PARTIAL REPLACEMENT OF BITUMEN WITH MOLASSES

A THESIS

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

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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(Assistant Professor Grade - II)

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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 **"PARTIAL REPLACEMENT OF BITUMEN WITH MOLASSES"** submitted for partial fulfillment 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 any other degree/diploma. I am fully responsible for the contents of my project report.

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **“PARTIAL REPLACEMENT OF BITUMEN WITH MOLASSES”** in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil Engineering**, Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Arpan Chaudhary (151622) & Manik Ohri (151626)** during the period from July 2018 to May 2019 under the supervision of **Mr. Chandra Pal Gautam,** Assistant Professor(Grade II), Department of Civil Engineering**, Jaypee University of Information Technology,Waknaghat.**

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

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This project report gives a detailed description of the study work done on the project topic **"PARTIAL REPLACEMENT OF BITUMEN WITH MOLASSES"** for the partial fulfilment of the requirementsfor the degree of Bachelor of Technology in Civil Engineering, under the supervision of **Mr. Chandra Pal Gautam.**

We gratefully acknowledge the Management and Administration of Jaypee University of Information Technology, Waknaghat for providing us the opportunity and hence the environment to initiate and complete our project now.

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ABSTRACT

Bituminous concrete is a composite material which consists of mineral aggregates, bitumen as a binder & air voids. With the increase in energy cost & requirement of bitumen and other petroleum increases worldwide, and also the requirement of a better quality of pavements as well as worry about the pollution. The bitumen releases carbon dioxide when heated, which is very harmful to human health. We need to add some non-toxic material into the bitumen binder to reduce pollution. So, alternative binders are required to modify, partial replacement or totally replacement of bitumen binder. Such an alternative binder is Molasses. Molasses is a residue of sugar cane obtained during the process of manufacturing of sugar. This research is intended for partial replacement of bitumen binder with molasses.

The study compares the results of conventional bitumen and bitumen containing molasses using laboratory tests. The tests which we performed are – penetration, ductility, softening point, Marshall stability tests. We prepared samples having different percentages of bitumen and different percentages of molasses to find the optimum percentage. Percentage of bitumen (4%, 6% & 8%) and percentage of molasses by weight of bitumen (4%,8%,10%,12% & 16%).

The research study concludes that the partial replacement of bitumen with molasses improves the Marshall characteristics, and also the strength and stability increases at 6% bitumen content and 8% molasses content. Modified bitumen increases penetration and softening point. The specific gravity remains the same but ductility decreases. Release of carbon dioxide reduces as the amount of the bitumen reduces. Overall research conclude that the optimum value of modified bitumen is 8% which is feasible to partial replace bitumen with molasses.

Keywords- Bitumen, Binder, Molasses, Marshall Stability, Replacement, Carbon dioxide

CHAPTER 1

INTRODUCTION

1.1 General

Energy plays a vital role in the boom of growing nations like India. Within the context of low availability of non-renewable energy resources coupled with the needs of large quantities of energy for materials like bitumen, the significance of the use of commercial waste cannot be ignored. At the time of manufacturing of bitumen from the crude oil large amount of benzene, Sulphur dioxide & nitrogen oxide are released. The company can control these released gases to some extent, but the bitumen is heated to the excessive temperatures during the transportation and application process, the carbon dioxide gas is released into the environment which is very harmful and causes lung diseases and serious threat to the atmosphere.

1.2 Background

As India is an evolving country, roads and highways play an essential role in the connectivity of one place to other, as per future consents and for the development of India proper road network is the essential key. Transportation facilities are one of the required factors for the developing county. With the length of 4.32 million Km India is the 3rd largest road network in the world as per the census of 2011. Generally, in India, flexible pavement type of roads is preferred. The pavements extensively categorized into two types that are, Flexible pavement & Rigid pavement. The rigid features of the pavement are related to the rigidity or flexural strength or slab action, so the distribution of load is on the subgrade of the soil over a wide area.

Flexible pavement consists of bituminous concrete mix positioned over the granular base layer supported by the compacted soil, referred to as the subgrade. Flexible pavement includes subgrade, sub-base, base coarse & surface coarse. The upper layer of the road has surface coarse and traffic load directly applied on this layer. Comparatively, this layer is made of bituminous concrete which is having great quality and expensive materials as. Generally, bituminous concrete consists of two things, aggregates and bitumen as a binder. Aggregates are tough, inert substances which include sand, gravel, crushed stones and primarily based on the size of the particle aggregates are categorized into 3 coarse aggregates, fine aggregates & fillers. Approximately ninety to ninety-five percent of mixture constitutes of aggregates.

Bitumen is defined as a mixture of organic fluids which are exceptionally viscous, blackish, sticky nature, fully soluble in carbon disulphide, and consists of primarily of polycyclic aromatic hydrocarbons. Naturally, it occurs in the form of petroleum or crude bitumen is a sticky, form of petroleum such as a tar which is so thick & heavy that it needs to be heated or added water(diluted) before it'll flow. It is obtained from residual fraction by the crude oil fractional distillation. It is the heaviest fraction & having a highest boiling point, boiling at 525°C (997°F). The mixture of aggregates and bitumen referred for bituminous mixture, in British English. The road surfaces are the general term used for the bitumen in Australian English. It is normally used for the paving roads. The aggregates are added to the bitumen which is known as a bituminous mixture. The main purpose of the bitumen is waterproofing & as an adhesive for the hundreds of years. It has also been used as the roofing felt and flat roofs sealing.

These days, industries of road construction, providing tensile strength to resist distortion, protecting the pavement structure made with bitumen, protecting subgrade from moisture, and offering a smooth, skid-resistant surface for travelling that resists the wear from traffic, so bitumen binder is specifically used as an intermediate & surface layers of the flexible pavements. The natural constituents are on the edge of extinction. As day by day construction of the roads are increasing very fast so the need for the natural material for the construction is also increasing. The boom in the energy cost, need for the development of the pavement high-quality, the demand of petroleum in the world in addition to the problem over pollution and the weather change emphasis on the growth of alternative binders to partially replace or full replacement of the bitumen binder. We need some alternatives which help to improve the environment, that are workable, and that are not toxic, one of the alternatives is sugar cane by-product known as molasses.100 tons of sugar cane will provide 10-11 tons of sugar and 3-4 tons of molasses.

Molasses is the final waste obtained from the preparation of sugar by repetitive crystallization. It is the form of fluid left after all the sugar extracted from the sugar cane or sugar beet which is economical, cane juice is 3-4 per cent extracted from the sugar cane. It is usually very thick, having changeable viscosity, and dark. Molasses has been used in many ways that are in tobacco, as an additive in livestock feeds, for yeast production, it is also used as an alternative fuel from ethanol fermentation. The bituminous binder is less expensive than concrete, so we need the alternative that gives us road surface acceptable, performance should be good, cheaper & also consider the industrial by-product used as an alternative. The aim of this research is to test and study as an alternative partial replacement for bitumen binder to improve the properties of road, and material which is available nearby, and make less pollution.

1.3 Problem Statement

It has been necessary to find an alternative binder to replace bitumen binder. The world is facing a major problem of climate change, and global warming which is our concerned as an engineer, it is caused by greenhouse gases. Burning of carbon fuels discharges into the climate releases carbon dioxide gas. Molasses is used in various kind of industries because of its binding and non-polluting characteristics. No production of toxic gases on heating which is much safe for the environment. It is very easy to carry and used in various processes. It is very necessary due to a large amount of Carbon dioxide released by bitumen, in one-gallon of bitumen having approximately 8-37 percent of carbons. Due to the oil content of bitumen surfaces of the bitumen roads in wet conditions become greasy.

Another problem is absorbing of heat as the surface of the road is black and the heavy vehicles lift the surface of the road, which is very dangerous for the public and for motor vehicles also. Road safety is our first preference over anything. One of the main issues is the melting of bitumen requires a large amount of heat during transportation & application. Water reaction tears the bond between the aggregate and bitumen. These all are the major problems which should be overcome as soon as possible to make eco-friendly roads i.e. less polluting road. Release of carbon dioxide is the big problem which should be resolved using the alternative binder like we use molasses. As a result, use of nearby available material like molasses as an alternative replacer of the bitumen binder.

Adding or partial replacement of molasses was an old idea in the industries of construction. There were some studies showed the replacement & one study showed fully replacement of bitumen binder with some material made from molasses and totally non-petroleum based. The result was that the new mix is non-toxic, having dry-granulated form, no hot storage is required, fifty percent greater durability, resistance to fatigue, wear & tear, less cracking, less fading and solvents, less volatile releases, and make a non-slippery road, and safer to travel, much better performance than bitumen.

1.4 Aim of the study

1. To study the effect of sugarcane molasses in bituminous concrete.

2. To select the optimum percentage of sugarcane molasses in bituminous concrete.

3. To compare the relevant engineering properties of modified mix with conventional bitumen.

1.5 Scope of the Study

1. Determining of optimum sugarcane molasses in bituminous concrete by varying the molasses content.

2. The qualities expressed in SI units are to be viewed as the standard. No different units of estimation are incorporated into this standard.

1.6 Constituents of the thesis

1. Chapter One – It describes the significance of the problem zone and a brief introduction to the research.
2. Chapter Two – It gives a description of the literature regarding the pavement concepts and materials of pavement and studies done in past and work done or work going on the pavements using molasses as a material.
3. Chapter Three – Describes the experimental work done and also the procedures of the experimental work.
4. Chapter four – Analysis of results.
5. Chapter five – conclusion came from the research work we had done before and references for this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Pavement comprises of different layers of different material supported by a layer known as sub-grade. Usually, the pavement has 3 layers i.e. rigid pavement, flexible pavement and composite pavement. The rigid features of the pavement are related to the rigidity or flexural strength or slab action, so the distribution of load is on the subgrade of the soil over a wide area. Flexible pavement consists of bituminous concrete mix positioned over the granular base layer supported by the compacted soil, referred to as the subgrade. Flexible pavement includes subgrade, sub-base, base coarse & surface coarse. Whereas composite pavement is the combination of both the pavements (rigid pavement & flexible pavement). We say flexible pavement flexible because the structure of pavement wholly deflects under loading. Rigid pavement supports loads through flexural action over bearing action. They include many layers of selecting materials designed prudently to distribute loads gradually from the pavement surface to the layers underneath. The design of the pavement is like that load transmitted to each consecutive layer does not exceed the load-bearing capacity of layers. Generally, a flexible pavement structure consists of: -

- Surface coarse – This is the upper layer &traffic load is applied on this layer. It is constructed with high quality of materials. It may have composed of one or many different hot mixed asphalt sub-layers. Hot mixed asphalt is a mix of fine aggregates & coarse aggregates & bitumen as a binder. Usually, the water from the surface that goes to base coarse is prevented by this layer only. It offers a smooth, well-bonded surface without loose particles, the resistance of aircraft loads stresses, & provides skid-resistant surface deprived of causing wear and tear on tires.

- Base coarse – The layer below the hot mixed asphalt layer. The main structural component of the flexible layer is the base coarse. The imposed load from the wheel is distributed uniformly to the foundation, sub-base, sub-grade. The quality of base coarse depends on composition, physical properties & material compaction. The area deals with the frost action or sub-grade is soil enormously weak. Usually consists of aggregates.

- Sub-base coarse – The layer below the base coarse layer. It functions the same as base coarse that in the distribution of loads this layer gives additional support to the base and upper layer. The material choice is not that much issue as that of the base coarse layer because it is subjected to the lower load stresses. It may or may not be required. It comprises of granular material which stabilized or compacted properly.

Flexible pavement section is shown in Figure. 2.1. Our study concentrates on the top layer (surface). Hot mix bitumen layer.

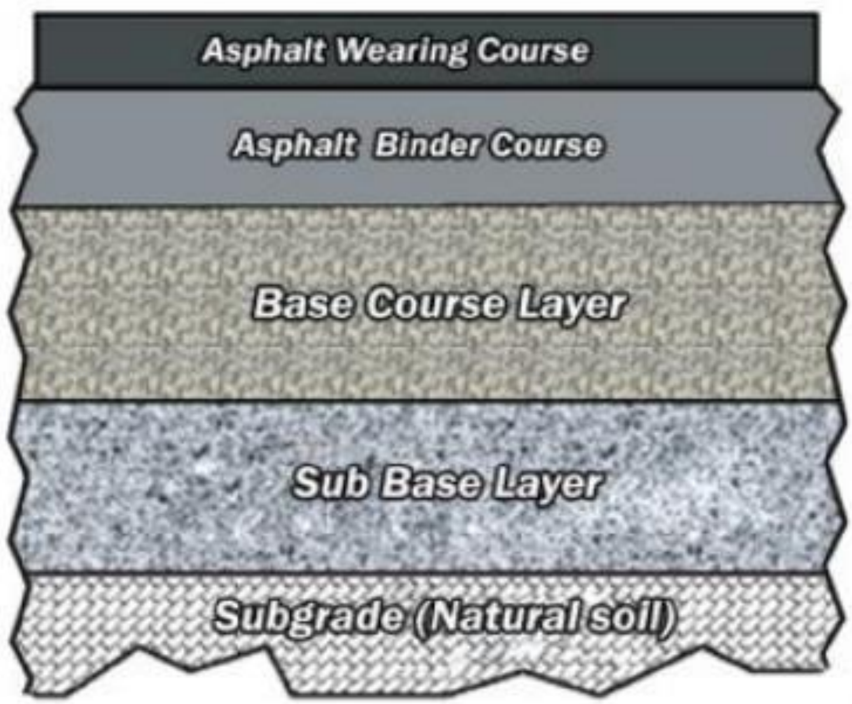

Figure2.1 Typical flexible pavement vertical section structure (Mohammed, 2013)

2.2 Reviews

TimajAbdulahi, Addis Ababa University, (2017).

