USE OF MODIFIED BITUMEN BY LIGNIN AND WASTE PLASTIC IN BITUMINOUS CONCRETE

A Project submitted

in Partial Fulfillment of the

Requirement for the Degree of

MASTER OF TECHNOLOGY

in Transportation Engineering
by

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CERTIFICATE

Certified that **SHIVAM VERMA (ROLL NO. 1180465008)** has carried out the research work presented in this project entitled **"USE OF MODIFIED BITUMEN BY LIGNIN AND WASTE PLASTIC IN BITUMINOUS CONCRETE"** for the award of **MASTER OF TECHNOLOGY** (TRANSPORTATION ENGINEERING) from Babu Banarasi Das University, Lucknow, under my guidance and supervision. The project embodies results of original work, and studies are carried by the student himself and the contents of the project do not from the basis for the award of any other degree to the candidate or to anybody else from this or any other university.

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DECLARATION

I, hereby declare that the work which is being presented in the **MASTER OF TECHNOLOGY** Thesis Report entitled **"USE OF MODIFIED BITUMEN BY LIGNIN AND WASTE PLASTIC IN BITUMINOUS CONCRETE",** in fulfillment of the requirements for the award of the MASTER IN TECHNOLOGY in **Transportation Engineering (Civil Engineering)** and submitted to the Department of Civil Engineering of Babu Banarasi Das University, Lucknow (U.P) is an authentic record of our own work carried out during the period of August 2018 to June 2020 under the guidelines of **Prof. D.S. Ray, Department of Civil Engineering.** The matter presented in this thesis report has not been submitted by me for the award of any other degree elsewhere.

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ABSTRACT

A nation's development mainly depends on the development of transportation of the country. As flexible pavement is majorly used in India, it is important that steps has to be taken to increase the life of the bituminous pavements. Flexible pavement is often subjected to problems like rutting, cracking, and other failures due to repeated traffic loads and also emits large quantities of CO_2, CH_4 and N_2O. In this project, we have used the waste materials like lignin and plastic as a replacement material for bitumen in the percentage of 2&2%, 4&4%, 6&6%, 8&8%, 10&10%, 12&12% respectively. It has been found that waste material lignin and plastic can act as a binding material for asphalt hence improving the properties of the bitumen and also contributes to reduce CO_2, CH_4 and N_2O emissions. By the mix proportions which is analyzed and determined by series of tests like penetration, ductility, softening point, Flash & Fire point and Marshall Stability test. it is found that the mix proportion of 8&8% has efficient results when compared to other proportions used.

Key Words - Bitumen, Lignin, aggregate, Plastic

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Bitumen is widely used for the construction of highway and airport pavements, which together account for approximately 85% of the worldwide consumption of bitumen. Generally, hot mix asphalt emits large quantities of CO_2, CH_4 and N_2O. This material is part of the high carbon emissions disaster area of the high-way industry, which is unfavorable to the development of a low-carbon economy. The usage of alternative sustainable binders (Lignin &plastic), which can replace the bitumen, contributes to reduce CO_2, CH_4 and N_2O emissions.

Another challenge for the bitumen industry is that the petrochemical industry is becoming more and more efficient in breaking down higher chain hydrocarbons to lower chain hydrocarbons with higher added value than bitumen. This has an effect on the availability and quality of bitumen. The use of alternative sustainable binders broadens the availability. The alternative polymer that will be used as a partly alternative for bitumen originates from nature and is called lignin.

Lignin is one of the most abundant naturally occurring polymer present in plant material. Compared to bitumen lignin has high amount hydroxyl group. It makes lignin more hydrophobic and more compatible with lignin. Composition of lignin varies from species to species. An example of composition from an aspen sample is 63.4% carbon, 5.9% hydrogen, 0.7% ash (mineral component) & 30% oxygen. Approximate formula is $(C_{31}H_{34}O_{11})_{n}$. The chemical structure of lignin known to us today does reflect the structure of bitumen and therefore it could be used as an alternative for bitumen. In the present study, the VG-10 grade bitumen is used. The paper describes the proof of concept in using waste material lignin &plastic, as partial replacement of bitumen without losing its functionality. It has been found that lignin &plastic act as a binding material for asphalt hence improving the property of bitumen and reduce the emissions of CO_2, N_2O, CH_4 & also solve the problem of disposal of waste plastic. It also increased the strength & performance of the road.

1.2 BACKGROUND OF STUDY AND JUSTIFICATION

Lignin and plastic waste are incredible concern. Finding appropriate use for the waste plastic and lignin is the need of great importance. In India adaptable asphalt is significantly utilized. A Flexible asphalt is the one which comprise of different granular alongside bituminous layer on top. Because of increment in vehicle and populace, the asphalts are exposed to overwhelming traffic wheel loads, variable temperatures and so forth. This leads to deformation of asphalt which might be caused incidentally or changeless. The most widely recognized troubles discovered are rutting, water harm and warm breaking. Henceforth it is significant that progression has been taken to expand the life of bituminous asphalts. As there is expanding request in parkway development, specialists and researchers are attempting to improve the exhibition of bituminous asphalt. Black-top cements are generally utilized in asphalts. Bitumen is the normally happening result of unrefined petroleum. Because of increment in vehicles in ongoing year the street surface has been presented to high traffic bringing about deformation of asphalts because of over the top pressure. Asphalt distortions happens when asphalt doesn't have adequate solidness, ill-advised compaction and lacking asphalt quality. The presentation of asphalt is dictated by the properties of bitumen. Bitumen is a viscoelastic material with reasonable mechanical and rheological properties for water sealing and defensive covering for rooftops and streets, as a result of its great grip properties. One of the most significant properties of bitumen blend is its capacity to oppose pushing and rutting under traffic. Subsequently solidness ought to be all the more enough to deal with traffic sufficiently, yet not more than the traffic models require. Low dependability cause disentangling and stream of the street surface. A few upgrades in pavements properties have been accomplished by choosing the best possible beginning rough, to make black-top. From down to earth experience it is demonstrated that the adjustment of black-top cover with polymer added substances, offers a few advantages. To upgrade the different building properties of black-top numerous modifiers, for example, lignin, polyethene based polymers, styrene-based polymers, polychloroprene and different oils have been utilized in black-top. Lignin is a natural restricting material that ties the cells, strands and vessels which comprise wood and the lignified components of plants, as in straw. It is the second most plentiful sustainable carbon source on Earth. Around 40 and 50 million tons of lignin are delivered worldwide as a generally non popularized squander item yearly. Lignin delivered from mash and paper businesses. The utilization of Plastic has been expanded step by step. On account of all these there is an expanded use of plastic the removal of plastic has gotten troublesome.

In India 16.5 million tone of plastic are produced annually and only 3 to 4 million tons of waste plastic are recycled. Disposal of waste materials including waste plastic has become a serious problem and waste plastics are burnt for apparent disposal which cause environmental pollution. This one of the best ways to use of these waste material lignin and plastic in bituminous road.

1.3 PROJECT ACTIVITIES

The waste material lignin and plastic could be used in road construction and the field tests withstood the stress and proved that waste materials lignin and plastic used after proper processing as an additive would enhance the life and strength of pavement and also minimizing the cost of bitumen. The present study highlights the developments in using waste material lignin and plastic to make bituminous pavements. The rapid rate of urbanization and development has led to increased lignin and waste plastic production. As plastic is a non-biodegradable, it remains in environment for numerous years and disposing waste plastic at landfill are unsafe since toxic chemicals percolate out into the earth, and under-ground water and pollute the water bodies. Due to littering routines, insufficient waste management scheme, disposal of the waste plastic and lignin is a big problem for the civic authorities, especially in the urban areas. As mentioned above, disposal of the waste materials lignin and plastic is one of the serious problems for developing of country like India, at a same time India needs a large network of roads for its smooth economic and social development. Scarcity of bitumen need a deep thinking to ensure fast pavement construction.

At present the disposal of waste materials lignin and plastic has become a major waste management problem in the world. Hence in this present investigation efforts have made to identify the potential application of waste material lignin and plastic in civil engineering projects. In present study the aim is to is to investigate the optimum use of waste material lignin and plastic in bitumen for road pavement construction.

1.4 OBJECTIVE OF THE STUDY

1.4.1 GENERAL OBJECTVE

The main objective of the experimental investigation is to provided tools to evaluate and to improve the properties of pavement using waste material lignin and plastic such that it may be more confidently in roadways and driveways etc.

1.4.2 SPECIFIC OBJECTIVE

Keeping in the view of the above point the following specific objective have been set for study.

- To study the strength and stability characters of BC mix for VG-10 bitumen.
- To study on lignin and plastic modified asphalt mixtures to evaluate engineering properties using marshal stability.
- To study basic properties of aggregates and plain bitumen.
- To study the effect of waste material lignin and plastic on strength and stability characteristics of BC mix.
- To study of waste material lignin and plastic as useful binding material, save the bitumen concrete road.
- To mix the aggregate with the waste material lignin and plastic.
- To check the properties of bituminous mix specimen with mixing of waste material lignin & plastic.
- To find a suitable alternative over conventional material with cost reduction and improvement in strength and other parameter in flexible pavements.
- To study strength characteristics of waste material lignin and plastic and performance of stability characters of BC mix

1.5 SIGNIFICANCE OF THE STUDY

This study will be conducted to explore the idea about use of waste material in bituminous concrete with detailed laboratory Investigation will be carry out to find whether it is viable to use or not in terms of suitability, economically and environmentally. The present study will focus basically on these following points.

- Generally, traditional hot mix asphalt emits large quantities of CO_2, CH_4 and N_2O. The usage of alternative sustainable binders (lignin and plastic), which can replace the bitumen, contributes to reduce CO_2-emissions and at the same time broadens the availability of binders.
- To study the basic physical and mechanical properties of waste material lignin and plastic in order to contribute a better knowledge of its properties.
- To study the effect on Marshall Stability of bituminous mix with the addition of waste material lignin and plastic.
- To reduce the bitumen content by the addition of Waste material lignin and plastic in bituminous mix.
- Reduced the emissions of CO_2, N_2O and CH_4 gases and avoid the use of anti-stripping agents.
- As plastic and lignin are added to the aggregates, the moisture absorption ability of the aggregates decreases, resulting in better resistance to rain.
- Increase the strength and performance of pavement.
- Develop a technology, which is eco-friendly and no toxic gas evaluation.

1.6 SCOPE OF THE STUDY

The scope of the study to utilization of lignin and waste plastic in asphalt mixes modification to improve the performance of asphalt mixes and decrease pavement damage like rutting, thermal cracking and water damage.

1.7 CONCEPT OF LIGNIN AND PLASTIC ROAD

The lignin and waste plastic use in bituminous concrete concept is a recently developed idea that entails the creation of roads from recycled waste plastic and lignin. It features a prefabricated, modular and hollow road structure, all features that make the process of road construction easier faster and convenient compared to traditional road construction technique.

1.7.1 PROCESS OF LIGNIN AND PLASTIC ROAD

- **Wet Process**

  In this process lignin and waste plastic directly mixed with hot bitumen at 160 degree Celsius since a wet process require a lot of investment and bigger plants addition of stabilization and proper cooling mechanical stirrer is needed.

- **Dry process**

  This method involves collecting the lignin and waste plastic. The waste plastic putting them through a simple dry tumbling machine to shake of the dirt. The plastic cut into various pieces using shredding machine. It is sieved. The cut plastic pieces passing through 4.75 mm sieve and retaining at 2.36 mm sieve. To improve the compatibility of the lignin in asphalt, organic liquids is added to the mixture. Creosote and kerosene are effective in improving dispersion of lignin in the asphalt. The lignin and pieces plastic are then added slowly to the heated aggregate nearly 175^0C. This gives a uniform coating of lignin and waste plastic over the aggregates and the heated bitumen was added on it. A uniform mix is obtained. This uniform mix used in the constructions of the roads.

1.7.2 WHY USE LIGNIN AND WASTE PLASTIC IN BITUMINOUS CONCRETE

- Lignin and Plastic is a good binder
- Lignin and Plastic increase the melting point of the bitumen
- Durable and Corrosion resistant
- Economical and Longer life
- Improves aggregate impact value
- Light weight
- Maintenance Free
- Ease of Processing and Installation

1.7.3 ADVANTAGES AND DISADVANTAGES OF LIGNIN & PLASTIC ROAD

1.7.3.1 ADVANTAGE OF LIGNIN & PLASTIC ROAD

- Strong road with increased Marshal Stability Value.

- This is a very simple technology which does not involve any special machines deployment or other advanced skilled professionals.
- No stripping of road happens as provide considerably durability.
- Increase binding and better bonding of the mix.
- Reductions in pores in aggregate and hence less rutting and reveling.
- Use of higher percentage of lignin and waste plastic. Reduce the need of bitumen by around 8% to 10%.
- No effect of radiation likes UV.
- The cost of the road construction is also decreased.
- The maintenance of the road is almost nit.
- As plastic and lignin are added to the aggregates, the moisture absorption ability of the aggregates decreases, resulting in better resistance to rain.
- Higher resistance to rain and waterlogging.
- Increase the strength and performance of road.
- Contribute to eco-friendly technology.
- Reduced the emissions of toxic gas like CO_2, N_2O and CH_4.
- Disposal of lignin and waste plastic will no longer be a problem.
- The load is withstanding property increased. It helps to satisfy today's need for increased road transport.

1.7.3.2 DISADVANTAGE OF LIGNIN & WASTE PLASTIC ROAD

- Cleaning process- Toxics present in the co-mingled plastic waste would start leaching.
- During the road laying process- in the presence of chlorine will release noxious HCL gas.
- The component of the road, once it has been laid, or not inert.

CHAPTER 2

LITERATURE REVIEW

2.1 STUDIES ON LIGNIN AND WASTE PLASTIC FOR BITUMINOUS CONCRETE

2.1.1 MINAKSHI SINGHAL et al. (MAY 06)[35]

Flexible pavements with bituminous surfaces are widely used. Due to increased traffic intensity of roads, overloading of commercial vehicle and temperatures variations of pavements due to climatic changes leads to formation of various distresses like rutting, bleeding cracking, shoving and potholing of bituminous surfacing**.** Due to high temperatures, bitumen becomes very soft in summer and brittle in winter. Also, in developing country like in India, roadway construction taking place at a very high pace which require large demand of construction material that too eco-friendly and economical. Several studies have revealed that properties of bitumen and bituminous mixes can be improved or modified with addition of certain additives and the bitumen premixed with these additives or modifiers is known as "modified bitumen". The present study aims for use of modified bitumen by using plastic waste for road construction. The paper includes details of literature and methodology of using modifiers in bitumen and aims to provide highway construction in an eco-friendly and economical way. The modified bitumen mix shows better binding property, stability, density and more resistance to water.

2.1.2 Dr. R. Vasudevan (2007)[45]

This paper investigated that the coating of plastics reduces the porosity, absorption of moisture and improves soundness. The polymer coated aggregate bitumen mix forms better material for flexible pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient.Hence the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastics. Use of plastic bags in road help in many ways like Easy disposal of waste, better road and prevention of pollution.

2.1.3 Raji (2007)[44]

This paper studied the Utilization of marginal materials as an ingredient in bituminous mixes. They concluded that when plastic wastes can be used as additives on bituminous pavements. Hence in their study, the properties of bituminous mix when modified with shredded syringe plastic waste were investigated. The work was carried out by mixing shredded autoclaved plastic syringes with heated aggregates by dry process.

2.1.4 Amit Gawande (2012)[2]

The quantum of plastic waste in municipal solid waste is increasing due to increase in population, urbanization, development activities and changes in life style which leading widespread littering on the landscape. Disposal of waste plastic is a menace and become a serious problem globally due to their non-biodegradability and un aesthetic view. Since these are not disposed scientifically & possibility to create ground and water pollution. This waste plastic partially replaced the conventional material to improve desired mechanical characteristics for particular road mix. In conventional road making process bitumen is used as binder. Such bitumen can be modified with waste plastic pieces and bitumen mix is made which can be used as a top layer coat of flexible pavement. This waste plastic modified bitumen mix show better binding property, stability, density and more resistant to water.

2.1.5 Swami (2012)[3]

In this paper the Use of waste plastic in the construction of bituminous Road. They concluded that plastic waste consisting of carry bags, cups and other utilized plastic could be used as a coating over aggregates and this coated stone could be used for Road construction.

2.1.6 A. J. CHAVAN et. al. (may 2013)[7]

Disposal of waste materials including waste plastic bags has become a serious problem and waste plastic are burnt for apparent which cause environmental pollution. Utilization of waste plastic bags in bituminous mixes has proved that these enhance the properties of mix in addition to solving disposal problem. Plastic waste which is cleaned is cut into a size such that it passes through 2-3mm sieve using shredding machine. The aggregates mix is heated, and the plastic is effectively coated cove the aggregate. The plastic waste coated cover is mixed with hot bitumen and the resulting mix is used for road construction. The use of the innovative technology will not only strengthen the road construction but also increased the road life as well as will help to improve the environment. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50^0C and torrential rains create havoc, leaving most of the roads with big potholes. In my research work I have done a study on the methodology of using plastic waste in bituminous mixes and presented the various tests performed on aggregates and bitumen.

2.1.7 Hemmila V. (2013)[27]

The study represents the use of waste material like lignin in hot bituminous mixes to intensify pavement performance, protect environment and provided low cost roads.

2.1.8 R.Vasudevan (2015)[42]

This paper studied the addition of natural or synthetic polymers to bitumen is known to impart enhanced service properties By adding small amounts of polymers to bitumen, the life span of the road pavement is considerably increased and the purpose is to achieve desired engineering properties such as increased shear modulus and reduced plastic flow at high temperatures and increased resistance to thermal fracture at low temperatures.

2.1.9 P. J. Gundaliya (2016)[36]

This paper studied the viability of utilizing lignin as an antioxidant for arresting the aging of the bituminous binder. Oxidation is the primary cause of long-term aging in asphalt pavements. As a pavement oxidizes, it stiffens and can eventually crack. The use of an antioxidant as a performance enhancer in an asphalt binder could delay aging, thus increasing the life of an asphalt pavement. Lignin is highly available and well-studied antioxidant.

2.1.10 Dave van Vliet (2016)[18]

This paper studied the Bio-based waste is used to improve properties and environmental sustainability by shifting from fossil- based resources to bio-based resources. Bio-based resources are in favor from the sustainability point of view: they are renewable and do not contribute to climate change, as CO_2 is captured from the atmosphere as a result of photosynthesis in the original vegetal source. The usage of alternative sustainable binders, which can replace the bitumen, contributes to reduce CO_2-emissions. The paper describes the proof of concept in using lignin, as replacement or partial replacement of bitumen without losing its functionality.

2.1.12 R. MANJU et al. (MAY 2017)[43]

The waste plastic and its disposal a major threat to the environment. Which results in pollution and global warming. The utilization of plastic waste in bituminous mixes enhance its properties and also its strength. In addition, it will also be a solution to plastic disposal and various defects in pavement viz., pot holes, corrugation, ruts etc. the waste plastic used are poly-ethylene, poly-styrene, poly-propylene. The waste plastic is shredded and coated over aggregate and mixed with hot bitumen and resulted mix is used for pavement construction. This will not only strengthen the pavement and also increases its durability. The titanium-dioxide is used as a smoke absorbent material, which will absorb the smoke from the vehicles. This innovative technology will be boon for India hot-humid climate. It’s economical and eco-friendly. In this paper, we have discussed about the soil properties to be considered in design of pavement, process of construction flexible and plastic smoke absorbent pavement.

2.1.12 A. Logeshkumaran (2018)[8]

This paper studied the used of waste materials like lignin and plastic as a replacement material for bitumen in the different percentage. It has been found that lignin and plastic can act as a binding material for asphalt hence improving the properties of the bitumen. The usage of alternative sustainable binders, which can replace the bitumen, contributes to reduce CO_2-emissions and at the same time broadens the availability of binders and also increased the strength & performance of road.

2.2 LIGNIN

Lignin, derived from the Latin term lignum meaning “wood”, is an integral part of the secondary cell walls of plants. Lignin is an organic binding material that binds the cells, fibers and vessels which constitute wood and the lignified elements of plants, as in straw. It is the second most abundant renewable carbon source on Earth. About 40 and 50 million tons of lignin produced annually from pulp and paper industries worldwide as a mostly non commercialized waste product annually. Compared to bitumen lignin has high amount hydroxyl group. It makes lignin more hydrophobic and more compatible with lignin. Lignin contains a large-amount of phenolic groups, making it an effective antioxidant.

Composition of lignin varies from species to species. An example of composition from an aspen sample is 63.4% carbon, 5.9% hydrogen, 0.7% ash (mineral component) & 30% oxygen. Approximate formula is $(C_{31}H_{34}O_{11})_{n}$. Lignin is a hydrocarbon and consists mainly of carbon, hydrogen, and oxygen. Lignin constitutes 30% of non-fossil natural carbon and 20-35% of the dry mass of the wood. Lignin is a hydrocarbon and consists mainly of carbon, hydrogen, and oxygen. It is insoluble in water and liquor however dissolvable in feeble soluble arrangement. Lignin an intricate, cross-connected polymer, involving phenyl propene units, that is found in many plant-cell dividers. Its capacity gives off an impression of being to concrete together and stay cellulose strands and to harden the cell divider. Lignin lessens disease, spoil, and rot of cells in plant. It is among the most artificially latent of plant substances and gets by in fossils of woody stems.

Fig. 2.1 LIGNIN

The most important type of lignin includes Lignosulfonates, Soda lignin, Kraft lignin, and Hydrolyzed lignin. Lignosulfonates are the most commercial source of lignin that are available at low cost. These are anionic polymers that are typically soluble in water and obtained as a byproduct during the sulfite process of paper pulping. Low cost and eco-friendly nature of lignosulfonates have increased popularity of lignosulfonates in numerous applications. Lignosulfonates are commercially available in various product forms such as calcium lignosulfonates, sodium lignosulfonates and magnesium lignosulfonates.

Lignosulfonates have a long history of use on roads as a method for dust control and surface stabilization. Lignosulfonate road products are derived from the lignin that naturally binds cellulose fibers together to give trees and plants firmness. These products are a safe and economical alternative to petroleum and salt-based products that are also applied to road surfaces. Lignosulfonates have a natural adhesive property when moist. When applied to dirt roads, the lignosulfonate solution coats individual road particles with a thin adhesive-like film that binds the particles together. It acts as a dispersant, allowing the particles to pack closer together for a stronger surface. Consequently, water uptake by the road bed surface is greatly reduced and the binder is less likely to be washed away by rain.

2.2.1 LIGNIN AS BINDER

Lignosulfonates are an exceptionally powerful and sparing cement, going about as a coupling administrator or "paste" in pellets or compacted materials. Lignosulfonates used on unpaved boulevards reduce biological concerns from airborne clear particles and parity out road surface. The coupling limit makes it a significant piece of Coal briquettes, Biodegradable Plastic, Plywood and atom board, Earthenware creation, Creature reinforce pellets, Carbon dull, Fiberglass security, Manures and herbicides tile stick, Clean suppressants, Soil stabilizers.

2.2.2 LIGNIN AS DISPERSANT

Lignosulfonate keeps the grouping and settling of undissolved particles after suspensions. By joining the atom surface, it shields the particle from being pulled in to various particles and decreases the proportion of water expected to use the thing effectively. The dispersing property makes lignosulfonate supportive in Leather tanning, Cement blends, Concrete admixtures, Clay and earthenware production, Dyes and shades, Pesticides and bug sprays.

2.2.3 LIGNIN AS AN EMULSIFIER

Lignosulfonate adjust emulsions of non-solvent liquids, for instance, water and oil, making them significantly impenetrable to breaking. Lignosulfonates are crushing ceaselessly as emulsifiers in Pesticides, Asphalt emulsions, Wax emulsions, Pigments and dyes.

2.3 Benefits of Lignosulfonates for Road Applications

• **Creates a Denser, Firmer Road Cap –** Lignosulfonate treatment eliminates the sliding hazards of free dirt and gravel by binding it to a hard, skid-resistant surface.

