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A study on the effective Management of E-Waste Ceramic by its utilization as a replacement to aggregates in SDBC Grade-2 Mix

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ABSTRACT: Due to the increase in the demand of raw materials in the construction industry, there has been a serious depletion in the naturally available raw material in construction industry. In this regards, the non-biodegradable environmentally hazardous Electronic and Electrical waste arising from various Industrial and Domestic appliances was considered as an alternative raw material for the present research. The current study not only offers a solution to the ongoing crisis in effective safe disposal of E-Wastes, but also resolves the issue of dearth of raw materials. The present study targeted effective utilization of E-Waste Ceramic as a potential aggregate in SDBC Grade-2 Mix. The research subsequently investigated the probable changes in physical and strength properties of the mixes casted using Marshall Method of Mix Design, and conclusions were later drawn depending on the comparative result analysis for the best percentage replacement of aggregates by E-Waste ceramic as proposed for a roadway of width 3.75m for soil CBR of 4%. The study herewith hence postulated the best possible percentage replacement by weight of total mix and also conducted an approximate construction cost comparison.

KEYWORDS: Construction, Bituminous, Concrete, Ceramic, Aggregate.

1 INTRODUCTION

The most widely accepted definition of E-Waste is as per European Commission Directive "electrical or electronic equipment, which is waste including all components, subassemblies and consumables, which are part of the product at the time of discarding" [1]. In the last two decades, the global growth in E-Waste production has been exponential high largely due to increasing market penetration of products in developing countries, development of a replacement market in developed countries and a generally high product obsolescence rate together with decrease in prices and the growth in internet usage [2]. Today, E-waste is the fastest growing waste stream, about 4 per cent growth a year comprising of electrical appliances (such as fridges, air conditioners, washing machines, microwave ovens, and fluorescent light bulbs) and electronic products)such as computers and accessories, mobile phones, television sets and stereo equipment). Consequently the environmentally responsible waste management options are highly technological and require high financial investment, due to high level of trans-boundary (often illegal) movement of e-waste into developing countries for cheaper recycling. Consequently nations such has India are facing a severe problem towards its effective and safe disposal or recycling [3], [4].

2 SCOPE OF STUDY

A better infrastructural development reflects the nation's development as a whole. From past few decades pavement construction and latest developments in road sector have been dominating towards the infrastructural development of the nation. Due to the increase in the demand of raw materials in the construction industry, there has been a serious depletion in the naturally available raw material for construction. In this regards, extensive research is being carried out worldwide over the utilization of various non-biodegradable industrial and domestic waste as an alternative construction material to enhance the structural and functional properties of the system.

In this context, the non-biodegradable environmentally hazardous E- waste was considered as an alternative raw material for the present research, as a solution to the ongoing crisis in effective safe disposal of E-Wastes, and dearth of raw materials.

3 EXPERIMENTAL METHODOLOGY

In the initial stage, Aggregates selected for the study were tested for cleanliness, shape, strength, durability and water absorption, for SDBC Grade-2 mix. The aggregate blend satisfying the mid gradation limits were used for this study. 60/70 penetration grade bitumen was also collected and checked for its suitability for usage as per the specifications. The E-Waste Ceramic was checked for its suitability as aggregates and were prepared for 4.75mm IS sieve size for replacement. The aforementioned procedure was followed keeping in mind the specifications of MORT & H 4th Revision [5]. Marshall Specimens were later casted as per the selected mix design in triplicates for mixes with 0%, 5%, 10% 15% and 20% replacement of 4.75mm IS sieve slot with E-Waste ceramic by weight of total mix as shown in Figure 1. The percentage filler in all the mixes were kept constant as 2% by weight of total mix. All the specimens were later subjected to tests in order to access the Marshall Strength, Physical properties and the Optimum Binder Content for the respective percentage replacements [6]. The results so achieved was subjected to cost comparative analysis while considering for the construction of a 1km roadway having width of 3.75m for a soil California Bearing Ratio value of 4% using E-waste ceramic with that of the conventional material, by referring Schedule of rate -2013 as per Public Works Department, Karnataka [7].The further section provides us an outlook on the resultant changes in percentage OBC, Bulk density, Volume of bitumen, Voids filled with bitumen, Voids in mineral aggregates stability and flow with the increase in percentage ceramic replacement respectively.

