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RESIDUAL STRENGTH OF CONCRETE WITH CERAMIC WASTE AS COARSE AGGREGATE SUBJECTED TO ELEVATED TEMPERATURES

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Abstract: **The sanitary ceramics industry inevitably generates wastes, irrespective of improvements introduced in manufacturing process. The present study investigated the reuse of these wasted as recycled coarse aggregate in partial substitution (15%, 20%, & 25%) of natural coarse aggregate in the manufacture of structural concrete. The results demonstrate that recycled, eco efficient concretes present slightly lower mechanical strength when compared to conventional concrete. Concrete is exposed to elevated temperatures when subjected to accidental fires in buildings or when is close to furnaces and reactors, as encountered in industrial applications. In this study the influence of high temperatures (4000C) on the strength of conventional concrete and that with partially replaced coarse aggregate is investigated. The results showed that concrete with ceramic waste as coarse aggregate showed less reduction in strength as compared to conventional concrete.**

Keywords: **Ceramic aggregate, Elevated temperature.**

I. INTRODUCTION

Concrete is very important construction material. The main composition of concrete is cement, coarse aggregate (blasted rubble), fine aggregate (sand) and water. Concrete is a side made material unlike other materials of construction and was such can vary to a very great extent in its quality, properties and performance owing to the use of natural materials except cement.

Ceramic products are produced from natural materials which contain a high controlled firing at temperatures between 12000C and 12900C, these minerals acquire the characteristic properties of ‘fired clay’. Moreover, these ceramic wastes are products which have high strength, wear resistance, long service life, chemical inertness and non-toxicity, resistance to heat and fire and electrical resistance.

The generation and management of wastes from different productive activities constitute a serious environmental issue in modern society. The ceramic industry inevitably generates a percentage of products deemed unsuitable for sale, regardless of any improvements made to the process. The two principle reasons for the rejection of these items are breakage and defective shape, defects which do not affect the intrinsic properties of the ceramic material or firing defects as a result of too much or too little heat, which in this case do affect the physio-chemical properties.

Although most concretes are subjected to a range of heat no more severe than that caused by the weather, there are important cases in which concrete is exposed to much higher temperatures. Examples include building fires and some industrial applications where concrete is close to furnaces and reactors. Such fires of elevated temperatures result in most cases in considerable damage to the structure. Therefore, engineers are often faced with the problem of how and to what extent the fire damaged concrete structure should be retrofitted. It is widely accepted that concrete residual strength can be used as a significant indication of the damage sustained during fires of high temperatures.

II. EXPERIMENTAL DETAILS

A. Raw Materials

- The waste from ceramic industry (crushed to 12.5mm size)
- OPC 43 Grade cement
- 20 mm aggregates
- M sand

B. Tests and Results

Mainly three properties of concrete were studied, compressive strength, splitting tensile strength and flexural strength.

For the analysis of compressive strength, cubes of M30 mix were casted with different percentages of ceramic aggregate such as 0%, 15%, 20% and 25%.

For the analysis of splitting tensile strength, cylinders of M30 mix were casted with different percentages of ceramic aggregate (0%, 15%, 20% and 25%).

Similarly for the analysis of flexural strength, beams of M30 mix were casted with different percentages of ceramic aggregate (0%, 15%, 20% and 25%).

Table I. MIX PROPORTION

Type of concrete	Sand (kg/m^3)	Coarse aggregate (kg/m^3)	Ceramic aggregate (kg/m^3)	Cement (kg/m^3)	Water (kg/m^3)
Conventional concrete	677.71	1134.94	0	425.73	191.58
Concrete containing 15% ceramic aggregate	677.71	964.665	170.235	425.73	191.58
Concrete containing 20% ceramic aggregate	677.71	907.95	226.98	425.73	191.58
Concrete containing 25% ceramic aggregate	677.71	851.2	283.73	425.73	191.58

Table II. ANALYSIS OF CERAMIC AGGREGATE

SL NO.	CHEMICAL CONSTITUENT	CERAMIC AGGREGATE	
		Internal Part	External Part
1	SiO_2	68.41	58.23
2	Al_2O_3	24.46	9.1
3	Fe_2O_3	0.94	0.91
4	CaO	0.63	11.8
5	MgO	0.19	0.67
6	Na_2O	1.65	2.38
7	K_2O	2.8	1.63
8	P_2O_5	0.17	0.1
9	TiO_2	0.55	0.1
10	ZrO_2	0.08	12.62
11	Others	0.12	2.46

