Smt. Swathi D.P, et. al. International Journal of Engineering Research and Applications
www.ijera.com
ISSN: 2248-9622, Vol. 10, Issue 7, (Series-I) July 2020, pp. 58-62

RESEARCH ARTICLE OPEN ACCESS

An Experimental Study on Concrete by Partial Replacement of Sand with Ceramic Waste

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ABSTRACT
The main focus of this research is to study the strength of concrete with ceramic waste as fine aggregate. Increased construction activity and continuous dependence on conventional materials of concrete marking are leading to scarcity of the material and increased construction cost. In this study an attempt has been made to find the suitability of ceramic fine aggregate as a possible substitute for conventional aggregate in concrete. The ceramic industry is known to generate large amounts of ceramic wastes each year. Reusing these wastes in concrete could be a within situation. So we prefer ceramic waste to increase the strength and stability of concrete. The abstract should summarize the content of the paper. This paper presents the behavior of concrete with partial replacement of sand by ceramic at 10%, 20%, 30% and 40%. Cubes and cylinders are tested after 3, 7 and 28days of curing to obtained compressive strength and split tensile strength respectively. Data presented include the compressive strength, split tensile strength of concrete specimen with and without ceramic waste.

Keywords – ceramic waste, compressive strength, split tensile strength.

Date of Submission: 18-06-2020 Date of Acceptance: 06-07-2020

I. INTRODUCTION

The concrete is a mixture of cement, fine aggregates, coarse aggregates, water and admixtures if required which placed in the site and allowed to cure, becomes hard like a stone and give a significant strength. Due to the easily availability of constituent materials in bulk, it is the most common construction material now and in future. It has also been modified in different types of new forms like pre-stress concrete, Fiber reinforced concrete, high strength concrete etc. the most important property which engineers like is that it can be readily molded into desired structural items of various sizes and shapes at practically no considerable labour expenditure it has a high compressive strength. It is free from corrosion in plain cement concrete form and also in R.C.C form if proper cover is provided. It hardens with age and the process of hardening continues for long time after concrete has strength. Due to this property it is superior among all the construction material. It has binding property with steel and as it is weak in tension, the steel reinforcement is placed in cement concrete at suitable places to take up the tensile stress. This is termed as reinforce cement concrete. It forms a rigid surface which is capable of resisting abrasion and impact due to which it can also be used in road construction.

In this context, fine aggregate has been replaced by ceramic waste to find a comparative analysis for different parameter which is tested in the laboratories to find the suitability of the replacement adhered to the Indian standard specifications for its strength. The main objective is to provide more information about the effects of various proportion of sand as partial replacement of waste ceramic fine aggregate on workability, compressive strength, and tensile strength. Attempts have been made to investigate some property of ceramic waste and the suitability of those properties to enable ceramic waste to be used as partial replacement materials for sand in concrete. The use of ceramic waste in concrete is desirable because of its benefits such as useful disposal of waste products, reduction of river sand consumption as well as increasing the strength parameter.

II. EXPERIMENTAL PROGRAM

It is well known that strength of the concrete is depending on the properties of its ingredients .The materials used in the present investigation are as follows.

- Cement
- Coarse aggregate
- Fine aggregate
- Water
- Ceramic waste

II. I CEMENT

Cement is a well known building material, which has occupied an indispensable place in the construction works. Cement is finely powdered material which by itself is not a binder, develops binding property as a result of hydration. Cement is called hydraulic when the hydraulic products are stable in aqueous environment (water resistance). Some of the variety of cements is OPC, Portland-Pozzolana cement, Rapid hardening Portland cement, High alumina cement, Super sulphate cement, and High strength Portland cement 53 grade high power cement.

Generally OPC 43 grade is used for the construction works it confirmed to the requirement of Indian Standard Specification IS: 8112-1989. The test on cement is carried out as per IS: 4031-1991. The chemical composition of cement is given in table 1. The chemical properties of the cement obtained from the given in table 1.

