Appraisal of Sustainability of Wooden Charcoal as Filler in Stone Matrix Asphalt

Shahrukh Ali*, Saurab Jain**

Abstract

The main objective of this study is to examine the possible use of solid wastes charcoal for improvement of pavement strength, the use of asphalt material and its combination are used so that their strength and performance can be improved. For which the suitable mixture that is been adopted is Stone mastic asphalt which is better than bituminous Concrete. For minimizing the cost and increasing the effectiveness of roads, many different option are used for improvement by using different waste materials as a fillers among them wooden charcoal is best option. The Stone Mix asphalt is gap-graded mixture Consisting of Stone as Coarse aggregate, different binders are used (natural or artificial) as a stabilizers and. In the research work, the main objective is to compare the outcome obtained by using fillers like Stone dust, Portland cement, Fly ash with wooden charcoal. The properties that charcoal possesses are resistance to crushing, absorption, surface grading, moisture resistance to freezing, light weight, heating and synthetic resin glues which is the majority important for pavement of roads. Therefore its solidity and flow parameters and Air Void ratio are obtained so that it may be compare with different types of Fillers, From that we can set up a perfect combination so that it can be useful as a replacement as a filler for improving the quality and durability of pavement. Therefore aggregate gradation is taken as per IRC-SP-79 specification for SMA. The Binder Content is varied as 4%, 5%, 5.5%, 6%, 7% by weight of aggregates. 0.3% by is used as Optimum Binder Content. Binder of 60/70 penetration grade bitumen is used. For experiment, Marshall Test method is used for obtaining better results.

Keywords: Wooden charcoal, Filler material, SMA, Bituminous concrete.

Objective of the Study

The main Objective of the study is to check the suitability of Wooden charcoal as filler in SMA and then compare its properties obtained with different types of filler used and then study its effect on different properties of SMA and Study of different

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Marshall Properties using different fillers (Stone dust, Portland cement, Fly ash etc.) and then comparing the results with Wooden charcoal as filler also find out optimum binder Content using Marshall Method.

Introduction

The highway traffic in India is increasing at a faster rate with the increase in population and the road network has also expanded in different regions of India. This has led to an increase in the heavy vehicles volume as the travel time vehicle operating costs have increased tremendously due to fuel consumption and wear and tear of tire. Increase in truck traffic, there is also a huge difference in the maximum and minimum temperatures of the country. The maximum air temperature can reach even 50˚C in some part of the country and the resulting pavement temperature may reach up to 65˚C. With the increase in loading and temperatures, the pavements having various types of distresses at whole design life Rutting has been observed to be a major distress in flexible pavements and several study were carried out across the globe to quantify the mechanisms of rutting and to reduce the effective rut depth. SMA is gap graded mixture consisting of 70% to 80% coarse aggregate of total mass, 6% to 7% of binder, 8 to 12% of filler, and about 0.3 to 0.5% of fiber or stabilizer or additives. It provides a durable surfacing material, deformation resistant, suitable for heavy traffic loads. SMA is used as a durable asphalt surfacing option for residential streets. SMA forms an interlocks between aggregate to a stone skeleton which can sustain permanent deformation. The stone skeleton fully filled with bitumen and filler along with fiber so that it can bind them properly so as prevent drainage of binder and not to cause any problem while transportation and while placing.

Advantage of Matrix Asphalt

Better Rut Resisting Capacity caused by heavy traffic loading. It provides better resistance to skid of vehicles and also resists permanent deformation at high temperature. The surface texture properties are approximately similar to Open graded premix concrete (OGPC); the noise produced between the surface and tires of the roads reduces. SMA has greater Strength, higher longevity, and reduced moisture permeability over other usual mixes. Due to rough texture, it provides good frictional property and riding quality after surface film-coating of binder are removed by the repetition of traffic. Production and laying Cost is higher than Dense Bitumen’s concrete because due to greater longevity of the pavement.