This study attempts to study the conventional and rheological properties of binder mixes, HMA is made from this binder mixes and their sensitivity to moisture. In doing so, take a look at parameters had been evaluated. Based on the consequences received from this have a look at, the subsequent conclusions can be made.

Neat asphalt binder was more affected by ageing compared to asphalt binder containing Molasses. Meaning addition of Molasses to asphalt binder decreases the ageing effect of HMA mixtures. Addition of Molasses has affected rheological behaviour of asphalt binder thereby making the asphalt binder stiffer at high temperatures which results in a durable binder. From the test result obtained from FST, the master curve shows an improving behaviour for asphalt binder upon the addition of Molasses. Addition of Molasses on asphalt binder increases the stiffening property of asphalt binder at high temperatures (low loading frequencies). From the test result obtained from MSCR, the smallest total strain value was obtained for Molasses of 9%, followed by 6% and 3% Molasses. Therefore, the addition of Molasses improves the resistance of asphalt pavements to rutting.

The replacement of asphalt binder with Molasses at optimum binder content of 5%, decreased the stability, flow, unit weight and the Va% of the HMA, while the VMA and VFA percentages increased as the percentage of Molasses increased. The increment and reduction value of these properties of HMA up to 10% Molasses are within the Marshall criteria for heavy traffic.3% Molasses has nearly no effect at the TSR and all the mixes prepared for ITS take a look at had been determined to be moisture inclined and they're under the standards exact. Because of time and competitively priced limitations exact mixes had been no longer conducted so one can determine the most efficient Molasses content material because the advocated molasses content for this studies is applicable simplest for optimum binder content of 5%. In well-known, the purpose of this research that is addition Molasses to asphalt binder became to provide an economical and locally to be had binder which keeps the property of neat asphalt binder. Therefore, it may be concluded that its miles possible to in part replace asphalt binder with Molasses for sporting coarse up to 9% at dry areas.

Prakash, K. S.,Phanindra M., Surya S. R.,andNaresh J., (2014).

According to the study, bitumen the residue left over from petroleum distillation is in the course of the arena the most widespread bonding agent used for roadway creation. Crude petroleum is a fossil mineral useful resource and a gasoline source so one can be used up inside next 50years. Increasing strength expenses and the robust international demand for petroleum has encouraged the improvement of opportunity binders to modify or update asphalt binders. The benefits of the use of opportunity binders are that they could shop natural resources and decrease energy consumption while maintaining, and in a few instances enhancing pavement overall performance. Because of pressing need for infrastructure, rehabilitation and protection, the creation and application of such sustainable and environmentally friendly materials like sugar cane waste molasses are required. And these days the call for lies round 200 million lots.

A modified mix of bitumen has improvised Marshal Characteristics. We saw the values of marshal stability test hiked up to 13% and then declines and flow value also decline when the molasses is added. We can attain steady & more durable. It gives us improvised pavement features i.e. visibility, safety, long life, strength, workability, and very important is the environment. This modified bitumen mixture (bitumen with molasses) is good for the environment, the main objective is zero emission. This research paper tells about the molasses benefits in mixing with bitumen such as it will decrease the releasing of the carbon dioxide. Modified bitumen reduces the voids in the mixture, prevention of moisture absorption. It will also help in making eco-friendly roads.

Jayanthi, Mahalakshmi, M., Miyares. ,Abhirami, and Shankar, K, (2014).

According to this study, the world has emerged as increasingly more involved over the worldwide climate change concept to be caused by greenhouse gases, chief among them anthropogenic carbon dioxide that's launched into the ecosystem from burning carbon fuels. In order to lessen the carbon emission content material, non-toxic material added with the bitumen. Such material is molasses, that's the residue in sugar production technique . Non-petroleum based binders may be made light-coloured bitumen so that it reduces the urban heat island effect. Superplasticizers are a crucial component of self-compactness to offer necessary workability together with a viscosity enhancing agents (VMA) for stability. The carbon content material and viscosity of the bitumen is reduced by using adding these substances into the bitumen and for that reason will increase self-compactness and eco-friendly.

From this look at the behaviour of bitumen changed with molasses improves ductility, penetration and Marshall Characteristics. The investigation now not best makes use of beneficially, the stable waste molasses however additionally offers us improved pavement characteristics including avenue protection, visibility, long lifestyles, power, recycling, workability and any other one that is surroundings. By the usage of molasses to the bituminous mix amount of release of carbon dioxide decreases and also merchandise of molasses additionally decreases which might be very harmful to human fitness. The street can withstand heavy visitors and a better carrier. This modification now not only adds cost to molasses however may even increase era which is eco-friendly.

GemechuYilikalMose, PalaniPonnurangam, (2018).

The objective of this study is investigating the impact of cane molasses at the performance of the bottom bitumen. Sugar cane molasses is a natural waste fabric received from raw sugar during the refining process at sugar refineries. The results of cane molasses per cent alternative on bitumen were examined by way of numerous laboratory tests such as PG (Performance Grade), RTFO (Rolling Thin-Film Oven). The have a look at discovered that as the share of Molasses-A, Molasses-B and Molasses-C increases from zero to twenty %, zero to ten % and zero to five %, the PG become stepped forward with the aid of 28.12%, 15.79% and 8.57 % respectively. The PG decreases by means of 36.87%, 28.38% and 12.76% and further, the ductility decreases through 21.36%, 6.79% and five.83% for 15% molasses-A, 10% Molasses-B and 10% Molasses-C combinations respectively. The cost analysis also signifies that the value of the base bitumen improved by way of 17.4 %, 8.93 % and 2.35% for the usage of Molasses-A, Molasses-B and Molasses-C respectively. From this the look at, it becomes concluded that as in step with DSR performance testing machine, 20% molasses-A, 10% Molasses-B and 5% Molasses-C improves the performance of authentic bitumen with distinctive charge.

As in step with the laboratory effects, the overall performance grade of the treated base bitumen (40/50) with 20% molasses-A, 10% Molasses-B and five% Molasses-C improve the overall performance of the original bitumen with the aid of 28.12%,15.79% and 8.17% respectively. The penetration grade decreases by 36.87, 28.38% and 12.76 % and further, the ductility decreases via 21.36%, 6.79% and 5.82% for 15% molasses-A,10% Molasses-B and 10% Molasses-C combinations respectively. Also, as consistent with RTFO test end result in the performance grade after growing older remains equal for molasses-A and reduces through one grade for Molasses-B and Molasses-C treated bitumen as compared with overall performance earlier than getting old. As consistent with RTFO check result the performance grade after getting older and before ageing had been the same besides for 15%and 20% of Molasses-B and 15% of Molasses-C combinations. Generally, molasses-A 20% aggregate improves four grades in comparison with SHRP guide from 58 to eighty-two similarly Molasses-B and Molasses-C improves 3 and a pair of respectively. The softening factor common temperature became improved as the percentage of mixture increases; and which means that the density and hardness of the combination progressed as in accordance with ASTM D36 specification.

Dr A. Gandhimathi, S. Abinaya, (2017).

This research turned into finished to endorse using shredded waste plastic bottles (PET) for the change of bitumen binder with unique cognizance at the development of an effective pavement fabric that utilizes the plastic waste even as catering to the desires of varying climatic conditions prevailing in India and also the heavy hundreds on pavements. This paper in detail presents the take a look at on the technique of the use of waste plastic bottles (PET) in modifying bituminous binders and the diverse checks executed on 60/70 grade bitumen. A precise analysis of the engineering properties inclusive of Penetration check, Ductility test, Viscosity check, Softening point take a look at and Specific Gravity to take a look at are carried out on each traditional and modified bitumen samples for diverse chances of replacements including zero, 10, 20 and 30% respectively. This PET modified bitumen showed improved first-rate with % of superior substitute falling among 10% to twenty%. Reduce thermal cracking without load, resistance to fatigue, decrease stripping and bond of aggregate bitumen increases, the durability of pavement also increases, cost decreases, clean-environment.

Şeyma ÖZTÜRK, M. Kürşat ÇUBUK, Deniz ARSLAN, Metin GÜRÜ, (2017).

A new additive cloth composed of sugar beet molasses and fly ash became synthesized in laboratory situations. It turned into known as molasses-based totally fly ash compound (MFAC) and used to modify the base bitumen of 50/70 penetration grade with one of a kind concentration from 1% (w/w) to eight% (w/w). The outcomes of MFAC on the rheological houses of the bottom bitumen had been investigated via penetration, softening factor, dynamic shear rheometer (DSR) and bending beam rheometer (BBR) assessments. The quick and long term ageing of the bitumen samples for DSR and BBR applications have been finished with rolling thin film oven test (RTFOT) and Pressure ageing vessel (PAV). Also, Marshall checks were accomplished as a way to determine the outcomes of the additive on bituminous combination houses. According to the BBR take a look at effects, MFAC was discovered to improve the creep stiffness (S) of the bottom bitumen by using 14 % indicating the higher overall performance of the modified bitumen at low temperatures. Synthesized substances, namely MFAC, were used to adjust base bitumen. In this observe, 50/70 penetration of bitumen was used to modify the system. Penetration and softening factor assessments are inverses of each different. If lower softening factor and better penetration are check results, $G^*/\text{Sin}\delta$ parameters of unaged specimen increase in DSR. Original and short time period ageing parameters display that rutting. According to the BBR test results, MFAC turned into located to improve the creep stiffness (S) of the bottom bitumen via 14 % indicating the higher overall performance of the modified bitumen at low temperatures. As an end result, the use of MFAC changed bitumen in cold and rainy areas, in heavy motor and height-hour traffic highways will supply growth for motorway pavement performance.

Prince Ghalayan, Er. Sumit Rana, (2017).

The use of the progressive era will no longer best support the street construction but moreover, boom the road existence as well as will help to enhance the surroundings. Plastic roads may be a boon for India’s warm and extraordinarily humid climate, wherein temperatures frequently go 50°Cand torrential spots of rain create havoc, leaving most of the roads with huge potholes. This paper includes the effects of the several laboratory assessments executed on bitumen, aggregate and bitumen-aggregate plastic blend.

The effect of this study together with that of previous researches are positioned to be encouraging for the destiny researchers who are interested to work in this area. The inattention of not unusual submergence issues, immoderate summer season temperature and terrible pavement creation practice and particularly environmental dangers because of waste plastic, the use of waste plastic in avenue construction may additionally convey cheap blessings inside the many ways. After accomplishing laboratory exams on bitumen binder and mixtures with extremely good polymer content material fabric and after analyzing the data and comparing the outcomes, the following conclusions are drawn: - These results show that with the growth of waste plastic in bitumen increases the houses of mixture and bitumen. The maximum appropriate use of plastic can be 12 % of bitumen based totally on Marshal Stability check. The changed bitumen suggests an applicable result when as compared to conventional consequences. For all changed binders organized, the penetration values lower as waste plastic ratio will boom at the equal time as softening point values increase as waste plastic ratio will increase. The coating of aggregates with waste plastic reduces the absorption of moisture. By the use of waste commodity plastics in a binder, amendment carries the advantage of a cheap, technologically effective method of improving traditional binder performance and offers a possible manner to control plastic waste. This has brought an extra cost in minimizing the disposal of plastic waste is the eco-friendly method.

Anurag V. Tiwari and Y R M Rao, (2017).

The study evaluates the addition of shredded waste plastic within the bituminous concrete which leads to sizeable growth within the balance cost and Marshall Properties of the combination. The look at reveals that the usage of waste plastic in bituminous concrete is comfortable and sustainable for road advent.

Addition of eight per cent of the LDPE and HDPE plastic waste improves the stability fee of the mixture which ends up within the boom within the durability of the mixture. Due to the addition of plastic waste, the go along with the waft price will boom ensuing inside the improvement inside the workability. Addition of plastic waste results in a decrease within the air voids which reduces the bleeding of bitumen. The volumetric and Marshall houses of the combination show appropriate development and will fulfil the desired limits. The use of waste plastic in bituminous concrete is secure and sustainable for road introduction.

A.Boomika, M.A.Naveen, J. Daniel Richard, A.MythiliR.Vetturayasudharsanan, (2017).

In this venture, we've got used the waste substances like lignin and plastic as an alternative material for bitumen in the share of five&10%, 10&15%, 15&20%, 20&25% respectively. It has been determined that lignin can act as a binding material for asphalt, for this reason, improving the residences of the bitumen. By the combination proportions that is analyzed and decided through series of tests like penetration, ductility, viscosity, softening factor, it's miles discovered that the combined percentage of 15&20% has green results when compared to other proportions used.

The properties of bitumen which includes ductility, viscosity, softening factor, penetration were superior in all of the aspects which facilitates in growing the existence span of the pavements. A gradual boom is found in those kinds of houses of bitumen through in component changing it with lignin and plastic up to 15% and 20% respectively.

MONIKA MOHANTY, (2013).