Contents	IS requirements
CaO	60-67%
SiO_2	17-25%
Al_2O_3	3-8%
Fe_2O_3	0.5-6%
MgO	2.5%
SO_3	2-2.5%
Other oxides	5%

Table-1: Chemical composition of ordinary Portland cement

Sl. No	Properties	Test Result
1	Fineness of cement	2.33%
2	Standard consistency	30%
3	Initial setting time	45min
4	Final setting time	430min
5	Specific gravity	3.12

Table-2: Physical properties of ordinary Portland cement

II. II COARSE AGGREGATE

The coarse aggregate is define as an aggregate most of which is retained on 4.75mm IS sieve. The aggregates are formed due to natural disintegration of rocks or by artificial crushing of the rock or gravels. Thus the aggregates derive many of their properties from their parent rocks. The common coarse aggregate are crushed stone and gravel. The size of the aggregates generally used was 20mm down IS sieve. Generally angular aggregates affect the workability or stability of the mix which depends upon the interlocking of the particles.

Sl., no	Property	Values
1	Specific gravity	2.56
2	Fineness modulus	7.54
3	Water absorption	1%

Table-3: Physical properties of coarse aggregate

II. III FINE AGGREGATE

The fine aggregate are particles which will pass through 4.75mm IS sieve. It is also called as sand. Generally consider to have a lower size limit 0.07mm. The material between 0.06mm and 0.002mm is known as silt. The silt particle is termed as clay.

II. IV WATER

Water is very important ingredient in the concrete mass, as it actively participates in the chemical reaction with cement. It has been estimated that on an average of water by weight of cement is required for chemical reaction in cement compounds. Portable water free from injurious salts was used for mixing and curing.

II. V CERAMIC WASTE

Ceramic waste is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials. Ceramic waste powder is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, utilization of the ceramic waste powder in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. It is most essential to develop eco-friendly concrete from ceramic waste. Indian ceramic production is 100 Million ton per year. In the ceramic industry, about 15%-30% waste material generated from the total production. However, the ceramic waste is durable, hard and highly resistant to biological, chemical, and physical degradation forces. The advancement of concrete technology can reduce the consumption of natural resources.

Fig-1: Ceramic Waste

Constituents	Ceramic (%)
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

Table-4: Chemical Composition of Ceramic

Sl., no	Properties	values
1	Specific gravity	2.52
2	Fineness modulus	2.92
3	Water absorption	0.62%

Table-5: Physical Properties of Ceramic

III. NOMINAL PROPORTIONS

The concrete mix is designed as per IS: 456-2000 for the normal concrete. The grade of concrete, which we adopted, is M20. The concrete mix proportion (cement: fine aggregate: coarse aggregate) is 1:1.8:3.1 by volume and water cement ratio of 0.5

IV. EXPERIMENTAL METHODOLOGY

In the present study, we used concrete cube moulds of size (150×150×150)mm for compression test and (150mm diameter & 300mm height) cylinders for split tensile test. The specimens are casted for M20 grade concrete by replacing of sand by ceramic waste (0% to 40%).Hand mixing is to be used for concrete mixing. After casting the required specimens, the specimens will be cured by normal water curing at temperature 27˚±2˚c.After curing, the cubes are subjected to compression test for 3, 7 and 28 days and cylinders are subjected to tensile test for 28 days by using compression testing machine at the rate of loading 140 kg/cm^2 or 14 N/mm^2/min as per IS: 516-1959.

The materials which are free from the organic impurities were sieved and the weigh batching for ingredients was done. The concrete ingredients were weighed and mixed. The concrete cubes of (150×150×150) mm and cylinders of 150 mm diameter and 300mm height were casted with 0%, 10%, 20%, 30%, 40% ceramic as partial replacement for fine aggregate was casted. The specimens are stored in the laboratory atmosphere for 24 hours from the time of adding water to the ingredients. Temperature was maintained at 27 ± 2^0 C. The specimens are of solid cubes and beams were kept immersed in clean water for curing after 24 hours of casting.

