EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF BITUMEN WITH LIGNIN AND PLASTIC

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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 5&10%, 10&15%, 15&20%, 20&25% respectively. It has been found that lignin 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, viscosity, softening point, it is found that the mix proportion of 15&20% has efficient results when compared to other proportions used.
Key Words - Bitumen, Lignin, Plastic

1. INTRODUCTION:

Bio-based waste is utilized to enhance properties (lifetime of the material) and ecological maintainability by moving from fossil based assets to bio-based assets. Bio-based assets are in support from the maintainability perspective: they are renewable and don't add to environmental change, as CO2 is caught from the climate subsequently of photosynthesis in the first vegetal source. As bitumen is created from fossil sources the black-top market is searching for options with higher maintainability as far as CO2 emanation. The utilization of option reasonable folios, which can (somewhat) supplant the bitumen, adds to lessen CO2-discharges. The paper depicts the utilization of lignin and plastic as an "incomplete" substitute for bitumen. The option polymer that has been investigated as an "incompletely" elective for bitumen begins from nature and is called lignin. Lignin is a standout amongst the most inexhaustible common polymers (by cellulose and semi cellulose) show in plant material. The substance structure known today reflects the structure for bitumen and along these lines it could be utilized as an option for bitumen in applications like material or black-top. The paper depicts the confirmation of idea in utilizing lignin and plastic, as substitution or fractional substitution of bitumen without losing its usefulness. Extensive measure has been accomplished for the transfer of these waste plastic. These plastics are significantly non-biodegradable so that can be utilized as a modifier in bitumen and to upgrade their quality. It was thought convenient to test these material and create detail to upgrade the utilization in Road making in which higher financial return are conceivable. The fundamental particular ought to be planned and endeavors are to be made to most extreme utilization of waste plastic in upper layer of street asphalt. By utilizing plastic and lignin in fitting extents as a substitution for bitumen the outcomes are effective and useful.

2. MATERIALS USED:

BITUMEN:

Bitumen is a mix of common lipids that are incredibly gooey, sticky, absolutely dissolvable inn carbon disulphide and is made out of exceptionally combined polycyclic hydrocarbons. Actually happening or rough bitumen is a sticky, tar like kind of oil which is so thick and considerable that it must be warmed or debilitated before it will stream. At room temperature, it is much like chilly molasses.

Fig 2.1. Bitumen

Refined bitumen is the remaining part gained by incomplete refining of crude oil. It is the heaviest bit and the one with the most surprising limit, rising at 525OC. Unadulterated bitumen with passageway level 60-70 and EG-30 is used and assembled from the turnpike plant. Diverse tests are guided on bitumen to assess its consistency, degree, thickness, temperature shortcoming, and security.

CHARACTERISTICS:

BITUMEN ADHERES

Bitumen has good glue qualities under certain conditions. Still in presence of water the bond creates a few issues. The greater part of the totals utilized as a part of street development have a powerless negative charge at first glance. The bitumen total bond is a result of a frail scattering power. Water is profoundly polar and subsequently gets firmly connected to the total uprooting the bituminous covering.

ELASTICITY:

When a string is taken from a bitumen sample and extends or prolongs it, it can return to a length near its unique length in the long run. For a few bitumen this procedure may take longer time than others. This tendency is called as the flexibility of bitumen.

PLASTICITY:

At the point when temperatures are increased, and in addition when a heap was connected to bitumen, the it will stream, however won't come back to its original position after load is expelled. This condition was alluded to as plastic conduct. Applying a heap implies that you put a weight on the bitumen keeping in mind the end goal to subject it to stretch. This could be in a lab or in the bitumen last position in the street and it is done to evaluate the bitumen response to the heap.

VISCO-ELASTIC:

Bitumen is a Viscoelastic substance. It might be either thick or versatile relying upon the temperature or the heap it is conveying. At greater temperatures there is more stream or plastic conduct, while at lower temperatures and brief length stacking, the bitumen has a tendency to be firm and flexible. In middle of the road temperatures it has a tendency to be a blend of the two.