• **Safe for the Environment –** Lignosulfonates are non-toxic when appropriately applied, making them safe for foliage and surface water surrounding roadways. Lignosulfonates are not corrosive like other dust control items and can be applied without unique equipment or clothing.

• **Improves Safety –** By controlling dust clouds, visibility on dirt roads is significantly expanded, adding to driving comfort and safety.

• **Improves Efficiency –** Vehicles can travel over roads treated with lignosulfonates very quickly, eliminating of the need to re-route traffic. Dust is less likely to enter motor parts, reducing equipment maintenance requirement.

• **Reduces Road Repairs –** Hardened road surfaces are less likely to suffer the ribbed "washboard" impact basic with untreated gravel or dirt roads. As a result, frequent grading can be reduced or eliminated.

2.4 SPECIFICATIONS OF SODIUM LIGNOSULFONATES

Table 2.1 Specification of Sodium Lignosulfonates

Items	Standards	Test Results
Visual Appearance	Broun power	Broun power
Water insoluble substance (%)	≤1.5	1
Solid Content (%)	≥92	93
PH Acidity	7.0- 9.0	8

Moisture Contents (%)	≤7	5
Lignosulphonates Contents (%)	≥50	52
Ca Mg (%)	0.3-1.5	0.8
Reducing sugar Contents (%)	≤6	3
Water Reducing of Mortar	≥8	10

2.5 CLASSIFICATION PLASTIC OF PLASTIC

There are two groups of plastic

1. Thermoplastic
2. Thermosets

2.5.1 THERMOPLASTIC

Thermoplastic are those plastics which gets often when heated. They can be easily recycled and used again to manufacture additional products.

Thermoplastic make up 80% of plastic produced today.

Linear polymers and branched polymers are example of thermoplastic

Table 2.2 Examples of thermoplastic

Types of plastic	Uses
High density polyethylene (HDPE)	Used of piping, Automobile fuel tanks, Bottles, Toys.
Low density polyethylene (LDPE)	Used of plastic bag, Cling films, Flexible containers.
Polyethylene Terephthalate (PET)	Used of bottle, Carpets, Food packing
Polypropylene (PP)	Used in food containers battery cases, Bottle crates, Automotive parts of fibers.

2.5.2 THERMOSET

Thermoset are those plastic which can’t be heated and if they are heated, they become hard. Thermoset can’t me remoulade like thermoplastics. Thermoset are valued for their durability and strength.

- Thermoset make up the remaining 20% of plastic produced.
- They are hardened by curing and can’t be re-melted and therefore difficult to recycle. They can sometimes ground and used as a filler material.
- Cross-linked polymers (two or more joined by side chains) are thermosets.

Table 2.3 Examples of Thermoset

Type of plastic	Uses
Polyurethane (PU)	Use of coating, Finished, Gears, diaphragms, Cushions and Car seats.
Epoxy	Used of adhesive, In sports equipment, Electrical and Automotive equipment etc.
Phenolics	Used of ovens, Automotive parts, Circuit boards etc.

2.6 PLASTIC FACT FILE

- It is estimated that 100 million ton are plastic are produced each year.
- More than 20,000 plastic bottles are needed to obtain 1 ton of plastic.
- The world's annual consumption of plastic material has increased from around 5 million tons in the 1950's to nearly 100 million tones today.
- In India the consumption of plastic has more than doubled since 1995-2000 from about 1.8 million tones to about 5 million tones today.
- Plastic consumption is growing about 4% every year in western Europe.
- Plastic packaging total 42% of total consumption and very little of this is recycled.
- One tones plastic is equivalent to 20,000 two little drinks bottles or 120,000 carrier bags.
- Plastic make up around 7% of the average household dustbin.

2.7 BENEFITS OF PLASTICS

The considerable growth in plastic use is due to the beneficial properties of plastics they include:

- Light weight than competing materials, reducing fuel consumption during transportation.
- Extreme durability.
- Extreme versatility and ability to be tailored to meet very specific technical need.
- Resistance to chemicals, water and impact.
- Good safety and hygiene properties for good packaging.
- Excellent thermal and electrical insulation properties.
- Relatively inexpensive to produce.

2.8 SOURCES OF GENERATION OF WASTE PLASTICS

The production and consumption of the plastic is increasing all over the world due to its benefit. And the generation of waste polythene is also increasing at the same rate which is causing a major problem of the world. There are various types of sources which are producing the waste polythene. There sources are classified as below:

Table 2.4 Sources of generation of waste polythene

Sources	**Waste polythene generation**
Household	• Carry bags • Bottles • Containers • Trash bags
Health and medical	• Disposable syringes • Glucose bottles • Blood and euro bags • Intravenous tubes

Hotel and catering	• Packaging items • Minerals water bottles • Plastic plates, Glasses, Spoons • Plastic bags
Air/Rail Travel	• Mineral water bottles • Plastic plates, Glasses, Spoons • Plastic bags

These sources are producing waste polythene in huge amount, improper disposal of waste polythene can cause the problem like breast cancer, reproductive problem in humans and animals, genital abnormalities etc.

CHAPTER 3

METHODOLOGY AND DATA CALCULATION

3.1 BASIC RAW MATERIALS

The materials used are as follows:

1) Aggregates
2) Bituminous binder
3) Lignin
4) Waste Plastic

3.1.1 AGGREGATES

There are various types of mineral aggregates used in manufacture bituminous mixes can be obtained from different natural sources such as glacial deposits or mines or can be used with or without further processing. The aggregate can be further processed and finished to achieve good performance characteristics. Industrial by-product such as steel slag, blast furnace slag, fly ash etc. Sometimes used by replacing natural aggregate to enhance the performance characteristics of the mix. Aggregates contribute up to 90-95% of the mixture weight and contribute to the most of the load bearing and strength characteristics of the mixture. Hence, the quality and physical properties of the aggregates should be controlled to ensure a good pavement. The tests carried out to assure the quality of aggregates includes Aggregate Impact test, Crushing Test, Los Angeles Abrasion Test and Shape test for Flakiness Index and Elongation Index. In addition to the above specific gravity and water absorption tests were also carried out for the aggregate to ensure its suitability for the proposed pavement with modified bitumen. Aggregates are the three types.

3.1.1.1 COARSE AGGREGATES

The aggregates retained on 4.75mm sieve are called as coarse aggregates. Coarse aggregates should be screened crushed rock, angular in shape, free from dust particles, clay, and vegetation’s and organic matters which offer compressive and shear strength and shows good interlocking properties. In my present study, coarse aggregate used with specific gravity 2.75.

Fig. 3.1 Coarse Aggregate

3.1.1.2 FINE AGGREGATES

Fine aggregates should be screened quarry dusts and should be free from clay, Loam, vegetations or organic matter. Fine aggregate consisting of the stone crusher dusts were collected from a local crusher with fractions passing 4.75mm and retained on 0.075mm IS sieve. Its fills the voids in the coarse aggregates and stiffens the binder.

In this study, fine stone and slag are used as fine aggregates whose specific gravity has been found to be 2.6 and 2.45.

Fig. 3.2 Fine Aggregate

3.1.1.3 FILLER

Aggregates passing through 0.075mm IS sieve is called as filler. It fills the voids, stiffens the binder and offers permeability. In this study, stone are used as filler whose specific gravity has been found to be 2.7 and 2.3.

3.1.2 BITUMINOUS BINDER

Bitumen acts as a binding agent to the aggregates, fines and stabilizers in bituminous mixtures. Bitumen must be treated as a viscoelastic material as it exhibits both viscous as well as elastic properties as a normal temperature. At low temperature it behaves like and elastic material and at high temperature its behavior is a like a viscous fluid.

In this research work VG-10 asphalt binder is used. Grade of bitumen used in the pavements should be selected on the basis of climatic conditions and their performance in past. It fills the voids, cause particle adhesion and offers impermeability.

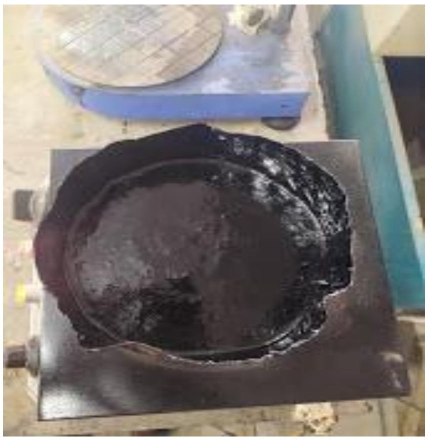


Fig. 3.3 Bitumen VG-10

3.1.3 LIGNIN

Lignin is an organic binding material that binds the cells, fibers and vessels which constitute wood and the lignified elements of plants, as in straw. Compared to bitumen lignin has high amount hydroxyl group. It makes lignin more hydrophobic and more compatible with lignin. One of the most predominant sources of lignin is the paper industry. In the process of paper making tremendous efforts are made to remove as much lignin as possible. The most important type of lignin includes Lignosulfonates, Soda lignin, Kraft lignin, and Hydrolyzed lignin. In this study, Lignosulfonates are used as a binder. Lignosulfonate are the most commercial source of lignin that are available at low cost. Lignosulfonates are commercially available in various product forms such as calcium lignosulfonates, sodium lignosulfonates and magnesium lignosulfonates.

Fig. 3.4 Sodium Lignosulfonates

3.1.4 Waste Plastic

In this present study Polypropylene, Low density polyethylene, High density polyethylene and Polypropylene is used as stabilizing additives to improve the performance characteristics of pavement.

Fig.3.5 Waste Plastic

3.2 MATERIALS USED

3.2.1 AGGREGATES

For preparation of bituminous mixes aggregate as per MORHT grading as given in Table-3.1 respectively. The specific gravity of given in Table- 3.2.

Table 3.1 Aggregates gradation for bituminous concrete

Sieve size (mm)	Percentage passing	Spec. Limit of % passing
40	100	100
25	96.8	85-100
20	73.72	71-95
12.5	60.8	58-82
10	54	52-72
4.75	38	35-50
2.36	35	28-43
0.6	22	15-27
0.3	18	7-21
0.15	11	5-15
0.075	5	2-8

Table 3.2 Specific gravity of aggregates

Types of aggregates	Specific gravity
Coarse	2.71
Fine	2.61
Filler	2.62

3.2.2 BITUMEN

One conventional commonly used bituminous binder, namely VG-10 bitumen was used in this investigation to prepare the samples. There are several tests to be done to find out the physical properties of bitumen. The physical properties thus obtained are summarized in Table- 3.

Table 3.3 Physical properties of binder

TESTS	TESTS RESULTS
Penetration value test at 25^0C	88
Softening point test, ^{0}C	45
Ductility test at, 27^0C	75
Flash point test, ^{0}C	225
Fire point test, ^{0}C	237

3.2.3 LIGNIN

In present study sodium lignosulfonates is used as additive. To improve the compatibility of the sodium lignosulfonates in asphalt, organic liquids were added to the mixture. Creosote and kerosene were effective in improving dispersion of sodium lignosulfonates in the asphalt.

Fig. 3.6 Sodium lignosulfonate mixed with kerosene

3.2.4 WASTE PLASTIC

In present study Polypropylene, Low density polyethylene, High density polyethylene and Polypropylene is used as stabilizing additive. The waste plastics were collected, they were washed and clean by putting them in hot water for 2-3 hours. They were then dried.

3.2.4.1 SHREDDING

The dried waste plastics were cut into small pieces of size 2 mm maximum. This is because to maintain uniformity in size of plastic in mix with aggregate. When waste plastic is to be added with aggregate it is to be ensured that the mixing will be proper. This will help in increasing the properties of the blend and also will make the mixture samples homogeneous.

Specific gravity of waste plastic was found as 0.905.

Fig. 3.7 Shredded Waste Plastic

3.3 PREPARATION OF LIGNIN AND PLASTIC MIXED AGGREGATE

Collection of waste polythene from roads, garbage trucks, dumpsites and compost plants, rag pickers, waste-buyers. Clean and dried waste polythene is shredded into small pieces (2 mm to 4 mm). The initial mixing method involved heating the lignin and Bitumen to about 110 to 180 degree Celsius on a hot plate with a different percentage and mixing them with a spatula for several minute. After the samples of lignin and Bitumen are prepared by the desired process the various tested need to be performed on the samples (Lignin & bitumen). The tests done are penetration test, ductility, softening point, Flash & Fire and find out the optimum bitumen content of Lignin and Bitumen mixed. lignin purchased from market will be in powdered form and need to be heated to approximate temperature of 125°C to make it viscous.

To improve the compatibility of the lignin in asphalt, organic liquids were added to the mixture. Creosote and kerosene were effective in improving dispersion of lignin in the asphalt. The bitumen VG-10 was also heated up to its melting point for good mixing.

The Plastic is also heated to about 110^0C to 180^0C and plastic will be ready to be blended with the bitumen. After analyzing the best mixing time various samples of Plastic and bitumen are prepared at various percentages by volume. The tests done are penetration test, ductility, softening point, Flash & Fire and find out the optimum bitumen content of Plastic and Bitumen mixed.

After heating lignin and plastic will be ready to be blended with the bitumen. As the lignin and plastic is to be blended with bitumen so best mixing time needs to be determined. And for this various samples of same concentration needs to be made and on the basis of test results the best mixing time will be determined. This will help in increasing the properties of the blend and also will make the mixture samples homogeneous.

After analyzing the best mixing time various samples of the bitumen are prepared at various percentages by volume. All the samples prepared need to be homogeneous and mixed to the time determined. After the samples of lignin, plastic & bitumen are prepared by the desired process the various tested need to be performed on the samples.

For Marshall Stability test the aggregate heated up to 160^0C to 170^0C and the prepared sample of Lignin, Plastic and bitumen blended with aggregate at different percentage. After homogeneous mixing the samples are ready to performed for Marshall tests. The tests done are penetration test, ductility, softening point, Flash & Fire and Marshall stability test and find out the best optimum bitumen content of Lignin, Plastic and Bitumen mixed.

Fig. 3.8 Preparation of Lignin and Waste Plastic mixed aggregate

3.4 EXPERIMENTAL WORK ON RAW MATERIAL

The experimental works carried out in this present investigation. It involves mainly two processes. i.e.

- Preparations of Marshall samples
- Tests on samples

In this project the specific gravity of waste plastic used was as per the guidelines provided in ASTM D792-08.

3.4.1. DETERMINATION OF SPECIFIC GRAVITY OF WASTE PLASTIC

The procedure adopted is given below:

1) The weight of the waste plastic in air was measured by a balance. Let it be denoted by "a".
2) An immersion vessel full of water was kept below the balance.
3) A piece of iron wire was attached to the balance such that it is suspended about 25 mm above the vessel support.
4) The plastic was then tied with a sink by the iron wire and allowed to submerge in the vessel and the weight was measured. Let it be denoted as "b".
5) Then plastic was removed and the weight of the wire and the sink was measured by submerging them inside water. Let it be denoted as "w".

The specific gravity is given by:

$$\mathbf{S = a / (a + w - b)}$$

Where: -

a = apparent mass of specimen, without wire or sinker, in air.

B = apparent mass of specimen and of sinker completely immersed and of the wire partially immersed in liquid.

W = apparent mass of totally immersed sinker and of partially immersed wire.

For the experiment, it was found that: -

A = 19gm, b = 24gm, w = 26gm.

S = 19/ (19+26-24) = 19/21 = 0.90476

Take s = 0.905.

3.4.2 TEST ON PREPARED BITUMEN

3.4.2.1 PENETRATION TEST

The penetration of bitumen is defined as the distance in tenth of a millimeter that a standard needle will penetrate into the bitumen under a load of 100 gm applied for five second, at 25^0C. Penetration test is the most usually adopted test on bitumen to grade the material regarding its hardness. Depending on the atmosphere condition, bitumen of different penetration grades is used, in warmer regions lower penetration and in colder regions bitumen with higher penetration value is used.

In penetration test, bitumen is softened at a pouring consistency between 80^0C to 110^0C.The sample material is thoroughly mixed to make it homogeneous and free from air bubbles. The sample material is then filled the containers are allowed to cool in the atmosphere for one hours. At that point it is placed in temperature-controlled water bath at a temperature of 25^0C for a time of 60 minutes. A standard needle is allowed to penetrate into the surface for 5 second under the correct loading. This is done by means of an instrument known as penetrometer. This test is standardized by IS: 1203-1978.

Fig. 3.9 penetration test

S. No.	SAMPLE	PENETRATION
1	1	92
2	2	88
3	3	84

Average Penetration value (VG-10) = $\frac{Penetration\ Value}{No.of\ Samples}$

Average Penetration Value (VG-10) = $\frac{(93+88+84)}{3} = 88$

3.4.2.2 SOFTENING TEST

The softening point is the temperature at which the substance attains a particular degree of softening under specified condition of test. The softening point of a bitumen binder is a temperature at which a disc of the binder softens sufficiently to permit a steel ball, initially placed on the surface, to fall through the disc and a prescribed distance. It is generally determined by Ring and Ball test. Softening point essentially is a temperature at which binder have an equal viscosity. Bitumen with higher softening point might be preferred in warmer place.

In this test, two metal rings are filled up with hot bitumen and permit to cool in air for 30 minutes. The excess bitumen is cut and the rings are put supports. Right now, the temperature of water is kept at 5^0C per minutes. The temperature of water is raised at uniform rate of 5^0C per minutes with a controlled heating unit, unit the bitumen softens and touches the bottom plate by sinking of balls.

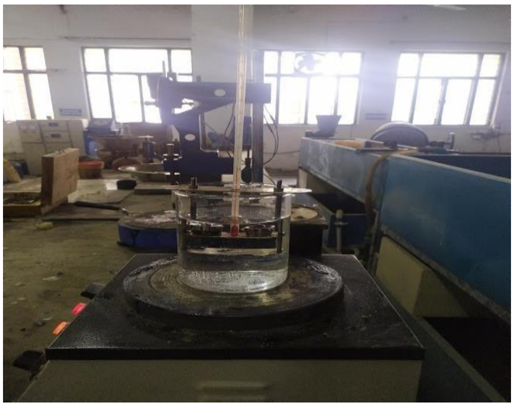


Fig. 3.10 Softening Test

S. No.	Sample	Softening (^{0}C)
1	1	48
2	2	46
3	3	41

Average Softening = $\frac{(48+46+41))}{3} = 45\ ^0$C

3.4.2.3 DUCTILITY TEST

In the flexible pavement construction where bitumen binder is used, it is important that the binder from ductile thin film around the aggregates. The servers as a satisfactory binder is improving the physical interlocking of the aggregate bitumen mixed. Under traffic load the bituminous pavement layer is subjected to repeated deformations and recoveries. The binder material which does not possess sufficient ductility would crack and thus provide pervious pavement surfaces. Ductility test is carried out on bitumen to test property of binder. The ductility is expressed as the distance in centimeters to which a standard briquette of bitumen can be stretched before the thread breaks. The bitumen sample is heated and poured in the mold assembly placed on a plate. The sample along with the molds are cooled in air and then in water bath maintained at 27^{0}C. The mold assembly containing the sample is replaced in water bath of the ductility testing machine for 85 and 95 minutes. The side of the mold are removed, the clips hooks in the machine and the pointer is adjusted to zero. The distance up to the point of breaking of the thread is reported in centimeters as the ductility value.

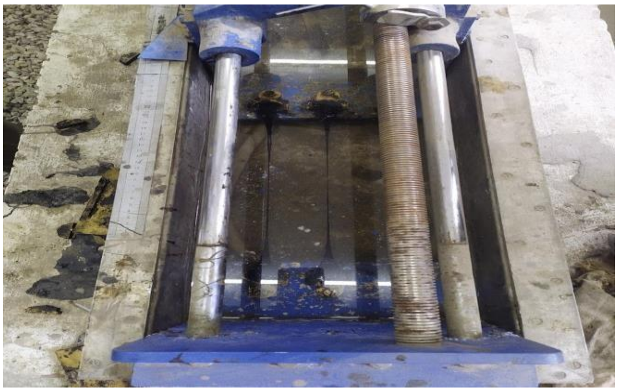


Fig. 3.11 Ductility Test

S. No.	Sample	Ductility (cm)
1	1	79
2	2	74
3	3	71

Average Ductility = $\frac{(79+74+71)}{3} = 75$

3.5 SAMPLE PREPARATION

3.5.1 MARSHALL SAMPLING MOULD

The specification of the Marshall sampling mold and hammer are given in table 3.4.

Table- 3.4 Dimensions of Marshall Sampling Mold & Hammer

APPARATUS	VALUE	WORKING TOLERANCE
	MOULD	
Average internal diameter, mm	101.2	0.5
	HAMMER	
Mass, kg	4.535	0.02
Drop height, mm	457	1.0
Foot diameter, mm	98.5	0.5

Fig. 3.12 Marshall Sampling mold

Fig. 3.13 Marshall hammer

3.5.2 MIXING PROCEDURE

The mixing of ingredients was done as per the following procedure (STP 204-8).

1) Required quantities of coarse aggregate, fine aggregate and mineral fillers were taken in an iron pan. The aggregate was heated to a temperature 165^0 to 190^0C.
2) The bitumen VG-10 was also heated up to its melting point for good mixing.
3) The required amount of shredded waste plastic and lignin was also heated at 110 to 180 degree Celsius on a hot plate, and mixing them with a spatula for several minutes. The mixing was then poured into a container for storage.

4) To improve the compatibility of the lignin in asphalt, organic liquids were added to the mixture. Creosote and kerosene were effective in improving dispersion of lignin in the asphalt.
5) After the prepared mixture of lignin and plastic, the bitumen was added and mixed lignin, plastic and bitumen for 15-20 minutes. The prepared mixture was added to the aggregate and mixed homogenously.
6) Then the mixed was transferred to a casting mold.
7) This mix was compacted by Marshall hammer. The specification of this hammer and height of release etc. are given in Table – 3.4
8) The 75 number of blows were given each side of the samples then these samples with molds were kept separately and marked.
9) The Marshall test specimens were prepared by adding 4, 4.5 and 5 percent of bitumen by weight of prepared mix aggregates using Marshall method of mix design.

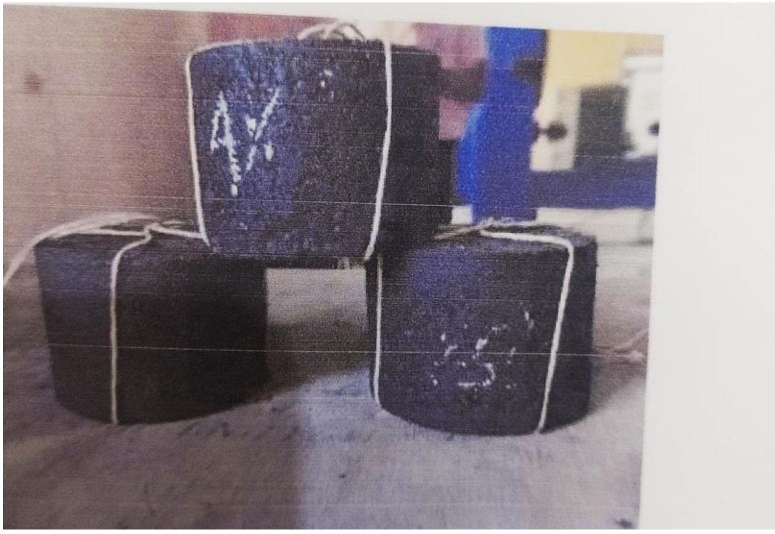
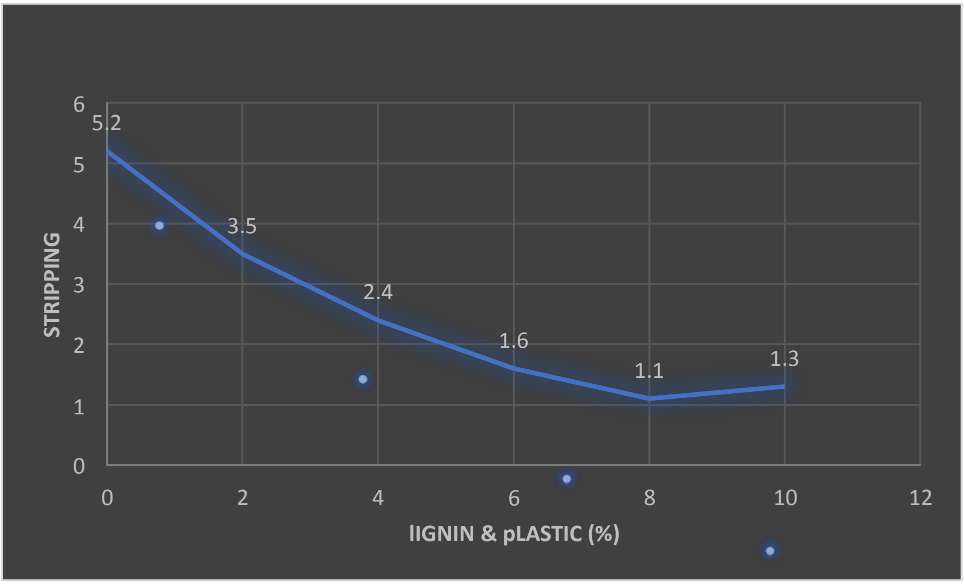


Fig. 3.14 Marshall Sample

3.6 STRIPPING VALUE

Stripping value is the determination of binding strength of aggregate and the bitumen. It is tested by immersing prepared bitumen mix aggregate in water for 24 hours. When prepared bitumen mixes aggregate immersed in water, the water penetrates into the pore and voids of the stone resulting in the peeling of the bitumen. This in turn results in the loosening of the aggregate and forming potholes. 200 gm of prepared mix bitumen was taken and cooled to room temperature and weighted. The mixture was immersed in water bath maintained at 40^0C for 24hrs. After 24hrs the stripping value was observed and percentage of stripping was noted and the result are tabulated in Table – 3.5

Table- 3.5 Stripping Value



3.7 SAMPLE CALCULATION

The various test conducted for the bitumen sample with different proportion of mixing are discussed below.

