Lignin As Partial Replacement For Bitumen

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Abstract

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 favour 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.

As bitumen is produced from fossil sources, and the asphalt market is looking for alternatives with higher sustainability in terms of low CO_2 emission. The usage of alternative sustainable binders, which can (partly) replace the bitumen, contributes to reduce CO_2-emissions.

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 (next to cellulose and hemi cellulose) 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.

About Bitumen:-

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. Bureau of Indian Standards (BIS) in year 1950 for the first time introduced paving grade bitumen specifications and classified it on penetration (IS: 73- 1950) and were revised in the years 1962 and 1992. BIS revised (IS: 73-1992) specifications based on Viscosity (at a temp 60°C) in 2006 July to improve some qualities of bitumen. As per these specifications, there are four grades VG-10, VG-20, VG-30 & VG-40.

Presently about 90-95% of the total road length globally is paved with bitumen. And the overall demand for the bitumen accounts for about 100 million tons per year i.e., about more than 700 million barrels are consumed annually.

The majority of asphalt used commercially is obtained from petroleum. Nonetheless, large amounts of asphalt occur in concentrated form in nature. Naturally occurring deposits of bitumen are formed from the remains of ancient, microscopic algae(diatoms) and other once-living things. These remains were deposited in the mud on the bottom of the ocean or lake where the

organisms lived. Under the heat (above 50 °C) and pressure of burial deep in the earth, the remains were transformed into materials such as bitumen, kerogen or petroleum.

Natural deposits of bitumen include lakes such as the Pitch Lake in Trinidad and Tobago and Lake Bermundez in Venezuela. Natural seeps occur in the La Brea Tar Pits and in the Dead Sea.

Bitumen also occurs in unconsolidated sandstones known as "oil sands" in Alberta, Canada, and the similar "tar sands" in Utah, US. The Canadian province of Alberta has most of the world's reserves, in three huge deposits covering 142,000 square kilometres (55,000 sq mi), an area larger than England or New York State.

Table 1 VISCOSITY GRADE (VG) BITUMEN SPECIFICATION AS PER IS 73:2006

Characteristics	VG-10	VG-20	VG-30	VG-40
Absolute Viscosity, 60°C, poises, min	**800**	**1600**	**2400**	**3200**
Flash point, C, min	**220**	**220**	**220**	**220**
Penetration at 25°C	**80-100**	**60-80**	**50-70**	**40-60**
Softening point °C, min	**40**	**45**	**47**	**50**
Ductility	**70**	**50**	**40**	**25**
Specific gravity	**0.99**	**0.99**	**0.99**	**0.99**
Float Test				
Water Content Max	**0.2%**	**0.2%**	**0.2%**	**0.2%**

Application of Bitumen

Bitumen is widely used in the construction of asphalt roads and bituminous membrane products. Bitumen is commonly used to build highways and motorways. Bitumen has excellent water-proofing properties and is widely used for making roofing products along with a range of other household and industrial applications, from emulsion paints to sound-proofing. Bitumen is also used for surfacing airfield runways and air strips and taxi ways. For the Marine construction industry bitumen is used for hydraulic applications such as canal lining, underwater tunnels, river bank protection, dam construction and sea defences. There are also numerous industrial applications like roofing felt material, printing inks, packaging paper, linoleum, electrical cable / Junction box insulation, mastic for roofing of terraces, and duplex paper manufacture. Bitumen Suppliers Limited can meet all your individual requirements.