BITUMEN AGES:

Aging represents the change in the properties of bitumen after some time, which is created by outside condition. These progression is noticeable as it breaks or disintegrating regions. The point at which the bitumen is presented to environmental conditions, the bitumen atoms respond to oxygen, as it brings about a change in the structure and arrangement of the bitumen. The procedure of consolidating in presence of oxygen, known as oxidation, makes the bitumen to wind up distinctly weak and hard and to change shading from dim chestnut or dark to dim. This change is generally alluded to oxidative solidifying or age solidifying. This type of maturing happens all the more as often as possible in hotter climatic or amid warm seasons, bringing about more seasoned asphalts to break all the more effectively. The condition can likewise happen where the surface movies of bitumen are thin, or if there has been deficient compaction amid development.

LIGNIN:

Lignin is a class of complex organic polymers that form important structural materials in the support tissues of vascular plants and some algae. Lignins are particularly important in the formation of cell walls, especially in wood and bark, because they lend rigidity and do not rot easily. Lignin constitutes 30% of non-fossil natural carbon and 20-35% of the dry mass of wood. 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.

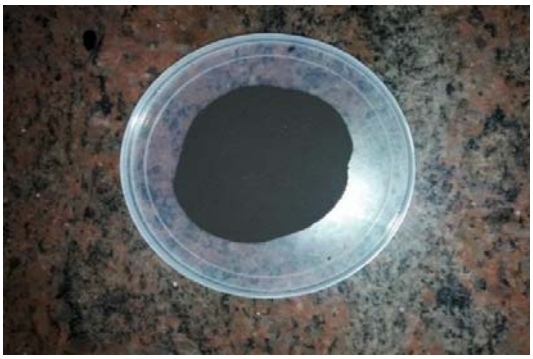

Fig 2.2. lignin

LIGNIN AS BINDER:

Lignosulfonates are an exceptionally powerful and sparing cement, going about as a coupling operator or "paste" in pellets or compacted materials. Lignosulfonates utilized on unpaved streets lessen ecological worries from airborne clean particles and balance out street surface. The coupling capacity makes it a valuable part of:

Coal briquettes, Biodegradable Plastic, Plywood and molecule board, Earthenware production, Creature bolster pellets, Carbon dark, Fiberglass protection, Manures and herbicides tile glue, Clean suppressants, Soil stabilizers

LIGNIN AS DISPERSANT

Lignosulfonate keeps the bunching and settling of undissolved particles after suspensions. By joining the molecule surface, it shields the molecule from being pulled in to different particles and lessens the measure of water expected to utilize the item successfully. The scattering property makes lignosulfonate helpful in:

Leather tanning, Cement mixes, Concrete admixtures, Clay and ceramics, Dyes and pigments, Pesticides and insecticides

LIGNIN AS AN EMULSIFIER

Lignosulfonate balances out emulsions of non-soluble fluids, for example, water and oil, making them profoundly impervious to breaking. Lignosulfonates are grinding away as emulsifiers in: Pesticides, Asphalt emulsions, Wax emulsions, Pigments and dyes

2.3 PLASTIC

Plastics are natural substances shaped by macro cells called polymers. These polymers are extensive gatherings of monomers connected by a compound procedure called polymerization. Plastics give the fundamental adjust of properties that cannot be accomplished with different materials, for example, shading, lightweight, delicate touch and imperviousness to ecological and natural debasement.

Truth be told, plastic alludes to a condition of the material, yet the material itself: manufactured polymers ordinarily called plastics are really engineered materials that can accomplish the plastic state, i.e., when the material is gooey or liquid, and no resistance properties to mechanical anxiety. This state is achieved when the material gets to be distinctly strong plastic state ordinarily by warming, and is perfect for various generation forms and that this state is the point at which the material can be taken care of in the structures that exist today. So the word plastic is an approach to allude to manufactured materials fit for going into a plastic state, yet plastic is not really the gathering of materials to which this word alludes day by day.

Fig 2.3. Plastic

2.3.1 CHARACTERSTICS

The properties and attributes of most plastics (however not generally satisfied in certain unique plastics) are these:

Easy to work and shape, Have a low creation cost, Possess low thickness, Tend to be waterproof, Good electrical encasings, Acceptable acoustic protection, Good warm protection, however most cannot withstand high temperatures, Resistant to consumption and numerous compound components; Some are not biodegradable or effortlessly recyclable, and on the off chance that they consume, are exceptionally dirtying.

