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Utilization Ceramic Waste Substituting Natural Coarse Aggregate in Concrete

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ABSTRACT

India is marked as a developing country; new developments can be seen widely in the field of constructions. With the increase in population, the developments have increased leading to more constructions for our own needs. Construction industry needs construction materials in a huge demand which includes cement, sand and aggregates. Also these materials are from non- renewable natural resources and expensive.

Use of natural resources emerges to the concern for protecting environment. And to preserve these resources like aggregates, alternative materials should be used which are rejected as waste. Construction Industry has its own merits and demerits, one among the most serious demerit is disposal of waste and a solution to this problem can be obtained by finding a way to reuse these wastes in the most effective manner keeping in mind to economize expenditure. Ceramic waste includes brick wall (debris), ceramic tiles and ceramic waste of utensils. Present practice of disposal of these ceramic wastes is only landfill. It is because of the lack of knowledge and experience, unavailability of measures and risk avoidance. It is predicted that 30% of the total ceramic material brought daily to the site changes to waste because of the improper handling of the materials and this turns to be a huge amount when calculated for a project.

These wastes cannot be recycled in any way and hence causes disposal problem and loss to the industry. This waste is hard, durable and resistant to all type of declining forces and these properties make them an alternative for the replacements which has to be done for the concrete production. Use of ceramic waste in concrete makes it economical and also solves the disposal issues. During study, casted concrete blocks with partial replacement of aggregates (coarse) with ceramic waste material and observed the mechanical and durability properties.

KEYWORDS

Natural aggregate, Ceramic Waste, Slump test, Compressive Strength

INTRODUCTION

Ceramic products are part of the essential construction materials used in most buildings. Some common manufactured ceramics include wall tiles, floor tiles, sanitary ware, household ceramics and technical ceramics. They are mostly produced using natural materials that contain high content of clay minerals. However, despite the ornamental benefits of ceramics, its wastes among others cause a lot of nuisance to the environment. As a general note, Omole and Isiorho reported the devastating influence of solid wastes in the Nigerian community. Ceramic wastes are separated into two categories in accordance with the source of raw materials.

One category is formed through generated fired ceramic wastes by structural ceramic factories that use only red pastes for product (brick, blocks and roof tiles) manufacture. The second encompasses fired ceramic wastes which are produced in stoneware ceramic (wall, floor tiles and sanitary ware). Meanwhile during ceramic production, studies have shown that about 30% of the material goes to wastes, and currently they are not beneficially utilized. This attests to the need for exploring innovative ways of re-using ceramic wastes.

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Aggregates constitute about 70% of total constituents in concrete production. The cost is increasing as a result of high demand from rural and urban communities. Numerous researchers have identified ceramics as having the potential to replace natural aggregates. Some investigations have suggested that ceramic wastes are good materials which could substitute conventional aggregates in concrete. The influence of ceramic tiles wastes on the structural properties of concrete made using laterite was recently investigated. It was reported that ceramic based laterized concrete performed considerably well when compared to the conventional concrete.

Overall, ceramic waste utilization can solve problems of aggregate shortages in various construction sites. Moreover it can reduce environmental problems related to aggregate mining and waste disposal. However, most of the previous investigations were carried out using sanitary ware and electrical insulator ceramics, with not much information as regards the use of ceramic floor and wall tiles. Thus, there is a need to explore the usability of ceramic floor and wall tiles, because these ceramic products are produced at different temperatures which invariably determines their microstructures. Consequently, the current study explores the mechanical characterization of concrete made using ceramic floor and wall tiles wastes from construction and demolition sites as partial replacement of natural aggregates.

Materials

Ceramic wastes, such as flowerpots, tiles, and brick ware were broken into small pieces of about 5 - 40 mm in size by a hammer. These small pieces were fed into vibrator and then sieved to obtain the required sizes of 14 - 20 mm. Fig. 1 shows the sample of ceramic waste coarse aggregate.

Fig 1: Ceramic Waste

Mix Design

Following Table 1 shows the design proportions of M25 grade of concrete for $1m^3$ concrete.

Table 1. Design praportions

Water	Cement	Coarse aggregate	Fine aggregate
197.16	492.9	1082.013017	663.1692686
Ratio			
0.4	1	2.195197844	1.34544384

Seven series of mixes in our study were considered. The first series was a control mix containing 100% NA, then after continuous 5%, 10%, 15%, 20%, 25% and 30% NA was replaced by Ceramic Waste.