In this study, three forms of mixes i.e. SMA, DBM and BC are organized with VG30 grade bitumen used as a binder. The effect of the addition of waste polyethene in the form of regionally available synthetic milk with logo OMFED packets within the bituminous mixes has been studied by way of varying concentrations of polyethylene from zero% to two. Five% at an increment of 0.5%. Using the Marshall Method of mix layout, the most suitable bitumen content material (OBC) and most fulfilling polyethylene content (OPC) had been determined for specific sorts of mixes. It has been observed that the addition of two% polyethylene for SMA and DBM mixes and 1.5% polyethylene for BC mix effects in most effective Marshall Properties where stone dust is used as filler. But whilst small fraction of first-rate aggregates is changed by means of granulated blast furnace slag and filler is changed by using fly ash, finest Marshall Properties for all forms of mixes result with simplest 1.5% polyethylene addition. The OBCs in case of modified SMA,BC and DBM mixes through the use of stone dust as filler are observed four% and OBCs in case of changed (i) SMA, and (ii) BC, and DBM via the usage of fly ash and slag are found to be five% and four% respectively. Using the same Marshall specimens organized at their OPCs and OBCs via the use of both (i) stone dust as filler and (ii) changing of stone dust by using fly ash and fine aggregate by way of slag, for check under regular and moist situations it is located that the retained stability increases with addition of polyethylene inside the mixes, and BC with polyethylene results in highest retained balance observed through DBM with polyethylene and then SMA with polyethylene. Addition of polyethylene reduces the drain down impact, although these values aren't that full-size. It can be referred to that the drain down of SMA is slightly extra than BC without polyethylene. However, for all mixes prepared at their OPC, there is no drain down. It is located from the static creep test that deformation of mix commonly decreases with the aid of addition of polyethylene at all check temperatures used. The BC mixes with polyethylene result in minimal deformation in comparison to others. From the above observations, it's far concluded that use of waste polyethene in shape of packets used in milk packaging regionally effects in progressed engineering houses of bituminous mixes. Hence, this research explores no longer simplest in utilizing most beneficially, the waste non-degradable plastics, but also affords a possibility in resulting in advanced pavement fabric in surface guides for that reason making it more durable.

G. Ramesh Kumar, S. Bharani, R. S. SujithKumar, (2017).

This study affords outcomes of the waste plastic and polypropylene which have been used as a modifier by means of a quantity of 1%, 3%, 5% & 7% by using the weight of bitumen in making the bituminous mixture for pavement programs. When waste plastic is blended with bitumen it increases its water resistivity, capability and balance. Marshal balance test is considered to stimulate with discipline condition. Flow and balance of the mixture boom after incorporating waste plastic. On the idea of experimental paintings, it is concluded that the asphalt combinations with waste plastic and polypropylene modifier may be used for flexible pavement construction in a warmer area from the point of view of stability and flow characteristics.

Plastics will boom the melting point of the bitumen. The use of progressive technology no longer best bolstered the road construction but additionally multiplied the road lifestyles as properly as will help to enhance the environment and also growing a source of profits. In this modification process, plastics-waste is coated over mixture in evaluation with conventional combination, the stableness has been accelerated with the aid of including 7% of Waste Plastic and 5% of polypropylene. The flow of mix got reduced through including 7% of Waste Plastic and 5% of Polypropylene when as compared to conventional mix. It is discovered that the Marshall Quotient nearly doubled with admire to the control mixture at 5% Polypropylene content material and 7% Waste Plastic content and is found that it is slightly higher with waste plastics additive. It can be inferred that these stabilized SMA provide better resistance in opposition to permanent deformations than the manipulate combination. The density of WP and PP is a lot less than that of aggregates and they will penetrate into the aggregates and a right coating is shaped over it. Owing to the filling assets presented via these additives resulting in a less air void inside the stabilized aggregate as compared to the manipulate mixture. It is hoped that in close to the destiny we can have strong, the technique is eco-friendly.

A.Logeshkumaran, (2018).

In this mission, we've got used the waste substances like lignin and plastic as a substitute material for bitumen inside the percentage of 5%&10%, 10%&15%, 15%&20%, 20%&25% respectively. It has been located that lignin can act as a binding cloth for asphalt subsequently improving the houses of the bitumen. By the mix proportions that are analyzed and decided by way of a collection of assessments like penetration, ductility, viscosity, softening point, it is observed that the mix percentage of 15%&20% has efficient consequences when in comparison to different proportions used.

The properties of bitumen along with ductility, viscosity, softening factor, penetration has been stepped forward in all the elements which help in growing the existence span of the pavements. A sluggish boom is located in a lot of these houses of bitumen by way of partly changing it with lignin and plastic up to 15% and 20% respectively. From those experimental examine, it's miles evident that the ductility property of bitumen could be very plenty accelerated up to 20% when in comparison with traditional bitumen sample. The increase in ductility belongings enhances the binding assets of the bitumen. The penetration value has been elevated as much as 9.94%. The softening point will increase to a percentage of 5.83%. The viscosity of the in part changed bitumen has an increase of approximately 5.95%. The stability and flow of the partially changed bitumen has accelerated as much as 5.1% and 4.49% respectively whilst in comparison to that of the traditional bitumen specimen. But those boom in cost stops whilst the proportion of replacement of lignin will increase above 20%. It results in the formation of lumps inside the bitumen combination which reduces the binding property of the bitumen and also influences the glide of the bitumen main to exposure of combination.

Julius KibitiM'Ndegwa, (2017).

This paper is an analysis of the production of molasses and sugar in 4 factories in Kenya with an examination of those components and the way they make a contribution to the financial system and or infrastructure of the use. The take a look at turned into carried out through laboratory evaluation of cane molasses to establish the components of the molasses that have an effect on first-rate of avenue production soil substances. Data on manufacturing become accumulated from four sugar factories through a questionnaire. The records on sugar manufacturing became found important due to the fact molasses production depend upon sugar production. This means that the better the sugar manufacturing the better the molasses manufacturing. The records additionally showed a growing trend in annual sugar productions. Consequently, this will translate to a growth in molasses manufacturing annually.

Sugar factories in Western Kenya record excessive manufacturing tiers of sugar and molasses with the fashion were hoping to boom over time. There is but lots wastage on molasses specifically due to over-spillage. Molasses is likewise underutilized in spite of the possible diversified makes use of. The better the production of sugar inside the factories, the better the manufacturing of molasses. If well managed, molasses can be positioned to diverse uses which include the creation of roads. This may also have a massive wonderful impact on infrastructural development and especially the development of youngster rural roads. This will really result in quickened monetary improvement of rural groups.

Ch. Devi& D. Kranthi, (2017)

In this study, take a look at on the methodology of using plastic waste in bituminous mixes and presented the numerous exams executed on bitumen. The primary object of this mission is to research & look at how the waste plastic can be efficaciously applied in the creation of bendy pavement as a binder material for replacing the content of bitumen and in detail manner & it's a success application. Our present paintings are assisting to take care of both those factors. The use of modern technology will no longer only make stronger the road production but also increase the street existence as well as will assist to improve the environment.

Plastics are useful additives in bitumen to make the flexible pavements enhance and to lead them to final longer Bitumen replaced with 7% of plastic offers accurate electricity, the excessive ductile price for low penetration and exhibits excessive softening factor. This can face up to any type of climate and withstands to high visitor's conditions, whilst as compared to normal bitumen.This manner does no longer evolve any harmful gases. With the utilization of this modern era, the secure disposal of plastics may be finished without worrying or inflicting harm to the character. This technique solves foremost issues on earth, results in the safe disposal of plastics and reinforced pavements. If this method is adopted, it makes efficient in waste disposal. Once the plastic waste is separated from municipal strong waste, the natural count number can be converted into manure and used.

2.3 Summary of reviews

Generally, the bitumen and aggregates are the basic materials to whom the test are performed. Now a day, modification of bitumen or partial or full replacement of bitumen was presented and the main focus behind it. This research is mainly for utilizing waste materials in road construction, one of the waste material is molasses. In this research, we use molasses as a partial replacement of bitumen. Molasses is used as an alternative binder in many countries, so it is good for our country too. After studying previous research papers partial replacement of bitumen with molasses is beneficial for our country. We prepared the specimens for laboratory tests.

CHAPTER 3

MATERIALS AND METHODS

3.1. General

The purpose of this area is to show the examination methods used in this investigation.

The test strategy for this examination was divided into three parts.

- Segment one principally dealt with the determination of properties of conventional bitumen.
- Segment two determines the properties of partially replaced conventional bitumen with waste sugarcane molasses.
- Segment three dealt with determining the optimum percentage of waste sugarcane molasses to be replaced with the conventional bitumen.

3.2 Material Properties

Materials required for this examination are Aggregates, Bitumen and Molasses.

3.2.1. Aggregate

Aggregate is a significant part of the pavement structure. Their main function is to bear load coming to the pavement from the wheel loads. So, it is essential to study the properties of the aggregate. Aggregate need to oppose the wear movement in view of the abrasive action of the wheel load, breaking down due to the atmosphere and the highest magnitude of wheel load. A wide variety of mineral aggregates have been used to make bituminous concrete mixes. In order to determine the properties of these aggregates, there are a number of laboratory tests has been coordinated and these tests are

- Crushing Test as per IS:2386 part-IV
- Los Angeles Abrasion Test as per IS:2386 part-IV

- Impact Test as per IS: 2386 part-IV
- Soundness Test as per IS:2386 part V
- Shape Test as per IS 2386 part-I.
- Specific Gravity and Water Absorption as per IS: 2386 part III

The results of the aggregate properties are shown in Appendix A.

3.2.2. Bitumen

Bitumen is obtained by the fractional distillation of crude petroleum. Bitumen is hydrocarbon material of either common or pyrogenous cause found in gaseous, liquid, semisolid or solid form and is totally dissolvable in carbon disulfide and in carbon tetrachloride. Bitumen is used in the pavement due to its binding and water-proofing property.The characteristics properties of the bitumen to be used depend upon the type of bituminous construction. At room temperature in-situ, bitumen is solid and for all intents and purposes non-volatile and the vapour pressure of in-situ bitumen is underneath the purpose of control of acknowledgement for regular instrumentation. There are different grades of bitumen based on its viscosity. Bitumen of Viscosity Grade 30 was used in the experiment. To find the properties of the bitumen following tests have been performed

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

The results of these tests are shown in Appendix A.

3.2.3. Molasses

Molasses is the dark, a sweet, syrupy outcome made in the midst of the extraction of sugars from sugarcane and sugar beets. Molasses can change in shading, sweetness, and nutritional content dependent upon the variety or how much sugar has been isolated. Molasses has a rich history in the Caribbean and Southern United States, where sugarcane and sugar beets are vivaciously cultivated. Molasses was in like manner a predominant sugar all through the United States in the mid-twentieth century. In the midst of the sugar making process, juice isolated from sugarcane or sugar beets is boiled down until the sugars crystallize and precipitate out and the dark syrup left is Molasses.Major mineral components found in molasses are potassium, sodium, calcium, silicon and magnesium. For the purpose of research molasses from Pallia Kalan, sugar factory was taken. The exact chemical composition of molassesis hard to predict because it varies with soil where it is grown, climatic condition, cane variety and processes condition of the factory. To find the properties of the modified bitumen following tests have been performed

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

The results of these tests are shown in Appendix A.

3.3 Tests on Aggregates

3.3.1. AggregatesCrushing Test

This test is performed in accordance with IS 2386 Part IV. Aggregate Crushing Value is the percentage by weight of crushed aggregates when subjected to specified loading. This test is done in order to find the resistance of aggregates against crushing due to wheel loads. Crushing Value of aggregates demonstrates its quality. Lower Crushing Value is suggested for pavement construction as it shows a lower crushed part under the application of wheel load and would give a longer life to the pavement. The test comprises of oppressing the sample of aggregate in the standard mould to a pressure test under standard load conditions for this aggregate passing through 12.5mm and retaining on 10 mm is taken. These aggregate are then put in a cylindrical measure of the diameter of 115 mm and height of 180mm in three layers. Each layer is tamped for 25 times with the help of a tamping rod. Then this sample is transferred in the test cylinder in three layers and tampered again with the help of the tamping rod. Then the load is applied to this sample at the rate of 4 tonnes per minute up to 40 tonnes by the compressing machine. Then the aggregate is passed through the sieve of 2.36 mm sieve is weighed and expressed as a percentage of total aggregate and is called Aggregate Crushing Value. The results are shown in **Annexure A**. The results of this

$$Aggregate\ Crushing\ Value = \frac{W_1}{W_2} \times 100$$

Where,

W_1= Weight of material passed through 2.36 mm sieve

W_2 = Total weight of Aggregates taken

Figure 3.2 Compression Testing Machine

Figure 3.1 Crushing of aggregates in cylindrical vessel

3.3.2. Los Angeles Abrasion Test

This test is performed in accordance with IS 2386 Part IV. This test is used for measuring the hardness property of the aggregate. The standard of this test is to discover the rate of wear because of relative scouring activity between the aggregate and steel balls utilized as an abrasive charge. This test comprises of a hollow cylinder having an inner diameter of 70cm and length of 50 cm and is mounted to rotate about its horizontal axis. An abrasive charge comprising of cast iron circular spheres of 48 mm diameter and weight 340-445 g is set in the cylinder alongside the aggregate.The number of spherical balls to be placed depends upon the grading of the aggregate. The weight of the aggregates to be used depends upon the grading and varies from 5 kg to 10kg.

