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Analysis of mix design of concrete using ceramic waste

M Faizan Dhrolwala[1], Kaushik Kanani[2], Divyesh Patel[3]

[1]*Civil Engineering., Vadodara Institute of Engineering.*
[2]*Civil Engineering., Vadodara Institute of Engineering.*
[3]*Civil Engineering., Vadodara Institute of Engineering.*

Abstract-*This paper presents an experimental study on the properties of concrete containing ceramic wastes. The ceramic industry inevitably generates wastes, irrespective of the improvements introduced in manufacturing processes. In the ceramic industry, about 15%-30% production goes as waste. These wastes pose a problem in present day society, requiring a suitable form of management in order to achieve sustainable development. In this research study the (OPC) cement has been replaced by ceramic waste powder accordingly in the range of 0%,5%,10%,15%, 20% and aggregate has been replaced by ceramic waste aggregate accordingly in the range of 0%, 5%,10%,15%, 20% by weight for M-25 grade concrete. Compressive Strength test was carried out on hardened concrete cubes after 7 and 28 days curing in water. Results show that concrete with partial cement replacement by ceramic powder and ceramic aggregate although it has minor strength loss possess increase durability performance. In current paper the analysis of varies properties of ceramic aggregates is carried out to validate adoptability of the same as normal aggregates. In both cases, sustainable efforts were made to reduce the quantity of concrete. Reuse of this kind of waste has advantages in aspect of economic and environmental, reduction in the number of natural spaces employed as refuse dumps. Indirectly, all the above contributes to a better quality of life for citizens and to introduce the concept of sustainability in the construction sector.*

Keywords*—Ceramic Waste, Compressive Strength, Ecofriendly, Industrial Waste, Low Cost, OPC Cement, Sustainable.*

I. INTRODUCTION

Generally, in design of concrete mix, cement, fine aggregates and coarse aggregates are used from long back, which plays a crucial role in designing of a particular grade of concrete. But now-a-days there are some new materials which are locally available with low cost which can be introduced for replacing the fine aggregates, coarse aggregates as well as cement to get the comparablestrength,the present study involves understanding the behavior and performance of ceramic waste in concrete. The need to reduce the high cost of Ordinary Portland Cement requires intensified research into the use of locally available materials that could be used as partial replacement for Ordinary Portland Cement (OPC) as well as the aggregate which is use in construction work.In India, the amount of waste in the different production stages of the ceramic industry reaches nearly to 3–7% of its global production meaning millions of tons of calcined-clays per year that are just land filled[1].From 2010 to 2015, the world's annual consumption of cement rose from 3313 million metric tons to 4193 million metric tons [2]. These is also associated with major environmental issues like emission of CO2 and cement manufacturing is the third largest CO_2 producer which emits 50% of all industrial CO_2 (for every 1ton of cement produced, 0.94 ton of CO_2 is released in the air), 1.6 ton of natural resources is consumed to produce 1 ton of cement[3].

Indian ceramic production is 100 Million ton per year. In the ceramic industry, about 15% - 20% waste material is generated from the total production[4].This waste is not recycled in any form at present. However, the ceramic waste is durable, highly resistant to biological, chemical, and physical degradation forces. The Ceramic industries dump the waste 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 occupancy of a vast area of land, especially after the powder dries up, so it is necessary to dispose the ceramic waste quickly. Ceramic waste is produced from ceramic industry as the end product of polishing and finishing.

The principle waste coming from the ceramic industry is the ceramic powder. Ceramic wastes are generated as a waste during the process of dressing and polishing. It is estimated that 15 to 30% waste is generated during production of raw material[5], and although a portion of this waste is utilized on-site for refilling excavation pit.The disposal of these waste materials acquire large land areas and remain scattered all around, spoiling the aesthetic of

the entire region. Fig.1 shows the ceramic waste powder which is used in current research. The typical microscopic views of Ceramic Particles are shown in Fig.2[6].

"Fig.1 Ceramic powder"

"Fig.2 Microscopic view of ceramic particles"

II. MATERIALS USED

2.1 Cement

The Ordinary Portland Hathi cement 53 grade conforming to IS: 12269:1987 has being used. Normal consistency of cement is 30%, initial setting time is 78 minute, final setting time is 152 minute and specific gravity is 3.15.

2.2Ceramic waste powder

Ceramic waste is produced from ceramic industry at the end process of polishing and finishing. This ceramic slurry waste is avail from Morbi ceramic area, Gujarat. The material cost negligible. But the processing of the same for usage as raw material for construction industry adds up a little bite. This waste was available in the form of paste and after drying and hand crushing it was passed through 90 microns and used as cement replacement. Specific gravity of ceramic waste powder is 2.33, water absorption is 2.4 and chemical property is as shown below:

"Table 1: Chemical composition of ceramic waste powder"

Materials	Ceramic Powder (%)
Silicon Dioxide(SiO_2)	78.20
Aluminum Oxide (Al_2O_3)	0.820
Iron Oxide (Fe_2O_3)	4.32
Calcium Oxide(CaO)	1.510
Magnesium Oxide (MgO)	3.580
Chloride (CL)	0.302
Sulphur as Sulphur Trioxide (SO_3)	0.064
Loss of Ignition	3.590

2.3 Coarse aggregate

Locally available 20mm size aggregate is used. Physical property is determined, specific gravity of coarse aggregate is 2.81, and fineness modulus is 6.94.