V. COMPRESSIVE STRENGTH OF CONCRETE

Normally the compression strength of the concrete is a measure of quality of concrete for a particular mix. The result of the compressive strength are tabulated in Table-6

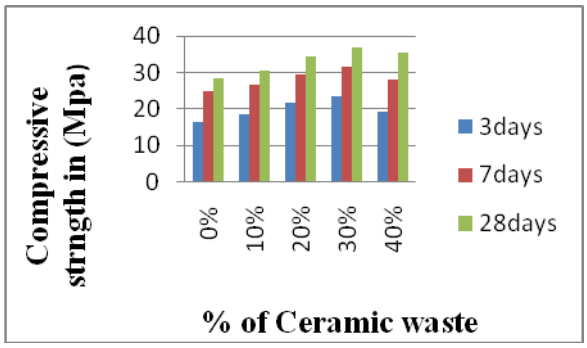

Chart-1: Graphical Representation of 3, 7 and 28 days Compressive Strength of Concrete

Sl., no	Percentage of addition of ceramic waste	w/c ratio	Compressive strength Mpa		
			3days	7days	28days
1	0%	0.5	16.44	24.80	28.44
2	10%	0.5	18.60	26.67	30.40

3	20%	0.5	21.78	29.55	34.45
4	30%	0.5	23.56	31.56	36.67
5	40%	0.5	19.33	28.22	35.56

Table-6: Compressive Strength

VI. SPLIT TENSILE TEST FOR CONCRETE

Normally the split tensile strength of the concrete is a conducted to determine the tensile strength of the concrete. The results of the split tensile strength of cylinders are tabulated in table and variation with age as shown in chart.

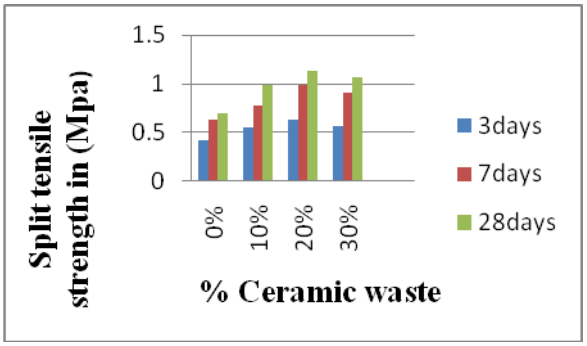

Chart-2: Graphical representation of 3, 7 and 28 days split tensile strength of concrete

Sl. no	Percentage of addition of ceramic waste	w/c ratio	Compressive strength Mpa		
			3days	7days	28days
1	0%	0.5	0.42	0.63	0.70
2	10%	0.5	0.55	0.77	0.99
3	20%	0.5	0.63	0.99	1.13
4	30%	0.5	0.56	0.91	1.06

Table-7: Split Tensile Strength

VII. RESULTS AND DISCUSSION

From Table 6, we can observe that, increase in the percentage of ceramic as a replacement for sand results in increasing the compressive strength up to 30% from graph; we can clearly say that, further increase in ceramic percentage beyond 30% results in gradual decrease in strength.

From chart 2, we can observe that, For 28 days, there is an increase in tensile strength of concrete with addition of 10% ceramic is about 41.4%, concrete with addition of 20% ceramic is about 61.42%, and concrete with addition of 30% ceramic is about 51.42%

VIII. CONCLUSION

Based on the experimental investigation studies, the following conclusions can be drawn. Ceramic waste is used as one of the alternative material for the fine aggregate. Ceramic can be used as partial replacement for fine aggregate in M_{20} grade concrete. Ceramic replacement at 30% shows higher compressive strength at all ages. Based on availability, sustainability, cost and embodied energy point of view, Ceramic waste can be used for M_{20} grade concrete up to 30% replacement. The ceramic based concrete can be used as eco-friendly, cost effective and energy efficient in construction industry.

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.

IX. FUTURE SCOPE

Ceramic can be added in other percentage for concrete for different water cement ratio. Ceramic waste can be used in mortar cubes and check the properties. Investigation on behavior of concrete in structural applications. Fatigue resistance of concrete can be studied. Applications of these concrete in road works may be explored. Flexural strength and other workability and durability studies can be undertaken.

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Smt. Swathi D.P, et. al. "An Experimental Study on Concrete by Partial Replacement of Sand with Ceramic Waste". *International Journal of Engineering Research and Applications (IJERA)*, vol.10 (07), 2020, pp 58-62.