EFFECTIVE REPLACEMENT OF CEMENT WITH CERAMIC WASTE ON STRENGTH CHARACTERISTICS OF CONCRETE

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Abstract : Concrete is the widely used material in construction around the world and cement, a major constituent of concrete is being costly and only moderately available, researches or experiments are conducted to study the variations in the strength characteristics of concrete by replacement of cement partially or fully by cheaper or locally available materials. Ceramic waste is one of the most abundant waste material available now a days . Ceramic waste powder was formed in industries dumped away in open lands which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, use of the ceramic waste powder in various industrial sectors especially in the construction and glass industries would help to protect the environment. It is most essential to develop eco-friendly and nature free concrete from ceramic waste to protect environment from environmental pollution and the society. Which indirectly helps for reducing the greenhouse gas(co2).there is a large amount of carbon dioxide released in the cement production. In this research study the (OPC) cement has been replaced by ceramic waste powder accordingly in the range of 0%, 15%, 30% & 45%, by weight of M-25 grade concrete. Concrete mixtures were produced, tested and compared in terms of compressive strength to the conventional concrete. These tests were carried out to evaluate the mechanical properties for 7, 14 and 28 days. 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%, 15%, 30%, & 45% of ceramic waste. The aim of the investigation is to study the behaviour of concrete while replacing the ceramic waste with different proportions in concrete.

Keywords—Ceramic Waste, Compressive Strength, Split tensile strength, Low Cost, OPC Cement,

I. INTRODUCTION

Concrete is the most widely used material in construction industry and causes reduction of natural resources like sand, coarse aggregates and other alternatives. In India so many waste products are producing like manufacturing wastes, thermal wastes etc. Concrete is nothing but a combination of aggregates both fine and coarse, Cement and water. Comparing to all other ingredients in concrete, cement is considered to be the expensive material. Cement is one of the major producers of carbon dioxide, which is the main cause of global warming. To reduce global warming caused by cement can be reduce by replacing cement with other cementing alternatives. Among all the waste materials ceramic waste also one of the major waste product produced by the ceramic industry. Indian ceramic production is 100 Million ton per year. In the ceramic industry, about 15% to 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 powder 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. The advancement of concrete technology can reduce the consumption of natural resources. They have forced 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.

Objectives of the study:

- Increasing the use of slag in construction and economizing the construction.
- Improving the ecology of nature by decreasing the unnecessary use and digging of river sand by making slag as an alternative material.
- Conducting tests on the concrete cubes prepared with partial replacement of sand with slag to check the suitability of the material.
- Decreasing the cost of construction by minimizing the costly materials and replacing with cheap and locally available materials.

