out by using experimental methods to evaluate the performance of asphalt concrete with Asphalt 60/70 penetration and 60/70 penetration resin modified binder and its suitability in road pavement precisely in hot mix asphalt.

2.2.2. Result And Discussion

(a) The unconfined compressive strength performance

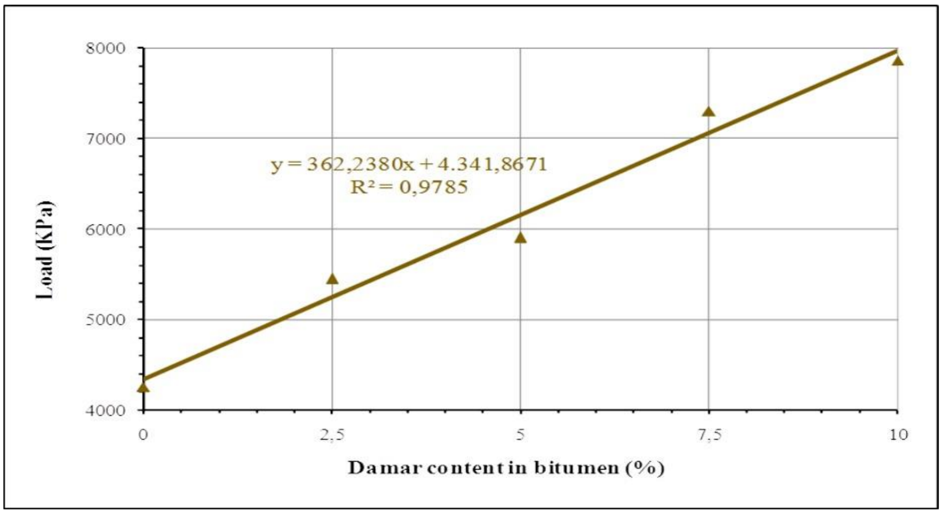


Fig. 2.1: Graphical representation of unconfined compressive strength performance.

(b) The permeability performance

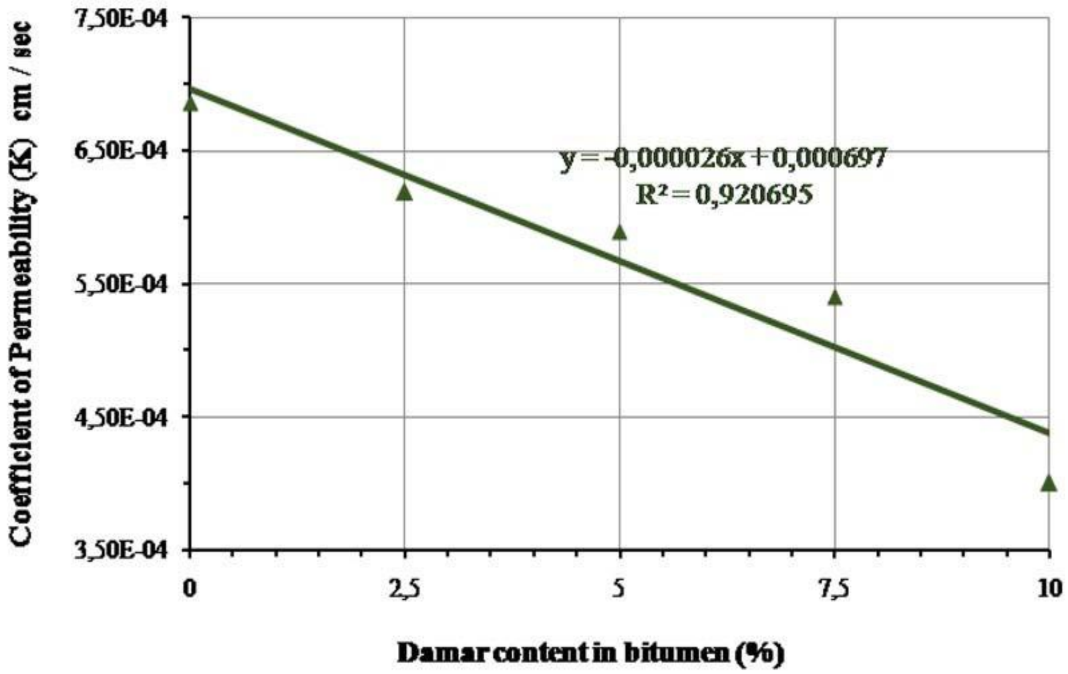


Fig 2.2: Graphical representation of permeability performance.

2.2.3. Conclusion

1. For all the asphalt concrete mixtures the value of optimum bitumen content were relatively similar and this result was based on Marshall mix design. As the results obtained on replacement with resin showed higher Marshall stability indicating better and improved stability of conventional asphalt mixtures.
2. The ITSZ value increases with the increase in the dammar content. And even the direct tensile strength is getting higher with the increase of dammar content.
3. With the dammar content varying from 5% and 10% the result of UCS test was very strong .
4. The better volumetric properties were indicated as the asphalt mix concrete showed lower permeability with higher content of resin in the asphalt concrete mix.

2.3. Partial replacement of bitumen using waste cooking oil, tire rubber powder and palm oil fuel ash

Md Tareq Rahman, Mohd Rosli Hainin, Wan Azelee Wan Abu Bakar (2017

2.3.1.Method and Evaluation

(a) Selection of material.

(b) Preparation of sample.

(c) Laboratory Evaluation.

2.3.2. Conclusion

Less percentages of bitumen in binder mixture for the construction of flexible pavement involving waste cooking oil and tire rubber powder as the replacement for conventional bitumen. Conclusions that can be made from this research work are as follows.

1. Penetration test and softening test are the two physical tests that can be used to determine the optimum and efficient mixing ratio. In the case of waste cooking oil the optimum ratio among all the mixing ratios was found to be 5%. Softer samples were obtained for replacement more than 5% and making the sample not eligible for application in the construction of flexible pavement in warmer region. Up to 15% successful replacement of bitumen has been done with all modifiers.
2. Standard laboratory tests have been used to check physical and rheological properties and control sample has been used to assess the performance of the sample. Similar physical properties like Bitumen 80/100 were exhibited which were promising. The rheological properties are still within acceptable limit thus were fine.
3. To improve the viscosity of binder mixture use of waste tire rubber and POFA can be done. The presence of tire rubber powder and POFA resulted in higher viscosity, where tire rubber powder was used as replacement of bitumen and POFA was used as additive in the mixture. Different samples contains different tire rubber powder proportions.

2.4. Alternative binders for flexible pavement

Maniruzzaman A. Aziz , Md Tareq Rahman , Mohd. Rosli Hainin , Wan Azelee Wan Abu Bakar(2015)

Alternative binders are the binders which are not derived from crude oil. They are derived from other source such as bio based materials. They may be derived completely on partially from bio materials. There are three outcomes by which these bio based binders can replace the conventional fuel based binders.

1. Direct alternative consists of 75–100% bitumen replacement of bitumen.
2. Bitumen extender consists of 10–75% bitumen replacement.
3. Bitumen modifier consists of less than 10% bitumen replacement.

2.4.1. Different alternative binders

1. Bio oil.
2. Waste cooking oil.
3. Tire rubber.
4. Polymer, plastic.

2.4.2. Conclusion

Some of the alternate environment friendly, cost effective substances were found by the researchers which can be used as alternative binders differing with just their respective optimum percentages at which they need to be replaced for maximum stability. The results obtained were really very good and promising. As the percentages of bitumen decreases the percentage of bio based binders increases. With the association of more research and study with other additives these bio based binders and waste materials can be an effective alternative of bitumen. In the road and highway industry use of bio-oil and waste cooking oil can be of great importance.

The results of neat bitumen mixture resembles with that of bio based binders. For finding the efficient percentage of bio-based material more research is needed. Optimum result that will not only be effective enough for road construction but also offer potential for industrial production on a large scale can be obtained only through proper mixing and modification process. As this is a new alternative some new and advanced considerations needed to be done or incorporated in this study. Plant and field aging may not adequately be represented by

RTFO (Rolling Thin-Film Oven) and PAV(Pressure Aging Vessel). Experimental considerations start with determining an aging index to compare against neat asphalt for better results. For the normal time–temperature correlations to still hold range of time periods and temperatures should be conducted with RTFO. Same thing is applicable for PAV, the temperature at which it should be running is 60 degree C for extended time periods and comparison should be done between the results. Aggregate and gradation dominate the pavement performance result as they vary fracture and strength characteristics. Predicting the contribution of bio based binders is still not readily possible. For checking the impact of a new material on fracture and strength properties default mixture testing is needed. Check for the fatigueperformance also needed to be done.

2.5. Effect of using fly ash as alternative filler in hot mix asphalt

Raja Mistry Tapas Kumar Roy(2016)

2.5.1. Materials

(a) Aggregate: Locally available aggregates having specific gravity of 2.89 and 2.73 for coarse and fine aggregate respectively were used in this study. The continuous aggregate gradation of DBM gr-2 set by MORT&H specifications was selected.

(b) Bitumen:VG 30 grade paving bitumen collected from Haldia petrochemicals, India was used in this investigation to prepare HMA mixes after confirming to IS: 73 : 2002**.**

(c) Fller: conventionally used hydrated lime (HL) collected locallyand fly ash (FA) obtained from Kolaghat thermal power plant situated in West Bengal, India were used as fillers.

2.5.2. Method

(a) Design of DBM mix: The main purpose of using Marshall mix design methos is to the design the HMA mixes. The specified/standard samples of Marshall specimens are made. 75 blow are applied on each of the face in accordance with ASTM: D6926 which is having different contents of bitumen between 3.5% and 6.5% by the total weight of aggregates at an increment of 0.5% for control mixes (i.e. the mixthat contain 2% HL as filler) as well as mix containing 2%, 4%, 6% and 8% FA as filler.