Sample 1 - Bitumen without replacement

Sample 2 - Bitumen with partial replacement of 2% lignin & 2% plastic

Sample 3 - Bitumen with partial replacement of 4% lignin & 4% plastic

Sample 4 - Bitumen with partial replacement of 6% lignin & 6% plastic

Sample 5 - Bitumen with partial replacement of 8% lignin & 8% plastic

Sample 6- Bitumen with partial replacement of 10% lignin & 10% plastic

Sample 7- Bitumen with partial replacement of 12% lignin &12% plastic

3.7.1 CALCULATION FOR 4%, 4.5% AND 5% OF BITUMEN CONTENT

Weight if the sample in air (Wa) = 1200 gm

Weight of the sample in water (Ww) = 692 gm

Weight of coarse aggregate (W_1) = 715 gm

Weight of fine aggregate (W_2) = 375 gm

Weight of filler (W_3) = 62 gm

Weight of bitumen (W_b) = 48 gm

Specific gravity of coarse aggregate (G_1) = 2.71

Specific gravity of fine aggregate (G_2) = 2.61

Specific gravity of filler material (G_3) = 2.62

Specific gravity of bitumen (G_b) = 1.01

(1) Bitumen content = 4%

Stability = 11.20 KN   Flow value = 3.85 mm

Specific gravity of specimen / Bulk density = Gm

$$Gm = \frac{Wa}{Wa - Ww}$$

$$Gm = \frac{1200}{1200 - 692} = 2.36$$

Theoretical specific gravity with-out considering the air voids = Gt

$$Gt = \frac{W1 + W2 + W3 + Wb}{\frac{W1}{G1} + \frac{W2}{G2} + \frac{W3}{G3} + \frac{Wb}{Gb}}$$

$$Gt = \frac{715 + 375 + 62 + 48}{\frac{715}{2.71} + \frac{375}{2.61} + \frac{62}{2.62} + \frac{48}{1.01}} = 2.50$$

Volume of air voids (Vv), % = $\frac{(Gt - Gm)}{Gt} \times 100$

Vv % = $\frac{(2.50-2.36)}{2.46} \times 100 = 3.25$

Volume of bitumen (Vb), % = $\frac{Wb/Gb}{\frac{W1+W2+W3+Wb}{Gm}}$

Vb (%) = $\frac{48/1.01}{\frac{715+375+62+48}{2.36}} = 9.34$

Voids of mineral aggregate, VMA (%) = Vv+Vb

VMA (%) = 5.61+9.34

VMA (%) = 14.95

Void filled with bitumen, VFB

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

VFB = $\frac{9.34}{14.94} \times 100$

VFB = 62.51

(2) Bitumen content = 4.5 %

Stability = 14.64 KN Flow Value = 3.28 mm

Gm = $\frac{1200}{1200-695} = 2.37$

Gt = $\frac{712+370+64+54}{\frac{712}{2.71}+\frac{370}{2.61}+\frac{64}{2.62}+\frac{54}{1.01}} = 2.48$

Vv (%) = $\frac{2.48-2.37}{2.48} \times 100 = 4.43$

Vb (%) = $\frac{\frac{54}{1.01}}{\frac{712+370+64+54}{2.37}} = 10.55$

VMA (%) = 4.43+10.55

VMA (%) =14.98

VFB (%) = $\frac{10.55}{14.98} \times 100$

VFB (%) = 70.42

(3) Bitumen content = 5 %

Stability = 15.85 KN Flow Value = 3.58 mm

Gm = $\frac{1200}{1200-697} = 2.38$

Gt = $\frac{718+357+65+60}{\frac{718}{2.71}+\frac{357}{2.61}+\frac{65}{2.62}+\frac{60}{1.01}} = 2.46$

Vv (%) = $\frac{2.46-2.38}{2.46} \times 100 = 3.25$

Vb (%) = $\frac{\frac{60}{1.01}}{\frac{718+357+65+60}{2.38}} = 11.78$

VMA (%) = 3.25+11.78

VMA (%) = 15.08

VFB (%) = $\frac{11.78}{15.03} \times 100$

VFB (%) =78.37

Table 3.5 Result of Marshall Test

Bitumen (%)	Lignin (%)	Waste Plastic (%)	Stability (KN)	Flow Value (mm)	Air Voids (%)	Bulk Density (gm/cm^3)	VMA (%)	VFB (%)
4	0	0	11.20	3.85	5.61	2.36	14.95	62.51
4.5	0	0	14.64	3.28	4.43	2.37	14.98	70.42
5	0	0	12.85	3.95	3.25	2.38	15.03	78.37
4	2	2	15.25	3.76	4.63	2.33	15.07	62.82
4.5	2	2	17.38	3.67	4.40	2.35	14.20	70.68
5	2	2	15.20	3.67	3.24	2.37	15.01	78.48
4	4	4	20.20	3.48	4.52	2.32	14.44	63.26
4.5	4	4	19.85	3.32	4.38	2.36	14.72	71.57
5	4	4	17.34	3.54	3.21	2.34	14.82	79.02
4	6	6	22.15	3.34	4.35	2.35	14.17	63.90
4.5	6	6	20.85	3.47	4.35	2.33	14.48	71.82
5	6	6	18.95	3.65	3.86	2.36	14.80	79.84
4	8	8	23.42	3.15	4.34	2.36	13.92	64.40
4.5	8	8	21.80	3.57	4.32	2.37	13.87	72.47
5	8	8	19.14	3.75	2.82	2.38	14.52	80.25
4	10	10	17.45	3.12	4.32	2.35	13.64	64.28
4.5	10	10	17.28	3.21	4.30	2.35	13.72	72.87
5	10	10	15.36	3.18	2.58	2.36	14.23	80.72
4	12	12	9.20	2.99	4.25	2.34	13.52	64.25
4.5	12	12	11.55	3.02	3.85	2.33	13.63	73.21
5	12	12	10.85	3.12	2.32	2.35	13.98	81.38

CHAPTER 4

ANALYSIS OF RESULT

4.1 PLOTTING CURVES FOR WASTE PLASTIC

4 curves were plotted. i.e.

- Penetration value v/s Waste Plastic content.
- Ductility value v/s Waste Plastic content.
- Softening point v/s Waste Plastic content.
- Flash & Fire value v/s Waste Plastic content.

Table 4.1 Data for Plotting Curves (Waste Plastic)

Waste Plastic (%)	Optimum Bitumen Content (%)	Penetration value (1/10th of mm)	Ductility value, (cm)	Softening point, (^{0}C)	Flash point (^{0}C)	Fire point (^{0}C)
0	4	88	75	45	225	237
1	4	86	71	47	215	225
2	4	84	67	49	212	218
3	4	82	63	52	207	216
4	4	80	60	55	202	213
5	4	77	57	57	188	201
6	4	72	53	58	171	186
7	4	67	47	61	165	174
8	4	63	41	63	162	170
9	4	58	35	65	158	167
10	4	54	31	67	154	161

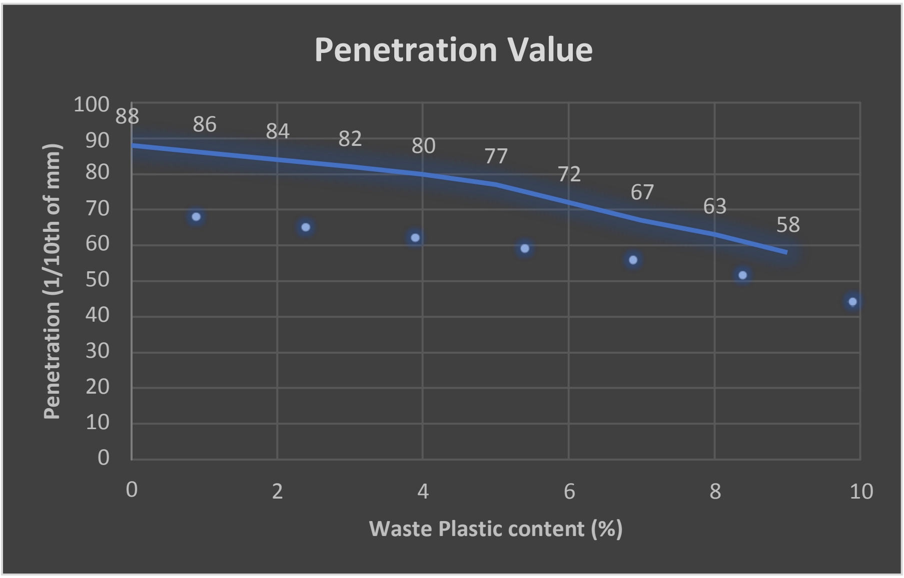


Fig. 4.1: Penetration value v/s Waste Plastic content

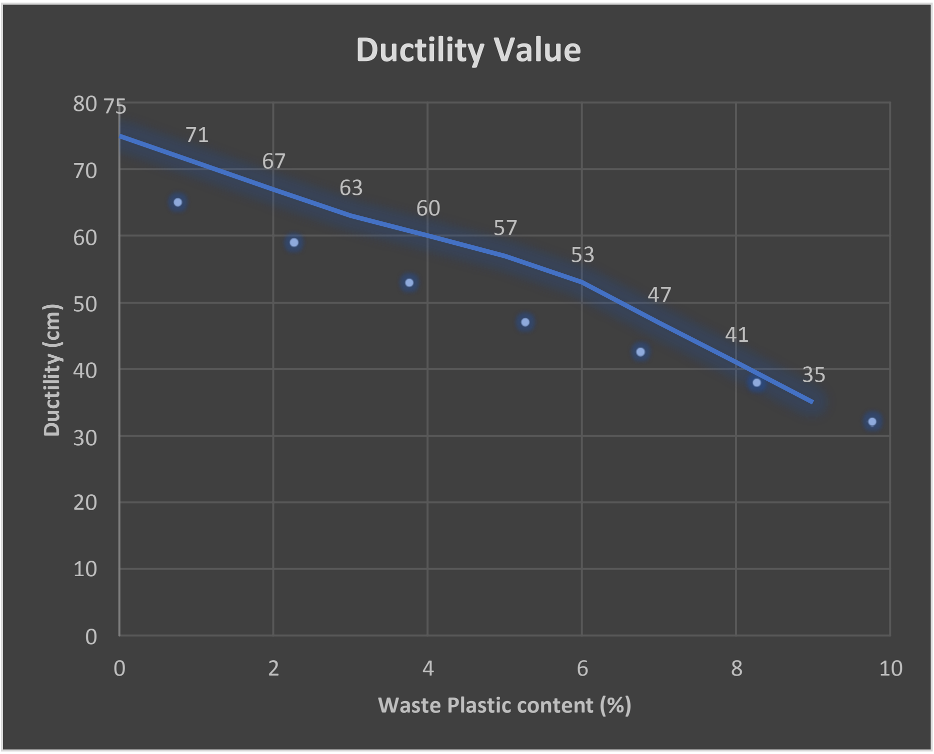


Fig. 4.2: Ductility value v/s Waste Plastic content

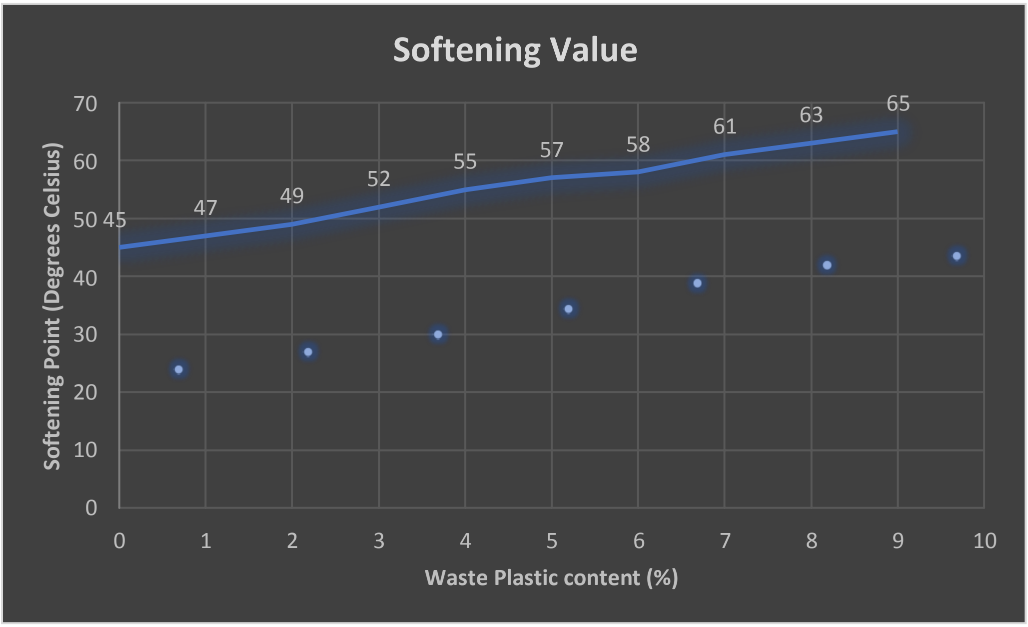


Fig. 4.3: Softening point v/s Waste Plastic content

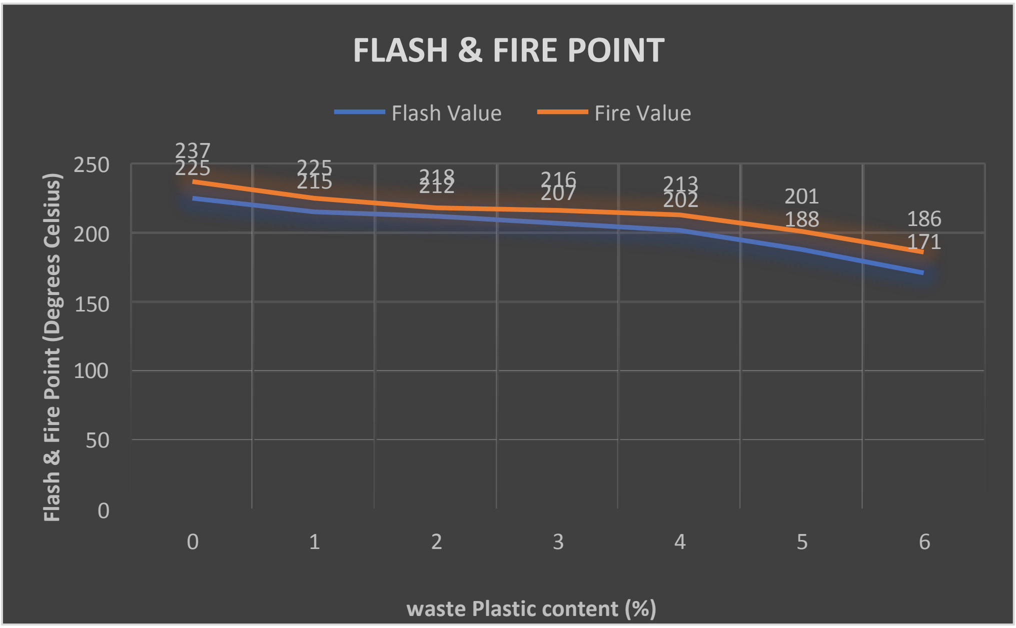


Fig. 4.4: Flash & Fire value v/s Waste Plastic content

4.2 PLOTTING CURVES FOR LIGNIN

4 curves were plotted. i.e.

- Penetration value v/s Lignin content.
- Ductility value v/s Lignin content.
- Softening point v/s Lignin content.
- Flash & Fire value v/s Lignin content.

Table 4.2 Data for Plotting Curves (Lignin)

Lignin (%)	**Optimum Bitumen Content (%)**	**Penetration value (mm)**	**Ductility value, (cm)**	**Softening point, (^{0}C)**	**Flash point (^{0}C)**	**Fire point (^{0}C)**
0	4	88	75	45	225	237
1	4	85	70	44	219	230
2	4	83	66	43	215	224
3	4	80	61	42	212	218
4	4	76	55	39	208	213
5	4	71	50	37	201	210
6	4	67	44	35	295	205
7	4	62	38	33	186	198
8	4	56	33	31	180	192

