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PROPERTIES OF HIGH STRENGTH CONCRETE WITH REPLACEMENT OF WASTE CERAMIC AS FINE AGGREGATE

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Abstract
According to this study, concrete is made up of a number of different ingredients including cement, fine aggregate, coarse aggregate, and water. In civil engineering and environmental studies, one of the biggest challenges is figuring out how to keep up with the rising demand and price of concrete in a sustainable way. In order to find solutions to these problems, research is being done to see whether industrial wastes may be used in concrete production, which would have a positive effect on the environment. Ceramic trash ranks high among the most significant garbage. About 30 percent of all ceramics manufactured are now discarded as trash without being recycled. Experimental efforts are performed to evaluate the mechanical characteristics of high-strength concrete using Ceramic Waste as Fine Aggregate at several concentrations (0%, 5%, 10%, 15%, and 20%) and to compare this material to conventional concrete.
Keywords: Concrete, Waste Ceramic, Fine Aggregate, Water, Coarse Aggregate.

I. INTRODUCTION

In comparison to the other materials, the concrete's high compressive strength will grow to the addition of ceramic waste and fly ash. [1, 3, 5]. With environmental concerns in mind, we may reuse the detritus from construction sites in concrete. [2,4]. Because fine aggregate is so closely linked to the ubiquitous building material concrete, it plays a pivotal role in the industry. The current situation is expected to result in a rise in sand demand, which in turn would cause the price of river sand to rise gradually. As a result, M-sand is now being used in practise. But there are limits on how much M-sand may be produced before failing certain quality tests. Since this need for sand persists, a new fine aggregate has been introduced: crushed ceramic tile waste. Because ceramics cannot be recycled and reused, 30% of all ceramic objects produced every day are thrown away at little or no cost [6, 7]. Indian building sectors use concrete at a pace of roughly 400 million tonnes annually, a number that might rise to a billion tonnes in a decade or less. Because concrete is formed from a wide variety of materials already found in the earth's crust, it drains its assets over time, putting a pressure on the environment [4]. All the industrial, medicinal, agricultural, and other types of trash from the rural and urban regions contribute to the over 2500 million tonnes of solid waste produced year, which has a substantial impact on the environment. The removal of these wastes poses a number of problems that have an impact on the environment. There is a significant potential for adverse

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health and environmental effects from the massive quantities of ceramic waste now produced by the ceramics industry. However, there is currently more discussion about the possibility of using such ceramic waste in the building industry. Although this sort of consumption generates solid waste, it is far easier to manage than the pollution and garbage generated by the source industry. Concrete components may be easily recycled from the non-biodegradable ceramic materials used for floor tiles, wall tiles, weather course tiles, sanitary ceramic items, electrical ceramic insulators, ceramic utensils, etc. [9]. Many benefits, including cost savings, less waste, and fewer negative effects on the environment, are associated with its substitution.

II. LITERATURE SURVEY

[1] Devadas Manoharam P and Sentharamai R M, (2005), ''Concrete with ceramic waste aggregate', Cement & Concrete Composite". Use of hazardous industrial wastes in concrete-making will lead to greener environment. In ceramic industry about 30% production goes as waste, which is not recycled at present. In this study an attempt has been made to find the suitability of the ceramic industrial wastes as a possible substitute for conventional crushed stone coarse aggregate. Experiments were carried out to determine the compressive, splitting tensile and flexural strengths and the modulus of elasticity of concrete with ceramic waste coarse aggregate and to compare them with those of conventional concrete made with crushed stone coarse aggregate. The properties of the aggregates were also compared. Test results indicate that the workability of ceramic waste coarse aggregate concrete is good, and the strength characteristics are comparable to those of the conventional concrete.

[2] Fernando, Pacheco-Torgal and Said Jalali, (2010), "Compressive strength and durability properties of ceramic wastes-based concrete". This paper presents an experimental study on the properties and on the durability of concrete containing ceramic wastes. Several concrete mixes possessing a target mean compressive strength of 30 MPa were prepared with 20% cement replacement by ceramic powder (W/B = 0.6). A concrete mix with ceramic sand and granite aggregates were also prepared as well as a concrete mix with natural sand and coarse ceramic aggregates (W/B = 0.5). The mechanical and durability performance of ceramic waste-based concrete are assessed by means of mechanical tests, water performance, permeability, chloride diffusion and also accelerated aging tests. Results show that concrete with partial cement replacement by ceramic powder although it has minor strength loss possess increase durability performance. Results also shows that concrete mixtures with ceramic aggregates perform better than the control concrete mixtures concerning compressive strength, capillarity water absorption, oxygen permeability and chloride diffusion. The replacement of cement and aggregates in concrete by ceramic wastes will have major environmental benefits.

[3] Giridhar Valikala, Sudarsana Rao hunchate and Vaishali. G. Ghorpade ''Influence of water absorption of the ceramic aggregate on strength properties of ceramic aggregate concrete''. The Present paper investigates the influence of water absorption of ceramic waste aggregate on strength properties of ceramic aggregate concrete. Compressive strength and split tensile strength of concrete made with ceramic waste aggregate is studied with replacement of natural coarse aggregate by ceramic waste aggregate at 0%, 20%, 40%, 60%, 80% and 100%.

