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Experimental Study on Replacement of Cement by Using Ceramic Waste in Concrete

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Abstract: ***Ceramic waste is one of the major industrial waste products obtained from ceramic Industry. Indian ceramic production is 100 million ton per year. In the ceramic Industry, about 25% - 30% waste powder is settled by sedimentation and then dumped is land and sea which results in environmental pollution. In addition to this, dust is formed in summer which is threatening both agriculture and public health. Therefore utilization of the ceramic powder in concrete is most essential to develop eco-friendly concrete. In this project, experimental study has been done for the cement to be replaced by ceramic waste powder accordingly in the range of 0%, 10%, 20% and 30% by weight. The grade of concrete used in this project is M_{20} grade concrete, the concrete specimen is casted, tested and compared in terms of compressive and split tensile strength to the conventional concrete. These tests were carried out the after curing of 7 days and 14 days. The optimum strength is obtained in this project is by the replacement of ceramic waste by 20% over the cement. On further replacement of ceramic waste it gradually reduces the strength of the concrete. Thus, the efficient replacement is 20% of ceramic waste.***
Keyword: ceramic waste powder, optimum strength.

I. INTRODUCTION

The manufacture of ordinary Portland cement is decreasing all over the world in view of the popularity of blended cement on account of lower energy consumption, environmental pollution, economic and other technical reasons. Since Cement manufacture causes environmental impacts at all stages of the process. The amount of CO_2 emitted by the cement industry is nearly 900 kg of CO_2 for every 1000 kg of cement produced. So in order to reduce the usage of cement, an alternative material shall be used to replace this by available materials like ceramic waste.

In addition to helping the environment, uses of recyclable wastes offers eco-friendly nature. According to the Integrated National Plan on waste 2008-2015,NHIW is all waste generated by industrial activity which is not hazardous in order MAM/304/200, of the 8th February, in accordance with the European List of Waste (ELW).

The India produces 100 million ton ceramic waste per year. In the ceramic industry, about 15%-30% waste material generated from the total production. This waste is not recycled in any form at present. However, the ceramic waste is durable, hard and highly resistant to biological, chemical, and physical degradation forces. The ceramic industries are dumping the ceramic powders. This leads to serious environmental and dust pollution and occupation of a vast are of land, especially after the powder dries up so it is necessary to dispose the ceramic waste quickly and use in the construction industry. The pressure on the disposal of ceramic wastes leads to focus on recovery, reuse of natural resources and find other alternatives. The use of the replacement materials offer cost reduction, energy savings, arguably superior products and fewer hazards in the environment.

A. Objectives

Following are the main objective of this article:

1) To understand the characteristics behavior of the ceramic waste concrete.

2) To find out the compressive strength of concrete by replacing ceramic wastes in various proportions.

II.LITRETURE REVIEW

O.Zimbili, et. at.(vol.8,2014), “A Review on the Usage of Ceramic Waste in Concrete Production” They results shows that after optimization (11-14% substitution) the cement blend performs better, with no morphological difference between the cement blended with ceramic waste, and that blended with other pozzolanic materials. When optimized, both produced good results, better than when natural aggregates are used. However, the research on ceramic wastes as partial substitute for fine aggregates or cement has not been overly exploited as the other areas. This review has been concluded with focus on investigating whether ceramic wall tile

wastes used as partial substitute for cement and fine aggregates could prove to be beneficial since the two materials are the most high-priced during concrete production.

V.V. Agarwal, et.at.(vol.4,2014),"Analysis of the Strength and Durability of the Concrete with Partially Replaced by the Ceramic Slurry Waste Powder" The paper discuss that ceramic slurry waste powder is replaced by cement in concrete. Concrete grade M25 was made by replacing by 0% to 30% of Ordinary Portland 53 grade cement with ceramic slurry waste powder passing through 90 microns. Compressive strength, flexural strength, water absorption and sorptivity are determined with water cement ratio 0.48. The result shows core compressive strength achieved up to 30% replacement of ceramic waste powder without affecting the characteristic strength of M25.

Amit Kumar D. Raval, et.at.(vol.4,2013), "Ceramic Waste effective Replacement of Cement for Establishing Sustainable Concrete" The utilization of the ceramic waste powder in various industrial sectors especially the construction, agriculture, glass and paper industries would help to develop eco-friendly concrete from ceramic waste. In this research study the (OPC) cement has been replaced by ceramic waste powder accordingly in the range of 0%, 10%, 20%, 30%, 40% & 50% by weight of M20 grade concrete. Tests were carried out to evaluate the mechanical properties for 7, 14 and 28 days. As a result, the compressive strength achieved up to 30% replacing cement with ceramic waste. This research work is concerned with the experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing cement via 0%, 10%, 20%, 30%, 40% and 50% of ceramic waste. Keeping all this view, the aim of the investigation is to study the behavior of concrete while replacing the ceramic waste with different proportions in concrete.