2.4 AGGREGATE

Aggregate is likewise utilized for base and sub-base courses for both adaptable and inflexible asphalts. Aggregates can either be common or produced. Regular aggregates are for the most part extricated from bigger shake developments through an open excavation(quarry). Separated shake is normally decreased to usable sizes by

mechanical squashing. Made aggregates is regularly a bye result of other assembling enterprises.

Aggregates are devoured in substantial amounts to meet street development and other framework improvement exercises. Recognize that aggregate is not recently earth or soil that is promptly accessible from a boundless number of areas.

Aggregates, truth be told, incorporates numerous unmistakable evaluations of sand and rock, differing both in their geologic birthplace and in their consequent handling. ordinarily utilized preparing procedures incorporate pulverizing, screening and washing. Every item sort is produced to meet set building details.

3. MIXING METHODS

The initial mixing method involved heating the plastic, lignin and asphalt to about 110 to 180 degree Celsius on a hot plate, and mixing them with a spatula for several minutes. The mixture was then poured into a container for storage. Although the blend appeared homogeneous during mixing, lumps of lignin floated to the top of the storage container upon reheating.

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.

Fig 3.1. Lignin lumps

Fig 3.2. Lignin mixed with kerosene

4. EXPERIMENTAL INVESTIGATION TEST FOR BITUMEN

There are several tests to be done to find out the properties of bitumen. The tests done are penetration test, ductility, viscosity, softening point, Marshall stability test etc.., The standard values for each test is specified in the below table,

Table 4.1. Standard values for bitumen tests

TESTS	STANDARD VALUES
Penetration	80 to 225
Ductility	Not less than 50
Viscosity	40secs to 120secs
Softening point	$30^{o}C$ to $70^{o}C$

5. RESULTS AND DISCUSSION

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

Note:

Sample 1 - Bitumen without replacement

Sample 2 - Bitumen with partial replacement of 5% lignin & 10% plastic

Sample 3 - Bitumen with partial replacement of 10% lignin & 15% plastic

Sample 4 - Bitumen with partial replacement of 15% lignin & 20% plastic

Sample 5 - Bitumen with partial replacement of 20% lignin & 25% plastic

PENETRATION TEST

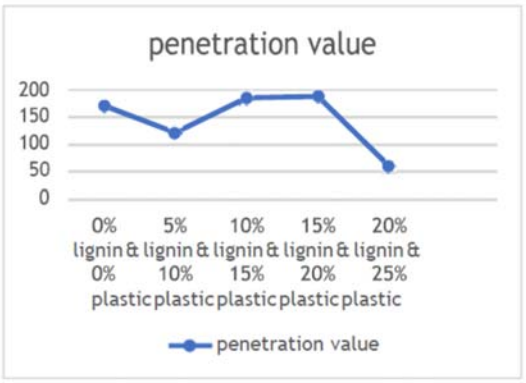

Fig 5.1. Percentage of replacement vs Penetration value

The penetration values with various percentage of partial replacement of bitumen by lignin and plastic are given in the above tabulation. From these values it is evident that the penetration values of the sample has been increased significantly after the partial replacement when compared to the conventional samples. It has been observed that there is an increase of 9.94% in the penetration values.

SOFTENING POINT

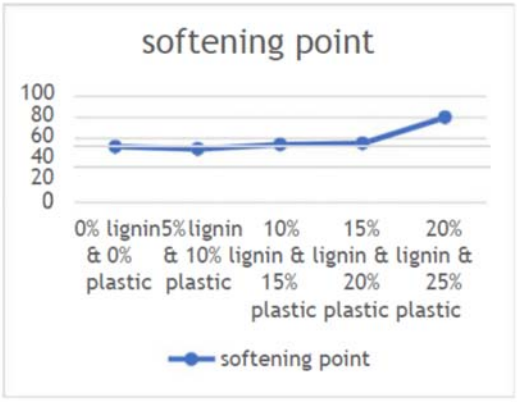

Fig 5.2. Percentage of replacement vs Softening point(oc)

The results observed from the softening point test has been indicated in the above provided table. The softening point increases to an percentage of 5.83% after partially replacing it with lignin and plastic to a certain extent.

