MIX DESING BY USING CANDLE WAX AND SUGARMOLASSES MODIFIER IN BITUMEN FOR SUSTAINABLE DEVELOPMENT

Submitted in partial fulfillment of the requirements of the degree of

MASTER OF TECHNOLOGY

In

CIVIL ENGINEERING

By

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2017

DECLARATION

I, Insha hafiz (11208553), hereby declare that this thesis report entitled **"Mix Design by using wax and sugar molasses modifier in bitumen for Sustainable Development "**submitted in the partial fulfillment of the requirements for the award of degree of Master of Civil Engineering, in the School of Civil Engineering, Lovely Professional University, Phagwara, is my own work. This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

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CERTIFICATE

Certified that this project report entitled **"Mix Design by using wax and sugar molasses modifier in bitumen For Sustainable Development" s**ubmitted individually by student of School of Civil Engineering, Lovely Professional University, Phagwara , carried out the work under my supervision for the Award of Degree. This report has not been submitted to any other university or institution for the award of any degree.

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ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of my task would be incomplete without mentioning the people whose constant guidance and encouragement made it possible.

I am deeply indebted towards the other faculty members who extended their help to me directly or indirectly and I am grateful to all of them without it would have been impossible for me to complete my seminar study in time. I take pleasure in presenting before you, my report which is result of great cooperation and guidance of Assistant Professor “Amit Kumar Yadav”.

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ABSTACT

Bitumen is obtained from the distillation of petroleum. It is basically a sticky type of black viscous liquid and is the semi-solid form of petroleum. It i found in natural deposits and sometime. The bitumen is used as a sort of binding agent throughout the world and its need is on increasing alarm. so the modification of the bitumen needs to be done so that it can be more lasting and also the environment is not on risk by using this bitumen

This study is basically based to modify bitumen by using candle wax and sugar molasses. Various tests were being done in order to find out what will be the effect on the bitumen by adding smaller percentages of waxes as well as molasses in the bitumen. The purpose to do this modification was that to lower the temperature of the bitumen when the production is being done. The modification was done and the results were being recorded with the Hot mix asphalt technologies. By adding waxes at various percentages like 1%,2%,3%,4%,.Also the molasses were being added to it at varying percentages with the bitumen. The results showed that by adding waxes on bitumen the viscosity is increased as the wax content is being decreased and by this the compaction temperature and there addition temperature was also decreased. By adding molasses it was found that there was an increase in the softening point of the bitumen, The workability , strength was also increased but the penetration value was reduced.

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INTRODUCTION

1.1 General:

Bitumen is defined as a viscous liquid that constitutes the mineral oil, which possess a variety of hydrocarbons which will have a high or increased molecular weight and these hydrocarbons contain small proportions of oxygen, nitrogen and also of sulphur..additionally it also has hydrocarbon derivatives which are being soluble in carbon disulphide .bitumen is either black or it can be brown in colour ,according to its mode of derivation .It has good water proofing and adhesive that is the sticking properties .Also its hardness and its volatility properties is also very satisfactory..

From the past few decades the combinations of bitumen and the aggregates are being used in order to pave the roads .the reason being that these are not costly, and can be easily applied in road constructions. In this the major contributing ones are the aggregates but bitumen also plays a more significant as well as important role in the performance of the pavement.

Bitumen is important because it has good binding property and holds the aggregates particles together. It greatly contributes to the durability of the mixes as well as it also provides good stability. the major distress that are being generated are the process of the Fatigue, process of rutting and as well as the low-temperature cracking, stripping is also there which is also the main contributor of the distress. Their properties are also related to the bitumen that is being used for the purpose of road construction. Rutting occurs because when the temperature is quite high, the bitumen tends to lose its property of cohesion and by this rutting is being generated under heavy loads. The process of fatigue is there because when excess repetition of loads exceeds the threshold value. Cracking occurs when the bitumen tends to shrink. The process of stripping is there because of the low adhesion properties lying at the surface of the bitumen containing aggregates.

Due to the recent development the volumes of the traffic and the heavy axle loads are being increasing tremendously, so the researchers try to make ways of improving the bitumen mixture by increasing their performance and for this the best way to do is by modification of the bitumen with the help of certain additives.

For the modification various technologies are being used in this regard. For converting bitumen into warm mix asphalt which helps in decreasing the asphalt or bitumen compaction temperatures as well as the binders used in it. By this the fluidity of the binders is also reduced. The temperature properties of the warm mix asphalt increases from 100°C to l40°C, with the addition of the hot mix asphalt or the bitumen having the range of 150°C to 180°C.Taking the viewpoint of the environment and the economic ones, the technologies contributing to the use of warm mix asphalt contributes to the reduction of the compaction temperature and also of the mixing. Proper care needs to be taken for the wearing resistance.

Also various WMA technologies are now being used in order to decrease the temperature associated with the mixing and compaction. Here the technologies may differ but the only goal is to reduce the viscosity of the bitumen, enhancing the workability property of the bitumen as well as the emission conditions of the asphalt or the bitumen. From the various additives being used, FT paraffin contributes massively on the good performance of the bitumen or asphalt.

As non renewable energy is being depleted day by day and there is scarcity of its availability so as a civil engineer, it is our duty to protect the mother earth and for that the in context to road construction, the searches should be done for a cheaper substitute to the bitumen or the asphalt. The wastes that are being generated by industries can be used for the modification purpose.

When the bitumen is being manufactured from crude oil, in this process large amount of gases like benzene, sulphur dioxide and also nitrogen oxide are being evolved out in the atmosphere and these can be little bit controlled in the industry, but when the process of transportation and the application process takes place, bitumen gets heated to high temperatures. When this heating is there, the harmful gas carbon dioxide (CO_2) gets released and by this various diseases occurs, like the lung diseases. It is also a serious threat to the environment. So the waste generated by the industry taking example of sugarcane industry, sugar molasses can be modified with the bitumen. As bitumen is a sticky form of the petroleum and is tar like, it is very thick that it should be firstly heated or it should be diluted well before it can flow. At the room temperature, this bitumen is very much of the type of cold molasses.

As our environment is being getting decayed due to the use of the cement and the bitumen , so modification of bitumen by using sugar beet molasses that it is used as the additive

Material and is basically a organic waste material which is obtained from sugar when the refining operation takes place at the sugar refineries. It is basically a thick, and dark brown kind of syrup, having 50% quantity of sugar content. In other areas also it is used like in fertilizer industry. It has also has 20% of water n it. Also a material was synthesized in the lab with the help of sugar beet molasses and boron oxide and was being knows]n as molasses-based boron oxide(MBOC).Then the bitumen was being modified by using two materials , one was sugar beet molasses and the other one being MBOC separately in order to investigate these modifications.

The properties of the bituminous mixes were also done by using various laboratory tests which constituted the penetration, softening point, Marshall Stability and much more. Bitumen nowadays is used in road construction and also in other areas also for a longer span of time. The bitumen is basically a complex material; the reason for its complexities is due to the various large numbers of chemical compositions that include asphalt or bitumen.

1.2 Bitumen/Asphalt:

Till 20^{th} century the bitumen or asphalt was called as" asphaltum", this word was derived from the Greek work "asphalt". Asphalt is also known as bitumen and is sticky, black in colour. It is having high amount of viscosity and is a semi-solid type of petroleum. Sometimes it is also called a pitch because it is being found in natural deposits. These two terms asphalt and bitumen are sometimes used as synonyms of each other, meaning natural. Referring to American English, the product is known as Bitumen while the term asphalt is mainly used as the residue of petroleum which is refined by the process of distillation. Sometimes these are called as "tar" in common language. Another terminology being used for this "pitch". Mainly about 70% use of bitumen is done primarily areas of road construction .In this main role that binder does is that it binds up or mixes it with the other aggregates in order to get asphalt or bituminous type of concrete. Also it is used in sealing up of the roofs and also for it water roofing.

1.2.1 Bitumen Composition:

Basically the composition of asphalt/bitumen is being categorized into 4 sub categories which are shown in the following diagram:

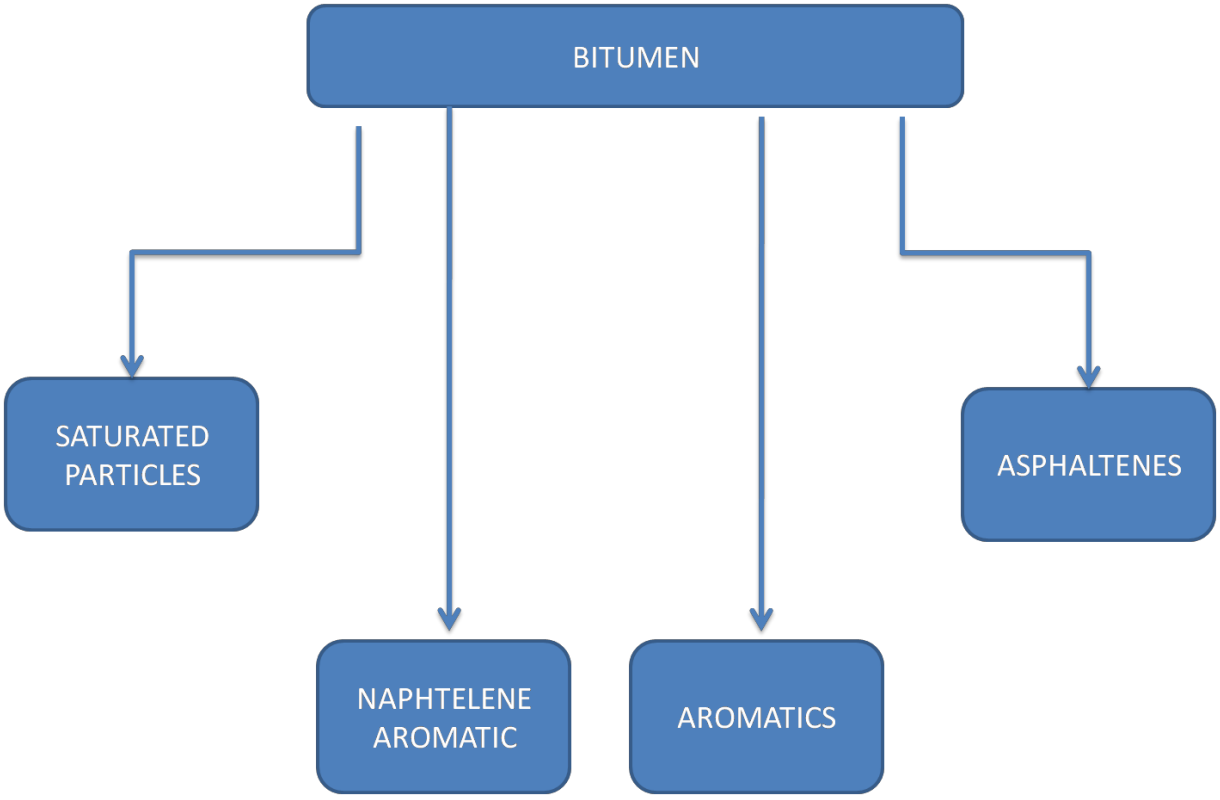

Figure 1.1 shows the various composition of bitumen.

- **Saturated particles:** having hydrocarbons. The percentage of the saturates will depend mainly on the softening point.
- **Naphthene aromatic:** These have partially hydrogenated kind of aromatic type of compounds.
- **Aromatics:** These have higher molecular weight phenol.
- **Asphaltenes:** They have large molecular mass phenols and also some portions of heterocyclic particles.

In this the "|aromatics" are the major contributing materials .In addition to that ,some of the bitumen consists of organic sulphur materials, and in this the sulphur present is up to 4%.,also it has nickel particles plus some particles of vanadium ,having less than 10ppm level

in thee petroleum products.

