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Impact of clay brick dust on durability parameters of bituminous concrete

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Abstract

Bituminous Concrete (BC) is widely used as wearing surface in flexible pavement. BC as a construction material mainly consists of coarse and fine aggregates in defined proportions and bitumen as binding agent. After compaction, it offers smooth compacted surface for the road users.

In the present study, effect of replacement of sand to brick dust on properties of Bituminous Concrete (BC) is studied in this research. Aggregates of size 20mm, 10mm, sand and VG-30 grade bitumen were used in this research. To check the feasibility of raw materials to be used in pavement, all physical tests on aggregates and bitumen were performed as per relevant IS codes. To design Bituminous Concrete (BC), Grading 1, proportioning of aggregates was carried out. Marshall method was used for determining of Optimum Binder Content (OBC). Average of bitumen content corresponding to maximum stability, maximum bulk density and 4% air voids was taken as OBC of BC mix. At OBC, three durability tests were performed i. e., Marshall Quotient, Tensile Strength Ratio (TSR) test and Permeability tests were conducted for all the replacements. Based on above study, it was concluded that brick dust in the range of 5% – 10% can be used as partial replacement of sand in

BC mixes. In the range of 5% – 10% replacement, durability parameters conducted in this research were within the permissible limits specified by MoRTH. On exceeding replacement more than 10%, there was drastic change in the properties of the mix.

Introduction

India has the second largest road network in the world after the USA with 4.69 million kilometers of road network [1]. Indian government is also spending a very high budget on road infrastructure development of our country. In the union budget 2021, the Government of India sanctioned around Rs. 1.18 lakh crores to the Ministry of road transport and highways (MoRTH) for road infrastructure development in India [2]. High infrastructure development al brings increased demand for natural resources. The primary raw materials used in the construction of flexible pavement are coarse aggregates, fine aggregates and sand. There is a massive demand for road aggregates for the construction and maintenance of roads. The annual need for natural sand in India is 750 million tons and is estimated to reach 1350 million tons by 2025 [3], [4]. This will create a severe burden on the environment and there is a high need to look for alternative materials in place of natural resources. The utilization of waste materials in the construction of highways is a good solution for sustainability.

India is the world's second-largest clay brick producer, having a total of 0.14 million brick kilns [5], [6]. Small-scale industries dominate brick kilns in India with minimum economic, technical, and organizational capability. Although alternative of clay bricks are available in the market but still the consumption of clay bricks is the highest. The quantity of brick dust produced in brick kilns may reach up to 15% of total brick production, whose disposal is a big problem for brick manufacturing industries [7]. Also, brick dust/waste is generated during the demolition of structures. Dumping of this waste material requires costly land as well as pollutes the environment. The utilization of this waste material in road construction can provide a better waste management solution for brick manufacturing industries and at the same time, can reduce the requirement for virgin aggregates for the highway sector.

Studies are available in which brick industry waste is either used as filler or replacement of coarse aggregates in bituminous mixes. Almadwi and Assaf. (2020) [8], observed that the use of recycled brick powder (BP) from building and deconstruction debris as filler in hot-mix asphalt (HMA). Two HMA mixes were prepared: one with BP and one with limestone powder as a control (LSP). Natural desert sands were also incorporated into the mix. Results were drafted based on rutting, creep compliance, indirect tensile strength modulus (ITSM), and moisture susceptibility tests. It was observed that BP-based mixes outperformed LSP-based mixtures in terms of mechanical properties. 10% – 15% was found to be the optimum dosage for BP and LSP. Another study conducted by Mir Anzar Hamid (2018) [9], used brick dust and concrete dust as fillers in bituminous mixes. Results were compared on the basis of Marshall parameters. Air voids and VMA were seen to be increasing on the increase in filler content. It was reported that brick dust showed almost similar properties to that of concrete dust. A study using seven different types of fillers in a dense graded bituminous macadam mix was carried out by Choudhary Jayvant et al. (2018) [10]. Waste materials included are red mud, copper tailings, rice straw ash, glass powder, brick dust, carbide lime and limestone dust.