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RESULTS AND DISCUSSION

(A) Slump test

- To measure the consistency of concrete by using slump cone.
- It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows.
- Slump cone size 200mm bottom diameter, 100 top diameter and 300 mm height

Fig 2: Slump test

Table 2. Results of slump test

Sr No.	Description	Average Slump Value
1	Slump value	83 mm
2	Slump value for ceramic waste	76 mm

(B) Compressive strength test

- To determining the compressive strength of concrete cubes.
- Compression test is the most common test conducted on the hardened concrete, partly because it is very easy and simple to perform.
- Cubes size of 150mm X 150mm X 150mm.

Table 3. Compressive Strength of concrete

Sr. No.	Replacement of Natural aggregate by CW	Compressive Strength (N/mm2)							
		7 Days				28 Days			
		Spe. 1	Spe. 2	Spe. 3	Average	Spe. 1	Spe. 2	Spe. 3	Average
1	0%	22.65	21.98	22.34	22.32	36.52	34.21	35.02	35.25
2	5%	21.86	25.85	26.32	24.68	35.78	36.02	36.76	36.19
3	10%	26.31	24.25	25.63	25.40	36.69	34.47	39.81	36.99
4	15%	26.02	27	26.69	26.57	40.28	36.08	38.76	38.37
5	20%	29.16	27.16	26.6	27.64	40.1	39.2	36.66	38.65
6	25%	28.8	28.07	27.07	27.98	37.9	41.05	38.12	39.02
7	30%	20.92	25.36	23.86	23.38	35.05	31.54	32.09	32.89

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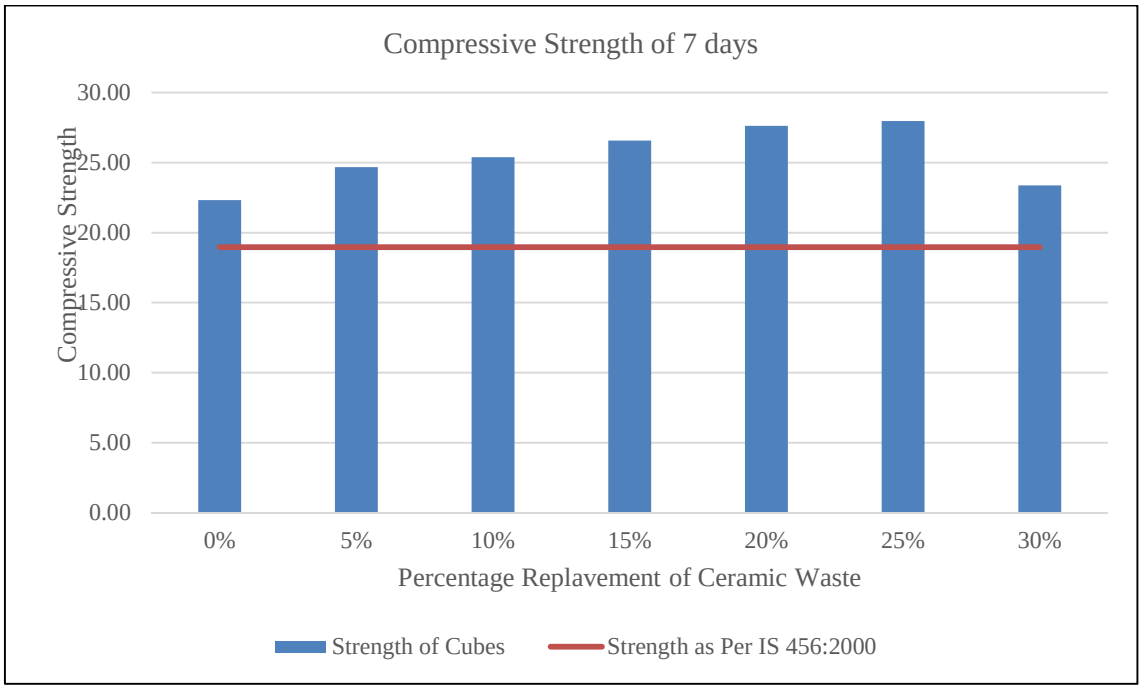