1.2.2 Occurrences of bitumen:

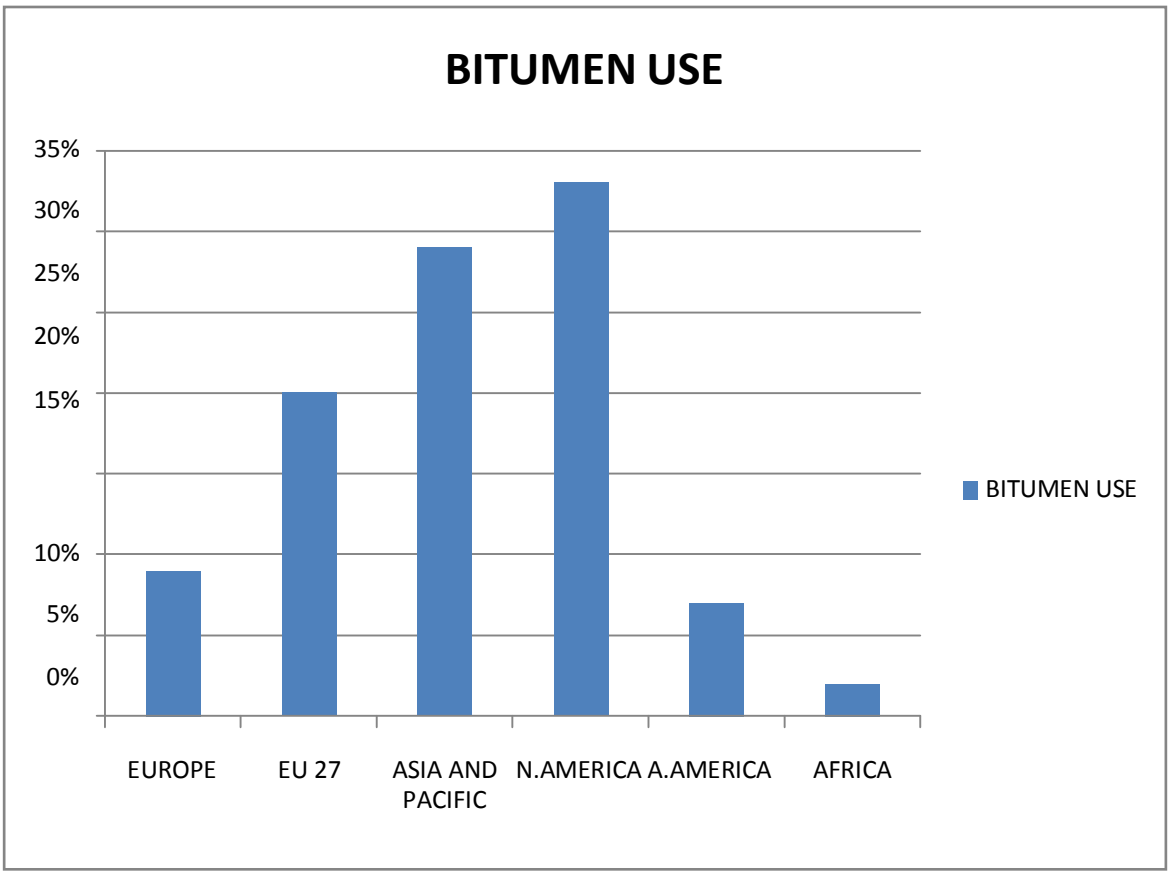

Figure 1.2 shows the whole global bitumen use

This chart shows the bitumen use in various countries. In this, North America has the highest percentage of use of bitumen. The figure shows that where the use of bitumen is high and where it is quite low. This also shows the various countries how much use of bitumen is over there.

Bitumen is mainly derived from the products associated with petroleum and it occurs naturally in large amounts. The bitumen is being used since older period of time. These are formed under the crust of the earth and the pressure being very high. By this process the remains that are left will be transformed into a material being called as asphalt or bitumen

Apart from petroleum, Bitumen can also be derived in the form of sandstones that are impregnated. Examples of these are “bituminous rocks” or the “tar sand”.

1.2.3 Uses of bitumen:

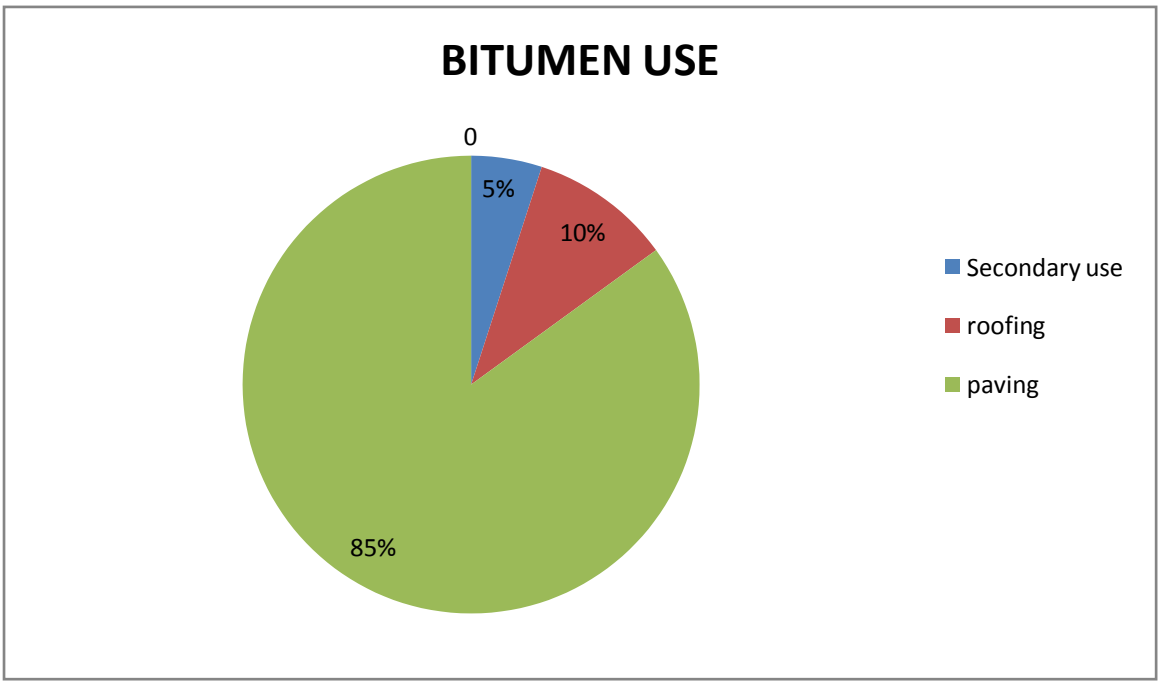

Figure 1.3 shows the various uses of bitumen

This figure shows the uses of the bitumen such as secondary, roofing, paving. In secondary it is 5%, in roofing it is 10%, in paving it is highest of them all having 85%.

It is used in:

- **Road Constructions:**

In UK, almost 85-90% is being used in the maintenance of the road as well as for the construction of the roads.

- **Hot Mixtures:**

In the hot mixtures like of the hot mixtures of asphalt, Bitumen is being used as a binder for binding up the aggregates. Firstly the hot bitumen is delivered to the plant, then the hot mix asphalt is being produced. After its production it is then transported to the construction site.

- **Surface Dressing:**

Surface dressing is mainly used in the process of the maintenance of the roads. It is done by spraying a little of thin film of the binder on the road with the help of mobile spray vehicle T hen after that stone chippings are being applied , then rolling is done

- **Water Proofing:**

Bitumen helps in water proofing. It also helps to prevent the seepage from the water, also the 10% of the whole production of the bitumen is used in these areas like to do the water proofing also the roofing applications also

- **Floorings:**

In factories bitumen is used in the mastic floorings.

On an average approximately 102 million tonnes per year of bitumen is being used worldwide. From this date almost 85% of this bitumen is used in road constructions in the form of a binder. The process of manufacturing of binder concrete involves the, mixing of materials like fine aggregates, gravels and small rocks with the binder associated with it also.

1.2.4 Applications of Bitumen:

- **Long Lasting:**

In order to have long lasting surfaces and solid base lines, the roads are now designed to meet these criteria. The span of time also gets increased and can last for longer durations of time. It should withstand heavy loads of traffic and the number of defects should be minimum.

- **Design Criteria:**

The design criteria i mainly constituted by the structural design taking into account. The structural design mainly depends on the loading of the pavement in order to withstand heavy loads without the further maintenance of the roads. In the construction the asphalt consists of various layers. The lower layer consists of the sub grade followed by a sub base layer. The sub base layer is used to provide the proper drainage.

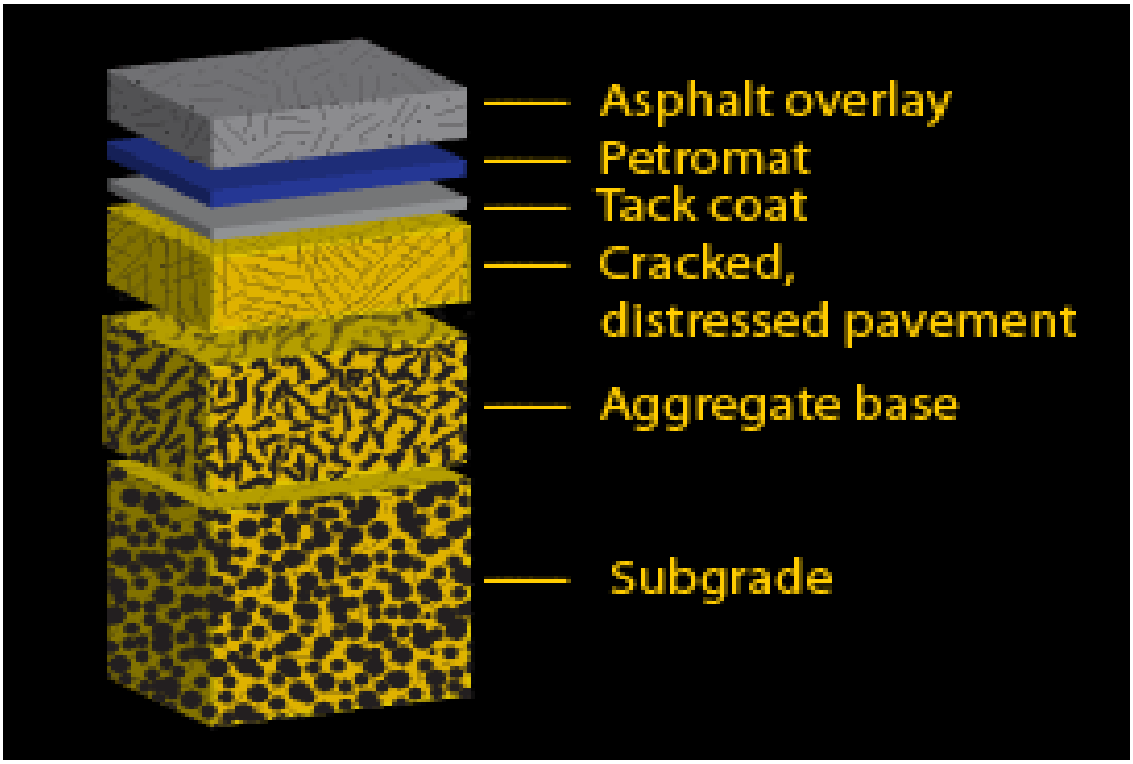

Figure 1.4 showing the overall stress distribution in bitumen

In this, the asphalt overlay has the highest stress distribution followed by the next layer Petro mat, and then the last layer that is r sub grade layer.

Figure 1.5 showing different layers of bitumen

The roads of the bitumen are divided into layers so that weight component is being balanced equally also, there is grain action given to all layers and is distributed grain wise. In order to have good strength properties more finer and good quality material is used in the upper layer and it gets decreased as we go down to the lower layers.. The binding between the layers should be good and much strong in order to have a good bearing capacity. The bitumen mainly consists of three main layers and these are:

- Upper layer.
- Binder course.
- Bitumen base course.

1.3 Specification of Bitumen and Its Products:

Figure 1.6 depicts the picture of a bituminous road

As per the industries and the various tests the safety, the physical properties and the durability of the bitumen. The main performance of the bitumen is being described by the physical properties of the bitumen.

1.3.1 Penetration Graded Bitumen:

In this the penetrating property of the bitumen is being focused mainly. In this the ,the hardness of the bitumen is being calculated and is being measured by the depth of needle in tenths of mm and a standard needle is being placed vertically and is then allowed to penetrate for about 5 seconds.

If by this test the penetrating property of the bitumen is less; it indicates that the bitumen is hard. Various penetrating grades of the bitumen are as follows:

- **BITUMEN 80/100 grade.**
- **BITUMEN 85/100 grade.**
- **BITUMEN 60/50 grade.**
- **BITUMEN 50/70 grade.**
- **BITUMEN 160/100 grade.**

1.3.2 Oxidized or Blown Bitumen Grade;

Under proper controlled environment, firstly the penetration grade bitumen is being taken and then air is blown in a continuous or in a staggered way. which helps in controlling the oil content that is being present in the bitumen while its starts to get oxidized. These blown or oxidized bitumen is used in the manufacturing of roofing felts as an anti-slip layer. When the full blowing is done then the properties tend to change fully and it behaves different from the penetration grade bitumen.