Table 3.1 : Grading of Aggregates for Test Samples

Sieve size (square hole)	**Weight of test sample in gm**							
Passing (mm)	**Retained on (mm)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**
80	63					2500*		
63	50					2500*		
50	40					5000*	5000*	
40	25	1250					5000*	5000*
25	20	1250						5000*
20	12.5	1250	2500					
12.5	10	1250	2500					
10	6.3			2500				
6.3	4.75			2500				
4.75	2.36				5000			

Source : IS 2386 Part IV,1963

Table 3.2 : The Abrasive Charge

Grading	No of Steel balls	Weight of charge in gm.
A	12	5000 ± 25
B	11	4584 ±25
C	8	3330 ± 20
D	6	2500 ± 15
E	12	5000 ± 25
F	12	5000 ± 25
G	12	5000 ± 25

Source : IS 2386 Part IV,1963

The cylinder is then closed and rotated at the speed of 30-33 rpm for a sum of 500 - 1000 rotations depending upon the grading of the aggregates.After rotations, aggregates are passed through 1.7mm sieve and the passed fraction is expressed in percentage and is known as Los Angeles Abrasion Value. The results are shown in **Annexure A**.

$$Los\ Angeles\ Abrasion\ Value = \frac{W_1}{W_2} \times 100$$

Where,

W_1= Weight of material passed through 1.7 mm sieve

W_2 = Total weight of Aggregates taken

Figure 3.3 Los Angeles Abrasion Test Apparatus

3.3.3. Impact Test

This test is done in accordance with IS 2386 Part IV. This test measures the resistance of aggregates to the pounding action or impact. Aggregates passing through 12.5 mm and retained on 10 mm sieve is used for this test. These aggregates are filled in a steel cup in three layers, and each layer is tamped for 25 times. The steel cup is having an internal diameter of 10.2 cm and height if 5 cm which is attached to the metal base plate of impact testing machine. Then the metal hammer having the weight of 13.5 kg to 14 kg is dropped for 15 times from a height of 38cm through the vertical guides over the specimen. Then the aggregate is passed through 2.36 mm sieve. the aggregate passed is expressed in fraction to total aggregate is taken and is expressed in represented which is known as Aggregate Impact Value. The results are shown in **Annexure A**.

$$Impact\ Value = \frac{W_1}{W_2} \times 100$$

Where,

W_1= Weight of material passed through 1.7 mm sieve

W_2 = Total weight of Aggregates taken

Figure 3.4 Impact Testing Machine

3.3.4. Soundness Test

This test is done in accordance with IS 2386 part V. Soundness test is meant to have a look at the resistance of aggregates to weathering motion, via conducting accelerated weathering test cycles. When porous aggregate is subjected to freezing and thawing they can disintegrate easily. In this test, aggregate are immersed in sodium sulfate or magnesium cycles for 16-18 hours and then dried in an oven at 105°C-110°C to a constant weight. This is done for five cycles. Then the loss of weight is calculated in percentage by passing the aggregate through a specified sieve. In general, the loss in weight of aggregate in this test should not exceed 12 percent in the case of sodium sulfate and 18 percent in the case of magnesium sulfate. The results are shown in **Annexure A**.

$$Soundness\ Value = \frac{W_1}{W_2} \times 100$$

W_1 = Loss of weight after five cycles

W_2 = Total weight of the aggregates taken.

3.3.5. Shape Tests

This test is done in accordance with IS 2386 part I. Shape test is done in order to determine the percentage of flaky and elongated particles. Aggregates which might be flaky or elongated are destructive to better workability and stability of mixes.

3.3.5.1 Flakiness Index

The flakiness Index is characterized as the rate by weight of total aggregates whose least measurement is under 0.6 times their mean size. This test is not applicable for sizes smaller than 6.3 mm. In this test, the aggregates to be sieved is first sieved through a set of sieves and isolated into specified size ranges. The percentage of aggregates of specified size ranges which get passed through the designated slots of thickness gauge is calculated and is termed as Flakiness Index. The results are shown in **Annexure A**.

$$Flakiness\ Index = \frac{W_1}{W_2} \times 100$$

Where,

W_1= weight of aggregates which get passed through the slots of thickness gauge

W_2 = Total weight of aggregates taken.

Figure 3.5 Flakiness Guage

3.3.5.2 Elongation Index

The elongation index of an aggregate is described as the percentage by weight of aggregates whose greatest size is 1.8 times their mean size. This test is also not applicable to particles having a size smaller than 6.3 mm. In this test, the aggregates to be sieved is first sieved through a set of sieves and isolated into specified size ranges. The percentage of aggregates of specified size ranges which get passed through the designated slots of length gauge is calculated and is termed as Elongation Index. The results are shown in **Annexure A**.

$$Elonagation\ Index = \frac{W_1}{W_2} \times 100$$

Where,

W_1= weight of aggregates which get passed through the slots of the length gauge

W_2 = Total weight of aggregates taken.

Figure 3.6 Elongation Guage

3.3.6. Specific Gravity and Water Absorption Test

This test is done in accordance with IS 2386 part III. Specific Gravity is the measure of quality and strength of the aggregate. While water absorption gives the measure of strength and porosity of the aggregate. In this test, two kg of aggregates is taken in the basket and is immersed completely in water for about 24 hours. Then the weight of the aggregates in water is measured and then aggregates surface dried and weight of aggregates is again measured. After drying the aggregates in the oven for 24 hours at a temperature of about 110°C the weight of aggregates is again measured. Specific Gravity of aggregates is calculated by dividing the weight of aggregate by the weight of an equal volume of water. Water absorption is calculated by dividing the weight of water absorbed to the weight of oven dried aggregates. The results are shown in **Annexure A**.

$$Specific\ Gravity\ of\ Aggregate = \frac{W_3}{W_3 - (W_1 - W_2)}$$

$$Apparant\ Specific\ Gravity\ of\ Aggregate = \frac{W_3}{W_4 - (W_1 - W_2)}$$

$$Water\ Absorption = \frac{W_3 - W_4}{W_4} \times 100$$

Where,

W_1 = Weight of Saturated aggregates with Basket

W_2 = Weight of Basket in Water

W_3 = Weight of Surface Dry Aggregates

W_4 = Weight of Oven dried Aggregates

Figure 3.7 Spring balance

Figure 3.8 Mesh

3.4 Tests on Bitumen and Modified Bitumen

3.4.1. Softening Point Test

This test is performed in accordance with IS 1205 1978. The softening point means the temperature at which the bitumen achieves a specific level of relaxing under the determinations of the test. The test is led by utilizing Ring and Ball device. A metal ring containing test of bitumen is suspended in a fluid like water or glycerin at a given temperature. A steel ball is set upon the bitumen test and the fluid medium is warmed at a rate of 5°C per minute. Temperature is noted when the mollified bitumen contacts the metal plate which is at a predefined distance beneath and this temperature Is known as Softening Point. The softening point of bitumen varies from 35°C to 70° for pavement construction. The results are shown in **Annexure B**.

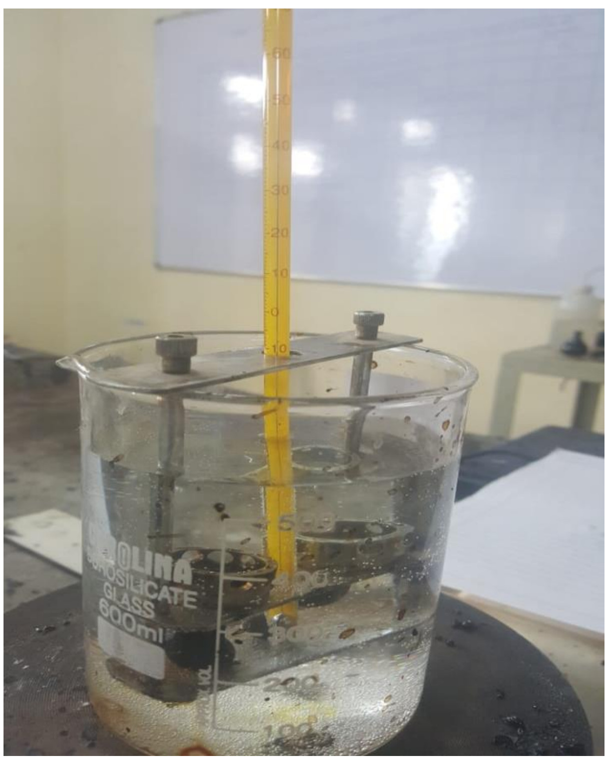

Figure 3.9 Beaker & Thermometer

Figure 3.10 Rings (with & without bitumen)

3.4.2. Penetration Test

This test is performed in accordance with IS 1203 1978. Penetration Value gives the measure of the consistency of the bitumen. The test is performed using penetrometer. It consists of a penetration needle which is released into the bitumen sample for 5 seconds. No less than three penetration tests are made on this sample by testing at separations 10mm apart. The weight of the needle is 100 gm. The measurement of penetration is done in one-tenth mm units.Firstly bitumen is poured into the mould and allowed to cool for 30 minutes and then put in the water bath for 60 minutes. After then the needle is released and dial gauge reading is noted down. The results are shown in **Annexure B**.

Figure 3.11 Penetrometer With Needle

3.4.3. Ductility Test

This test is performed in accordance with IS 1208 1978. The determination of ductility of bitumen is essential to prevent cracking of bitumen under traffic loads which may cause water to percolate through the pavement resulting in disintegration and failure of the pavement. The ductility value is the measure of distance at which bitumen specimen breaks upon pulling apart. The bitumen sample is heated and put into the mould. Now the sample is allowed to cool in the air and then allowed to cool in the water bath maintained at a temperature of 27°C for about 60 minutes. The mould is then placed in the ductility testing machine. The rate of application of pull is 5 cm per minute. The ductility value is affected by the temperature of bitumen, the dimension of the briquette, air voids in the sample. The minimum value of bitumen varies from 50 cm to 75cm depending upon the grade of the bitumen. The results are shown in **Annexure B**.

Figure 3.12 Ductility Test Apparatus

3.4.4. Specific Gravity Test

This test is done in accordance with IS 1202 1978. Specific Gravity of the Bitumen is the ratio of the weight of a given volume of bitumen to the weight of a given volume of water at a standard temperature of 27°C. The specific gravity of the bitumen helps in designing the bitumen mix. The Specific Gravity of the bitumen depends upon its chemical properties. Bitumen having a large amount of impurities or aromatic impurities will have high specific gravity. Generally, the Specific Gravity of Bitumen varies from 1.10 to 1.25. The results are shown in **Annexure B**.

$$Specific\ Gravity\ of\ Bitumen = \frac{(W_2 - W_1)}{(W_3 - W_1) - (W_4 - W_2)}$$

Where,

W_1= Weight of empty Specific Gravity Bottle,

W_2= Weight of Specific Gravity Bottle + Bitumen,

W_3= Weight of Specific Gravity Bottle + Water,

W_4= Weight of Specific Gravity Bottle + Water + Bitumen.

Figure 3.13 Specific Gravity Bottle

3.5 Marshall Stability Test

This test is used to determine the optimum binder content. The stability of the test estimates the most extreme burden upheld by the test sample at a loading rate of 5.08 cm/minute. .Marshall Stability is the maximum value of the load at which the test specimen fails. During loading, the flow value that is the deformation of the test sample with the load is also measured.

3.5.1 Preparation of the sample

1. About 1200 gm of aggregate is taken and is heated to a temperature of 175°C-190°C.
2. Modified Bitumen is heated to a temperature of 120°C-140°C starting with the trailing percentage of 4% of the weight of the mineral aggregates.
3. The heated aggregates and modified bitumen is blended at a temperature of 154°C-160 °C.
4. The blend is put in a mould and compacted by a rammer with 75 blows on either side at temperature.
5. Keep the mix in the mould for 24 hours and after that expel the sample from the mould with the help of test extractor.
6. The weight of the sample is measured in the air as well as in water.

7. The specimen is kept immersed in a water bath at a temperature of 60°C for about 30 to 45 minutes.
8. The given specimen is ready to load in the Marshall Stability test apparatus.
9. Vary the percentage of bitumen and the molasses in the modified bitumen and repeat these steps again.

Figure 3.14 Marshal Stability Test Apparatus

3.5.2. Mix Properties

3.5.2.1 Theoretical Specific Gravity of the Mix (G_t)

Theoretical Specific Gravity is given by

$$G_t = \frac{W_1 + W_2 + W_3 + W_b}{\frac{W_1}{G_1} + \frac{W_2}{G_2} + \frac{W_3}{G_3} + \frac{W_4}{G_4}}$$

Where,

W_1= Weight of coarse Aggregates in the mix,

W_2= Weight of fine Aggregates in the mix,

W_3= Weight of filler in the Mix in the mix,

W_4= Weight of the bitumen in the mix,

G_1 = Specific Gravity of the Coarse Aggregate,

G_2= Specific Gravity of the Fine aggregates,

G_3= Specific Gravity of the Filler,

G_b = Specific Gravity of the Bitumen.

3.5.2.2 Bulk Specific Gravity of the Mix (G_m)

Bulk Specific Gravity of the Mix is given by

$$G_m = \frac{W_m}{W_m - W_w}$$

Where,

W_m= Weight of Mix in air,

W_w= Weight of the mix in water.

3.5.2.3 Air Void Percent (V_v)

Air Void Percent is given by

$$V_v = \frac{G_t - G_m}{G_t} \times 100$$

Where,

G_t = theoretical Specific Gravity of the Mix,

G_m = bulk specific Gravity of the Mix.

3.5.2.4 Percent Volume of Bitumen (V_b)

Percent Volume Bitumen of the mix is given by,

$$V_b = \frac{\frac{W_b}{G_b}}{\frac{W_1+W_2+W_3+W_b}{G_m}}$$

Where,

W_1 =Weight of the Coarse Aggregate,

W_2= Weight of the fine Aggregate,

W_3 =Weight of the Filler,

W_b= Weight of the Bitumen,

G_b= Specific Gravity of the Bitumen,

G_m = Bulk Specific Gravity of the Mix.

3.5.2.5 Voids in Mineral Aggregates (VMA)

Voids in Mineral Aggregates is given by

$$VMA = V_v + V_b$$

Where,

V_v = Percent Air Voids in the Mix,

V_b= Percent Bitumen Content in the Mix.

3.5.2.6 Voids Filled with Bitumen (VFB)

Voids filled with Bitumen is given by,

$$VFB = \frac{V_b}{VMA} \times 100$$

Where,

V_b= Volume of Bitumen,

VMA= Voids in Mineral Aggregates.

The results of Marshall Stability Test are shown in **Annexure** C.

Marshal Stability test Photos

Figure 3.15 Sample for Testing

Figure 3.16 Mould for Compaction

Figure 3.17 Samples in Water Bath

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 General

This part displays the impact on the binder property due to the addition of molasses in bitumen. The tests results are utilized to make compare the properties of the binder through bargraphs and linegraphs.

