International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-3, Issue-8, August 2015

Durability of Concrete with Ceramic Waste as Fine Aggregate Replacement

Hitesh Kumar Mandavi, Vikas Srivastava, V.C. Agarwal

***Abstract*- The over exploitation of natural resources is the cause of concern now days. Due to excess sand excavation both legal and illegal manner the environment gets badly affected. Construction industries required huge amount of natural fine aggregate for their respective projects. Sand is the major component of concrete which is naturally available and hence limited in availability. If other alternative may reduces the over exploitation of natural resources, will reduces the burden on environment. This paper presents the result of an experimental study carried out in which waste ceramic tiles was used as a partial replacement of natural sand in the range of 10 to 50 percent at an interval of 10 percent. The optimum replacement level was determined based on the result of compressive strength. Durability of concrete made using ceramic waste at optimum replacement level was also determined. Result shows that ceramic waste can effectively been used in concrete as partial replacement of natural sand with improved strength and durability.**

***Index Terms:* - Crushed ceramic tiles, Cement (PPC), coarse aggregate, durability, fine aggregate, compressive strength, workability.**

I. INTRODUCTION

Fine aggregate is major constituent of concrete. For construction purpose these aggregates play an important role in concrete. Those resources are being exhausted vary rapidly. Due to regular exploration of new sites, exploiting up to a critical condition being one of the reason for flood problem in India and world. The government had restricted or even banned in some site due to over mining of sand or sand excavation. The project was more concern on scarcity of natural resources and its effect on environment problem. India is amongst the leading producers of ceramic tiles. As per a recent PwC report Indian ceramic tiles industry grew by around 11% in 2013-14 and is expected to reach a size of Rs 301 billion by 2016, growing at a15% CAGR. Globally India is ranked third and accounted for over 6% of total global production. This industry is largely unorganized, to the extent of 50%. As per a report by Transparency Market Research "Ceramic Tiles Market" forecast 2012-2018 that market share of ceramic tiles at a CAGR is of 8.6% from 2012 to 2018. Ceramic tiles industries share 750 million sq.m of world. Although India produces around 6% of the world's ceramic tiles, heavy domestic consumption has limited export volumes to very limited levels (SH.50. COVER STORY- CERAMIC TILES., Jan-Feb 2015). The consumption of these ceramic tiles is not appropriate, huge amount of waste ceramic tiles usually disposed on a large area. The waste ceramic tiles may be good alternative of natural sand by using ceramic waste as partial replacement of natural sand in concrete. Improvement in mechanical property in concrete is obtained besides much needed conservation of natural sand is resorted. In the present investigation an experimental program was carried out to determine the strength and durability properties of concrete made using ceramic waste as partial replacement of fine aggregate as well as of referral conventional concrete.

Hitesh Kumar Mandavi, Student M.. Tech (Structural Engg), Civil Engg Department, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad-211007, India.

Vikas Srivastava, Assistant Professor, Civil Engg Department, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad-211007, India.

V.C. Agarwal, Professor and Head, Civil Engg Department, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad-211007, India.

II. MATERIALS

A. Cement

In the present study, Portland Pozzolanic Cement (PPC) of single batch was used throughout the investigation. The PPC used was confirming to IS1484: 1999. Fly ash based Portland Pozzolana cement of Birla Gold brand was used in the experiment. Initial setting time and final setting time are 240 minute and 315 minute respectively. The specific gravity of cement is 2.71 & consistency is 30%.

B. Fine Aggregate

For the experimental study, sand acquired from Yamuna River near Allahabad. Fine aggregate was confirming to IS 383: 1970. It was pass through 4.75 mm size of IS sieve having specific gravity of 2.31 was used.

C. Coarse Aggregate

Coarse aggregate obtain from local sources divided in two fractions i.e. 20 mm and 10 mm for experimental purpose. Coarse Aggregate used in experimental study was confirming IS 383: 1970. The fraction of these aggregate was in a ratio 60:40. Both aggregate are sieved separately. Specific gravity and water absorption of these aggregate were 2.62 and 0.82 respectively

D. Ceramic Waste

Ceramic tiles were obtained from building construction sites. For this Experiment a Varmora Verified tiles was used. Its bulk density and water absorption were 2.35 gm/cc and 0.08% respectively.

E. Superplasticizer

KEM SUPLAST 101 S is a synthetic super plasticizer based on sulphonated naphthalene. It is a brown liquid instantly dispersible in water. It can provide up to 25% reduction in Water, thereby reducing permeability and increasing strength. The amount of plasticizer is such that it should not be used more than 1% of cement used during casting of a batch of concrete.

III. DESIGN MIX

As per the IS 10262: 2009 guideline, M25 grade of mix design concrete was prepared. Water Cement ratio was .46 according to the slump test obtain. Thus the mix proportion obtains for M25 mix design is 1:1.54:3.

