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EXPERIMENTAL INVESTIGATION ON WASTE PORCELAIN AS A PARTIAL REPLACEMENT OF BOTH FINE AND COARSE AGGREGATES IN CONCRETE

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Abstract
The aim of this project is to replace the aggregates in concrete including both fine and coarse partially with the porcelain material. Porcelain is a ceramic material made by heating materials like kaolin, in a kiln to temperatures between 1,200 and 1,400 °C. These materials are resistant to acids and chemicals as glass, but with greater strength. While transporting the porcelain from industry to market many porcelain utensils and cutleries breaks. These damaged porcelain materials end up in landfills since recycling those damaged materials is not widely or effectively used. Moreover, it is negligible in terms of ecological balance. Thus, these porcelains are pushed to end up as a land waste. This project aim is to replace both the fine and coarse aggregates with the porcelain aggregates and then to study its properties and capability under the normal condition. The porcelain taken for this project is completely from the wastes and damaged pieces. Then it is cleaned with the sanitary liquid for the prevention of contamination and then crushed with the hammer and separated into coarse and fine particles using the sieve and then used for the partial replacement for aggregates in the concrete. The concrete prepared for the first phase includes the replacement of fine and coarse aggregate separately in different mixes of different proportions. Then in phase two both the coarse and fine aggregate will be simultaneously replaced by the porcelain, based on the best comparative result from the mixes of the phase one. 25% of fine aggregate and 35% of coarse aggregate is replaced simultaneously in concrete grade of M25, the test results shows that it gives an improved performance than a conventional concrete, improves its overall compressive and tensile strength.

***Keywords* – porcelain waste, recycling, compressive strength, split tensile strength**

1. INTRODUCTION

Concrete has become a basic need for every structure nowadays. The increasing population of the world puts a lot of pressure on the civil engineer to develop a cost effective as well as an eco-friendly structure according to the need of human beings. Fine and coarse aggregates are obtained from quarrying of large rocks which leads to a great destruction to the environment and further the disposal of the huge amount of demolition waste was another problem[1,6].

The objective of this research is to study the utilization of ceramic waste as a partial replacement of fine and coarse aggregate in concrete.

The properties such as flexural strength and compressive strength of concrete incorporating porcelain waste in partial replacement of sand and coarse aggregate were examined and compared. With the ever increase in the demand of river sand and decrease in its availability, there is an

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immediate need for finding suitable alternatives which can replace m-sand partially or at a high proportion. Quarrying has created a very difficult situation, also there is great fear from environmentalist and ecologist that in the future there may be scarcity of river sand and the environment and the ecology will be distorted.

2.REVIEW OF LITERATURES

2.1 Dong Seok Seoa, Hyun Geun Hana, Kyu Hong Hwang and Jong Kook Leea. Recycling of waste porcelain body is important and useful from an environmental and economic point of views. In this study, recycled ceramic raw material was obtained by crushing and milling from waste porcelain bodies. Using the recycled powder with a particle size of 0.5[2]-2.0 μm, a porcelain ceramic batch composition was prepared by mixing 100-50 wt% of normal ceramic raw materials and 0-50 wt% of the recycled powder. Sintering properties of the porcelain ceramics at sintering temperatures of 1150-1350^{o}C were investigated. The porcelain body with 10 wt% of the recycled powder sintered at 1200^{o}C showed the highest sintered density of 2.5g/cm^3. When sintered above 1300^{o}C, many cracks and pores were observed in the porcelain body due to over sintering and preferential shrinkage of the glassy phase during cooling.

