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Waste Ceramic Powder as Alternative Concrete - Based Cementitious Materials

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Abstract: ***The main integrant for constructing a building is concrete. Most of the waste is produced during the demolition of a building. Nowadays construction sectors and manufacturing industries have increased day by day. One of the uses of waste industries as well to minimize the construction material cost, few materials can replace as the by - product of concrete. To reduce the waste of dumping, we can be used as a replacement material in making concrete which will make the pollution - free environment. In the field of civil engineering and construction materials, it has been found that ceramic waste is one of the major waste materials and has become the most effective material in concrete. In this study, the Ordinary Portland Cement - 53 Grade (OPC) has been replaced by crushed ceramic waste tile powder of different percentages such as 5%, 10%, 20%, 30%, 40%, 50%. Paver block & Concrete cubes were, tested and compared with conventional Paver and blocks by finding their compressive strength through experimental investigation. The Paver Block Test was carried out to evaluate the Compressive strength properties of Paver blocks for 7, 14 and 28 days. The main aim of this research paper is to find the performance characteristics of paver block by using waste ceramic as a replacing the Ordinary Portland cement 53 grade***.

Keywords: Cement, Ceramic Waste, Compressive Strength, Paver Block, sand

1. Introduction

A pollution - free and eco - friendly environment are achieved by adopting green concrete in the Civil & Construction industries. Green concrete is made by effective utilization of waste materials like Waste plastics, Ceramic Waste, Construction Waste, and so on produced in the concrete industries and it is a revolutionary topic that impacts the environment by reducing the emission of Carbon dioxide (CO2). The pollutants on the environment can be reduced by the utilization of waste materials in our existing concrete. The uses of Natural materials increase day by day, which causes a serious problem for the Environment also the cost of materials increases daily. Put the critical situation to using the alternative ways and find the better solution of the recycling of material. The construction industry can be used differently

Waste like ceramic wastes, plastics wase PPE waste, etc, In this way, we can contribute to solving this environmental problem. The Indian ceramics industry, which is comprised of wall tiles, floor tiles, sanitary ware materials, bricks, and roof tiles, refractory materials, and ceramic materials for domestic and other use is producing approximately 25 to 35 MT per annum waste generated. According to the research it has been found that about 150 million tons of ceramic have been produced per year. From that total production, around 25% to 35% has become waste material without recycling from the ceramic industry at present. The ceramic powder has various advantages such as cost - saving, energy Saving and reduces the hazards materials to the environment. Ceramic waste can be used in concrete to increase the compressive strength and physical and chemical properties of concrete.

2. Methodology

2.1 Properties of materials

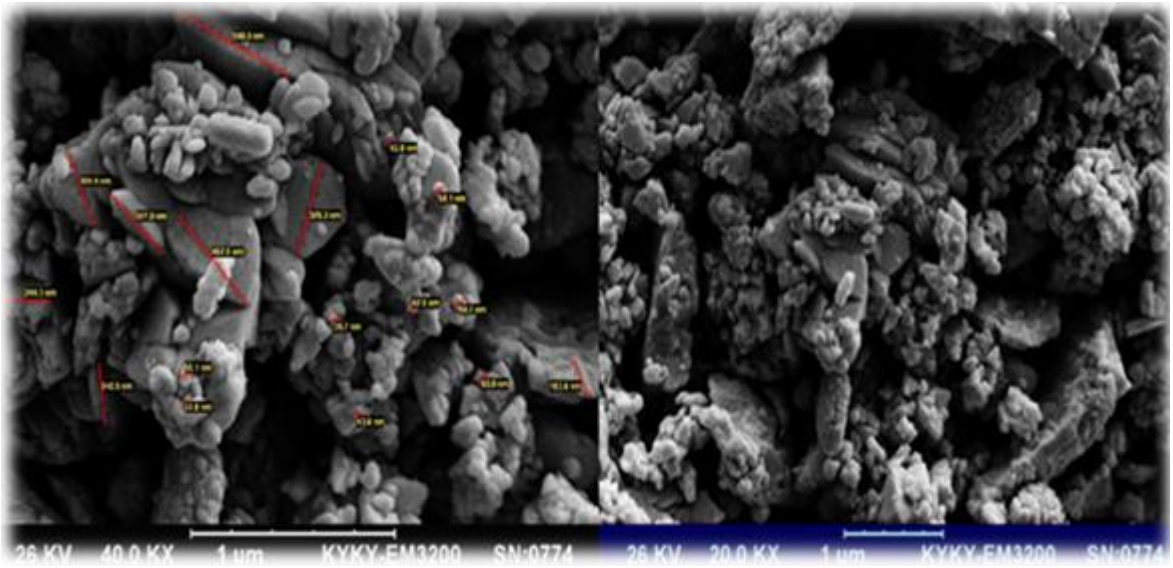
Ceramic Tile Powder: It is brittle, heat - resistant, and corrosion - resistant materials made by shaping and then firing an inorganic, non - metallic material, such as clay, at a high temperature The waste used for this study were obtained from ceramic sanitary ware industry waste produced. The waste ceramic employed in the laboratory study was supplied by a ceramic factory in Kolkata. The ceramic surfaces were washed from running water to eliminate dregs, unwanted materials, and sediment. When it dried ceramics were granulated to particle sizes of 2 to 4.75 mm (0.079 to 0.187 in.). Thereafter, granule waste ceramics were ground to powder of sizes 1 to 100 µm (0.000039 to 0.0039 in.) which is shown in fig. After the grind, the size of waste ceramic powder and Cement was approximately the same. The chemical and physical characteristics of CWP was determined using X - ray Fluorescence (XRF) and the results are shown in Table Also, the shape and angular particles of waste ceramic tiles were found by XRD and SEM imaging and are shown in Fig. respectively. . Fineness is found to be 8.5%.