4.2 Softening Point

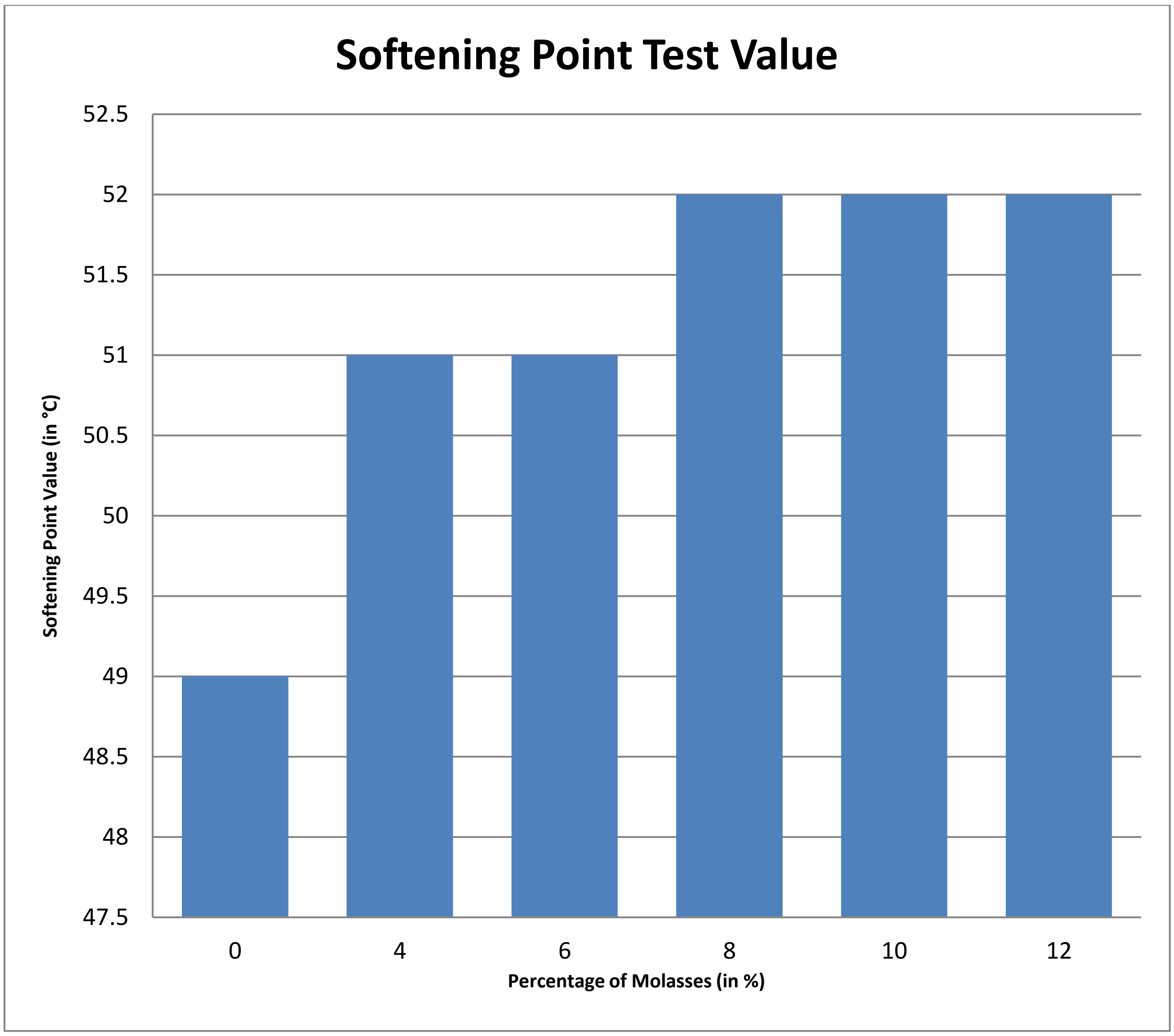

Figure 4.1 Bar Graph between Softening Point v/s Different Molasses % (Modified Bitumen)

From the given Figure 4.1, it can be seen that the softening point is increasing with an increase in molasses content. Although, the values have not increased much still this will help in sustaining against higher temperature and will have a longer service life.

4.3 Penetration Test

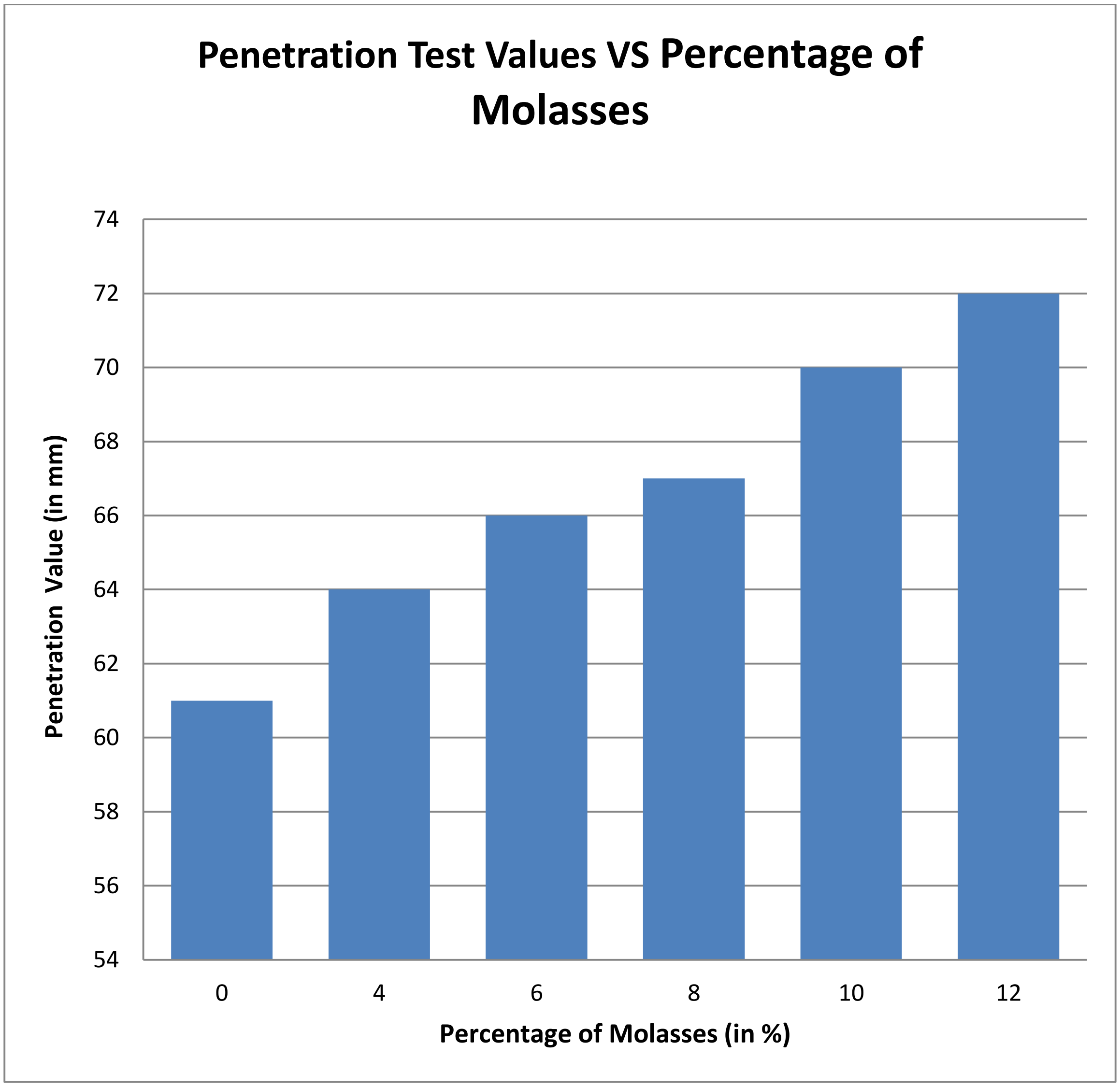

Figure 4.2 Bar Graph between Penetration value v/s Different Molasses % (Modified Bitumen)

From the Figure 4.2, it can be seen that on increasing the molasses content, the penetration value is increasing. This shows that molasses have a great impact on the penetration value of the bitumen. Thus the addition of molasses on bitumen is making it soft leading to increased resistant against temperature variation. This can be due to decrease in viscosity of the bitumen due to increasing in the molasses content. Thus, the increase in molasses content in bitumen makes it softer and more resistant to temperature variation.

4.4 Ductility Test

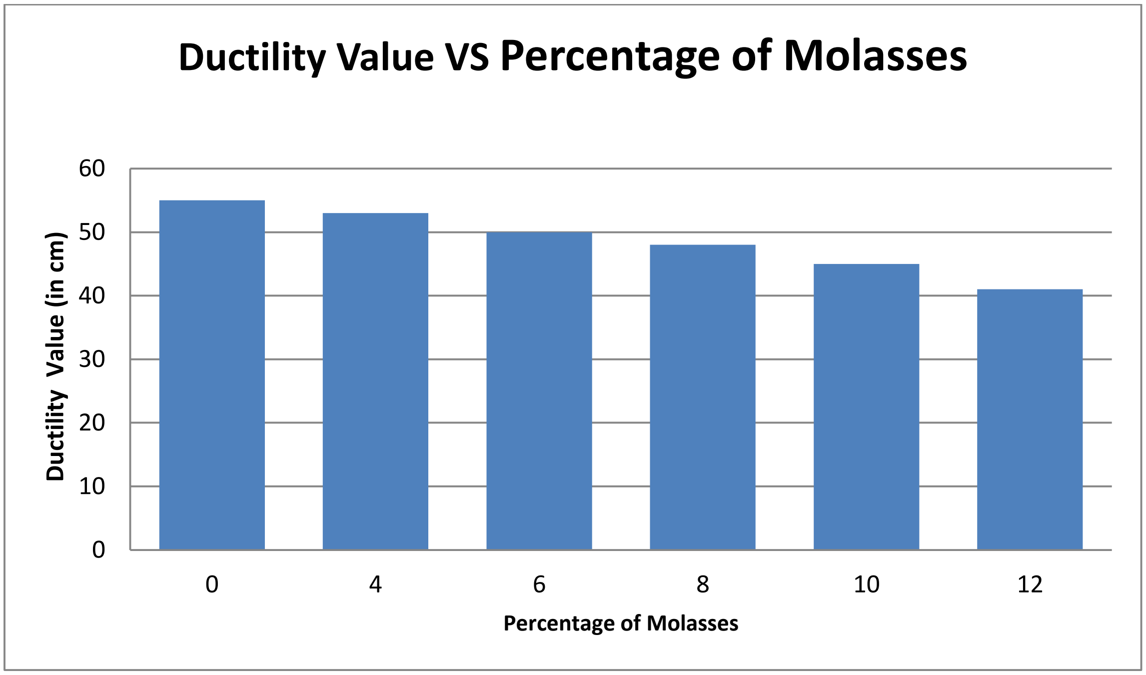

Figure 4.3 Bar Graph between Ductility value v/s Different Molasses % (Modified Bitumen)

From the Figure 4.3, it can be seen that with an increase in molasses content, ductility value is decreasing. The decrease in ductility value shows that the breaking of the binder bond due to the presence of molasses in a binder. The decrease in the ductility value is somewhat lesser.

4.5 Specific Gravity

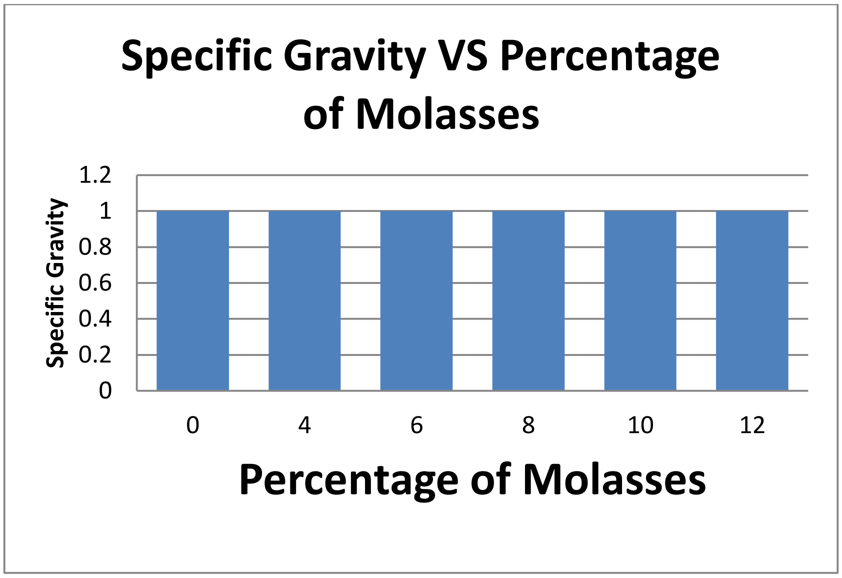

Figure 4.4 Bar Graph between Specific Gravity v/s Different Molasses% (Modified Bitumen)

From the Figure 4.4, it can be seen that there is no much variation in specific gravity of binder with an increase in binder content. This can be justified as the specific gravity of sugarcane molasses is comparable to that of a molasses.