2.2 Sadic Azeez, Remya Raju, Dr. P.R Sreemahadevan Pillai The use of waste products in concrete not only makes it economical, but also helps in reducing waste disposal problems. In this paper it is planning to replace both fine aggregate and cementitious material with the rejects from ceramic industries. After the physical and chemical analysis of quartz powder and grog, it will be able to identify its chemical and mineralogical composition. During the physical analysis like grain size analysis, it is able to determine the utility size i.e. whether it can be replaced for sand or cement. In this paper both fine aggregate and cement is replaced with quartz and grog simultaneously and also fine aggregate alone is replaced with different proportions of quartz and grog. After the experimental analysis and testing an optimum replacement of 5% fine aggregate and 5% cement is possible. It is also found that compressive strength and splitting tensile strength of replaced specimens increases up to 25% replacement of fine aggregate without replacing cement.

2.3 Jian-Tong Ding and Zongjin Li, The effects of metakaolin and silica fume on various properties of concrete were investigated and compared in this study. Seven concretes were cast at a water/binder ratio of 0.35 with 0, 5, 10, and 15% cement replaced by either metakaolin or silica fume. The concretes were tested for slump, compressive strength, free shrinkage, restrained shrinkage cracking, and chloride diffusivity by ponding. Metakaolin-modified concrete showed a better workability than silica fume-modified concrete. As the replacement level was increased, the strength of the metakaolin-modified concrete increased at all ages similarly to that of the silica fume-modified concrete. Both mineral admixtures reduced free drying shrinkage and restrained the shrinkage cracking width. However, the cracking time was earlier for these two concretes[3-5]. The two admixtures also greatly reduced the chloride diffusivity of the concrete.

3. RAW MATERIALS AND ITS TESTS

3.1 Cement

The most common cement used is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 grades conforming to IS: 8112-1989 is used. Specific gravity, consistency tests, setting time test and fineness modulus are the testes conducted to check the properties of cement.

3.2 Fine Aggregate

In general, natural river sand is used as a fine aggregate. Nowadays river sand is scarce and it is not available easily in the market thus m-sand is used in this project. M-sand having 4.75 mm maximum size particles was used. It was tested as per Indian Standard IS: 383-1970.

3.2.1 Specific gravity test

The aim is to determine the specific gravity of fine aggregate. The apparatus used are Pycnometer, 10 mm sieve, measuring jar, weighing balance.

3.2.2 Sieve analysis

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves.

Table 1 Physical properties of M-Sand

Material	M-Sand	Fine Porcelain
Specific gravity	2.71	2.52
Water absorption	1.21%	1.83%
Bulk Density	1661 kg/m^3	1555 kg/m^3

3.3 Coarse Aggregate

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383-1970 are used.

Water absorption test

This test helps to determine the water absorption of coarse aggregates as per IS: 2386 (Part III) – 1963. For this test a sample not less than 2000 g should be used.

3.3.1Specific gravity test

The aim is to determine the specific gravity of coarse aggregate. The apparatus used are Pycnometer, 10 mm sieve, measuring jar, weighing balance. Thus by doing so the specific gravity can be found. The specifc gravity aims to find the performance and its workability in certain condition.

3.3.2Aggregate impact value test

This test is done to determine the aggregate impact value of coarse aggregates as per IS: 2386 (Part IV) – 1963. The apparatus used for determining aggregate impact value of coarse aggregates is Impact testing machine conforming to IS: 2386 (Part IV)- 1963,IS Sieves of sizes – 12.5mm, 10mm and 2.36mm, A cylindrical metal measure of 75mm dia. and 50mm depth, A tamping rod of 10mm circular cross section and 230mm length, rounded at one end and Oven.

3.3.3 Gradation of coarse aggregate

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per is: 2386 (part 1) – 1963. In this we use different sieves as standardized by the code and then pass aggregates through them and thus collect different sized particles left over different sieves.

then pass aggregates through them and thus collect different sized particles left over different sieves.

