USING STEEL POWDER IN BITUMINOUS CONCRETE: AN EXPLORATORY STUDY

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Abstract:
The disposal of huge amount of discarded waste material like steel powder, steel fibre, plastic, polythene bags, bottles, rubber tyres, glass waste, plastic granulates, etc., which are generated in huge quantity is a challenge as it causes environmental hazards on their disposal. The possibility of using all these waste materials as modifier for the production of bituminous concrete is justified. Research studies revealed that consumption of waste product in construction or production processes minimizes the adverse effect on environment resulting from their production. To simulate with the field conditions, Marshal Stability test was performed on the samples prepared by partially replacing Optimum Bitumen Content with waste materials. The laboratory testing results indicate that by using waste materials, bituminous concrete of required strength and density can be obtained and an environment friendly green pavement can be prepared with less material cost. All these materials can be used as cost-effective filler in Hot Mix Asphalt (HMA).

Keywords: Bituminous Concrete, Marshall Stability Method, Optimum Binder Content, Waste Materials.

1. INTRODUCTION

Bituminous concrete is widely used around the world due to its primary function in road and pavement construction. Bituminous concrete pavements have been distinguished with economic feasibility, simplicity of construction, maintenance, repair and possibility of the material to be recovered and reused, thus resulting in their wide application on the roads of the majority of world countries. However the strength properties can be affected by the ambient temperature as well as the intensity and volume of traffic. The combined effect can result in the formation of transverse and longitudinal cracks, and other defects in flexible pavements. The problem worsens due to inefficient maintenance of the pavement. In order to minimize the deterioration and increase the service life of the designed road, the bituminous layers should be improved with regard to performance properties, such as resistance to permanent deformation, fatigue, wear, stripping, aging, etc. This can be made feasible by using some modifications in binder or mixes simultaneously. In order to achieve economy, emphasis is being laid on use of waste material. Following are the various types of waste materials that are to be used:-

a) Steel Powder
b) Steel Fibre
c) Fly ash
d) Waste plastic
e) Waste glass
f) Crumble rubber
g) Polythene Bags
h) Plastic Bottles

2. RESEARCH STUDIES ON VARIOUS TYPES OF WASTE MATERIAL USED IN BITUMINOUS CONCRETE

Relevant research work and studies are reviewed here:

2.1 Serin S, Morova N, Saltan M, Terzi S (2012) performed laboratory study on the usability of steel fibre in order to bear the stresses occurring at the surface layer of pavement, which are directly subjected to the traffic effects, was investigated. In this context, specimens were produced and tested under Marshall Stability Test, and the optimum bitumen content value for the aggregates sample to be used was determined. Results showed that based on the determined value for the optimum bitumen content (5.5%), three specimens for each of a series of different fibre rates (0%, 0.25%, 0.50%, 0.75%, 1.0%, 1.5%, 2.0%, 2.5%) were prepared and the optimum value for fibre rate that results in the best stability value was determined as 0.75%. As a result, steel fibre additions can be used in binder course of flexible pavement because of its positive stability impact.

2.2Umadevi Rongali, Gagandeep Singh, Anita Chourasiya , Dr.P.K.Jain(2013) has experimentally shown the benefits of composites of fly ash and plastic waste in Bituminous Concrete (BC) mixture for the construction of flexible pavement. The study showed that it can be used as cost-effective mineral filler in hot mix asphalt (HMA) paving applications. The findings indicate that BC containing composite as substitute of traditional filler is an acceptable material for bituminous road construction.

2.3 Melbouci B., Sadoun S., Bilek A. (2014) performed experimental that the Thermo-recycling is an economical means of using raw materials such as aggregate and bitumen. It contributes indirectly to the protection of the environment. The introduction of plastic PR-PLAST-S (anti ruts) to strengthen new asphalt mix with asphalt millings not only

seems a promising solution to recycle the old road materials, but it is also economical and efficient for improving the resistance to permanent deformation that leads to ruts. Such coating formulas can be considered for the maintenance of wearing course of flexible pavements. To simulate the problems of wearing, Marshall Tests and normal Duriez tests have been performed on various formulations of plastic reinforced asphalt concrete. The results show that recycling of pavements can be performed without restrictions up to 30% of milled. With plastic pellets, mixtures behave like new asphalt above 6% addition of PR-PLAST-S.

2.4 Zaydoun T. Abu Salem, Taisir S. Khedawi, Musa Bani Baker, Raed Abendeh, Al-Zaytoonah(2014) carried out a laboratory study to evaluate the performance of asphalt concrete mix, where some of fractional fine aggregate is substituted with different percentages of crushed glass materials of 5%, 10%, 15% and 20% of aggregate. The Marshall method was used to examine the influence of the Optimum Asphalt Content (O.A.C.) at different fine glass percentages and the resistance against water. It was concluded that satisfactory performance of upper asphalt pavement layers can be achieved by adding glass waste with 10% of the mix.

2.5 Kavyashree L Magadi, Anirudh N, Mallesh, K.M.(2016) concluded that the steel slag can be used as a replacement material for coarse aggregates to fulfil the grading requirements for the DBM. They performed various tests to characterize the physical properties of aggregates, steel slag and bitumen. The chemical tests on steel slag also showed good result. Mechanical characteristics of the mixtures were evaluated by Marshall Stability and Indirect tensile strength tests. Mixes with steel slag were compared with the control mix and it was found that mixes with steel slag satisfied the MoRT&H standards. The steel slag replacing the coarse aggregate even improved the mechanical properties of bituminous mixtures and thus resulting as suitable for use in the construction of road.