(b) Marshall stability, flow and Marshall quotient tests: By using Marshall Stability test we cam find out the optimum bitumen content (OBC) relative to different proportions of mixes. Therefore, it is important to perform Marshall Stability test and flow test on every sample under a loading rate of 50.5 mm/min at 60°C based on ASTM: D6927.Marshall quotient, which is a kind of pseudo stiffness, can be calculated as the ratio of stability to flow.

2.6. Alternative Binders for Sustainable Asphalt Pavements

Thomas J. Kazmierowski, Robert B. McGennis ,Delmar Salomon, Christopher David Abadie Terry S. ArnoldGaylon L. Baumgardner Amit Bhasin(2012)

2.6.1. Conclusion

For hardened base binders coffee grounds work as a solvent this property is also improved because of high olefinic content and low aromaticity thus preventing the increase in viscosity because of oxidation during laboratory aging.

2.7. Evaluation of bio-materials' rejuvenating effect onbinders for high-reclaimed asphalt content mixtures

Davide Lo Presti, Paul Marsac, Simon Pouget, Ferhat Hammoum, Emmanuel Chailleux, Gordon D Airey (2017)

2.7.1. Materials

A Reclaimed Asphalt (RA) source in France wasselected for the study. RA binder was recovered followingthe EN 12697-4:2005 Fractionating Column by distillation procedure. Two different biomaterialswere selected to be studied as replacementfor conventional virgin binders in high-RA contentmixtures. The first bio-material is a binder producedfrom 100% renewable resources. Specifically, thisbio-material is a blend of pine resin (80%) and linseedoil (20%). These types of blends exhibit viscoelasticand thermo-rheologically simple behaviour.The second bio-material is a vegetal binder containingpolymers which was selected due to differentadvantages that polymers provide to bindersfor asphalt mixtures.

2.7.2. CONCLUSION

For the production of high-RA content mixtures (50%) at the binder level of study bio binders should have the potential to replace conventional and modified binders as per this paper. Two bio binders and two more traditional petroleum-based binders (conventional and modified) have been analyzed and blended to study the rejuvenating effect that they produce over RA. Rheology and the application of the δ-method was used to obtain the effect and assess the results.

High viscous response or capability to have low phase angles at high temperatures, to produce rejuvenating high-RA content mixtures suggest the rheological characterization of the bio binders revealed that they are thermo-rheologically simple materials with desired properties. The cross-over frequencies versus rheological indexes space can be used to appreciate the rejuvenating effect over RA by the bio binders and conventional binders that were studied upon. The blend of bio binders with RA generates less elastic and softer binders, having a comparable effect to traditional petroleum-based binders.

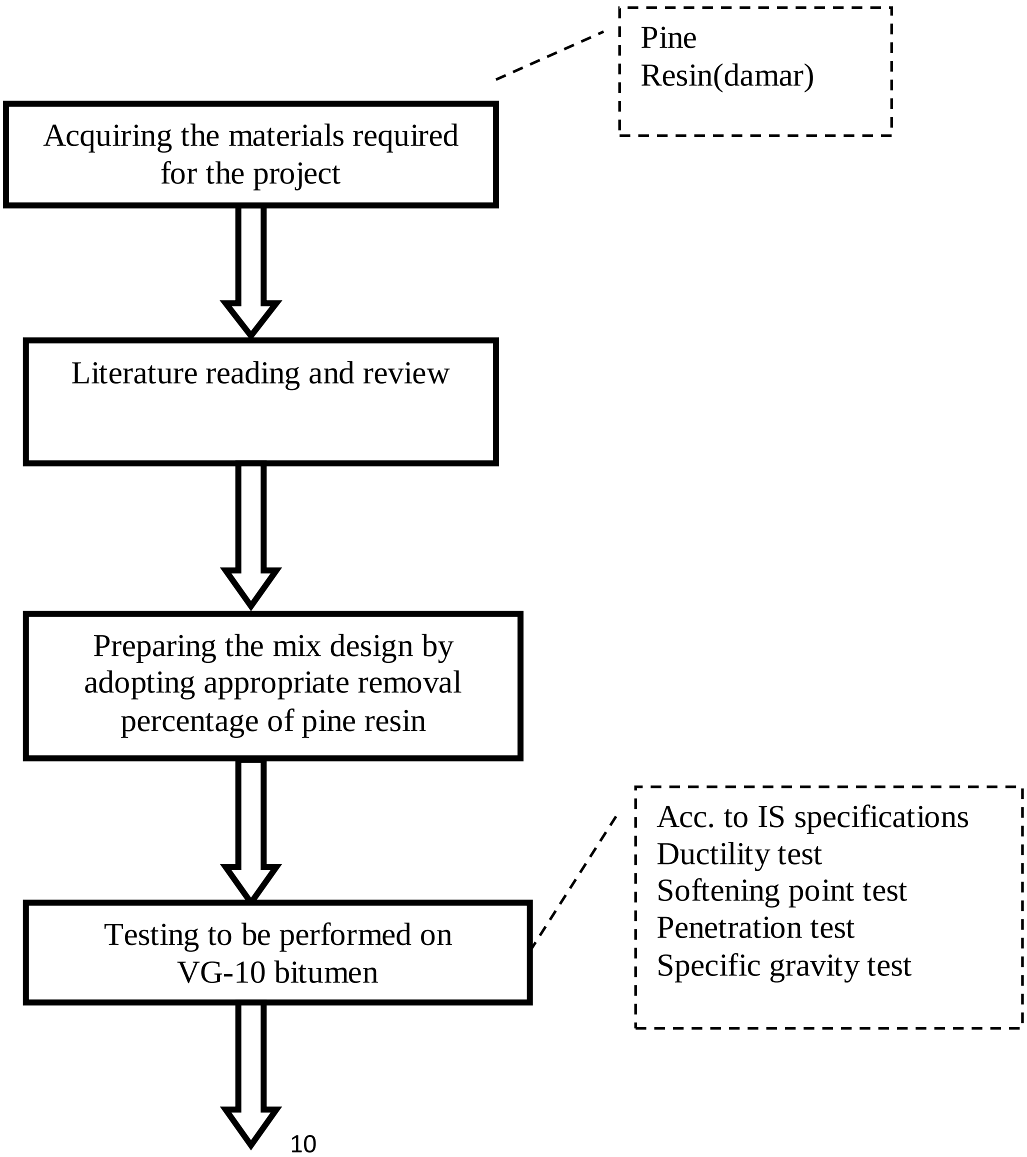
critical temperatures compared to 50/70 pen bitumen and RA blends with traditionally used binders, which would lead to similar rutting resistance in the asphalt mixture in terms of performance prediction, blends of RA and bio binders show equivalent rutting. In comparison to the rest of blends of RA and bio binders showed improved fatigue resistance. Without compromising rutting behavior RA fatigue performance can be enhanced with bio binders is a fact which cannot be ignored.

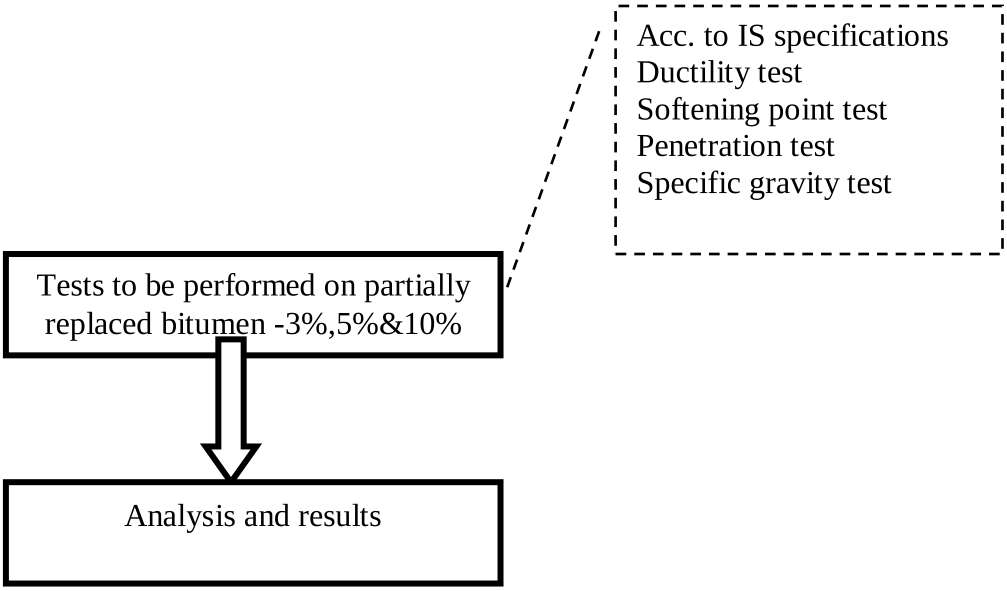
CHAPTER 3
METHODOLOGY

3.1 General

This chapter consists of 3 stages. The first stage consists of the material required for the bitumen and aggregate testing. The second stage consists of the equipment's required for the preparation of bitumen and aggregate samples and apparatus required for their testing. The last stage consists of the methodology which will be followed for performing the various test of the project.

3.2 Work plan





3.3 Material

Resin is a sticky, gelatinous or synthetic natural compound. In its initial state it is highly viscous and it hardens as its treatment process is done. It is readily soluble in alcohol , but due to lignin present in it, solubility in water is zero. Pine resin is a compound which is classified in many different ways according to its uses and consumption criteria. It also has many different applications depending on its availability and consumer requirements (on daily basis). The places where its availability is more than enough it is used for medicinal purposes and as an alternate bio asphalt.

Plants are the only source of resin. Pine sap is a classic example of its natural presence having a characteristic sharp odor of terpene compounds found naturally. For thousands of years humans have been using resin produced from different verity of plants. Some plants leave out similar substances known as gum or gum resin that does not interact with water. This gum is more softer and more malleable. Resin that is obtained from plants can be dark brown in color, it varies in hardness and depicts an opaque nature. As this resin contains unstable compounds thus are extremely volatile.