Table 2 Physical properties of Coarse Aggregate

Material	Coarse Aggregate	Coarse Porcelain
Specific gravity	2.54	2.57
Water absorption	0.54%	1.65%
Bulk Density	1425 kg/m^3	1387 kg/m^3

3.4 Porcelain waste

The porcelain wastes are collected from the dumping yards and on the garbage bins. Most of the collected porcelain were damaged or broken. Then it is washed with the sanitary liquids to prevent the contamination. Then with the help of the hammer it is broken into smaller pieces. While breaking the porcelain utensils and cutleries into smaller pieces care is to be taken that it does not cause any damage to the person who breaks it. Then it is divided into the fine and coarse porcelain aggregate using the sieves of suitable sizes. Then the porcelain is done for the physical property testing.

Table 3 Physical properties of porcelain

Material	Fine Porcelain	Coarse Porcelain
Specific gravity	2.52	2.57
Water absorption	1.83%	1.65%
Bulk Density	1555 kg/m^3	1387 kg/m^3

3.5 Water

Water fit for drinking is generally fit for making concrete. Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully

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4.Concrete Mix Design

4.1 Stipulations for proportioning

Table 4 Proportions

Grade designation	M_{25}
Maximum nominal size of	20mm
Workability	75mm - 90 mm
Types of aggregate	crushed angular
Exposure condition	Mild
Minimum cement content	300 kg/m^3
Maximum cement content	450 kg/m^3
Maximum water cement ratio	0.55

Test data for materials

Cement = OPC 53 grade conformed to IS 12269

Specific gravity:

Cement = 3.15
Fine aggregate = 2.71
Coarse aggregate = 2.54

Water absorption:

Fine aggregate = 1.21%
Coarse aggregate = 0.54%

Sieve analysis

Coarse aggregate = Conforming graded as per IS 383:1970 requirement 20mm down sizes
Fine aggregate = Zone – II

Table 5 The conventional mix proportion

Cement	Fine aggregate (M-Sand)	Coarse aggregate	Water
345 kg/m3	764 kg/m^3	1158 kg/m^3	186 kg/m^3
1	1.1	2.05	0.54

5.Preparation of Specimens

5.1 Mixing of concrete

Mixing is done by hand. The performance of the concrete is influenced by the mixing. The quality of concrete is influenced by the homogeneity of the mix material used while mixing and placing of fresh concrete. A proper mix of concrete will achieve good strength of concrete and better bonding of cement with the aggregates.

5.2 Casting of mould

The mould is prepared simultaneously while the concrete is mixed. The inner side of the mould is applied with the oil for the lubricative purpose. Then using the trowel, the concrete is placed into layer by layer in the mould. After the completion of the concrete on the mould, the top edge of the concrete is tapped with the trowel for the uniform distribution of the concrete on the mould.

5.3Curing

After the casting is done the sample has to be kept in the moist and humid place free from vibration and in the stable grounds.

If the setting of the concrete is completed, the mould is dismantled and the hardened concrete samples are kept under the water until the testing of it has to be done. Before the testing is to be done the samples are taken out and it is air dried for 5 hours.

6.RESULTS AND DISCUSSIONS

6.1Compressive strength test -Phase 1

A grade of the concrete should be recognized based on the compressive strength of the concrete. The test is carried out as per IS: 516-1959. The test specimens are marked and removed from the moulds and unless required for test within 24 hours. The specimen is placed between the steel plates of CTM and load is applied at the rate of 140 kg/cm^2/min. And the failure load is observed from the load indicator of CTM.

Table 6 Compressive strength of cube 7th day Fine aggregate replacement.

% Of Replacement	Load(kN)	Average Load (kN)	Average compressive Strength
0%	418.9 424.7	421.875	18.75
10%	488.7 492.3	491	21.8
25%	531.6 538.4	535	23.78
35%	505.4 510.6	508	22.57

Table 7 Compressive strength of cube 7th day Coarse aggregate replacement.

