Replacement of Lime by Marble Dust and Fly-ash in Mastic Asphalt- A Review

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Abstract: There is an enormous amount of investment involved in highway construction, and about 60 percent of highway construction costs are associated with pavement construction. Bituminous materials are commonly used for pavement construction, mainly due to their excellent binding properties, water proofing properties and relatively low cost. For bitumen concrete mixing, however, the strength of bitumen concrete depends on all the materials used in the mix model, i.e. bitumen, coarse aggregate, fine aggregate and filler. Mastic asphalt is potentially advantageous paving material and has gained wide acceptance in road construction technique. Therefore, there is a need to explore the use of various types of waste materials like Stone Dust, Marble Dust, Slag, Fly-ash, Brick Dust, Cement by Pass Dust and Rise Husk Ash, steel slag etc. The present study examines the effect of lime replacement in mastic asphalt preparation with fillers such as Fly-ash and Marble Dust and Fly-ash + Marble dust. Furthermore, the present study may reduce the cost of mastic asphalt, which is the main reason for its limited use, and may also enhance the properties of mastic asphalt as well as cater for industrial waste disposal such as; fly-ash and marble dust.

Keywords: Mastic Asphalt, Bitumen, Marble dust, Fly-ash, Paving Materials.

1. INTRODUCTION

There is a need for human mobility. Everyone travels for food or pleasure from time immemorial. A closely related necessity is to move raw materials for delivery to a production system or finished goods. Transportation meets humanity's basic needs. Transport plays a major role in the human civilization's growth. For example, the strong connection between human settlement evolution and the proximity of transport facilities could be easily observed. There is also a strong correlation between the reliability of transportation facilities and living standards, as a result of which society places high expectations of transportation facilities. In other words, transport issues must be addressed analytically, economically sound, socially responsible, environmentally sensitive, technically reasonable and sustainable. Instead, for both men and material, the transport solution should be safe, quick, comfortable, convenient, economical and environmentally friendly. A road pavement is a structure consisting of superimposed layers of processed materials above the natural soil subgrade, the primary function of which is to distribute the loads applied to the subgrade of the vehicle. The pavement structure should provide an acceptable riding quality surface, adequate skid resistance, favorable characteristic reflecting light, and low noise pollution. About 90% of the Indian Highways have a paved surface with bituminous layers that are built and maintained using natural road aggregates and bitumen, a petroleum material that is blended at high temperatures to create hot mix asphalt. Mastic asphalt is an ideal material for a wide range of construction applications, both new construction and renovation, requiring a smooth, seamless, durable surface [1]. It offers total roofing and tanking waterproofing integrity and acts as a tough flooring and paving work surface. This standard covers the requirement for Mastic Asphalt to be used as a bearing in different situations of heavy-duty road pavement. Nonetheless, it is not advised to use this product where abundant lowering of fuel oil is required on the pavement layer, such as bus depots, gas filling stations and service stations.

The bitumen Mastic Asphalt is an intimate homogeneous mixture of mineral fillers and well graded fine and coarse aggregate with a hard grade bitumen, cooked and laid hot, trowelled and floated by means of a wooden float. Under normal temperature conditions, the mixture settles into a cohesive, voidless and impermeable solid mass. Over the mastic laid surface, the bitumen mastic is normally used as a wearing course, hard stone chips precoated with bitumen are grafted or spread and rolled to create a skid-resistant surface. [2]

Marble dust is a waste material that is produced in the world in significant quantities. During the cutting process of marble, 20-30% of a marble block becomes waste marble dust. In India, marble dust is deposited by sedimentation and then washed away, resulting in contamination of the atmosphere, in addition to forming dust in summer and affecting both farming and public health. Therefore, the use of marble dust in various industrial sectors will help to protect the environment, especially in the building, agriculture, glass and paper industries.