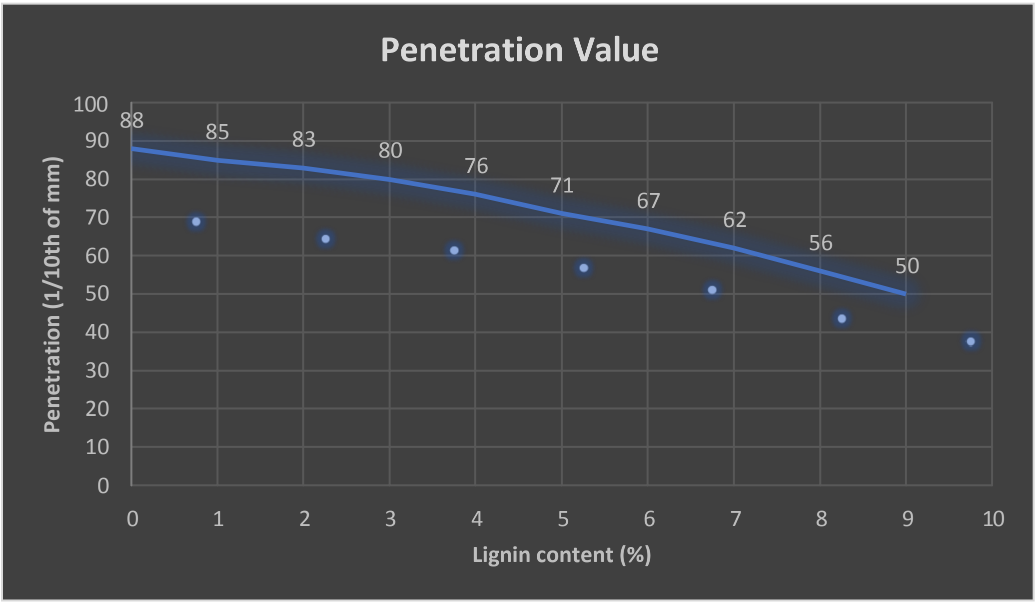


Fig. 4.5: Penetration value v/s Lignin content

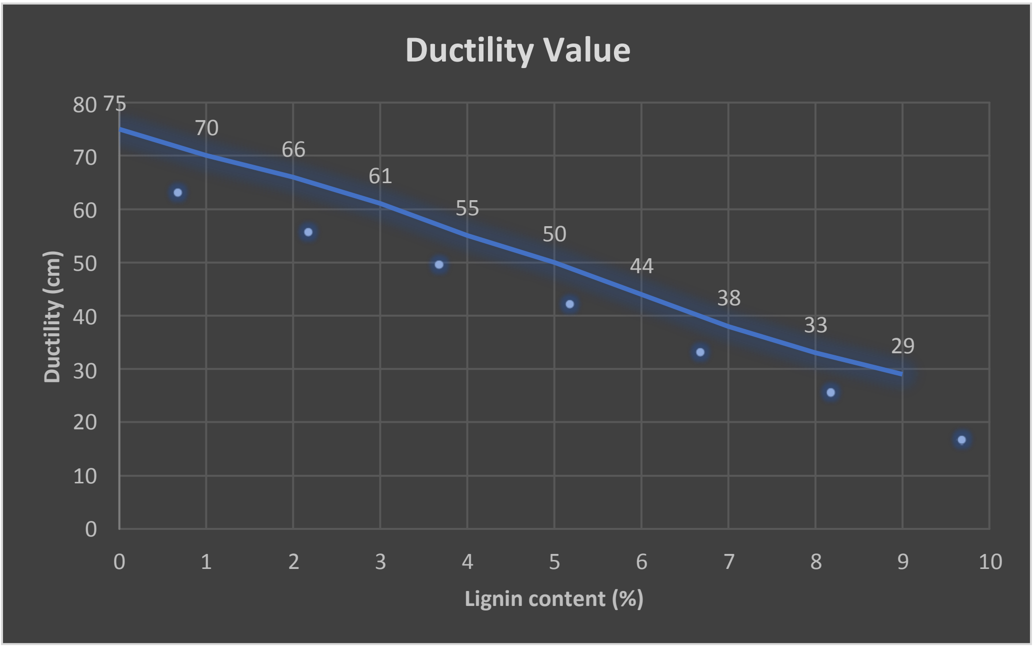


Fig. 4.6: Ductility value v/s Lignin content

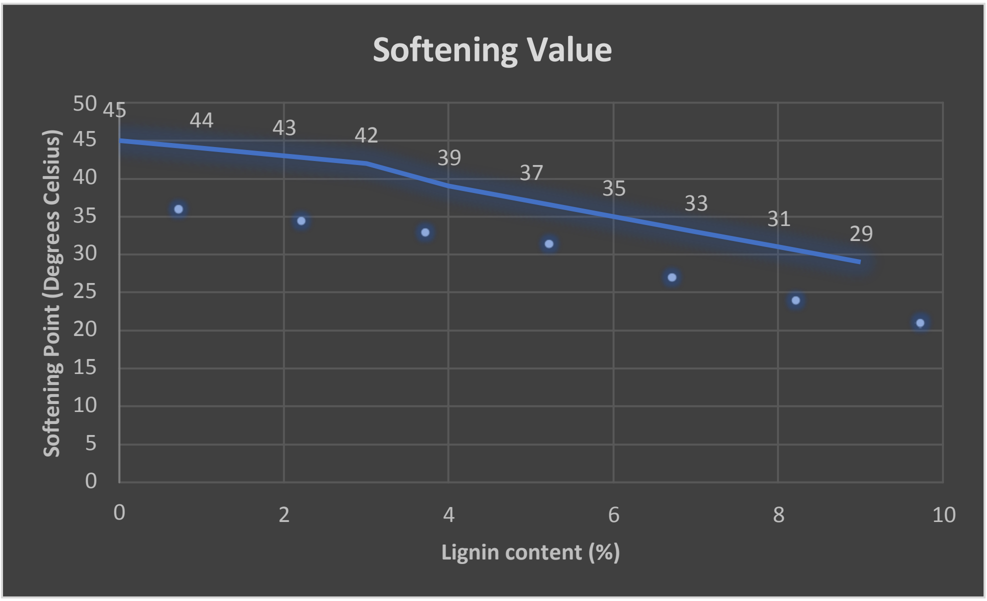


Fig. 4.7: Softening point v/s Lignin content

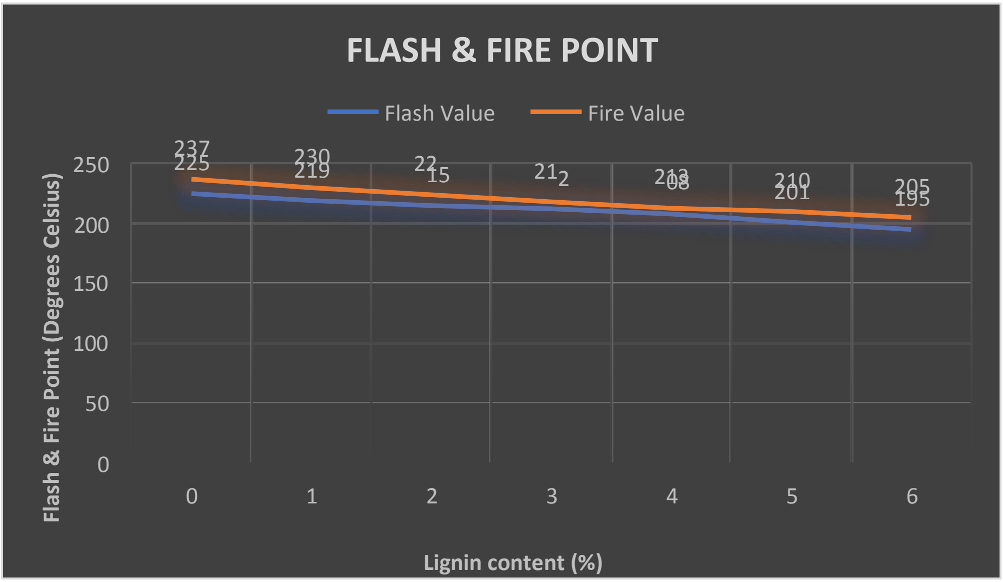
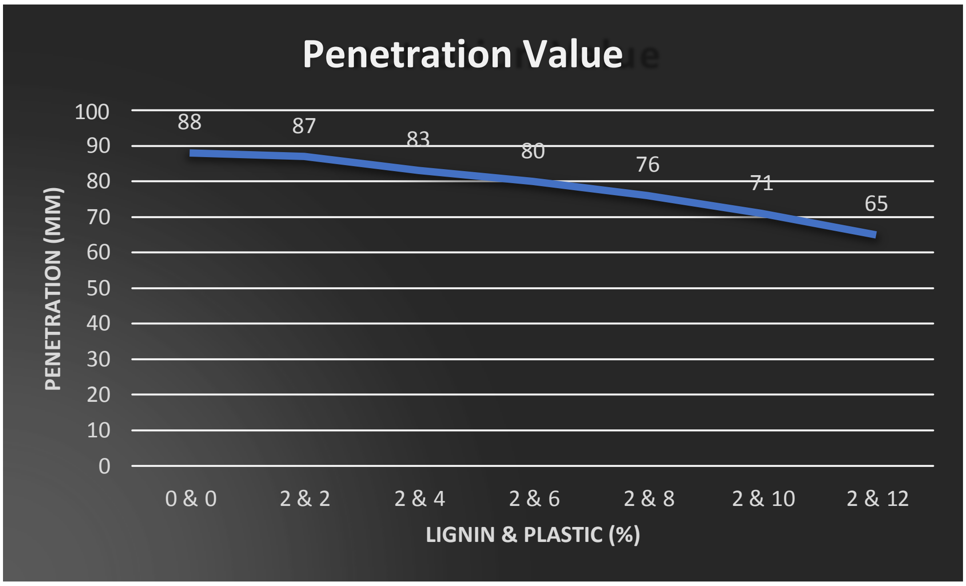


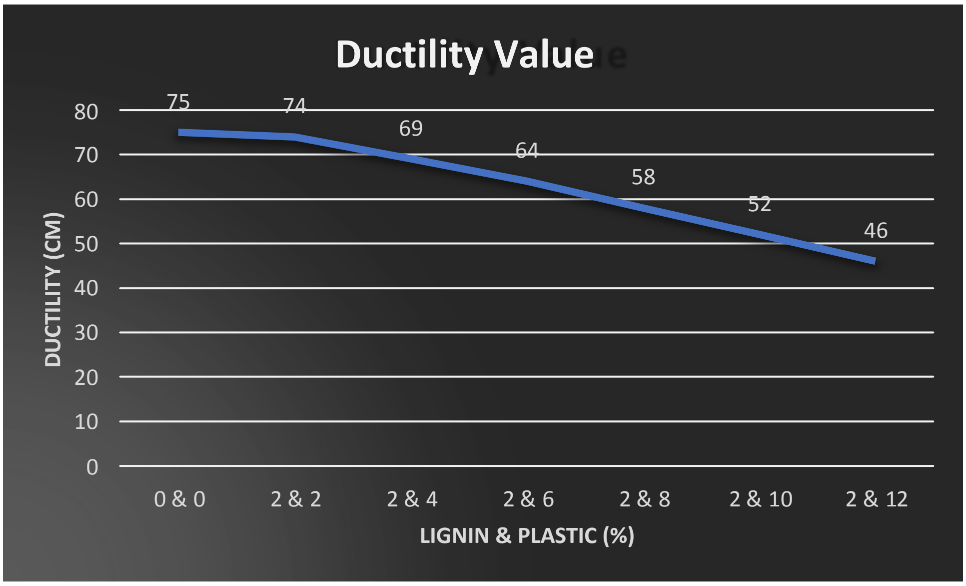
Fig. 4.8: Flash & Fire value v/s Lignin content

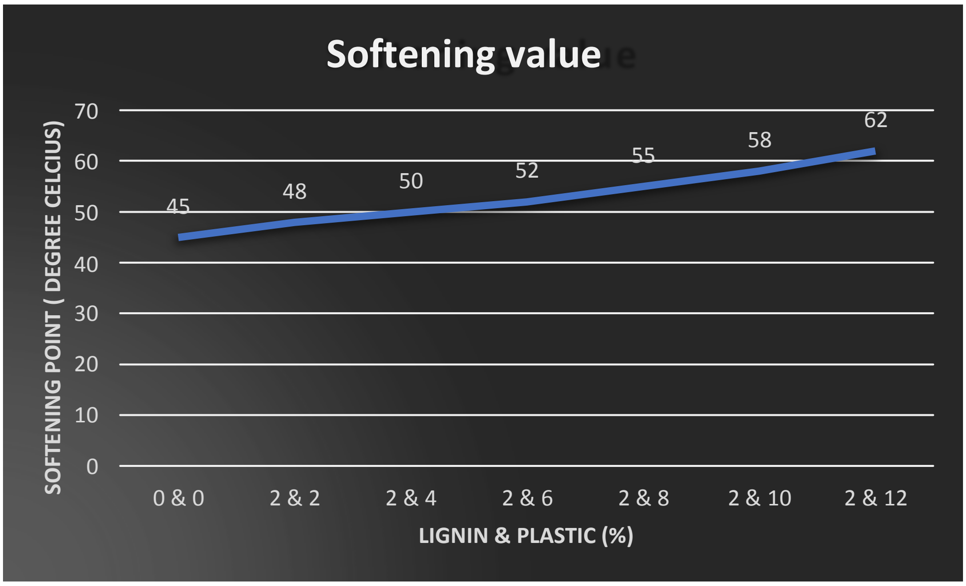
4.3 PLOTTING CURVES FOR LIGNIN & PLASTIC AT DIFFERENT PERCENTAGE

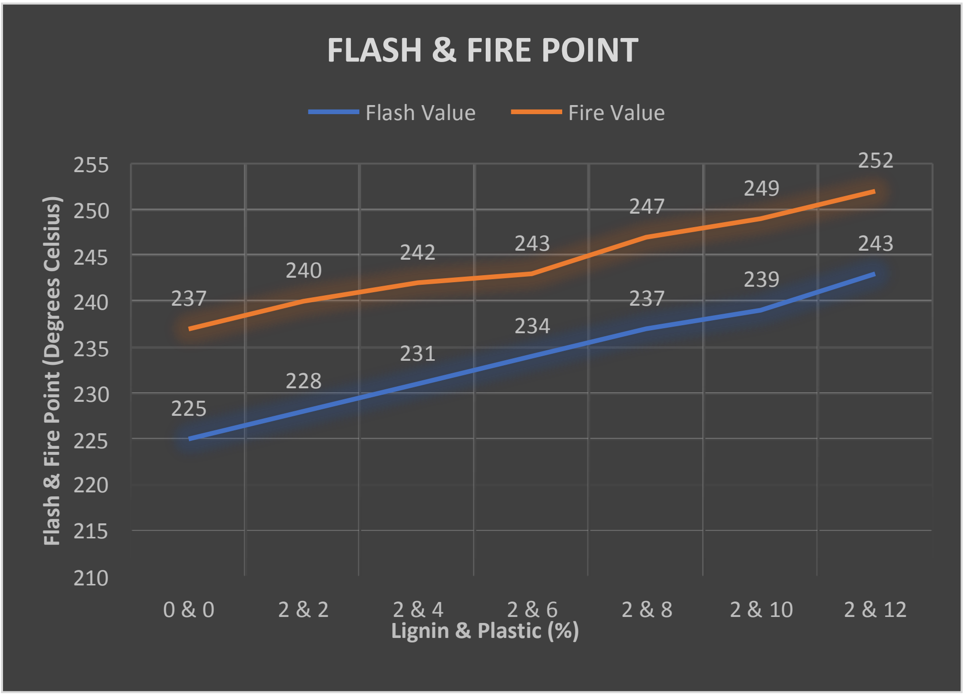
- 0 % lignin & 0 % plastic
- 2 % lignin & 2 % plastic
- 2 % lignin & 4 % plastic
- 2 % lignin & 6 % plastic
- 2 % lignin & 8 % plastic
- 2 % lignin & 10 % plastic
- 2 % lignin & 12 % plastic

Bitumen (%)	**Lignin (%)**	**Plastic (%)**	**Penetration Value (mm)**	**Ductility Value (cm)**	**Softening Value (^{0}C)**	**Flash Value (^{0}C)**	**Fire Value (^{0}C)**
4	0	0	88	75	45	225	237
4	2	2	87	74	48	228	240
4	2	4	83	69	50	231	242
4	2	6	80	64	52	234	243
4	2	8	76	58	55	237	247
4	2	10	71	52	58	239	249
4	2	12	65	46	62	243	252


Penetration Value
PENETRATION (MM)
100
90
80
70
60
50
40
30
20
10
0
88
87
83
80
76
71
65
0 & 0
2 & 2
2 & 4
2 & 6
2 & 8
2 & 10
2 & 12
LIGNIN & PLASTIC (%)

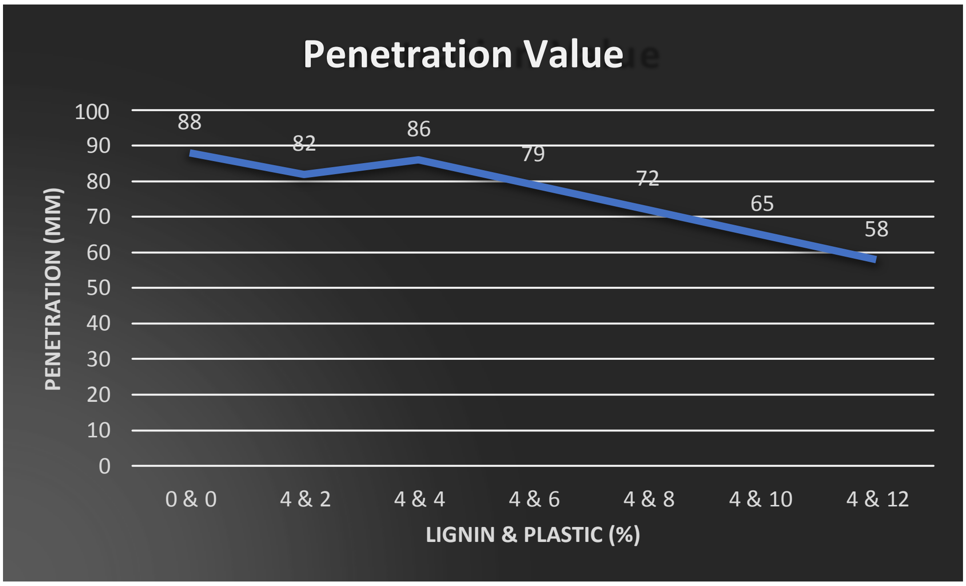

Ductility Value
DUCTILITY (CM)
80
70
60
50
40
30
20
10
0
75
74
69
64
58
52
46
0 & 0
2 & 2
2 & 4
2 & 6
2 & 8
2 & 10
2 & 12
LIGNIN & PLASTIC (%)

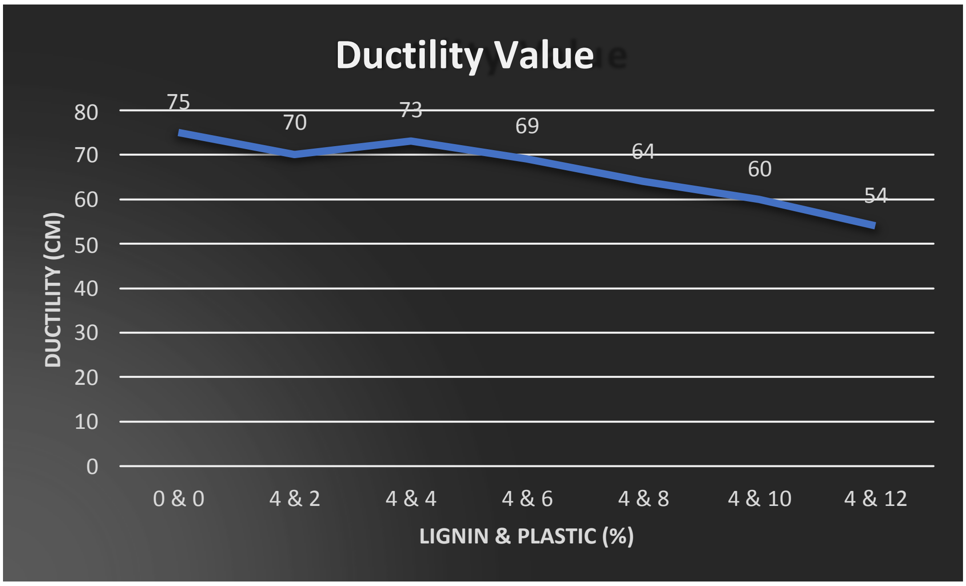

Softening value
SOFTENING POINT (DEGREE CELCIUS)
70
60
50
40
30
20
10
0
45
48
50
52
55
58
62
0 & 0
2 & 2
2 & 4
2 & 6
2 & 8
2 & 10
2 & 12
LIGNIN & PLASTIC (%)

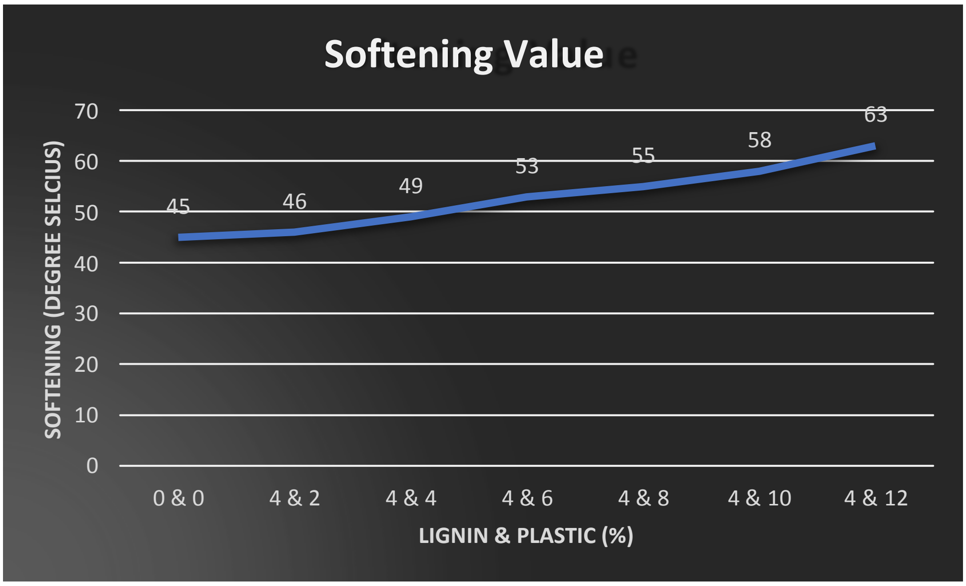

FLASH & FIRE POINT
Flash Value
Fire Value
Flash & Fire Point (Degrees Celsius)
255
250
245
240
235
230
225
220
215
210
237
240
242
243
247
249
252
225
228
231
234
237
239
243
0 & 0
2 & 2
2 & 4
2 & 6
2 & 8
2 & 10
2 & 12
Lignin & Plastic (%)

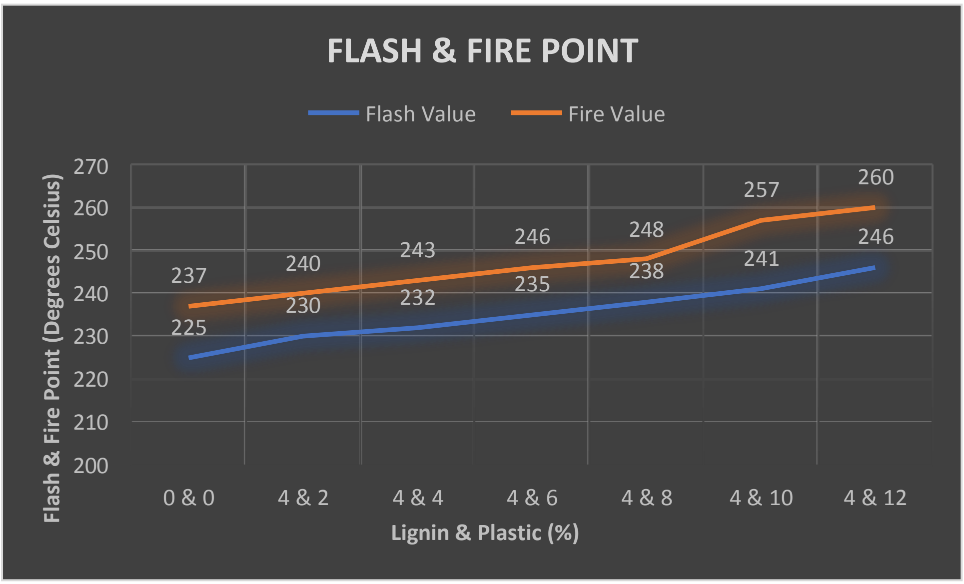
- 0 % lignin & 0 % plastic
- 4 % lignin & 2 % plastic
- 4 % lignin & 4 % plastic
- 4 % lignin & 6 % plastic
- 4 % lignin & 8 % plastic
- 4 % lignin & 10 % plastic
- 4 % lignin & 12 % plastic

Bitumen (%)	**Lignin (%)**	**Plastic (%)**	**Penetration Value (mm)**	**Ductility Value (cm)**	**Softening Value (^{0}C)**	**Flash Value (^{0}C)**	**Fire Value (^{0}C)**
4	0	0	88	75	45	225	237
4	4	2	82	70	46	230	240
4	4	4	86	73	49	232	243
4	4	6	79	69	53	235	246
4	4	8	72	64	55	238	248
4	4	10	65	60	58	241	257
4	4	12	58	54	63	246	260


Penetration Value
100
90
80
70
60
50
40
30
20
10
0
PENETRATION (MM)
88
82
86
79
72
65
58
0 & 0
4 & 2
4 & 4
4 & 6
4 & 8
4 & 10
4 & 12
LIGNIN & PLASTIC (%)

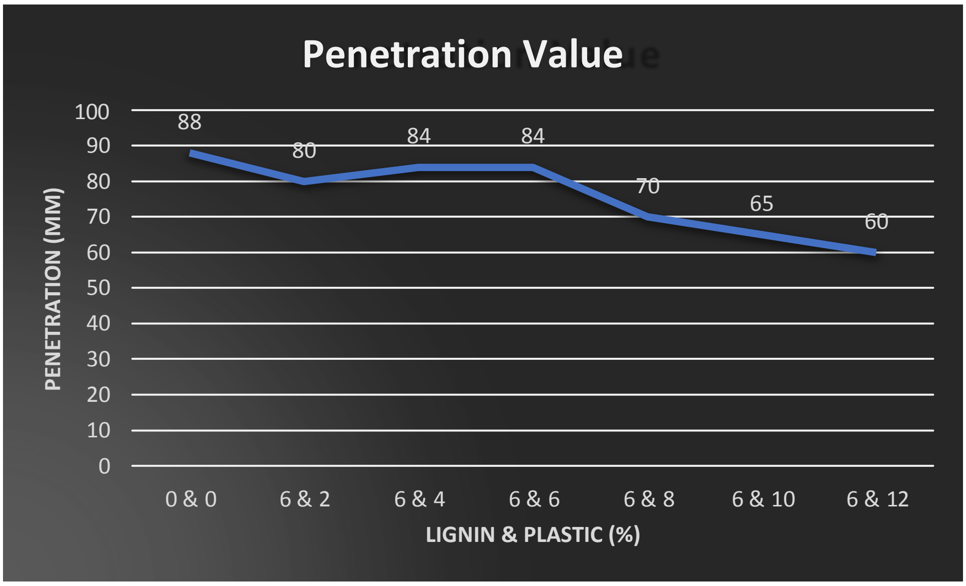

Ductility Value
80
70
60
50
40
30
20
10
0
DUCTILITY (CM)
75
70
73
69
64
60
54
0 & 0
4 & 2
4 & 4
4 & 6
4 & 8
4 & 10
4 & 12
LIGNIN & PLASTIC (%)

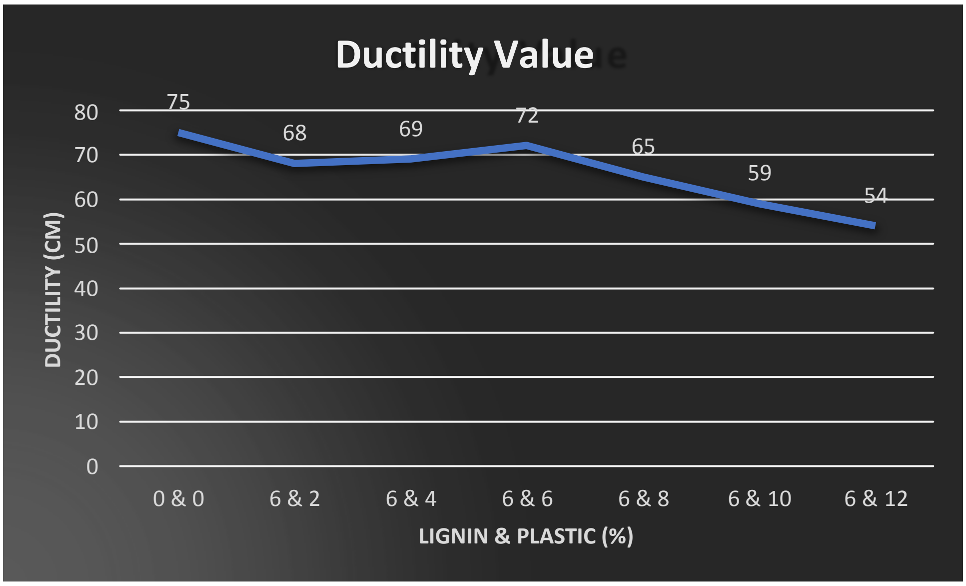

Softening Value
SOFTENING (DEGREE SELCIUS)
70
60
50
40
30
20
10
0
45
46
49
53
55
58
63
0 & 0
4 & 2
4 & 4
4 & 6
4 & 8
4 & 10
4 & 12
LIGNIN & PLASTIC (%)