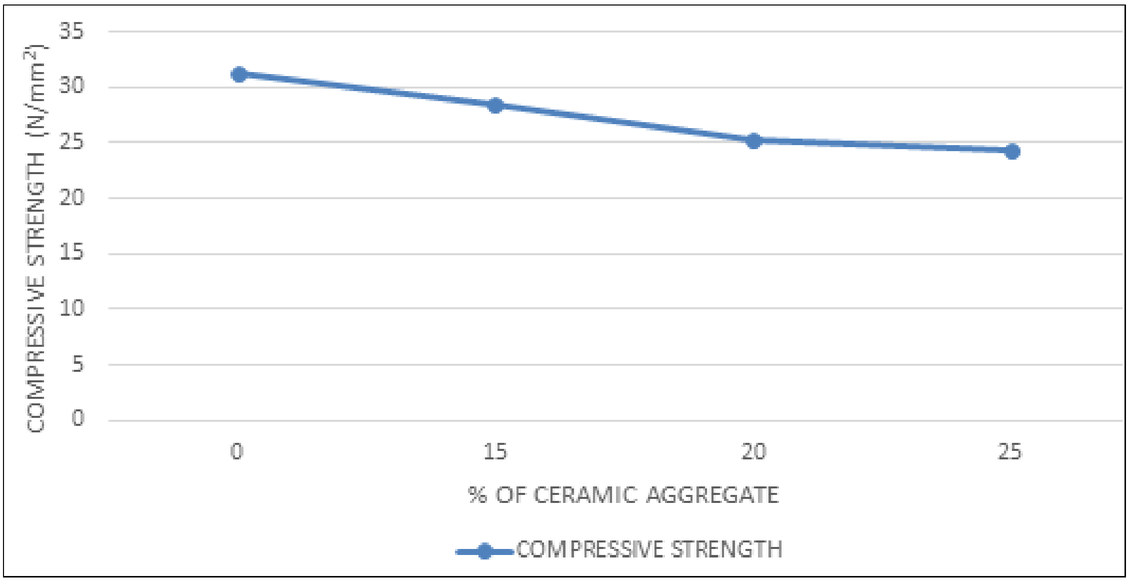
C. Compressive strength Analysis

To analyze the compressive strength, concrete cubes (15x15x15cm) were casted in M30 mix by replacing 15%, 20% and 25% of coarse aggregate by ceramic aggregate. Compressive strength was tested after 28 days.

Table III. 28 DAY COMPRESSIVE STRENGTH OF M30 CONCRETE

% of coarse aggregate replaced	Specimen no	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)	% decrease in strength
0	1	29.5	31.32	0
	2	30.8		
	3	31.8		
	4	31.5		
	5	33		
15	1	30.3	28.52	8.93
	2	29.5		
	3	27.3		
	4	28.6		
	5	26.9		
20	1	26.2	25.36	19.02
	2	27.1		
	3	25.8		
	4	24.2		
	5	23.5		
25	1	25.4	24.42	22.03
	2	26		
	3	23.7		
	4	24.3		
	5	22.7		

