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AN EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF CONCRETE AT ELEVATED TEMPERATURES BY PARTIAL REPLACEMENT OF CEMENT WITH CERAMICWASTE

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Abstract - *This project reports the results of an experimental study on replacement of (OPC) cement by ceramic waste powder accordingly in the range of 0%, 10%, 20%, 30% 40% by weight of M-35 grade concrete.. These tests were carried out to evaluate the properties of concrete for 7 and 28 days. As a result, the compressive strength is achieved up to 30% replacing of cement with ceramic waste .compression tests are also done for cube specimens at elevated temperature.e.,100^{0}c, 200^{0}c, 300^{0}c, 400^{0}c, 500^{0}c. Keeping all this in view, the aim of the investigation is to study the properties of concrete while replacing the ceramic waste with different proportions in concrete.*

Key Words: ceramic waste, compression test, split tensile test, fire resistance of concrete.

1. INTRODUCTION

Today there are critical shortages of natural resources, in the present scenario. Production and utilization of concrete has rapidly increased, which results in increased consumption of natural aggregates. Generally in design of concrete mix, cement , fine aggregates and coarse aggregates are using from long back, which plays a crucial role in designing of a particular grade of concrete. But now a days there is a scarcity in aggregates. So, some new materials which are locally available for low cost have to be introduced for replacing the fine aggregates, coarse aggregates and as well as cement to get the same strength. The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on environment. Presently Ceramic waste is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials.

Ceramic powder is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials. In 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 and highly resistant to biological, chemical, and physical degradation forces. The Ceramic industries are dumping the waste in any nearby pit or vacant spaces, near their unit , although notified areas have been marked for dumping. This leads to serious environmental and dust pollution and occupation of a vast area of land, especially after the powder dries up so it is necessary to dispose the Ceramic waste quickly and use in the construction industry. As the ceramic waste is piling up every day, there is a pressure on ceramic industries to find a solution for its disposal.

In the present investigation, a feasibility study is made to use ceramic powder as an admixture in cement concrete and compressive strengths are found for different percentages of partial replacements

2. MATERIALS AND METHODOLOGY

The evaluation of ceramic waste for use as a replacement of cement material begins with the concrete testing. Concrete contains cement, water, fine aggregate, coarse aggregate and 10%, 20%, 30%, 40% of the cement is replaced with ceramic waste, the data from the ceramic waste is compared with data from a standard concrete without ceramic waste. Three cube samples were cast on the mould of size 100X100X100 mm and 300X150mm cylinders for each concrete mix. After about 24 hrs the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7 and 28 days for compressive strength test and split tensile test. Along with that the compressive strengths for7& 28 days are determined on cubes

when subjected to temperatures of 100^0 200^0, 300^0 ,400^0 &500^0 c.

MATERIALS

CEMENT:

Ordinary Portland cement is by far the most important type of cement. The OPC was classified into three Grades viz., 33 Grade, 43 Grade and 53 Grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988.

Physical properties of Portland cement (53 grade)

S. No.	Properties/Characteristics	Test results	Requirements as per IS 12269-1987
1	Normal Consistency	33%	---
2	Setting time a) Initial Setting Time b) Final Setting Time	 93 minutes 293 minutes	 Not less than 30 minutes Not more than 600 minutes
3	Specific Gravity	3.13	---
4	Fineness of cement by sieving through sieve No.9 (90 microns) for a period of 15 min.	2.90%	<10% (by weight)
5	Compressive strength of cement (28 days)	53 MPa	53 MPa
6	Specific surface area	3200 cm^2/gm	---

Chemical composition (%) of cement:

Composition	Percentage
SiO_2	21.52
Al_2O_3	6.16
Fe_2O_3	4.60
CaO	63.36
MgO	0.83
SO_3	1.87
IR	1.30
Loss of ignition	1.64

AGGREGATE:

Aggregate properties greatly influence the behavior of concrete, since they occupy about 80% of the total volume of concrete. The aggregate are classified as

(1) Fine aggregate

(2) Coarse aggregate

PROPERTIES OF FINE AGGREGATE:

S.No.	Property	Test Result
1.	Specific Gravity	2.60
2.	Bulk density (Kg/m^3)	1543(loose state) 1750(dry rodded)
3.	Fineness Modulus	2.76
4.	Zone	II

PROPERTIES OF COARSE AGGREGATE:

S.No.	Property	Test Result
1.	Bulk density (Kg/m^3)	1468 [loose state] 1611 [dry rodded]
2.	Specific Gravity (G)	2.8
3.	Fineness Modulus	7.14

WATER:

Clean potable water was used for mixing concrete. Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete and steel.