4 RESULTS AND DISCUSSION

The complete set of results has been depicted along Chart 1 to 7. As observed from Chart 1, it can be confirmed that the optimum binder content was found to remain constant with the increase in E-Waste ceramic.

Fig. 1. ***Marshall Specimens casted for the study.***

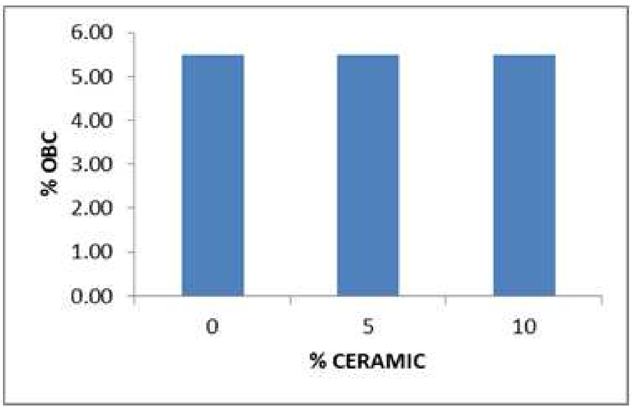

Chart 1. ***% Ceramic v/s % Optimum Binder Content (OBC).***

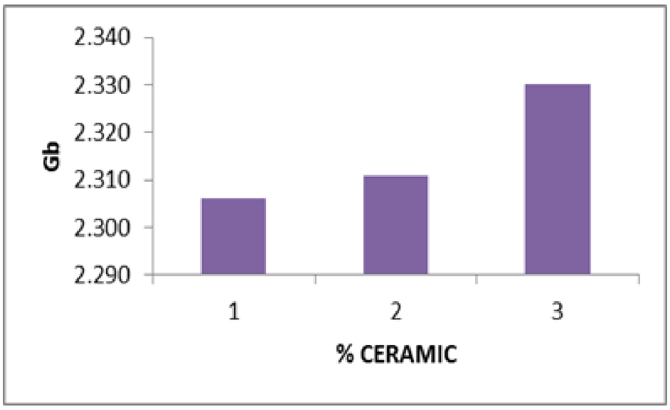

Chart 2. ***% Ceramic v/s Bulk Density (Gb).***

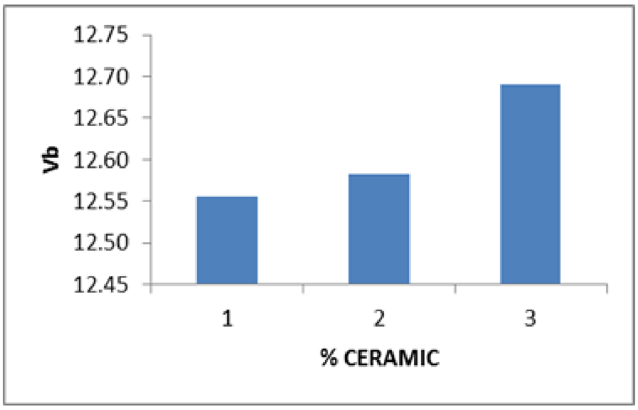

Chart 3. ***% Ceramic v/s % Volume of Bitumen (Vb).***

Also as seen from Chart 2 and Chart 3, the bulk density and volume of bitumen was found to increase with the increase in percentage of E-Waste ceramic. The present study also drew the inference that there was a gradual drop in voids filled with bitumen with the increase in percentage ceramic. The same was found to increase from 5% replacement and has been depicted in Chart 4.