The properties of Chemical Composition of Ceramic Tile Powder are:

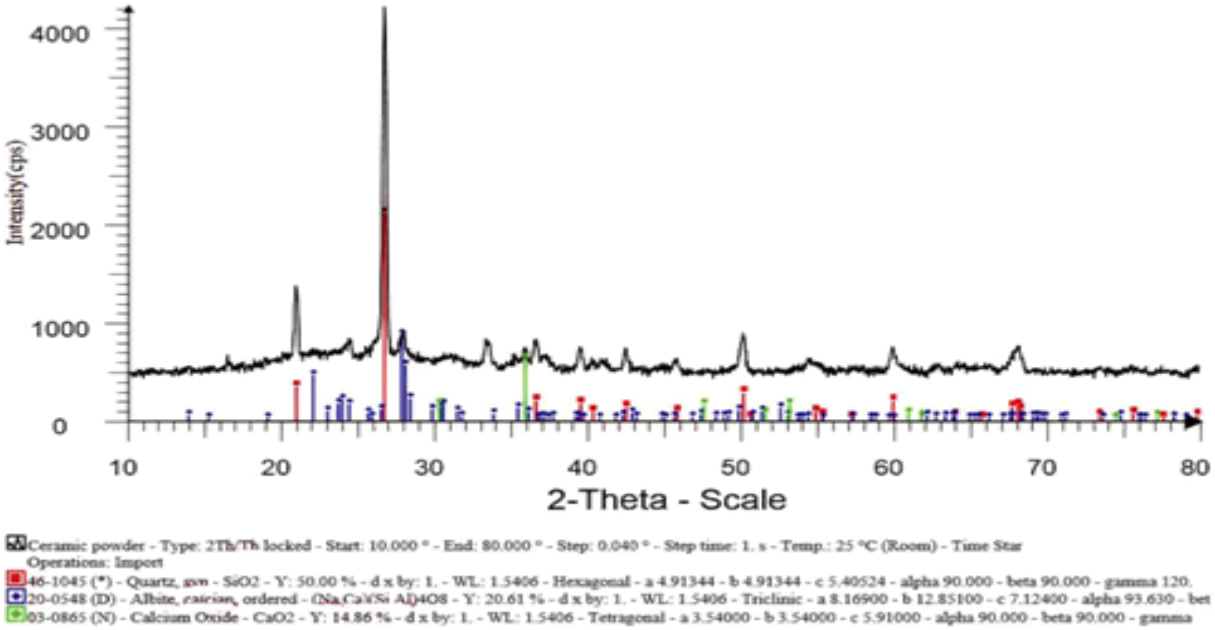
S. No	Ingredients	Chemical Composition
1.	SIO2	63.5
2.	AL2O3	17.9
3.	CaO	5.9
4.	Mn2O3	0.02
5.	Cl	0.0054
6.	SO3	0.098
7.	K2O	2.08
8.	P2O5	0.16
9.	Na20	0.68

Waste Ceramic Tiles

Waste Ceramic Powder



SEM image of ceramic waste powder. (Note: 1 µm = 0.000039 in)



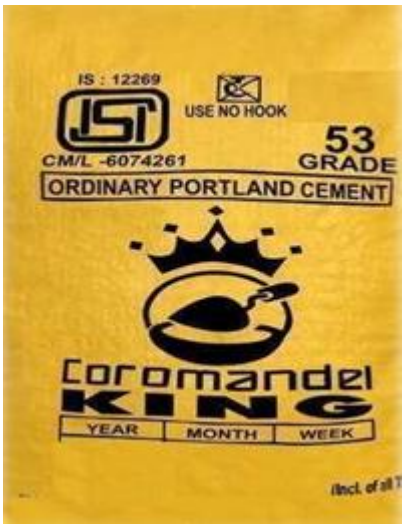
The physical properties of Ceramic Tile Powder are:

S. No	Physical Properties	Value
1.	Moisture content %	0.2
2.	Specific density g/cm3	2.65
3.	Specific area cm2/g	5546
4.	Consistency	31.9
5.	Bulk Density	1580
6.	Aggregate abrasion value, Los Angeles (%)	20.9

Cement: Cement is one of the important binding materials in concrete. Cement is made by heating of limestone (calcium carbonate) with different small quantities of other material like Silica, iron, etc. it's heating around 1450 °C in a kiln, this process is known as calcination, whereas a molecule of carbon dioxide (CO_2) is liberated from the limestone to form calcium oxide (CaO) /quicklime. Then it has blended with the other materials that have been included in the mixer.

The cement which is using have the following properties.

S. No	*Characteristics*	*Value*
1	Fineness (by Blaines apparatus)	<225 m2/Kg
2	**Soundness**	
	a) Le Chatelier method	<10
	b) Autoclave test	0.9%
3	**Setting time**	
	a) Initial setting time in minutes	30
	b) Final setting time in minutes	600
4	**Compressive strength**	
	a) 72 +/ - 1 hour (3 days)	27MPa
	b) 168 +/ - 2 hours (7 days)	37MPa
	c) 672 +/ - 4 hours (28 days)	53Mpa



Ordinary Portland cement 53

Fine Aggregate: The aggregates are passing 4.75 mm Tyler sieve and.075 mm sieve is retained. Fine aggregate (Sand) is a very important civil engineering material. In construction works, sands are used as a fine aggregate material. Fine aggregate (Sand) is a form of silica (quartz) and might be siliceous argillaceous, or calcareous depends upon the composition. Natural sands are formed from weathering of rocks. The grains of sand may be angular, sharp, or rounded.

Most of the fine aggregate (sand) particles should pass from No.4 to No.16 sieves. But most of the fine aggregate (sand) should not contain very fine particles. The various sizes of sand particles are determined by using 'Sieve Analysis

Fine aggregate (Sand)

Quarry Dust: Quarry dust is one of the byproducts of the crushing process which is a concentrated material to use as aggregates for concreting purposes, especially as fine aggregates. In quarrying activities, the rock has been crushed into Different sizes; during this process, the dust generated is called quarry dust and it is formed as waste materials. So, it becomes as a useless material and also results in the air pollution. Therefore, quarry dust should be used in construction works, which will reduce the cost of construction and the construction material would be saved and the natural resources can be used properly. Most of the developing nations are under pressure to replace fine aggregate (Sand) in concrete with an alternate material. it has been used for different work in the construction industry, such as building materials (Paver, bricks), road development materials, and many more places. The benefit of quarry dust are cost - effective, easily available, consumption reduces the pollution in the environment, and is effectively used to replace river sand.

Physical Properties are as follow:

- Specific gravity: 2.53
- Fineness modulus: 2.42
- Density: 1.87gm/cc
- Void ratio: 0.41

Quarry dust

Coarse Aggregate: it is the important material used for making concrete. Aggregates occupy about72 - 75% of the volume of concrete and they greatly influence the strength of concrete. These are cheaper than cement and admixtures.

The aggregate imparts density to concrete. Coarse aggregates are the particles that retain on a 4.75 mm sieve. The surface area of coarse aggregate is less than fine aggregates (Sand). it acts as inert filler material for concrete.

Coarse aggregate

3. Mix Ratio

Cement, sand, Coarse aggregate, Quarry dust and waste ceramic tiles, were taken in the (1: 1: 2: 0.5.0.5) proportion. which are corresponding to M - 40 grade mix concretes. The concrete was produced by mixing all the ingredients homogeneously in concrete mixture machine. To this dry mix of concrete materials required water, which we are giving in the ratio of (w/c=0.37) and the entire concrete was again mixed in Concrete Mixture machine Homogeneously. Admixture are given to the concrete in the ratio of 0.002%. after the 10 - minute mixing, this wet concrete was poured into the moulds and put this mould in vibration machine for compaction., these specimens were given smooth finish and taken out from vibration table. After 1day the specimens were demoulded it. these specimens were put in sunlight for 6hours to dry the materials and then after transferred to curing tanks where they were allowed to cure for required number of days. For evaluating compressive strength, specimens of dimensions 200x100x80 mm were prepared. The load is applied 140Kg/m3/minute or 5.2 KN per second as per IRC: SP: 102 - 2014 and IS 516 - 1959. For evaluating the split tensile strength, cylindrical specimen of diameter 150mm and length 300mm were prepared. Split tensile strength test was carried out on 3000kN capacity compression testing machine as per IS: 5816 - 1959. The cast materials were cured on open - air and subsequent strength measurements were taken on 7, 14 and 28. Days.