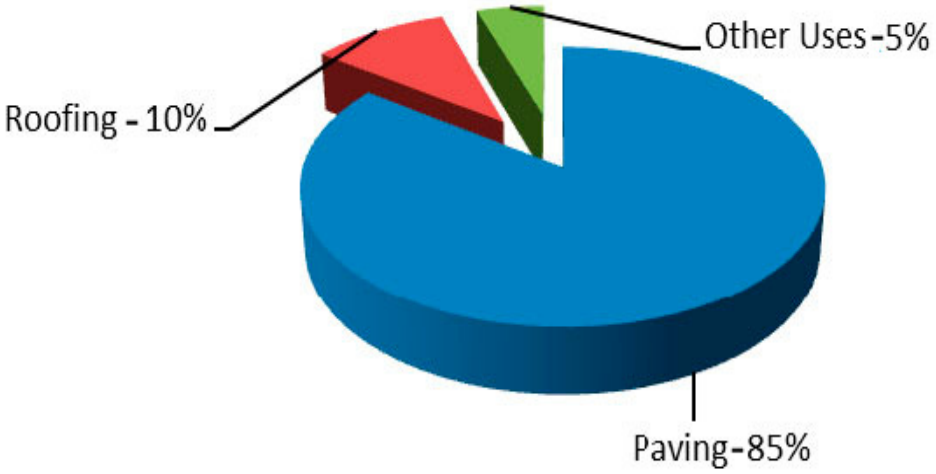

Figure 1 Application Of Bitumen

About Lignin:-

Lignin is an organic binding material that binds the cells, fibres 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. The lignols that crosslink are of three main types, all derived from phenylpropane: 4-hydroxy-3-methoxyphenylpropane, 3,5-dimethoxy-4-hydroxyphenylpropane, and 4-hydroxyphenylpropane. The former tends to be more prevalent in conifers and the latter in hardwoods.

There are two principal categories of lignin: those which are sulphur bearing and those which are sulphur-free. It is the sulphur bearing lignins which have to date been commercialized. These include lignosulphonates (world annual production of 500,000 tons) and Kraft lignins (under 100,000 tons p.a.). Due to the lack of suitable industrial processes, the sulphur-free lignins are as yet non-commercialized.

As a natural and renewable raw material, obtainable at an affordable cost, lignin's substitution potential extends to any products currently sourced from petrochemical substances.

It is not possible to define the precise structure of lignin as a chemical molecule. All lignins show a certain variation in their chemical composition. However the definition common to all is a dendritic network polymer of phenyl propene basic units.

Figure 3.1

Lignin in powder form

Figure 3.2

Lignin when Heated

Figure 3.3 Chemical Structure Of Lignin

Present Applications of Lignin

The areas in which lignin is applicable include:

a) Multy-polarity related products

Lignin contains both hydrophilic and hydrophobic groups. Specific treatments can strengthen either characteristic for particular applications as in emulsions and dispersants.

b) Materials

Lignin is a natural branched and crosslinked network polymer which lends itself to use in materials. Binders, thermoset, etc.

c) Agriculture

Lignin and lignin derived products play an important role in the formation of soils and in plant and animal nutrition.

d) High purity / value applications

High purity support materials or active substances: lignin can be used as support materials for food and cosmetic applications comprising gels or emulsifiers; specially prepared lignins are suitable as an active substance with anti-oxidant, anti-bacterial and anti-viral properties. These qualities have already been explored and could play an important role in the future.