2.4 Ceramic Aggregate

Ceramic waste are collected from Morbi. It is not readily available in 20mm size. It needs to be crushed for required size. Itsphysical properties are similarto that of normal coarseaggregates, which is shown in below table 2.

"Table 2: Laboratory tests on ceramic aggregate"

Properties	**Tests**	**MethodologyAdopted As per IS code**	**Ceramic aggregate**	**Normal aggregate**
Toughness	Impact test	IS:2386 (Part 4)	19%	14.44%
Crushing strength	Crushing test	IS:2386 (Part 4)	28.80%	21.99%
Hardness	Los-Angeles abrasion test	IS:2386 (Part 4)	8.34%	7.6%
Hardness	Deval abrasion test	IS:2386 (Part 4)	8.212%	7%
Specific gravity	Specific gravity	IS:2386 (Part 3)	2.67%	2.955%

2.5 Fine aggregate

Locally available river sand is used. As per IS 383:1970, sand is confirming to Zone III. Specific gravity of the sand used is 2.69 and the water absorption value is 0.45%.

2.6 Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully.

III. MIX DESIGN

A mix M25 grade was designed as per Indian Standard method (IS 10262-2009) and the same was used to prepare the test samples.

"Table 3: Types of concrete mix"

Concrete mix	Replacement of cement (%)		Replacement of Coarse Aggregate (%)		W/C Ratio
	Cement (%)	Ceramic powder (%)	Coarse aggregate (%)	Ceramic aggregate (%)	
A0	100	-	100	-	0.48
A1	100	-	95	5	0.48
A2	100	-	90	10	0.48
A3	100	-	85	15	0.48
A4	100	-	80	20	0.48
A5	95	5	100	-	0.48
A6	90	10	100	-	0.48
A7	95	5	85	15	0.48

For M25 grade of concrete, 6 cubes were casted for each batch of A0, A1, A2, A3 ,A4,A5,A6and A7. Concrete cubes having size of 150 x 150 x 150 mm were prepared for all mixes to test 3 samples of a mix at 7 and 28 days.Slump cone

test was performed on all mixes to assess the workability of concrete for different percentages of replacing materials. Compressive strength test is conducted on cubes after 7 and 28 days curing period as shown in figure no. 3, for each mix 6 samples were tested. Compressive strength of each mix is taken as average of the 3 samples.

"Figure 3. Compression testing machine"