II. LITERATURE REVIEW

- Ceramic wall tiles are used as building material in the field of construction. Manufacturing of ceramic tiles require different raw material like clay, potash, dolomite, feldspar, talc and different chemicals like sodium silicate, sodium tri poly phosphate (STPP) in ceramic production. The temperature in the kiln varies from 200.c to 1200.c.this variation of manufacturing; therefore there is a pozzolanic reactivity in such material. In ceramic industry about 5-10% production goes as waste in various processes while manufacturing (this waste percentage goes down if the technology is installed in new units.) this waste of ceramic industries dumped at nearby places resulting in environmental pollution causing effect to habitant and agricultural lands. Therefore using of ceramic waste powder in concrete would benefit in many ways in saving energy & protecting the environment. The cost of deposition of ceramic waste in landfills will be saved. Raw materials and natural resources will be replaced. Which indirectly helps for reducing the greenhouse gas(co2).there is a large amount of carbon dioxide released in the cement production. In this research study ceramic waste powder from ceramic wall tiles industry is used as replacement to cement in concrete in an incremental order like 0%, 10%.20%, 30%, 40%, 50% and 60% by weight of cement in concrete for M 25 grade.
- It is a well-established fact that the performance of a ceramic component critically depends on the manufacturing process. In particular, initial powder characteristics and processing, including cold forming and sintering, have a strong impact on the mechanical properties of the components as they may generate a defect population (micro cracks, density gradients, pores, agglomerates) within the green and sintered compounds. In particular, the mechanical characteristics of the solid obtained after cold forming (the so-called 'green body') strongly affect the subsequent sintering process and thus the mechanical properties of the final piece. Many technical, still unresolved difficulties arise in the forming process of ceramic materials. In fact, if on one hand the compact should result intact after ejection, should be handleable without failure and essentially free of macro defects, on the other hand, defects of various nature are always present in the green bodies, negatively affecting local shrinkage during sintering.
- Ceramic dust is produced as waste from ceramic bricks, roof and floor tiles and stoneware waste industries. Concrete (M35) was made by replacing % (up to 30%) of cement (OPC 53) grade with ceramic dust (passing 75µm) shows good workability, compressive strength, split tensile strength, flexural strength and elastic modulus. In this experimental investigation, concrete specimens were tested at different age for different mechanical properties. The results show that with water cement ratio (0.46), core compressive strength increase by 3.9% to 5.6% by replacing 20% cement content with ceramic dust. It was observed that no significant change in flexural strength and split tensile strength when compared to the conventional concrete.

III. METHODOLOGY

In this experimental study we used OPC cement, The most common cement used is ordinary Portland cement. Ordinary Portland cement 53 grade pertaining to IS 8112:1989 is used. Various physical tests like fineness, specific gravity, consistency tests, etc. are conducted as per IS 4031.

DESIGN SPECIFICATIONS:

Characteristic compressive strength of concrete = 25Mpa

Workability of concrete = 65mm (slump)

Nominal size of the aggregate used in the design= 20 mm

Specific gravity of cement = 3.15

Specific gravity of coarse aggregates = 2.83

Specific gravity of fine aggregates = 2.64

Specific gravity of Ceramic waste = 3.02

Grade of cement used = OPC 53 grade

Gradation of sand = zone III

Ceramic waste

Ceramic waste can be used in concrete to improve its strength and other durability factors. Ceramic waste can be used as a partial replacement of cement or as a partial replacement of fine aggregate sand as a supplementary addition to achieve different properties of concrete.

PHYSICAL PR0PERTIES OF CERAMIC WASTE

Specific gravity	3.02
Density	2.0-6.0gms/cm3

Mix design:

All the concrete mixes in the project are prepared as per IS: 10262-2009. This standard was first prepared in the year 1982 and later revised in the year 2009. The following prerequisites are to be taken into consideration before designing a concrete mix:

Characteristic compressive strength of concrete below which only specified portion of test results is allowed to fall at 28 days.

Degree of workability desired.

Limitations on the water cement ratio and the minimum cement content to ensure adequate durability.

Type and maximum size of aggregate to be used.

Standard deviation(s) of compressive strength of concrete.

- Target strength for mix proportion (IS 10262:2009 table 1)

Fck= fck+ 1.65 x S

Where S = Standard deviation = 4N/mm2

Fck= 25 + 1.65 x 5 = 31.6 N/mm2

Step 1-Selection of water cement ratio:

From table 5 of IS 456,

Maximum water cement ratio =0.5

Hence we take W/C Ratio as 0.43

Step 2 - Selection of water content:

From IS 10262-2009 the maximum water content is 186 lit/m3

Hence we adopt water content as 186 lit/m3

Step 3 -Calculation of cement:

W/C = 0.45

So cement content = 425.73 kg/m3

Minimum cement content = 320 kg/m3

Step 4 - proportion of volume of coarse aggregate(CA) to fine aggregate(FA) (from IS: 10262-2009 table-3)

For 20 mm size aggregate and zone III sand, CA proportion = 0.64

Hence proportion of fine aggregate = 0.36

Step 5 - Mix calculations per unit volume:

Volume of cement = (mass of cement/Sp.gr. of cement)x(1/1000)