4.6 Marshall Mix Design

4.6.1. Marshall Stability VS Binder Content

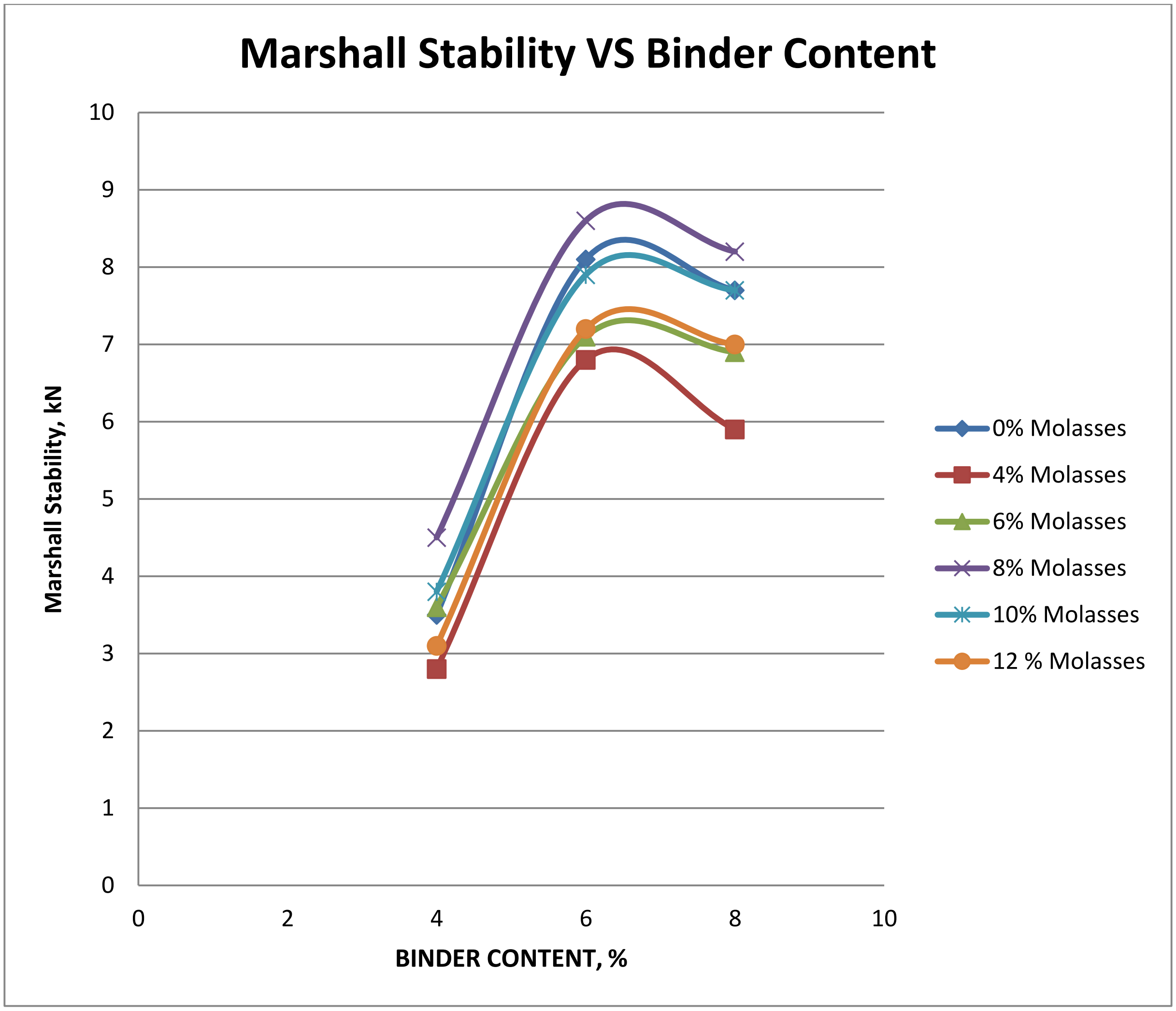

Figure 4.5 Graph between Marshall Stability v/s Binder Content (different % of bitumen& molasses)

As appeared in Figure 4.5., with increment in bitumen content Marshall Stability increments however up to certain content after it begins diminishing. This pattern is observed because firstly the binder fills the voids in the mineral aggregate but after a certain point when all the voids get filled up this extra binder create extra space which cannot take any load. The Marshall Stability is found to highest in 8% Molasses replacement and at a total binder content of 6%. As the Molasses content is increased beyond this decrease in Stability value is observed due to the decrease in the ductility value of the binder.

4.6.2. Flow Value VS Binder Content

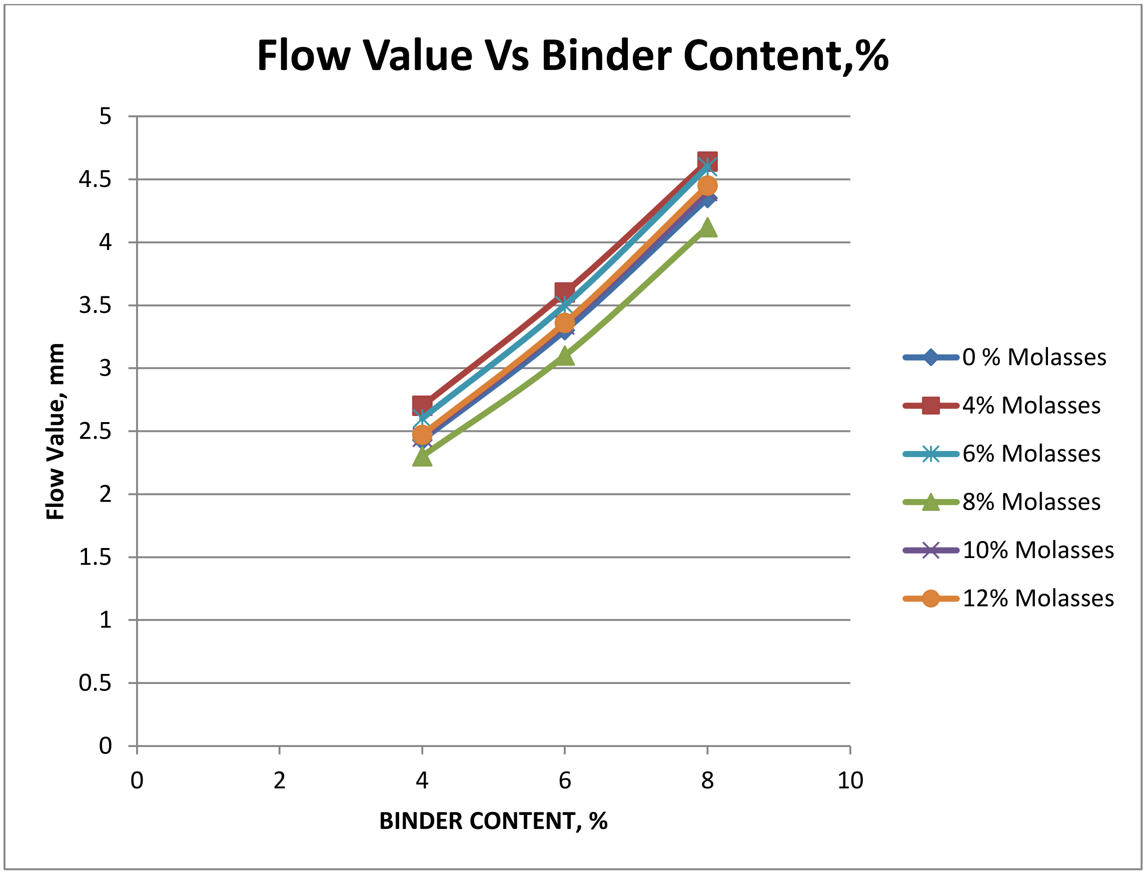

Figure 4.6 Graph between Flow value v/s Binder Content % (Different % of bitumen & molasses)

As shown in the Figure 4.6, due to improper binding Flow value is highest at 4% partial replacement of bitumen with molasses. At the 8% partial replacement of bitumen with sugarcane molasses, the flow value is minimum. This is justified because at 8% partial replacement of bitumen with bitumen maximum Marshall Stability Value is observed. At 12% partial replacement of bitumen with molasses a flow value is increasing due to a decrease in ductility of the binder due to sugarcane molasses.

4.6.3. Voids Filled with Bitumen Vs Binder Content

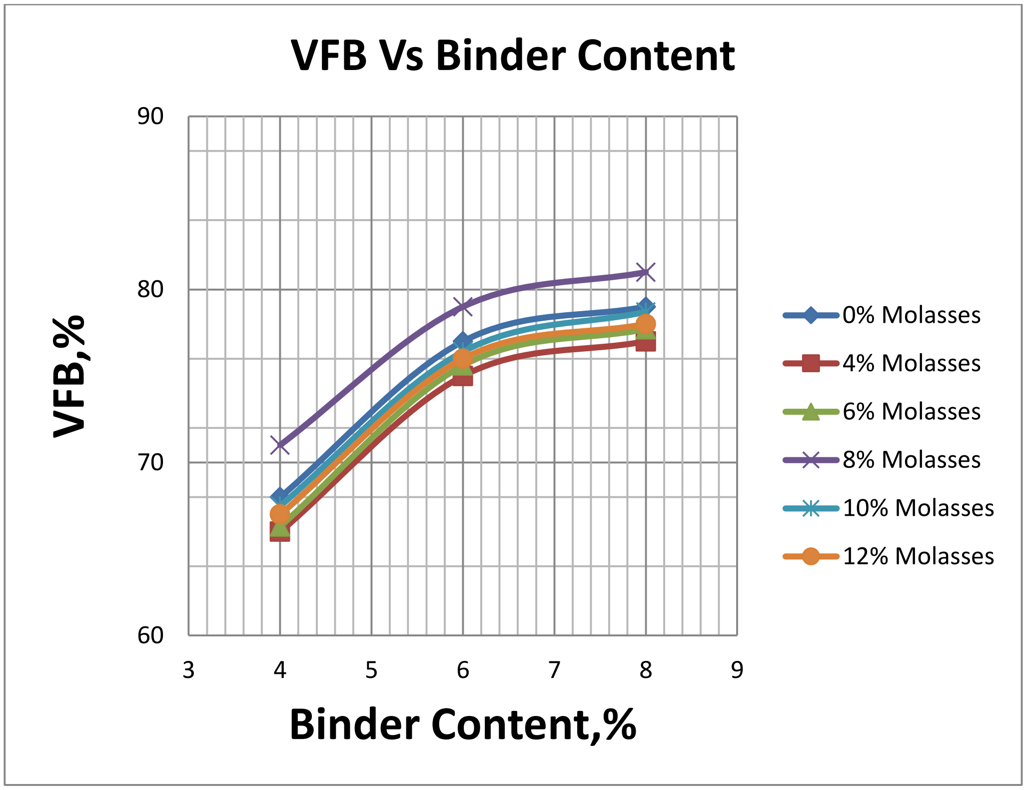

Figure 4.7 Graph between VFB% v/s Binder Content % (Different % of bitumen & molasses)

As appeared in the Figure 4.7 , as the binder content is increasing the voids filled with the bitumen is also increasing reaching a maximum value, then becoming almost constant value. At the partial replacement of bitumen with 8% Molasses Content, voids filled is maximum as justified by the maximum stability value at this content.

4.6.4. Air Voids Vs Binder Content

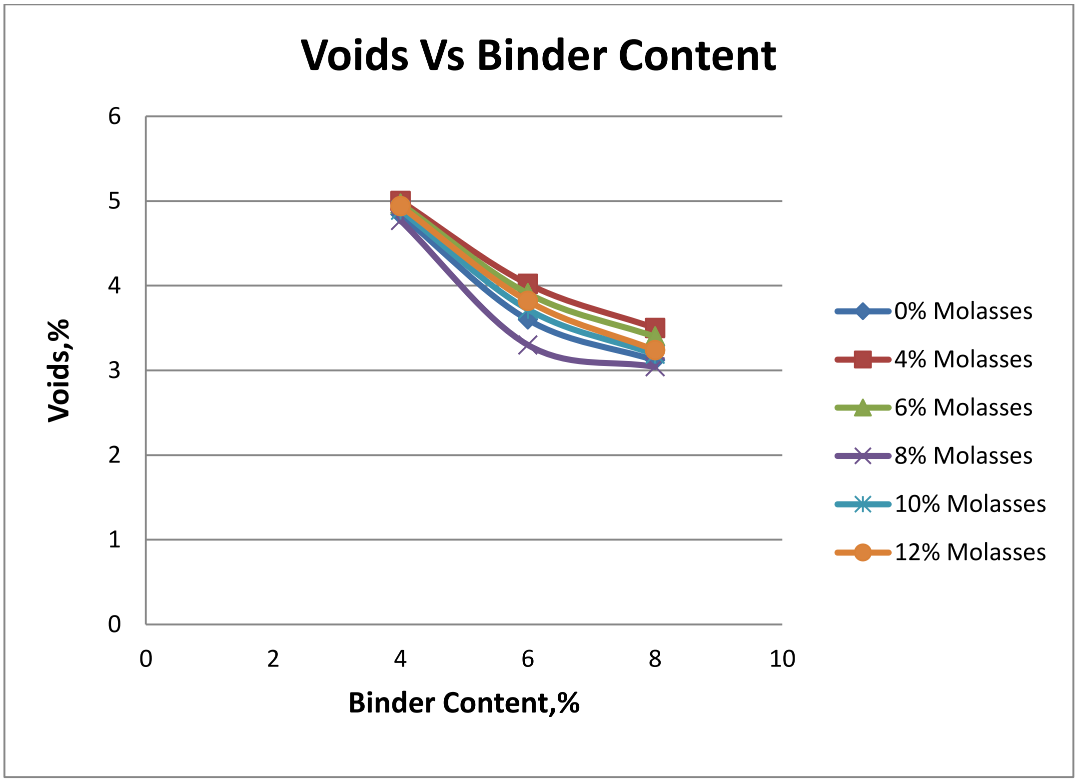

Figure 4.8 Graph between Voids % v/s Binder Content % (Different % of bitumen & molasses)

As shown in the Figure 4.8, as the binder content is increasing, the percentage of the volume of voids is decreasing. We are getting a minimum percentage of the volume of voids at 8% partial replacement of bitumen with sugarcane molasses.