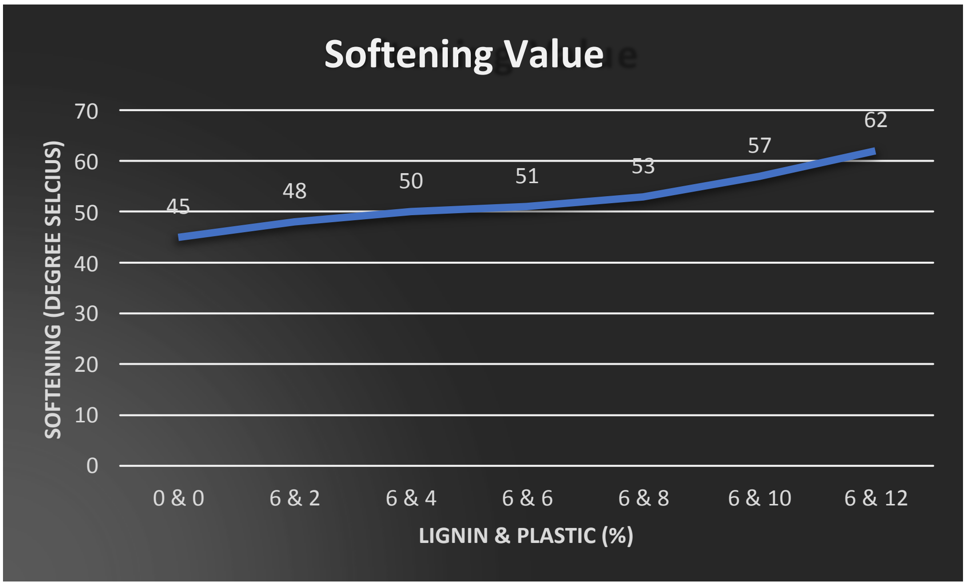

FLASH & FIRE POINT
Flash Value
Fire Value
Flash & Fire Point (Degrees Celsius)
270
260
250
240
230
220
210
200
237
240
243
246
248
257
260
225
230
232
235
238
241
246
0 & 0
4 & 2
4 & 4
4 & 6
4 & 8
4 & 10
4 & 12
Lignin & Plastic (%)

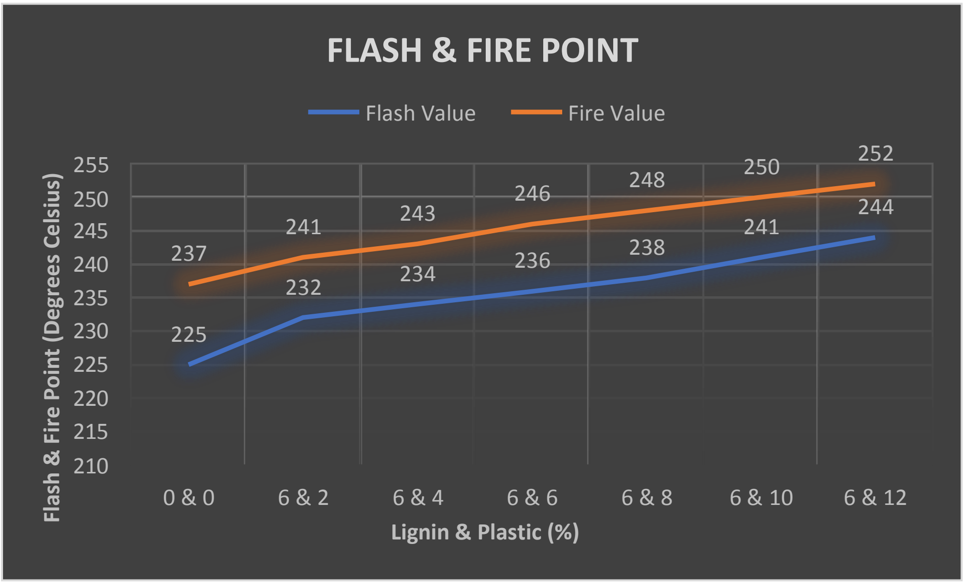
- 0 % lignin & 0 % plastic
- 6 % lignin & 2 % plastic
- 6 % lignin & 4 % plastic
- 6 % lignin & 6 % plastic
- 6 % lignin & 8 % plastic
- 6 % lignin & 10 % plastic
- 6 % lignin & 12 % plastic

Bitumen (%)	**Lignin (%)**	**Plastic (%)**	**Penetration Value (mm)**	**Ductility Value (cm)**	**Softening Value (^{0}C)**	**Flash Value (^{0}C)**	**Fire Value (^{0}C)**
4	0	0	88	75	45	225	237
4	6	2	80	68	48	232	241
4	6	4	82	69	50	234	243
4	6	6	84	72	51	236	246
4	6	8	70	65	53	238	248
4	6	10	65	59	57	241	250
4	6	12	60	54	61	244	252


Penetration Value
PENETRATION (MM)
100
90
80
70
60
50
40
30
20
10
0
88
80
84
84
70
65
60
0 & 0
6 & 2
6 & 4
6 & 6
6 & 8
6 & 10
6 & 12
LIGNIN & PLASTIC (%)

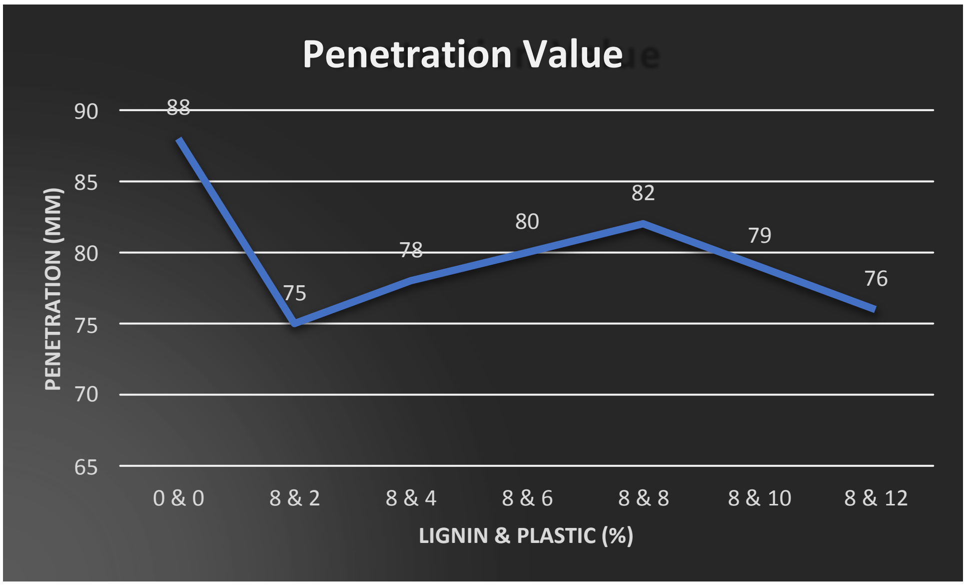

Ductility Value
DUCTILITY (CM)
80
70
60
50
40
30
20
10
0
75
68
69
72
65
59
54
0 & 0
6 & 2
6 & 4
6 & 6
6 & 8
6 & 10
6 & 12
LIGNIN & PLASTIC (%)

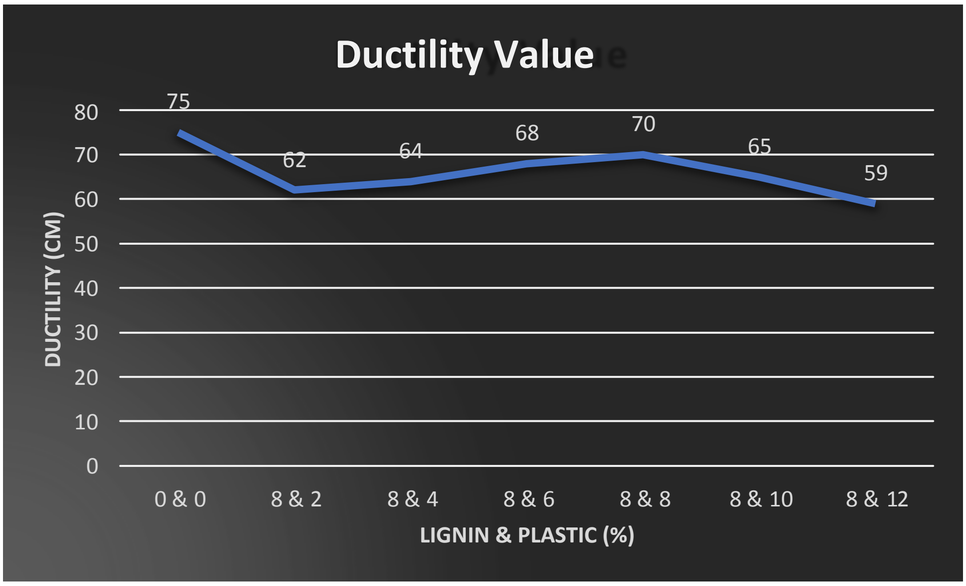

Softening Value
SOFTENING (DEGREE SELCIUS)
70
60
50
40
30
20
10
0
45
48
50
51
53
57
62
0 & 0
6 & 2
6 & 4
6 & 6
6 & 8
6 & 10
6 & 12
LIGNIN & PLASTIC (%)

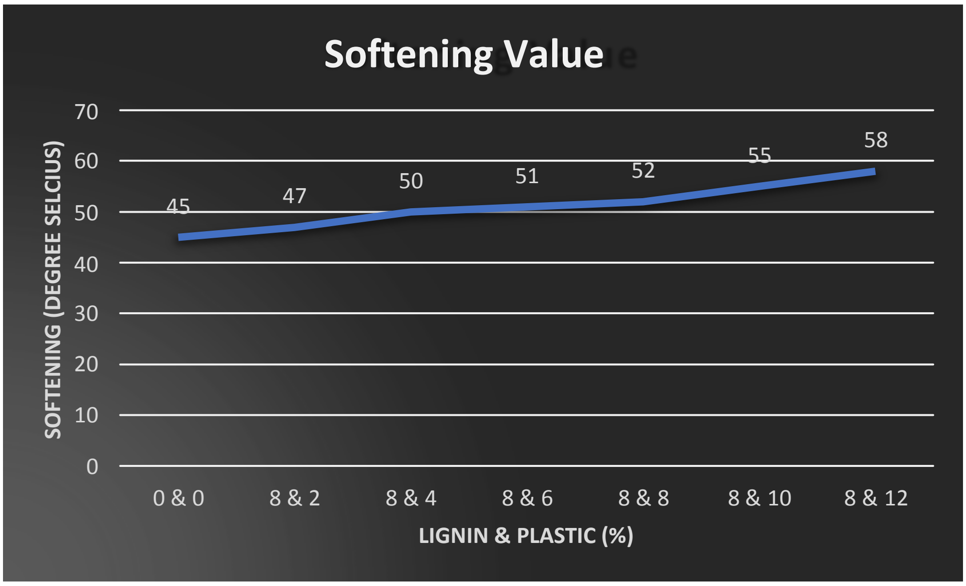

FLASH & FIRE POINT
Flash Value
Fire Value
Flash & Fire Point (Degrees Celsius)
255
250
245
240
235
230
225
220
215
210
237
241
243
246
248
250
252
225
232
234
236
238
241
244
0 & 0
6 & 2
6 & 4
6 & 6
6 & 8
6 & 10
6 & 12
Lignin & Plastic (%)

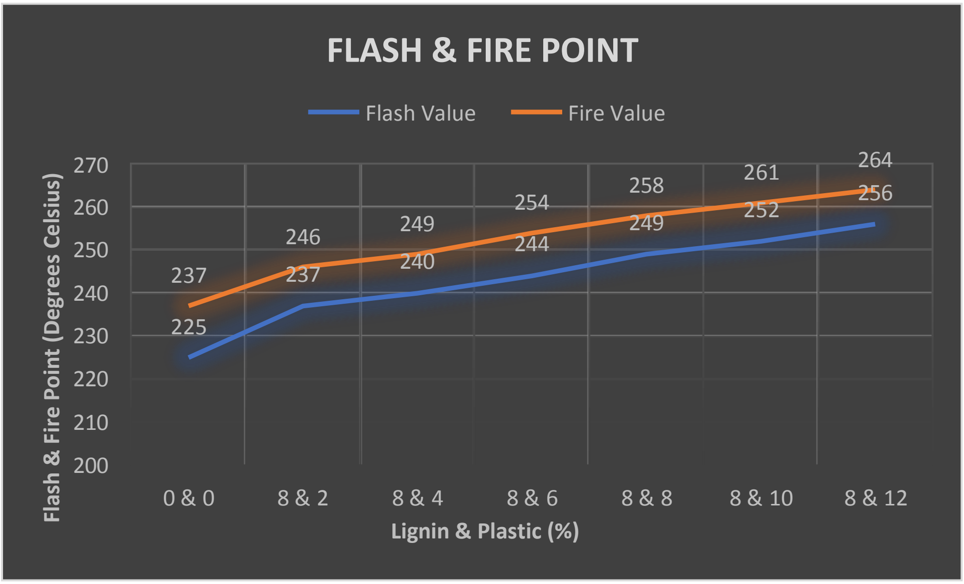
- 0 % lignin & 0 % plastic
- 8 % lignin & 2 % plastic
- 8 % lignin & 4 % plastic
- 8 % lignin & 6 % plastic
- 8 % lignin & 8 % plastic
- 8 % lignin & 10 % plastic
- 8 % lignin & 12 % plastic

Bitumen (%)	**Lignin (%)**	**Plastic (%)**	**Penetration Value (mm)**	**Ductility Value (cm)**	**Softening Value (^{0}C)**	**Flash Value (^{0}C)**	**Fire Value (^{0}C)**
4	0	0	88	75	45	225	237
4	8	2	75	62	47	237	246
4	8	4	78	64	50	240	249
4	8	6	80	68	51	244	254
4	8	8	82	70	52	249	258
4	8	10	79	65	55	252	261
4	8	12	76	59	58	256	264


Penetration Value
PENETRATION (MM)
90
85
80
75
70
65
88
75
78
80
82
79
76
0 & 0
8 & 2
8 & 4
8 & 6
8 & 8
8 & 10
8 & 12
LIGNIN & PLASTIC (%)

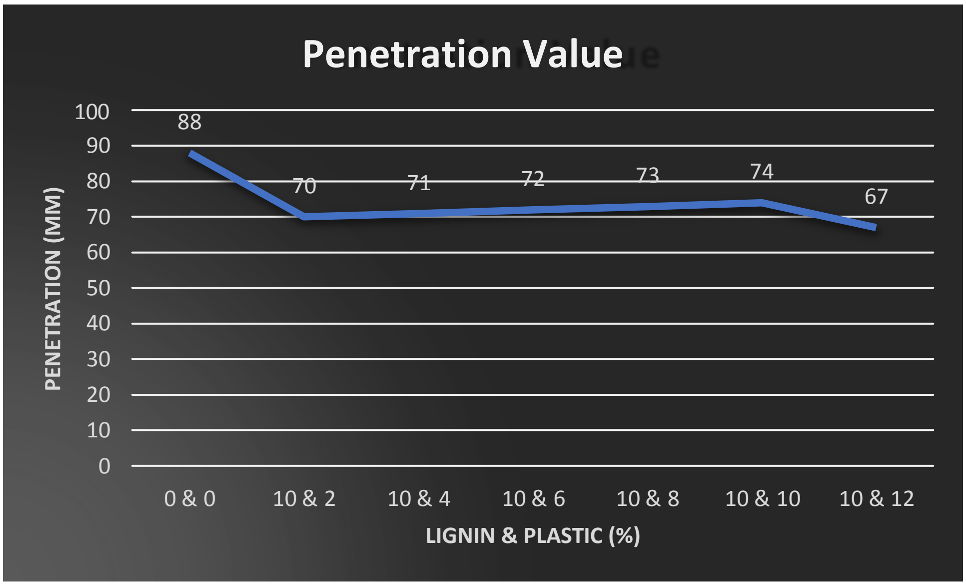

Ductility Value
DUCTILITY (CM)
80
70
60
50
40
30
20
10
0
75
62
64
68
70
65
59
0 & 0
8 & 2
8 & 4
8 & 6
8 & 8
8 & 10
8 & 12
LIGNIN & PLASTIC (%)

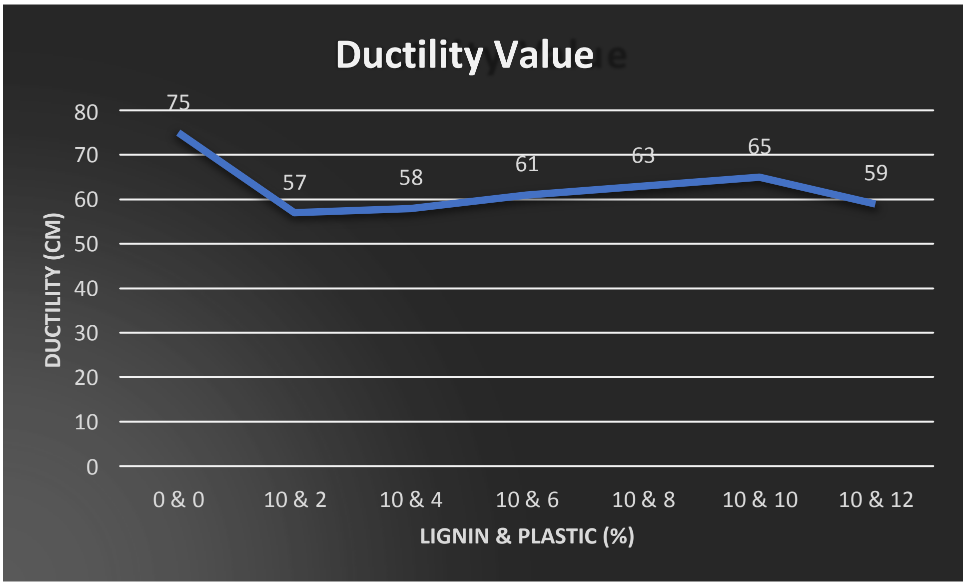

Softening Value
SOFTENING (DEGREE SELCIUS)
70
60
50
40
30
20
10
0
45
47
50
51
52
55
58
0 & 0
8 & 2
8 & 4
8 & 6
8 & 8
8 & 10
8 & 12
LIGNIN & PLASTIC (%)

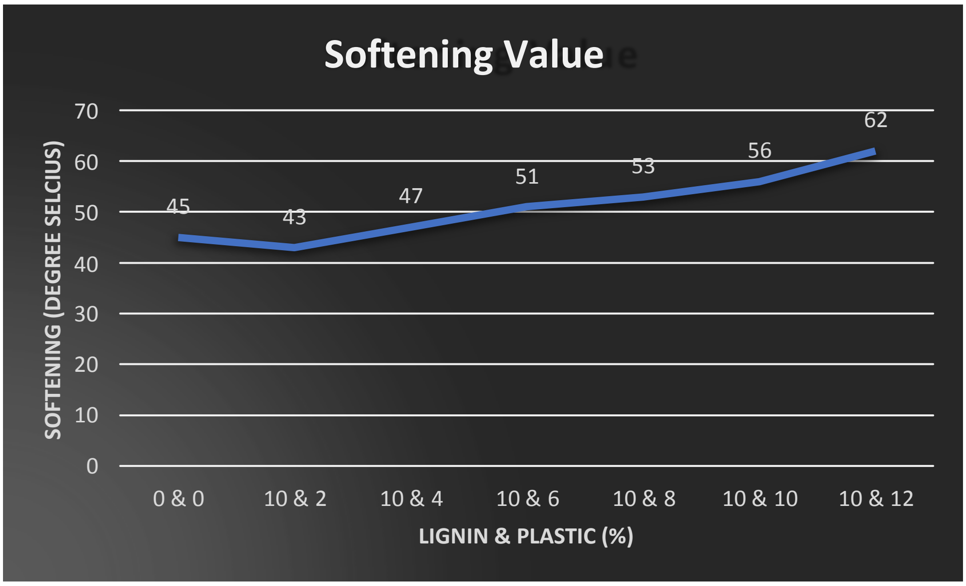

FLASH & FIRE POINT
Flash Value
Fire Value
Flash & Fire Point (Degrees Celsius)
270
260
250
240
230
220
210
200
237
225
246
237
249
240
254
244
258
249
261
252
264
256
0 & 0
8 & 2
8 & 4
8 & 6
8 & 8
8 & 10
8 & 12
Lignin & Plastic (%)

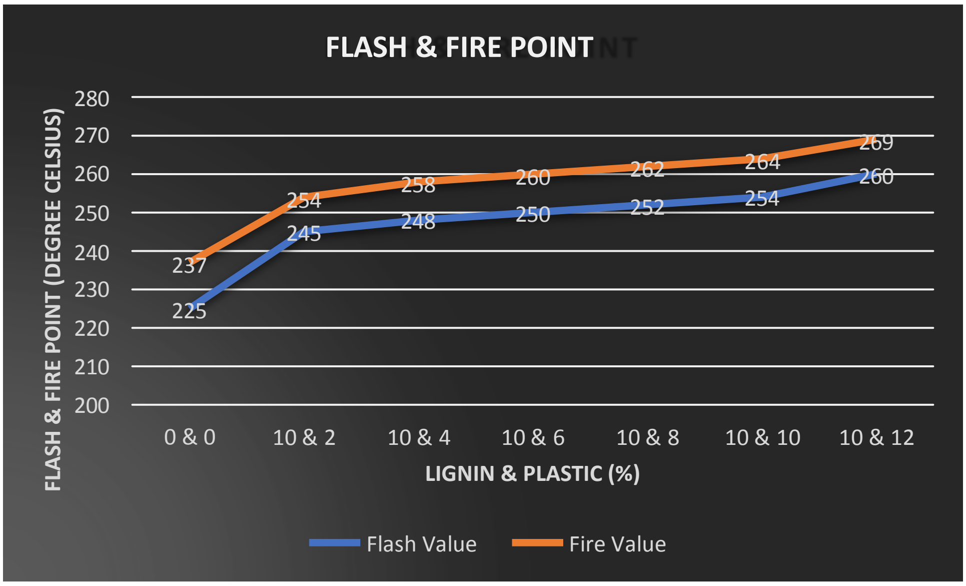
- 0 % lignin & 0 % plastic
- 10 % lignin & 2 % plastic
- 10 % lignin & 4 % plastic
- 10 % lignin & 6 % plastic
- 10 % lignin & 8 % plastic
- 10 % lignin & 10 % plastic
- 10 % lignin & 12 % plastic

Bitumen (%)	**Lignin (%)**	**Plastic (%)**	**Penetration Value (mm)**	**Ductility Value (cm)**	**Softening Value (^{0}C)**	**Flash Value (^{0}C)**	**Fire Value (^{0}C)**
4	0	0	88	75	45	225	237
4	10	2	70	57	43	245	254
4	10	4	71	58	47	248	258
4	10	6	72	61	51	250	260
4	10	8	73	64	56	252	262
4	10	10	74	65	62	254	264
4	10	12	67	60	64	260	269


Penetration Value
PENETRATION (MM)
100
90
80
70
60
50
40
30
20
10
0
88
70
71
72
73
74
67
0 & 0
10 & 2
10 & 4
10 & 6
10 & 8
10 & 10
10 & 12
LIGNIN & PLASTIC (%)


Ductility Value
DUCTILITY (CM)
80
70
60
50
40
30
20
10
0
75
57
58
61
63
65
59
0 & 0
10 & 2
10 & 4
10 & 6
10 & 8
10 & 10
10 & 12
LIGNIN & PLASTIC (%)


Softening Value
SOFTENING (DEGREE SELCIUS)
70
60
50
40
30
20
10
0
45
43
47
51
53
56
62
0 & 0
10 & 2
10 & 4
10 & 6
10 & 8
10 & 10
10 & 12
LIGNIN & PLASTIC (%)


FLASH & FIRE POINT
FLASH & FIRE POINT (DEGREE CELSIUS)
280
270
260
250
240
230
220
210
200
237
254
258
260
262
264
269
225
245
248
250
252
254
260
0 & 0
10 & 2
10 & 4
10 & 6
10 & 8
10 & 10
10 & 12
LIGNIN & PLASTIC (%)
Flash Value
Fire Value

4.4 PLOTTING CURVES FOR LIGNIN & WASTE PLASTIC

curves were plotted. i.e.