Fillers Used: Basically Filler are fine particles which when passed through 2.36 mm sieve and retained in 0.075 mm sieve. Generally the Filler we used are waste materials that are produced from industries or from any natural products to decrease the cost and increase its workability and strength. As filler are used to reduces the Voids gaps so that the compaction between Coarse and Fine aggregate increases to provide better Stability of the pavement. The fillers that are used in experimental process are as follows:

Stone Dust: Stone are the cheapest material basically obtained by crushing the stones such that the size of the particles is retained in 0.075mm sieve.

Portland Cement: Cement also used as filler due to its lump property due to it can bind the particles properly.
Fly Ash: Fly Ash are the industrial waste materials produced from the (thermal power plant) industries which can used as a replacement for fillers and the cost of fly ash very low. The Fly Ash used in the project Work

Wooden Charcoal: Concrete pavements suffer from discernment that they contribute a considerable amount of carbon dioxide (CO2) to the environment due to the use of Wooden Charcoal it binds the aggregates together. Wooden Charcoal is a light, black residue, consisting of carbon, obtained by removing water and other volatile constituents from vegetation substances.

Charcoal produced by heating of wood or other substances in the absence of oxygen. It is usually an impure form of carbon as it contain ash, The resulting soft, brittle, lightweight, black, porous material resembles coal.

Properties of Wooden Charcoal

- High Strength property compare to other fillers due to its low specific weight and hardness. It shows high modulus property.
- High lignin Content as it has high resistance to weather and therefore suitable material for construction of road.
- It shows good abrasion resistance Characteristics and durability and it has low Cellulose Content.

Experimental Details

Coarse Aggregate: The coarse aggregate should be crushed rocks which should pass through 19mm sieve and retained in 4.75 mm sieve. The rocks should be well graded, cubic shape and rough surface for good compaction. The hardness should be such that it can resist the traffic load. Generally Stone Chips are used as coarse aggregate but in this research project work Slag is used for comparing the results.

Fine Aggregate: Fine aggregates are generally stone crusher dusts with fractions passing through 4.75 mm and retained on 0.075 mm IS sieve. The fine aggregate should consist of 100% fine crushed stone dust which should be clean, hard to resist pressure, durable for long period, cubic shape and free from soft pieces.

Mineral Filler: Aggregate which passes through 0.075mm sieve is called filler. Mineral fillers have significant impact over the properties of SMA mixes. It increases stiffness of asphalt & mortar matrix and affects workability, aging characteristics and moisture resistance. It helps to reduce drain-down in the mix which improves the longevity of the mix by using required amount of asphalt in the mix and maintains adequate amount of void in the mix. Different types of mineral fillers that are used in the SMA mixes such as: Stone dust, Slag Cement or dust, Ordinary Portland cement (OPC), hydrated lime, Fly Ash, Wooden Charcoal etc. The main objective of the experiment is that by using different filler with SMA mix and comparing the results obtained by which we can find out the most suitable filler for SMA mix.

Binder: Bitumen acts as binding agent to the Coarse and fine aggregates and stabilizers in SMA mixtures. SMA mixes are very rich in mortar binder which increases the aging of the mix. Properties of bitumen depend on temperature. Bitumen shows viscous as well as elastic property. Bitumen used for the experiment is of 60/70 penetration grade. Standard Properties of bitumen are:
**Stabilizers:** Stabilizers are used to reduce the air void present between the aggregates and also to bind them together so that no bleeding of bitumen can occur. Due to which Compaction increases and drain down of bitumen decreases. Cellulose fiber is used as stabilizer in the experiment. Cellulose fiber is obtained from chemical farm and then cleaned properly. It is then cut into pieces of 10-15mm for proper mixing with aggregates.

**Molding:** The sample mixed with bitumen is then compacted by using Marshall Compaction Moulds. The compaction is done using a hammer of 4.54 kg which is allowed to fall from a height of 40cm. The sample is compacted with 50 blows on each side. The sample is allowed to dry for 24 hours. sample is taken out from the mould with the help of Sample Ejector.

**Weighting:** The sample Weight, Radius and Height is measured. Then the sample is Coated with Paraffin/Wax and again measured. The sample weight in water is measured.