1.3.3 Viscosity Graded Bitumen:

As the name implies, these type of bitumen are being classified in terms of the viscosity at the standard temperature and normally it is taken as 60°C.

1.4 Products of bitumen:

1.4.1 Cut-Back Bitumen:

When the viscosity of the bitumen id decreased due to the addition of some kind of solvent is known as cut-back bitumen. The main solvent used is “kerosene”. The solvent has an important role in it, the kind of solvent mainly helps to control the curing time and the amount of the solvent decides the viscosity of bitumen. This bitumen is basically used for the spraying purpose. The cut back bitumen is of two types:

- **RAPID CURING (RC).**
- **MEDIUM CURING (MC).**

1.4.2 Modified bitumen:

Various types of the chemical agents are used in order to enhance the performance of the bitumen and that bitumen by:

- Crumb rubber.
- Polymers.
- Sulphuric acid.

1.4.3 Fluxed bitumen:

When in the bitumen the viscosity is being decreased by using some oils it is called as fluxed bitumen. The oils used in this are mainly the vegetable oils and some of the gas oils.

1.4.4 Bitumen Emulsion:

It consists of three main parts;

- Bitumen
- An emulsifying agent.
- Water.

In this the binder is mainly used mainly used are cut-back modified bitumen or any kind other bitumen but modifies ones..Bitumen emulsions are mainly used in the surfacing and dressing of the roads.

1.5 Benefits of Bitumen:

- **Reduction Of Noise:**

Bitumen road surfaces have the low noise level in comparison to other road surfaces being the traditional ones. These bitumen surfaces decrease the level of noise when a car strikes the road surfaces. The porous surfaces decrease the noise level by almost 50%.\

- **Surface Water Disposal:**

In bitumen surfaces the surface water dressing and drainage properties are very good. In recent developments new methods are being adopted which have helped the drainage a n d disposal of water to dispose off quickly, and by this the visibility o gets increased when the drivers sees the road if the road is wet. Also by this diver can easily indentify the various road marking in any condition of the weather.

- **Skid Resistance:**

Bituminous surfaces have good skid resistance and by this the grip between the road surfaces and the tires of the road gets increased. Mainly skid resistance focuses on two points like the drainage and texture. These road surfaces have highest protection when the roads are having some grades which are changing, and of curves.

- **Easy Maintenance:**

Bitumen road surfaces can be easily maintained. Also their cost of maintaining it is quote economical and is cheap.

1.6 Waxes in Bitumen:

Before going into the detail of effect of wax in bitumen, the bitumen itself has some quantity of wax in it.

1.6.1 Definition and Classification:

The term wax was firstly use in bee wax. But due to new technologies, it was made significant on various important issues like wax being applied to solids as well as on liquids. The waxes that are in bitumen are being differentiated into three main types and these are:

- Macro crystalline:

These have usually 30% carbon content and these are crystallized in large amount of crystals. When the amount of carbon content is 40% or even higher, then on this smaller type of crystals are being generated.

- Microcrystalline:

These have greater percentage of ‘isopraffin’ or the branched type of hydrocarbons. These mainly give us the fineness that is being associated with the crystals. It has high molecular weight and also greater melting point.

- Amorphous or non crystalline:

These have carbon atoms which are in branched form. Also there are hetero atoms in it as well. These are elastic as well as ductile.

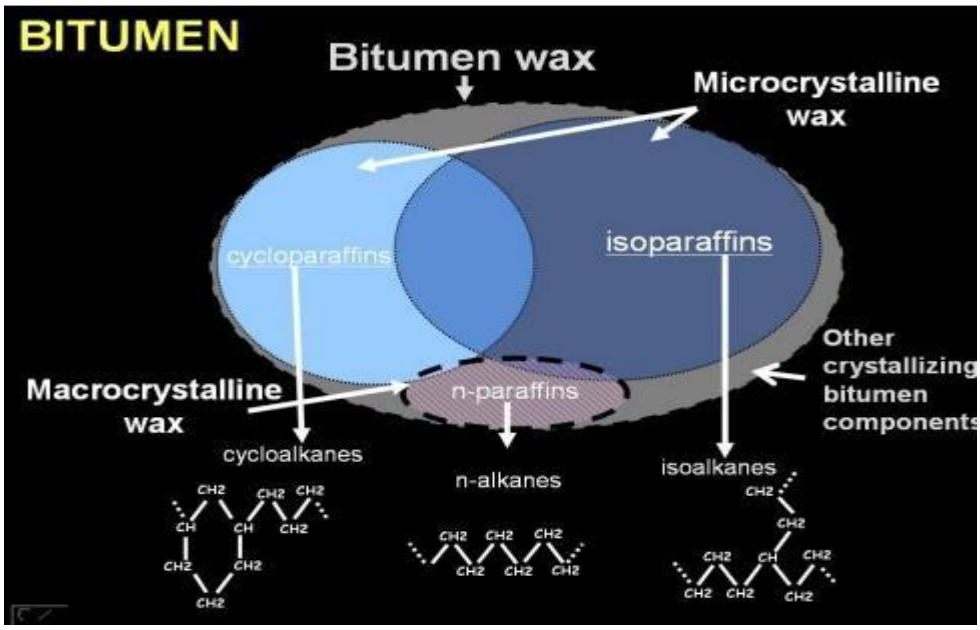

Figure 1.7 depicts the overall wax content in bitumen

This figure depicts that what are various kind of waxes in bitumen and their properties are discussed below.

1.6.2 Paraffin wax:

Paraffin wax is defined as a soft white material which is basically colorless in nature. It is being extracted from petroleum coal and then the mixing is being done. This mixing occurs having about 20 to 40 carbon atoms in it. The melting point of the wax is 37°C and the Boiling point is greater than 370°C. At room temperature it is generally hard in nature and when the temperature is being increased it starts to melt. Examples of the paraffin wax are mostly found in candles and also in the lubrication processes. Paraffin wax was formed in the year 1867. Paraffin wax when chilled is then precipitated. The various technical methods are being implied to separate the particles. The filtration of the product is being easily and is done economically. The purification of the wax is being done using various methods like the chemical treatment, decolourization process with the little addition of the soda, then fractional distillation , and the process of recrystallization. Synthetic waxes are also there and were being introduced after the world war 2^{nd}.These synthetic waxes were being produced by the process called as FISCHER-TROPSCH REACTION. By this process coal gas gets converted in to hydrocarbons..This synthetic wax is quite harder than paraffin wax and is colour is also much whiter, also has unique characteristics. These also have high purity and by this property it can be used as replacement of various waxes. These are further oxidized to form a little pale-yellow and are hard in nature. And then with aqueous solution

of the various organic or the inorganic materials they are being fed. It is also used for tanning agent for leather.

1.6.3 Applications of Paraffin wax:

I. Wax paper.
II. Polishes.
III. Cosmetics
IV. Extraction process.
V. Making perfumes from flowers.
VI. Base for medical ointments.
VII. Waterproofing coating.

1.6.4 Properties of Paraffin wax:

I. It is odourless.
II. It is white in colour.
III. It has no taste.
IV. It is basically a waxy solid.
V. Melting point is between 46°C-68°C.
VI. Its density is around 900kg.
VII. Insoluble in water.
VIII. Soluble in ether, benzene.
IX. It burns rapidly.
X. It is not being affected by chemical reactants.
XI. Heat of burning is around 42KJ/g.
XII. Acts as perfect electric type of insulator.
XIII. It has resistances values between the range of 10^3 and 10^{17} in terms of ohm meter.
XIV. It has particular heat capacity of about $2.14Jg^{-1}K^{-1}$
XV. Its heat of fusion is about $200\text{-}220Jg^{-1}$.
XVI. It is used in dry wall for house materials building.
XVII. It can be coupled with retractable radiators.
XVIII. It mainly gets expanded up when heat is given
XIX. By this expanding up it starts to melt.

XX. It is used in wax thermostatic elements which mainly involve use in industries .also in domestic process.

XXI. It can be used as anti-cracking agent.

XXII. It is also used as moisture repellent.

1.6.5 Manufacturing of wax:

It is mainly manufactured from the refining done on the slack wax which acts as a lubricating oil. Firstly the excess oil is being removed out from the slack wax and this is mainly done the process called as the CRYSTALLIZATION. The slack is being added with the desired amount of quantity like the KETONE. After this, it is being allowed to cool. Then after cooling ,it is then crystallized and then the residue left behind is then mixed with the slack wax .when this process gets completed, then filtration of the products takes place and is done by adding solid with some solvent and liquid oil and solvent. Then recovery process is carried out from the final production using the distillation process and the product is termed as "wax". When the percentage of oils from the wax is being reduced then the product is considered to be refined. Further more in order to remove the odour and the colour this product is then again processed. Lastly the mixing of the product is being carried out to achieve desirable properties regarding the melting and the boiling points.

1.6.6Advantages of paraffin wax in bitumen;

- By this the fuel and the energy gets saved.
- There is about 30% decrease in the pollutants like the carbon dioxide.
- The temperature used in the compaction as well as in the mixing of the binder of the asphalt or bitumen is reduction and is of the range of 20°C to 40°C.
- The compaction operation also gets enhanced by this.
- The time span used for the construction also is decreased.
- The bitumen can be easily distributed in the colder region.
- The ageing of the bitumen gets decreased also.
- The properties regarding to the rheological properties is also increased.
- It is a FISCHER-TROPSH and by the temperature gets decreased.
- The strength of the materials gets also increased against the imposed loading on the road surface.

1.7 Molasses:

Molasses is also called as BLACK TREACLE. It is generally a viscous kind of by-product of the refined sugarcane or the sugar beets. It is generally dark in colour, and is somewhat sweet in taste. It is also a syrup kind of by-product obtained during the extraction of the sugar from the sugarcane and also from the sugar beet..In molasses the colour gets varied also and also sweetness is also altered in this..These variations are dependent on the various forms of how the extraction of the sugar is taking place. Molasses is an organic waste material which is being extracted from the raw sugar when the refining process is completed. It has almost 50% sugar in it. Crystallization of more sucrose cannot take place due to the reason it has large amount of time as well as expense constraints in it. It also has about 25%of water in it as well.

1.7.1 Properties of molasses:

- The specific gravity of the molasses is about 1.01 g/ml@20°C.
- The melting point of the molasses is 0°C.
- Its boiling point is 100°C.
- The vapour pressure at about 20°C is 14.
- It is soluble in water.
- When it is heated and decomposed, it will emit acid fumes.
- It should be used with proper ventilation.
- It is stored in general storage area.