Pine resin has the ability to replace conventional asphalt as it contains complex organic polymers. These polymers form one of the most vital structural compound in the support tissues of vascular plants and some algae. It is called LIGNIN. Lignins are a vital compound for the formation of cell walls, particularly in bark and wood because they lend rigidity and do not rot easily. The chemical composition of lignins consists of crosslinked phenolic polymers. Dry weight of a woody plants consists of about 28% of lignins. Lignins are the most abundant organic compounds after cellulose. The amount of lignin present in a plant varies and may be different for plants of same species.

Conventional bitumen (VG10) supplied by Himachal Pradesh Public Work Department (HPPWD), SHIMLA (HP).

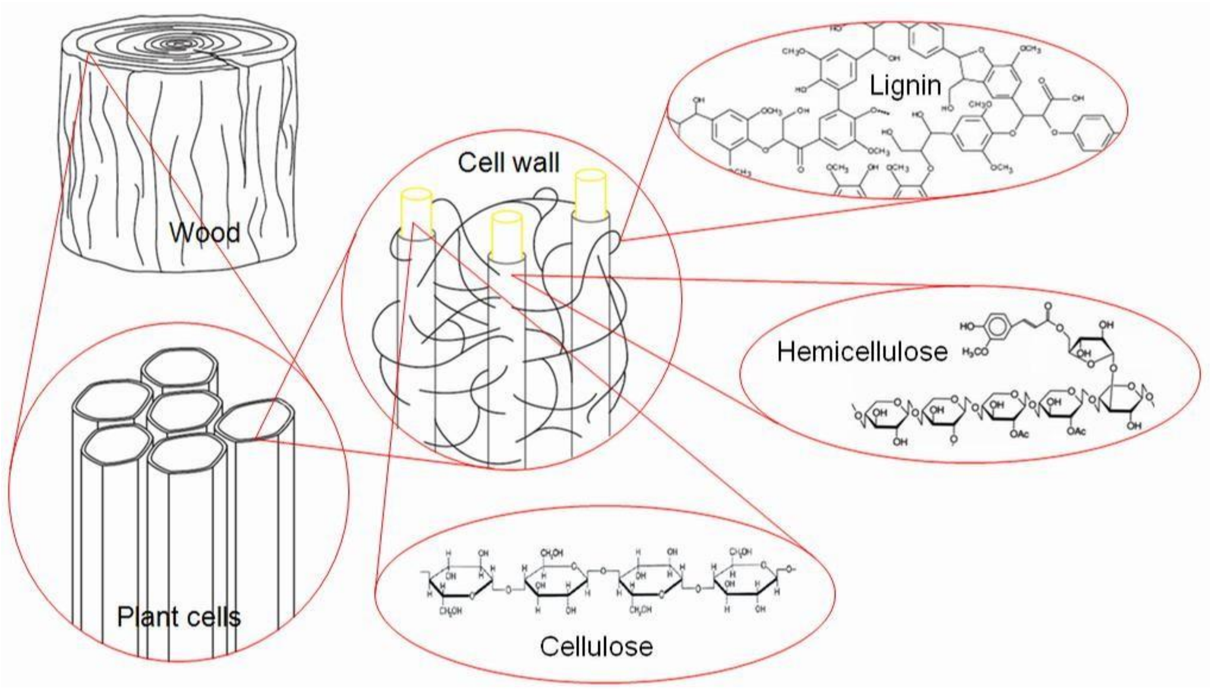


Fig 3.1 : The cross linking of phenolic group do not allow the absorption of water to the cell wall, which makes ita strong water repellent

3.3.1 Procurement

The Pine resin used in this project was obtained from Chail, Himachal Pradesh, India.

Fig 3.2: Method of collecting Pine resin

Fig 3.3: A drop of pine resin

3.4 Equipments used

Sr. No.	Equipments used
1.	Induction
2.	Water bath
3.	Ductility test machine
4.	Specific gravity bottle
5.	Penetrometre
6.	Ring and ball apparatus
7.	Thermometer
8.	Weighing machine

Table 3.1: List of equipments used

Fig. 3.4: Water bath

Fig. 3.5: Weighing machine

Fig. 3.6: Specific gravity bottles

Fig. 3.7: Pine resin.

3.5 Tests Performed on bitumen

3.5.1 Ductility Test

Ductility is a measure of elasticity of adhesiveness of bitumen. Ductility is measured as the distance in centimeters to which an standard briquette of bitumen sample can be stretched before the thread breaks. As per I.S. 1208-1958, the test should be conducted at 27° C and the pull should be applied at the rate of 50 mm per minute.

Procedure

1. Heat the bitumen sample so that it becomes fluid in state and then pour it in the briquette assembly and then place it on a brass plate.
2. All components of assembly including bitumen briquette along with brass plate is allowed to cool in air.
3. All components of assembly now are kept in a water bath which is maintained at 27°C for about 85 to 95minutes.
4. The ductility of bitumen may vary from 5cm to 100cm for different bitumen grades, but for satisfactory performance it should not be less than 50cm.

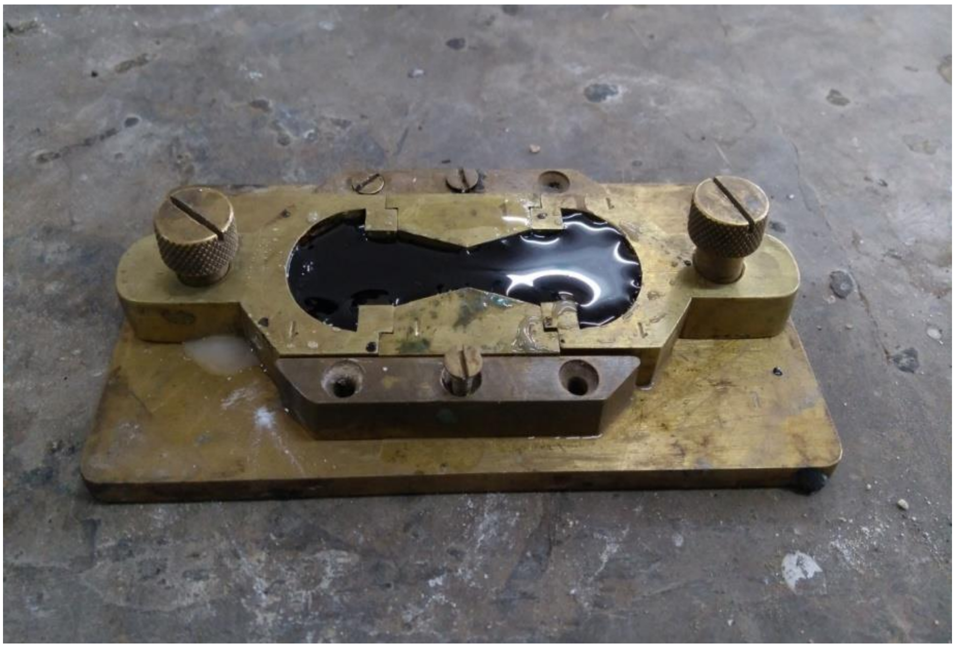


Fig 3.8: Ductility test mould

3.5.2 Softening Point test

Softening point is defined as the temperature at which a substance attains a particular degree of softening under specified conditions of test. Usually softening point for different grades of bitumen used for pavements varies from 35°C to 70°C.

Procedure

1. Heat the material to a temperature between 75° to 100° beyond the approx. softening point until it becomes a complete fluid.
2. Take this sample and place it in the brass and ring and then suspend it in water at a given particular temperature
3. Then a steel ball is kept on the sample of bitumen and the water bath is heated so that the temperature of the bath rises be 5°C in one minute.
4. Now the temperature is noted at which the softened bitumen touches the metal plate which is already placed at a particular distance below the ring. This temperature is known as the softening point of the bitumen.

   Higher the softening point, harder the grade of the bitumen.

Fig 3.9: Ring and ball apparatus

3.5.3 Penetration Test

This test is applied almost exclusive bitumen. For tars, cutback and emulsions other consistency are used. This test is the measure of the hardness or the softness of the bitumen sample. In this test the depth in millimeter is measured to which a needle of standard load will penetrate downwards in 5 seconds, while the temperature of the bitumen sample is maintained at 25^{o} C.

Procedure

1. The containers of the sample are first placed in a water bath which is maintained at 25° C for about one hour.
2. After one hour take out the sample from the water bath and the loaded needle is brought in contact with the upper surface of sample and the needle is allowed to penetrate for 5 seconds and then the final reading is noted.

Fig 3.10: Penetrometer showing the penetration value.

3.5.4 Specific Gravity Test

The purpose of this test is to find out the specific gravity of semisolid bitumen road tars, creosote and anthracene oil as per IS:1202- 1978. Specific gravity of bitumen is defined as the ratio of mass of given volume of bitumen to the mass of equal volume of water both taken at a specified temperature.

Fig. 3.11: Specific gravity bottle being filled with bitumen

Procedure

1. Weigh the specific gravity bottle along with the stopper. Let it be “weight A”.
2. Take the weight of specific gravity bottle filled with distilled water (weight B).
3. Now fill the bottle half with the material and weigh it. (weight C).

4. Not weigh the specific gravity bottle which is about half filled with material and the other half filled with distilled water (weight D).

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

3.5.5 Marshall Stability Test

It is done to determine the maximum load that can be carried by a specimen that is tampered/compacted at a standard test temperature which is 60^0 C. It is also done to determine the optimum binder content of the aggregate mix type and the traffic intensity. Marshall stability vs. %bitumen can also be drawn with the help of this test.