CERAMIC WASTE:

Ceramic material is hard, rigid. It is estimated that 15 to 30% waste are produced of total raw material used, and although a portion of this waste may be utilized on-site, such as for excavation refill. . Reuse of this kind of waste has advantages economic and environmental, reduction in the number of natural spaces employed as refuse dumps.

Physical properties of Ceramic waste:

S. No.	Property	Test Result
1.	Specific Gravity	1.89
2.	Bulk density (g/cm^3)	1.26
3.	Impact Test	23.69 %
4.	Water Absorption	6.56 %

Chemical composition (%) of waste ceramic:

Composition	Ceramic powder %
SiO_2	63.29
Al_2O_3	18.29
Fe_2O_3	4.32
CaO	4.46
MgO	0.72
P_2O_5	0.16
K_2O	2.18
Na_2O	0.75
SO_3	0.10
CL	0.005
TiO_2	0.61
SrO_2	0.02
Mn_2O_3	0.05
Loss of ignition	1.61

PREPARATION OF TEST SPECIMEN:

MIXING:

The materials weighed according the mix design proportions and the cementations materials are thoroughly blended and then the aggregate is added and mixed followed by gradual addition of water and mixing.

WORKABILITY TESTS

SLUMP CONE TEST:

To conduct the Slump test first the mould is thoroughly cleaned and should be greased around the inner surface of slump cone. Now it is filled in four layers, each approximately ¼ of the height of the mould. Each layer is tamped 25 times by the tamping rod which is of 16mm dia and 0.6m long, taking care to distribute the strokes evenly over the cross section.

COMPACTION FACTOR TEST:

Compaction factor measures the workability in an indirect manner by determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height.

CASTING OF SPECIMENS:

The cast iron moulds are cleaned and it is applied with mineral oil on all sides before concrete is poured in to the moulds. The moulds are top surface is finished level and smooth as per IS 516-1969. Moulds were kept on table vibrator and the concrete was poured into the. The moulds in three layers by tamping with a tamping rod and the vibration were effected by table vibrator after filling up moulds. The specimens were removed from moulds after twenty four hours.

CURING OF THE SPECIMEN:

The test specimens shall be stored on the site at a place free from vibration, under damp matting, sacks or other similar material for 24 hours + ½ hour from the time of adding the water to the other ingredients. The temperature of the place of storage shall be within the range of 22^0 to 32 ^{0}C.

TESTING OF THE SPECIMEN:

COMPRESSION TESTING:

The compression testing machine used for testing the cube specimens is of standard make. The

capacity of the testing machine is 2000 KN. The machine has a facility to control the rate of loading with a control valve .The figs are cleaned and oil level is checked, and kept ready in all respects for testing.

SPLIT TENSILE TEST:

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure.

COMPRESSIVE STRENGTH TEST FOR ELEVETED TEMPERETURES:

Cubes were casted and tested for compressive strength of concrete specimens at different ages of 7 and 28 days after exposed to elevated temperatures of 100^{o}C, 200^{o}C ,300^{o}C ,400^{o}C 500^{o}C for duration of 1 hour in the furnace as shown in Fig