1.7.2 Manufacturing of molasses:

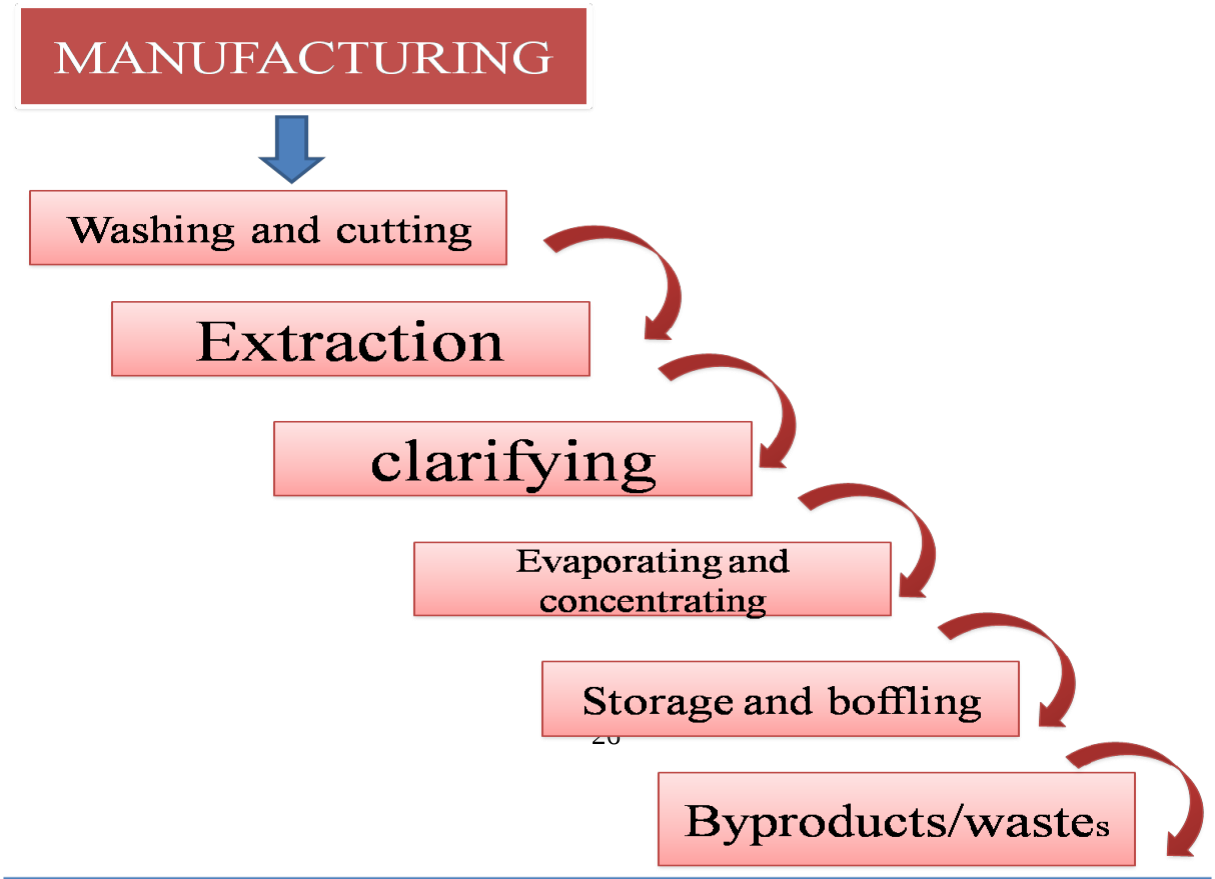

Figure 1.8 depicts the steps for the manufacturing of molasses.

In the manufacturing process mainly there is sugar extraction and then the refining process. It is done in a circular way firstly it is washed and then hot water is being applied on it. It is done in six basic steps which involve:

A. Washing and cutting:

- Firstly, the conveyor belts are being loaded with sugarcane stalks.
- Then hot water sprays are used over them in order to get rid of the dirt and debris.
- Then the stalks are being cut into small pieces or shreds by a rotating blades.
- Then they are passed into tunnel kind of machine which is generally called as fumes.
- In these fumes, the leaves and weeds are being separated.
- Then to remove any further dirt, they are being pushed into a pump.
- Then the beet gets cut into smaller pieces with a help of a slicer.

B. Extracting the juice:

Extraction is mainly achieved in two ways," diffusion" and "milling"

- In diffusion the stalks that are being cut get dissolved in hot water.
- In milling, rollers are used and these stalks are being used to pass under these rollers.
- By milling the juice comes squeezing out of the pulp.
- Then water is sprayed when the process is going on so that the juice is completely dissolved.

C. Clarifying the juice:

After the juice has been extracted out it needs to be clarified out. It is done by:

- By adding milk of the lime and of carbon dioxide, it is being clarified.
- The juice gets piped put and then it is well heated and gets mixed with lime.
- The juice gets passed over various carbon filters.
- By this a mud like structure gets generated called as "carb juice".
- This carb juice gets pumped through heater sand then it is send to clarifying machine.
- The mud gets settled down at the bottom and the clear juice gets piped to another sort of heater and heated with carbon dioxide.
- Then filtering of the mud is done to get a yellow liquid called as thin juice.

D. Evaporating and concentrating the syrup:

- The thin juice that is being obtained is pumped into an e3vaporator

- This evaporator boils the juice till the water gets dissipated and only the water is remaining over there.

- Then the sugar starts to crystallize out of the syrup, getting a new substance called as massecuite.
- Then it is separated into a centrifuge, and the sugar crystals fall apart from the syrup.

E. Storage and baffling:

- For the storage purpose large storage tam used.
- Then in the bottling machine it is being pumped along a conveyor belt to the bottling machine where the pre-measured traces of molasses.

F. By-products:

- As molasses is itself a waste generated in the processing of sugarcane.
- After the processing of the juice is processed , the dry stalk waste often known as biogases, it is being used as fuel in plant.
- Beet pulp is used when the processing of the pet foods is there.
- From the dry residue, it is used in the manufacturing process of various cosmetics, polish and the various paper coatings.

1.7.3 Types of molasses:

The following figure depicts the types of the various molasses and these are categorized as:

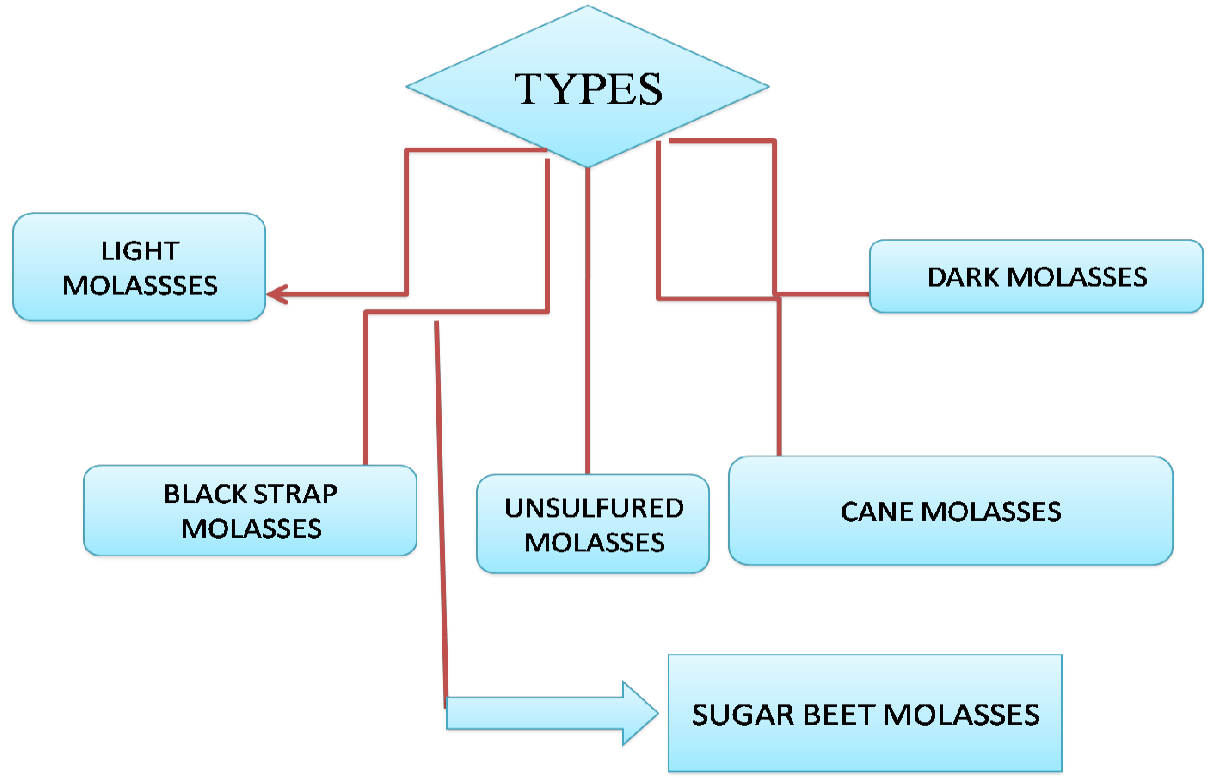

Figure 1.9 shows the various types of molasses.

A. Light molasses:

- It is very light in colour.
- It is having high sugar content i n it.
- In the texture type of view it is highly viscous.

B. Dark molasses:

- Here the molasses is much dark in colour.
- It consists of less sugar.

C. Black-strap molasses:

- It contains of molasses consists the lowest amount of sugar.
- It contains concentration of the various vitamins and minerals.
- Its colour is very dark.
- The texture of this is very viscous.
- It has a spicy flavor as well.

D. Sulphured and unsulfured molasses:

- Sulphured: It is defined as that kind of molasses that gets treated with sulphur dioxide as a form of preservative.

- Unsulfured: they have lighter and much more cleaner flavour of sugar.

E. Cane molasses:

- It is mainly used for baking purposes.
- It is also for cooking purposes.

F. Sugar beet molasses:

- It is different from the sugarcane molasses because in this only the syrup that is being left from the crystallization process is called as molasses.

CHAPTER 2

REVIEW OF LITERATURE

1. Oscar J.Reyes-Oritiz, Luis G. Fuentes, Allex E. Alvarez:

This research that they did is based on the mechanical responses of asphalt mixtures modified with bitumen. In this the Colombian asphalts were being modified with natural waxes. By this modification, the mechanical properties as well as the dynamic properties were being analyzed. Firstly in this, the categorization of the materials was being done. In categorization it is being seen whether the material is granular aggregate or fine aggregate. Then the content of the determination of the wax is being done, and right quantity of the asphalt was being added to the mixture. Then preparation of warm mix asphalt was being made and then these are being compacted at the various level of temperature like 110°C,130°C and 150°C in order to analyze the mechanical and dynamic properties. In this resilient moduli(RM), the indirect strength(ITS),,strength. Tests were done to find the asphalt properties. By this the natural waxes being added will help to decrease the viscosity and also the energy consumption gets decreased.

The conclusion of this study was that the waxes named Soy and Carnauba waxes which are used in order to modify the penetration grade of 60/70, the compaction and production temperatures get decreased up to 20°C and 40°C.Also these waxes were also used to decrease greenhouse effect gases, thus the fuel in the process of production is also saved.

2. Baha Vural Kok and Mustafa Akpolat :

This research is being made on effect of using (sasobit) SBS on the engineering properties of bitumen. The rheological properties as well as the mechanical properties were being analyzed by the sasobit modified bitumen. These were done by various rheological bitumen tests which involved dynamic shear rheometer(DSR), bending beam rheometer (BBR).For performance tests like dynamic creep fatigue, toughness index test. The sasobit enhances the effectiveness

especially at medium as well as in high temperature. The sasobit was being used in the case where there are two modifiers are being mixed with two binders, especially in terms of fatigue performance.

The conclusion of this study was that the SBS modification was being proved to be more

effective than sasobit modification done on the bitumen surfaces and in this the additives were being used alone. In this the better performance was being achieved when the quantity of 3%SBS and 3% sasobit was being made. When these both were adde3d to the same binder then the replacement of 3-4%Sasobit was made to 1%of SBS depending on the ratio between SBS/Sasobit. Also here by the SBS modification, the stiffness did not increase as much as compared to Sasobit modification generally at lower temperatures.

3. Ylva Edwards et.al:

This research is based on the influence of waxes on bitumen and asphalt concrete mixture performance. In this experiments were being conducted and these studies consists of almost 160/220 penetration grades bitumen, also two isolated waxes of bitumen plus, five commercial waxes were used. Additional to that one polyphosphoric acid, Asphalt concrete slabs, in which there is base or modified bitumen. These were being prepared and then testing was being done over them. For the determination of the properties of the binder various tests was being done like dynamic shear rheometer(DSR), bending beam rheometer(BBR), differential scanning calorimeter(DSC).By these tests various properties like penetration, viscosity properties, softening point properties were being calculated. At 40°C Dynamic creep test was also being done.

The conclusion was that binder test results showed that magnitude and the kind of effect of that bitumen rheology does depends on the bitumen itself, also on the type of crystallizing fraction in the bitumen. The amount of additive used also play a vital role. When polyphosphoric acid was being added to a 160/220 type of penetration grade of bitumen, the result was that there will be decrease in the stiffness property at low temperature and at high temperature there is an increase in the complex modulus. Also the most decisive factor of the effect of wax on bitumen depends on the range of temperature and also on wax chosen for bitumen. By the wax the viscosity gets reduced because the melting of the crystallized wax. In BBR test the property regarding the hardening was being checked at-25°C and it was seen that there is an increase in the hardening index consisting natural wax as compared to the non waxy bitumen. By this research also the using the addition of the commercial waxes it showed positive effects on the ageing properties of the bitumen.

