"EXPERIMENTAL INVESTIGATION FOR UTILIZING CERAMIC WASTE IN BITUMINOUS ROAD PAVEMENT"

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ABSTRACT: *In Today's era of development production of waste has increased rapidly with reduction in disposal areas. Construction industry is one of the biggest sources for waste production. For sustainable development and to reduce disposal problems recycling and reusing are of prime importance. The increasing economic cost and lack of availability of natural material have opened the opportunity to explore locally available waste material. Indian construction industry produces large amount of ceramics waste every year, which is comprised of wall, floor tiles, roof tiles, sanitary ware, etc. According to the characteristics of those ceramic wastes they may be integrated as partial substitute to natural aggregates in bituminous road paving mix which will reduce demand of extractions of natural aggregate and landfill pressure leading to sustainable road construction and reduction in manufacturing cost of waste management. Bituminous mix is the most commonly used pavement material which contains approximately 95% aggregate and 5% bitumen materials by weight. Hence this study focuses on use of ceramic waste as a partial substitute to natural aggregate in bituminous road paving mix. In this study different samples of bituminous paving mix with ceramic waste proportion 0%, 10%, 20%,30% & 40% by weight as a replacement of aggregate and keeping the bituminous content constant where prepared in the laboratory Marshall Mix Design Method. Different tests like Marshall Properties (flow value, stability).Were performed and various properties like stability, strength, economy etc. were studied.*

***Keywords*:** Waste, Ceramic, Bitumen, Natural Aggregate, Marshall Properties (flow value, stability),

1. INTRODUCTION

The advancement of experimental study can reduce the consumption of natural resources and reduce the burden of pollutants on the environment. The cost of natural resources is increased day by day. They have forced to focus on recovery, reuse of natural resources and find other alternatives. The use of the replacement materials offer cost reduction, energy savings, arguably superior products, and fewer hazards in the environment.

Construction industries are one of the major waste producing industries. Ceramic waste is generated from construction industries and renovations of houses with an important impact on environment and humans. Indian ceramic production is 100 Million ton per year. In ceramic industry, about 15%-30% waste material generated from the total production. This waste is not generally recycled in any form. However, the ceramic waste is durable, hard and highly resistant to biological, chemical, and physical degradation forces.

Ceramics can be defined as heat-resistant, nonmetallic, inorganic solids that are generally made up of compounds formed from metallic and nonmetallic elements. Although different types of ceramics can have very different properties, in general ceramics are corrosion-resistant and hard, but brittle. Most ceramics are also good insulators and can withstand high temperatures. These properties have led to their use in virtually every aspect of modern life. The two main categories of ceramics are traditional and advanced. Traditional ceramics include objects made of clay and cements that have been hardened by heating at high temperatures. Traditional ceramics are used in dishes, crockery, flowerpots, and roof and wall tiles. Advanced ceramics include carbides, such as silicon oxide (sio2), aluminum oxide, (Al_2O_3), Calcium Oxide (CaO), silicon nitride (Si_3N_4), sodium oxide (Na2O), potassium oxide (K2O), and many other materials, including the mixed oxide ceramics that can also act as superconductors. There is need to use ceramic waste productively and properly.

The road is one of the vast areas where we can use that waste. Bituminous paving mix is most common material used for construction of road in which natural aggregates are required in great amount .this paper studies the possibility of replacement of natural aggregate with ceramic waste. This will reduce the depilation of natural aggregate which are available in finite amount and also reduce the waste management problem arising from disposal of waste ceramic which will ultimately results in sustainable road development with reduced environmental hazard.

2. METHODOLOGY

2.1 Materials

In this study following material are used

2.1.1 Ceramic waste aggregate:

Ceramic waste aggregate obtained from disposal area of Amravati University were used. The ceramic waste consist of ceramic tiles, stone ware etc.as shown in figure 2.1 dimension of the waste tiles and stone ware are large and cannot be used directly in bituminous paving mix .so we had prepared the waste into the laboratory with the use hammer and convert into Type II gradation as shown in fig 2.2. Its size range between 6 mm to 12.5 mm which is used as a partial replacement to natural course aggregate in with in bituminous mix instead of coarse aggregate.

Figure 2.1: Ceramic waste near Amravati University

Figure 2.2: Prepared Ceramic waste by hammer.

2.1.2 Aggregate

The aggregate used in the study is mainly were obtained from the local stone crusher of basalt mine. Since basalt is found in very large amount in this area and possess satisfying properties required for construction of road pavement.

Course Aggregate

Course aggregates size generally ranges between 10 mm to 20 mm as shown in fig 2.3. In bituminous road construction, coarse aggregate is generally used in carpet layer of pavement. The density of course aggregate is generally 1600 kg/m^3, where as its specific gravity is 2.62.

