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Experimental Study on Properties of Concrete by Partial Replacement of Ceramic Waste as Coarse Aggregate and Egg Shell as Fine Aggregate

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***Abstract*— Concrete is today the largest consumable material in the world that utilizes the natural resources such as sand, crushed stone and water. Due to the depletion of these natural resources for concreting, research is being carried out nowadays to reduce the consumption of these resources. In our project, we tend to utilize egg shell and ceramic waste by partially replacing it in concrete. The egg shell and ceramic waste is equally replaced for fine aggregate and coarse aggregate respectively in percentages of 5%, 7.5%, 10%, 12.5% and 15% during the manufacture of concrete. The concrete is cast in cubes and cylinders and it is tested for compressive strength and tensile strength to find the optimum percentage of their replacement.**

Keywords*— Egg shell, Ceramic waste

I. INTRODUCTION

Throughout the world, concrete is being widely used for the construction of most of the structures. Hence, it has been properly labeled as the backbone to the infrastructure development of a country. A huge quantity of concrete is required for it that consumes most of natural resources. Unfortunately, India is not self-sufficient in the production of cement. Fine and coarse aggregate though available, it is available in minimum amount. Also depletion of natural resources for aggregate causes more impact to the environment. This makes the construction activities very costlier. Currently the entire construction industry is in search of suitable and effective the waste product that would considerably minimize the use of ingredients of conventional concrete and thereby reducing the construction cost. Few of such products have already been identified such as rice husk, fly ash, silica fumes, egg shell, ceramic waste etc… Among these egg shells is found to have good prospects in minimizing the usage of sand as it is rich in calcium. Also ceramic waste can be replaced for coarse aggregate. So, the concept of our project is partially replacing the fine aggregate by egg shell and coarse aggregate by ceramic waste.

II. OBJECTIVE OF THE PROJECT

- To utilize egg shell and ceramic waste in the manufacturing of concrete.
- To determine the optimum percentage of replacement of egg shell and ceramic waste as fine aggregate and coarse aggregate respectively in concrete.
- To study the compression strength and split tensile strength of the concrete by partially replacing the aggregates.

III. GENERAL

Eggshell consists of several mutually growing layers of $CaCO_3$. In the innermost layer of 3 layers, that grows on the outermost egg membrane creates the base on which palisade layer constitutes the thickest part of the eggshell. The top layer is a vertical layer covered by the organic cuticle. The egg shell primarily contains calcium, magnesium carbonate (lime) and protein. In many other countries, it is the accepted practice for eggshell to be dried and can be used as a source of calcium in animal feeds. The quality of lime in eggshell waste is influenced greatly by the extent of exposure to sunlight, raw water and harsh weather conditions. It is the fine grained powder with suitable proportion which is sieved to the required size before use with concrete/mortar.

Ceramic waste aggregate contains 100% residual product that can be used as aggregate in Green concrete. Utilization of ceramic waste in concrete production will preserve the clean environment and reduces the usage of natural resources. Use of industrial waste as aggregate in concrete is the only real potential for utilization of bulk quantities of waste and also prevention of depletion of natural resources.

IV. MATERIAL PROPERTIES

- Cement: 53 Grade ordinary Portland cement is used in the present investigation. The properties of cement are determined as per the IS 4031: 1968
- Fine aggregate: Locally available river sand conforming to Grading zone 2 of IS: 383-1970.
- Egg shell replacing fine aggregate in proportions.

TABLE 1 PROPERTIES OF EGG SHELL

S.No	Test particulars	Value obtained
1	Specific gravity	0.85
2	Moisture content	1.18
3	Bulk density	0.8 (g/m^3)
4	Particle Density	1.012 (g/m^3)
5	Porosity (%)	22.4 %
6	Surface area	21.2 m^2/g

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- Coarse aggregate: Locally available crushed blue granite stones conforming to graded aggregate of nominal size 20 mm as per IS: 383-1970.
- Ceramic tile waste replacing coarse aggregate in proportions.

TABLE 2 PROPERTIES OF CERAMIC WASTE

S.No	Test Particulars	Value obtained
1.	Specific gravity	2.5
2.	Fineness modulus	1.28
3.	Water absorption	0.8%

V. ADVANTAGES OF EGG SHELL

- Considerable reduction in alkali-silica and sulphate expansions.
- Meets the most stringent environmental regulations nationwide.
- Ideal for painting in occupied spaces.
- Excellent durability and washable finish.
- Resist mold and mildew on the paint film.
- Saves money, less material required.
- Meets strict performance and aesthetic requirements

VI. ADVANTAGES OF CERAMIC WASTE

- Ceramics usually have combination of stronger bonds called ionic and covalent bonds.
- This type of bond result in high elastic modulus and hardness, high melting points, low thermal expansion and good chemical resistance.
- Ceramic waste aggregate contains 100% residual product as aggregate.
- Ceramic waste material is hard and rigid.