4. K.Shyam Prakash, M.Phanindra, S.Ram Surya ,J. Naresh:

From the department of civil engineering,PVP Sidharta Institute of Technology, Kanuru Vijayawada and Department of civil engineering MVR college of Engineering have done research on the Percentage replacement of bitumen with sugar waste molasses. The

introduction of sugar cane molasses was done on bitumen in order to get sustainable and eco friendly environment. The various type of tests were being conducted like the Aggregate Crushing value, Aggregate Impact value test, Specific gravity, water absorption tests, Los angles test, Abrasion test, Flakiness index and Elongation Index of coarse aggregates. Also the test on bitumen were also done like Penetration value, Ductility, Softening point, Viscosity test, specific gravity and flash and fire point. The replacement was being done upto 15% and then the graph was also being plotted by the tests being conducted. Here till 13% the stability goes on increasing and then it gets somewhat decreased.

The conclusion of the study, the marshal stability got increased up to 13% and then it gets decreased. The flow characteristics also got decreased with the addition of the molasses. Here the optimum binder content is 4.7%. By this the road safety, strength, workability, were increased by the addition of molasses. From the viewpoint of saving the addition of molasses when was being done here the amount of carbon dioxide got decreased .Also the void ratio was also decreased by the addition.

5. Metin Guru, M.Kursat Cubuk, Deniz Arslan, Sina Aminbakhsh:

This research was being done on Effect of sugar Beet Molasses and Molasses-Based Boron oxide compound on bitumen properties. In this ,the base bitumen were being modified by sugar beet molasses and molasses based boron oxide compound(MBOC).In this 50/70 penetration grade bitumen was being used the each material was being added between 1% and 10% by weight. In this also various types of properties were being examined which included the rotational viscosity, penetration property, softening point, ductility tests, marshal stability test dynamic shear rheometer(DSR), Nicholson stripping tests. By this test, the performance of the bituminous mixes was being improved by MBOC and by sugar beet molasses it remained same.

The conclusion from this research was that the viscosity and the softening point were reduced but the penetration value was increased up to 5%,when again the concentration of MBOC was further increased then there was increase in the viscosity and softening points, but the penetration of the base of the bitumen was also decreased. When the bitumen was modified with molasses the ductility was increased, but when MBOC was used the ductility property was being decreased. In this when the molasses was being added there was no increase in the stability. When the concentrations of MBOC were made higher, then the

marshal stability and the stripping values were improved.

6. Suleman Arafat Yero and Mohd. Rosli Halnin:

They did research on the effects of the viscosity characteristics related to the bitumen/asphalt. They did modification of the bitumen with the help of sasobit wax on the penetration grade of bitumen of 60/70.They noticed that the viscosity of the bitumen affects its workability and also the shape of the bitumen mix. In this warm mix technologies were being used. The binder mixtures were used with varying quantities of the wax 1%, 2%, 3%, 4%, and also 5%.It was seen that the adhesiveness of the binder keeps on getting reduced at greater temperature. They give meaningful data on the increase in the viscosity at low temperature and also reducing the kinematic viscosity at higher temperatures at the presence of the wax. They have greater hydrocarbons in the binder and these modify the properties of the binders.

From this research the conclusion was drawn that as in the bitumen the addition of the bitumen was being made, it is used for lowering the compaction temperature. Also the viscosity of the binder gives effective coating of binder should be done property. At lower temperature good workability is achieved regarding to mix asphalt when the 3% addition of the wax content is done.

7. Marek Iwanski, Anna Chomicz-Kowalska, Justyna Mrugala:

The research was based to check the applications of the wax in order to modify the foamed bitumen parameters. As the reduction of the asphalt production temperature is there son they did the modification. In this study they used foamed bitumen in hot mix asphalt. By doing this the temperature of the bitumen got reduced to 30°C-40°C.For improvement purposes they used FT-wax and the percentage was about 0.5%..The tests were being performed on 35/50 and 50/70 grade of bitumen and also the percentage was made about 0.5% to 2.5%.

The conclusion that was made was that by this modification there was lot of differences in the value of the basic characteristics of the bitumen. The binder got hardened by this and also there was a decrease in the susceptibility of the binder and was being deformed. By the increase content of wax there was an improvement in the foaming power of the bitumen.

8. Hassan Fazelli, Hamid Behbahani, Amir Ali Amini, Jafar Rahmani, and Golazin Yadollahi:

They did research on different temperature properties of the bitumen by FT-Paraffin wax. To conduct this research they used various binder of the type PG 58-22 as being as base and then they modified with 1%,2%,3%,4%,5% of Sasobit. The modified binder was checked both at lower and higher degree by a test called as super pave test (SHRP).

The conclusion that was being drawn from this was that after the addition of the FT- paraffin wax its performance was being improved. Also the resistance of the material was also increased against the shape. Also it was seen that viscosity of the bitumen was increased and the compaction temperatures of bitumen was also decreased.

9. Igwe, E.A et.al:

The research was on what effects will be when candle wax on the physical properties of the bitumen having grade 80/100.In this, the quality of binder was improved with the help of various methods. The performance of the bitumen was also increased by adding these various percentages of the wax in the bitumen. Also by using candle wax which is anon-bituminous modifier the modification in the physical properties was being done.

The conclusion which was drawn from this included that the use of the wax in bitumen will modify the physical properties of the bitumen. The wax content was between the range 18.88%- 0.54%. In this the modified bitumen was having better properties than the unmodified ones. The addition of FT-paraffin wax up to 4.1% and thus by further increasing, the ductility of the bitumen.

10. P.K Das and B.Birgisson:

They did research on the low temperature of the cracking performance of the wax being added to bitumen. In this they said that the road construction scenario is the main contributor for the emission of the greenhouse gases, which cause the changes of the climate. For this the warm technologies are being used in which they have used about 4% of the commercial wax. Also the various tests were also being conducted

The conclusion that was being obtained by this was that the stiffening property of the bitumen being modified was being obtained with the help of various tests like the penetration tests, softeni8ng tests, and forced ductility tested. When the addition of about

4% of wax was done the penetration property was decreased, and the softening point was also increased in this. For the viscosity a test was being done called as Brookfield viscosity test at about v135°Cand also 165°C. If the stiffening property becomes less than the viscosity will be high.

2.1 SCOPE OF THE STUDY:

- Due to increased road traffic and road developments, the roads are having higher problems of rutting, thermal cracking, stripping of the pavement.
- These problems arise due to increased heavy axle wheel loads. Therefore there is a need to tremendously modify the bitumen with certain types of additives and modifiers so that the performance of the road is not altered.
- Also by modifying the bitumen, it saves the maintenance cost in the long and the medium run. By this the financial problem will not arise.
- The purpose of this study is also to decrease the value of the various distresses caused by the pavement and to balance these and improve the damages.

2.2 OBJECTIVES OF THE STUDY:

- To study the properties of the bitumen when added with small quantities of candle wax and sugar molasses.
- To analyze the effect on the softening properties of the bitumen.
- To investigate on the strength parameters of the bitumen with the addition of the modifiers
- To study about whether the bituminous mix is sustainable or not.
- To study about the economic and financial aspects that is being generated by the bitumen and the various mixes.
- To evaluate about the effects on the environment.

CHAPTER 3

MATERIALS AND RESEARCH METHODOLOGY

3.1 Materials:

In this study the grade of bitumen being used is VG 30. For the modifying purpose the materials being used are candle wax and sugar molasses, by varying or altering their percentages in the bitumen. By these materials various tests and methods are being applied to obtain the desired results.

3.2 Methodology:

In this various tests were being conducted which included:

3.2.1 Penetration test:

A. Apparatus used:

- **Needle:** It consists of a steel needle as per ISI specification needed for test.
- **Water bath:** The capacity of this is not less than 10litres.
- **Penetrometer:** It is the main apparatus of the test and is having a gauge in there that measures the readings in unit of one tenth of a millimeter.

B. Theory: This test is done in order to find out the in order to predict the hardness as well as softness of the bitumen. In this the depth is being measured in tenths or (0.01) mm. In this a standard0 needle is being used and is allowed to penetrate vertically in about 5seconds.This is done by using penetrometer and it consists of needle assembly and in this the weight of 100g.In this the consistency is being demined in this process.

C. IS: Code: For penetration test of the bitumen the IS code which is being used is IS1203-1978.

Figure 3.10 showing penetration machine

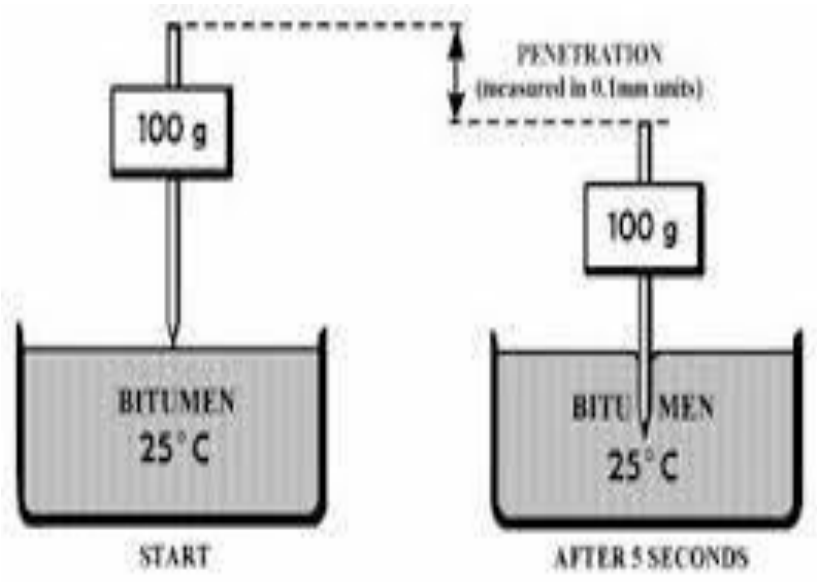

Figure 3.11 showing the needle being penetrated

D. Procedure:

- Firstly, the bitumen is being heated up to 75℃ to 100℃.
- Then the bitumen gets poured into a container and then in a temperature control water bath at a temperature of about 25℃ for about an hour.
- Then after pouring the bitumen is then taken out and the needle is arranged in order to make contact with upper surface of the sample.
- Then the dial is is arranged to zero.
- After adjusting the needle is released for about 15 seconds.
- Then the last reading is taken with the help of dial gauge.
- Normally three readings are taken out and then the average of these is taken in order to find the penetration of the bitumen.

In this, mainly the penetration value of the bitumen les between 20-225.If the bitumen is having 80/100 grade it shows the range of penetration of bitumen is 80-100. Lesser the penetration value, the harder is the bitumen.

3.2.2 Ductility test:

A. Theory: The ductility test gives the measure regarding the tensile properties of the bitumen. The tensile property means the ability of the bitumen to deform under the loading. When\ the ductility value is not good, and then crack is likely to occur. Ductility is measured in distance in about centimeters to which standard briquette can stretch before it starts to break.

B. Apparatus required:

Ductility machine, Briquette mould in which the distance of clips should be 30 mm, width of mould clip should be20 mm, thickness 10mm.

C. IS: Code: The code used foe the docility test used is IS: 1208-1978.

D. Procedure:

Firstly the bitumen is heated up.

- After heating the bitumen is poured in to a mould kind of assembly.
- Then the bitumen is being cooled in air in a water bath at 27℃.
- Then the sides of the mould are being removed, the clips are hooked and the pointer is then set to zero.
- Then the two clips are pulled apart @50 mm per min.

- Then the ductility value is calculated.
- The ductility value is the distance up till the time where thread tends to break.

Paving bitumen	**Minimum ductility values**
Assam petroleum A25	5
A 35	10
A 45	12
A65, A90, A100	15
Bitumen from sources other than Assam Petroleum S35	50
S45, S60, S90	75

Table 1 shows recommended values for ductility test.

3.2.3 Softening point test:

A. Theory: Softening point is defined as the temperature at which a particular degree of softness is being attained under given set of conditions. In this higher is the softening point, low is the temperature susceptibility. Mainly the softening point of the bitumen is 25°C till 75°C.

B. Apparatus: Ring and ball apparatus ,metallic support, water bath, heating device.

C. Code: The IScode used foe the softening point test is IS:1205-1978.

D. Procedure:

- In the brass ring the bitumen sample is suspended in the liquid.
- Then the liquid temperature is heated at the rate of 5°C per min.
- Then the temperature is noted where the softened bitumen touches the metal which is being placed just below the ring
- This temperature will be called as softening point of the bitumen

3.2.4 Viscosity test:

A. Theory: Viscosity is defined as the inverse of fluidity. It is defined as the

measurement of flow. This property allows the bitumen to spread, penetrate into the voids and also for coating purpose. For this orifice meter is used to find the viscosity of binders like the bitumen. Also various viscometers are used for the measurement of viscosity purpose. Viscosity has basically four grades VG 10, VG 20, VG 30, and VG 40.