Due to the influence of water absorption and external porcelain nature, strength of ceramic concrete is declining gradually but strength of ceramic concrete is more than the targeted mean strength even after replacing 100% of natural coarse aggregate.

[4] Hafiz Waheed-ulHasan, Humera Ahmed, Sabahat Alamgir and Sajjad Ubin (2014) "Experimental investigation of tensile and flexural strength of ceramic waste concrete".
Different types of ceramics products are available in the market, which are being used for a wide variety of applications. Bricks, tiles, sanitary wares, sewer-pipes, pottery etc. are the common examples of ceramic products. The wastes generated from different products have constituted a serious adverse environmental impact in the societies. Therefore, use of ceramic waste as partially replacement material of any of constituents of the concrete, will not only control the product waste tactfully but will also economize concrete manufacturing cost. Moreover, depleting sources of sand in Pakistan triggered the dire need of replacement of fine aggregate of the concrete. Experiment research was conducted to investigate the effect on compressive, tensile and flexural strength of concrete with the use of industrial ceramic waste as a partial replacement of fine aggregate in the concrete at the age of 28 days. Four types of concrete mixtures were tested in this research i.e., CC-0, CC-10, CC-15, and CC-20, where CC-0 stands for Reference Concrete and CC-10, CC-15 & CC-20 stand for concretes having 10%, 15% & 20% ceramic waste as sand replacement material respectively. Tests for compressive strength, modulus of rupture, split cylinder and double punch were performed. It revealed that the concrete produced with ceramic waste has more tensile strength, flexural strength and compressive strength when compared with reference concrete, which explicitly opened a door to use of industrial ceramic waste in concrete production.

[5] AnkitJhamb, Electricwala Fatima and Rakesh Kumar, (2013), ''Ceramic dust as construction material in rigid pavement''. 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

Test method analysis:

- ✓ Concrete contains cement, fine aggregate, coarse aggregate, and water, according to this study.
- ✓ One of the biggest challenges in civil engineering and environmental studies is meeting the rising demand and price of concrete sustainably.
- ✓ To find solutions, scientists are researching whether industrial wastes can be used to make concrete, which would benefit the environment.
- ✓ Ceramic trash is important. About 30% of all ceramics are no longer recycled.

- ✓ The mechanical properties of high-strength concrete using Ceramic Waste as Fine Aggregate at 0%, 5%, 10%, 15%, and 20% are evaluated and compared to conventional concrete.

III. (i)MATERIALS

- **CEMENT:** The cement is a one of the binding materials which used widely among these modern days, it can create bond between fine and coarse aggregate in concrete. In this research Ordinary Portland Cement of 53 Grade was used for the entire work and care has been taken to store it based on the reference of standard codes. The cement was tested for physical requirement in accordance with standards and the values are given in Table 1.
- **Fine aggregate (FA):** The River sand is used in this experiment is clean and it is free from clay, silt and other impurities. Medium and fine sand shall be used for the mortars. Coarse sand shall be sieved through 2.36mm sieve and used to make the concrete.
- **Ceramic Fine aggregate (CFA):** The waste disposed as a waste from the ceramic industry is the broken ceramic pieces do not uniform in shape and sizes, most of them are in the crushed and in fine texture only. It is obtained mainly during the processing of polishing, dressing and laying, which is around 25% of total raw material used. The waste ceramic tiles and crushed ceramic waste are used as replacement.
- **Coarse aggregate (CA):** Coarse aggregate used in this study is dry and clean. It is free from moisture content, dust, dirt and other foreign matter like clay, graphite etc. The size of the stone varies from 20mm, 12.5mm size and it should retain in a 5mm square mesh and well graded such that voids do not exceed 42%.
- **Water:** Potable water is used in mixing of concrete and the suspended solid matter is less than 200mg/l. The quality of water used in mixing and curing of concrete is clean and clear which free from physical and chemical impurities.

Table 1: Properties of Cement

Property	Value	Range as per IS
Standard consistency	29.5%	27 - 33%
Initial Setting Time	38 Minutes	30 Minutes (min.)
Final Setting Time	430 Minutes	600 Minute (max.)
Specific Gravity	3.15	3.1 – 3.25

The slump test for concrete is an important test; to measures the workability of fresh concrete and it measures the consistency of the concrete. It is mentioned that the state of fresh concrete and is visibly shows the ease with which the concrete flows.

(ii) TEST PROCEDURE

A. Water absorption:

Water absorption test was performed on both types of coarse aggregates by keeping the samples immersed in water and removing the excess water on surface of the samples after 24 hrs and measuring the saturated weight. After that the samples were kept in oven by maintaining 100 ±5°C for one day. Oven dry weight of the samples is recorded, and the water absorption is evaluated.

B. Compressive strength:

Six cube specimens for each replacement percentage were cast according to the design mix. The size of cubes is
150x150x150mm. To study the workability, slump cone test and compaction factor tests were performed. Specimens were compacted in table vibrator and de-moulded after 24 hrs and cured in water pond @ temperature of 27 ±2° for a period of 28days. After completion of curing period, specimens were removed from pond, kept for drying and then tested in compression testing machine of 2000 KN Capacity.