Figure 2.3: Course Aggregate

Fine Aggregate

Fine aggregate used was of size between 4.5 mm to 6 mm as shown in fig 2.4. It is generally used in bituminous road construction to give smooth appearance to road surface. The specific gravity of fine aggregate is 2.72.

Figure 2.4: Fine Aggregate

2.1.3 Filler (Stone Dust):

Filler or stone dust is the dust produce by crushing of stone aggregate. This dust is used as filler material in bituminous mix. Size of stone dust particle generally ranges between 75 micron to 4 mm as shown in fig 2.5. Specific gravity of stone dust is 2.50.

Figure 2.5: Filler

2.1.4 Bitumen

60/70 grade (VG-30) is being used as shown in fig 2.6. Where 60-70 represent the penetration value of 6 to 7mm of bitumen. Bitumen is work as a good binder material in flexible pavement. The Specific gravity of bitumen is 1.02.

Figure 2.6: Bitumen

2.2 Testing on Materials

Following test were performed on materials to determine mechanical properties of the materials which are used in bituminous paving mix. Obtain values were compared with standard values as shown in table no 3.1.

2.2.1 Test on Ceramic waste aggregate

a) Aggregate impact value
b) Crushing value
c) Los Angeles Abrasion value
d) Specific gravity
e) Water absorption

2.2.2Test on Natural aggregate

a) Aggregate impact value
b) Crushing value
c) Los Angeles Abrasion value
d) Specific gravity
e) Water absorption

2.2.3 Test on Bitumen

a) Penetration test
b) Softening Point Test
c) Ductility.
d) Flash point test

2.3. Experimental procedure

In the experimental part of this study Marshall Test Method has been used. In this experiment locally waste ceramic was used as a partial substitute to natural aggregate in bituminous road paving mix for wearing course. Various samples with Waste ceramic proportion 0%, 10%, 20%, 30%, and 40% percentage by natural aggregate weight were prepared. Bituminous proportion was kept constant as 4.5% for all the samples. Total 15 samples were prepared, such as three per each proportion of waste ceramic and values are shown in the observation table as mean of three readings as experimentally obtained. All the samples were prepared and kept for 24 hr. at room temperature and then in hot water about 60°C for 20 minute. Marshall Stability test were performed as shown in fig no 2.6 and following values were recorded and the values are shown in the observation table 3.3

Figure 2.7: Marshal Stability Apparatus while performing experiment

From experimental study following observation were recorded and following results were drawn.

3. OBSERVATIONS

Various tests as stated in 2.2, 2.2.1 & 2.2.2 were performed on natural aggregate and ceramic aggregate, values were recorded and compared with ideal standard values as shown in observations table no 3.

Table-3.1: Physical properties of natural aggregate & ceramic aggregate

Sr No	Test Performed	Test Method	Test Result Observed for aggregate	Test Result Observed for Ceramic aggregate	Indian Standard limits
1	Aggregate impact value in %	IS-2386 (P-IV)	7.53	8.975	<30%
2	Crushing value in %	IS-2386 (P-IV)	15.44	19.36	<30%
3	Los Angeles Abrasion value in %	IS-2386 (P-IV)	10.68	19.08	< 40%
4	Specific gravity	IS-2386 (P-III)	2.62	2.508	NA
5	Water absorption in %	IS-2386 (P-III)	0.76	0.88	< 2%

Various test as stated in 2.2.3, were performed on bitumen and values were recorded and compared with ideal standard values as shown in observations table no 3.2

Table-3.2: Physical Properties of Bitumen

Sr No	Bitumen Properties	Results	Indian standards	Standards limits
1	Penetration test(25°C)	64	IS 1203 - 1978	50-70
2	Softening Point Test	52.7	IS 1205 - 1978	35°C - 70°C
3	Ductility	73	IS 1208 - 1978	Min - 40cm
4	Flash point test	241	IS 1209 - 1978	min175° C

All the samples were tested for marshal stability test and marshal parameter were recorded and calculation are done for calculating bulk density(Gm),air voids (VV),volume of mineral aggregate (VMA) and volume filled with bitumen (VFB) .as shown in observation table.

Table-3.3: Marshall Test Result on Bituminous paving with various proportion of waste ceramic

Sr No	Ceramic Waste (%)	Bitumen (%)	Marshall Stability (KN)	Flow Value (mm)	Bulk Density (Gm)	Air voids (VV)	VMA (%)	VFB (%)
1	0%	4.5	16.48	2.91	2.342	5.105	15.142	66.26
2	10%	4.5	15.64	2.43	2.335	5.119	15.260	66.157
3	20%	4.5	14.89	2.61	2.321	5.458	15.405	64.569
4	30%	4.5	14.33	2.78	2.307	5.770	15.657	63.147
5	40%	4.5	12.58	2.98	2.295	6.019	15.855	62.037

The numerical data is presented graphically in the form of following graphs. The graphs of above all four values with respective change ceramic Aggregate content are plotted below.