=0.135 m3

Volume of water = (mass of water/Sp.gr. of water)x(1/1000)

= 0.191 m3

Volume of aggregate = 1-(0.135 + 0.191)

= 0.674 m3

Volume of CA = 0.64 x 0.674

= 0.43136 m3

Volume of FA = 0.36 x 0.674

= 0.24264 m3

Now volume of FA , water and CA remain same for every mix, where as the volume of Cement is being proportioned for cement and ceramic

Mass of the CA = Volume of CA x SP.gr. of CA x 1000

= 0.43136 x 2.83 x 1000

= 1220.7488 kg/m3

(i) For 0% replacement mix

Mass of cement = volume of cement x Sp.gr. of cement x1000

= 0.135 x 3.15 x 1000

= 425.25 kg/m3

(ii) For 15% replacement mix

Mass of cement = 0.85 x volume of cement x Sp.gr. of cement x1000

= 0.85 x0.135 x 3.15 x 1000

= 361.46 kg/m3

Mass of ceramic = 0.15 x volume of ceramic x Sp.gr. of ceramic x1000

= 0.15 x 0.135 x 3.02 x 1000

= 61.15 kg/m3

(iii) For 30% replacement mix

Mass of cement = 0. 7 x volume of cement x Sp.gr. of cement x1000

= 0.7 x0.135 x 3.15 x 1000

= 297.67 kg/m3

Mass of ceramic = 0. 3 x volume of ceramic x Sp.gr. of ceramic x1000

= 0. 3 x 0.135 x 3.02 x 1000

= 122.31 kg/m3

(iv) For 45% replacement mix

Mass of cement = 0. 55 x volume of cement x Sp.gr. of cement x1000

= 0.7 x0.135 x 3.15 x 1000

=233.88 kg/m3

Mass of ceramic =.45 x volume of ceramic x Sp.gr. of ceramic x1000

= 0.45 x0.135 x 3.02 x 1000

= 183.46kg/m3

IV. RESULTS AND DISCUSSIONS

GENERAL

The compressive and split tensile has been determined from laboratory testing of cubes and cylinders for different concrete mixtures with partial replacement of sand with quarry dust. The results of the tests conducted on concrete of various replacements are presented

WORKABILITY OF CONCRETE

Slump value (in mm) of different concrete mixes, prepared by partial replacement of cement with ceramic is represented in the table to study the workability of the concrete mixes:

Workability of concrete

Cement: Ceramic	Slump value (mm)
0:100	80
25:75	65
50:50	60
75:25	45
100:0	30

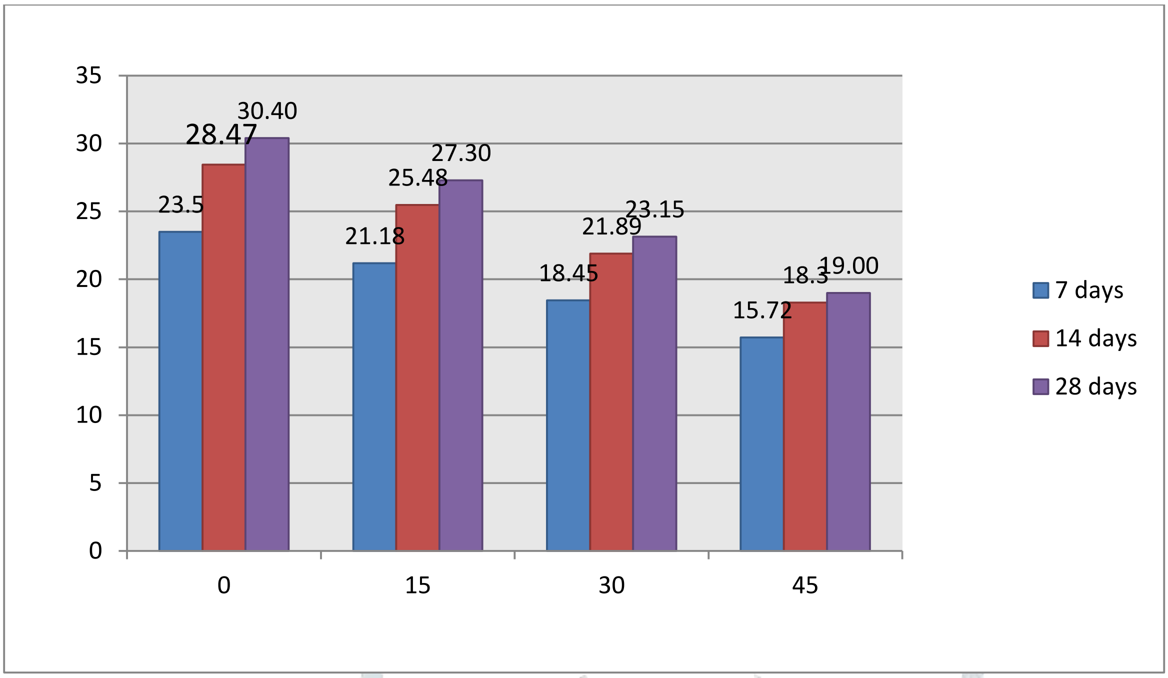
COMPRESSIVE STRENGTH

The compressive strength of a material is that value of uni-axial compressive stress reached when the material fails completely.

Mean compressive strength (in MPa) of M25 grade concrete

% Replacement	7 days	14 days	28 days
0	23.5	28.44	30.40
15	21.18	25.48	27.3
30	18.45	21.89	23.15

45	15.73	18.3	19.0



Mean compressive strength (MPa) vs cement replacement (%)

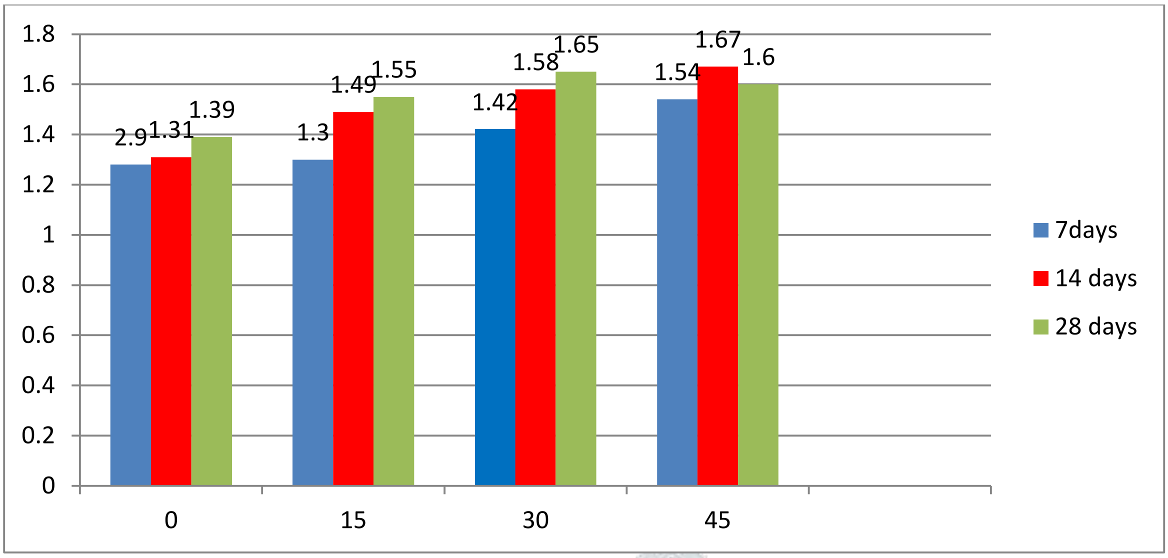
From fig.5.3.1 it was observed that for increase of replacement of cement with ceramic waste the compressive strength goes on decreasing from 30.40 MPa to 19 MPa

SPLIT TENSILE STRENGTH:

Split tensile strength is tested by keeping cylindrical specimens in the compressive testing machine and the loading is applied radially until the failure of the specimen occurs.