C. Split tensile strength:

Six cylindrical specimens for each replacement percentage were cast according to the design mix. The cylindrical specimens are of 150mm diameter and 300mm height. Specimens were de-moulded after 24 hrs and cured into pond @ temp of 27 ±2° for a period of 28 days. Split tensile strength is measured by testing cylinder under diametric compression. Based on the load at which the cylinder splits, the split tensile strength is computed.

IV. RESULTS & DISCUSSIONS

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EXPERIMENTAL RESULTS:-

Compressive Strength of Concrete:

Grade of concrete = M60

Area of concrete cube A = $150*150mm^2$

A = $22500mm^2$

Compressive strength of concrete = Load/Area N/mm^2

Table 2: Average Compressive strength of Concrete

% Of Ceramic Waste	Average Compressive Strength of Concrete (MPa)		
	3 days	7 days	28 days
0%	20.23	41.28	67.42
5%	21.04	45.12	70.12
10%	22.12	48.88	73.89
15%	22.25	49.61	74.16
20%	20.61	45.38	68.72

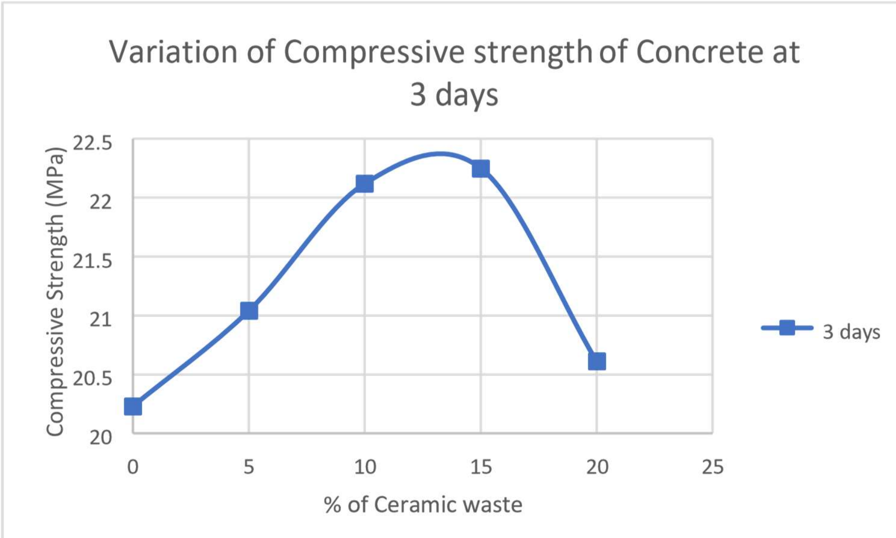

Figure 1: Variation of Compressive strength of Concrete at 3-Days

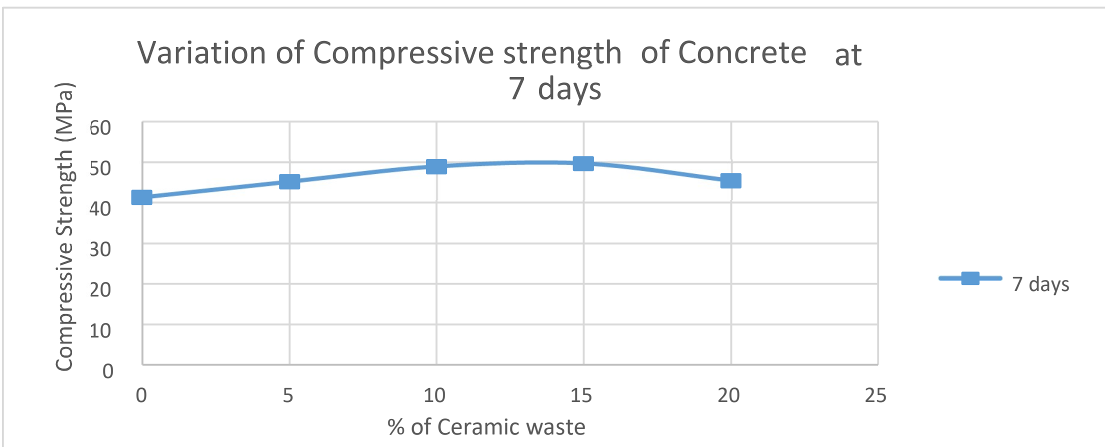

Figure 2: Variation of Compressive strength of Concrete at 7-Days

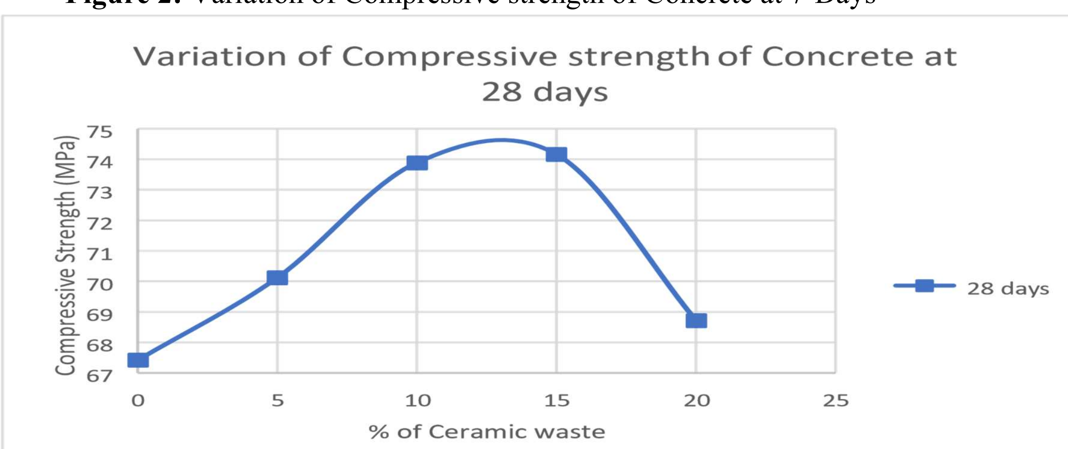

Figure 3: Variation of Compressive strength of Concrete at 7-Days

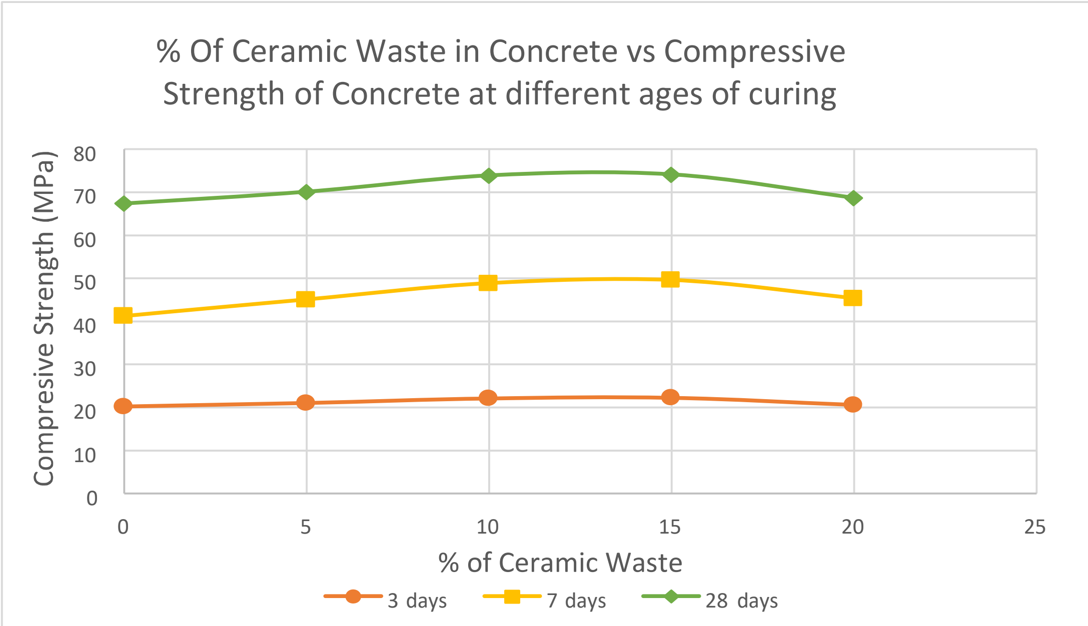

Figure 4: Variation of Compressive strength of Concrete at 3,7, 28-Days

Split Tensile Strength of Concrete:

Diameter of cylinder D = 150mm Length or Height of the cylinder

L = 300mm

$\pi Dl = 1,41,300$

Area of concrete Cylinder $A = 2\pi r^2 + 2\pi rh$ mm^2

$A = 2*3.14*75^2 + 2*3.14*75*300$

$A = 17671.45$ mm^2

Split Tensile Strength of Concrete $= 2P/\pi DL$

Table 3: Average Tensile strength of Concrete

% Of Ceramic Waste	**Average Split Tensile Strength of Concrete (MPa)**		
	3 days	**7 days**	**28 days**
0%	2.56	3.94	4.83
5%	2.60	3.96	4.95
10%	2.82	3.98	5.09
15%	3.24	4.33	5.12
20%	2.98	4.18	4.73