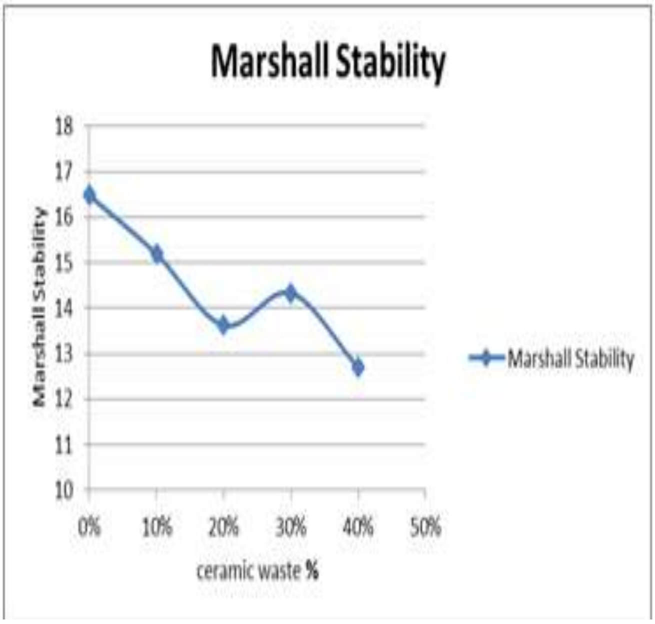

Figure 3.1: Graph showing Marshal Stability Values V/s Ceramic Aggregate

Fig no 3.1 shows the graph of marshal stability values for various proportions of waste ceramic in bituminous paving mix.in above graph x-axis represents % of ceramic & y-axis represents M.S values in (KN).

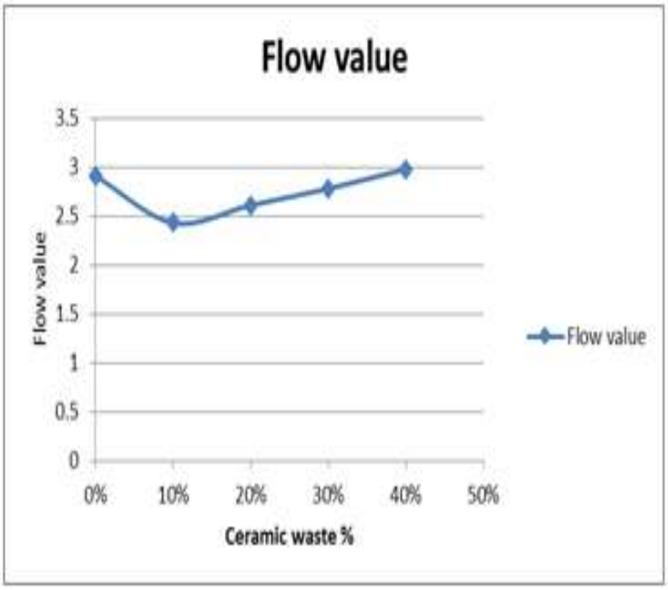

Figure 3.2: Graph showing Flow Values V/s Ceramic Aggregate

Fig no 3.2 shows the graph showing variation of flow value with respect to waste ceramic aggregate proportions in bituminous paving mix.in above graph x-axis represents % of ceramic & y-axis represents flow values in (mm).

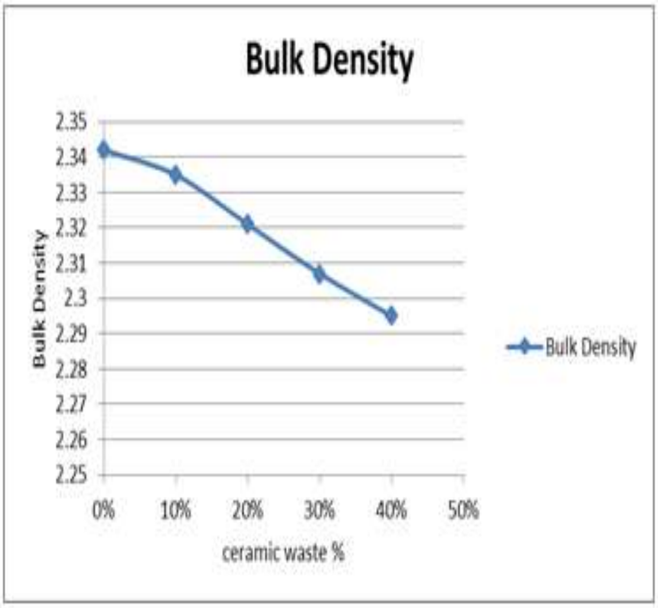

Figure 3.3: Graph showing Bulk density V/s Ceramic Aggregate

Fig no 3.3. Shows the graph of bulk density for bituminous paving mix with different proportions of ceramic waste aggregate .in above graph x-axis represents % of ceramic & y-axis represents bulk density.

