Use of Ceramic Powder in Concrete - Strength & Durability Properties

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Ceramic wall tiles are used as building material in the field of construction. Manufacturing of ceramic tiles require different raw material like clay, potash, dolomite, feldspar, talc and different chemicals like sodium silicate, sodium tripoly, phosphate (STPP) in ceramic production. In the ceramic industry, about 15%-30% production goes as waste. These wastes poses a serious threat to the environment by polluting the habitant and agricultural lands. Therefore using of ceramic waste powder in concrete would benefit in many ways in saving energy & protecting the environment. The cost of deposition of ceramic waste in landfills will be saved. Raw materials and natural resources will be replaced. Which indirectly helps for reducing the greenhouse gas (co2).There is a large amount of carbon dioxide released in the cement production. In this research study the (OPC) cement has been replaced by ceramic waste powder accordingly in the range of 0%, 10%, 20%, 30% 40%, & 50% by weight for M-25 grade concrete. The wastes employed came from ceramic industry which is in Rusayl (Muscat, Oman) industrial area. Based on experimental investigations concerning the compressive strength of concrete, the following observations are made:
(a) The Compressive Strength of M25 grade concrete increases when the replacement of cement with ceramic waste up to 30% by weight of cement and further replacement of cement with ceramic powder decreases the compressive strength.
(b) Concrete on 30% replacement of cement with ceramic waste, compressive strength obtained is 26.77 N/mm2and vice-versa the cost of the concrete is reduced up to 13.27% in M25 grade and hence it becomes more economical without compromising concrete strength than the standard concrete. It becomes technically and economically feasible and viable. It is the possible alternative solution of safe disposal of ceramic waste. Reuse of this kind of waste has advantages 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 Powder, Industrial Waste, Cost Effective, Green Concrete

1. **Introduction**

Environmental issues associated with ceramic tile and sanitary ware manufacturing primarily includes the following:

1) Air Emissions, Greenhouse Gases, and Energy Efficiency
2) Wastewater
3) Solid waste

Each year, thousands of heaps of wastes are disposed of in landfills, which effects occupation and degradation of valuable soil [1] Depletion of natural resources is a common phenomenon in developing nations like India due to rapid urbanization & industrialization, involving construction of bases and other conveniences. Indian ceramic production is 100 Million ton per year. In the ceramic industry, nearly 15%-30% waste material generated from the full production [2] this wasteland is not recycled in any course at present. Withal, the ceramic waste is durable, heavy and extremely resistant to biological, chemical, and physical degradation forces. The Ceramic industries are dumping the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping [3]. This contributes to severe dust and environmental pollution and occupation of an immense expanse of solid ground, especially after the powder dries up and then it is necessary to throw out the Ceramic waste quickly and employ in the construction industry [4] As the ceramic waste piles up every day, there is a pressure on ceramic industries to get a resolution for its disposition. The advancement of concrete technology can reduce the consumption of natural resources [7] 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. From the studies of [8] paper industry waste was used in concrete and tested as an alternative