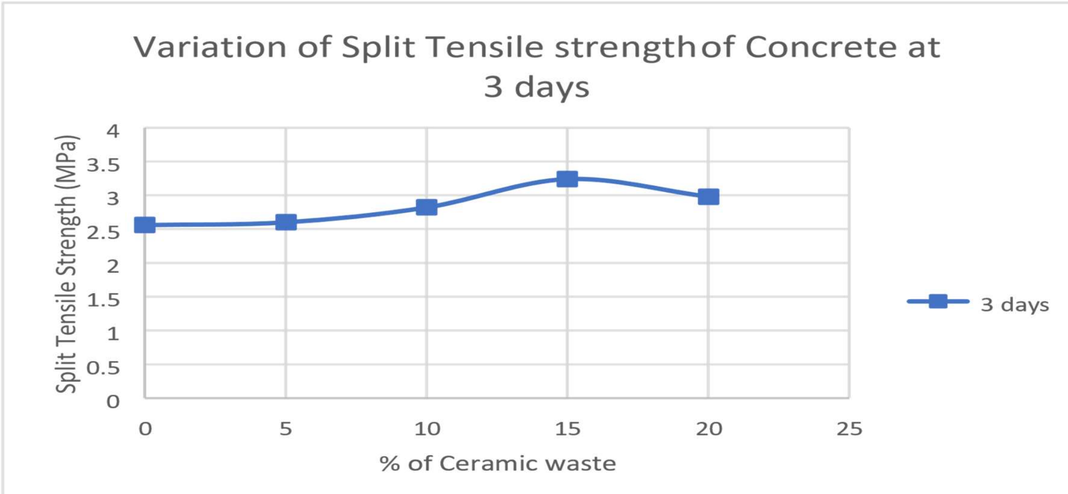

Figure 5: Variation of Tensile strength of Concrete at 3-Days

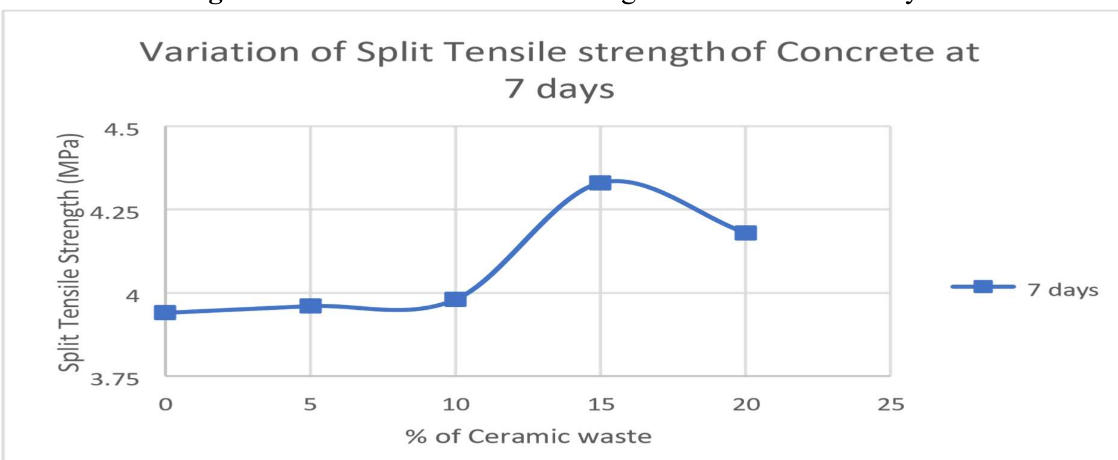

Figure 6: Variation of Tensile strength of Concrete at 7-Days

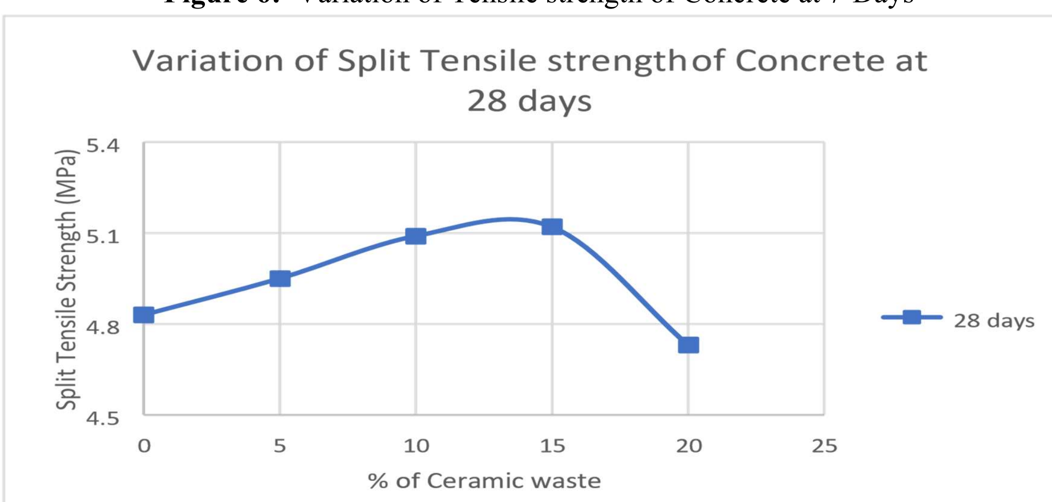

Figure 7: Variation of Tensile strength of Concrete at 28-Days

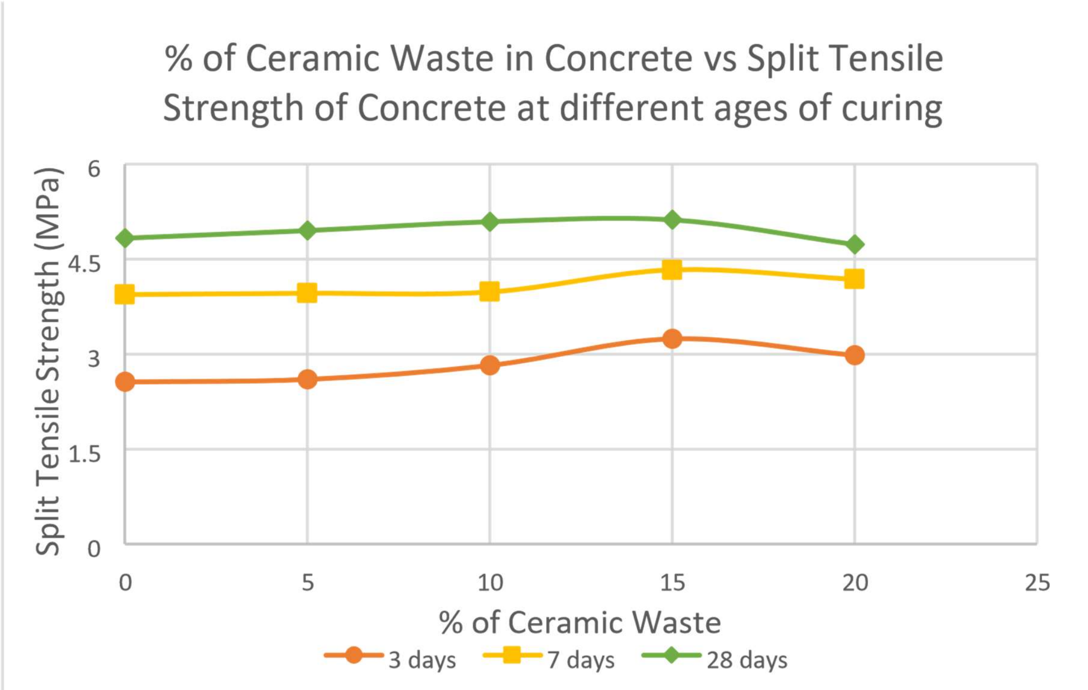

Figure 8: Variation of Tensile strength of Concrete at 3,7,28-Days

Flexural Strength of Concrete:
Dimensions of concrete beam = 500*100*100 mm; The flexural strength or modulus of rupture $f_b = pl/bd^2$ when > 13.0cm for 10cm specimen or $f_b = 3pa/bd^2$ when a < 13.3 cm but > 11.0 cm for 10 cm specimen. Where, a = the distance between the line of fracture and the nearer support, b = width of specimen (cm), d = failure point depth (cm), l = supported length (cm) = 40cm.

Table 4: Average Flexible Strength of Concrete (MPa)

% Of Ceramic Waste	**Average Flexural Strength of Concrete (MPa)**		
	3 days	**7 days**	**28 days**
0%	4.41	5.27	7.42
5%	4.40	4.86	6.89
10%	5.50	6.06	8.61
15%	7.26	8.35	10.20
20%	5.09	5.83	8.43