DUCTILITY TEST

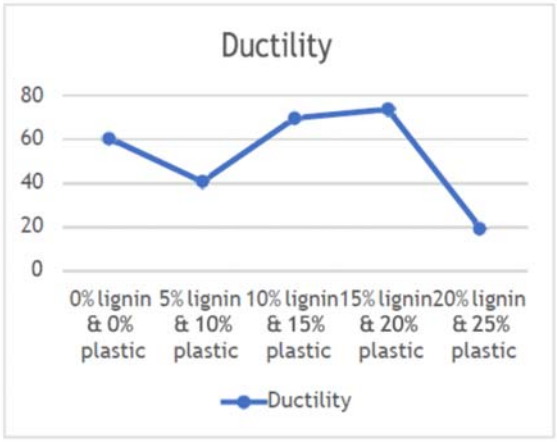

Fig 5.3. Percentage of replacement vs Ductility(cm)

The ductility values of the bitumen sample taken with and without any replacement has been recorded in the above given tabulations. It has been observed that there is an increase of about 20% in the ductility property of the bitumen after partially replacing the bitumen with lignin and plastic.

VISCOSITY TEST

Fig 5.4. Percentage of replacement vs Viscosity(secs)

The viscosity of various samples with various mix proportions are listed above. The viscosity of the partially replaced bitumen has an increase of about 5.95% of its value when compared to that of the conventional bitumen specimen.

MARSHALL STABILITY TEST

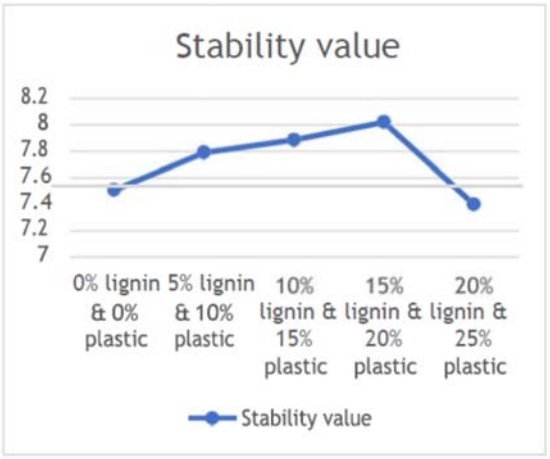

Fig 5.5. Percentage of replacement vs Stability value

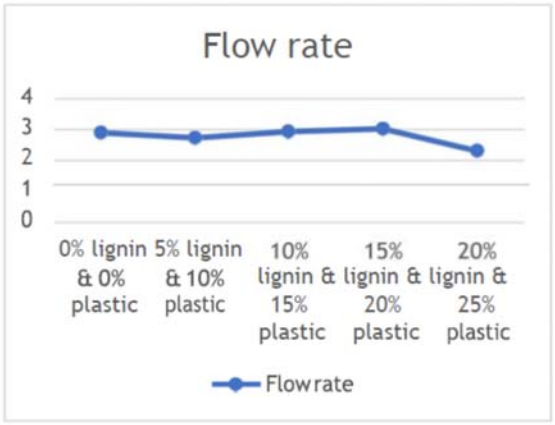

Fig 5.6. Percentage of replacement vs Flow rate

The stability and flow rate of various samples are listed above. The stability and flow rate of the partially replaced bitumen has increased up to 5.1% and 4.49% respectively when compared to that of the conventional bitumen specimen.

6. CONCLUSION

Bitumen is a non-renewable source which should be efficiently used where these replacements (Lignin and Plastic) plays a main role. By consuming 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, the results are very effective when compared to the usual usage of bitumen in the construction of pavements. The properties of bitumen such as ductility, viscosity, softening point, penetration were improved in all the aspects which helps in increasing the life span of the pavements. A gradual increase is observed in all these properties of bitumen by partially replacing it with lignin and plastic up to 15% and 20% respectively.

From these experimental study, it is evident that the ductility property of bitumen is very much increased up to 20% when compared with conventional bitumen sample. The increase in ductility property enhances the binding property of the bitumen. The penetration value has been increased up to 9.94%. The softening point increases to an percentage of 5.83%. The viscosity of the partially replaced bitumen has an increase of about 5.95%. The stability and flow rate of the partially replaced bitumen has increased up to 5.1% and 4.49% respectively when compared to that of the conventional bitumen specimen. But these increase in value stops when the percentage of replacement of lignin increases above 20%. It leads to formation of lumps in the bitumen mixture which reduces the binding property of the bitumen and also affects the flow of the bitumen leading to exposure of aggregate.

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