Graph I. COMPRESSIVE STRENGTH VS % OF CERAMIC AGGREGATE



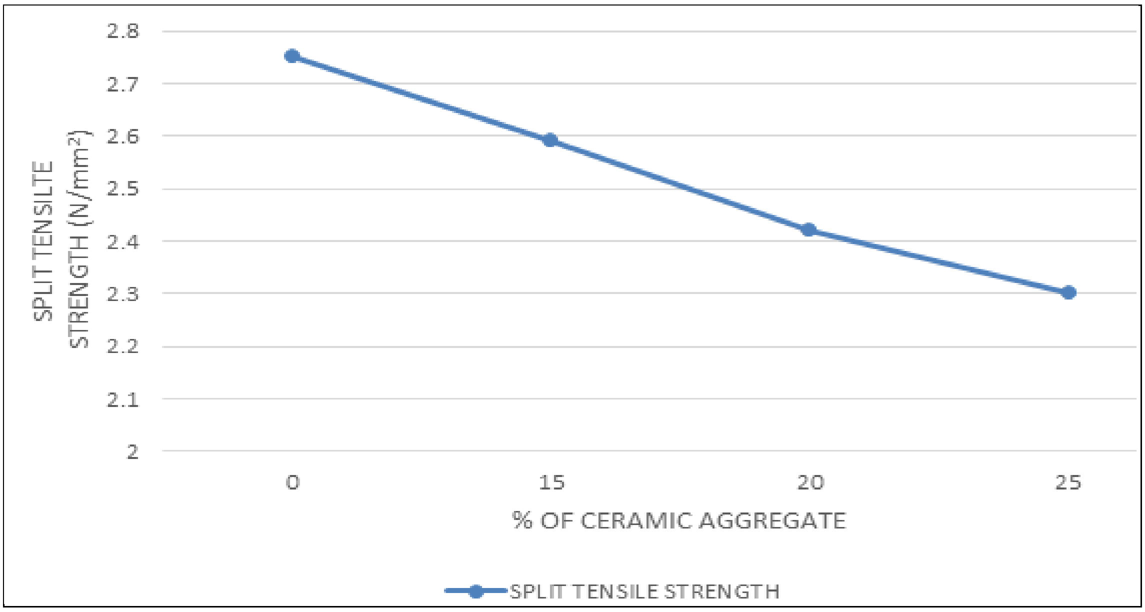
D. Splitting tensile strength analysis

In order to analyze the splitting tensile strength, concrete cylinders (15cm diameter 30cm height) were casted in M30 mix by replacing 15%, 20% and 25% of coarse aggregate by ceramic aggregate. Splitting tensile strength was tested after 28 days.

Table IV. 28 DAY SPLITTING TENSILE STRENGTH OF M30 CONCRETE

% of coarse aggregate replaced	Specimen no	Split tensile strength (N/mm^2)	Average Split tensile strength (N/mm^2)	% decrease in strength
0	1	2.71	2.75	0
	2	2.83		
	3	2.54		
	4	2.97		
	5	2.7		
15	1	2.72	2.59	5.8
	2	2.55		
	3	2.53		
	4	2.58		
	5	2.6		
20	1	2.53	2.42	12
	2	2.46		
	3	2.37		
	4	2.35		
	5	2.42		
25	1	2.34	2.3	16.36
	2	2.29		
	3	2.37		
	4	2.24		
	5	2.28		