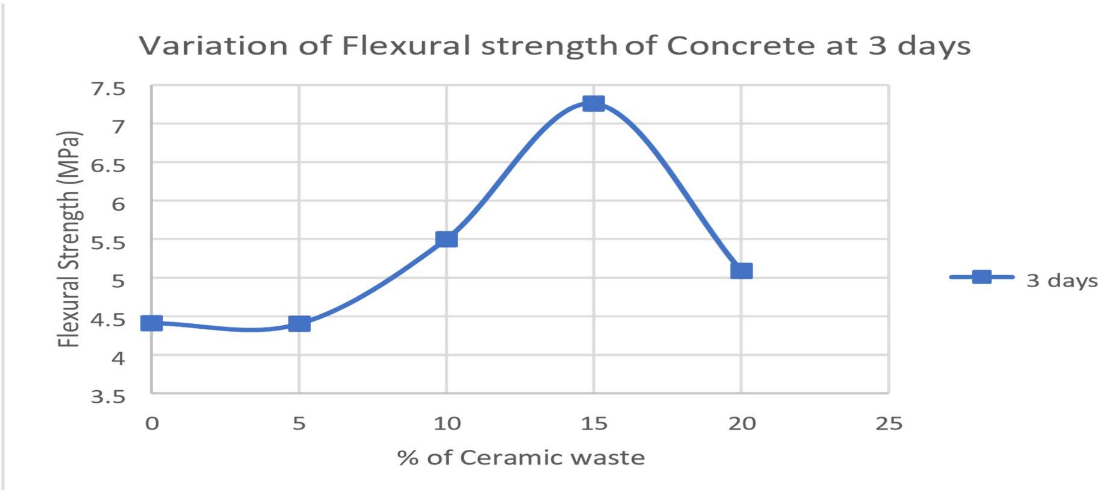

Figure 9: Variation of Flexural strength of Concrete at 3-Days

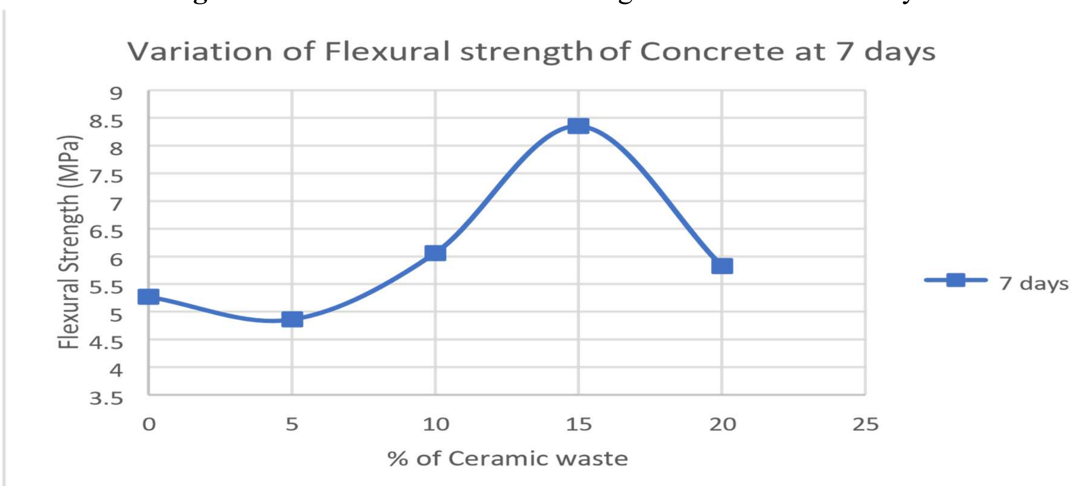

Figure 10: Variation of Flexural strength of Concrete at 7-Days

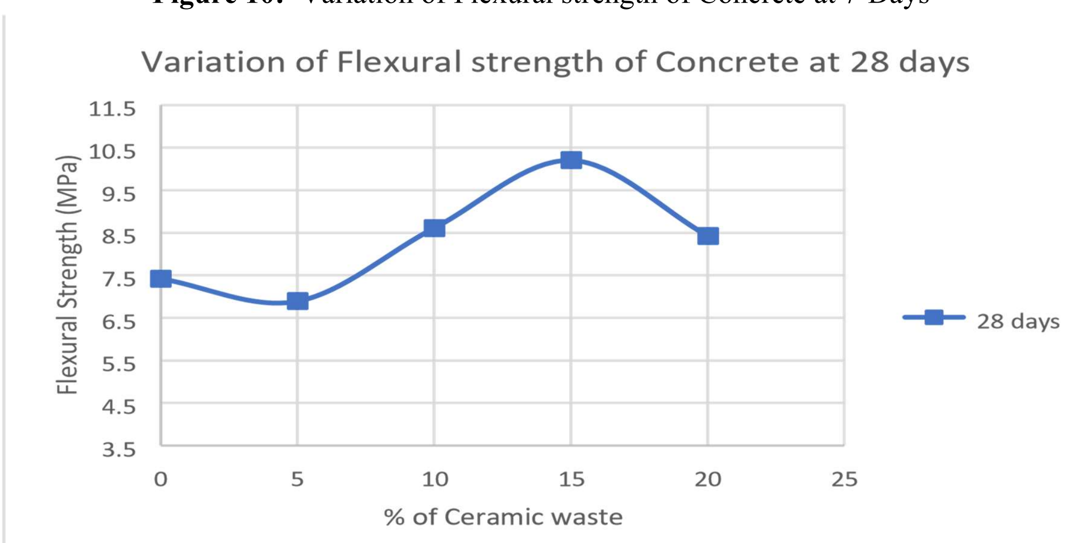

Figure 11: Variation of Flexural strength of Concrete at 28-Days

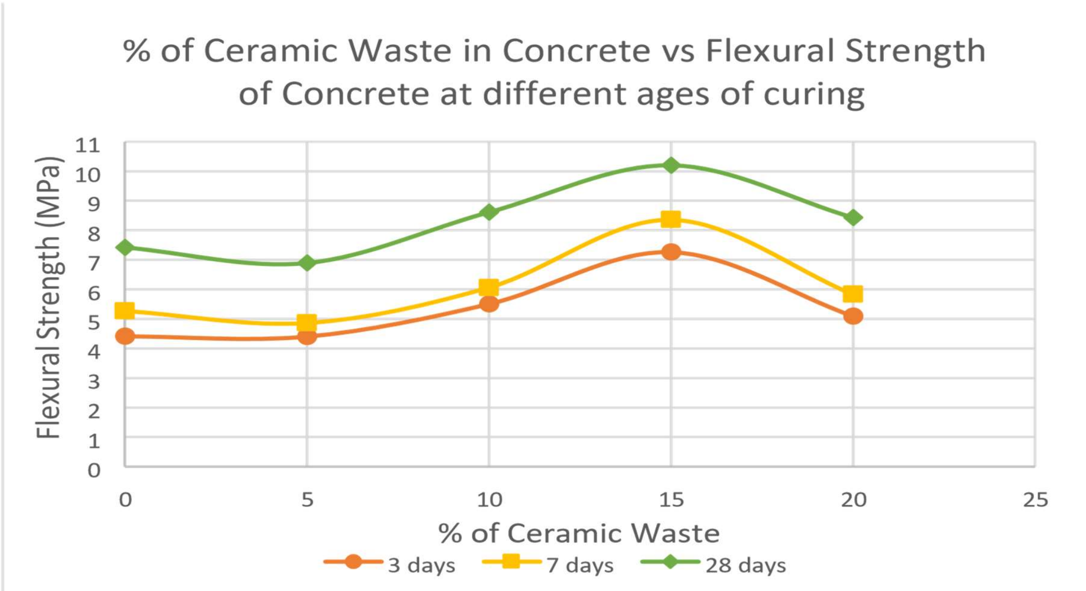

Figure 12: Variation of Flexural strength of Concrete at 3,7,28-Days

V. CONCLUSIONS

- Based on the results of this investigation, it is concluded that ceramic waste aggregate has the potential to replace natural fine aggregate in concrete as its physical properties are well within the range specified by IS: 383-1970.
- So it is advised that if locally considerable amount of ceramic waste is available, use 15% partial replacement of ceramic waste (insulators crushed with Roll crusher and Pulveriser crusher) in fine aggregate.
- The compression test results for 15% replacement are increased by 10% as compared to the conventional concrete at 28 days, for the remaining replacements there is no significant change compare with conventional concrete.
- The split tensile test results for 15% replacement are increased by 6% as compared to the conventional concrete at 28 days, for the remaining replacements there is no significant change compare with conventional concrete.
- The flexural test results for 15% of ceramic waste replacement are increased by 27% as compared to the conventional concrete at 28 days, for the remaining replacements there is no significant change compare with conventional concrete.
- Workability of ceramic waste aggregate concrete decreases with increase of percentage replacement of natural fine aggregate with ceramic waste aggregate. This is mainly due to the higher water absorption of ceramic waste aggregate leading to lesser water content in the mix. This fact is revealed by both slump and compaction factor tests.

VI. REFERENCES

[1] Devadas Manoharam P and Sentharamai R M ''Concrete with ceramic waste aggregate', Cement & Concrete Composite", 27, pp.910- 913,2005.

[2] Fernando, Pacheco-Torgal and Said Jalali (2010), 'Compressive strength and durability properties of ceramic wastes based concrete', RILEM 2010.

[3] GiridharValikala, Sudarsana Rao hunchate andVaishali. G. Ghorpade ''Influence of water absorption of the ceramic aggregate on strength properties of ceramic aggregate concrete'', International Journal of Innovative Research in Science, Engineering and Technology,Vol. 2, Issue 11,2013.