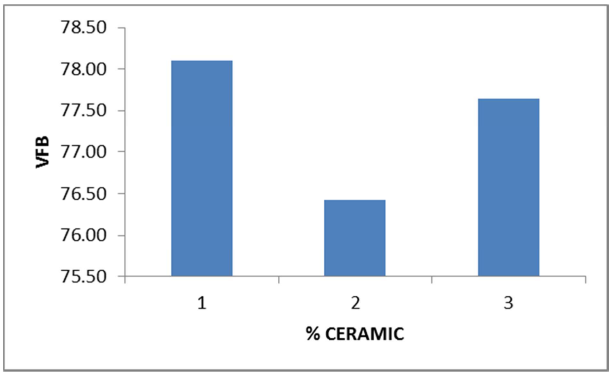

Chart 4. ***% Ceramic v/s Voids filled with bitumen (VFB).***

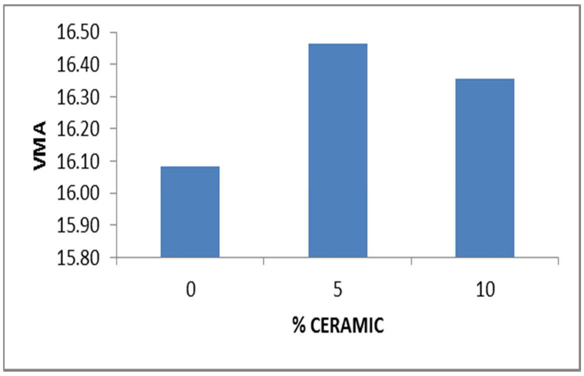

Chart 5. ***% Ceramic v/s Voids in mineral aggregate (VMA).***

Further studies on this as visualized in Chart 5 and Chart 6 revealed that the void in mineral aggregates and stability was seen to increase till 5% replacement and later then gradually decreased thereafter. Eventually from Chart 7, it may be stated that the Marshall flow increased till 5% ceramic replacement with aggregate and decreased thereafter. The results of the cost estimation comparison for 1km roadway of 3.5m width for soil CBR 4% when we consider a total Expense in Construction of Road using conventional materials of about INR 1340317.125/km, with a total Expense in Construction of Road with 10% E-Waste ceramic replacement to be around INR 1331933.982/km provides us as net saving of INR 8383.143/km.

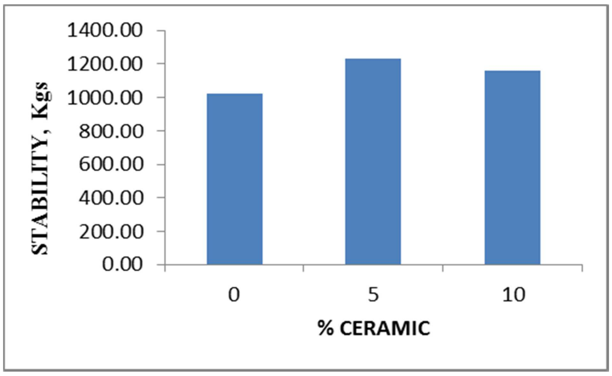

Chart 6. ***% Ceramic v/s Stability.***

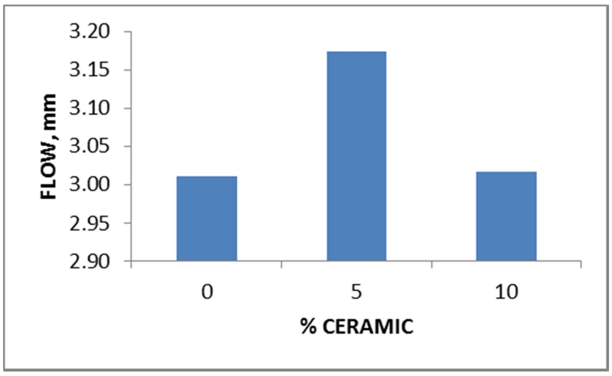

Chart 7. ***% Ceramic v/s Flow.***

5 CONCLUSION

The study involved replacement of aggregates from 4.75 mm IS size slot from the gradation by the selected and prepared E-Waste ceramic at 0%, 5%, 10%, 15% and 20% replacement respectively. These individually were subsequently casted into Marshall Specimen for each such percentage replacement to determine the respective OBC's. Based on the OBC's obtained for both neat mix and mixes with E-Wastes ceramic, specimen were further casted, tested and compared for Marshall Strength and Physical properties. The study concluded that the Percentage replacement of Aggregate with E-Waste ceramic of size 4.75mm IS sieve could be done effectively up to 10% by weight of total aggregate mass. The 10% replacement was found to be idealistic, since it was found to give a similar and yet better results when compared to mixes casted with no ceramic replacement. In the present context of applicability, it need to be mentioned that the informal sectors that are deeply involved in e-waste recycling must evolve into more formal sectors, to ensure proper adaptation of the present developed technology.

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