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Ceramic Aggregate Comparison with Conventional Aggregate

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Abstract Concrete cost is increasing day by day, along with scarcity in availability of construction material. There is need to find out substitute and cheap construction material. Study shows that ceramic waste is created in surplus amount while manufacturing and cutting tiles. This can be used for casting of concrete. This paper presents the properties of ceramic aggregates in comparison with locally available conventional aggregate for impact and water absorption values.

Keywords Ceramic, Concrete, Coefficient Of Thermal Expansion.

1. Introduction

We can see that material cost is increasing day by day in construction industry. In order to maintain cost of houses, we need to find out more cost saving alternative construction materials. This will help in providing affordable houses to customers. Recent increase in industrial growth has resulted in increase of various types of industrial, urban and construction waste. This waste is often dumped resulting in land, water, soil and air pollution, ultimately increasing existing environmental problems. Even National and International waste disposal policies have failed to control this and the consequent expenditure caused in getting rid of this waste

This waste, if managed correctly can be transformed to a cost saving raw material. This will simultaneously lead to sustainable development and conservation of natural resources. Ceramic goods contain high proportion of clay minerals. They have properties of fired clay on behave of the controlled manufacturing thermal processing. Thus, showing properties like resistance to heat, fire and electricity; durability, chemically inert behaviour, and stability throughout its service life. It is made up of silica, aluminum oxide, iron oxide, and other compounds in lesser proportions resulting into its acidic nature.

Research carried out worldwide shows great potential of these wastes to be recycled. These materials show extremely versatile characteristics on behalf of their pozzolanic properties. They can be successfully used in construction industry for manufacture of concrete. Their physical properties help them to be used as aggregate in manufacture of mortar and concrete

2. Experimental Work

Tests were carried on normal and ceramic aggregate to find out their comparative properties. Procedure and results are as follows.

2.1. Impact Test On Ceramic Aggregates

According to reference [1], procedure for impact test is as follows:

1) The apparatus consists of a steel test mould with a falling hammer as shown in Figure the hammer slides freely between vertical guides so arranged that the lower part of the hammer is above and concentric with the mould.

Figure 1. Impact Test

2) The material used is aggregate passing a 12.70 mm sieve and retained on a 9.52 mm sieve. It shall be clean and dry (washed if necessary) but it must not be dried for longer than 4 hours nor at a temperature higher than 〖110〗^oC otherwise certain aggregates may be damaged.

3) The whole of the test sample (mass A) is placed in the steel mould and compacted by a single tamping of 25 strokes of the tamping rod.

4) The test sample is subjected to 15 blows of the hammer dropping 381 mm, each being delivered at an interval not less than one second.

5) The crushed aggregate is sieved over a 2.36 mm sieve. The fraction passing 2.36 mm is weighed to the nearest 0.1 g (mass B). The fraction retained on the sieve is also weighed (mass C). If {A-(B+C)}>1 gram, the result shall be discarded and a fresh test made.

6) The aggregate impact value is calculated as

B/A x 100

Table 1. Impact Test On Aggregate

Aggregate	A(gm)	B(gm)	Impact Value
Normal Aggregate	724	30	4.14%
Ceramic Aggregate	484	60	12.39%

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2.1. Water Absorption Test On Aggregates

Figure 2. Aggregate Samples

According to reference [1], procedure for water absorption test is as follows:

1) About 2 kg of aggregate sample is washed thoroughly to remove fines, drained and placed in wire basket and immersed in distilled water at a temperature between 22- 32º C and a cover of at least 5cm of water above the top of basket.

2) Immediately after immersion the entrapped air is removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop at the rate of about one drop per second. The basket and aggregate should remain completely immersed in water for a period of 24 hour afterwards.

3) The basket and the sample are weighed while suspended in water at a temperature of 22° – 32°C. The weight while suspended in water is noted.

4) The basket and aggregates are removed from water and allowed to drain for a few minutes, after which the aggregates are transferred to the dry absorbent clothes. The empty basket is then returned to the tank of water jolted 25 times and weighed in water.