4.6.5. Bulk Unit Weight Vs Binder Content

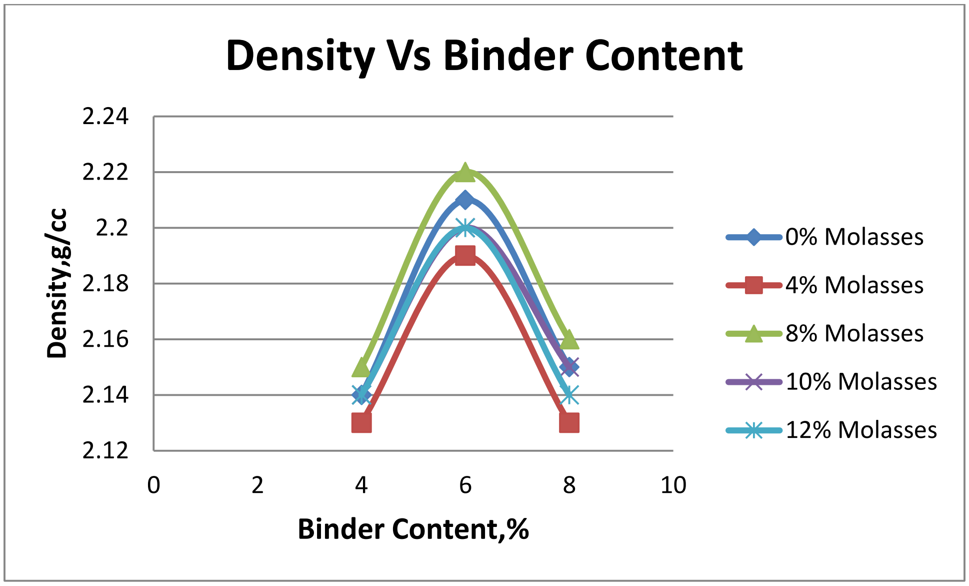

Figure 4.9 Graph between Density v/s Binder Content % (Different % of bitumen & molasses)

As shown in the Figure 4.9, the Bulk Unit Weight of the specimen increases up to optimum binder content. Beyond optimum binder content, the bulk unit weight starts decreasing as now binder starts replacing aggregate thus reducing bulk unit weight. The maximum Bulk Unit weight is obtained at the partial replacement of bitumen with molasses by 8%.

CHAPTER 5

CONCLUSION

Addition of sugarcane molasses has increased certain properties of the binder like Marshall Stability, penetration value, softening point, bulk unit weight etc. at a certain content for a particular grade of bitumen. This can help in increasing the strength of the pavement as well as will help in making road resistance to temperature variation and maintaining a long service life that too using the waste sugarcane molasses. To get ideal content of sugarcane molasses, factors such as, the blending time, temperature, qualities, and source of the Sugarcane Molasses and bitumen type must be considered since these are the variables that administer the subsequent performance of bitumen blends.

5.1 Conclusion

Based on the results of the experiment following remarks can be derived

- Mixing of Sugarcane Molasses shows a great impact on the properties of the Bitumen like Marshall Stability, penetration, ductility, softening Point etc.
- Marshall Stability is maximum at the binder content of 6 % with partial replacement of bitumen of 8 %.
- Penetration Value and Softening Point is increasing withanincrease in the content of sugarcane molasses.
- Ductility Value is decreasing with increase in Molasses Content.
- Change in Molasses Content has not shown an impact on Specific Gravity of Binder

5.2 Recommendations

Thereare following recommendations on the base of the results that are –

- Molasses can be used as a partial replacer of bitumen.
- It may be likely to use lower bitumen when molasses is used.

- 8% molasses with 6% of bitumen can be used to replace partially bitumen binder with molasses. For more resistance to moisture, we may add adhesive agents in the mixture.

5.3 Future study

There is always a possibility for future research in the area of bitumen binders. So future research study may consider: -

- Further studies are required to test different grades of bitumen with different percentages of molasses.
- Further research is required to describe the chemistry of binders including molasses and bitumen binder.
- Like this study determines the optimum value of molasses as 8% and the optimum value of bitumen as 6%. Therefore, further research is required to determine Optimum Molasses Content and also Optimum Bitumen Content.
- Life cycle cost analysis should be considered for the construction of roads using molasses with comparison to the conventional bitumen roads.

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Internal Links

[1] https://www.researchgate.net/publication/299471374_PERCENTAGE_REPLACEMENT_OF_BITUMEN_WITH_SUGARCANE_WASTE_MOLASSES

[2] https://www.britannica.com/topic/molasses

[3] https://www.researchgate.net/project/Replacement-of-Bitumen-with-Waste-Molasses

[4] https://nptel.ac.in/courses/105101087/23-Ltexhtml/p7/p.html

ANNEXURE A

Mix Design Calculations	**Various Tests-** Crushing, Abrasion, Impact, Soundness, Shape-Specific Gravity	**A**

A.1 AGGREGATE TEST RESULTS

Table A.1 : Aggregate Test Results

Test	**Actual Value**
Aggregate Crushing Value	28.70%
Los Angeles Abrasion Value	19%
Aggregate Impact Value	26%
Soundness Value(Using Sodium Sulfate and Magnesium Sulfate)	0.1% & 0.3%
Shape Test(Flakiness&Elongation)	21.64% & 19.56%
Specific Gravity	2.46
Water Absorption	1.95%

A.2 GRADING OF AGGREGATES

Table A.2 : Grading of Aggregate for Marshall Mix Design

Nominal Aggregate Size	13mm
Sieve Size in mm	**Percentage Passing by Weight**
19	100
13.2	79
9.5	70
4.75	53
2.36	42
1.18	34
0.6	26
0.3	18
0.15	12
0.075	4

ANNEXURE B

Modified Bitumen Results	**Various Tests-** Softening Point Penetration, Ductility, Specific Gravity	**B**

B.1 Softening Point Test Results

Table B.1 : Softening Point Test Results

Molasses Content in %	**Softening Point Value in °C**
0	49
4	51
6	51
8	52
10	52
12	52

B.2 Penetration Test Results

Table B.2 : Penetration Test Results

Molasses Content in %	**Penetration Value in mm**
0	61
4	64
6	66
8	67
10	70
12	72

B.3 Ductility Test Results

Table B.3 :Dutility Test Results

Molasses Content in %	**Ductility Value in cm**
0	55
4	53
6	50
8	48
10	45
12	41

B.4 Specific Gravity Test Results

Table B.4 : Specific Gravity Test Results

Molasses Content in %	**Specific Gravity**
0	1
4	1
6	1
8	1
10	1
12	1

ANNEXURE C

Marshall Mix Design	**Marshall Stability Test**	**C**

C.1 Marshall Stability Value

Table C.1 : Marshall StabilityValue (in kN) Test Results

Binder Content in %	**At 0% Molasses**	**At 4% Molasses**	**At 6% Molasses**	**At 8 % Molasses**	**At 10 % Molasses**	**At 12% Molasses**
4	3.5	2.8	3.6	4.5	3.8	3.1
6	8.1	6.8	7.1	8.6	7.9	7.2
8	7.7	5.9	6.9	8.2	7.7	7

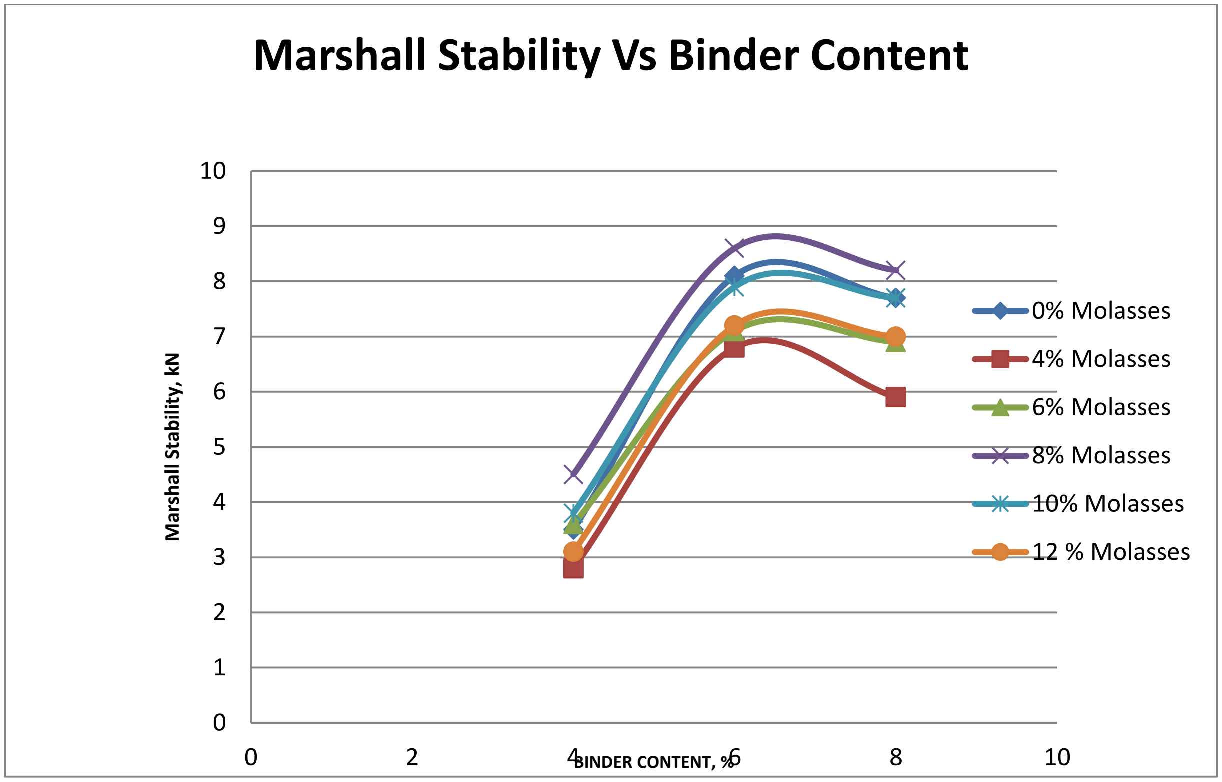

Figure C.1 Graph between Marshall Stability v/s Binder Content (different % of bitumen& molasses)

C.2 Flow Value VS Binder Content

Table C.2 : Flow Value (in .25 mm units) Test Results

Binder Content in %	**At 0% Molasses**	**At 4% Molasses**	**At 6% Molasses**	**At 8 % Molasses**	**At 10 % Molasses**	**At 12% Molasses**
4	2.43	2.7	2.6	2.3	2.45	2.47
6	3.3	3.6	3.5	3.1	3.34	3.36
8	4.35	4.64	4.6	4.12	4.4	4.45

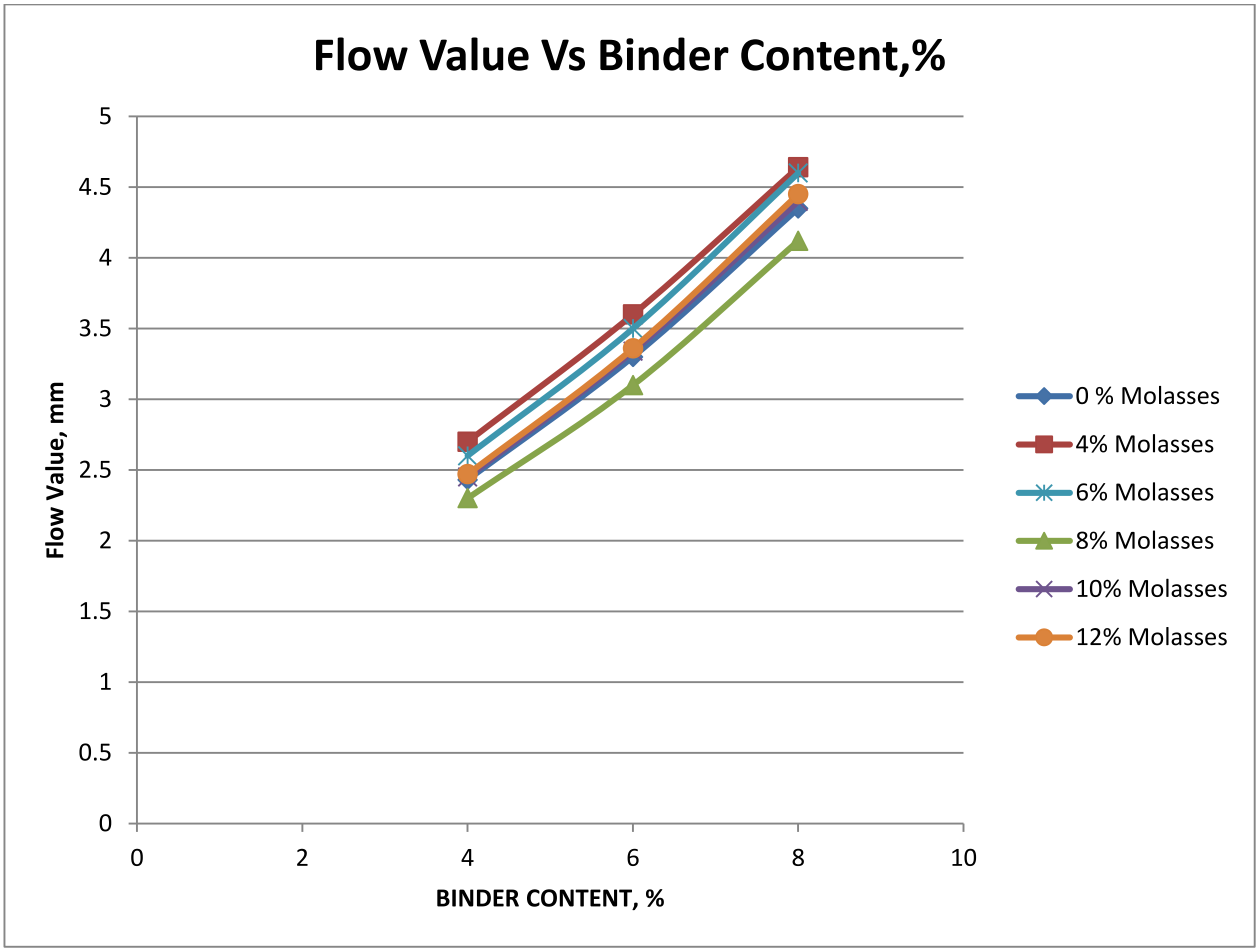

Figure C.2 Graph between Flow value v/s Binder Content % (Different % of bitumen & molasses)