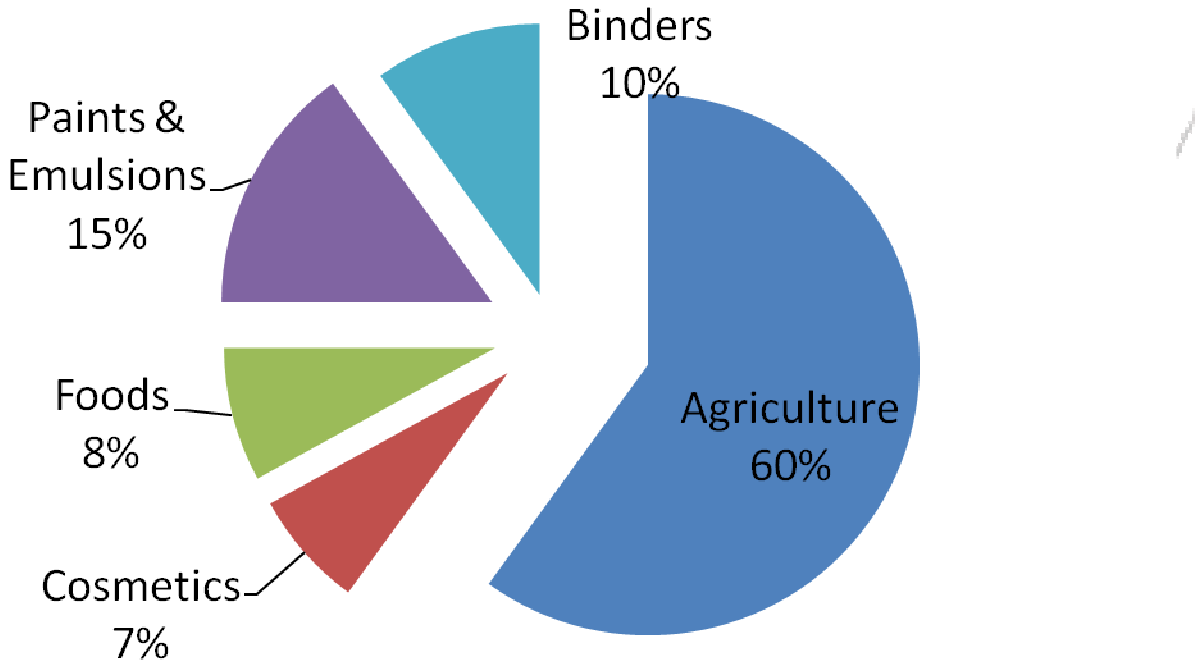

Figure 3.4 Application Of Lignin

Need of Study:-

Generally, traditional hot mix asphalt emits large quantities of CO2, CH4 and N2O. This material is part of the high carbon emissions and is disaster to the high-way industry, which is undesirable to the development of a low-carbon economy.

Heavy rain and other extreme weather conditions damage the asphalt road, and the roads need to be repaired frequently.

Melting asphalt produces lots of harmful green house gases. Also costly petroleum is required to produce asphalt.

Another challenge for the bitumen industry is that the petrochemical industry is becoming very much efficient in breaking higher chain hydrocarbons to lower chain hydrocarbons with higher added value than bitumen, which has an adverse effect on the availability of bitumen. So the asphalt market is looking for alternatives with higher sustainability in terms of CO2 emission. The usage of alternative sustainable binders, which can (partly) replace the bitumen, contributes to reduce CO2-emissions and at the same time broadens the availability of binders.

Also the production of petrochemical industry is getting decreased as the resources are on verge of extinction. So being the byproduct of oil refining the production of bitumen is also getting decreased.

In order to deal with the above mentioned problems it is important to find a alternative of bitumen, which will satisfy its functions and properties as well and also will not have adverse effect on environment in terms of carbon emission and will not contribute towards climate change.

METHODOLOGY

1. Collection of Bitumen (VG-10) Samples

In this step the various samples of bitumen VG-10 grade are extracted from the bitumen drum after reaching the softening point. The samples extracted needs to be free from any organic or inorganic impurity.

2. Basic Tests on Bitumen Samples

The various samples extracted are tested on various parameters and the test results are noted for comparison with the samples prepared after the blending of bitumen and lignin.

3 Collection and Preparation of Lignin

As the lignin purchased from market will be in powdered form and need to be heated to approx temperature of 125°C to make it viscous. After heating lignin will be ready to be blended with the bitumen.

4. Determination of Best Mixing

As the bitumen is to be blended with lignin 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.

5. Preparation of various samples of bitumen (VG-10) with lignin at various percentages

After analyzing the best mixing time various samples of the bitumen lignin are prepared at various percentages by volume. All the samples prepared need to be homogeneous and mixed to the time determined.

6. Performance of Various Tests on Various Samples Prepared

After the samples of lignin bitumen are prepared by the desired process the various tested need to be performed on the samples. The test will be same as done on the bitumen grade VG-10.

7. Results

This involves the comparison of the test reports of the samples at various concentration of lignin with the basic results of bitumen gradeVG-10.

8. Conclusion/ Recommendations

On the basis of the various test results it was found that up to 35% by volume bitumen can be replaced by lignin. On the basis of the test performed as per IS 73:2006 it was possible but to find the exact effect and percentages will be determined after performing advanced test on the binder.

3. REFERENCES

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