Graph II. SPLITTING TENSILE STRENGTH VS % CERAMIC AGGREGATE



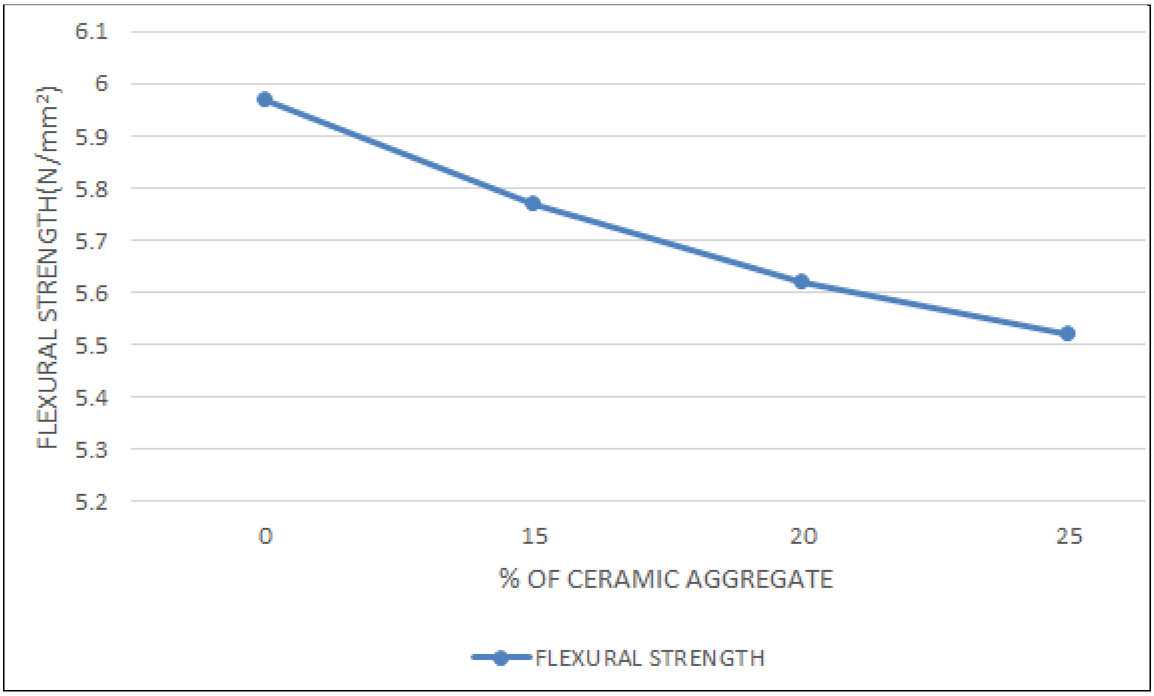
E. Flexural strength analysis

To analyse the flexural strength, concrete beams (50X10X10cm) were casted in M30 mix by replacing 15%, 20% and 25% of coarse aggregate by ceramic aggregate. Flexural strength was tested after 28 days.

Table V. 28 DAY FLEXURAL STRENGTH OF M30 CONCRETE

% of coarse aggregate replaced	Specimen no	Flexural strength (N/mm^2)	Average flexural strength (N/mm^2)	% decrease in strength
0	1	5.92	5.97	0
	2	6		
	3	6		
15	1	5.85	5.77	3.35
	2	5.76		
	3	5.7		
20	1	5.68	5.62	5.86
	2	5.6		
	3	5.6		
25	1	5.54	5.52	7.53
	2	5.58		
	3	5.45		

Graph III. FLEXURAL STRENGTH VS % CERAMIC AGGREGATE

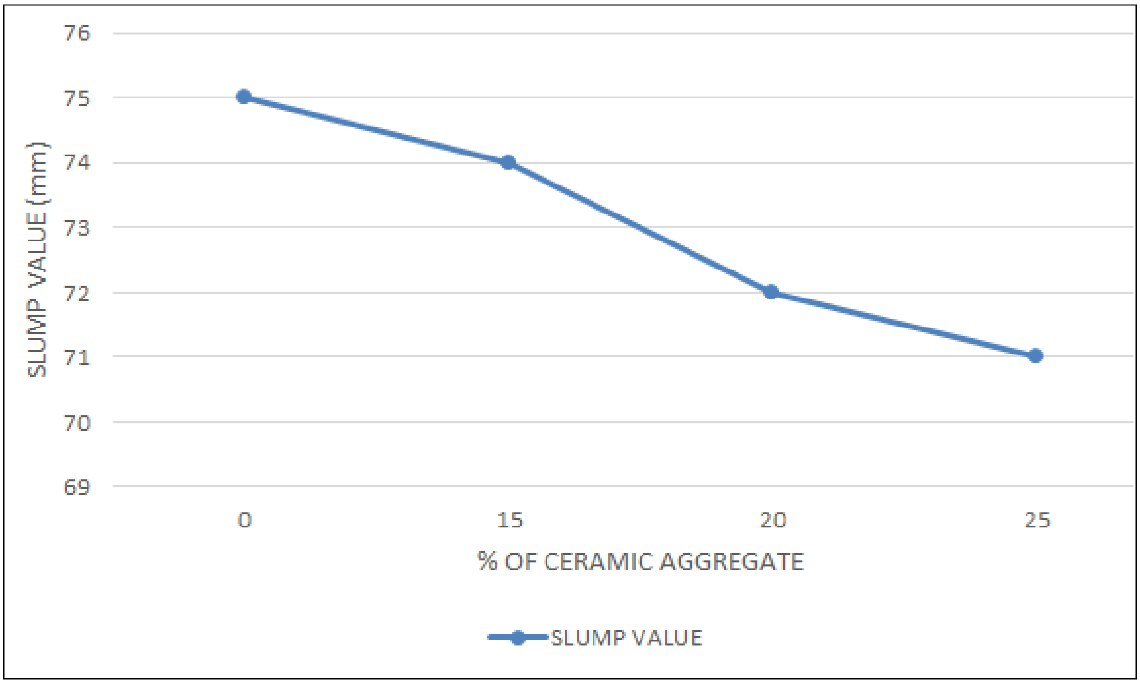


F. Workablity

Table VI. SLUMP TEST RESULTS

% of coarse aggregate replaced	Slump value (mm)
0	75
15	74
20	72
25	71

Graph IV. % OF CERAMIC AGGREGATE VS SLUMP VALUE



G. Residual strength analysis

G.1 ***Compressive strength***

In order to analyse the compressive strength, concrete cubes (15X15X15cm) were casted in M30 mix by replacing 25% of coarse aggregate by ceramic aggregate. The cubes were subjected to temperatures of 4000C.