Table 5.4: Mean split tensile strength (in MPa)

% Replacement	7 days	14 days	28 days
0	1.28	1.31	1.39
15	1.3	1.49	1.55
30	1.42	1.58	1.65
45	1.54	1.67	1.60



Mean split tensile strength (MPa) vs cement replacement (%)

It was observed that for 30% replacement of cement with ceramic we attained a maximum strength of 1.65MPa

V. CONCLUSIONS

Based on experimental investigations concerning the compressive strength of concrete, the following observations are made:

(a) The Compressive Strength of **M25 grade** Concrete decreases when the replacement of Cement with Ceramic Powder up to **45% replaces** by weight of Cement

(b) The Split Tensile Strength of **M25 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 Split Tensile Strength.

(c) Utilization of Ceramic waste results in increasing of Split Tensile Strength and it is very useful in construction of structures where more tensile strength is required

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

(d) Using Ceramic Wastes in Concrete can solve several environmental problems.

(e) While using ceramic tiles as partial replacement of fine aggregate, workability decreased with increase in replacement level.

(f) Ceramic waste can effectively be used as alternative & supplementary materials in concrete

VI. REFERENCES

ChandanaSukesh and KanakambaraRao.S, (2013) “Partial Replacement of Sand with Quarry Dust in Concrete”, IJITTE.

Devi M and Kannan. K, (2011), “Analysis of strength and corrosion resistance behaviour of inhibitors in concrete containing quarry dust as fine aggregate”, published in the ARPN Journal of Engineering and Applied Sciences, November.

Hudson B P, (1997), “Manufactured sand for concrete”, The Indian Concrete Journal, May.

Ilangovana. R, Mahendrana.N, and Nagamanib.K, “Strength and durability properties of concrete containing quarry rock dust as fine aggregate”, ARPN Journal of Engineering and Applied Sciences.

IS: 383-1970, specification of coarse and fine aggregate from natural sources for concrete, Bureau of Indian Standard, New Delhi, India.

IS 4031-1988, methods for physical properties of cement, Bureau of Indian Standard, New Delhi, India.

Jaafar M S, W.A.Thanoon, M.R.A.Kadir and D.N.Trikha, (2002), “Strength and Durability characteristics of high strength autoclaved stone dust concrete”, The Indian concrete journal, December.

Joseph O. Ukpata, Maurice E. Ephraim and Godwin A, (2012), “Compressive strength of concrete using lateritic sand and quarry dust as fine aggregate”.ARPN Journal of Engineering and Applied Sciences, January.

Lohani.T.K, Padhi.M, Dash K.P and Jena.S, (2012) “Optimum utilization of Quarry dust as partial replacement of sand in concrete”, International Journal of Applied Sciences and Engineering Research.

M.S. Shetty, Concrete Technology Theory and Practice, 5th edition, S.Chand& Co. Ltd., New Delhi.

Mithanthaya I R and Jayaprakash Narayan, (2002) “Replacement of Sand by Quarry Dust for Plastering and in the Pavement Design”, Proceedings of National

SachinBalkrishnaKandekar, AmolJagannathMehetre and Vijayshree A, (2012), “Strength Of Concrete Containing Different Types Of Fine Aggregate”. International Journal of Scientific and Engineering Research, September

IS CODES USED:

IS 10262-2009 - CONCRETE MIX DESIGN
IS 456-2000 - PLAIN AND REINFORCED CONCRETE
IS383-1970- SPECIFICATION FOR COARSE AND FINE AGGREGATES
IS516 -1959-METHODS OF TESTS FOR STRENGTH OF CONCRETE