Apparatus

1. Mould Assembly: cylindrical moulds of 10 cm diameter and 7.5 cm height consisting of a base plate and collar extension
2. Sample Extractor: for extruding the compacted specimen from the mould
3. Compaction pedestal and hammer.
4. Breaking head
5. Loading machine
6. Flow meter, water bath, thermometers

Procedure

1. Heat the specimens to 60 ± 1^o C. e may use water bath for 30-40 minutes or an oven for minimum of 2 hours.
2. Now remove the specimens from the oven or the water bath. Place it in the lower segment of the breaking head. The upper segment of the breakinghead of the specimen is placed in position. Now place the whole assembly in position on the testing machine.
3. The flow meter is placed over one of the post and is adjusted to read zero.
4. Now apply the load at a rate of 50 mm per minute until the maximum load reading is obtained.
5. Observe the max. load reading in Newton. At the same time, the flow which is recorded on the flow meter in units of mm was also noted.

Fig. 3.12: Marshall stability test apparatus

Fig. 3.13: Sample being placed on Marshall Stability test apparatus.

3.6 Tests on Aggregates

3.6.1 Crushing value test

This test follows the Indian Standard code IS:2386 Part-IV, 1963. This importance of this test is to obtain the crushing value of coarse aggregates and then to determine the suitability of these aggregates for use in construction of road pavements of different types and at different locations. The crushing value of these aggregates gives us the ability of the aggregates to withstand a moderately compressive force that is applied on them. This value gives us the strength of the aggregates and this values should be as minimum as possible.

Procedure

1. The cylinder is kept on the base plate and is weighed (W).
2. Three layers of samples are made and each layer is tampered 25 times. If the material is weak, care should be taken. Now weigh this (W1).
3. The surface of the aggregates must be levelled with care. Now put the plunger such as it rests horizontally on the surface. It should me noted that the plunger should not jam in the cylinder.
4. Now place this on the loading platform of CTM.
5. Now the load is being applied uniformly. Note that 40 T load is applied in 10 minutes.
6. Now the load is released and the material is removed from cylinder.
7. The material is sieved with 2.36 mm IS sieve. Loss of fines should be considered.
8. Then take the weight of the material that passes through IS sieve.

Fig 3.14: Crushing value setup

3.6.2 Aggregate Impact value test

This test follows the Indian Standard code IS:2386 Part-IV, 1963. By using this test we can find the impact value of aggregates. The property possessed by materials to resist any impact applied on them is known as toughness. Aggregates may break down into smaller pieces due to the impact caused by the weight of vehicles. Therefore the particles must possess higher value of toughness so as to resist their break down due to impact. This property is measured by impact value test. The impact value of any aggregate is defined as a measure of resistance to any sudden impact/shock and it may change from its resistance to gradually applied compressive load.

Procedure

1. Collect the aggregates that pass through 12.5 mm sieve and which retain on 10 mm sieve. Now dry them in oven for 4 hours at a temperature of 100° C -110° C.
2. Fill the cylinder up to one third with aggregates. Now tamper it 25 times with the round end of tamping rod.
3. Now fill the cylinder in two more layers and tamper each layer 25 time as done in the previous step.
4. The aggregate's overflow gets cut off by the tamping rod.
5. Now weigh the total sample in the measuring cylinder which is nearing to 0.01 gm.
6. Now shift the aggregates to the cup which is fixed in a particular position on the base plate of machine. Now tamp it 25 times.
7. Now lift the hammer to 38 cm above the upper surface of the sample in the cup and make it fall freely o the sample. Apply 15 such blows. The duration between the blows must be less than one second. Now the sample of aggregates is taken off from the cup and is sieved through 2.36 mm sieve until no significant amount of sample passes. Now weigh the fraction that has passes accurately to 0.1 gm. Now repeat these steps for new samples of aggregates.
8. Take the weight of oven dried sample be W1 and the wt. of sample that has passed the 2.36 mm sieve to be W2 gm. The impact value of aggregates is expressed as the percentage of fines formed in the terms of the total wt. of sample

Table-1: Classification of aggregate based on the 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

Table 3.2: Classification of aggregate based on the aggregate impact value

3.6.3 Specific gravity and Water absorption

The test specifications are in accordance with the Indian standard code IS:2386 Part-IV 1963. Water absorption of the given sample of aggregates is determined using this test. An idea about the strength of the aggregates is obtained by its capability of water absorption. Porosity of the aggregates is directly proportional to the water absorption capacity of the aggregates and these aggregates are not considered suitable until and unless they are found sustainable based on different test like test of strength, impact and hardness.

Procedure

1. Net amount of aggregates to be taken is 2kg which are than to be washed thoroughly so as to remove all the fines it is than drained and placed in the wire basket which is than immersed in distilled water at a given temperature of 22 degree C to 32 degree C with a depth of 50 mm below the top of the basket.
2. The basket is than dropped at a rate of one drop per second about 25 times and this process helps in the removal of the entrapped air in the basket.
3. The total immersion period for the basket and the aggregates is about 24 ± 0.5 hours and these should be completely immersed.
4. At a temperature of 22° to 32°C the basket and the sample are then weighed while suspended in water. If the situation arises that the basket needs to be transferred than they should be jolted 25 times as described in the above steps for the complete removal of entrapped air.

5. The suspended weight (W1) is noted in grams. For drying of the aggregates they are taken out of water and kept as it is for few minutes to let the water dry off after which aggregates are transferred to one of the dry absorbent cloths.
6. The weight in the water W2 grams is taken after the empty basket is returned to the tank of water and jolted for 25 times.
7. This absorption process is carried on until it is assured that no more water can be removed from the aggregates through this dry clothing. The aggregates are then transferred to another dry clothing spread in single layer and these aggregates are than further allowed to dry off for at least 10 minutes until the aggregates are completely surface dry an extended drying period of about 10 to 50 minutes may also be required.
8. The process of surface drying should not involve any such procedure like direct sunlight or any other source of heat and not even to the atmosphere.
9. To accelerate the drying of the aggregate surface a gentle current of unheated air may be used during the first ten minutes.
10. W3 is than noted in grams which is the surface dried aggregate weight. Oven drying is used with the temperature of 110 degree C for 24 hours and the aggregates are kept in a shallow tray.
11. W4 is than noted which is the weight of cooled aggregates. Not more than two tests should be carried out concurrently.

Fig 3.15: Water Absorption test

3.6.4 Flakiness index and elongation index

The test specifications are in accordance with the Indian standard code IS:2386 Part-II 1963. The percentages of flaky and elongated particles determine the shape of the aggregate particles contained in it. Angularity number is used for determining the shape of gravel. For assessing the shape of the aggregate flakiness and elongation tests are conducted on coarse aggregates. For higher workability and stability to be achieved in aggregate flaky and elongated aggregates should be avoided in mixtures. These particles if used cause interlocking problems and create a great deal of problems during compaction and desired degree of compaction cannot be achieved. Most common cause for the pavements to break down under heavy loading is the excessive use of flaky and elongated aggregates in base course and construction of bituminous and cement concrete type pavements. For improving the workability of cement concrete road rounded aggregates are preferred. When the shape of aggregates deviates more from the spherical shape, as in the case of angular, flaky and elongated aggregates, the void content in an aggregate of any specified size increases and hence the grain size distribution of the graded aggregates has to be suitably altered in order to obtain minimum voids in the dry mix or the highest dry density this not only provides better interlocking properties but also improves strength quality thus use of angular shape aggregates is preferable.

Procedure

1. The sieve analysis is performed according to the Indian Standard Code.
2. Weight (W1) is the weight of 200 pieces which are to be tested.
3. Each fraction is then gauged for thickness on thickness gauge, or in bulk on sieve having elongated slots all this for the effective separation of flaky materials.
4. With an accuracy of at least 0.1% of test sample the amount of flaky materials passing the gauge is weighed.
5. Let W1 be the weight of the flaky or elongated materials passing through the gauge. Similarly W1,W2,W3, etc. be the weights of the fraction passing and retained on the specified sieve thus total weight be the sum of all the above mentioned weights. W1,W2,W3... as the weights of the materials passing through each specified thickness gauges is mentioned and again the total weight of the materials passing through different gauges is the sum of all the weights found in grams.

6. The flaky material passing the various thickness gauges expressed as a percentage of the total weight of the sample gauged is expressed as flakiness index.
7. x1,x2,x3... as the weights of the material from each fraction retained on the specified gauge is noted and total weight is the sum of all the above mentioned weights respectively.

Fig 3.16: Shape test

3.6.5 Los-Angeles Abrasion value test

The test specifications are in accordance with the Indian standard code IS:2386 Part-VI 1963. The main purpose of the test is to find the compatibility of aggregates for its use in the road construction. Measure of the wear and hardness is referred to as abrasion. For the use of wearing course surface it becomes a crucial property for aggregates. The aggregates used in the surfacing course are subjected to wearing action at the top all just due to heavy traffic movement. The abrasion is caused when traffic moves on the road and fine particles like dust, soil or even water which comes between the wheels of vehicle and road surface causing abrasion to the wearing surface course. Causing an impact on aggregates using standard steel balls and mixing them with aggregates and rotating them in a drum for specific number of revolutions is the principle of Los Angeles abrasion test. The Los Angeles Abrasion Value is the percentage wear of the aggregates due to rubbing with steel balls.

Fig 3.17: Los-Angeles test setup

Sl. No.	Types of pavement layer	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, 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

Table 3.3: Los-Angeles values

3.7 General Specifications For Marshall Stability Test

- Replacement of bitumen with both pine resin and waste cooking oil.
- Grading according to IRC for VG10 type bitumen i.e.

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

Table 3.4: IRC grading for VG-10

Fig.3.18: Grading for VG10 bitumen.

CHAPTER 4

RESULTS

4.1 When replaced with pine resin (replacement by weight).

4.1.1 Ductility Test Results

Observations

Total weight of sample 1= 300gm

Total weight of sample 2= 291gm(VG-10)+ 9gm(pine resin)

Total weight of sample 3= 292.5gm(VG-10)+ 7.5gm(pine resin)

Total weight of sample 4= 297gm(VG-10)+ 3gm(pine resin)

Sr.No.	Sample	Ductility in cms
1.	VG-10 (without replacement)	75
2.	Bitumen with 3% by weight replacement(pine resin)	0(failure)
3.	Bitumen with 2.5% by weight replacement(pine resin)	0(failure)
4.	Bitumen with 1% by weight replacement(pine resin)	2

Table 4.1: Ductility test results (pine resin)

Fig. 4.1: Ductility failure

The above depicted tabular shows that as the percentage of replaced bitumen decreases and pine resin content increase the ductility decreases and the sample is becoming more and more rigid thus making it less ductile.