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3. **Results**

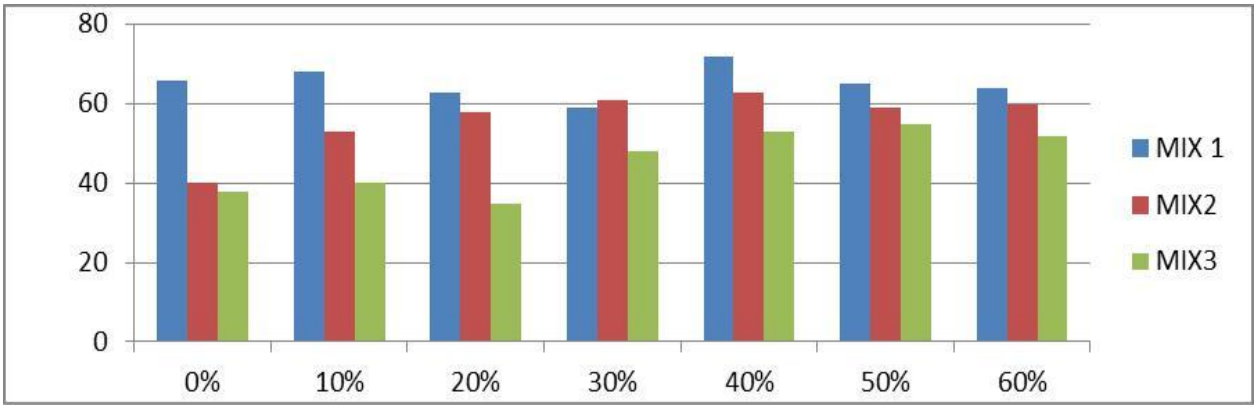
The mix proportion for M 25 is and W/C ratio of 0.46 was casted. Slump test was tested when the concrete in fresh concrete. The cubes, beams and cylinders were tested for compressive strength, split tensile strength and flexural strength. These tested were carried out at age of 7 days, 14 days and 28 days.

Workability Test Results:

Slump Test:

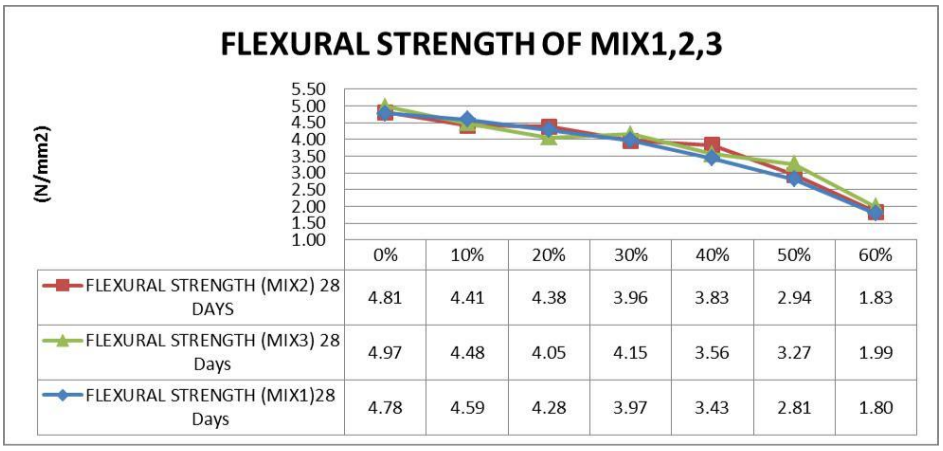
MIX	*SLUMP FOR MIX 1*		*SLUMP FOR MIX 2*		*SLUMP FOR MIX 3*	
	VALUE (mm)	*VARIATION (%)*	*VALUE (mm)*	*VARIATION (%)*	*VALUE (mm)*	*VARIATION (%)*
0%	*66*	*0*	*40*	*39.3*	*38*	*42.4*
10%	*68*	*-3.03*	*53*	*19.6*	*40*	*39.3*
20%	*63*	*4.5*	*58*	*12.1*	*35*	*46.9*
30%	*59*	*10.6*	*61*	*7.5*	*48*	*27.2*
40%	*72*	*-6.06*	*63*	*4.5*	*53*	*19.6*
50%	*65*	*1.51*	*59*	*10.6*	*55*	*16.6*
60%	*64*	*3.03*	*60*	*9.09*	*52*	*21.2*

Table – 2 Comparisons of Slump Values



Graph 1: Comparisons of Slump Values

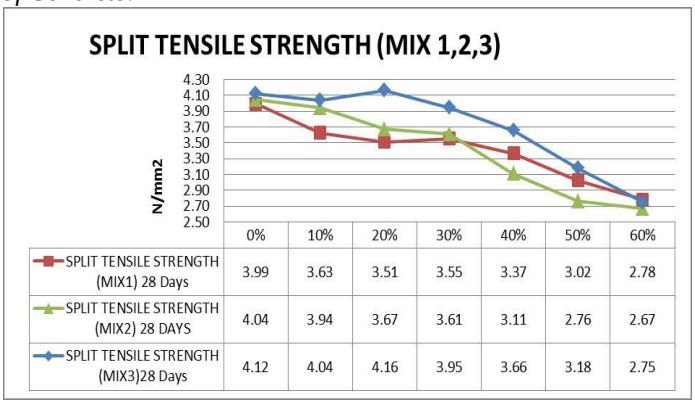
2. Flexural Test of Concrete:



	0%	10%	20%	30%	40%	50%	60%
FLEXURAL STRENGTH (MIX2) 28 DAYS	4.81	4.41	4.38	3.96	3.83	2.94	1.83
FLEXURAL STRENGTH (MIX3) 28 Days	4.97	4.48	4.05	4.15	3.56	3.27	1.99
FLEXURAL STRENGTH (MIX1)28 Days	4.78	4.59	4.28	3.97	3.43	2.81	1.80

Graph 3: Comparison of Flexural Strength of Mix 1, 2, 3

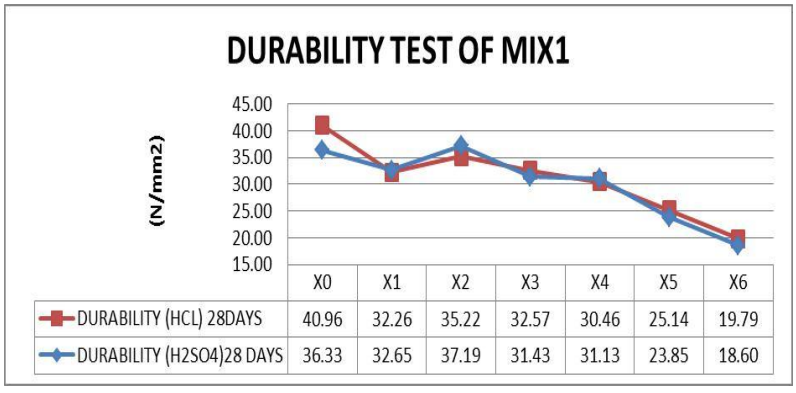
3. *Split Tensile Test of Concrete:*



	0%	10%	20%	30%	40%	50%	60%
SPLIT TENSILE STRENGTH (MIX1) 28 Days	3.99	3.63	3.51	3.55	3.37	3.02	2.78
SPLIT TENSILE STRENGTH (MIX2) 28 DAYS	4.04	3.94	3.67	3.61	3.11	2.76	2.67
SPLIT TENSILE STRENGTH (MIX3)28 Days	4.12	4.04	4.16	3.95	3.66	3.18	2.75

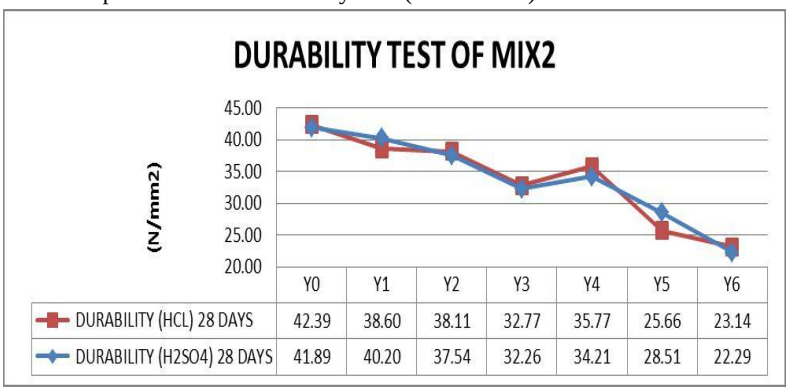
Graph 4: Comparison of Split Tensile Strength of Mix 1, 2, 3