- Penetration value v/s Lignin & Waste Plastic content.
- Ductility value v/s Lignin & Waste Plastic content.
- Softening point v/s Lignin & Waste Plastic content.
- Flash & Fire value v/s Lignin & waste Plastic content.
- Marshall Stability value v/s Lignin & Waste Plastic.
- Marshall Flow value v/s Lignin & Waste Plastic.
- Air Voids v/s Lignin & Waste Plastic.
- Voids filled with bitumen (VFB) v/s Lignin & Waste Plastic

For each % of Lignin & Waste Plastic, 3 samples have been tested, So the average value of the 3 were taken.

Table 4.3 Data for Plotting Curves (Lignin & Waste Plastic)

Lignin (%)	Waste Plastic (%)	Optimum Bitumen Content (%)	Stability (KN)	Flow Value (mm)	Air Voids (%)	Voids Filled With Bitumen VFB (%)
0	0	4	11.20	3.86	5.61	62.51
2	2	4	15.25	3.76	4.63	62.82
4	4	4	20.20	3.48	4.52	63.26
6	6	4	22.15	3.34	4.35	63.90
8	8	4	23.42	3.15	4.34	64.40
10	10	4	17.45	3.12	4.32	64.28
12	12	4	9.30	2.99	4.25	64.25

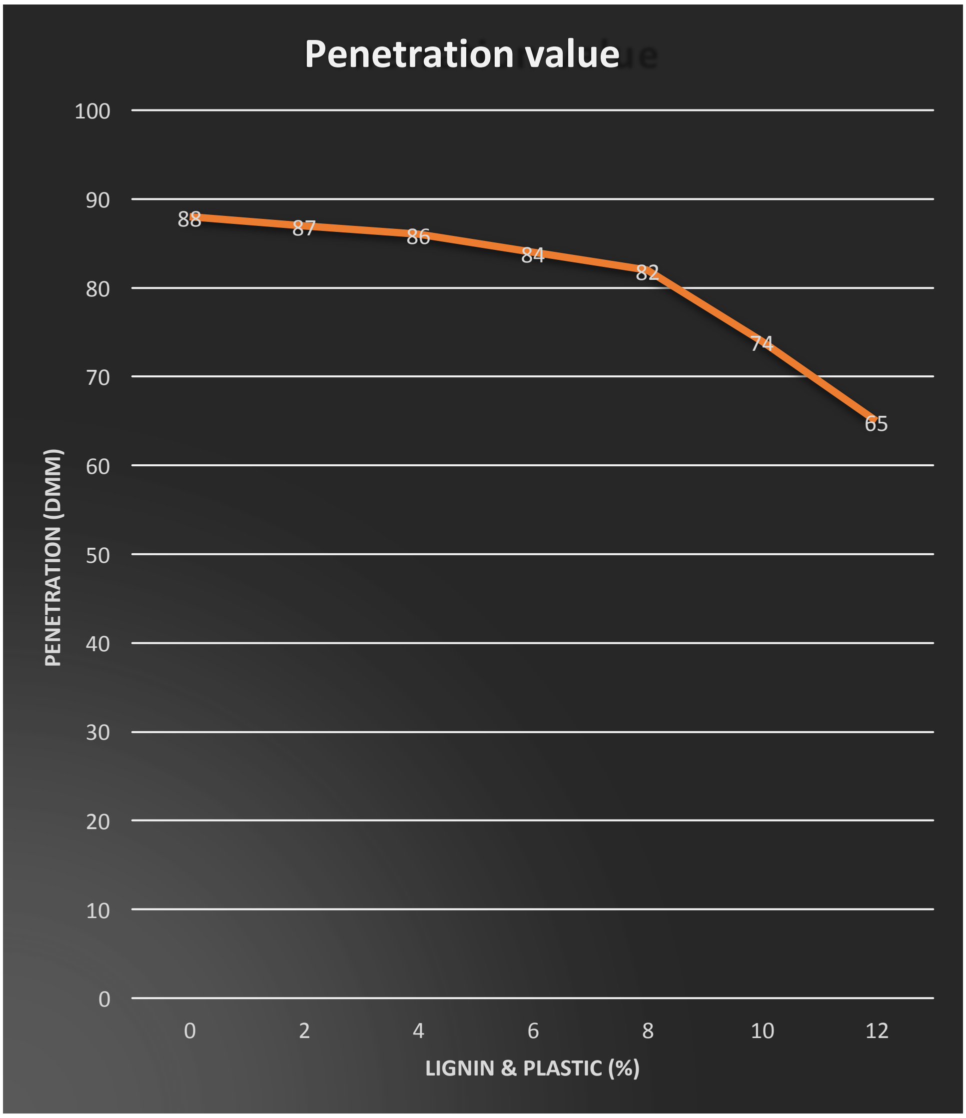


Fig. 4.9: Penetration value v/s Lignin & Waste Plastic content

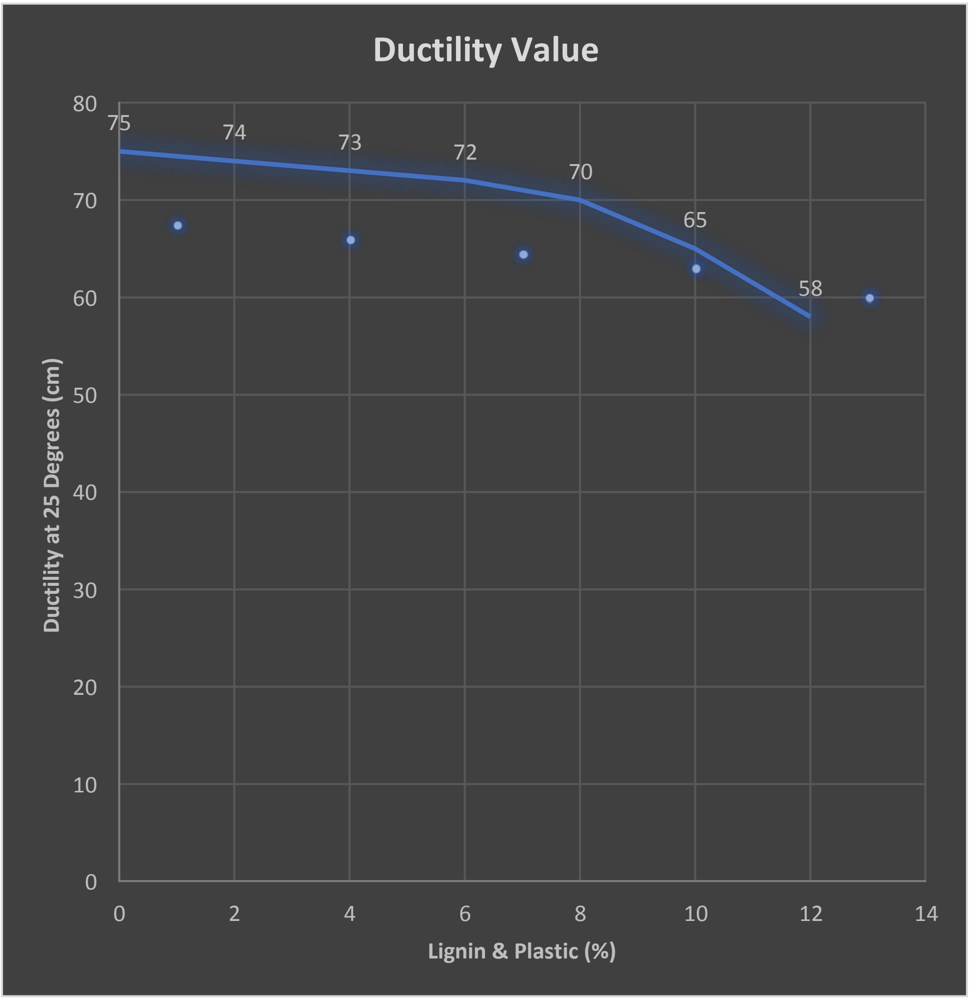


Fig. 4.10: Ductility value v/s Lignin & Waste Plastic content

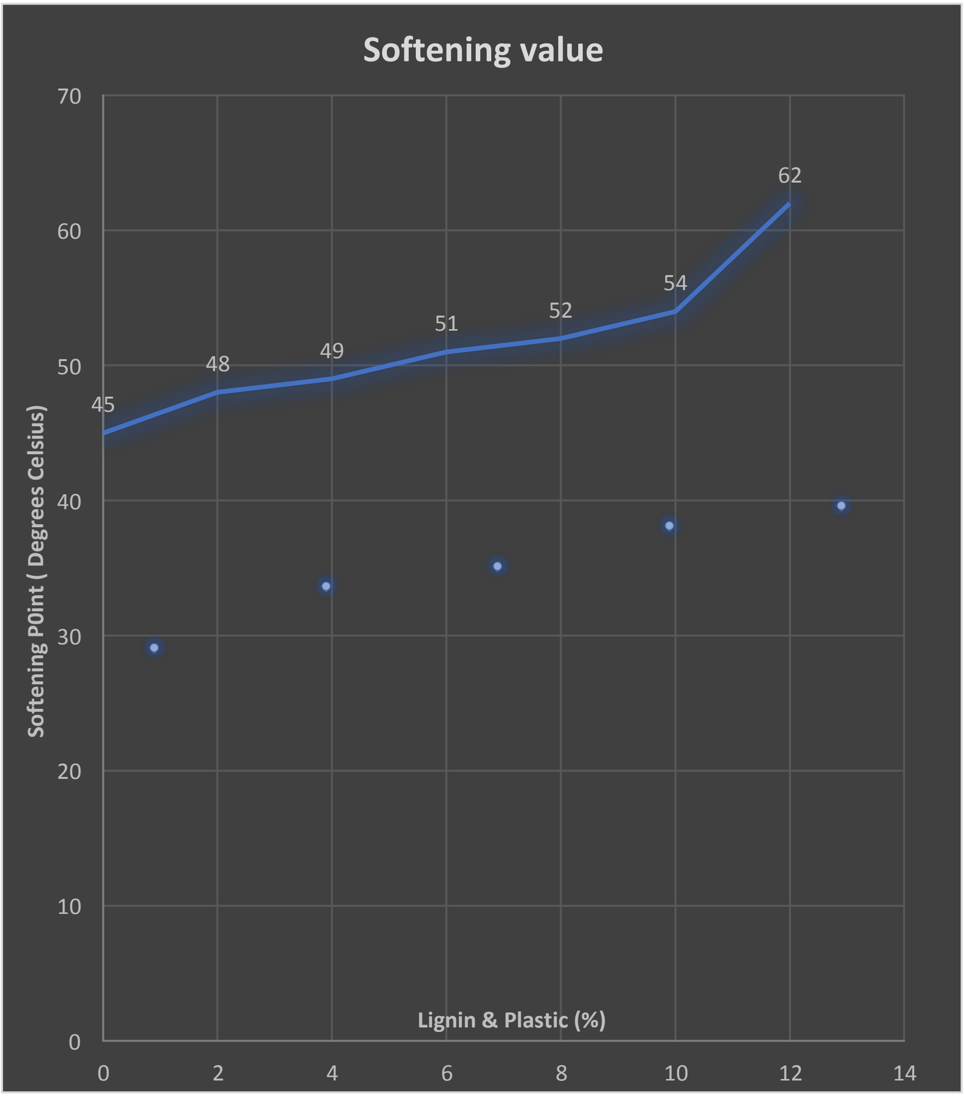


Fig. 4.11: Softening point v/s Lignin & Waste Plastic content

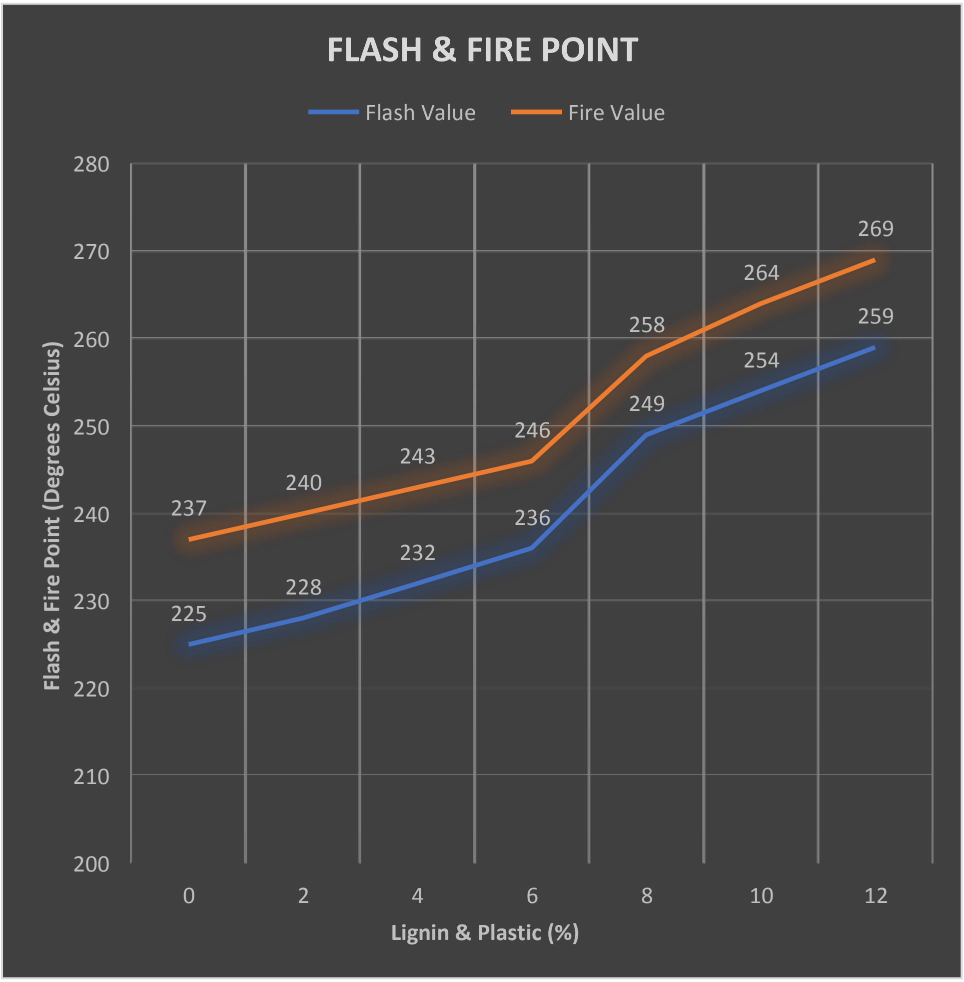


Fig. 4.12: Flash & Fire point v/s Lignin & Waste Plastic content

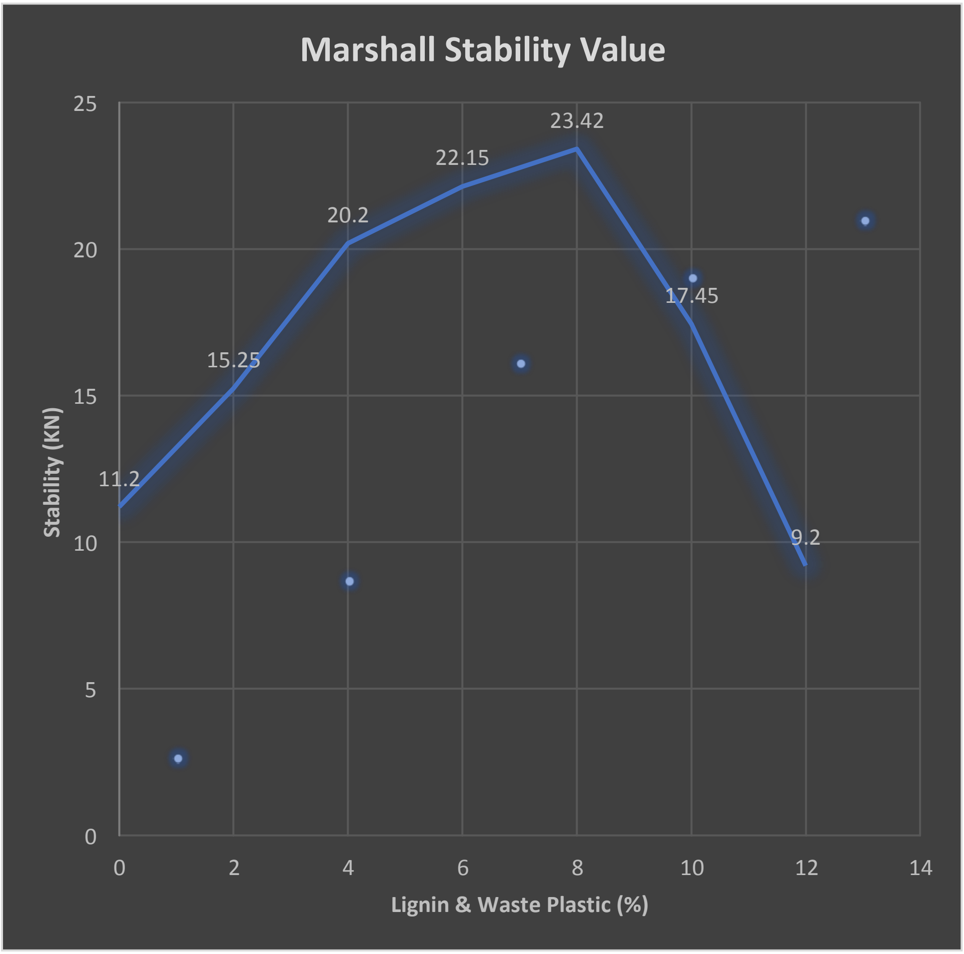


Fig. 4.13: Marshall Stability value v/s Lignin & Waste Plastic content

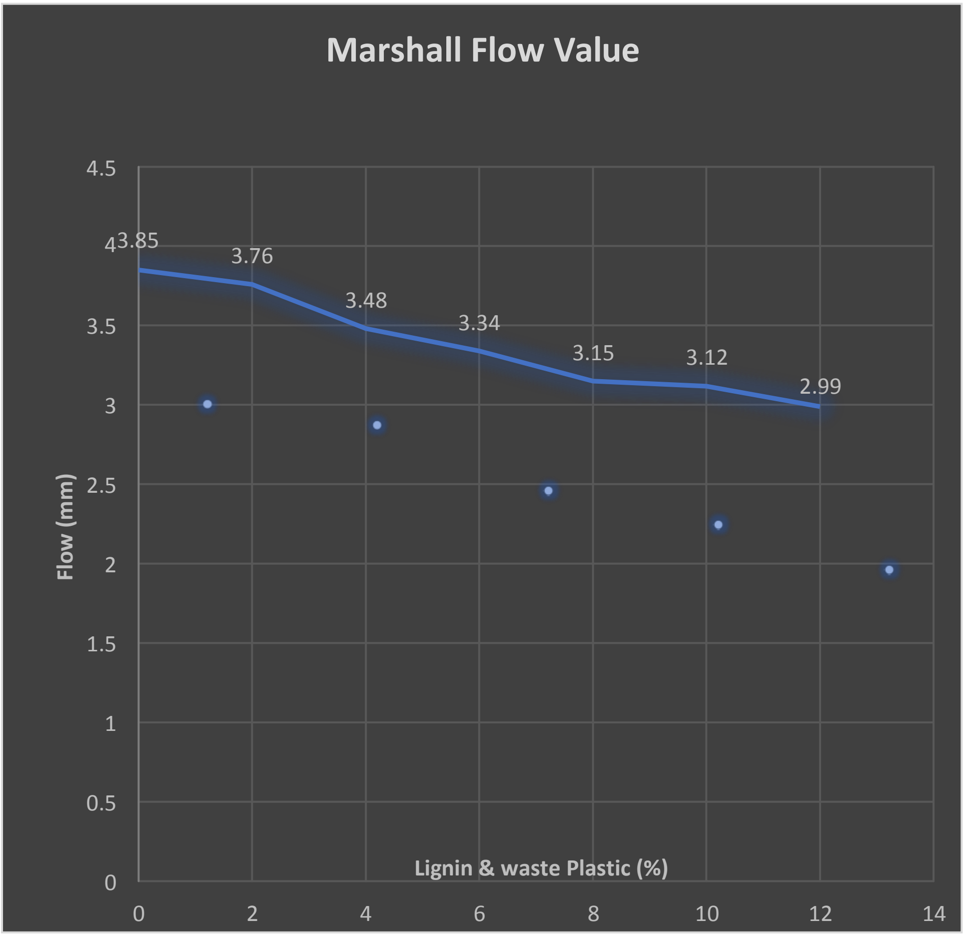


Fig. 4.14: Marshall Flow value v/s Lignin & Waste Plastic content

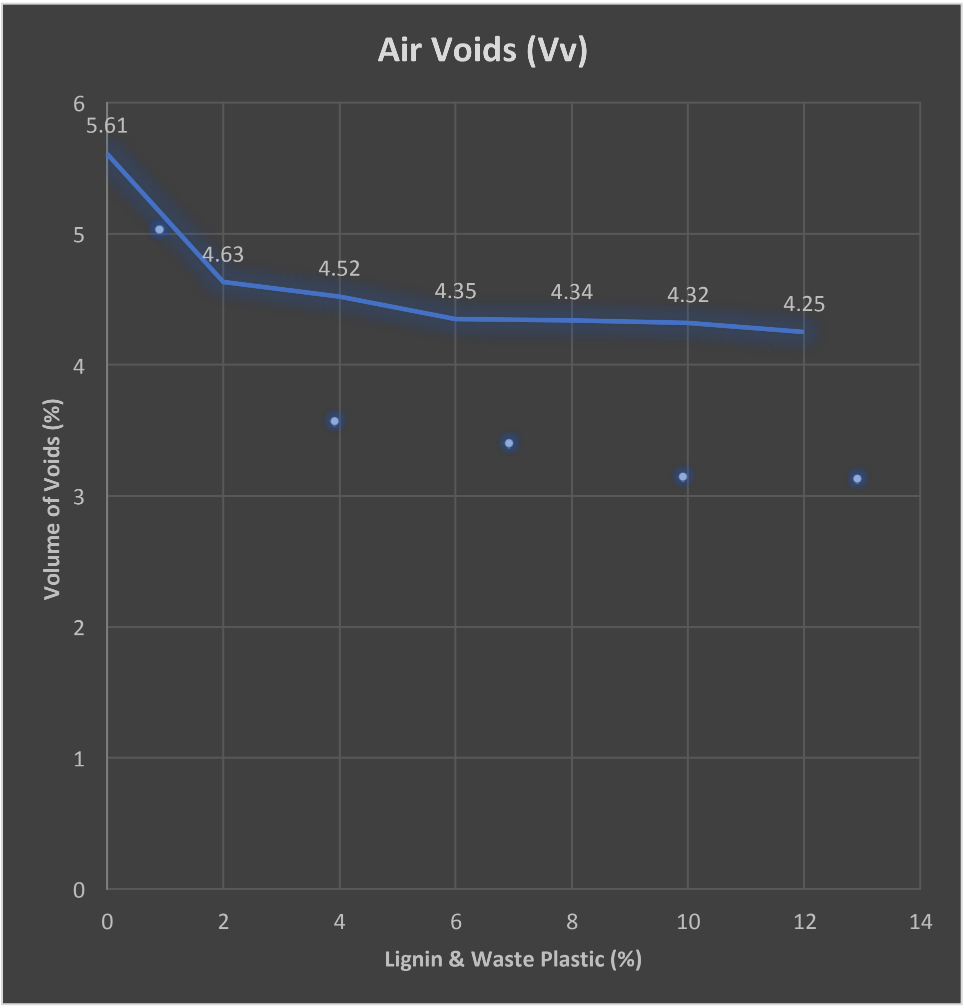


Fig. 4.15: Air Voids v/s Lignin & Waste Plastic content

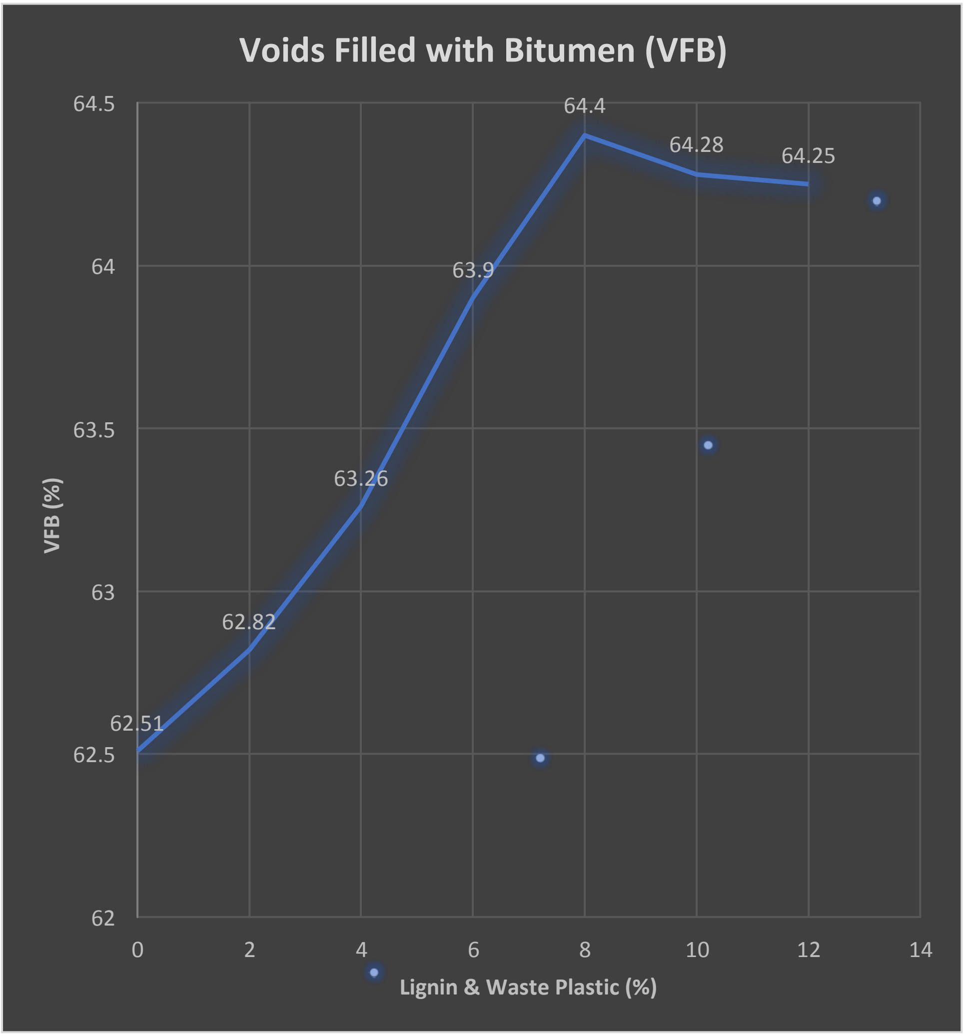


Fig. 4.16: Voids filled with bitumen (VFB) v/s Lignin & Waste Plastic content

4.5 COST ANALYSIS

Cost estimation of Lignin & Waste Plastic: -

Cost of bitumen VG- 10 for 1 Kg. is 35 Rs/-.