Fly ash is a product of coal combustion that has numerous technologies in road construction. In highway construction, the use of fly ash is growing day by day and new applications have been created. Fly ash is a finely divided residue produced by the combustion of pulverized coal in an electric thermal power plant. The coarser ash particles are referred to as bottom ash or are collected from the bottom of the combustion chamber, while the lighter fine ash particles, referred to as fly ash, are suspected to remain in flue gas. The electrostatic precipitators or the filler fabric bag house or combination of both can also be used to remove fly ash before exhausting the flue gases.

2. MATERIAL TO BE USED IN THE PRESENT STUDY

2.1 Coarse Aggregates

The coarse aggregate consists of clean, hard, durable, crushed rock free of disintegrated parts, organic and other harmful matter, and adherent coating. They are hydrophobic, low porosity and meet the physical requirements [3-6] as per the table no. 1.1.

Table 1.1 Physical properties of coarse aggregates

Property	Test	Specifications
Cleanliness	Grain size analysis	Max 5% passing 75µ sieve
Particle size	Flakiness and Elongation	Max 30% (combined)
Strength	Los Angeles Abrasion Value	Max 40%
	Aggregate impact value	Max 30%
Polishing	Stone polishing value	Min 55
Durability	Soundness	

	Sodium sulphate Magnesium sulphate	Max 12% Max 18%
Water absorption	Water absorption	Max 2%
Stripping	Coating and stripping of bitumen aggregates	Minimum retained coating 95%
Water sensitivity	Retained tensile strength	Min 80%

2.2 Fine Aggregates

The fine aggregate is crushed material or naturally occurring or combination of the two; passing 2.36 mm sieve and retained on 75µ sieve. The material should be hard, clean, dry and free from dust or other deleterious material.

Table 1.2 Grading of fine aggregates inclusive of filler

IS sieve	Percentage by weight of aggregates
Passing 2.36mm sieve but retained on 0.600mm	0-25
Passing 0.600 mm sieve but retained on 0.212 mm	10-30
Passing 0.212 mm sieve but retained on 0.075 mm	10-30
Passing 0.075 mm	30-55

2.3 Filler

Lime and fly-ash are substances that can be used as fillers. Limestone powder that passes 75 microns sieve and weighs up to 80 percent of calcium carbonate is commonly used. Lime is the commonly used standard filler material. However, it is possible to use fly-ash and marble dust.

2.4 Bitumen

As per IS: 73-1961 or industrial bitumen as per IS: 702-1961 of appropriate quality meeting the requirement of physical properties [7] as per the table no. 1.3.

Table 1.3 Physical Properties of Bitumen

Property	Test Method	Requirements
Penetration at 25%	IS: 1203	15±5
Softening point, %	IS: 1205	65±10
Loss on Heating (% max)	IS: 1212	2.0
Solubility in trichloroethylene, % by mass min,	IS: 1216	95
Ash (mineral matter), % by mass max.	IS: 1217	1.0

3. ROLE OF FILLER IN MASTIC ASPHALT

Fillers have played a major and important role in the properties of HMA mixtures, especially in terms of air voids, mineral aggregate voids. Fillers increase the asphalt mortar matrix's rigidity. Fillers also affect HMA mixtures ' workability, tolerance to humidity, and aging characteristics. Different types of mineral fillers may be used in the HMA mixes such as stone dust, marble dust, cement by pass dust, slag, fly Ash, hydrated lime and RHA etc. Therefore in the present work Marble dust and Fly-ash are used as filler materials for the replacement of lime in mastic asphalt.

4. NEED OF THE STUDY

The vast climate variation, different physical characteristics, and mountainous terrain have great influence in India's road construction operations. Mastic Asphalt was first laid in India in 1961. Because of its high cost factor, lack of knowledge, its use I d is still limited until today to special locations. Therefore, due to the use of various additives or fillers, it is necessary to study changes in the bitumen content of mastic asphalt.