4. Durability Test on Concrete:

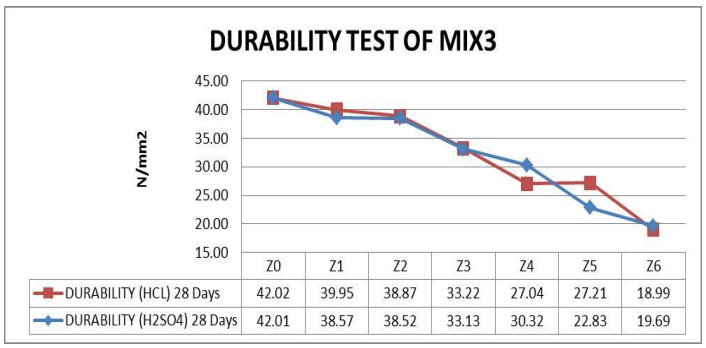


	X0	X1	X2	X3	X4	X5	X6
DURABILITY (HCL) 28DAYS	40.96	32.26	35.22	32.57	30.46	25.14	19.79
DURABILITY (H2SO4)28 DAYS	36.33	32.65	37.19	31.43	31.13	23.85	18.60

Graph 5: Effect on Durability Test (Acid Attack) – Mix 1



Graph 5: Effect on Durability Test (Acid Attack) – Mix 2



Graph 5: Effect on Durability Test (Acid Attack) – Mix 3

4. Conclusion & future scope

A. Conclusions:

Various tests are performed in order to know the effect of sodium silicate binder on CWP & cement concrete. Conclusion is based on results discussed above are as follows:

1) When Sodium silicate used as binder with cement, the setting time of cement get affected.

2) Water gets dehydrated from the mix while testing initial & final setting time of cement but initial & final time fall as per specified in code.

3) Slump value for mix 1 decreases with respect to conventional concrete, while adding 10% & 40% replacement of CWP increases by 3.03% & 6.06% respectively.

4) Slump value for mix 2 decreases with respect to the conventional concrete mix done in mix 1.

5) When in mix 1 CWP only is used in different varying percentage of cement (0% to 60%), compressive strength decrease from 0% to 39.7% respectively.

6) When in mix 2, CWP & 1% sodium silicate of water is used in different varying percentage of cement (0% to 60%) compressive strength decreases from -1.3% to 38.3% respectively with compare to the conventional concrete.

7) When mix 3, CWP & 2% sodium silicate is used in different varying percentage of cement (0% to 60%) compressive strength -1.3% to 42% with respect to conventional concrete.

8) Concrete on 30% replacement of cement with CWP compressive strength obtained is 33.44 N/mm2 of mix 3 (i.e., 30% CWP & 2% Na2SO4) can be recommended.

9) When observing the cost of concrete at this point is reduced up to 16.3% in M25 grade of concrete and becomes economical with compromising the target strength of concrete.

10) By following the same above percentage replacement split tensile strength of mix 3 is 3.95 & only about 1% of loss is observed with compare to conventional concrete.

11) Flexural is observed in mix 3 (i.e., 30% CWP &

1% Na2SO4) as greater than mix 1 & mix 2, while taking mix 3 (i.e., 30% CWP & 2% Na2SO4) as higher side in compression and split tensile strength, we find flexural strength is decreased by 13.1% which is preferable.

12) Durability properties of mix 3 (30% replacement of CWP) is better than mix 1 and mix 2.

13) Finally, this research can be made applicable if it is used in READY MIX CONCRETE PLANTS as quality of concrete is important one.

B. Future Scope of Work:

Further testing and experiment can be done on ceramic waste concrete, as it is highly recommended to indicate strength characteristics of this type of material for application in normal or low rise structural concrete.

Some recommendations made for further studies:

1) Experiment can be done by varying water/cement ratio, to know the varying strength parameters while addition of sodium silicate, in order to get better grip on workability.

2) More investigations and research can be done on the strength characteristics of ceramic waste powder as Cementous material which is also a pozzolanic material.

3) Non-destructive testing like Rapid Chloride Penetration Test (RCPT) can be done to support its suitability for structural concrete.

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