4.1.2 Softening Point Test Results

Observations

Total weight of sample 1= 300gm

Total weight of sample 2= 291gm(VG-10)+ 9gm(pine resin)

Total weight of sample 3= 292.5gm(VG-10)+ 7.5gm(pine resin)

Total weight of sample 4= 297gm(VG-10)+ 3gm(pine resin)

Sr. No.	Sample	Ball(1) Temperature (ºC)	Ball(2) Temperature (ºC)	Mean value softening point (col 3+col 4)/2
1.	VG-10 (without replacement)	40	40	40
2.	Bitumen with 3% by weight replacement(pine resin)	71	69	70
3.	Bitumen with 2.5% by weight replacement(pine resin)	70	71	71.5
4.	Bitumen with 1% by weight replacement(pine resin)	63	63	63

Table 4.2: Softening point test results (Pine resin)

1. The above mentioned tabular data depicts that the softening point increases as the percentages of pine resin in the bitumen content is increased.
2. this can be explained by the fact that the sample after replacement is getting more hardened thus balls are taking more time to attain the temperature at which they touch the bottom of beaker.

Fig 4.2: Ring and ball apparatus.

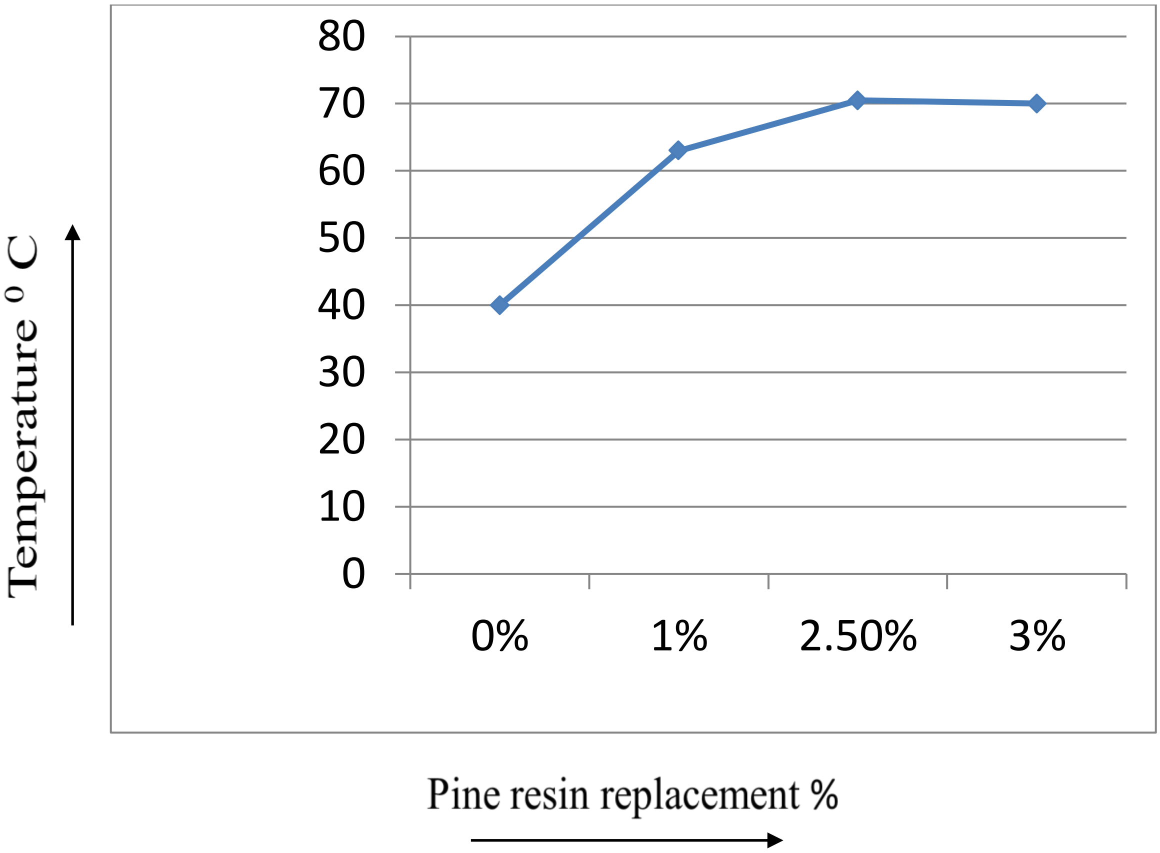


Fig. 4.3: Graph for Softening point test results. (when replaced by pine resin)

4.1.3 Penetration Test Results.

Observations

Total weight of sample 1= 300gm

Total weight of sample 2= 291gm(VG-10)+ 9gm(pine resin)

Total weight of sample 3= 292.5gm(VG-10)+ 7.5gm(pine resin)

Total weight of sample 4= 297gm(VG-10)+ 3gm(pine resin)

Sr.No.	Sample	Penetration value 1(mm)	Penetration value 2(mm)	Penetration value 3(mm)	Mean Value of penetration(mm)
1.	VG-10 (without replacement)	78	80	78	78.67
2.	Bitumen with 3% by weight replacement(pine resin)	8	6	8	7.33
3.	Bitumen with 2.5% by weight replacement(pine resin)	8	7	9	8
4.	Bitumen with 1% by weight replacement(pine resin)	11	13	10	11.33

Table 4.3: Penetration test results (pine resin)

1. Above data depicts that as the percentages of pine resin is increased in the bitumen replacement the penetration value tends to decrease.
2. The sample is getting stiffer with increasing pine resin content. Therefore the needle is not able to penetrate easily. Hence, decreasing the value of penetration.

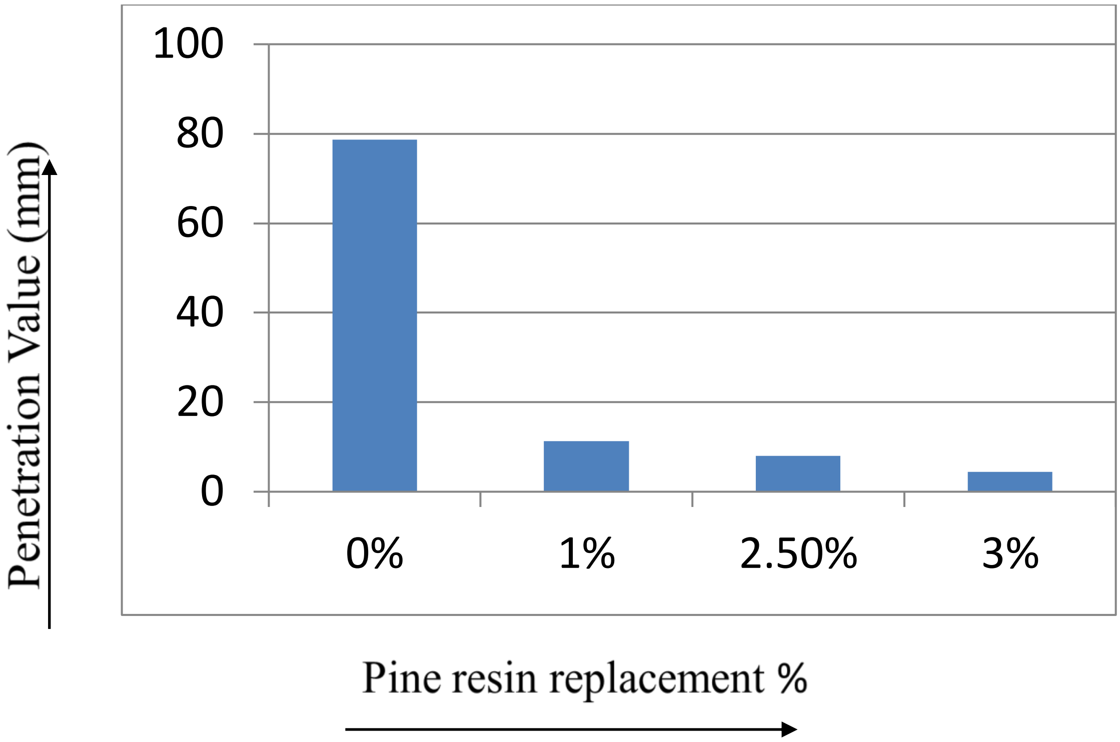


Fig 4.4: Graph for penetration test (when replaced with pine resin)

4.1.4 Specific Gravity Test Results

Observations

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

Sr.No.	Sample	A(gm)	B(gm)	C(gm)	D(gm)	Specific Gravity
1.	VG-10 (without replacement)	**26**	**70**	**45**	**71**	**1.01**
2.	Bitumen with 3% by weight replacement(pine resin)	**20**	**64**	**41**	**65**	**1.05**
3.	Bitumen with 2.5% by weight replacement(pine	**26**	**81**	**50**	**81**	**1**

	resin)					
4.	Bitumen with 1% by weight replacement	**20**	**64**	**40**	**64**	**1**

Table 4.4: Specific gravity test results (pine resin)

4.2 With waste cooking oil as replacement (General specifications)

- Total weight of sample = 291gm(Bitumen)+9gm(Waste cooking oil) (3%)
- Total weight of sample = 285gm(Bitumen)+15gm(Waste cooking oil) (5%)
- Total weight of sample = 279gm(Bitumen)+21gm(Waste cooking oil) (7%)

4.2.1 Ductility tes

Sr No	Sample	Ductlity in cms
1.	Bitumen with 3% replacement by weight with Waste cooking oil.	85
2.	Bitumen with 5% replacement by weight with Waste cooking oil.	Did not break. (Distance from bottom surface less than 1cm)
3.	Bitumen with 7% replacement by weight with Waste cooking oil.	Did not break. (Distance from bottom surface less than 1cm)

Table 4.5: Ductility test results (Replaced with waste cooking oil)

The data mentioned above depicts that the ductility of the sample is increasing at an incredible rate as the waste cooking oil percentages is increased this is because the waste cooking oil is making the sample more softer than original bitumen without replacement.