II. MIX PROPOTIONS

The mix proportion of M20 grade of concrete with W/C ratio is 0.5.

Table 1.

Cement	Fine Aggregate	Course aggregate
1	1.49	3.08

Mix Proportions of M20 Grade of concrete

The quantity of the various materials for M20 grade concrete can be worked out for the ratio and their respective replacement values are given below.

TABLE 2.

Material	Convectional Concrete	10% Ceramic Waste	20% Ceramic Waste	30% Ceramic Waste
Cement (Kg/m³)	12.5	11.25	10	8.75
Ceramic Powder (Kg/m³)	0	1.25	2.5	3.75
Fine Aggregate (Kg/m³)	18.75	18.75	18.75	18.75
Course Aggregate (Kg/m³)	37.5	37.5	37.5	37.5

III. EXPERIMENTAL TASKS

A. Compression Test

Compression Test was conducted on 150mmX150mmX150mm cubes. Concrete specimens were removed from curing tank and cleaned. In the Compressive testing machine, the cube is placed with the cast face at right angles to that of compressive faces, then load is applied at a constant rate of 1.4Kg/cm² minute up to failure and the ultimate load is noted. The load is increased until the specimen fails and the maximum load is recorded. The compression test is carried out for three samples of each replacement ratios to find the strength at 7 and 14 days.

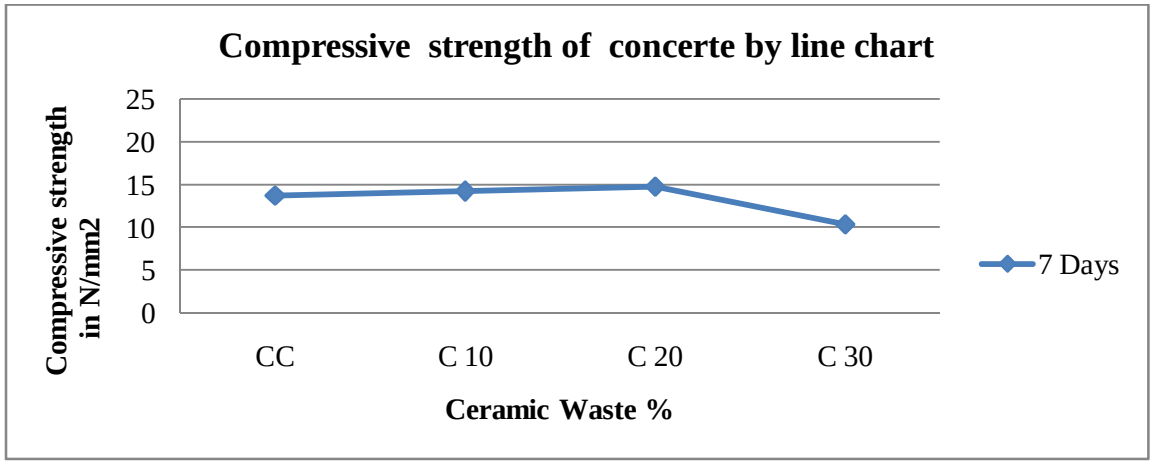
Compressive strength = Load/Area of cross section

TABLE 3. 7 days & 14days compressive strength

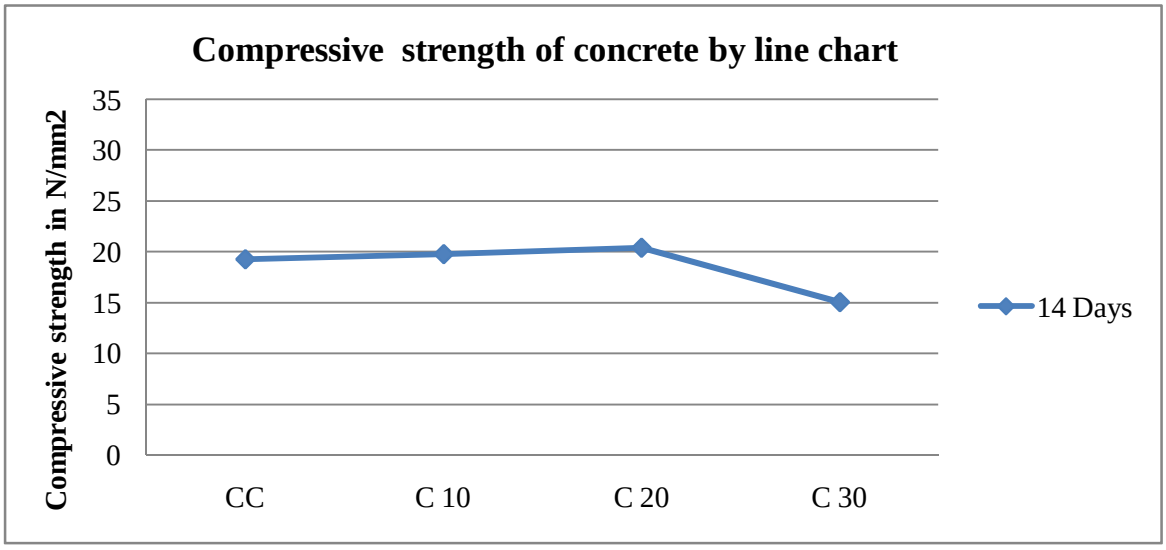
Name of Specimen	Ceramic Waste (%)	Cement (%)	Day of Testing (days)	Compressive Strength of Concrete (N/mm²)			Avg. Comp. Strength of Concrete (N/mm²)
CC	0	100	7	13.56	13.95	13.75	13.75
			14	19.26	19.02	18.95	19.06
C-10	10	90	7	14.02	14.25	14.36	14.21
			14	19.85	19.65	19.88	19.79
C-20	20	80	7	14.55	14.95	14.78	14.76
			14	19.88	20.55	20.75	20.39
C-30	30	70	7	10.55	10.35	10.12	10.34
			14	14.80	15.25	15.15	15.07