5. PREVIOUS RESEARCH WORK

Although a lot of works were conducted about using marble dust and fly-ash in many work area, but there is not any work in the literature about use of marble dust and fly-ash as a replacement of lime in mastic asphalt. The present study examines the effect of lime replacement in mastic asphalt preparation with fillers such as Fly-ash and Marble Dust and Fly-ash + Marble dust. Furthermore, the present study may reduce the cost of mastic asphalt, which is the main reason for its limited use, and may also enhance the properties of mastic asphalt as well as cater for industrial waste disposal such as; fly-ash and marble dust.

Abdelaziz Mahrez and Mohamed Rehan Karim (2010) Modification / reinforcement of asphalt has received considerable attention as viable solutions to improve flexible quality of pavement. This is driven mainly by the unsatisfactory performance of conventional road materials that are subject to dramatic increases and shifts in traffic patterns. This paper presents the characteristics and properties of glass fiber reinforced Stone Mastic Asphalt. Laboratory tests were conducted to evaluate such related properties of asphalt mixture with different fiber contents. The tests undertaken comprise the Marshall test, indirect tensile test, creep test and fatigue test using repeated load indirect tensile test. The results showed that the addition of fiber does affect the properties of bituminous mixes, by decreasing its stability and increasing the voids in the mix. Stiffness properties of reinforced SMA mix were enhanced by about 12% as compared to control mix. Mixes with more than 0.2% fiber content exhibited lower resistance to permanent deformation. The results indicated that the fiber has the potential to resist structural distress that occur in road pavement as result of increased traffic loading, thus improving fatigue life by increasing the resistance to cracking and permanent deformation especially at higher stress level.

Bindu C.S & Dr. K.S.Beena () The present study investigates the benefits of stabilizing the stone mastic asphalt mixture in flexible pavement with shredded waste plastic. Conventional (without plastic) and the stabilized SMA mixtures were subjected to performance tests including Marshall Stability, tensile strength and compressive strength tests. Triaxial tests were also conducted with varying percentage

bitumen by weight of mineral aggregate (6% to 8%) and by varying percentage plastic by weight of mix (6% to 12% with an increment of 1%). Plastic content of 10% by weight of bitumen is recommended for the improvement of the performance of Stone Mastic Asphalt mixtures. 10% plastic content gives an increase in the stability, split tensile strength and compressive strength of about 64%, 18% and 75% respectively compared to the conventional SMA mix. Triaxial test results show a 44% increase in cohesion and 3% decrease in angle of shearing resistance showing an increase in the shear strength. The drain down value decreases with an increase in plastic content and the value is only 0.09 % at 10% plastic content and proves to be an effective stabilizing additive in SMA mixtures.

Deprizon Syamsunur, Nazahath Naeem and Eric Loh () In this study, cockle shell ash was used as a filler material in Stone Mastic Asphalt (SMA) mix to verify the appropriateness and feasibility for the highly traffic roads. SMA is one of the new generations of asphaltic mix and adopted in many countries due to its excellent performance. The main objective of this study is to determine whether the cockle shell as a filler material can improve their performances of Stone Mastic Asphalt on its stability and flow. The manual compaction was carried out to obtain the shell ash and exploited to evaluate the volumetric properties of the design mix. The aggregate gradation of SMA 20 was utilized as the aggregates and 25% increment of cockle shell ash was added as a filler material in this study. The results were compared to conventional or 0% of cockle shell to check the suitability of the materials. The results obtained are adequate and meet the requirement of the standard for SMA Mix.