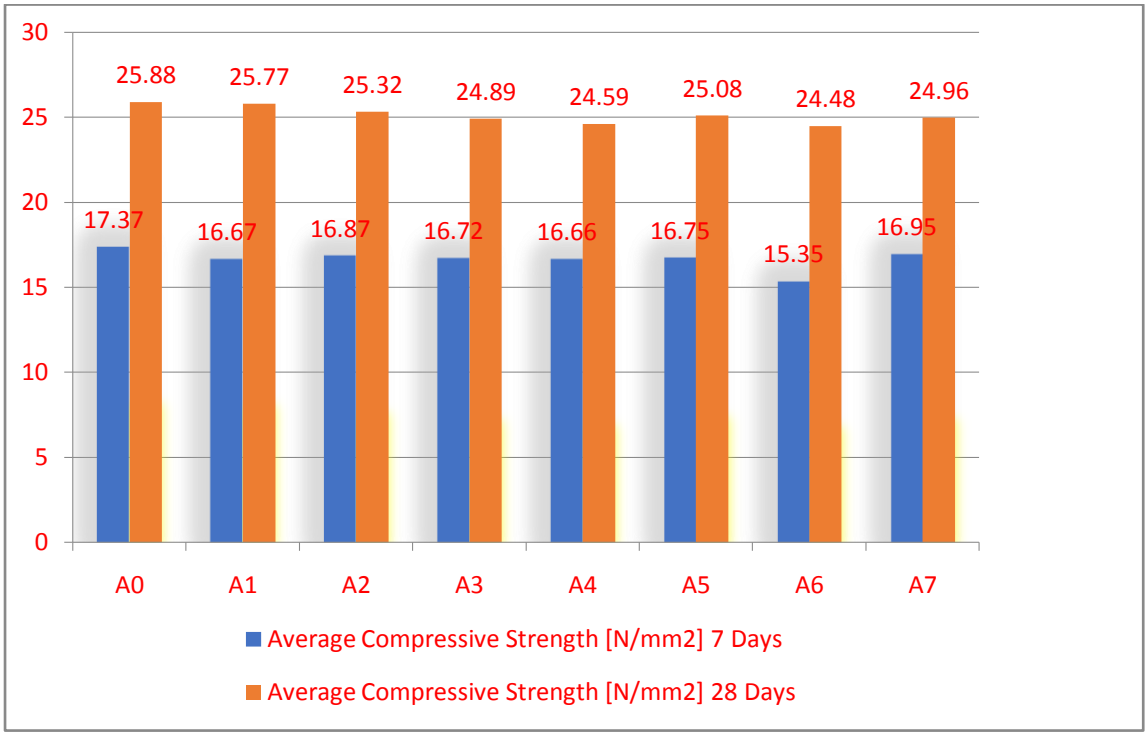
IV. RESULT AND ANALYSIS

Experimental investigation is done to determine the compressive strength of ceramic waste concrete.
Effect of ceramic waste powder and ceramic aggregate on compressive strength:

Compressive strength is determined at 7 and 28 days after successful curing period. As per the experimental result comparable strength can be achieve replacement of ceramic powder at 5% and replacement of aggregate 15%. Further addition of ceramic waste in concrete mix, compressive strength simultaneously decrease.

"Table 4:Compressive strength of cube(150x150x150) for m25 mix at 7, 28 days"

Concrete mix Type	Average Compressive Strength [N/mm^2]		Reduction of strength in %	
	7 Days	28 Days	7 Days	28 Days
A0	17.37	25.88	-	-
A1	16.67	25.77	4.19	0.42
A2	16.87	25.32	2.96	2.21
A3	16.72	24.89	3.88	3.97
A4	16.66	24.59	4.26	5.24
A5	16.75	25.08	3.70	3.18
A6	15.35	24.48	13.15	5.71
A7	16.95	24.96	2.47	3.68



"Figure 4: Compressive strength of cube"

V. CONCLUSION

Based on experimental investigations concerning the compressive strength of concrete, the following observations are made:

a) The compressive strength of M25 grade concrete decrease in some percentage when ceramic waste is added. While adding ceramic powder in concrete as a replacement of cement up to 5% feasible compressive strength can be achieved. While adding ceramic aggregate in concrete as a replacement of normal aggregate up to 15% feasible compressive strength can be achieved. While adding 5% of ceramic powder as replacement of cement 3.18% reduction in compressive strength is achieved, while adding 15% of ceramic aggregate as replacement of aggregate 3.97% reduction in compressive strength is achieved, while combining both ceramic powder 5% and ceramic aggregate 15% as replacement of cement and normal aggregate respectively 3.68% reduction in strength occurs. So, it becomes technically and economically feasible and viable.

b) construction industrycan betheend user ofallceramicwastesand in this waycan contribute tosolvethisenvironmentalproblem.Thenatureofconstructionindustry,especially the concreteindustry,issuchthatceramicwastescanbeusedsafely withnoneedfor dramaticchangeinproductionandapplicationprocess.It is use in low strength and low cost construction. Therefore, the replacement of cement and aggregate in concrete by ceramic wastes represents a tremendous saving of energy and has important environmental benefits**.** By using ceramic waste, we can also utilize the wastes in construction which is non bio degradable. High strength concrete can be obtained by adding different kinds of admixture. Utilization of Ceramic waste and its application are used for the development of the eco-friendly construction industry. Ononehand,thecostofdeposition of ceramic wasteinlandfillwillbe savedand,onthe other,raw materialsandnatural resourceswillbereplaced,thussavingenergy andprotectingtheenvironment.Accordingto someauthorsthebestwayfortheconstructionindustry tobecomeamoresustainableoneis byusingwastesfrom other industries as building materials.

c) By replacing coarse aggregate and cement by ceramic aggregate and ceramic powder respectively, reduction in the cost of the material can be observed as these materials are the waste product of ceramic

tiles manufacturing. Raw material is available locally and in low cost.Labours are required for collection and dumping the material. Skill labours are not required. Ceramic waste is waste products of different manufacturing item, thus can be available in low cost. compare to other admixtures used in concrete.By using of waste material produce in ceramic industry in the concrete, the cost is decreases so that it is use to developed the rural area of country and u ultimately it leads the development of country.

d) It is the possible alternative solution of safe disposal of Ceramic waste. The production of cement requires high energy input (850 kcal per kg of clinker) and implies the extraction of large quantities of raw materials from the earth (1.7 tonnes of rock to produce 1 tone of clinker).On the other hand the production of one tonne of cement generates 0.55 tonnes of CO_2 and requires an additional 0.39 tonnes of CO_2 in fuel emissions, accounting for a total of 0.94 tonnes of CO_2.

e) 1 m^3 of concrete cost 4800/-Rs. , while using ceramic powder 5% and ceramic aggregate 15% as replacement of cement and normal aggregate respectively cost is 4300/-Rs.. It means it can reduce 10% of construction cost/m^3. Which is very effective as economy point of view. Utilization of Ceramic waste and its applications are used for rural area development in construction industryand material sciences.

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