B. Compression Strength

The total number of 24 cubes for four mixes i.e. three cubes per mix was prepared for casting of 7 and 14 days curing. The compressive strength test results for the mixes were shown in the graph below. The graph was plotted against ceramic powder % and compression strength (N/mm²).



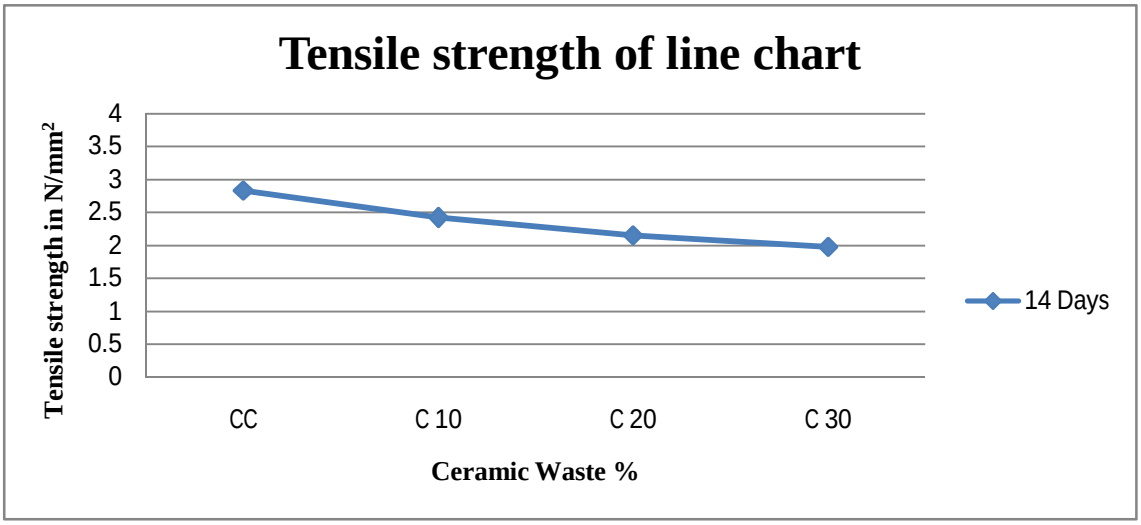
Graph 1: Compressive strength of cube in 7 days



Graph 1.2: Compressive strength of cube in 14 days by line chart

C. Tensile Test

Tensile strength is an important property of concrete because concrete structures are highly vulnerable to cracking owing to various kinds of loadings. However tensile strength of concrete is very low as compared to its compressive strength. Tensile test were conducted on four cubes per mixes on split-cylinder test. Split-cylinder test is the standard test, to determine the tensile strength in accordance with IS: 5816-1970. The standard test cylinder of concrete specimen (300mm X150 mm dia) is placed horizontally between the loading surfaces of Compression Testing Machine. The compression load is applied diametrically and uniformly along the length of cylinder until the failure occurs in vertical direction. Concrete cylinders split into two halves along this vertical plane due to indirect tensile stress generated by Poisson's effect.



Graph 3:Tensile strength of cylinder in 14 days by line chart

From the above results we can observe that in the 20% replacement of the ceramic waste in concrete gives the maximum compressive strength and minimum tensile strength.