[4] AnkitJhamb, Electricwala Fatima, Rakesh Kumar andSadanandSahu), ''Use of ceramic waste as filler in semidense bituminous concrete',American Journal of Civil Engineering and Architecture, Vol. 2, No. 3, pp. 102-106,2016.

[5] AnkitJhamb, Electricwala Fatima and Rakesh Kumar ''Ceramic dust as construction material in rigid pavement'',American Journal of Civil Engineering and Architecture, Vol. 1, No. 5, pp. 112-116,2013.

[6] Badorui AH, Mashitah M.D and Kin CC , "Recycling of homogenous ceramic tiles for the production of concrete block'', International Symposium on Environmental Management: Hazardous-Environmental Management Toward Sustainability, pp 25-28,2008.

[7] Hafiz Waheed-ulHasan, Humera Ahmed, Sabahat Alamgir and Sajjad Ubin (2014) 'Experimental investigation of tensile and flexural strength of ceramic waste concrete', Pakistan Journal of Science,Vol. 66 No. 1.

[8] IS:12269(1987),'Ordinary Portland cement, 53 Grade Specification', Bureau of Indian standard, New Delhi. IS 465 (2000),

[9] 'Plain and reinforced concrete-code of practice', Bureau of Indian standard, New Delhi.

[10] IS 10262 (2009), 'Concrete mix proportion-guidelines', Bureau of Indian standard, New Delhi.

[11] IS: 1199 (1959), 'Methods of sampling and analysis of concrete', Bureau of Indian standard, New Delhi.

[12] Pincha Torkittikul, Arnon Chaipanich, "Utilization of ceramic waste as fine aggregate within Portland cement and fly ash concretes", International Journal of cement and concrete composites, Vol 32, pp 440-449,2010.

[13] Derrick J. Anderson, Scott T. Smit, Francis T.K. Au (2016), "Mechanical properties of concrete utilising waste ceramic as coarseaggregate", International journal of Construction and Building materials, Vol 117,pp 20-28.

[14] Amitkumar D. Raval, Indrajit N. Patel and Prof. JayeshkumarPitroda, "Re-use of ceramic industry wastes for the elaboration of eco-efficient concrete', International Journal of Advanced Engineering Research and Studies, Vol. 2, Issue 3,2013.

[15] Arjun Verma, AkhilDhoundiyal, Jatin Malhotra, Punit Malik,
NitinYadav, and Piyushbhardwaj, "Mix design for concrete with crushed ceramic tiles as coarse aggregate", International Journal of Civil Engineering Research.Volume 5, Number 2, pp. 151154, 2014..

[16] Agrawal V.V, LaljiPrajapati and Patel I N , “Analysis of the strength and durability of the concrete with partially replaced by the ceramic slurry waste powde’’, International Journal of Emerging Technology and Advanced Engineering, Volume 4, Issue 3,2014.