B. IS: code: For this viscosity test the Code used is IS: 1206-1978.

C. Apparatus: Stopwatch, Tall graduated kind of cylinder, steel balls,

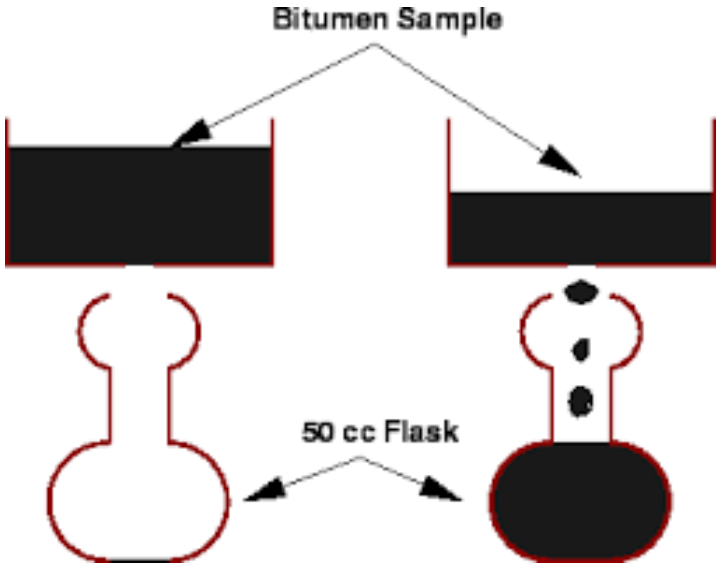

Figure 3.12 showing the viscosity test.

D. Procedure:

- In this the tar cup is properly leveled.
- Then after leveling bitumen is heated in a water bath up to the testing temperature.
- Then again material is heated up to 29°C after the testing temperature is attained.
- Then cooling is allowed and stirring is being made.
- When the temperature reaches up to 40°C, it is poured into the viscometer and leveling peg is inserted.
- Then a receiving plate is placed under the orifice.
- Bitumen starts to come done and time is noted by using a stopwatch.

3.2.5 Specific gravity test:

A. Theory: This test deals with finding out the specific gravity of the bitumen. The specific gravity is defined as the measurement taking water as reference. It is also known as the ratio of the density of the substance to an equivalent amount of water .the specific gravity is being measured by a devise known as PYCNOMETER.

B. IS Code: The code used for this test is IS: 1202-1978.

Figure 3.13 depicts a pycnomoter

C. Procedure:

- Take an empty specific gravity bottle and note down its weight. And name it was W1,
- Take bitumen and put it in the bitumen and take their weight, name it as W2.
- Then take the weight of the bottle filled with water and name it as W1.
- Then take the weight of the bottle filled with water and bitumen and name it as W4.

The specific gravity of pure bitumen is the range of 0.97-1.02. Depending upon proportion of the cutback bitumen they have lower value of specific gravity.

3.2.6 Loss on heating test:

A. Theory: In this when the bitumen is heated up, the volatility is there and is called as loss of heating. In this the bitumen gets hardened up.

B. Apparatus: Oven, Aluminum, Rotating shelf, Thermometer, containers, Balance.

C. IS: Code: The code used for the loss on heating test is IS: 1212-1978.

D. Procedure:

- After this it is heated to temperature of about 163°C for the time period of 3hours.
- After heated it is then again heated and then the loss of the heat is being determined.
- The loss of the defined is defined as the percentage by weight of the original sample.
- It is seen that the bitumen used in the pavement work should not exceed 1%loss in weight.
- For the penetration values of 150-200 almost 2%weight is being allowed.

3.2.7Aggregate crushing value test:

A. Theory: The aggregate crushing value gives a relative measure of the resistance of an aggregate crushing under gradually applied compressive load. With aggregate crushing value 30 or higher' the result may be anomalous and in such cases the ten percent fines value should be determined instead.

B. Apparatus:

- A steel cylinder 15 cm diameter with plunger and base plate.
- A straight metal tamping rod 16mm diameter and 45 to 60cm long rounded at one end.
- A balance of capacity 3 kg readable and accurate to one gram.
- IS sieves of sizes 12.5mm, 10mm and 2.36mm
- A compression testing machine.
- Cylindrical metal measure of sufficient rigidity to retain its from under rough usage and of 11.5cm diameter and 18cm height.

C. Sample preparation:

- Coarse aggregate passing 12.5mm IS sieve and retained on a10mm. IS sieve and heated at 100 to 110°C for 4 hours and cooled to room temperature.
- The quantity of aggregate shall be such that the depth of material in the cylinder, after tamping shall be 10 cm. The appropriate quantity may be found conveniently by filling the cylinder. Measure it in three layers of approximately equal depth, each layer being tamped 25 times with the tamping rod and finally leveled off using the tamping rod as straight edge, care being taken in the case of weaker materials not to break the particles.
- The weight of the material comprising the test sample shall be determined (weight A) and the same weight of sample shall be taken for the repeat test.

D. Procedure:

- Put the cylinder in position on the base plate and weigh it (W). Put the sample in 3

layers ,each layer being subjected to 25 strokes using the tamping rod ,care being taken in the case of weak materials not to break the particles and weigh it (W1)

- Level the surface of aggregate carefully and insert the plunger so that it rests horizontally on the surface, care being taken to ensure that the plunger does not jam in the cylinder.
- Place the cylinder with plunger on the loading platform of the compression testing machine.
- Apply load at a uniform rate so that a total load of 40T is applied in 10 minutes.
- Release the load and remove the material from the cylinder.
- Sieve the material with 2.36mm IS sieve, care being taken to avoid loss of fines
- Weigh the fraction passing through the IS sieve (W2).

E. Calculations:

The ratio of weight of fines formed to the weight of total sample in each test shall be expressed as a percentage, the result being recorded to the first decimal place.

Aggregate crushing value = (W2x100) / (W1-W).

- W2 =Weight of fraction passing through the appropriate sieve
- W1-W =Weight of surface dry sample.
- The mean of two results to nearest whole number is the aggregate crushing value.

3.2.6 Aggregate impact value test:

A, Theory:

- AIV is the percentage of fines produced from the aggregate sample after subjecting it to a standard amount of impact. The standard amount of impact is produced by a known weight, i.e. a steel cylinder, falling at a set height, a prescribed number of times, onto an amount of aggregate of standard size and weight retained in a mould. Aggregate Impact Values, (AIV's), below 10 are regarded as strong,
- Aggregate Impact Values and Aggregate Crushing Values are often numerically very similar, and indicate similar aggregate strength properties.

B. Sample Preparation:

- The test sample shall consist of aggregates the whole of which passes through ½ in B.S. test sieve and is retained on a 3/8 in B.S. test sieve.
- The aggregate comprising the test sample shall be dried in an oven for a period of

four hours at a temperature of 100-110 °C and cooled.

- The measuring cup shall be filled about one-third with the aggregate and gives 25 no. of blows with tamping rod.
- A further similar quantity of aggregate shall be added and a further 25 tamping given to the second and tot the last layer 25 tamping shall again be given and the surplus aggregate struck off using the tamping rod as a straight-edge.

- The net weight of aggregate in the measure shall be determined to the nearest gram (weight A) and this weight shall be used for the duplicate test on the same material.

C. Apparatus: Impact testing machine, Balance.

D. Procedure:

- The cup is fixed firmly in position on the base of the machine and the sample is placed on it and compacted by a single tamping of 25 strokes of the tamping rod.
- The hammer shall be raised until its lower face is 15 in. above from the upper surface of the aggregate in the cup, and allowed to fall freely on the aggregate.Type equation here.
- The test sample shall be subjected to a total 15 such blows each being delivered at an interval of not less than one second.
- The crushed aggregate shall then be removed from the cup and the whole of it sieved on No. 7 B.S. sieve until no further significant amount passes in one minute.
- The fraction passing the sieve will be weighted to an accuracy of 0.1 gram (weight B).The fraction retained on the sieve shall also be weighed (weight C), and if the total weight B + C is less than the initial weight (weight A) by more than 1 gm the result shall be discarded and a fresh test made. Two tests will be made.

3.2.7 Marshall stability test:

A. Theory: Marshall Stability can be defined as maximum amount of load which is being carried by the specimen at a standard temperature taken as 60°C.In this kind of method when the specimen gets loaded diametrically having the deformation rate of 50 mm per minute, the resistance to the plastic deformation of the compacted cylinder is being measured. In this mainly:

- Density-void tests or analysis.
- Stability-flow tests or analysis.

B, Apparatus:

Mould assembly having diameter as 10 cm and height being 7.5 cm, Simple extractor,

compaction pedestal and a hammer, Breaking head, Loading machine, Flow meter, water bath, thermometer.

C. Procedure:

- Firstly, three compacted samples are being made for each binder content.
- Then selection of appropriate grading is being done.
- Then determination of each proportion sixe is being taken.
- Specific gravity of the aggregate being taken is being calculated.
- Then the various stability tests are being performed
- Calculations are being done like the percentage of voids filled with bitumen in bitumen.
- Then the optimum binder content is being taken out.

D. Preparation of sample:

- Firstly the various aggregates like the course, fine aggregates and the filler materials properly proportioned in accordance with the standard.
- Then the required amount of mix is taken in order to have a compacted specimen having thickness 63.5mm, 1200 gram of aggregates, and filler material so as to produce the desired amount of thickness,
- The aggregates are heated at the temperature of 175℃ to 190°C.
- The bitumen is being heated to a temperature of 121℃ to 138℃ and then first trail of the bitumen is being added to aggregate and then these are mixed thoroughly.
- Then the mix is being placed in mould and then compaction is being done.
- Then after few minutes the mould is being extracted using a simple extractor.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Aggregate crushing value test:

	Sample1	**Sample2**
Total weight of dry sample (W_1) in gm	3000	3000
Weight of sample passing 2.36 mm sieve (W_2) in gm	730	717
Aggregate crushing value in %age=(W_2/W_1)*100	24.33	23.9

Table 2 showing aggregate crushing values

Now by calculating the Mean aggregate impact value is 24.115% and it is less than 40%.The crushing value for cement concrete road should not exceed 30% and for wearing course it should not exceed 40%.

4.2 Aggregate impact value test results:

	Sample 1	**Sample 2**
Total weight of dry sample (W_1) in gm	500	500
Weight of sample passing 2.36 mm sieve (W_2) in gm	85	93
Aggregate crushing value in %age=(W_2/W_1)*100	17	18.6

Table 3 showing aggregate impact values.

The mean crushing value for aggregates is 17.8%.

4.3 Penetration test values:

S.NO	Initial reading	Final reading	Penetration value(P)
1	90	166	70
2	93	160	63
3	92	155	60

Table 4 showing penetration values of bitumen

Mean penetration value= $(P_1+P_2+P_3)/3$

$P= (70+63+60)/3$

P=64 or 6.4mm.

- Penetration value when various varying quantities of wax were being added:

Percentage of wax	0% wax content	1% wax content	2.5% wax content	3% wax content	4.5% wax content
Penetration (P)	64	59	52	49	46

Table 5 showing penetration values of bitumen with varying wax content.

In this it is being seen that when percentage of wax are being increased in bitumen, the penetration value goes on decreasing.