3. RESULTS AND DISCUISSION

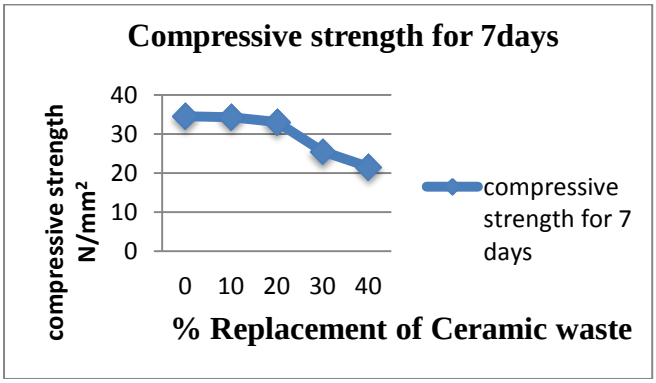
COMPRESSIVE STRENGTH:

In accordance with IS 516-1959 the compressive strengths of conventional and partially replaced cubes for 7 and 28 day strengths are determined by testing the cube specimens in compression testing machine.

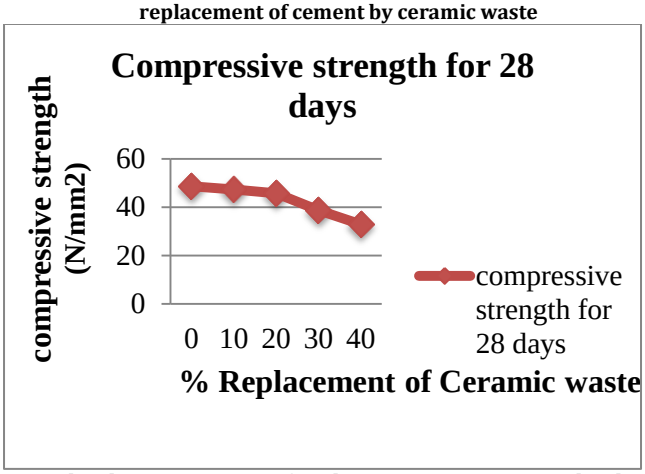
Compressive strengths for cubes at 7& 28 days curing

S.NO	Designation	% Replacement		Compressive Strength For 7 days in MPa	Compressive strength For 28 days in MPa
		Cement	Ceramic Waste		
1	A0	100%	0%	34.51	48.65
2	A1	90%	10%	34.49	47.26
3	A2	80%	20%	33.07	45.78
4	A3	70%	30%	25.51	38.67
5	A4	60%	40%	21.62	32.95

GRAPH:



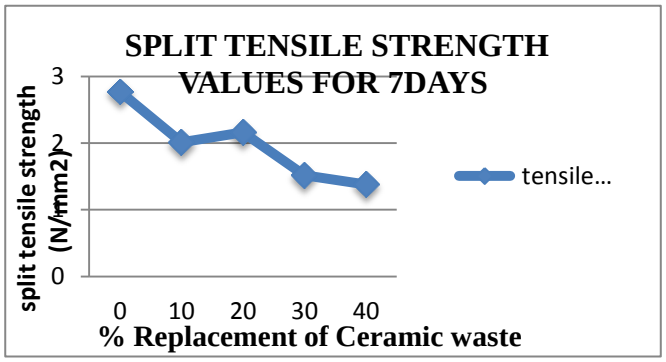
Graphical representation of 7 days compressive strength values for replacement of cement by ceramic waste



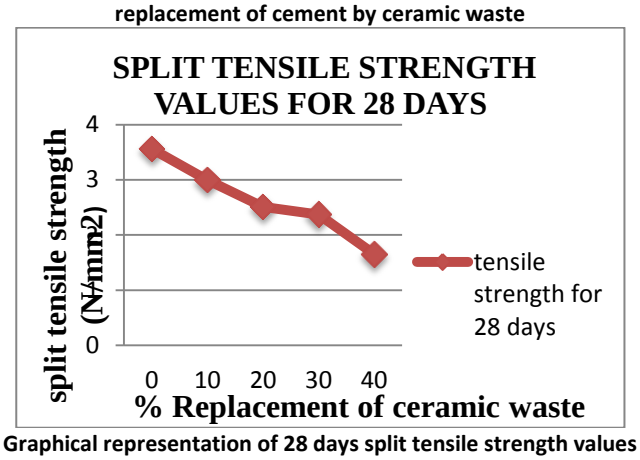
Graphical representation of 28 days compressive strength values for replacement of cement by ceramic waste