Fig 3: Compressive strength after 7 days

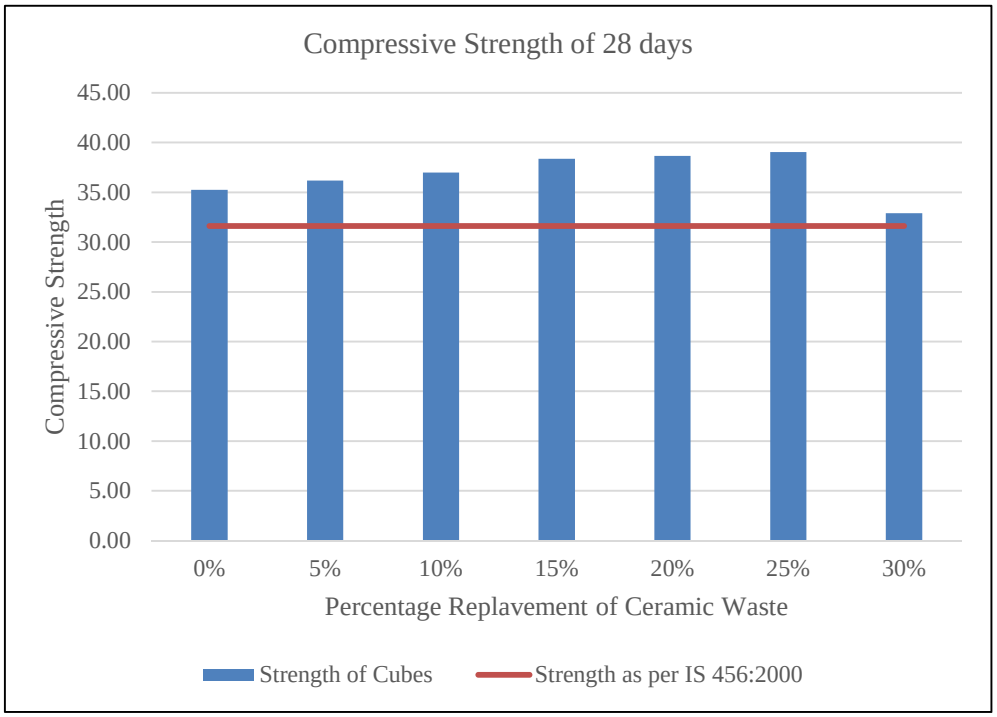

Fig 4: Compressive strength after 28 days

(C) Split tensile Strength Test

- To determining the split tensile strength of cylindrical concrete test specimens.
- The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension.
- For this cylinders are casted of size 150mm diameter 300mm height.

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Table 4. Split tensile Strength of concrete

Sr. No.	Replacement of Natural aggregate by CW	Split tensile Strength (N/mm2)							
		7 Days				28 Days			
		Spe. 1	Spe. 2	Spe. 3	Average	Spe. 1	Spe. 2	Spe. 3	Average
1	0%	4.32	4.35	4.74	4.47	7.46	7.24	7.02	7.24
2	5%	6.42	5.6	6.38	6.13	7.42	7.67	7.56	7.55
3	10%	6.08	6.36	6.58	6.34	7.86	7.74	7.61	7.74
4	15%	7.03	6.92	6.86	6.94	7.72	7.96	7.91	7.86
5	20%	7.04	6.98	7.36	7.13	7.98	8.12	8.02	8.04
6	25%	7.25	7.36	7.28	7.30	8.06	8.25	8.14	8.15
7	30%	6.46	7.22	6.58	6.75	7.89	7.94	8.01	7.95