IV. CONCLUSION

A. Based on experimental Investigations Concerning the Compressive Strength of Concrete, the Following Observations are made

1) The Compressive Strength of M20 grade Concrete increases when the replacement of Cement with Ceramic Powder up to 30% replaces by weight of Cement and further replacement of Cement with Ceramic Powder decreases the Compressive Strength.

2) Concrete on 20% replacement of Cement with Ceramic Powder, Compressive Strength obtained is 20.39 N/mm² and vice-versa the cost of the cement is reduced up to 10% in M20 grade and hence it becomes more economical without compromising concrete strength than the standard concrete. It becomes technically and economically feasible and viable.

3) Utilization of Ceramic waste and its application are used for the development of the construction industry, Material sciences.

4) The replacement of ceramic waste in concrete increases the hydration and the bond between cement and aggregates.

5) It is the possible alternative solution of safe disposal of Ceramic waste.

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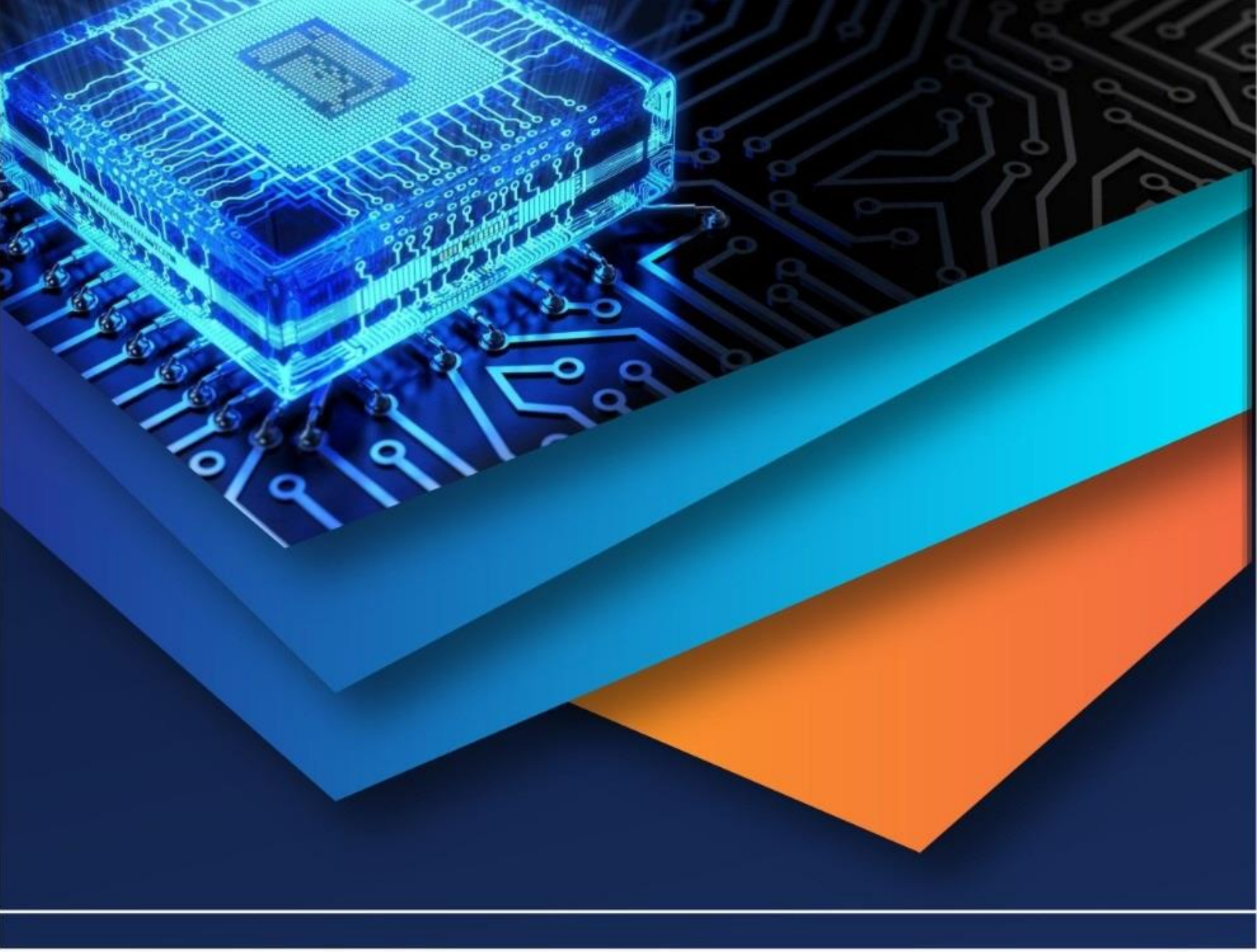
PHOTOGRAPHS


Mixing of Ingredients Casting of cubes


Curing of cubes Testing of Cubes


Failure of Cylinder Testing of Cubes



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