TABLE 1- Design mix proportion of M25 grade of concrete

S. No.	ID	SUP (g)	C (Kg)	W (Kg)	F.A. (Kg)	C.S. (Kg)	C.A. (Kg)	Slump (mm)
1	A0	8	3	1.40	4.60	-	9	90
2	A1	18	3	1.40	4.20	0.50	9	75
3	A2	30	3	1.40	3.70	0.90	9	60
4	A3	30	3	1.40	3.20	1.40	9	48
5	A4	30	3	1.40	2.80	1.80	9	40
6	A5	30	3	1.40	2.30	2.30	9	31

C = Cement, W = Water, F.A = Fine Aggregate, C.S = ceramic Sand, C.A = Coarse Aggregate, SUP = Superplasticizer, ID = Concrete Specimens.

IV. EXPERIMENTAL STUDY

This experimental perform through a cube of dimension 100mm x 100mm x100mm was casted. To obtain the durability of concrete containing ceramic tiles, ceramic sand replaced with natural fine aggregate at an interval of 10 up to 50 percent for 7& 28 days. The optimized percent of ceramic sand was obtained at 40 percent replacement. After optimization durability of concrete was carried out on optimize percent for 7, 28, 56, 120 days. Although plasticizer for mix design was 0.3 percent and 1 percent for ceramic sand by weight of cement. The batch of such sample was immerged on 10 percent chloride solution, 5 percent chloride solution & tape water.

A. Workability

Workability of concrete made using waste ceramic tiles was determined at different replacement level. The result of workability in terms of slump is given in table 2. The same results are shown in graphical form in figure 1 for visual observation. It is evident from the table and figure that workability of concrete made using ceramic waste decreased with increase in replacement level.

TABLE 2- Workability (slump) of concrete at different replacement level

S. No.	Specimen Designation	Replacement Level (%)	Slump (mm)
1	A0	0	90
2	A1	10	75
3	A2	20	60
4	A3	30	48
5	A4	40	40
6	A5	50	31

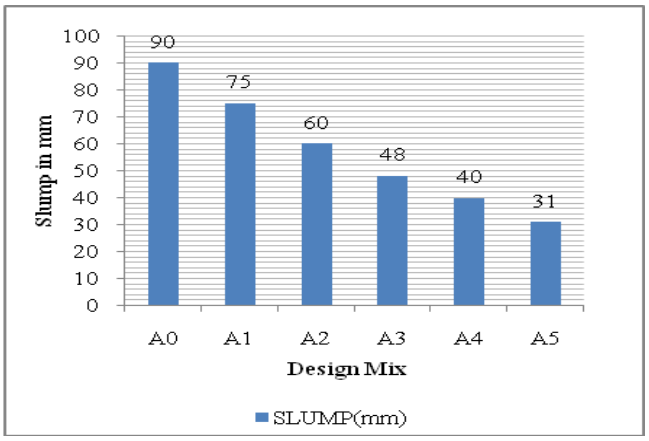

Fig. 1. Variation in slump for different design mix.

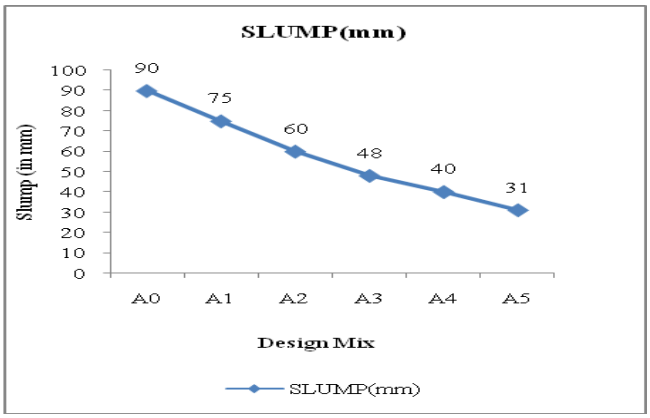

Fig. 2. Variation in slump for different design mix.

Fig. 3. Measurement of Slump

B. Compressive Strength

To obtain optimum compressive strength in concrete, a design mix proportion has been prepared. Compressive strength of different batch of concrete was tested for 7 days & 28 days,

through compressive testing machine. Each batch of mix had 3 sample used to obtain an average. From the table it is evident that, the compressive strength of concrete made using ceramic waste increased up to 40 percent replacement level and there after decreased. Increase in the compressive strength may be due to dense packing of voids by angular sized ceramic waste.

