"The Potential Pozzolanic Activity of Different Ceramic Waste Powder as Cement Mortar Component (Strength Activity Index)"

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Abstract— **Under the strong contemporary demand for modern and environmental friendly materials, natural pozzolan can be proved to be such material and several researchers have focused their research efforts in using it as a partial substitute in the manufacture of concrete and mortar. Pozzolans are divided into two categories, namely the natural and the artificial, as metakaoline and silica fume (SF). In recent years, the industry has shifted to using natural pozzolans because of their lower cost and accessibility. A pozzolan is a siliceous material that can be used as an inexpensive Substitute for cement in mortar mixtures. The objective of this experimental study was to examine the possibility of reusing ceramic materials waste from ceramic industry as partial cement replacement in mortar and concrete. The different types of ceramic waste were finely ground to specific sizes (0–45 lm, 45–75 lm and 75–150 lm) from different industries and its pozzolanic activity was determined. The compressive strength activity index at 7, 28 days and accelerated curing was determined in mortars produced with each finely grounded waste ceramics and different percentages of partial cement replacement. As per Indian standard mortar bar tests on 70.6*70.6*70.6 mm3 size mortar specimens were performed and results concluded with comparison to nominal mix specimen.**
own text.

Keywords— **Ceramic material, pozzolonic, consistency, strength activity**

I. INTRODUCTION

The overall size of the Indian ceramic industry is approximately Rs 18,000 crores. The production during 2011-12 stood at approx. 600 million square meters. In the ceramic industry, about 8% to 10% waste material is generated from the total production. Wastages generated in different manner should be 8 to10 % per production so INDIA generated approximate 55 million square meters / year. This waste is not recycled in any form at present. However, the ceramic waste is durable, hard and highly resistant to biological, chemical and physical degradation.

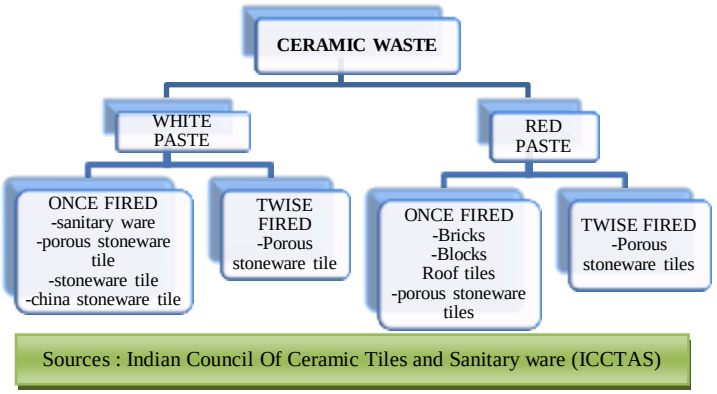

Fig 1. Ceramic classification

*Different ceramic products sub-types are:

- Wall And Floor Tiles
- Bricks And Roof Tiles
- Table-And Ornamental ware (Household Ceramics)
- Refractory Products
- Sanitary ware
- Technical Ceramics
- Vitrified Clay Pipes
- Expanded Clay Aggregates
- Inorganic Bonded Abrasives

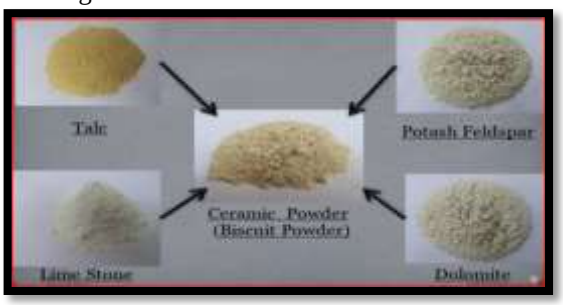

Fig.2 Common Ceramic material ingredient

The Ceramic industries are dumping the solids or powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping. This leads to serious environmental and dust pollution and occupation of a vast area of land, especially after the powder dries up so it is necessary to dispose the Ceramic waste quickly and use in the construction industry. As the ceramic waste is piling up every day, there is a pressure on ceramic industries to find a solution for its disposal.

The advancement of concrete technology can reduce the consumption of natural resources. 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, arguable superior products, and severe hazards in the environment.

Ceramic powder is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials. Ceramic waste powder is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health.

For proper utilization of these ceramic wastes in concrete industry, We decide to check suitability of different ceramic waste like wall tiles, floor tiles and sanitary ware from Bajaj industry, Crystalline industry and Gopi industry and Monali industry respectively.

II. SUITABILITY FOR CONCRETE AS PARTIALLY CEMENT

There are many benefits of ceramic powder that suits concrete to give better performance that are as below.