Vidhi Patel, Bhrugu Kotak, Abhijit Singh Parmar, Dhaval Patel () There are two types of pavement, one is flexible pavement and second one is rigid pavement. If the initial cost is considered, than the rigid pavement is costly, but the maintenance cost of it is low. And country like INDIA, its not possible to provide rigid pavement everywhere, so flexible pavement is the option only. In flexible pavement, it is required to be maintained at some interval of time so the cost of maintenance is should be minimum. At present, the maintenance cost is higher so now the method of maintenance has to be modified for the flexible pavement. To avoid the maintenance cost, the proper quality of work and material is important. So to improve the quality, various material or chemicals are used to improve the quality or to improve the property of the raw material. The study is about to improve the properties of bitumen. In Flexible pavement construction, modified bitumen can be used with fibres, Chemicals, Waste materials etc. for improving its properties. The most suitable fibres are used to improve its properties, i.e. Marshall Mix design, Viscosity, Ductility, and Specific Gravity. According to literature, Forta Fi- fibre is most advantageous for improving bituminous properties So here it is checked for its feasibility in our country to improve different bituminous property. 1%, 2 %, and 3 % of Forta Fi by its weight of Conventional bitumen mix is studied.

Swati Chandel, Ajay K Duggal, Naiyara Khan (2016) has studied the effect of partial replacement of lime by cement at the proportions of 3%, 6%, 9%, 12 % and 15% in the mix. Mastic asphalt samples were prepared with & without coarse aggregates to decide upon the optimum percentage upto which the replacement can be done for both the cases. Design codes such as IS, IRC & MORTH were consulted for the design of mastic asphalt and hardness number test was performed to set the criteria for the acceptability of the replacement percentage. Industrial grade bitumen was used as binder, stone dust was used as fine aggregate, aggregates of size ranging from 2.36 mm to 19 mm were used as coarse aggregates in the course work and the grading & physical requirements of the ingredients were selected as per specifications laid in Indian standard codes. It was observed for the specimens without coarse aggregates the results were neither satisfactory for proportion less than 9% nor more than 12%; while for specimens with coarse aggregates the maximum replacement possible is 12%.

RESEARCH METHODOLOGY

The objectives of the present study shall be achieved by following the below mentioned steps by step procedure:

1. Suitable materials shall be selected according to Indian Standards and Indian Road Congress codes for design of mastic asphalt.
2. A control mix shall be prepared to determine the percentage of lime and bitumen.
3. The optimum percentage of stone dust and coarse aggregates was also found out.
4. Mastic asphalt specimens were made with different proportions of marble dust, stone dust and combinations thereof.
5. Lime shall be replaced by fly ash by 3 to 15 % with an increment of 3%.
6. Test specimens shall be prepared by replacing lime with marble dust at suitable percentages say 3 to 15%.
7. Replacement of lime was done at different proportions such as (3+3)%, (3+6)%, (6+3)%, (6+6)%, (9+3)%, (9+6)%, (9+9)%, (3+9)%, (6+9)% of marble dust and fly ash respectively.
8. Mastic asphalt samples shall be prepared with & without coarse aggregates at each of the percentage.
9. Hardness Number Test shall be performed.
10. Analysis of results shall be done.

Conclusion:

After going through number of literature, it is observed that Mastic asphalt is going worldwide acceptance due to its good performance as wearing course at heavy duty pavements. A multitude of mineral fillers and fiber materials have been used in road construction for many years. They are incorporated in mastic asphalt mixtures to enhance its properties and performance. The use of mineral fillers which are usually by-products wastes having benefited in reducing the disposal problems, decreasing environment problems and also improving some properties of pavement. The cost of mastic asphalt pavement is exorbitant and it is one of the reasons for its limited use. Expenses of this construction can be reduced by various fillers. Mastic asphalt modified with various fillers has the potential to resist various structural distresses that occur in road pavement, thus improving fatigue life by increasing resistance to cracking and permanent deformation especially at higher stress level.

Further, it is observed that most of the studies are confined to the use of various fillers to enhance the properties of mastic asphalt but no work has been done in the field of replacement of lime by marble dust and stone dust in mastic asphalt. Change in the bitumen content of mastic asphalt due to use of various additives or filler is also not investigated yet. No work has been done to bring down the cost of mastic asphalt. Replacement of lime by combination of marble dust and stone dust in optimum percentage is also not well understood.

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