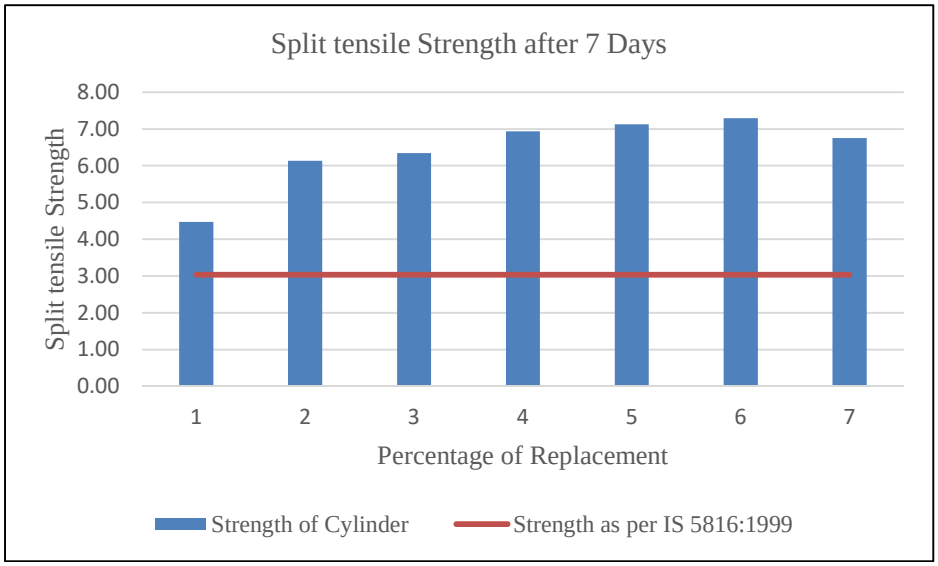

Fig 5: Split tensile strength after 7 days

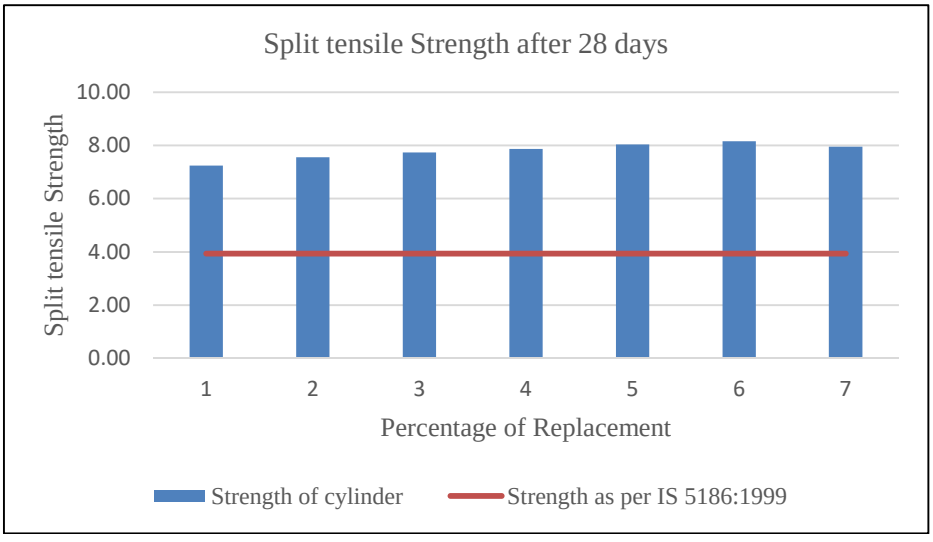

Fig 6: Split tensile strength after 28 days

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(D) Flexural Strength Test

- To determining the flexural strength of a test specimen of hardened concrete.
- Flexural strength is the one of the measure of the tensile strength.
- It is measured of the unreinforced concrete slab or beam to resist the failure in the bending.
- For this beams are casted of size 150mm X 150mm X 700mm

Table 5. Flexural Strength Concrete

Sr. No.	Replacement of Natural aggregate by CW	Flexural Strength (N/mm2)							
		7 Days				28 Days			
		Spe. 1	Spe. 2	Spe. 3	Average	Spe. 1	Spe. 2	Spe. 3	Average
1	0%	3.8	4.42	3.74	3.99	5.24	4.46	5.86	5.19
2	5%	4.6	4.17	4.32	4.36	6.27	6.04	5.97	6.09
3	10%	4.48	4.17	4.5	4.38	6.21	6.45	6.24	6.30
4	15%	4.79	4.2	4.36	4.45	6.56	6.41	6.32	6.43
5	20%	4.2	4.7	4.51	4.47	6.45	6.58	6.39	6.47
6	25%	4.5	4.37	4.61	4.49	6.57	6.69	6.32	6.53
7	30%	4.21	4.32	4.38	4.30	6.24	6.28	6.16	6.23