VII. EXPERIMENTAL METHODOLOGY

Initially the materials used in concrete are tested for its basic properties. Then the mix design is carried out according to the codal provisions. In the obtained mix proportions egg shell and ceramic waste is partially replaced for fine aggregate and coarse aggregate respectively in percentages of 5, 7.5, 10, 12.5 and 15. The concrete specimens are casted for the above mix proportions and cured in potable water till the date of testing. Then the specimens are tested for cube compressive test and cylinder is tested for split tensile test

Fig. I Egg Shell In Concrete

TABLE 3 MIX PROPORTIONS OF INGREDIENTS FOR 9 CUBES

% of replacement	Cement (kg)	Fine aggregate (kg)	Egg shell (kg)	Ceramic waste (kg)	Coarse aggregate (kg)	Water (l)
NC 0%	13.5	24.04	-	-	30.24	6.075
5%	13.5	22.59	1.17	1.53	29.07	6.075
7.5	13.5	21.96	1.8	2.25	28.35	6.075
10%	13.5	21.46	2.34	3.06	27.54	6.075
12.5%	13.5	20.79	2.97	3.78	26.82	6.075
15%	13.5	20.16	3.6	4.59	26.01	6.075

A) COMPRESSIVE STRENGTH

The compressive test is carried out on concrete cubical in shape. The cube specimen is of the size of 15cmX15cmX15cm.The test was carried out in the compression testing machine. Concrete cubes with Egg shell and ceramic waste with plain cement concrete were tested at 7 days , 14 days and 28 days. The grade of concrete mix is M20 and percentage of admixtures is 5% 7.5% 10% 12.5% 15% with respect to aggregates in concrete.

Compressive strength = $\frac{\text{load}}{\text{c/s area of cube}}$ (N/mm^2)

Fig Ii Compressive Strength Of Concrete

A) Split Tensile Strength

There are two methods are used to determine the tensile strength of cylinder. That has direct method and indirect method.Here the splitting tensile strength was done. The test consists of applying compressive line loads along the opposite generators of a cylinder placed with its axis. Due to this load tension will be occurs in the perpendicular direction of compressive line load, hence the cylinder may be fail by tension along the load direction .Concrete cylinder with egg shell and ceramic waste content and weretested at 7 days 28 day. The grade of concrete mix is M20 and percentage of egg shell and ceramic waste is 5%, 7.5%, 10% 12.5% 15%with respect to aggregate in concrete.

Split tensile strength = $\frac{2P}{\pi LD}$

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VIII. TEST RESULTS

TABLE 4 COMPARISON OF COMPRESSIVE STRENGTH OF CONCRETE

Mix	Percentage of replacement	Compressive strength		
		7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
CC	0%	15.92	18.45	25.18
M1	5%	15.23	17.70	20.36
M2	7.5%	15.74	20.11	23.34
M3	10%	16.57	19.74	19.71
M4	12.5%	18.85	21.30	26.13
M5	15%	13.67	10.92	15.00

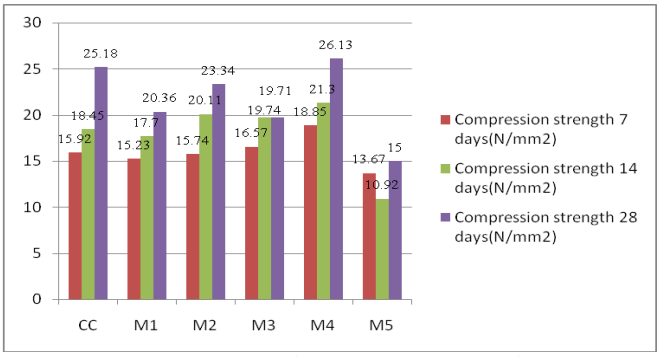

Fig Iii Comparison Of Compressive Strength Of Concrete

TABLE 5 COMPARISON OF SPLIT TENSILE STRENGTH OF CONCRETE

Mix	Percentage of replacement	Tensile strength	
		7 days (N/mm^2)	28 days (N/mm^2)
CC	0%	1.48	2.91
M1	5%	1.79	2.80
M2	7.5%	1.85	2.90
M3	10%	1.97	2.91
M4	12.5%	2.08	3.6
M5	15%	1.69	2.02

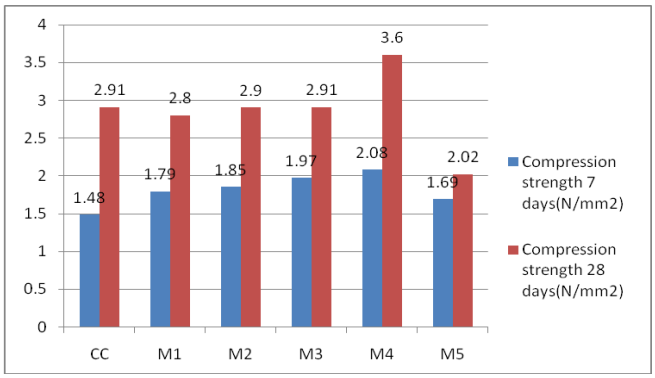

Fig Iv Comparison Of Split Tensile Strength of Concrete

IX. CONCLUSION

- The concrete is cast by partially replacing fine aggregate and coarse aggregate with egg shell and ceramic waste in various proportions such as 5%,7.5%,10%,12.5% and 15%.
- The compressive strength and split tensile strength reveals high strength of 12.5% replacement of egg shell and ceramic waste.
- At a age of 28 days curing, the compressive strength of 12.5% replacement is 3.8% higher than the conventional concrete.
- At a age of 28 days curing, the split tensile strength of 12.5% replacement is 23.7% higher than the conventional concrete.
- Thus egg shell and ceramic waste can be utilized in the manufacture of concrete at replacement rate of 12.5%.

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