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A REVIEW ON EFFECT OF SOLID WASTE FILLERS ON ASPHALT MASTIC AND ASPHALT MIXTURE

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ABSTRACT

The pavement works consumes more of natural resources through which depletion take place due to continuous consumption. So, it is required to regulate the usage of natural material and recommended to use some alternate materials in the form of replacement. Conventional fillers that are used in asphalt mix are stone dust, limestone, Portland cement, etc. In order to regulate usage of these materials utilization of waste/by-products as a filler such as marble dust, calcium carbide residue (CCR), Fly-Ash, brick dust, etc. In this review analysis the effect of solid waste products as fillers in asphalt concrete mixes and asphalt mastics were elaborated by means of mechanical properties, rheological properties and performance properties like resistance against rutting, cracking and fatigue. As a result, from various research works, the improvement in performance and properties of asphalt mastic and asphalt mixes were observed with utilization of solid waste mineral fillers.

KEYWORDS: *Asphalt Mastic, Asphalt Mix, filler, CCR, Marble Dust*

I. INTRODUCTION

Flexible pavements are most widely used due to its ease of construction, maintenance and economy. These pavements are made of asphalt mix. As these pavements experiences distress under continuous wheel loads which ultimately leads to the failure of pavement to control the failure regular maintenance is required which again involves use of natural resources. Extensive usage of materials which are obtained from mining leads to scarcity of naturally obtained material. To promote sustainability waste materials are used in pavement construction as fillers in asphalt mixes. Development of asphalt mixes which produced from solid waste controls the depletion of natural sources and therefore minimize the environmental effects. Disposal of solid wastes which are generated from industrial, mining, agriculture sectors generally done by landfills, combustion and recycling. And burning leads to air pollution. To limit landfill, there is a need to adopt eco-friendly & affordable usage of solid waste materials instead of traditional fillers in asphalt mixes.

Asphalt Mixture consists of Bitumen, Coarse aggregates, fine aggregates, and fillers in different proportion. Coarse aggregate means the particle size more than 4.75 mm and fine aggregate means the particle size less than 4.75 mm. The aggregate shall include the hard, clean, durable, crushed rock. These must be free from organic and other deleterious matter, adherent to coating and must be free of disintegrated pieces.

For understanding performance of asphalt concrete mixes, it requires knowledge on asphalt, asphalt mastic, asphalt mortar, asphalt mixture & also need to understand the influence of filler. The composition of mineral filler and bitumen is called asphalt mastic [12], [13], [14]. In the context, Mineral filler refers to particles passing through 75-micron sieve [11]. Conventionally used fillers are stone dust, lime stone dust, Portland cement, hydrated lime [21]. Mineral filler plays vital role in voids filling, bonding of fine and coarse aggregates, transferring of loads [15], [16]. Depending upon the cohesiveness, strength and stiffness of asphalt mastic, the asphalt mixture performance varied in terms of workability, water sensitivity, crack and rutting resistance [16], [17], [18]. The volume or weight fraction of filler particles majorly affects the stiffening of asphalt mastic [9].

Although filler used in asphalt mixes in less concentration, influences the properties of asphalt mixes. These properties ultimately linked with the filler interaction with bitumen, physical & chemical characteristics, volumetric concentration in the total asphalt mix. It also influences the strength & volumetric demands of the mix, aggregate-bitumen bonding which effects moisture damage of mix, aging of asphalt mix, influence on stiffening of bitumen which effects permanent deformation, fatigue life, cracking resistance, also influences on workability of mix, Optimum Binder Content (OBC) and material cost [20].

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The review study was conducted to find the influence of filler in asphalt mastic and asphalt concrete mix performance in terms of distress parameters such as resistance against rutting, cracking, fatigue and mechanical results such as Marshall stability, Indirect Tensile Strength, Tensile Strength ratio values. As well as review analysis on the utilization of solid waste materials in the form of mineral fillers in asphalt mixes such as calcium carbide residue, marble dust.

II. LITERATURE REVIEW

Dulaimi, A. et al. (2020) conducted study on substituting limestone filler with calcium carbide residue (CCR) using different ratios 0%, 3%, 6% by aggregate dry weight in Hot Mix Asphalt (HMA). Using CCR as filler, enhanced the performance of stiffness modulus, permanent deformation resistance, fatigue life (due to improvement in adhesion and cohesion of bituminous mixture), durability (based on water sensitivity results). Also described that CCR can be used as antistripping agent, CCR has no harmful impact on the environment by using it as filler in HMA based on toxicity characteristic leaching procedure (TCLP) test. Based on this study they evaluated that the CCR can be utilized as filler in Hot Mix Asphalt [1].

Nuh, B.P. et al. (2016)

In this research work it is described that CCR can be potentially utilized as mineral filler in Hot Mix Asphalt as its physical and chemical characteristics are in the specified limits. In this research ordinary Portland cement and calcium carbide waste used as fillers. They also evaluated based on the Marshall Stability test results the stability value increases by substituting the ordinary Portland cement filler with CCW (Calcium Carbide Waste) and flow values reduced as CCW content increases. And also stated that Cao content plays vital role to select CCW as a mineral filler utilizing in HMA [2].

Chandra, S. and Choudary, R. (2013)

Evaluated the usage of granite dust, marble dust, fly ash, hydrated lime and stone dust as fillers in Bituminous Concrete mixes. They stated that Marble dust potentially can be used as filler as its OBC value is low (economical) compare to other bituminous mixes, fatigue life is 50-70% higher and rutting life 40% higher than the conventional stone dust bituminous mixes [3].