4.2.2 Softening point test

Sr. No.	Sample	Ball(1) Temperature (°C)	Ball(2) Temperature (°C)	Mean value softening point (col 3+col 4)/2
1.	Bitumen with 3% by weight replacement (waste cooking oil.)	40	39	39.5
2.	Bitumen with 5% by weight replacement (waste cooking oil.)	41	42	41.5
3.	Bitumen with 7% by weight replacement (waste cooking oil.)	38	36	37

Table 4.6: Softening point test results (Replaced with waste cooking oil)

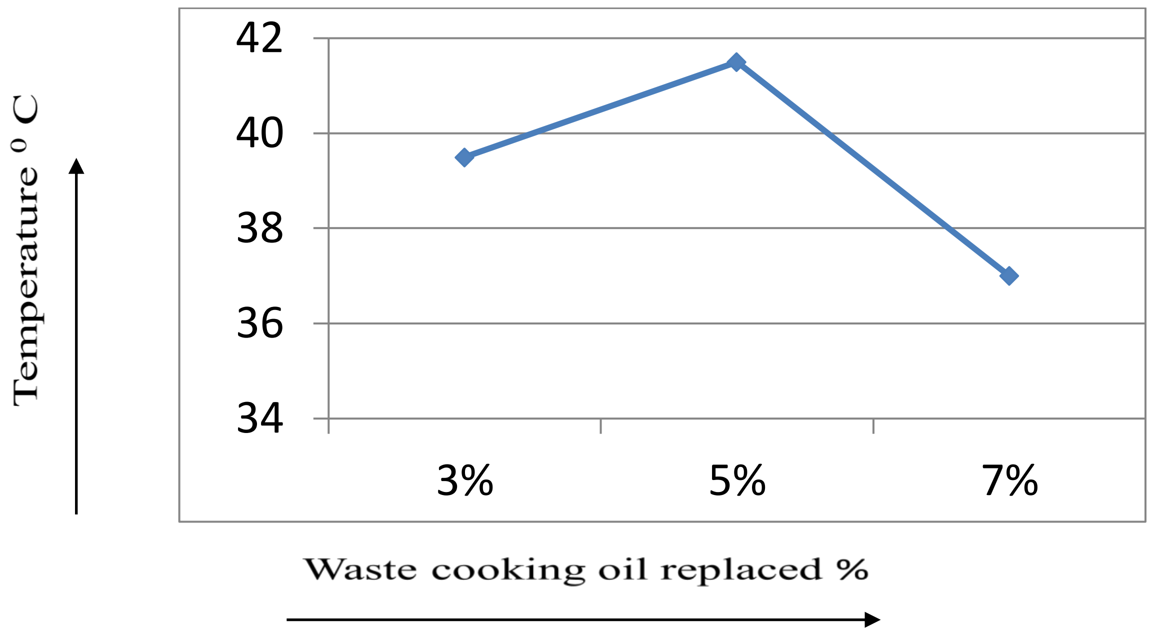


Fig. 4.5: Graph for softening point result (when replaced by waste cooking oil)

The softening point data clearly depicts that optimum percentage removal at which maximum temperature is obtained is 5% replacement with waste cooking oil.

4.2.3 Specific Gravity test

Sr. No.	Conventional bitumen	Bitumen + 3% waste cooking oil	Bitumen + 5% waste cooking oil	Bitumen + 7% waste cooking oil
1.	0.98	1.01	1.03	1.04

Table 4.7: Specific gravity test results (Replaced with waste cooking oil)

4.2.4 Penetration test

Sr.No.	Sample	Penetration value 1(mm)	Penetration value 2(mm)	Penetration value 3(mm)	Mean Value of penetration(mm)
2.	Bitumen with 3% by weight replacement (waste oil)	90	90	94	91.33
3.	Bitumen with 5% by weight replacement (waste oil.)	120	122	130	124
4.	Bitumen with 7% by weight replacement (waste oil.)	152	152	158	154

Table 4.8: Table for penetration test (Replaced with waste cooking oil.

1. Bitumen replaced with waste cooking oil showed larger penetrations.
2. Greater the amount of replacement (with waste cooking oil), greater the needle penetrated into sample.

3. When we replaced the bitumen with pine resin, the sample became stiff and the penetration value decreased. Whereas, when replaced with waste cooking oil, penetration value increased.
4. It showed more penetration than the conventional bitumen.
5. Table 4.7 shows the values of penetration at different percentages of replacement and the fig. 4.4 shows its graphical representation.

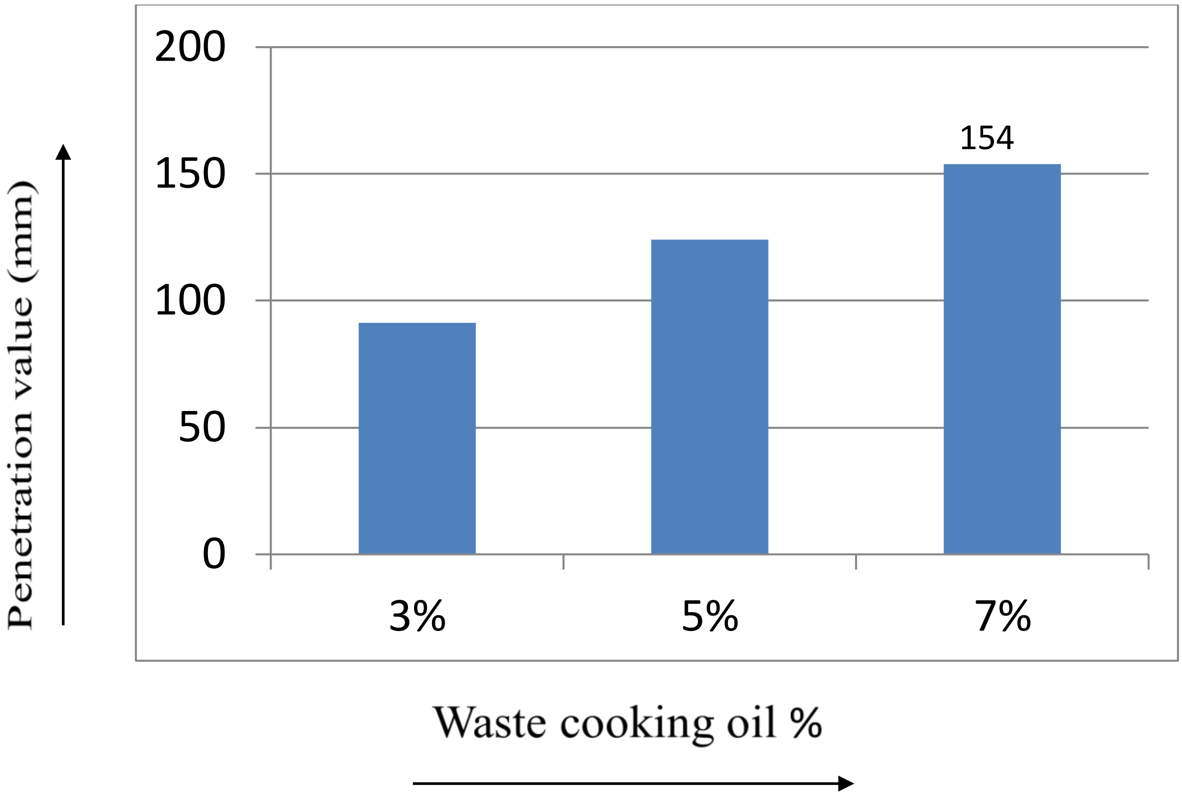


Fig. 4.6: Graphical representation of penetration test (waste cooking oil replacement)

4.3 Marshall Stability Test for pine resin replacement

Fig. 4.7: Sample 1

Fig. 4.8: Sample 2

A. Fig. 4.6 and Fig 4.7 shows the failure of samples when Marshall Stability was performed on them. (for 1% and 2.5% replacements with **pine resin** and OBC of 5.1%)

B. Same were the results obtained when Marshall Stability test was performed on samples with waste oil replacements.

C. So we decided to mix the two samples at different percentages to obtain a optimum value and perform Marshall Stability test on them.

4.4. Replacement of bitumen with 1% Pine resin and 1% waste cooking oil.

- Total weight of sample= 300gm
- Weight of pine resin added= 3gm

- Weight of waste cooking oil= 3gm
- Weight of bitumen= 294gm

4.4.1 Penetration test results

Sr.No.	A(mm)	B(mm)	C(mm)	Average Penetration (mm)
1.	48	47	47	47.33

Table 4.9: Penetration test results

All the results for penetration in this case are near to the desirable results thus we can increase the replacement percentages.

4.4.2 Specific Gravity test results

Sr.No.	Conventional Bitumen	Specific Gravity
1.	0.98	0.95

Table 4.10: Specific gravity test results

4.4.3 Softening point results

Sr.No.	Ball 1 Temperature	Ball 2 Temperature	Aggregate Temperature
1.	36	37	36.5

Table 4.11: Softening point results

These results are lesser than the expected values of the conventional bitumen softening point values thus assuring us of better results in further replacements.

4.4.4 Ductility test

Sr.No.	Ductility in cms
1.	53

Table 4.12: Ductility test results.