TABLE 3- Compressive Strength of specimens cured in tap water

S. No.	Specimen Designation	Replacement Level (%)	Compressive Strength (MPa)	
			7 Days	28 Days
1	A0	0	25.00	32.44
2	A1	10	25.66	37.40
3	A2	20	27.40	39.73
4	A3	30	28.60	39.13
5	A4	40	26.13	45.20
6	A5	50	25.26	31.00

Fig. 4. Compressive Strength Testing Machine

C. Durability

Durability of concrete made using ceramic waste (at optimum replacement level) was determine in tap water, 5%,10% chloride solution and this results were compared with the results of similar referral conventional concrete. The results of durability are shown in table 4 and table 5 and figure 6 and figure 7. It is evident that compressive strength of concrete decreased in chloride environment as compared to the specimens cured in tap water at 120 days. However compressive strength of specimen made using ceramic waste and cured in chloride environment was more than that of specimens of referral PPC cured in tap water.

TABLE 4-Conventional Concrete immersed in solutions

Days	Tap Water (MPa)	5% Chloride Solution (MPa)	10% Chloride Solution (MPa)
7	25.00	29.00	27.86
28	32.46	39.50	38.33
56	42.33	45.33	44.33
120	50.00	48.33	46.00

Fig. 5. Appearance of concrete cubes after withdrawal from 5%, 10% chloride solution and Tap water

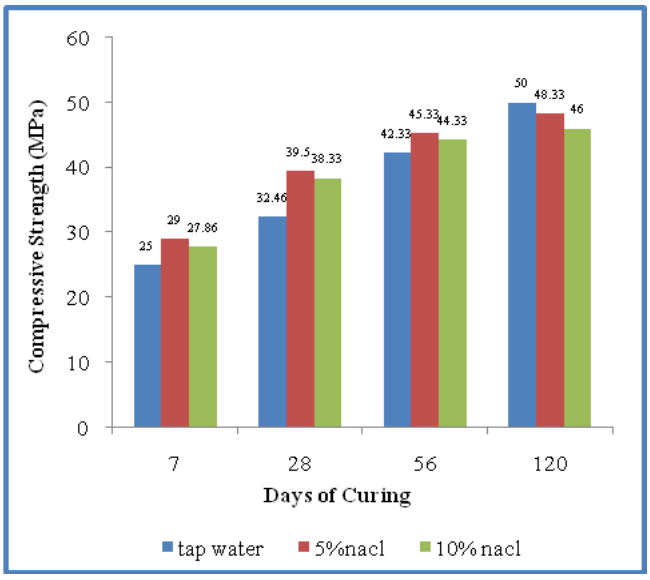

Fig. 6: Variation of Compressive strength of conventional concrete with age.

TABLE 5-Ceramic design mixes immersed in solution

Days	**Tap Water**	**5% Chloride Solution**	**10% Chloride Solution**

	(MPa)	(MPa)	(MPa)
7	**26.13**	**31.86**	**31.46**
28	**45.20**	**48.00**	**44.50**
56	**39.00**	**44.16**	**44.00**
120	**53.66**	**51.33**	**49.33**

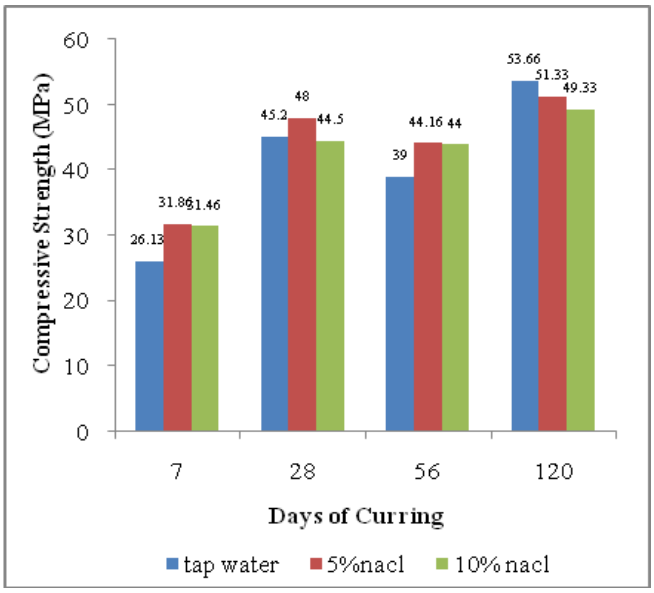

Fig. 7- Compressive strength of Ceramic mixed concrete

V. CONCLUSIONS

From the above study following conclusion may be drawn:

- While using ceramic tiles as partial replacement of fine aggregate, workability decreased with increase in replacement level.
- It is observed that, compressive strength of concrete made using ceramic waste increased with replacement level (up to 40%).
- Optimum replacement level of fine aggregate with ceramic waste is 40%.
- In chloride environment concrete with ceramic waste shows better performance than conventional concrete.
- Ceramic waste can effectively be used as alternative & supplementary materials in concrete.

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