Karasahin, M. and Terzi, S. (2007)

Investigated the usage of marble dust as filler material in asphalt mixes. In this context, marble dust and limestone dust taken as fillers and done experimental program in terms of dynamic plastic deformation test. This research describes as the filler to bitumen ratio increases plastic deformation decreases up to certain value of filler to bitumen ratio after that plastic deformation increases [4].

Tarbay, E.W. et al. (2019)

In this paper investigated the usage of waste and by- product materials like marble waste, granite waste, slag powder as an alternative to the traditional mineral filler limestone in hot mix asphalt. This research work illustrates that the waste marble filler mix showed greater Marshall stability value than the limestone filler mixes and also stated that mixes with marble dust yielded higher indirect tensile strength ratio. In this context the mastics prepared with marble waste had high in both softening point value and RV Viscosity compare to the traditional limestone mastic. They also evaluated based on pavement performance prediction by using QRSS software the above waste filler mixes exposed better rutting resistance compared to limestone mix [5].

Choudhary, J. et al. (2020)

Emphasized that the Marshall stability values of bituminous concrete mixes rises, OBC values decreases when there is an increase in filler content. In this study they used lime sludge and stone dust (SD) as fillers and found that SD mixes exhibited greater performance against moisture because of better adhesion, less content of active clay compared to lime sludge mixes [6].

Akhtar, M N. et al. (2019)

Explored the mechanical behaviour of Asphalt mastic using different fillers such as Stone dust, Brick dust, Fly ash class F with different concentrations 0%, 3%, 5% and 7% by weight of bitumen in flexible pavements. They found that with the utilization of mineral filler reduction in cracks observed due to even dispersion of particles based on microstructural investigations. This research work illustrates that by using rheological study with addition of mineral fillers there is an increase in rutting resistance, modified binders with fly ash mineral filler exhibited better rutting and fatigue resistance compared to brick dust and stone dust. And also evaluated that based on the Energy Dispersive X- ray (EDX) results the mineral fillers majorly consists of Cao and SiO2 which gives better adhesion between the asphalt binder and particles [7].

Choudhary, J. et al (2021)

In this research study waste wood ash (WA) and Hydrated lime (HL) taken as fillers and evaluated that the bituminous mastics consists of WA exhibited lower elastic nature, lower stiffness, higher resistance of fatigue than the mastics consists of HL filler. They stated that with usage of above two fillers the cracking and rutting resistance improved in bituminous mixes. They found that with increase of filler quantity the OBC decreased for both the mixes due to the filler acts as an extender of the bitumen. Also evaluated that as the increase in filler quantity the cracking resistance and rutting resistance improved. They investigated that, even though WA bituminous mixes exhibited acceptable moisture resistance, there is a decrease in resistance against moisture with increase in filler content in above both HL and WA bituminous mixes due to the lowering of apparent film thickness (AFT) and OBC [8].

Bastidas-Martínez, J. G. et al. (2021)

Performed study on the properties of asphalt mastics with usage of fillers Linz-Donawitz Steel Slag (LDSS), Portland Cement (PC), Hydrated Lime (HL) and Blast Furnace Slag (BFS) with mass and volume dosage type. They evaluated that asphalt mastic penetration values can be influenced by volume of particles, softening point values influenced by weight and count of particles that consists of filler and bitumen. They evaluated that by mass analysis, high viscosity can get when a greater number of particles that included by asphalt mastic and by volume analysis, high viscosity can get by a more weight of particles that included by asphalt mastic. They also found that with usage of above fillers the improvement in performance of

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asphalt mastics observed in terms of rutting resistance and fatigue resistance compared to control mastic with usage of limestone [9].

Mistry, R., & Roy, T. K. (2021)

In this research they studied on Bituminous mix and Bituminous mastic performance with usage of Fly ash (FA-F), Rice husk ash (RHA) as alternative fillers and hydrated lime as conventional filler. The filler percentage varies from 2%, 4%, 6% and 8 % by weight of aggregate and binder percentage varies from 4.5 % to 6.5% with increment of 0.5% by the weight of aggregate were taken for Marshall mix design. They conducted Marshall stability, ITS, TSR tests on bituminous mixes with usage of above fillers. They evaluated that at 4% and 6% filler contents the RHA mixes and FA mixes shows less OBC values i.e., 5.95% and 7.6% less than conventional HL bituminous mixes. They stated that as the freeze and thaw cycle increase the TSR values decreases of bituminous mixes containing the above both conventional and alternative fillers. And found that the RHA mixes shown greater ITS than the control HL mix. They also evaluated that FA-F and RHA mixes exhibited higher Marshall stability and Volumetric properties compared to control HL mixes. In this study also worked asphalt mastics prepared with above fillers with filler to bitumen (f/b) ratio of 0.5 to 1.4 with increment of 0.3 by mass dosage. They stated that the RHA mastics shown greater adhesion force than control HL mastic at 0.8 f/b ratio [10].

III. CONCLUSIONS

Based on the literature survey it is concluded that

1. The influence of a filler on asphalt mixes can change based on the quantity and type of dosage (volume or mass dosage) of filler.
2. As the filler content increases, stiffens the mastic and improve the penetration resistance there by rutting resistance increases.
3. With the usage of solid waste mineral fillers, the Marshall Stability, ITS and TSR values, fatigue, cracking and rutting resistance increases in the asphalt mixes.
4. CCR and Marble dust enhances the fatigue resistance, rutting resistance, Marshall Stability values compared to conventional asphalt mixes. And also, the Marble dust increases the softening point values of asphalt mastic and ITS values of asphalt concrete mix.
5. Based on literature review CCR and Marble dust can take as mineral filler alternative to conventional fillers in asphalt concrete mixes which uses in flexible pavement.

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