Table VII. RESIDUAL COMPRESSIVE STRENGTH

% of coarse aggregate replaced	Specimen no	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)	% reduction in strength
0	1	25.2	23.7	21
	2	23.54		
	3	22.3		
	4	24.41		
	5	25.2		
25	1	21.8	22.22	9
	2	22.4		
	3	23.2		
	4	21		
	5	22.7		

G.2 ***Splitting tensile strength***

In order to analyse the compressive strength, concrete cylinders (15cm diameter and 30cm height) were casted in M30 mix by replacing 25% of coarse aggregate by ceramic aggregate. The cubes were subjected to temperatures of 4000C.

Table VIII. RESUDUAL SPLITTING TENSILE STRENGTH

% of coarse aggregate replaced	Specimen no	Split tensile strength (N/mm^2)	Average Split tensile strength (N/mm^2)	% reduction in strength
0	1	2.08	2.16	21.69
	2	2.22		
	3	2.27		
	4	2.16		
	5	2.08		
25	1	2.05	2.07	10
	2	2.14		
	3	2		
	4	1.97		
	5	2.18		

G3. *Flexural strength*

In order to analyse the flexural strength, concrete beams (15X15X10cm) were casted in M30 mix by replacing 25% of coarse aggregate by ceramic aggregate. The beams were subjected to temperatures of 4000C.

Table IX. RESIDUAL FLEXURAL STRENGTH

% of coarse aggregate replaced	Specimen no	Split tensile strength (N/mm^2)	Average Split tensile strength (N/mm^2)	% reduction in strength
0	1	4.86	4.75	20.43
	2	4.7		
	3	4.7		
25	1	4.54	4.43	19.74
	2	4.45		
	3	4.32		

H. Discussions

The compressive strength, splitting tensile strength, flexural strength and slump were plotted against % of ceramic aggregate.

As the ceramic aggregate concentration increased the compressive strength, split tensile strength and flexural strength was found to decrease. This is due to the flaky nature of the ceramic aggregate which reduces the bond between aggregate and concrete. Workability of the concrete was also found to decrease with increase in percentage of ceramic aggregate.

The strength of concrete was found to reduce noticeably when subjected to elevated temperatures but the concrete with ceramic aggregate was found to be more resistant to higher temperatures.

III. CONCLUSION

The ceramic concrete has lower mechanical behavior in terms of compressive, tensile and flexural strength than conventional concrete. The mechanical properties of recycled concrete were found to decrease with increase in percentage of ceramic aggregate. This is due to the flaky nature of the ceramic waste which reduces the bond between the aggregate and concrete. This can be reduced by recycling the ceramic waste and making its surface rough. Ceramic aggregate does not interfere with the chemical reactions which occur during cement hydration whilst the concrete is setting and hardening. Ceramic concrete can be used for structural purpose where the load is not too high and in mild environments. The potential substitution of natural coarse aggregate by ceramic aggregate coming from the sanitary industry offers several technical, economic and environmental advantages.

There was considerable reduction in strength of the conventional concrete when subjected to elevated temperatures but the concrete with ceramic aggregate is more resistant to higher temperatures. So it can be used in places where concrete is in constantly subjected to high temperatures like in furnaces and in reactors.

REFERENCES

[1] M S Shetty, Concrete Technology: Theory and Practice, 7th edition, S Chand & Company Pvt.Ltd,New Delhi,2013

[2] C. Medina, M.I Sanchez de Rojas, M. Frias (2012), Reuse of sanitary wastes as coarse aggregate in eco efficient concrete, Cement and Concrete Composites 34,pp 48-54

[3] A.E Ahmed, A.H Al-Shaikh and T.I Arafat (1992), Residual compressive and bond strengths of limestone aggregate concrete subjected to elevated temperatures.

[4] IS 456-2000,'*Plain and Reinforced Concrete-Code of practice',*(Fourth Edition),Bureau of Indian Standards,New Delhi.

[5] IS 383-1970,*'Specification for Coarse and Fine Aggregates from Natural Sources for Concrete'*,(Second Edition),Bureau of Indian Standards, New Delhi.

[6] IS 10262-1982,'*Recommended Guidelines for Concrete Mix Design',* Bureau of Indian Standards, New Delhi.