**Marshall Test:** Marshall Mix design is generally used worldwide for conducting different test regarding Stability and flow Characteristics of the mix sample. It is also available at low cost. The sample is taken out of Hot water bath and placed in the Marshall Stability testing machine and loading is done at a constant rate of 5 mm per minute of deformation until failure. The total maximum load (kN) taken by the Specimen where failure occurs is taken as Marshall Stability. The stability value obtained is corrected by using correlation ratio table. The total amount of deformation which occurs at maximum load is recorded as Flow Value whose unit is 0.25mm.

**Analysis and Result**

**Marshall Stability:** The stability of the specimen is derived by the load taken by it and then multiplying with the correlation ratio which is obtained from thickness/height or volume of the sample. Theoretically with increase in Bitumen content, the stability also increases up to a certain point and then gradually decreases. This is due to with increase in bitumen content, the bond between the aggregate and the bitumen increases but with further increase, the strength between them decreases as the contact point between the aggregates become immobilize. Due to which mix become weak against plastic deformation. Simultaneously the stability Values also decreases.

**Flow Value:** Flow Value is defined as deformation caused when maximum load is applied where usually failure occurs. The flow value increases with increase in bitumen content. But the flow is gradually slow where stabilizers are not used. The flow increases very slowly initially but with increase in bitumen content, the flow value increases theoretically.
Figure 1. Stability Value Comparison Using Different Fillers

Table 1. Average Stability Value Comparison Graph with different Bitumen Content

<table>
<thead>
<tr>
<th>STABILITY (KN)</th>
<th>Bitumen content (%)</th>
<th>Stone dust as filler</th>
<th>Fly Ash as filler</th>
<th>Wooden Charcoal as filler</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4%</td>
<td>7.3</td>
<td>7.82</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>8.35</td>
<td>8.02</td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td>5.5%</td>
<td>9.1</td>
<td>8.91</td>
<td>8.4</td>
</tr>
<tr>
<td></td>
<td>6%</td>
<td>8.05</td>
<td>8.06</td>
<td>7.45</td>
</tr>
<tr>
<td></td>
<td>7%</td>
<td>7.9</td>
<td>7.88</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Figure 2. Flow Value Comparison using different Filler

Table 2. Average Flow value using different Fillers

<table>
<thead>
<tr>
<th>Flow Value (mm)</th>
<th>Bitumen content %</th>
<th>Stone dust as filter</th>
<th>Fly Ash as filter</th>
<th>Wooden charcoal as filter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4%</td>
<td>3.0</td>
<td>2.3</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>3.25</td>
<td>2.5</td>
<td>3.15</td>
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<tr>
<td></td>
<td>5.50%</td>
<td>3.6</td>
<td>2.8</td>
<td>3.7</td>
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<tr>
<td></td>
<td>6%</td>
<td>4.3</td>
<td>3.2</td>
<td>4.15</td>
</tr>
<tr>
<td></td>
<td>7%</td>
<td>4.45</td>
<td>3.7</td>
<td>4.55</td>
</tr>
</tbody>
</table>
From the graph, it is found that the maximum Stability Value obtained is 9.1 KN by using Stone dust as Filler at Optimum binder of 5.5% seconded by fly ash filler with stability value of 8.91 kN. Using Wooden charcoal as filler, an average Stability is obtained which is 8.4 KN. As the difference in Stability value is less which is 9.68% therefore Wooden charcoal can be used as a substitute as filler. Therefore it is proved that with increase in bitumen content, the Stability Value also increase but up to certain point i.e. 5.5% of bitumen content. After that the stability Value decreases due to excess use of bitumen which decreases the strength of the Mix.

Conclusions

The maximum stability obtained is 9.1 KN in case of Stone dust used as filler and the stability value obtained for wooden charcoal is 8.4 KN. As the Stability value is more than 8 KN in case of wooden charcoal as filler, it can be used as filler in SMA mix for pavement of roads. Flow increases with increase in bitumen content in case of all fillers used in the sample. Air voids decreases with increase in bitumen content for all the fillers used in the sample. From the experiment, it can be concluded that wooden charcoal can be used as a substitute for filler as it satisfies all the criteria to be used as filler.

References