- Non-magnetic
- Low thermal conductivity
- Sulphate-alkali resistance
- High strength
- Good wear resistant
- Durable and strong

III. SOURCES OF CERAMIC WASTE MATERIALS COLLECTED

Fig 3. Mix ceramic waste powder(monali industry-nandasan,kalol,Gujarat,India)

Fig.4 Bajaj wall tiles pvt.ltd (nandasan,kalol,Gujarat,India)

Fig.5 Crystalline floor tiles pvt.(nandasan,kalol, Gujarat,India) & Gopi Industry (Cera sanitary pvt.ltd) (jotana, Gujarat,India)

IV. STRENGTH ACTIVITY INDEX TEST

The purpose of these evaluations is to investigate the suitability of ceramic material as a replacement for cement in concrete mortar mixes.

Our objective is determining the pozzolanic activity of the material and to select from them, we have done this test on 3 different ceramic materials.

The pozzolanic activity is based upon a comparison of the compressive strength of mortar cubes containing pozzolans as a partial replacement for Portland cement to reference mortar cubes containing only Portland cement as binder. The mortar cubes are prepared, cast, cured and tested.

The ceramic material which has a strength index greater than 80% which respect to normal mortar cube result is called "pozzolonic material" and it has a very good contain of reactive silica which is responsible for higher strength as well durability criteria of concrete.

❖ Methodology (IS 650-1991, ASTM C109/C109M-08)

- In the test mixture, replace 20 % of the mass of the amount of cement used in the control mixture by the same mass of the test sample.
- The methodology of mixing is important in obtaining the correct results. First, each material must be measured.
- We have taken 1:3 proportions of cement and standard sand in mortar as per test procedure.
- The dry materials are then placed in a mortar mixer and mixed thoroughly, without water, to en-sure a uniform composition. Water is then added as per consistency test and mixed for several minutes, wetting all surfaces and creating a mortar paste.
- We took 4 batches, one for nominal mortar mix and 3 for different ceramic materials.
- We casted 3 cubes of size 70.6mm*70.6mm*70.6mm for each batch.
- After moulding, place the specimens in the moist room or closet at 23°C for 20 to 24 h. Remove the moulds from the moist room or closet and remove the cubes from the moulds. Place and store the cubes in water.
- After 24 hr, 3 out of 9 cubes for each batch kept in accelerated concrete curing tank for getting 56days strength in one day.Take the compressive strength results after 3 days for accelerated tank cube,28 days cube and 28 days cube.
- Temperature of Lab.: - 27'C
- Cement – Standard Sand Proportion: - 1: 3
- Weight of Cement per cube: - 200gm
- Weight of Standard Sand per cube: - 600gm (conforming to IS: 650-1966)

Fig.6 Vicat Apparatus (Conforming to IS: 4031-1968)

Sr. No.	Percentage of Water to be added (%)	Water (ml)	Penetration from bottom (mm)
1.	27	135	27
2.	28	140	20
3.	29	145	15
4.	30	150	10
5.	31	155	8
6.	32	160	5

TABLE 1. READINGS OF CONSISTENCY TEST

Result: -The Standard Consistency of the cement is 32%, Water:((P ÷ 4)+3) % of combined mass= {((32/4) +3) ÷100} x 800 = 88ml, Here 'P' is the consistency percentage obtain from standard
Ceramic material replaced: 20 % of cement = 40 gm

SR NO.	Material type	7 Days	28 Days	ACC.	Total
Cube 70.6x70.6x70.6 MM^3					
1	Normal Mix	3	3	3	36
2	CP1 (Monali Industry)	3	3	3	
3	CP2 (Bajaj Tiles)	3	3	3	
4	CP3 (Gopi Industry)	3	3	3	

Fig.7 Mortar mixture and Casted Mortar specimen of size 70.6x70.6x70.6 MM3

V. Calculation

Calculate the strength activity index with Portland cement as follows:

- Strength activity index with Portland cement =

$$\frac{\text{AAVERAGE COMPRESSIVE STRENGTH OF TEST MIXTURE CUBE MPA}}{\text{AVERAGE COMPRESSIVE STRENGTH OF CONTROL MIX CUBES MPA}}$$

*ACC= Accelerated curing

Table 2. Number of specimen used in strength activity index test

No	Mix	ACC N/mm^2	Index %	7 Days N/mm^2	Index %	28 Days N/mm^2	Index %
1	Normal Mix	43.44	-	27.54	-	32.05	-
2	CP1 (Monali Industry)	37.09	85.38	17.45	63.35	29.5	92.04
3	CP2 (Bajaj Tiles)	45.99	105.8	25.34	92.01	25.08	78.25
4	CP3 (Gopi Industry)	39.23	90.30	22.61	82.09	32.26	100.6

*ACC= Accelerated curing

Table 3.Results of strength activity index test

VI. Conclusion

- The experimental results presented in this paper showed that waste ceramic ground to an appropriate fineness can be considered a prospective pozzolana material suitable for the replacement of a part of Portland cement in concrete industry. This solution may have significant environmental and economical consequences.
- Based on pozzolonic strength activity index test , all three ceramic materials have pozzolonic property index greater than 80 % but the material from Gopi industry (sanitary ware products) have a continuous better performance for 7,28 days and in accelerated tank curing also.
- Hence, here possibility of Waste ceramic as recycled material used in concrete production increases and may beneficial to decreases further CO_2 burden to the environment and helpful for conserve natural resources.

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