% Of Replacement	Load(kN)	Average Load (kN)	Average compressive Strength, (N/mm^2)

0%	418.9 424.7	422	18.75
15%	475.4 480.6	478	21.244
25%	492.1 497.9	495	22.08
35%	504.8 511.2	508	22.578

Based on the test results observed in first phase at 25% of fine aggregate replacement the compressive strength gives better result and 35% replacement of coarse aggregate gives a satisfactory result, so the combination of these replacement is tested simultaneously and results are observed

6.2 Compressive strength test -Phase 2

Table 8 Comparison of Compressive strength of cube at 7,14 and 28days

% Of replacement	Average Compressive Strength (N/mm^2) 7 days	Average Compressive Strength (N/mm^2) 14 days	Average Compressive Strength (N/mm^2) 28 days
0%	18.75	20.90	24.76
Fine-25% Coarse-35%	24.28	25.31	27.95

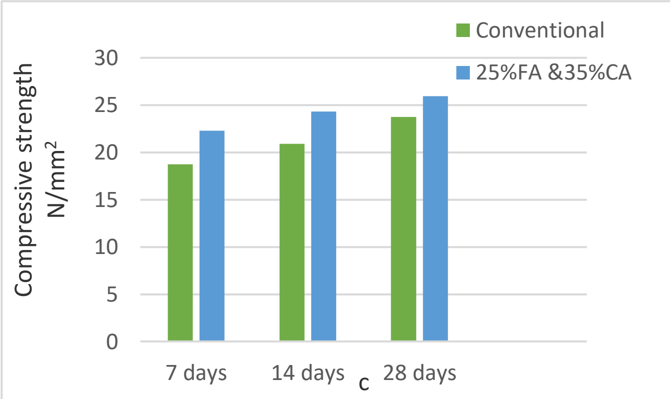

Chart 1 Compressive strength for FA&CA replacement in concrete

7 Flexural Strength

Table 9 Flexural strength of cylinder on 7th day for FA& CA replacement

% of Replacement	7th day for Fine replacement Average Flexural Strength (N / mm^2) 7 days	7th day for coarse replacement Average Flexural Strength (N / mm^2) 7 days
0%	3.065	3.065
15%	2.968	2.902
25%	3.044	2.956
35%	3..120	3.032

Table 10 Flexural strength of cylinder for simultaneous replacement of Fine and Coarse aggregate

% Of replacement	Average Flexural Strength (N / mm^2) 7 days	Average Flexural Strength (N / mm^2) 14 days	Average Flexural Strength (N / mm^2) 28 days
0%	3.065	3.419	3.627
FA-25%	3.664	3.932	4.105

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CA-35%			

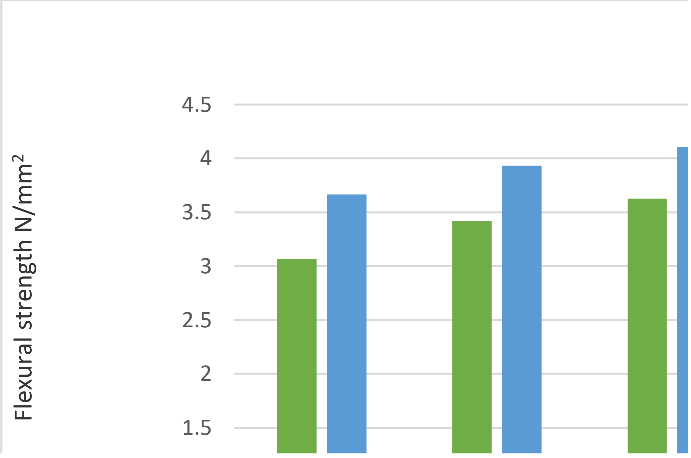

Chart 2 Flexural strength comparison of conventional concrete and replaced concrete

8.CONCLUSION

- The collected porcelain waste is crushed into coarse and fine particles, which is then separately added to the replacement of the concrete in phase 1, the result are interrupted and in phase 2 fine aggregate and course aggregate are replaced simultaneously by 25% and 35% and the results are analysed.
- Both Compressive and flexural strength are increased based on the effective replacement of CA and FA.
- Further research the project is continued above 35% replacement of coarse aggregate by porcelain waste, will provide a better strength.

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