4.5 Marshall stability test performed on different percentages of replaced pine resin and waste cooking oil.

4.5.1 Strength

Bitumen %	Bitumen with 1%pine resin ad 1%waste cooking oil	Bitumen with 1%pine resin ad 1.5%waste cooking oil	Bitumen with 1%pine resin ad 2%waste cooking oil	Bitumen with 1%pine resin ad 2.5%waste cooking oil
4%	1.67	1.77	1.99	1.72
4.5%	1.81	1.93	2.24	2
5%	2.12	2.31	2.51	2.3
5.5%	1.76	1.8	1.94	1.82

Table 4.13: Tabular form of Marshal Stability strength results

According to the Marshall stability values it can be inferred that as the optimum replacement percentage for maximum strength is 1%pine resin and 2% waste cooking oil.

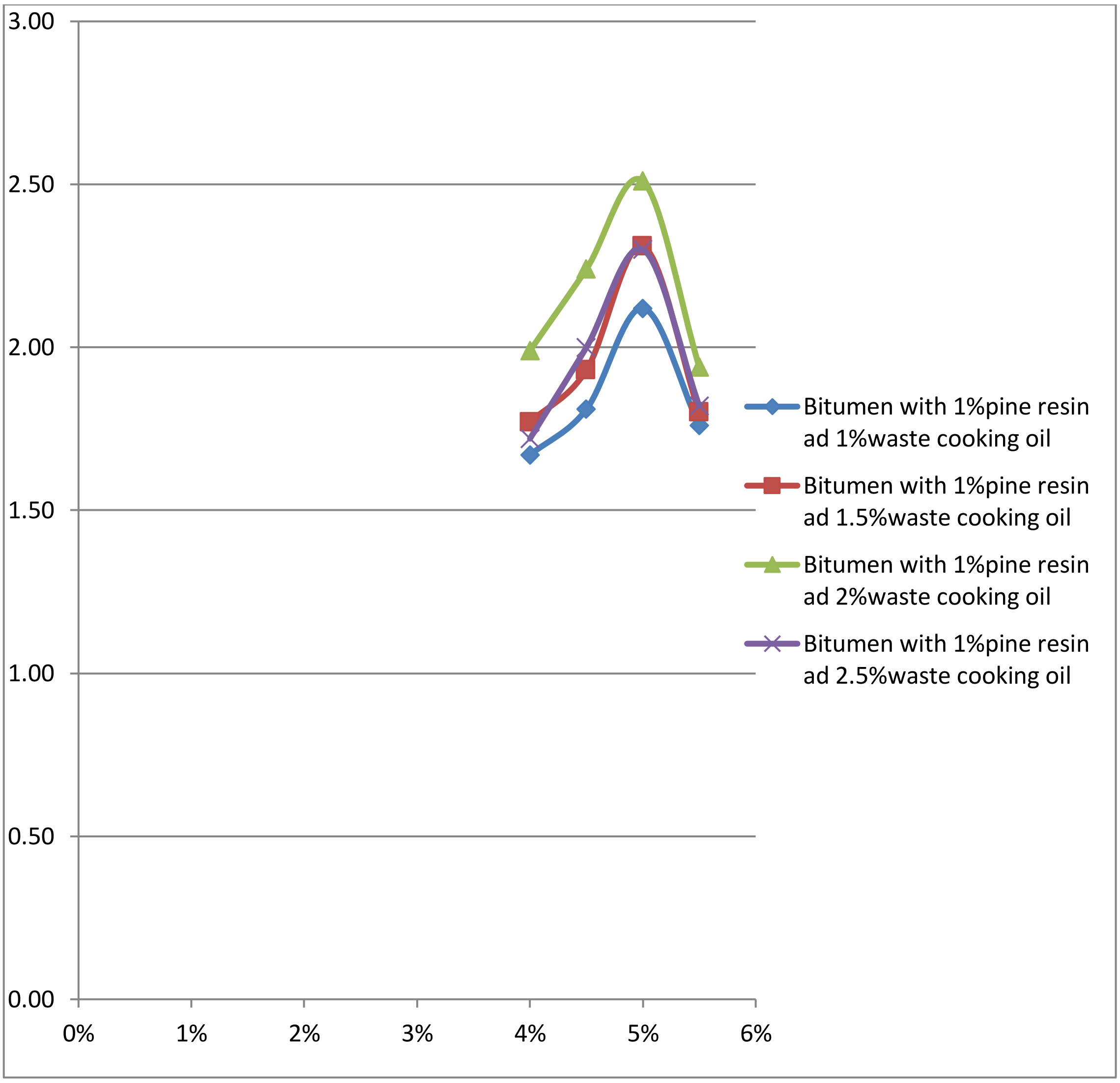


Fig. 4.9 : Graphical form of Marshall stability strength results

4.5.2 Flow value

Bitumen %	Bitumen with 1%pine resin ad 1%waste cooking oil	Bitumen with 1%pine resin ad 1.5%waste cooking oil	Bitumen with 1%pine resin ad 2%waste cooking oil	Bitumen with 1%pine resin ad 2.5%waste cooking oil
4%	2.3	2.49	2.55	2.87
4.5%	2.38	2.66	2.81	3.23
5%	2.67	2.79	3.1	3.42
5.5%	2.92	3	3.24	3.61

Table 4.14: Tabular form of Marshall stability flow value results

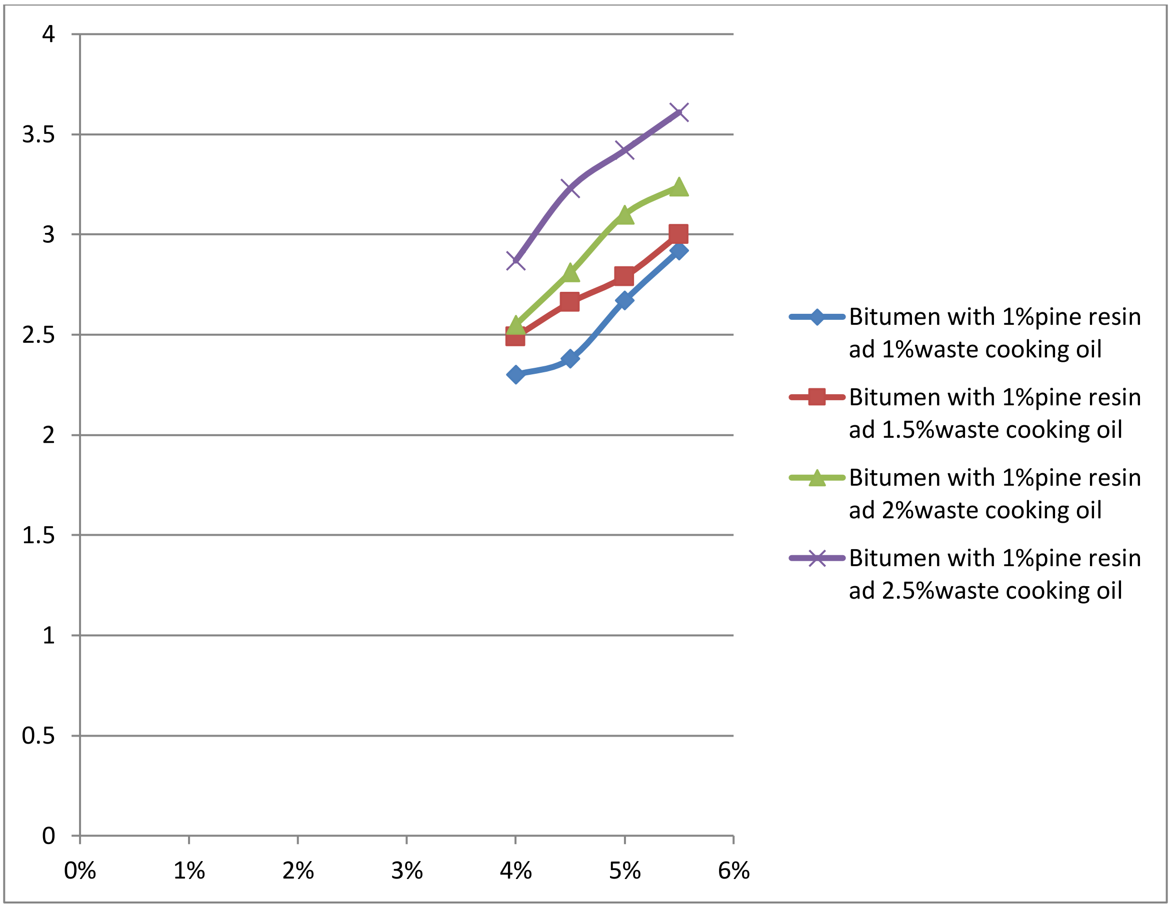


Fig. 4.10: Graphical form of Marshall Stability flow value results

4.5.3 Density

Bitumen %	Bitumen with 1%pine resin ad 1%waste cooking oil	Bitumen with 1%pine resin ad 1.5%waste cooking oil	Bitumen with 1%pine resin ad 2%waste cooking oil	Bitumen with 1%pine resin ad 2.5%waste cooking oil
4%	2.321	2.426	2.429	2.23
4.5%	2.413	2.437	2.438	2.31
5%	2.529	2.54	2.566	2.472
5.5%	2.27	2.27	2.29	2.31