S.NO	Designation	% replacement		Split Tensile Strength For 7 days	Split Tensile strength For 28 days
		cement	Ceramic Waste		
1	A0	100%	0%	2.77	3.56
2	A1	90%	10%	2.01	3.0
3	A2	80%	20%	2.16	2.50
4	A3	70%	30%	1.52	2.37
5	A4	60%	40%	1.38	1.65

GRAPH:



Graphical representation of 7 days split tensile strength values for replacement of cement by ceramic waste



Graphical representation of 28 days split tensile strength values for replacement of cement with ceramic waste

SPLIT TENSILE STRENGTH:

In accordance with IS-516 the split tensile strength of conventional and partially replaced concrete cylinders for 7 and 28 day strength is determined by testing the cylinder specimens in compression testing machine.

Split tensile strengths for cylinders at 7& 28 days curing

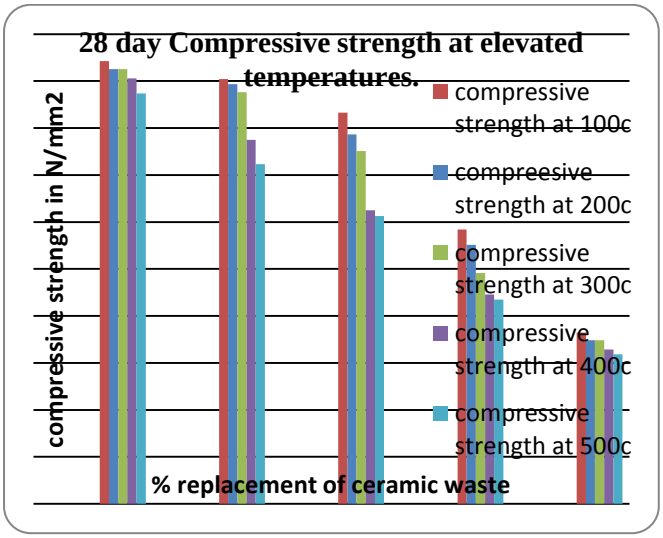
FIRE RESISTANCE OF CONCRETE:

Concrete cubes are tested for 100°C, 200°C, 300°C ,400°C &500°C for duration of 60 minutes in the furnace.

28 day Compressive strength results subjected to elevated temperatures

Temperature		100°C	200°C	300°C	400°C	500°C
Replacement (%)	Mix type	28 days strength in MPa	28 days strength in MPa	28 days strength in MPa	28 days strength in MPa	28 days strength in MPa
0	A0	47.12	46.28	46.28	45.3	43.7
10	A1	45.22	44.67	43.83	38.73	36.14
20	A2	41.63	39.32	37.54	31.26	30.64
30	A3	29.22	27.56	24.56	22.28	21.73
40	A4	18.23	17.42	17.42	16.44	15.92

GRAPH:



Graphical representation of 28 day compressive strength values for replacement of cement by ceramic at elevated temperatures

4. CONCLUSIONS

The following conclusions are drawn from the experimental investigations.

- The Compressive strength of concrete achieves the target strength up to 20% replacement of cement with ceramic powder. Further replacement of cement with ceramic powder there is a decrease in the compressive strength
- The decrease in compressive strength with the increase in replacement percentage of ceramic waste is due to the higher content of silica present in its composition, which leads to the loss of binding property of cement
- Concrete with ceramic waste powder has minor strength loss due to the pozzolanic reactivity of the different ceramic wastes
- The split tensile strengths of partially replaced concrete is slightly decreased when compared with the control mix
- The compressive strength of 10% & 20% partially replaced cubes are slightly decreased when subjected to elevated temperatures of 100^0-300^0 c. But decreased drastically with percentage replacement of 30% & 40% at 400^0 & 500^0 c. when compared to conventional concrete at these temperatures
- The use of ceramic waste in concrete should be promoted not only for analyzing the environmental aspects but also for economizing construction cost
- Utilization of ceramic waste and its application are used for the development of the construction industry, Material sciences
- It is the possible alternative solution of safe disposal of ceramic waste.

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