1 kg. = 35 Rs/-

Adding Lignin (according to test) = 8% of bitumen

Adding Plastic (according to test) = 8% of bitumen

Cost of lignin and plastic for 1 Kg. is 18 Rs/-

1 Kg. = 18 Rs/-

Sr. No.	**Particulars**	**Approx. Rate (Rs. / Kg)**
1	Plastic including transportation & Labor charges	8
2	Lignin including transportation	10
	Total	18

Value of 8% of 1 kg Bitumen = $\frac{1000}{100} \times 8 = 80\ gm$

Cost of 80 gm Bitumen = $\frac{35}{1000} \times 80 = 2.8 \cong 3\ Rs/-$

Now, cost of 80 gm Plastic = $\frac{8}{1000} \times 80 = 0.64 \cong 1\ Rs/$

Saving cost in 1 kg Bitumen (when adding 8 % Plastic) = 3-1 =2 Rs/-

Now, cost of 80 gm Lignin = $\frac{10}{1000} \times 80 = 0.8 \cong\ 1Rs/-$

Saving cost in 1 kg Bitumen (when adding 8 % Lignin) = 3-1 = 2 Rs/-

cost of 1000 gm bitumen = 35 Rs/-

Value of 16% of 1 Kg bitumen = $\frac{1000}{100} \times 16 = 160gm$

Cost of 160 gm bitumen = $\frac{35}{1000} \times 160 = 5.6\ Rs/-$

Cost of 160 gm bitumen = 6 Rs/-

Now, cost of 1000 gm lignin and plastic = 18 Rs/-

Cost of 160 gm lignin and plastic = $\frac{18}{1000} \times 160 = 2.88\ Rs/-$

Cost of 160 gm lignin and plastic = 3 Rs/-

Now, cost difference of 160 gm lignin & plastic and bitumen = 6-3 = 3 Rs/-

Total saving cost in 1 kg bitumen = 3 Rs/-

Now,

Total cost saving percentage in bitumen = $\frac{3}{35} \times 100 = 8.57 \cong 8\ \%$

Total saving cost in bitumen is 8%.

CHAPTER 5

CONCLUSIONS

5.1 GENERAL

From the study of the behavior of Lignin & Waste Plastic It was found that the modified mix process improved the properties of bitumen such as Penetration, Ductility, softening, Flash & Fire in all the aspects which helps in increasing the life span of pavements. A gradual increase has been observed in all these properties of bitumen by partially replacing it with Lignin and Waste Plastic up to 8% and 8% respectively.

The Marshall Stability value increased with Lignin and Waste Plastic content up to 8 % of Lignin and 8% of Plastic and thereafter decreases. We observed that the Marshall Flow value decreases upon addition of Lignin and Plastic, i.e. the resistance to deformations under heavy wheel loads increases and also the Value of the parameters like VMA, VA, VFB are within the requires specifications.

Considering these factors, we can assure that we can obtained a more stable and durable mix for the pavements by Lignin and Waste Plastic. The small investigation not only utilizes beneficially, the waste non-degradable Plastic and Lignin but also provides us an improved pavement with better strength and longer life period.

Lignin and Waste Plastic modified pavements would be a boon for India' s hot and extremely humid climate, where temperatures frequently rise 50^0C and torrential rains heavy leaving most of the roads with heavy distresses. This adversely affects the life of the pavements. The Lignin and waste Plastic show improved properties of pavements constructions. This can also reduce the amount of Lignin and waste Plastic which otherwise are considered to be a threat to the hygiene of the environment.

Generally, traditional hot mix asphalt emits large quantities of CO_2, CH_4 and N_2O. The usage of alternative sustainable binders (lignin and plastic), which can replace the bitumen, contributes to reduce reduced the emissions of CO_2, N_2O and CH_4 gases and avoid the use of anti-stripping agents.In this modification process the prepared mixed of Lignin, Plastic and bitumen sample blended with aggregate. This increased the surface area of the contact at the interface and ensures better bonding between aggregate and bitumen. This can also reduce the voids spaces present in the mix. This prevent the moisture absorption and oxidation of bitumen by entrapped air. The road can withstand heavy traffic and show better service life. This study will have a positive impact on the environment as it will reduce the volume of Lignin and Waste Plastic to the disposal of by incineration and land fillings. It will not only add value to Lignin and waste Plastic but will develop a technology, which is economical, eco- friendly, and no toxic gas evaluation.

5.2 FUTURE SCOPE

As the Population increased, the solid waste also increases proportionally. The best alternative is the usage of waste as construction material assuring a good disposal. As this method is economic the practice would be on satisfactory extent aiding the future generations for a good solid waste management. The main scopes are: -

- **Economic in terms of bitumen: -** The Lignin and shredded plastic in form polymer covers the aggregates and thus occupies a larger portion of the road reducing the quantity of bitumen needed
- **Efficient management of non-biodegradable waste: -** Lignin is a waste material produced from pulp and paper industries and Plastic is also harmful and non-biodegradable waste responsible mainly for land pollution. Utilization it for road construction will result in its efficient management.
- **Easy process without any new machinery: -** It is a simple and easy technique which does not involve any complex or new machinery.
- **Enhanced durability: -** The addition of Lignin and Waste Plastic to bitumen will help in improving the strength and durability of pavement.

REFERENCES

1) Aslam Shahan-ur-Rahman "Use of Waste Plastic in Construction of Flexible Pavement", New Building Material & Construction World, 2009.
2) Amit Gawande, G. Zamare, (2012), "An overview on waste plastic utilization in asphalting of roads."
3) ASTM D 4402 (2006), Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer, Annual Book of ASTM Standards 4.04, West Conshohocken, PA: ASTM International.
4) ASTM D 6521 (2004), Standard Practice for Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV), Annual Book of ASTM Standards 4.03, West Conshohocken, PA: ASTM International.
5) Al-Hadidy A.I., Yi-qui Tan (2009), "Effect of Polyethylene on Life of Flexible Pavement", Construction and Building Material, Vol. 23.
6) Aravind K., Das Animesh, (2007), "Pavement design with central plant hot-mix recycled asphalt mixes", Construction and Building Materials, Vol. 21, Dept. of Civil Engg., Indian Institute of Technology, Kanpur, India, pp 928–936.
7) A.j. Chavan (May 2013), Use of Waste Plastic in Flexible Pavement, International Journal of Application or Innovation in Engineering & Management, Vol. 2 Issue 4, 2013.
8) A. Logeshkumar (2018), "Expremental study of partial replacement of bitumen with plastic & lignin".
9) ASTM D 1559, "Test method of resistance of plastic flow of bituminous mixtures using Marshall Apparatus", American society for testing and materials.
10) Awwad M. T. and Shbeeb L (2007), "The use of polyethylene in hot asphalt mixtures", American Journal of Applied Sciences, volume 4, pp. 390-396.
11) AASHTO T 305, "Drain-down characteristics in un-compacted asphalt mixtures", American association of state highway and transportation officials.
12) Bindu C.S., Beena K.S. (2010), "Waste plastic as a stabilizing additive in SMA", International Journal of Engineering and Technology, Volume 2, pp. 379-387.

13) Button, j.W. and Little, D.N., Additive have Potential to Improve Pavement Life, 1998 (Road and Bridges: USA).
14) Bandopandhyay T. K., (Jan. – Mar. 2010), "Construction of Asphalt Road with Plastic Waste", Indian Center of Plastic in Environment (ICPE), ENVIS- Eco-Echoes, Vol.11, Issue 1.
15) Casey D., McNally C., Gibney A. and Gilchrist M. D. (2008), "Development of a recycled polymer modified binder for use in stone mastic asphalt", Journal of Resources, Conservation and Recycling, Volume 52, pp. 1167–1174.Authors.
16) Chavan A." (2013). "Use of Plastic Waste in Flexible Pavements" International Journal of Application or Innovation in Engineering and Management ISSN 2319-4847, Volume 2, Issue 4, April 2013.
17) Dun Qiao., (2010), "Utilization of sulfate-rich solid wastes in rural road construction in the Three Gorges Reservoir", Resources, Conservation and Recycling, Vol.54, College of Materials Science and Engineering, Chongqing University, China, pp 1368–1376.
18) Dave van Vliet, Ted Slaghek,cecile Giezen, Ingrid Haaksman (2016), "Lignin as a green alternative for bitumen".
19) Das, A., (1998). Analytical design of bituminous pavements based on field performance, unpublished PhD thesis, Civil Engineering Dept., IIT, Kaharagpur.
20) Denning, J.H. and Carswell, J., Improvement in rolled asphalt surfacing by the addition of organic polymers, Report LR 989, TRRL, Crowthrone 1981.
21) Das A. and Chakroborty P. (2010), "Principle of transportation Engineering", Prentice Hall of India, New Delhi, pp 294-299.
22) Donald W. Sundstrom, Herbert E. Kiel and Timothy H. Daubenspeck, Use of Byproduct Lignin as Extenders in Asphalt, Department of Chemical Engineering and Institute of Materials Science, The University of Connecticut,Industrial and Engineering Chemistry, 1983 Vol. 22 Nr. 3 Pag. 496.
23) Fernandes M. R. S., Forte M. M. C. and Leite L. F. M. (2008), "Rheological evaluation of polymer-modified asphalt binder", Journal of Material Research Volume 11, pp. 381-386.
24) Flynn F. (1993) "Recycle plastic finds home in asphalt binder" Journal Roads ans Bridges.

25) Guidelines for the design of flexible pavement (IRC 37-2001), Indian Road Congress, second revision, New Delhi.
26) Gawande. A. Zamare. G., Renge. V.C., Tayde.S., Bhar sakale.G (2012) "An Overview On Waste Plastic Utilization In Asphalting Of Roads" International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 3, March 2013.
27) Hemmila, V (2013), "Lignin- An adhesive raw material of the future or waste of research energy".
28) IRC: 111-2009, Specification for the dense Graded Bituminous Mixes.
29) IRC, "Guidelines for the design of flexible pavement", IRC: 37-1970, Indian Road Congress.
30) IRC:94-1986, Specification of dense bituminous macadam.
31) IRC SP: 53-2002, Guide lines on use of polymer and rubber modified bitumen in road construction.
32) IS: 1203 (1978), "Methods of testing tar and bituminous materials: determination of penetration", Bureau of Indian Standards, New Delhi.
33) IS: 2386 (1963), "Methods of test for aggregates for concrete (P-I): Particle size and shape," Bureau of Indian Standards, New Delhi.
34) IS: 2386 (1963), "Methods of test for aggregates for concrete (P-III): Specific Gravity, Density, Voids, Absorption, Bulking", Bureau of Indian Standards, New Delhi.
35) Minakshi Singhal, Yudhvir Yadav, Ranadip Mandal (2006), Use of modified bitumen in Highway construction, IJIRST – International journal for Innovation research in Science & technology, Vol. 2, issue 12.
36) P. J. Gundaliya (2016) "Utilization of Lignin as an antioxidant".
37) Sasane Neha, Gaikwad.Harish, Dr. J R Patil and Dr. S D Khandekar "Application of Waste Plastic as An Effective Construction Material in Flexible Pavement" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 - 0056 Volume: 02 Issue: 03 | June-2015 p-ISSN: 2395- 0072.
38) Savita Sharma, Shad Ahmad, Rupesh Kumar, Premchand Yadaav, Jtendar Kumar Dhavan "Partial Replacement of Bitumen by Using Plastic Waste in Bitumen Concrete".

39) Swami(2012) " Use of waste plastic in construction of bituminous road".
40) T. Subramani "Experimental Investigations on Coir Fibre Reinforced Bituminous Mixes" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 3, May-Jun 2012, pp.1794-1804.
41) T. KIRAN KUMAR et al. (2017), "Effect of polyethylene on life of flexible pavements", Journal of Construction and Building Materials, volume 23, pp. 1456-1464.
42) R. Vashudevan (2015) "addition of natural or synthetic polymers to bitumen".
43) R. Manju, Sathaya S, Sheema K 92017), International Journal of ChemTech Research, Vol. 10 No. 8, pp 804- 811.
44) Raji (2007) "Utilization of marginal as an ingredient in bituminous mix".
45) Vasudevan, R, Saravanavel, S, rajsekaran, S, and Thirunakarssu, D (2007) "Utilization of waste plastic in construction of flexible pavements", Indian Highways, Vol.34 no.7 IRC, pp 5-20.

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Research Article Volume 10 Issue No.2

A Review of Literature on Use of Modified Bitumen by Lignin and Waste Plastic in Bituminous Concrete

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Abstract:
Now a days, disposal of plastic waste is a serious problem due its non-bio-degradable characteristics. Bitumen is currently one of the most widely used binding materials in road pavement. The reasons due to which bitumen is mostly used as a binding material are its excellent binding characteristics, waterproofing properties and low cost as compared to other binders. In this paper, we have used the waste materials like plastic and lignin as a replacement material for modified bitumen in bituminous concrete with a different percentage. The objective of this study to find out the optimum percentage of bitumen that can replaced by waste material lignin & plastic.

Key Words: Plastic, Bitumen, Lignin.

I. INTRODUCTION

A nation's development mainly depends on the development of transportation of the country. As flexible pavement is majorly used in India, it is important that steps has to be taken to increase the life of the bituminous pavements. Flexible pavement is often subjected to problems like rutting, cracking, and other failures due to repeated traffic loads and hot mix asphalts emits the large amount of Ch_4, Co_2, N_2o, which cause environment pollution. In this study we have to used the waste materials like Lignin and Plastic as replacement material for modified bitumen in bituminous concrete with a different percentage and marshal test was performed on them. It has been found that lignin and plastic act as a binding material for asphalt hence improving the property of the bitumen and reduced the emissions of Ch_4, Co_2, N_2o and also solve the problems of disposal of waste plastic. It also increased the strength & performance of the road.

Dr. R. Vasudevan (2007)[2] This paper investigated that the coating of plastics reduces the porosity, absorption of moisture and improves soundness. The polymer coated aggregate bitumen mix forms better material for flexible pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient. Hence the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastics. Use of plastic bags in road help in many ways like Easy disposal of waste, better road and prevention of pollution.

Raji(2007)[3]This paper studied theUtilization of marginal materials as an ingredient in bituminous mixes. They concluded that when plastic wastes can be used as additives on bituminous pavements. Hence in their study, the properties of bituminous mix when modified with shredded syringe plastic waste were investigated. The work was carried out by mixing shredded autoclaved plastic syringes with heated aggregates by dry process.

Swami (2012)[4] In this paper the Use of waste plastic in the construction of bituminous Road. They concluded that plastic waste consisting of carry bags, cups and other utilized plastic could be used as a coating over aggregates and this coated stone could be used for Road construction.

Hemmila, V. (2013)[5] The study represents the use of waste material like lignin in hot bituminous mixes to intensify pavement performance, protect environment and provided low cost roads.

R. Vasudevan (2015)[6] This paper studied the addition of natural or synthetic polymers to bitumen is known to impart enhanced service propertiesBy adding small amounts of polymers to bitumen, the life span of the road pavement is considerably increased and the purpose is to achieve desired engineering properties such as increased shear modulus and reduced plastic flow at high temperatures and increased resistance to thermal fracture at low temperatures.

P. J. Gundaliya (2016)[7] This paper studied the viability of utilizing lignin as an antioxidant for arresting the aging of the bituminous binder. Oxidation is the primary cause of long-term aging in asphalt pavements. As a pavement oxidizes, it stiffens and can eventually crack. The use of an antioxidant as a performance enhancer in an asphalt binder could delay aging, thus increasing the life of an asphalt pavement. Lignin is highly available and well-studied antioxidant.

Dave van Vliet (2016)[8] This paper studied the Bio-based waste is used to improve propertiesand environmental sustainability by shifting from fossil- based resources to bio-based resources.

Bio-based resources are in favor from the sustainability point of view: they are renewable and do not contribute to climate change, as CO2 is captured from the atmosphere as a result of photosynthesis in the original vegetal source. The usage of alternative sustainable binders, which can replace the bitumen, contributes to reduce CO2-emissions.The paper describes the proof of concept in using lignin, as replacement or partial replacement of bitumen without losing its functionality.

A. Logeshkumaran (2018)[9]This paper studied the used of waste materials like lignin and plastic as a replacement material for bitumen in the different percentage. It has been found that lignin and plastic can act as a binding material for asphalt hence improving the properties of the bitumen. The usage of alternative sustainable binders, which canreplace the bitumen, contributes to reduce CO2-emissions and at the same time broadens the availability of binders and also increased the strength & performance of road.

II. CONCLUSION

From the review of literature on use of modified bitumen by lignin and waste plastic in bituminous concrete, the following conclusion can be drawn

• Bitumen is a non-renewable source which should be efficiently used where these replacements lignin and plastic plays a main role. By using these waste materials quantity of waste produced becomes less. Therefore, we conclude that by using lignin and plastic as a partial replacement of bitumen in pavements.
• To utilize waste material lignin and plastic as useful binding material, save the bitumen concrete road.
• To coat the aggregate with the waste material lignin and plastic.
• To check the properties of bituminous mix specimen with coating of waste material lignin & plastic.
• To find a suitable alternative over conventional material with cost reduction and improvement in strength and other parameter in flexible pavements.
• Use higher percentage of waste plastic & lignin.
• Avoid the disposal of waste plastic by burning & land filling.
• Reduced the need for bitumen by around 10% to 15%.
• Reduced the emissions of CO_2 , N_2O and CH_4 gases.

III. REFERENCES

[1]. A.Syed Mohamed ali, T.Jaganathaperumal "Experimental Performance Analysis on Waste Plastic Modified Asphalt & Asphalt Mixture – A Comparative Case Study" International Journal of Innovations in Engineering and Technology (IJIET) Volume 6 ISSN: 2319 – 1058.

[2]. ASTM D 4402 (2006), Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer, Annual Book of ASTM Standards 4.04, West Conshohocken, PA: ASTM International.

[3]. ASTM D 6521 (2004), Standard Practice for Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV), Annual Book of ASTM Standards 4.03, West Conshohocken, PA: ASTM International.

[4]. "Chavan A." (2013). "Use of Plastic Waste in Flexible Pavements" International Journal Of Application Or Innovation In Engineering And Management ISSN 2319- 4847, Volume 2, Issue 4, April 2013.

[5]. Dave van Vliet, Ted Slaghek, Cecile Giezen, Ingrid Haaksman "lignin as a green alternative for bitumen".

[6]. Gawande.A.Zamare.G.,Renge.V.C.,Tayde.S., Bharsakale.G (2012) An Overview On Waste Plastic Utilization In Asphalting Of Roads" International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 3, March 2013.

[7]. Karol J. Kowalski , Jan Król, Piotr Radziszewski, Raquel Casado, Víctor Blanco, Domingo Pérez, Víctor M. Viñas, Yvan Brijsse, Mia Frosch, Duy Michael Le, Matt Wayman, "Eco – friendly materials for a new concept of asphalt pavement" Transportation Research Procedia 14 (2016) 3582 – 3591.

[8]. Mrs.Vidula Swami, Abhijeet Jirge, Karan patil, Suhaspatil, Sushil patil, Karan salokhe "Use of waste plastic in construction of bituminous road" International Journal of Engineering Science and Technology (IJEST) ISSN : 0975-5462 Vol. 4 No.05 May 2012 2351.

[9]. Sasane Neha, Gaikwad.Harish, Dr. J R Patil and Dr. S D Khandekar "Application of Waste Plastic as An Effective Construction Material in Flexible Pavement" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 - 0056 Volume: 02 Issue: 03 | June-2015 p-ISSN: 2395- 0072.

[10]. Savita Sharma, Shad Ahmad, Rupesh Kumar, Premchand Yadaav, Jtendar Kumar Dhavan "Partial Replacement of Bitumen by Using Plastic Waste in Bitumen Concrete".

[11]. T. Subramani "Experimental Investigations on Coir Fibre Reinforced Bituminous Mixes" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www .ijera.com Vol. 2, Issue 3, May-Jun 2012, pp.1794-1804.

[12]. Use of Byproduct Lignins as Extenders in Asphalt, Donald W. Sundstrom, Herbert E. Kiel and Timothy H. Daubenspeck, Department of Chemical Engineering and Institute of Materials Science, The University of Connecticut, Industrial and Engineering Chemistry, 1983 Vol. 22 Nr. 3 Pag. 496.

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Research Article Volume 10 Issue No.7

Use of Modified Bitumen by Lignin and Waste Plastic in Bituminous Concrete

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Abstract:
A nation's development mainly depends on the development of transportation of the country. As flexible pavement is majorly used in India, it is important that steps has to be taken to increase the life of the bituminous pavements. Flexible pavement is often subjected to problems like rutting, cracking, and other failures due to repeated traffic loads. In this project, we have used the waste materials like lignin and plastic as a replacement material for bitumen in the percentage of 2&2%, 4&4%, 6&6%, 8&8%, 10&10%, 12&12% respectively. It has been found that waste material lignin and plastic can act as a binding material for asphalt hence improving the properties of the bitumen. By the mix proportions which is analyzed and determined by series of tests like penetration, ductility, softening point, Flash & Fire point and Marshall Stability test. it is found that the mix proportion of 8% &8% (Lignin & Plastic) has efficient results when compared to other proportions used.