2.6 Bansal Shubham, Misra Anil Kumar, Bajpai Purnima (2017) performed experimental attempts to utilize waste materials as partial replacement of bitumen to develop a modified binder for making bituminous concrete mix. To simulate with the field conditions, Marshall Stability Analysis was performed on the samples prepared by partially replacing 'Optimum Bitumen Content' with waste plastic (4%, 6%, 8% and 10%) and crumb rubber (5%, 10% and 15%). Experimental results demonstrated that partial substitution of bitumen with waste plastic results up to 16% increment in strength whereas with rubber material, about 50% increment in strength was observed as compared to the conventional mix (CM). Laboratory testing results indicate that by using waste materials, bituminous concrete of required strength and density can be obtained and an environment friendly green pavement can be prepared with less material cost.

2.7 Lukashevich Viktor, Efanov Igor, Viktor, Vlasov Olga Lukashevich (2018) performed experimental that the asphalt concrete pavement which is currently built in accordance with the existing requirements does not withstand the standard service life. Various kinds of damages occur. The major purpose of this work was evaluation of reinforcement fibers resistance to natural environment and climatic impacts within the conditions of experimental production construction and studying compactibility of asphalt concrete mixture with fiber reinforcement. Infrared spectroscopy and physical-chemical investigations of fibers were used to study changing properties of fiber-forming polymer. Research results revealed insignificant influence of natural environment and climatic impacts on the properties of fiber reinforcement material. In order to obtain the standard compaction factor of asphalt concrete additional compacting impact is not required.

2.8 Duhovny G S, Karpenko AV (2018) performed experimental that the High-temperature and low-temperature characteristics of the rubber-bitumen binder and rubber asphalt concrete based on it were researched. The determination method of binder's low-temperature characteristics is offered. The estimation of binder's and pavement's stability against technological and operational aging is evaluated. Estimation of environmental and economic aspects of using rubber crumbs is made. The possibility of using rubber crumbs as modifier of organic binder for production of asphalt concrete on its base is justified.

3. PROPOSED RESEARCH:

From the above mentioned studies, it may be conclude that many types of waste products can be used in bituminous mixes . Encouraged by it, it is considered that steel powder can also find a place in the bituminous mixes with all probability that when added in controlled quantity , it may even enhance the properties of Bituminous Concrete.

4. METHODOLOGY

In order to find the optimum usage of steel powder for its suitability in bituminous concrete mix by performing various tests, the following work methodology will be adopted and performed:

The gradation of the material will be done by sieve analysis and blending to be done to achieve the desired grading. Aggregate shall be tested for other properties as well.

Properties of bitumen binder shall be checked as per guidelines of IS:73 -2013 to verify that these meet the desired specifications .

4.1 Samples of Bituminous mix shall be prepared without using steel powder (Control Mix) to find out the optimum binder content for Bituminous Concrete. The job mix formula will be prepared by varying the percentage of binder in the aggregate blend and the specimen will be prepared by Marshall Method (as per ASTM D6927).

4.2 Steel powder used for this study will be procured from the steel powder supplier of Ludhiana.

4.3 Steel powder obtained will be in the fragments of steel i.e., steel scrap which is left over after cutting at hexa machine (steel industrial waste). Grading of steel powder will determined and the amount of it to be added will replace in varied proportions of 2%, 4%, 6%, 8% and 10% by weight of total mix of fine aggregate.

4.4 Samples of Bituminous Concrete shall be prepared at optimum binder content by addition of steel powder with varied percentages.

4.5 Various properties e.g. Marshall Stability, Flow Value, Density, VMA, VFB, Air Voids etc., shall be determined for samples on different proportions of powder.

4.6 The data so obtained will be analyzed to determine optimum dosage of steel powder and also make other suitable interpretations.

5 EXPECTED OUTCOMES

After completion of this experimental work the following results will be expected:

5.1 Performance of mix at different percentages of powder.

5.2 Optimum percentage of powder that can be used in Bituminous Concrete.

5.3 Effect of steel powder on different parameters of bituminous mixes viz Stability, Flow value, Voids in mineral aggregates, Voids in mix and Voids filled with bitumen.

5.4 Addition of powder in bituminous mixes will improve fatigue life by increasing the resistance to cracking and permanent deformation.

5.5 Thickness of the surface could be reduced to cater the same traffic load by addition of Steel powder in bituminous mixes.

5.6 If the crack emerges on the surface it might be possibile that it will be re-furnished by induction heat applied on the surface without using any binder.

6 CONCLUSIONS

After going through the variant test and studies carried out by different researchers, it may be concluded that:

6.1 Bituminous Mixes made by addition of various suitable waste material shows better results than control mix.

6.2 These studies essentially provide a better understanding of the good performance capabilities of bituminous mixes.

6.3 It might be possibility that modified mixes as compared to the conventional types can survive the heavy traffic load for a longer period of span.

6.4 The performances, such as strength, high temperature stability and resistance to stripping by use of waste material mix can achieve the standards of the bituminous concrete mix design.

6.5 The air voids are reduced as the percentage of waste material increased. The VFB is within the limits in all the mixtures so that it will not cause bleeding.

6.6 The use of discarded waste materials like rubber tires and discarded plastic bottles in bituminous concrete mix may aid in minimizing the construction costs of the road.

6.7 It may also contribute in preventing the environmental pollution caused by the dumping of such waste material in ground as well as water pollution.

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