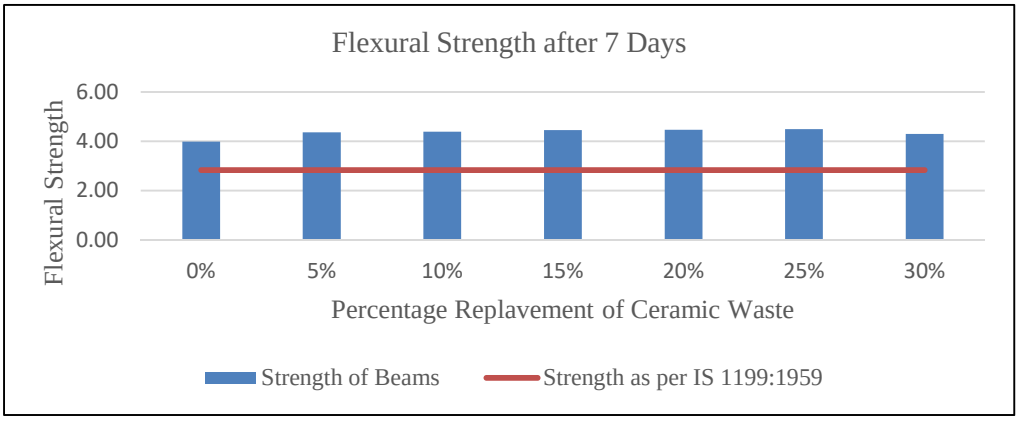

Fig 7: Flexural strength after 7 days

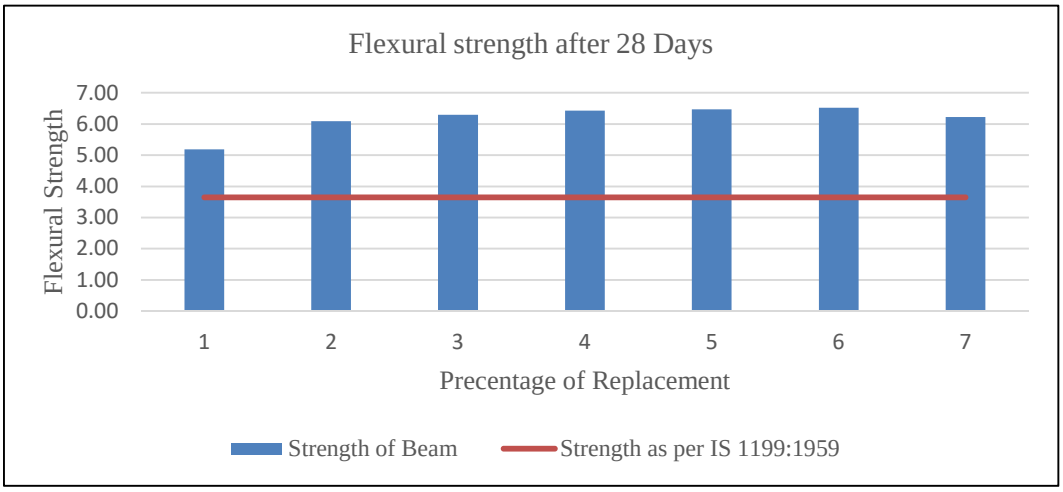

Fig 8: Flexural strength after 28 days

Conclusion

Day by day the demand of natural aggregates increased in to the market. Because of that the mining of hills also increased and that is directly affect to the environment. As per current research the constructions of new buildings is increased. So, the production of ceramic waste is also increased. The main aim of our work is to use ceramic waste in to the concrete in place of natural aggregate to save environment.

Slump test is one of the widly used test for measuring workability of fresh concrete. As per results the water absorption of ceramic waste is higher than natural aggregate. Which directly affect to the slump value. The slump value of concrete containing ceramic waste is quit lesser than the concrete with natural aggregate.

Compressive strength was gradually increased up to replacement of 25% than after, it was decreased. It shows the same scenario at 7 and 28 days.

Split tensile strength and flexural strength of concrete containing ceramic waste also shows same scenario as compressive strength. Split tensile strength and flexural strength was under allowable limit as per IS.

As per above results optimum percentage of replacement is 25%.

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