5) The aggregates placed on the absorbent clothes are surface dried till no further moisture could be removed by this cloth. Then the aggregates are transferred to the second dry cloth spread in single layer and allowed to dry for at least 10 minutes until the aggregates are completely surface dry. The surface dried aggregate is then weighed =W1 g

6) The aggregate is placed in a shallow tray and kept in an oven maintained at a temperature of 110° C for 24 hrs. It is then removed from the oven, cooled in an air tight container and weighted=W2 g.

7) Water Absorption = ((W1 – W2) / W2) X 100

Table 2. Water Absorption Test On Aggregate

Aggregate	W_1 (gm)	W_2 (gm)	Impact Value
Normal Aggregate	3010	2982	0.93%
Ceramic Aggregate	2954	2782	6.18%

2.1. Coefficient Of Linear Thermal Expansion Of Ceramic Aggregate

According to reference [2], the coefficient of thermal expansion (CTE) is defined as the change in unit length per unit change in temperature. It is usually expressed in microstrain (10-6) per degree Celsius (με/ºC) or microstrain (10-6) per degree Fahrenheit (με/ºF).The coefficient of linear thermal expansion shall be calculated from the measurements by the use of following formula:

$$C= (R_h-R_c)/ (G\ \Delta T)$$

Thermal expansion of aggregate has an effect on durability of concrete, particularly under severe exposure conditions or under rapid temperature change. Concrete is a heterogeneous material made out of cement, water and aggregates; which we assume to be acting as a homogeneous material even in RCC. But, when such material is exposed to various temperature conditions, coefficient of thermal expansion of various component materials severely affects the heat resistance of concrete and RCC. Caution needs to be taken in selection of aggregates for highly durable concrete so that the difference between CTE will not exceed 5.4 x 10-6 per ºC.

Figure 3. Heating Of Aggregate Samples

To find out CTE of ceramic aggregates, a simple experiment was carried out. Locally available ceramic aggregates were measured for their unheated dimensions i.e. Gauss dimensions. Then they were heated at 190ºC and 50ºC and respective dimensions were measured. Calculation work was carried out using above formula as follows:

Table 3. Coefficient Of thermal Expansion

Sample	G	R_h	R_c	CTE (ºC) (10^{-5})	CTE (ºF) (10^{-6})	Avg CTE (ºF) (10^{-6})
1	9.4	9.55	9.4	0.1	8.2	7.2
	3.85	3.95	3.9	8.9	6.7	
	3.9	3.95	3.9	8.8	6.6	
2	9.8	9.9	9.85	3.5	2.6	2.8
	8.75	8.85	8.8	3.9	2.9	
3	7.6	7.8	7.7	9.0	6.8	7.3
	5.1	5.25	5.15	0.1	1.0	
	8.8	8.9	8.8	7.8	5.8	
	7.9	8	7.9	8.7	6.5	

Table 4. Aggregate Test Results

Tests	Natural aggregate	Ceramic aggregate
Impact test	4.14%	12.39%
Water absorption	0.93%	6.18%

3. Conclusion

1) Higher value of water absorption of ceramic aggregate as compared to normal aggregate is observed because of pore sizes wide opening during the manual crushing and composition of clay content resulting into higher water absorption.
2) Both types of coarse aggregates have crystalline nature but major composition of ceramic waste aggregate was clay, which results in pore spaces at high temperature after burning.
3) Ceramic aggregates can be very effective in heat resistance as pore spaces created will reduce density of ceramic concrete.
4) Because of angular and flaky shape of aggregates, higher water/cement ratio is required to reduce the roughness of aggregate surface in concrete. Hence, they prove to be a cheaper substitute where concrete filling with lesser strength is required.
5) Smooth surface of aggregates enables thinner layer of paste to lubricate its movements with respect to normal aggregate particles.
6) For same workability, ceramic aggregates will show denser packing and will require lower paste content.
7) But, on the same hand, bond strength is reduced.
8) Because of dense packing and uniformity in shape, ceramic aggregates show higher impact values as compared to normal aggregates.

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