Table 4.15: Tabular form of Marshall stability density results

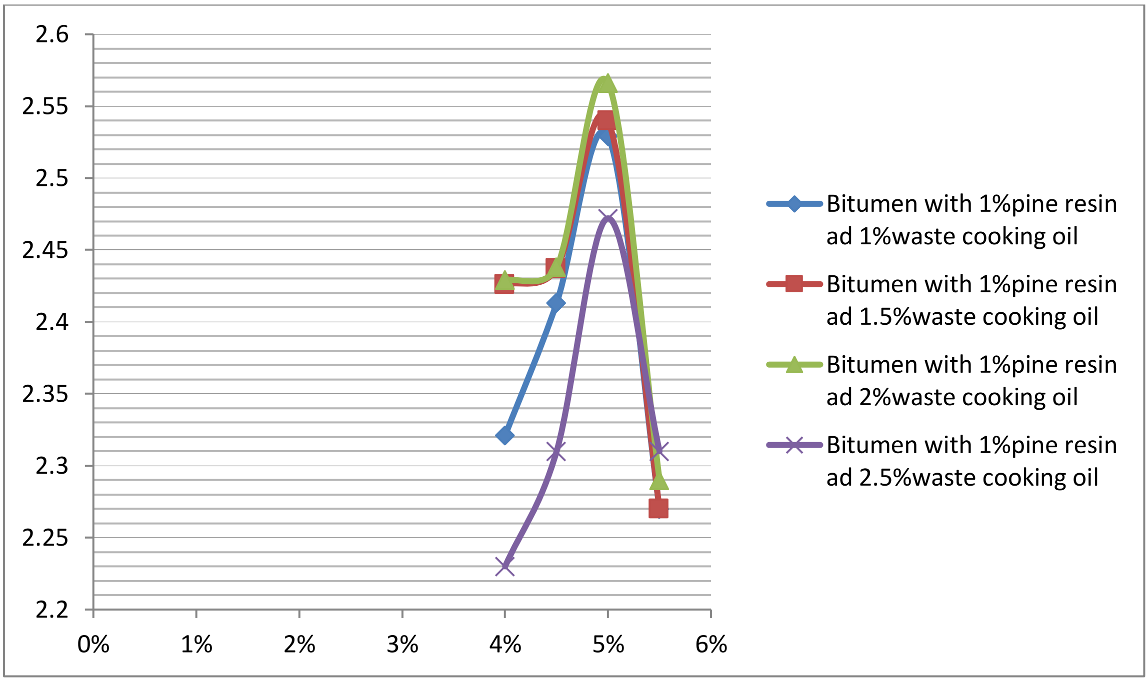


Fig4.11: Graphical form of Marshall Stability strength results

4.5.4 Voids filled with bitumen

Bitumen %	Bitumen with 1%pine resin ad 1%waste cooking oil	Bitumen with 1%pine resin ad 1.5%waste cooking oil	Bitumen with 1%pine resin ad 2%waste cooking oil	Bitumen with 1%pine resin ad 2.5%waste cooking oil
4%	60.36	66.33	67.93	68.21
4.5%	68.53	70.12	76.48	77.12
5%	74.86	76.94	80.45	80.55
5.5%	77.63	80.14	82.34	83.4

Table 4.16: Tabular form of Marshall Stability Voids filled with bitumen results

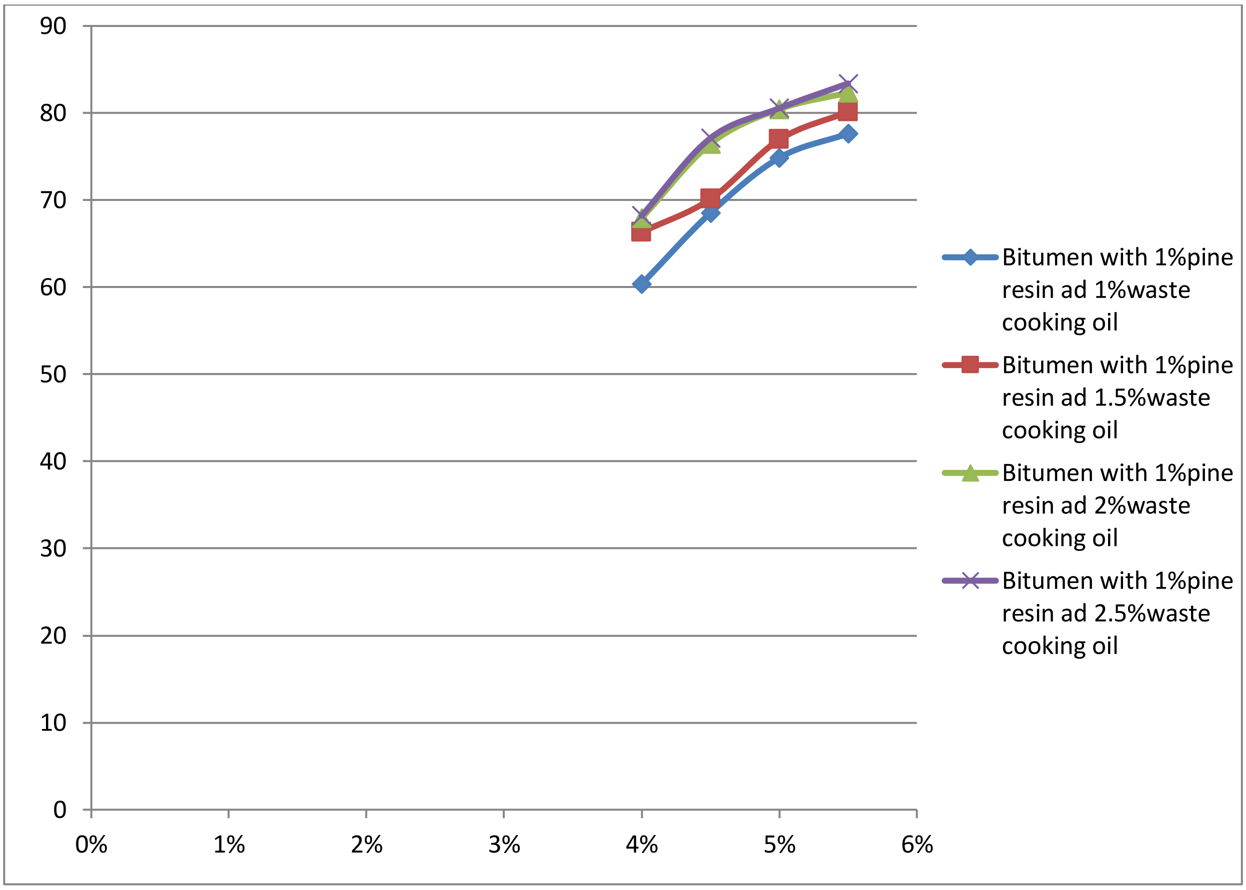


Fig. 4.12: Graphical form of Marshall Stability Voids filled with bitumen results

CHAPTER 5
CONCLUSION

The results mentioned before in this report depict that it is possible to replace the conventional bitumen with bio based binders . As per our experimental data we can successfully conclude that the conventional bitumen can be replaced with different percentages of pine resin and waste cooking oil respectively. The experiments depicted us that only replacing pine resin with conventional bitumen did not yielded desired results, the resultant after mixing conventional bitumen with pine resin formed a very rigid mixture which failed in most of the tests of bitumen like penetration test, ductility test etc. The over rigid mixture can be explained on the basis that on heating bitumen and pine resin at 120˚ C most of the volatiles vaporized resulting in lesser water in the voids which is essential for making the bitumen softer thus making a mix more rigid than normal bitumen.

These results differed in case of replacement with waste cooking oil. A more softer mix was obtained which again failed in all the tests involved in bitumen testing. It was also heated at the same temperature as the bitumen and pine resin was heated.

After the above two replacements we conclude that on replacement of bitumen with pine resin a rigid mix was obtained and on replacement of bitumen with waste cooking oil the mix obtained was softer thus replacing these with the conventional bitumen at the same time would give the desired result.

From the above results on both pine resin and waste cooking oil we obtained that pine resin on replacement at 1% was optimum as at this percentage most of the tests performed was successful and same happened in the case of waste cooking oil replacement and the optimum percentage obtained was 3%.

Thus we started the replacement of bitumen for Marshall stability test at 1% pine resin and 1% waste cooking oil which started to show desired results after performing marshal stability test at different percentages we concluded that optimum percentages replaced both of pine resin and waste cooking oil was 1% and 2% respectively. Because at these results the desired results were closest to some and some exceed standard results of VG-10 bitumen and each one of the replaced bitumen percentage is depicted in this report.

REFERENCE

1. Yami, M.A.D., Nasution, M.F. and Setyawan, A., 2017. Design and Properties of Renewable Bioasphalt for Flexible Pavement. *Procedia engineering*, *171*, pp.1413-1420.
2. Rahman, M.T., Hainin, M.R. and Bakar, W.A.W.A., 2017. Use of waste cooking oil, tire rubber powder and palm oil fuel ash in partial replacement of bitumen. *Construction and Building Materials*, *150*, pp.95-104.
3. Aziz, M.M.A., Rahman, M.T., Hainin, M.R. and Bakar, W.A.W.A., 2006. Alternative Binders for Flexible Pavement. *Carbon (C)*, *72*, pp.81-6.
4. Mistry, R. and Roy, T.K., 2016. Effect of using fly ash as alternative filler in hot mix asphalt. *Perspectives in Science, 8*, pp.307-309
5. Huang, S.C., Salomon, D. and Haddock, J.E., 2012. Alternative Binders for Sustainable Asphalt Pavements: Papers from a Workshop. Workshop Introduction. *Transportation Research E-Circular*, (E-C165).
6. Jiménez del Barco Carrión, A., Pérez-Martínez, M., Themeli, A., Lo Presti, D., Marsac, P., Pouget, S., Hammoum, F., Chailleux, E. and Airey, G., 2017. Evaluation of bio-materials' rejuvenating effect on binders for high-reclaimed asphalt content mixtures. *Materiales de Construcción*, *67*(327), pp.1-11.
7. Feng, Z.G., Rao, W.Y., Chen, C., Tian, B., Li, X.J., Li, P.L. and Guo, Q.L., 2016. Performance evaluation of bitumen modified with pyrolysis carbon black made from waste tyres. *Construction and Building Materials*, *111*, pp.495-501.
8. Hussein, A.A., Jaya, R.P., Hassan, N.A., Yaacob, H., Huseien, G.F. and Ibrahim, M.H.W., 2017. Performance of nanoceramic powder on the chemical and physical properties of bitumen. *Construction and Building Materials*, *156*, pp.496-505.
9. Rahman, M.T., Hainin, M.R. and Bakar, W.A.W.A., 2017. Use of waste cooking oil, tire rubber powder and palm oil fuel ash in partial replacement of bitumen. *Construction and Building Materials*, *150*, pp.95-104.