The following parameters were used for mix design

- Grade of concrete = M40
- Type of Cement = OPC - 53 Grade
- Brand of Cement = coromandel cement
- Admixture Used Super plastizer from SIKA
- Fine Aggregates =Zone III
- Specific Gravity of Cement = 3.19
- Specific gravity of FA = 2.63
- Specific Gravity of C. A
- 10mm = 2.67
- 6mm =2.64
- Moisture content of FA =9.3%

Mix Proportion for M40 grade Concrete

1) 1162.998 kg/m3 of coarse aggregate (maximum size 20mm)
2) 543.809 kg/m3 of natural river sand (sp. gr =2.63)
3) 435.409 kg/m3 of ordinary Portland Cement (O. P. C.)
4) 187.58 liters of water

4. Results and Discussion

Testing of Concrete

After casting, specimens were tested after 7, 14 and 28 days of curing. In this article, the procedure adopted for testing of specimens for various properties like compressive strength, split tensile strength and flexure strength have been discussed.

1) Compressive Strength

Compressive Strength Test: Preparation of Specimens: M - 30grade of concrete was designed by I. S 10262 - 1982. Batching was done as per the mix proportions with the help of electronic weigh balance machine. Placing and Compaction was done. Concrete blocks are kept in curing tank for 7, 14 and 28 days. After 28 days, concrete cubes were removed from curing tank to conduct tests on hardened concrete by using Compression Testing Machine (CTM) as shown in fig.

Compressive strength = P/A

Where, P = load in KN and A = Area of cross section

Compression Testing Machine (CTM)

Results and Discussion

1) Compressive Strength of PPE Materials Concrete (N/mm2)

Curing days	0% CWP	5% CWP	10% CWP	20% CWP	30% CWP	40% CWP	50% CWP
7 days	34.9	32.4	36.2	35.9	35.4	32.3	28.9
14 days	43.6	41.6	38.2	38.81	37.5	34.6	32.1
21 days	47.2	45.9	45.7	43.9	41.3	37.4	35.6

2) Water Absorption Test

It is one of the important parameters when we consider the durability of structures. According to IS code 1124 - 1974 water absorption test were taken. The paver blocks were placed in the oven. It was dried in the oven, and it was controlled in temperature at 110ºC for 72 hours. The gaps where the paver block is 25 mm to 30mm. After removal from the oven the paver was put an airtight container. The

weight of each paver block was noted. Then after the pavers were immersed in water tank for 30 hours. paver block removed from the water tank and shake it to remove excess water. Further paver was wiped with soft cloth to make it dried.

% of WSP	Wet weight	Dry weight	Water absorption%
5%	5.510	5.406	1.09
10%	5.498	5.421	1.42
15%	5.476	5.390	1.59
20%	5.456	5.309	2.76
30%	5.432	5.313	2.23

3) Durability Test on Concrete

The Acid attack is one of the most important aspects for consideration when we deal with the durability of concrete. Acid attack is particularly important because it primarily causes corrosion of reinforcement. Statistics have indicated that over 40 per cent of failure of structures is due to corrosion of reinforcement. The Paver were cast and kept at a temperature of 27OC± 2OC and at relative humidity of about 90% for 24 hours. After 24 hours the cubes were removed from the mould and immersed in clean and fresh water until they were taken out for testing. After 28 days of curing, the cubes were taken out, weighed accurately and were immersed in a 5% concentrated sulphuric acid (H2SO4) & 5 % hydrochloride acid (HCL) for another 28 days. After 56 days from the date of casting Paver are removed from acid curing and worst surfaces of Paver were removed. The specimens were weighed again and the weight difference before and after acid curing was determined. After that specimen were taken for compressive testing to measure their strength loss due to acid attack

5. Conclusion

This research paper considered the suitability of mortars produced incorporating Waste ceramic Tiles replacement of cement. Durability and Strength characteristics of the samples were examined, and selected samples were analysed further using Different tests. Based on the results obtained, the following conclusions are drawn:

1) With using 10 and 20% of waste ceramic tiles as cement replacement, the mechanical strength of specimens was considerably enhanced to pozzolanic reactions. The pozzolanic reactions of waste ceramic tiles were at their lowest values at early ages (7 and 14 days) in the concrete specimens.
2) Utilization of waste Ceramic tiles and its application are used for the development of the civil and construction industry.
3) It is the Better alternative solution of safe disposal of waste Ceramic Tiles.

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