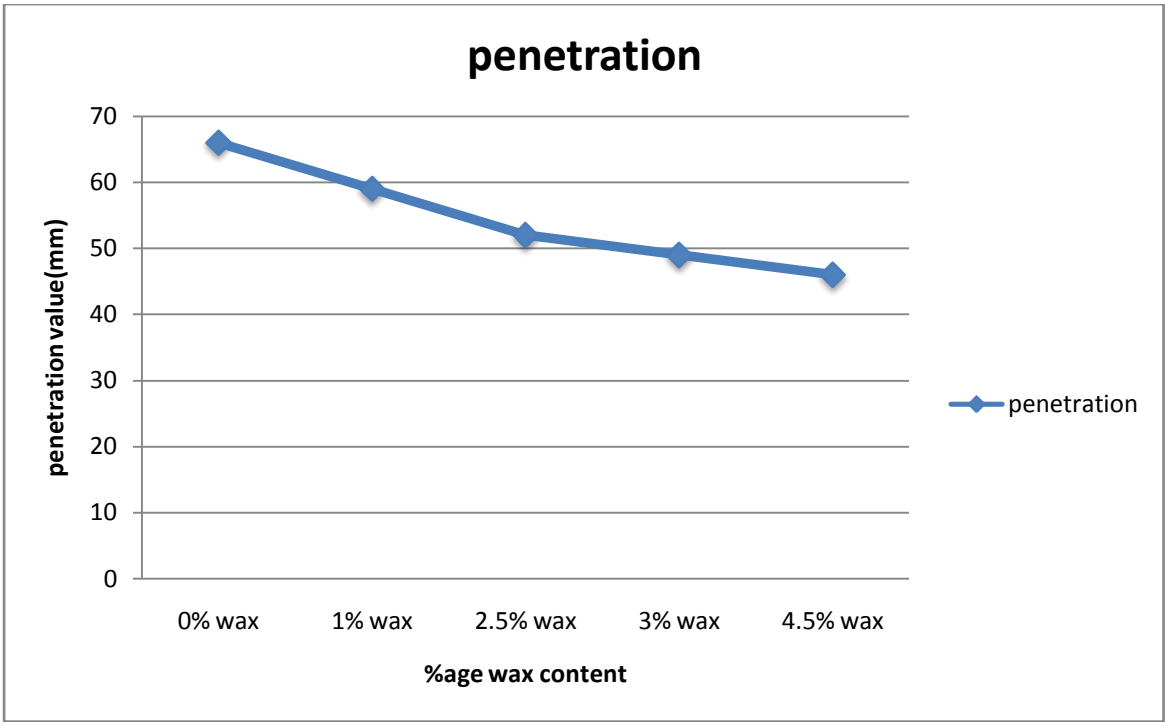

Figure 4.14 showing graphic representation of varying penetration values of wax content.

- Penetration values when both bitumen and wax were being added to the base bitumen:

,

Wax content (%)	Molasses (%)	Penetration(P)
0% wax	2% molasses	88
2% wax	4% molasses	85
4% wax	6% molasses	82
6% molasses	8%molasses	80
8% wax	10 % molasses	78

Table 6 shows penetration values of wax and molasses content

This shows that when the percentages of molasses are being increased, the corresponding penetration values are decreased.

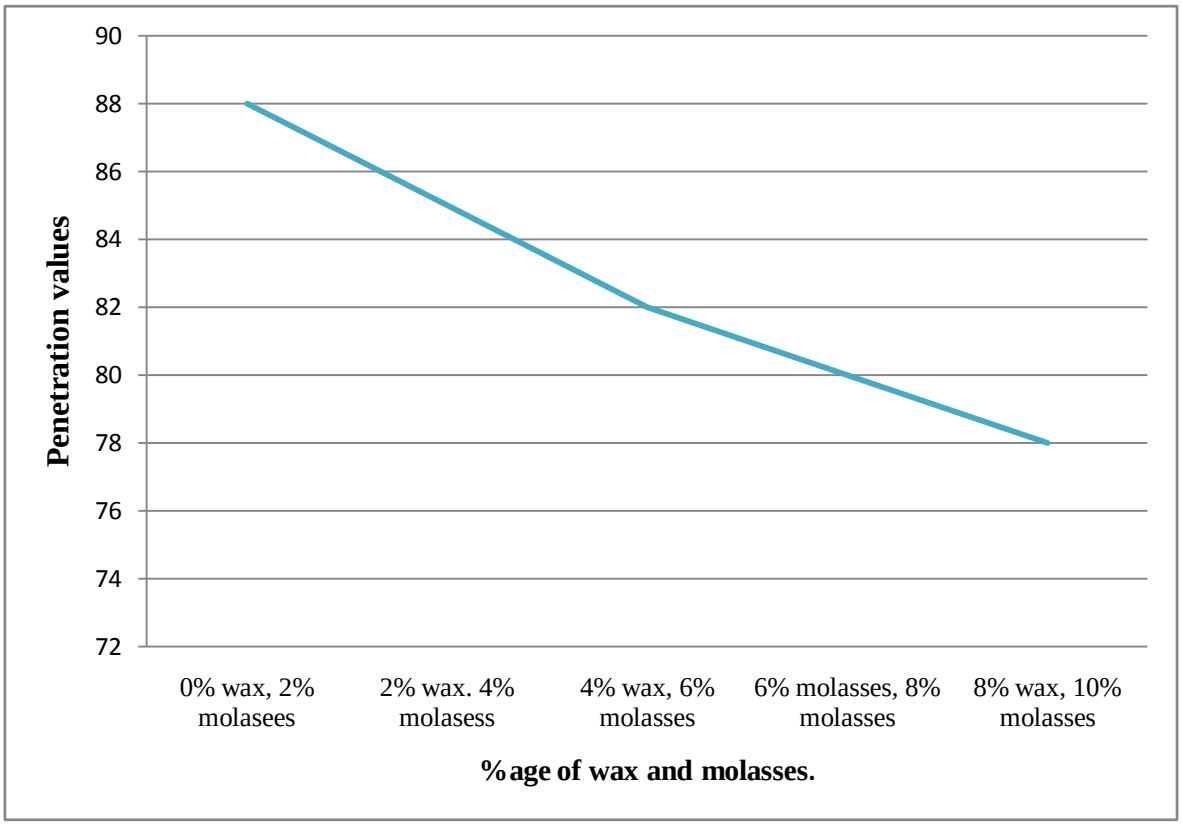

Figure 4.15 depicts addition of wax and molasses to bitumen.

4.4 Ductility test results:

Percentage of wax	0%wax	1%wax	2%wax	3%wax	4%wax
Ductility	74	72	69	64	60

Table 7 showing ductility values by varying percentages of wax.

This table depicts that when the percentage of wax is increased the ductility value gets decreased.

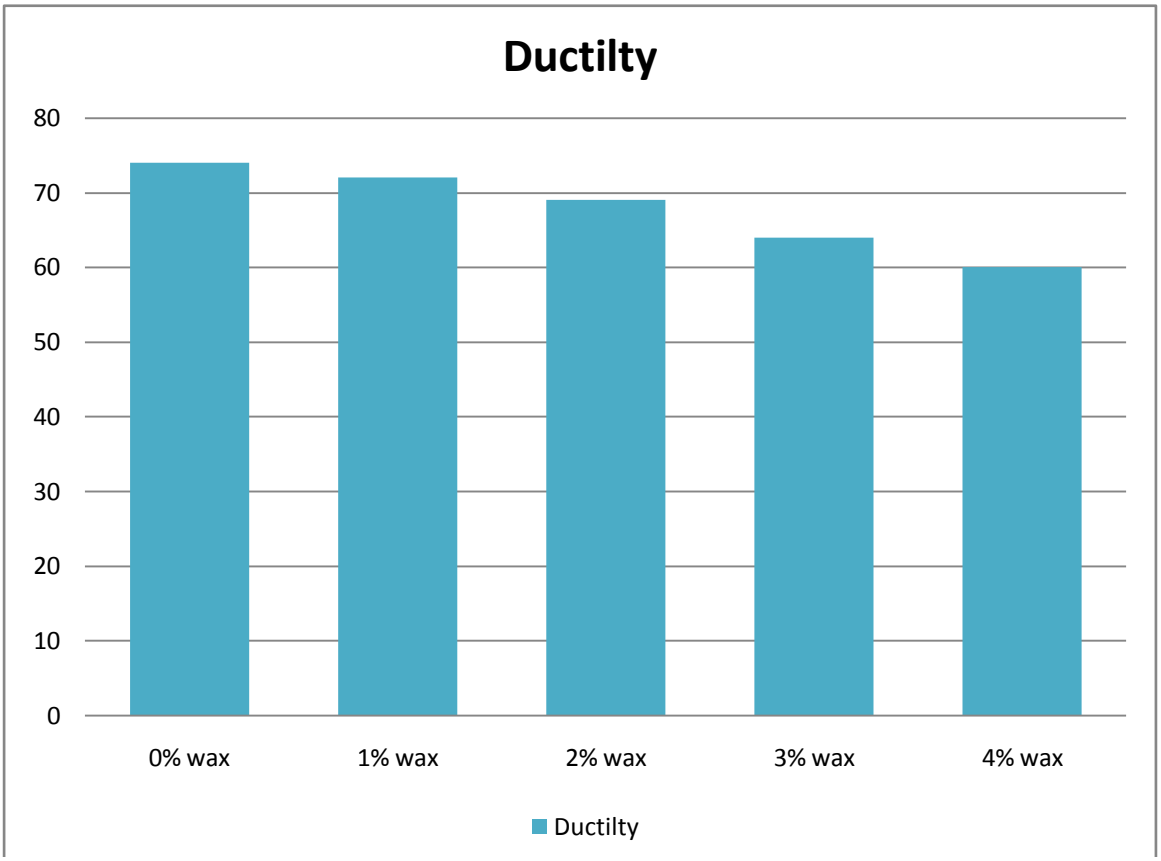

Figure 4.16 showing graphic representation of ductility values with the addition of wax.

4.5 Softening point test results:

- Penetration results when wax was being added to bitumen in varying percentages.

Percentage of wax	**1%wax**	**2%wax**	**3%wax**	**4%wax**	**5%wax**
Softening point	48	50	53	58	61

Table 8 showing softening point values of bitumen by addition of wax.

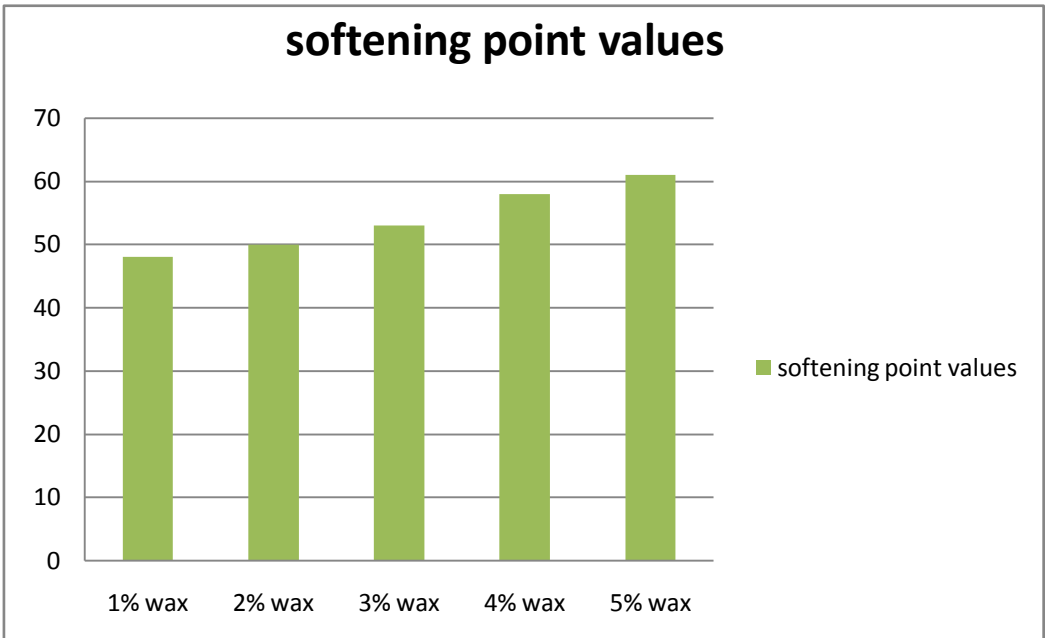

Figure 4.17 shows graphic representation of softening point values various percentages of bitumen by addition of wax.

- Softening point values when molasses is being added:

%age of molasses being added	Softening point values(°C)
0% molasses	46
2% molasses	43
4% molasses	39
6% molasses	40
8% molasses	44
10% molasses	47
12% molasses	50

Table 9 showing various softening point values when molasses are being added.