Results were drafted based on strength and volumetric properties. Performance against rutting, cracking and moisture susceptibility were also accessed. It was resulted that finer fillers showed better resistance to cracking. It was also observed that fillers having calcium content showed better adhesive properties and moisture susceptibility. Sarkar Dipankar et al. (2016) [11] used plastic-coated over-burnt brick aggregate (OBBA) in road construction. Shredded waste plastic was mixed in proportions of 0.38% – 0.60% of the dry weight of brick aggregates. Results were drafted based on Marshall parameters, Tensile Strength Ratio, stripping and fatigue life. A 56% improvement in stability value was observed at 0.54% plastic content as compared to plain aggregates. Based on TSR results, it was observed that modified aggregates showed better moisture susceptibility. Improvement in rutting and fatigue life was also observed at the same plastic proportion. Sutradhar Dipu et al. (2015) [12] studied the influence of concrete dust and brick dust as fillers on bituminous mixes. Authors suggested that the impact of fillers are crucial in filling spaces and thereby changing the elemental composition of the mix. The objective of this study was to determine the influence of fillers on bitumen blends. The qualities of bituminous mixes, including various fillers, were analyzed and compared. Marshall Stability test results showed that fly dust as filler performed well as compared to brick dust.

Research have been carried out on replacing fine aggregates with coal ash [13], steel slags [14] and basalt and limestone industry waste [15] in different types of asphalt mixes. Detailed studies on mechanical and durability parameters of asphalt mixes using these waste materials have been done previously and convincing results have been obtained.

From the above literature, it is summarised that brick dust in the range of 5% – 15% can be used as filler material in bituminous mixes. Brick dust has also been utilized as filler in Dense Bituminous Macadam (DBM) mixes. Studies on utilizing brick dust as a replacement for conventional aggregates in road construction are also available. Brick dust has the potential to be used as filler material in bituminous mixes. Its effectiveness as a replacement of fine aggregates needs to be explored. There is also a need to check the durability parameters of the bituminous mixtures containing brick dust as fine aggregate.

To overcome the above-stated issues, the present laboratory study was carried out to assess the durability parameters of clay brick dust as partial substitute for conventional fine aggregate in BC mixes.

Section snippets

Methodology

In this research, all the raw materials were procured locally. Coarse aggregates of size 20 mm and 10 mm, fine aggregate and mineral filler were procured from a local crusher and VG-30 grade bitumen was taken from the institute laboratory. To check the feasibility of aggregates and bitumen, physical tests were performed according to relevant IS codes.

Proportioning of aggregates was done to achieve the required gradation for BC (Grading I) as per MoRTH [16]. Marshall specimen were prepared at …

Physical properties of aggregates and bitumen

The physical properties of aggregates and bitumen need to be determined to check their feasibility as raw materials for use in BC (grading 1). Parameters and their permissible limit were determined from the Specification of Road and Bridge works (MoRTH-2013) and tests were performed as per relevant IS codes. The test results for aggregates and bitumen are presented in Table 1, Table 2 respectively.

The raw materials fulfilled the specifications required for Bituminous Concrete (Grading 1). Hence …

Conclusions

The following conclusions are drawn from the above test results:

- The clay brick dust can be used as a partial replacement for fine aggregate in the bituminous concrete mix. …
- Marshall Quotient value of the mix increased with 5% brick dust and then got decreased with higher replacement levels. However, the values remained within the acceptable range of MoRTH at 10% replacement level. Presence of more finer materials may have resulted in lower stability and higher flow values. …
- As percentage …

…

Future scope

- Advanced tests such as creep, fatigue, resilient modulus and rut resistance shall be conducted to judge the performance of bituminous mixes with brick dust as fine aggregates. …
- The same study shall be conducted on other types of bituminous mixes, such as in Mastic Asphalt, Dense Graded Bituminous Macadam (DBM), etc. …

…

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …

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