Key Words: Bitumen, Lignin, aggregate, Plastic.

I. INTRODUCTION

Bitumen is widely used for the construction of highway and airport pavements, which together account for approximately 85% of the worldwide consumption of bitumen.Generally,hot mix asphalt emits large quantities of CO_2, CH_4 and N_2O. This material is part of the high carbon emissions disaster area of the high-way industry, which is unfavorable to the development of a low-carbon economy.The usage of alternative sustainable binders (Lignin &plastic), which canreplace the bitumen, contributes to reduce CO_2-emissions. Another challenge for the bitumen industry is that the petrochemical industry is becoming more and more efficient in breaking down higher chain hydrocarbons to lower chain hydrocarbons with higher added value than bitumen. This has an effect on the availability and quality of bitumen. The use of alternative sustainable binders broadens the availability.The alternative polymer that will be used as apartly alternative for bitumen originates from nature and is called lignin. Lignin is one of the most abundant naturally occurring polymer present in plant material. The chemical structure of lignin known to us today does reflect the structure of bitumen and therefore it could be used as an alternative for bitumen.In the present study, the VG-10 grade bitumen is used.The paper describes the proof of concept in using waste material lignin&plastic, aspartial replacement of bitumen without losing its functionality. It has been found that lignin &plastic act as a binding material for asphalt hence improving the property of bitumen and reduce the emissions of CO_2, N_2O, CH_4& also solve the problem of disposal of waste plastic. It also increased the strength & performance of the road.

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II. MATERIALS USED

WASTE PLASTIC

Now a day disposal of waste plastic is a serious problem due to its non- bio-degradability. The waste plastic and its disposala major threat to the environment, which results in pollution and global warming. The utilization of plastic waste in bituminous mixes enhances its properties and also its strength. The waste polythene used like bottles, bags, milk pouches etc. collected from the residential area and domestic area. The plastic processing industry is estimated to grow to 22 million tons a year by 2020 from 13.4 million tons in 2015 and nearly (50-60%) half of this is single-use plastic, according to a Federation of India chambers of commerce and industry study.

Table.1. Different Types and sources of Waste Plastic

TYPES	SOURCES
Polythene (PE)	Water Bottle, Carry Bags, Sacks, Milk Pouches etc.
Polypropylene (PP)	Bottle Cap, Detergent Wrappers, Biscuits etc.
Polystyrene (PS)	Clear egg pack, Disposable cups, Protective Packaging etc.

LIGNIN

Lignin, derived from the Latin term lignum meaning wood, is an integral part of the secondary cell walls of plants.Lignin is an organic binding material that binds the cells, fibers and vessels which constitute wood and the lignified elements of plants, as in straw. It is the second most abundant renewable carbon source on Earth. About 40 and 50 million tons of lignin are produced worldwide as a mostly non commercialized waste product annually.Ligninproduced from pulp and paper industries. Lignin is a hydrocarbon and consists mainly of carbon, hydrogen, and oxygen. Lignin constitutes 30% of non-fossil natural carbon and 20-35% of the dry mass of wood. Compared to bitumen lignin has high amount hydroxyl group. It makes lignin more hydrophobic and more compatible with lignin. Composition of lignin varies from species to species. An example of composition from an aspen sample is 63.4% carbon, 5.9% hydrogen, 0.7% ash (mineral component) & 30% oxygen. Approximate formula is $(C_{31}H_{34}O_{11})_n$.

Figure.1. Lignin

Table.2. Specification of Lignin

Items	Standards	Test Results
Visual Appearance	Broun power	Broun power
Water insoluble substance (%)	≤1.5	1
Solid Content (%)	≥92	93
PH Acidity	7.0- 9.0	8
Moisture Contents (%)	≤7	5
Lignosulphonates Contents (%)	≥50	52
Ca Mg (%)	0.3-1.5	0.8
Reducing sugar Contents (%)	≤6	3
Water Reducing of Mortar	≥8	10

AGGREGATE

The aggregate grading is used for testing for all testing is taking from IRC: 2386 (Part III & IV).

Table.3. Test results of Aggregate

NAME OF THE TEST	RESULT	ACCEPTABILITY CRITERIA
Specific Gravity	2.74	2.5-3.0
Aggregate Impact Value (%)	15	<30%
Aggregate Crushing Value (%)	18.66	<30%
Los Angeles abrasion Value (%)	15	<30%
Flakiness Index (%)	16	Combined Value <30%
Elongation Index (%)	11	

BITUMEN

The bitumen used in this study was Viscosity Grade (VG) -10. Bitumen is cementations, amorphous, thermoplastic material and its stiffness is dependent on temperature, its black or dark in color that is found in different forms, such as rock asphalt, natural bitumen derived from oil.

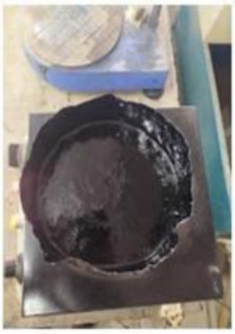

Figure.2. Bitumen

MIXING METHODS

Collection of waste plastic from roads, garbage trucks, dumpsites and compost plants, rag pickers, waste-buyers. Clean and dried waste plastic & shredded into small pieces (2 mm to 4 mm).The initial mixing method involved heating the lignin and plasticto about 110 to 180 degree Celsius on a hot plate, and mixing them with a spatula for several minutes.lignin purchased from market will be in powdered form and need to be heated to approximate temperature of 125^0C to make it viscous. To improve the compatibility of the lignin in asphalt, organic liquids were added to the mixture. Creosote and kerosene were effective in improving dispersion of lignin in the asphalt. The bitumen VG-10 was also heated up to its melting point for good mixing. After heating lignin and plastic will be ready to be blended with the bitumen. As the lignin and plastic is to be blended with bitumen so best mixing time needs to be determined.This will help in increasing the properties of the blend and also will make the mixture samples homogeneous. After analyzing the best mixing time various samples of the bitumen are prepared at various percentages by volume and the samples of lignin, plastic & bitumen are prepared by the desired process the various tested need to be performed on the samples.For Marshall Stability test the aggregate heated up to 160^0C to 170^0C and the prepared sample of Lignin, Plastic and bitumen blended with aggregate at different percentage. After homogeneous mixing the samples are ready to performed for Marshall tests. The tests done are penetration test, ductility, softening point, Flash & Fire and Marshall stability test and find out the best optimum bitumen content of mixed.

Figure.3. Lignin Mixed With Kerosene

PERFORM TESTS

There are several tests to be done to find out the properties of bitumen. The tests done are penetration test, ductility, softening point, Flash & Fire test Marshall stability test etc.

Table.4. Following the tests have been performed on bitumen

TESTS	TESTS RESULTS
Penetration value test at 25^0C	88
Softening point test, ^{0}C	45
Ductility test at, 27^0C	75
Flash point test, ^{0}C	225
Fire point test,^{0}C	237

Following the tests performed on aggregate: -

Table.5. Specific gravity of aggregates

Types of aggregates	Specific gravity
Coarse	2.71
Fine	2.61
Filler	2.62

Table.6. Aggregates gradation of bituminous concrete

Sieve size (mm)	Percentage passing	Spec. Limit of % passing
40	100	100
25	96.8	85-100
20	73.72	71-95
12.5	60.8	58-82
10	54	52-72
4.75	38	35-50
2.36	35	28-43
0.6	22	15-27
0.3	18	7-21
0.15	11	5-15
0.075	5	2-8

The results of the various test conducted for the bitumen sample with different proportion of mixing are discussed below.

Sample 1 - Bitumen without replacement
Sample 2 - Bitumen with partial replacement of 2% lignin &2% plastic
Sample 3 - Bitumen with partial replacement of 4% lignin &4% plastic
Sample 4 - Bitumen with partial replacement of 6% lignin &6% plastic
Sample 5 - Bitumen with partial replacement of 8% lignin &8% plastic
Sample 6- Bitumen with partial replacement of 10% lignin & 10% plastic
Sample 7- Bitumen with partial replacement of 12% lignin &12% plastic

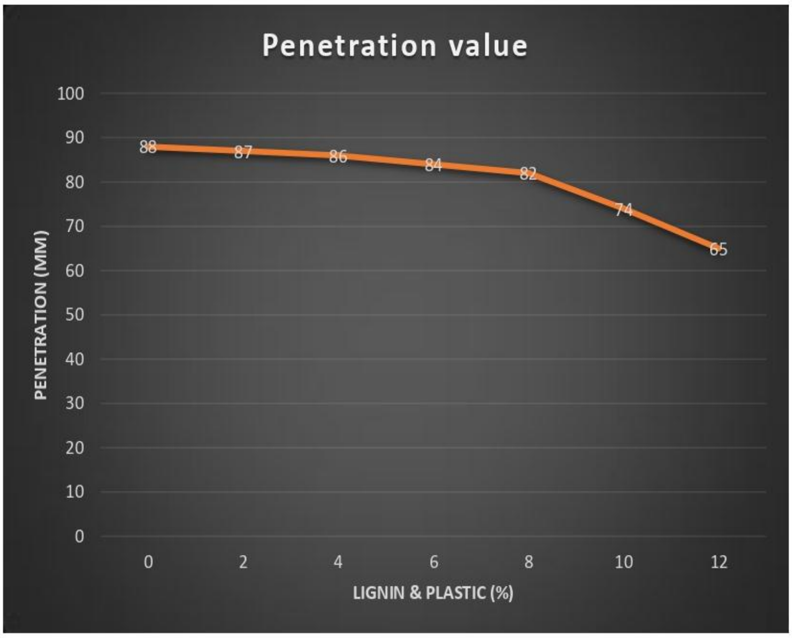

Figure.4. Penetration value v/s Lignin & Waste Plastic content

Figure.5. Ductility value v/s Lignin & Waste Plastic content

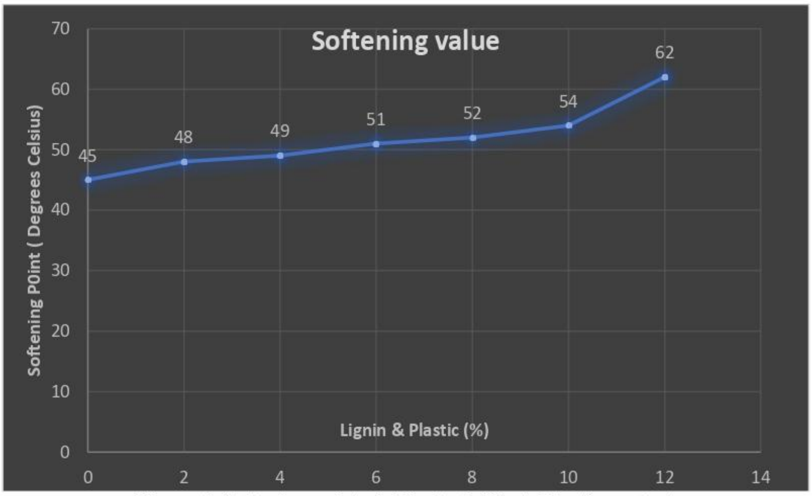

Figure.6. Softening point v/s Lignin & Waste Plastic content

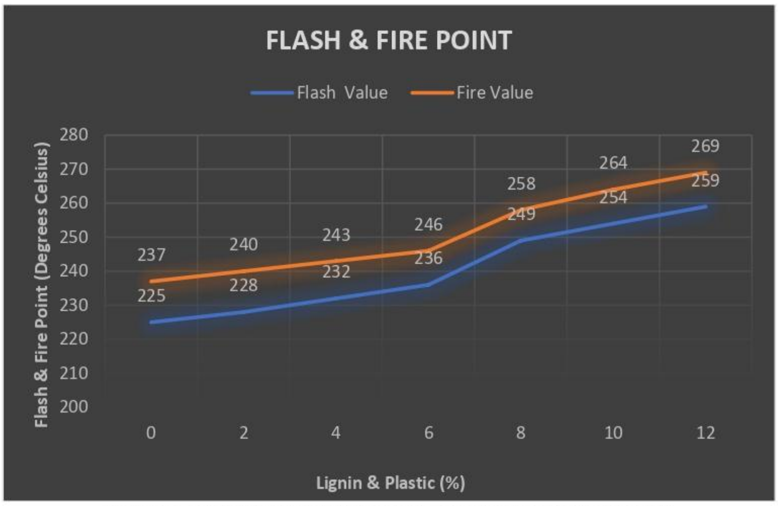

Figure.7. Flash & Fire point v/s Lignin & Waste Plastic content

MARSHALL STABILITY TEST

The Marshall Test specimens were prepared by adding 4% of binder content by weight of aggregate.
- Percentage air voids, Vv.
- Percentage volume of bitumen,Vb.
- Percentage void in mixed aggregates, VMA
- Percentage voids filled with bitumen, VFB

Table.7. Data for Plotting Curves (Lignin & Waste Plastic)

Lignin (%)	Waste Plastic (%)	Optimum Bitumen Content (%)	Stability (KN)	Flow Value (mm)	Air Voids (%)	Voids Filled With Bitumen VFB (%)
0	0	4	11.20	3.86	5.61	62.51
2	2	4	15.25	3.76	4.63	62.82
4	4	4	20.20	3.48	4.52	63.26
6	6	4	22.15	3.34	4.35	63.90
8	8	4	23.42	3.15	4.34	64.40
10	10	4	17.45	3.12	4.32	64.28
12	12	4	9.30	2.99	4.25	64.25

Figure.8. Marshall Stability value v/s Lignin & Waste Plastic content

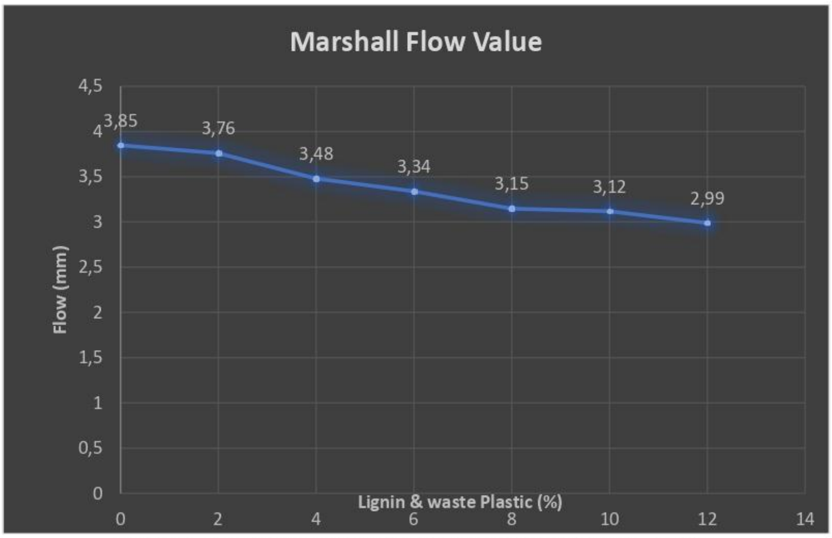

Figure.9. Marshall Flow value v/s Lignin & Waste Plastic content

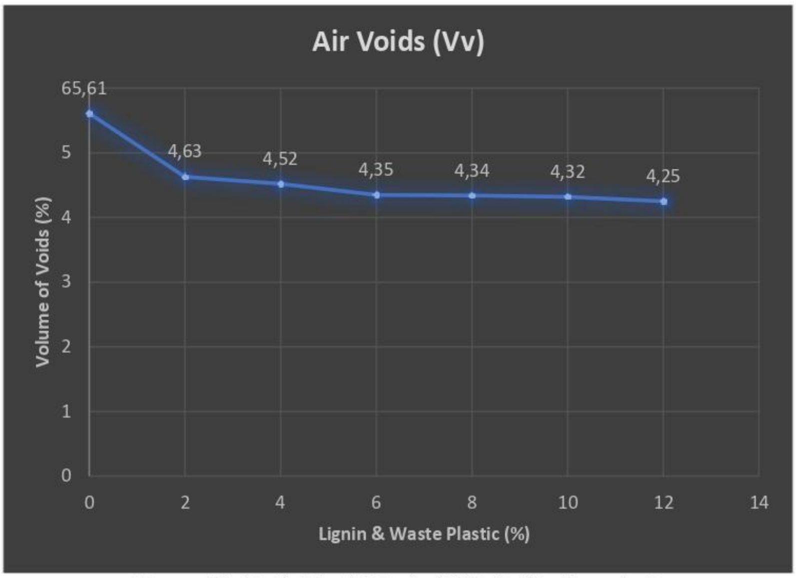

Figure.10. Air Voids v/s Lignin & Waste Plastic content

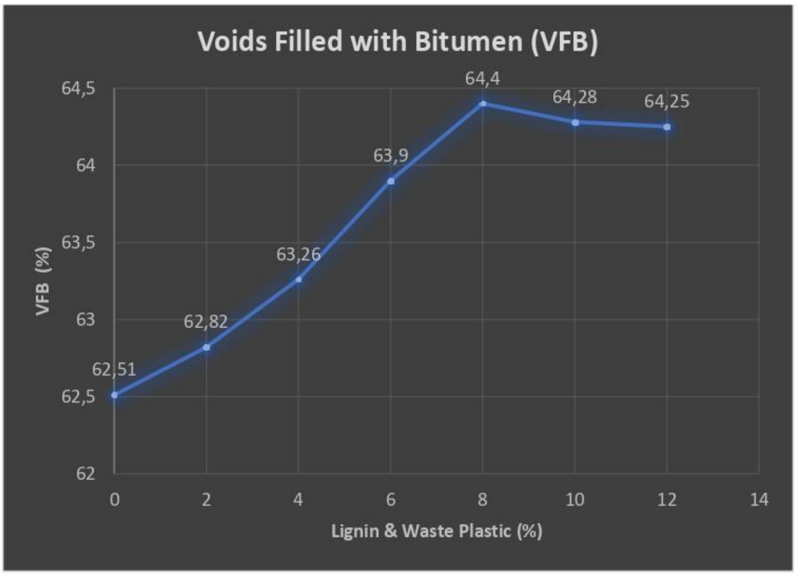

Figure.11. Voids filled with bitumen (VFB) v/s Lignin & Waste Plastic content

II. COST ANALYSIS

Cost of bitumen VG- 10 for 1 Kg. is 35 Rs/-.
1 kg. = 35 Rs/-
Cost of lignin (12 Rs./Kg) and plastic (8 Rs./Kg) for 1 Kg. is 18 Rs/-
1 Kg. (Lignin & plastic) = 18 Rs/-
cost of 1000 gm bitumen = 35 Rs/-
Value of 16% (8% Lignin + 8% Plastic) of 1 Kg bitumen $=\frac{1000}{100} \times 16 \ = 160gm$
Cost of 160 gm bitumen $=\frac{35}{1000} \times 160 \ = 5.6 \ Rs/-$
Cost of 160 gm bitumen = 6 Rs/-
Now, cost of 1000 gm lignin and plastic = 18 Rs/-
Cost of 160 gm lignin and plastic $=\frac{18}{1000} \times 160 \ = 2.88 \ Rs/-$

Cost of 160 gm lignin and plastic = 3 Rs/-
Now, cost difference of 160 gm (lignin & plastic and bitumen) = 6-3 = 3 Rs/-
Total saving cost in 1 kg bitumen = 3 Rs/-
Now,
Total cost saving percentage in bitumen = $\frac{3}{35} \times 100 = 8.57 \cong 8\,\%$

Total saving cost in bitumen is 8%.

III. CONCLUSION

From the study of the behavior of Lignin & Waste Plastic it was found that the modified mix process improved the properties of bitumen such as Penetration, Ductility, softening, Flash & Fire in all the aspects which helps in increasing the life span of pavements. A gradual increase has been observed in all these properties of bitumen by partially replacing it with Lignin and Waste Plastic up to 8% and 8% respectively.

The Marshall Stability value increased with Lignin and Waste Plastic content up to 8 % of Lignin and 8% of Plastic and thereafter decreases. We observed that the Marshall Flow value decreases upon addition of Lignin and Plastic, i.e. the resistance to deformations under heavy wheel loads increases and also the Value of the parameters like VMA, VA, VFB are within the requires specifications.

- Using higher percentage of Lignin and Waste Plastic.
- Reduce the need of bitumen.
- Lignin and Plastic increase the melting point of bitumen.
- Increase the strength and performance of the road.
- Avoid the use of anti- stripping agent.
- Avoid the disposal of waste plastic by the burn and land filling.
- As Lignin and Plastic are added to the aggregate, the moisture absorption ability of the aggregate decrease, resulting in better resistance to rain.
- Reduced the emissions of toxic gas like CO2, N2O and CH4.
- Higher resistance to rain and water logging.
- Total saving cost in bitumen is 8%.
- The load is withstanding property increased. It helps to satisfy today's need for increased road transport.
- Develop a technology which is eco-friendly, no toxic gas evaluation.

IV. REFERENCES

[1]. A.Syed Mohamed ali, T.Jaganathaperumal "Experimental Performance Analysis on Waste Plastic Modified Asphalt & Asphalt Mixture – A Comparative Case Study" International Journal of Innovations in Engineering and Technology (IJIET) Volume 6 ISSN: 2319 – 1058.

[2].A. Logeshkumar (2018), "Exprementai study of partial replacement of bitumen with plastic & lignin".

[3]. "Chavan A." (2013). "Use of Plastic Waste in Flexible Pavements" International Journal Of Application Or Innovation In Engineering And Management ISSN 2319- 4847, Volume 2, Issue 4, April 2013.

[4]. Dave van Vliet, Ted Slaghek, Cecile Giezen, Ingrid Haaksman "lignin as a green alternative for bitumen".

[5]. Gawande.A.Zamare.G.,Renge.V.C.,Tayde.S.,Bharsakale.G (2012)An Overview On Waste Plastic Utilization In Asphalting Of Roads" International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 3, March 2013.

[6]. Hemmila, V (2013), "Lignin- An adhesive raw material of the future or waste of research energy".

[7]. Karol J. Kowalski, Jan Król, Piotr Radziszewski, Raquel Casado, Víctor Blanco, Domingo Pérez, Víctor M. Viñas, Yvan Brijsse, Mia Frosch, Duy Michael Le, Matt Wayman, "Eco – friendly materials for a new concept of asphalt pavement" Transportation Research Procedia 14 (2016) 3582 – 3591.

[8]. Mrs.Vidula Swami, Abhijeet Jirge, Karan patil, Suhaspatil, Sushil patil, Karan salokhe "Use of waste plastic in construction of bituminous road" International Journal of Engineering Science and Technology (IJEST) ISSN: 0975-5462 Vol. 4 No.05 May 2012 2351.

[9]. P. J. Gundaliya (2016) "Utilization of Lignin as an antioxidant".

[10]. R. Vashudevan (2015) "addition of natural or synthetic polymers to bitumen".

[11].Raji (2007) "Utilization of marginal as an ingredient in bituminous mix".

[12]. Sasane Neha, Gaikwad.Harish, Dr. J R Patil and Dr. S D Khandekar "Application of Waste Plastic as An Effective Construction Material in Flexible Pavement" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 - 0056 Volume: 02 Issue: 03 | June-2015 p-ISSN: 2395- 0072.

[13]. Use of Byproduct Lignins as Extenders in Asphalt, Donald W. Sundstrom, Herbert E. Kiel and Timothy H. Daubenspeck, Department of Chemical Engineering and Institute of Materials Science, The University of Connecticut,Industrial and Engineering Chemistry, 1983 Vol. 22 Nr. 3 Pag. 496.

[14].Vasudevan, R, Saravanavel, S, rajsekaran, S, and Thirunakarssu, D (2007) "Utilization of waste plastic in construction of flexible pavements", Indian Highways, Vol.34 no.7 IRC, pp 5-20.

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