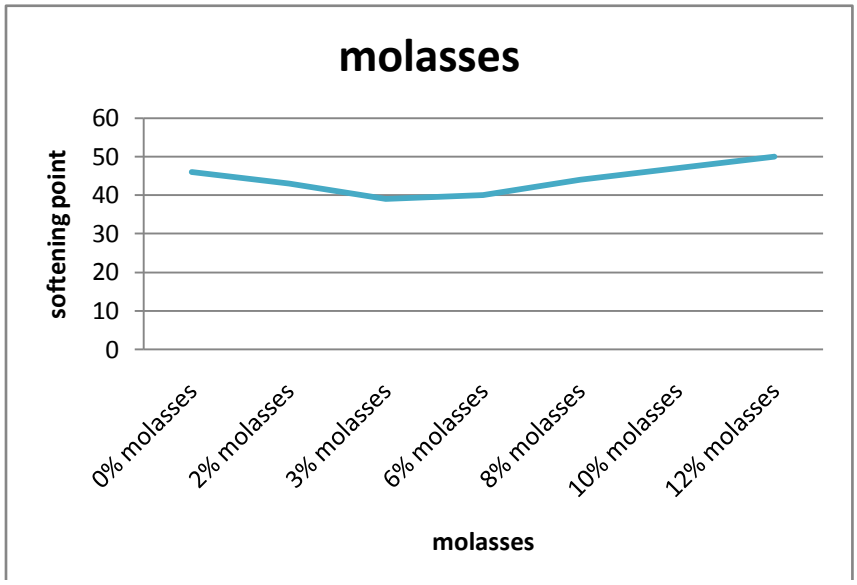

Figure 4.18 showing varying softening point values with different varying percentages of molasses.

- Softening point values when both molasses and wax are being added:

%age of Molasses	**%age of wax**	**Softening point values(°C)**
1%	1.5%	53
2%	2.5%	52
3%	3.5%	51
4%	4.5%	53
5%	5.5%	57
6%	6.5%	59
7%	7.5%	61
8%	8.5%	63
9%	9.5%	67
10%	10.5%	69

Table 10 showing softening point values with varying percentages of wax and molasses.

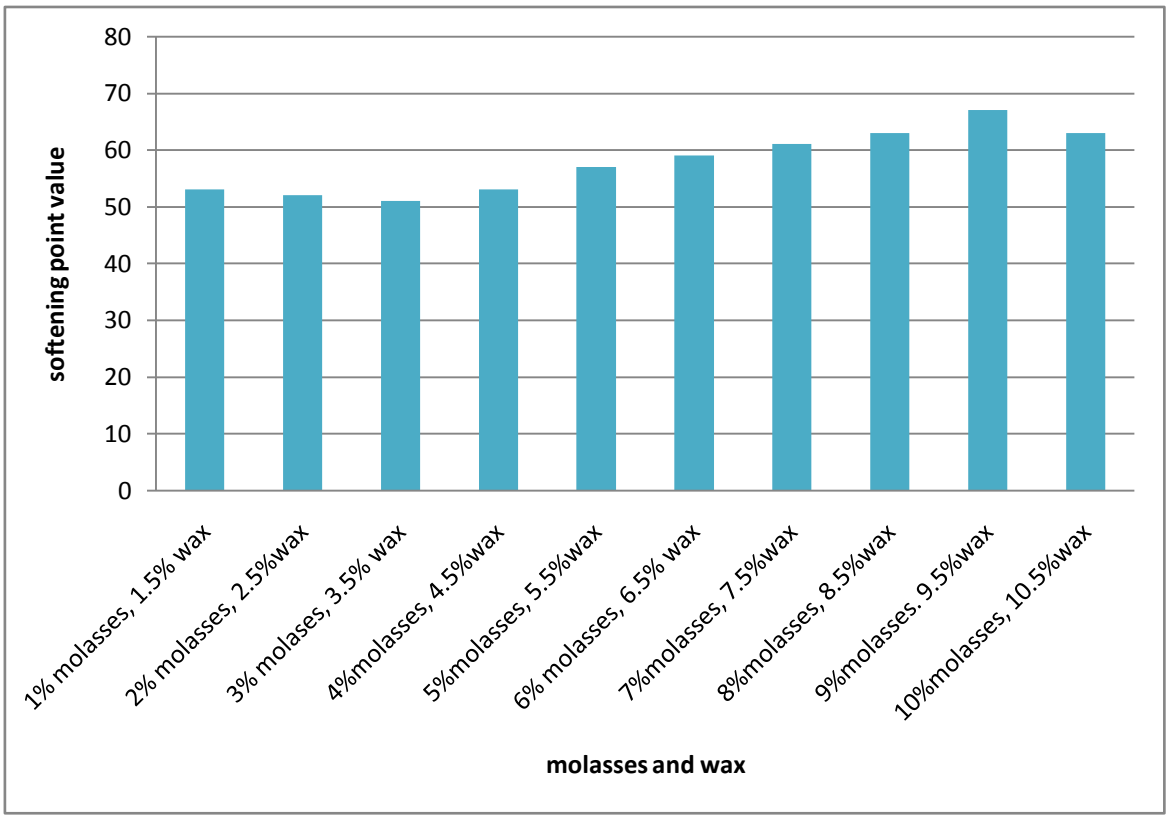

Figure 4.19 showing softening point values by varying percentages of molasses and wax.

4.6 Marshal stability test:

Results of BM Mix using VG-30 Grade Unmodified bitumen

S. No.	Bitumen Content	Marshall Stability Value	Flow Value	Bulk Density of the mix	Air Voids	VMA	VFB
		S	F	G_m	V_V		
	%	kN	mm	gm/cc	%	%	%
1.	4.5	9.53	4.05	2.15	6.63	12.7	66.9
2.	5.0	9.67	4.06	2.17	5.26	14.4	68.8
3.	5.5	9.53	4.19	2.16	4.94	13.8	67.2
4.	6.0	9.25	4.30	2.15	4.73	13.0	65.1
5.	6.5	8.93	4.31	2.14	4.31	12.3	61.1

Table 11 shows the BM mix using VG 30.

- **Variation of Stability Values, Flow Values, Bulk Density, Air Voids, VMA and VFB with wax and molasses Content.**

S. No.	Mix	Stability Value (kN)	Flow Value (mm)	Bulk Density (g/cc)	Air Voids (%)	VMA (%)	VFB (%)
1	Unmodified bitumen	9.67	4.46	2.17	5.26	14.40	68.8
2	5 % Molasses +4%Wax	11.67	3.93	2.21	4.67	16.10	73.5
3	6 % Molasses +5% Wax	13.55	3.62	2.52	3.12	18.70	76.2
4	7 % Molasses +6% Wax	13.16	3.17	2.45	3.24	18.60	70.1
5	7% Molasses +7% Wax	11.34	2.89	2.34	3.31	17.20	67.2

Table 12 shows various flow values, and voids present.

- **Variation of Stability Values of Mixes:**

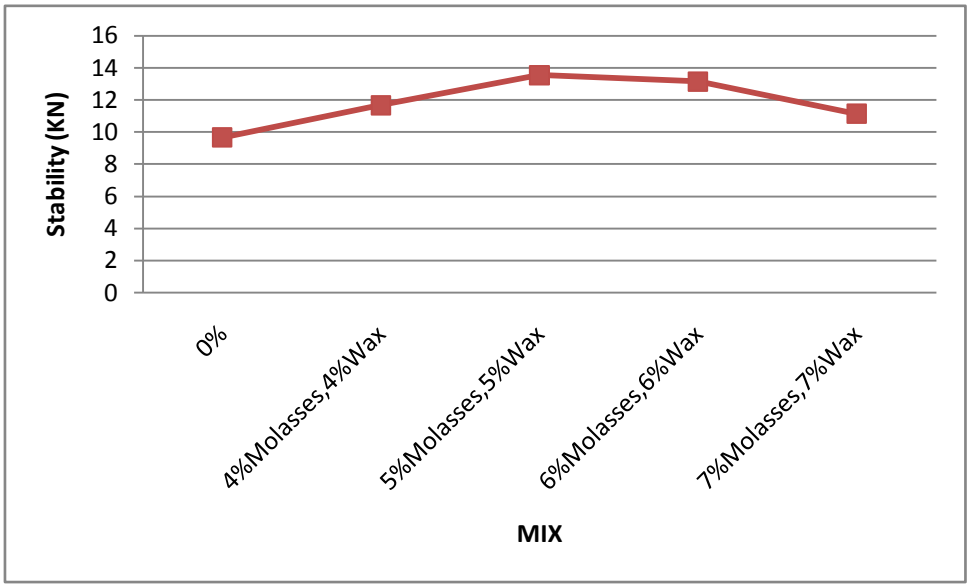

Figure 4.20 showing stability values.

- **Variation of Flow Values of Mixes:**

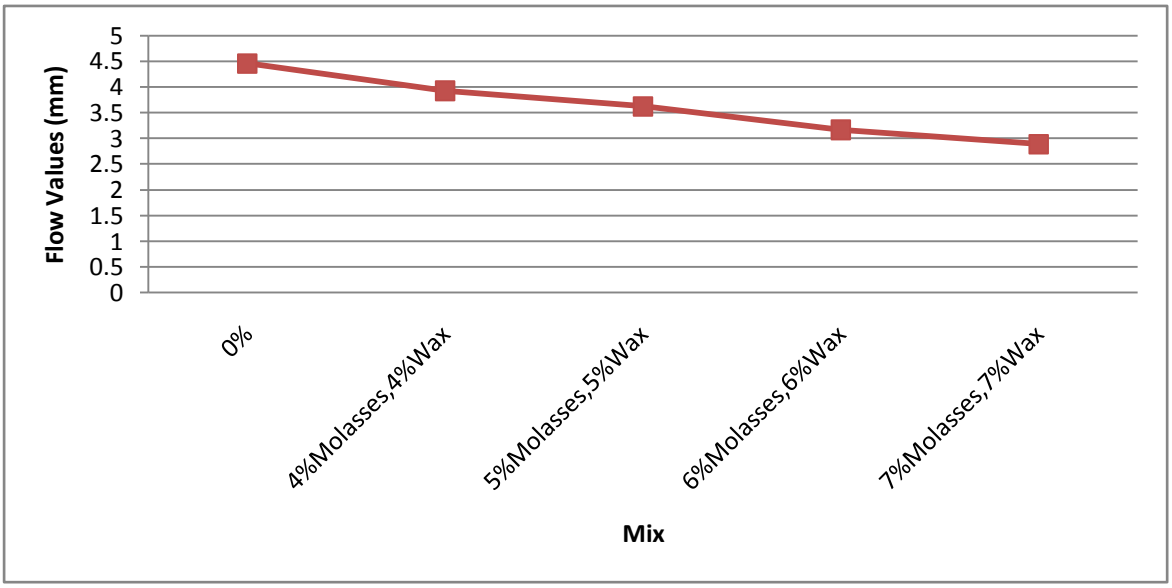

Figure 4.21 shows various flow values.

In this the stability gets increased up to addition of %%of molasses and 5% of wax, but then after more addition the stability gets decreased. Also the breakage point is 5% in the stability value. Also the flow value gets decreased by more addition in the marshal stability test.

CHAPTER 5

CONCLUSIONS AND FUTURE SCOPE:

From the study and investigations done, it was seen that:

- The stability of the bitumen was much better than the unmodified bitumen. It was seen that the stability of the bitumen got increased when it was modified up to 5% of both molasses and wax. So it is better to use modified bitumen which would provide greater stability.
- In order to improve or able to resist the various deformations like the boiling point, therefore the temperature needs to be increased so in that case the softening point values should be increasing and also by these addition of additives or modifiers and by experimentation done it gets increased up.
- The penetration values are being decreasing linearly at 4.6 mm when the modifiers candle wax were being added at 4.5% wax content and also it gets decreased when both wax and molasses were being added to un modified bitumen. Here the penetration values are less than 100 mm and if they got increased than 100mm which would be associated with the case of bleeding of the road pavement.
- Instead of wasting the waste of sugar molasses it is proved to have positive result on bitumen by various experimentations done, also the various amount of gases like the carbon dioxide gases, the release of these gases will be decreased by sugar molasses. Also by spraying waste material of sugar on aggregates, it is proven to improve it binding characteristics. By molasses the voids present in mix are reduced which would prevent the moisture absorption and the oxidation of bitumen, which would result that the road pavement will withstand heavy traffic loads and a better quality of service and thus an environment friendly atmosphere.
- In this study, the penetration value gets decreased and softening point values gets increased by the addition of wax, which would results in improved resistance to deformation of the bituminous mix. Also the compaction and construction temperature were reduced which would result in good bitumen performance and better performance for heavy road pavements.

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