C.3 VFB VS Binder Content

Table C.3 : Voids Filled with Bitumen (in %) Test Results

Binder Content in %	At 0% Molasses	At 4% Molasses	At 6% Molasses	At 8 % Molasses	At 10 % Molasses	At 12% Molasses
4	68	66	66.3	71	67.5	67
6	77	75	75.6	79	76.4	76
8	79	77	77.7	81	78.7	78

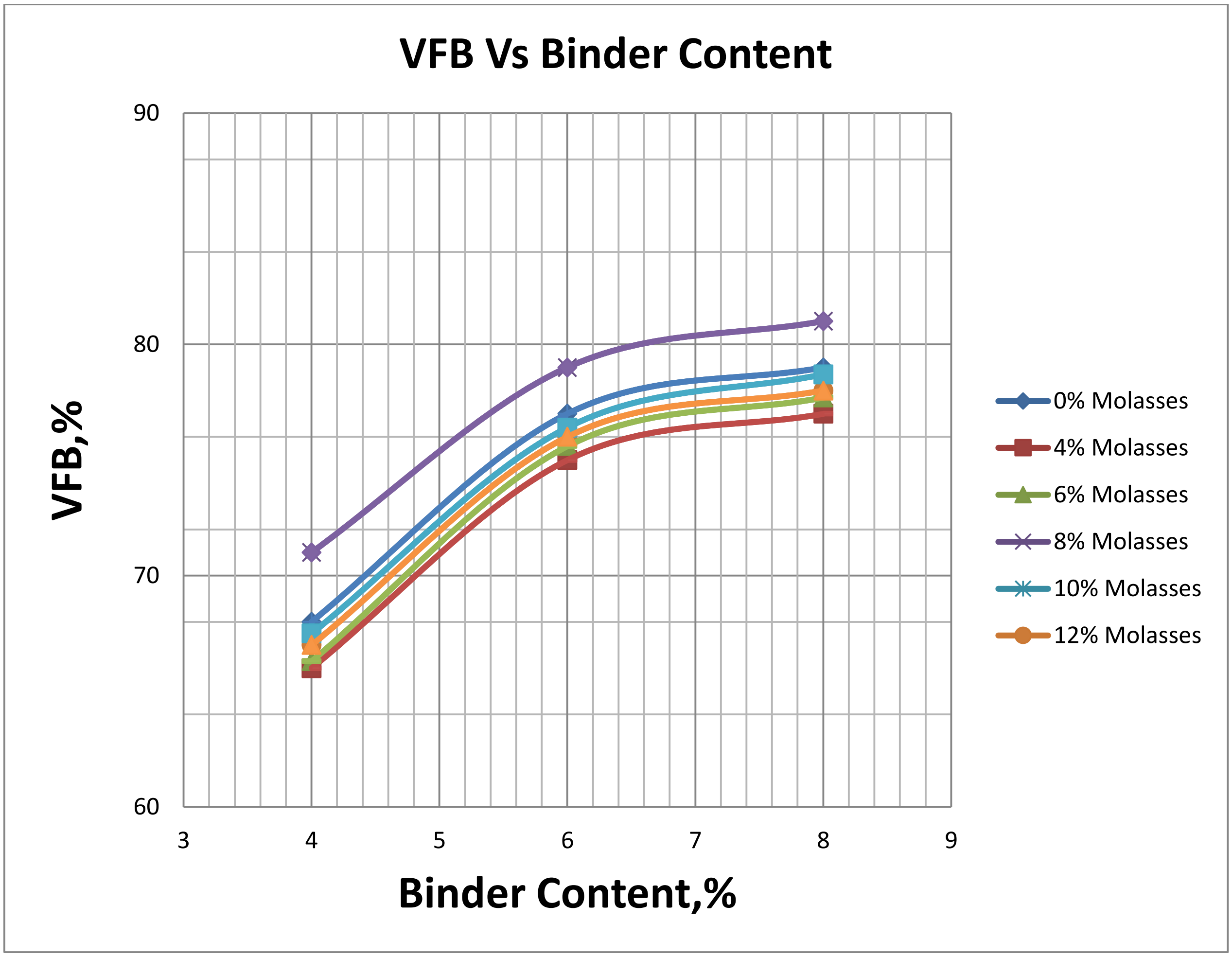

Figure C.3 Graph between VFB% v/s Binder Content % (Different % of bitumen & molasses)

C.4 Voids Vs Binder Content

Table C.4 : Voids (in %)Test Results

Binder Content in %	At 0% Molasses	At 4% Molasses	At 6% Molasses	At 8 % Molasses	At 10 % Molasses	At 12% Molasses
4	4.84	5	4.97	4.77	4.89	4.94
6	3.6	4.02	3.91	3.3	3.72	3.82
8	3.12	3.5	3.4	3.04	3.19	3.24

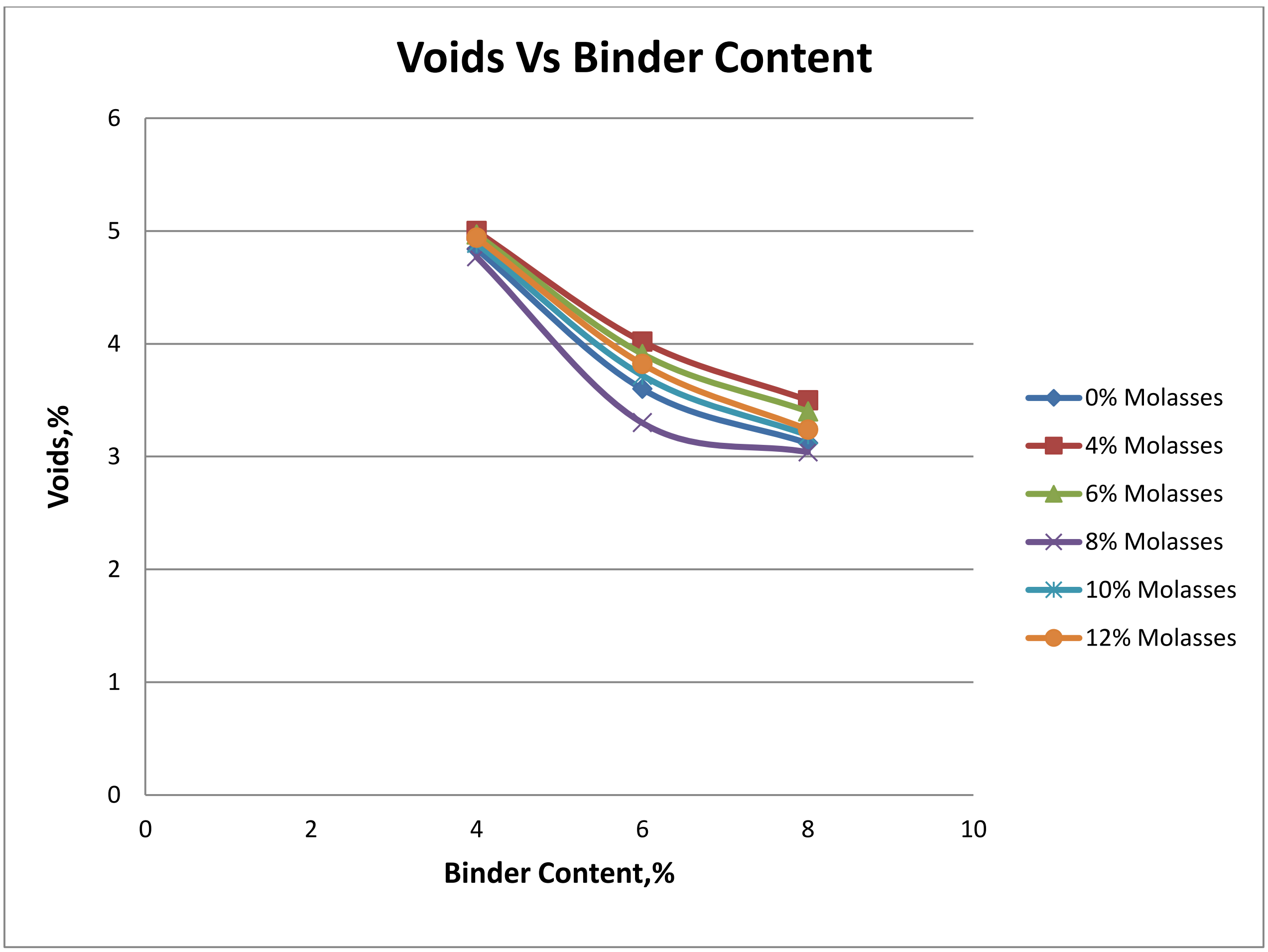

Figure C.4 Graph between Voids % v/s Binder Content % (Different % of bitumen & molasses)

C. 5 Bulk Unit Weight Vs Binder Content

Table C.5 : Bulk Unit Weight (in g/cc) Test Results

Binder Content in %	At 0% Molasses	At 4% Molasses	At 6% Molasses	At 8 % Molasses	At 10 % Molasses	At 12% Molasses
4	2.14	2.13	2.13	2.15	2.14	2.14
6	2.21	2.19	2.19	2.22	2.2	2.2
8	2.15	2.13	2.13	2.16	2.15	2.14

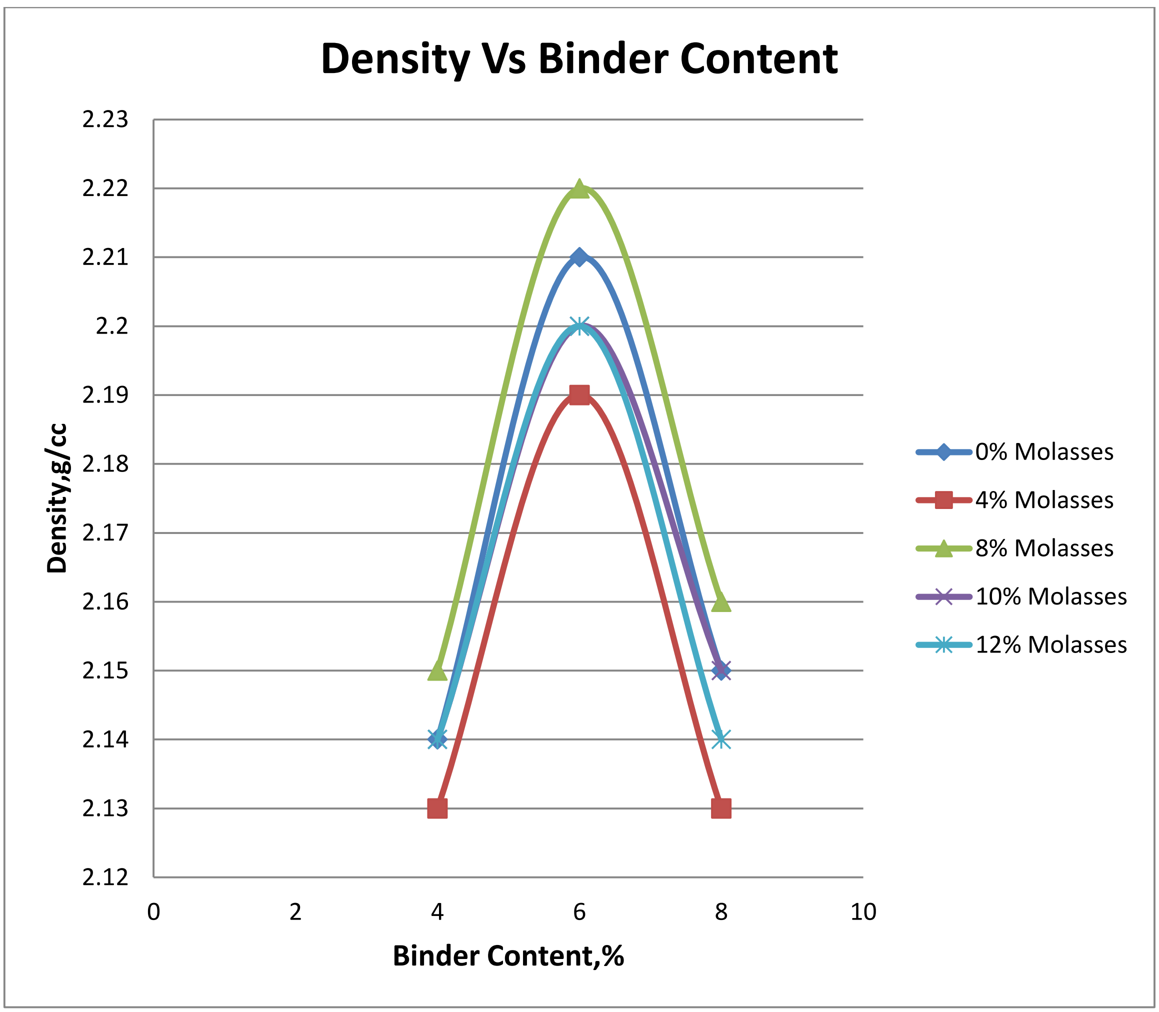

Figure C.5 Graph between Density v/s Binder Content % (Different % of bitumen & molasses)

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