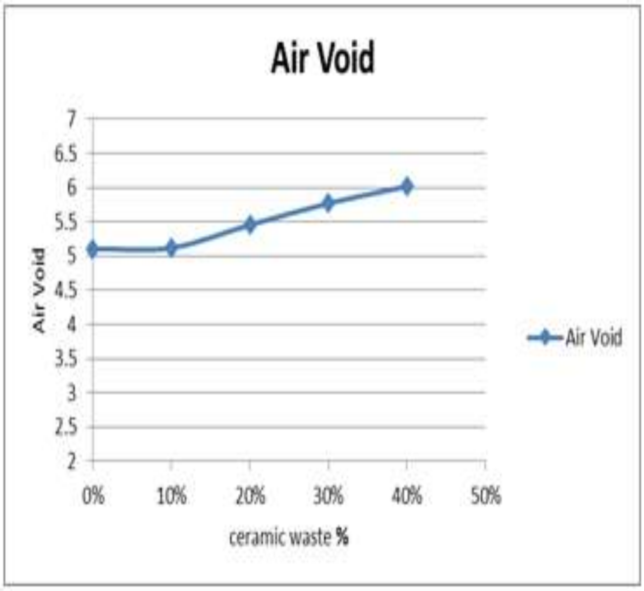

Figure 3.4: Graph showing Air Voids V/s Ceramic Aggregate

Figure no 3.4. Shows the graph of Air Voids (VV) for bituminous paving mix with different proportions of ceramic waste aggregate .in above graph x-axis represents % of ceramic & y-axis represents Air voids.

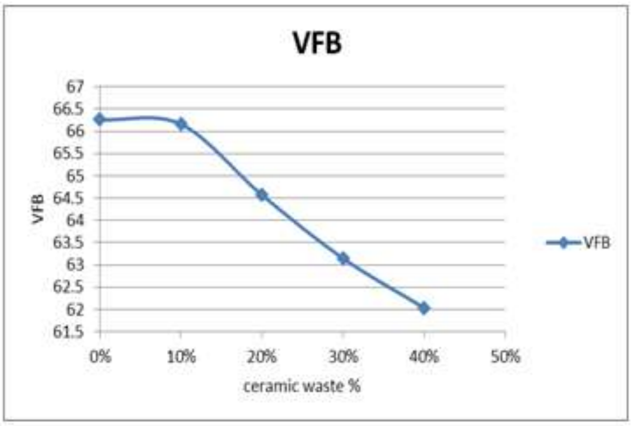

Figure 3.5: Graph showing VFB (volume filled with bitumen) V/s Ceramic Aggregate

Fig no 3.5. Shows the above graph of VFB the variation of VFB values for various proportions of ceramic waste aggregate in bituminous paving mix. In above graph x-axis represents % of ceramic & y-axis represents VFB values.

4. CONCLUSION

On the basis of laboratory investigations and obtained results in this study on use of waste ceramic in bituminous mix, the following conclusions can be drawn.

1. Locally available ceramic waste can be beneficially used in bituminous paving mix as a partial substitute to natural aggregate.
2. Problem of waste disposal can be solved to some extent by using ceramic waste as a substitute to natural aggregate.
3. Using locally available material for regular bitumen paving mix (without any modifier), optimum bitumen percent for 60/70 grade bitumen is found to be 4.5% of total mix.
4. It can be concluded that use of local ceramic waste in bituminous paving mix not only reduce pollution but also saves the conventional stone aggregate to a certain amount.
5. Variation of bulk density is below 2% for all the proportion of ceramic waste (i.e. 10%, 20%, 30%, and 40%) as compared to bulk density of conventional bituminous paving mix.
6. From the results it can be concluded that up to 30% replacement of natural aggregate by ceramic wastes gives optimum results.
7. Marshall Stability value reduces by 5.09% when the ceramic waste increased from 0% to 10% as a replacement to natural aggregate.
8. The marshal stability value reduce by 9.60% when waste is increased from o% to 20% as a replacement of natural aggregate.
9. Marshall Stability value reduces by 10.04 % when the ceramic waste increased from 0% to 30 % as a replacement to natural aggregate.
10. There is noticeable fall in M.S value when ceramic waste proportions is increased from 0% to 40% M.S value get reduced by 23.66%.

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