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EFFECT & STRENGTH OF CHARACTERSTICS OF HCl ON CERAMIC AGGREGATE CONCRETE

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***Abstract*— The word "ceramic" was originated from the Greek word "keramos", whose original meaning was "burnt earth Substitution of waste material in the preparation of concrete is a new concept for diminution of waste. Now a day's wastage is increasing rapidly throughout the world. This wastage is to be properly dumped or properly utilized in production of eco-friendly substances such as concrete. These days industries are increasing vastly with which waste is also being increased. The main aim of this work is to effectively use crushed ceramic waste as a replacement". Present research mainly focuses on examine of aggregate properties of ceramic waste and also comparison of the properties of ceramic aggregate with natural aggregate. To study the feasibility of ceramic waste aggregate usage into the concrete. To study the effect of acid on ceramic aggregate concrete in fresh state. To study the effect of acid on ceramic aggregate concrete in hardened state. To study the strength loss, weight loss characteristics of concrete.**

Thus, needful conclusions have been taken based on the experimental results. A new concrete composition is produced with replacing the natural coarse aggregate by ceramic waste aggregate at 0, 20, 40, 60, 80 and 100%. All test results of ceramic aggregate concrete are compared with reference concrete by which it concludes the suitability of ceramic aggregate into the concrete. Also water is replaced with hydrochloric acid at 5, 10 percentages and finally workability and strength is compared with conventional concrete.

***Keywords*— Effect & Strength, Ceramic Aggregate Concrete.**

I. INTRODUCTION

Concrete is the most widely used man-made construction material all around the globe because of its superior specialty of being caste in any desirable shape. It is material synonymous with strength and longevity has emerged as the dominant construction material for the infrastructure needs of the present situation. Around five billion tones of concrete have been used around the world wide every year, in terms of cost it is equivalent to 25 to 30% of the nation budget. It is also inevitable material in human life due to its enormous usage in modern way of construction. India has taken a sound decision on developing the infrastructural development in 21st century such as express high ways, airports, ports, power projects and tourism projects. In every construction aspects it requires concrete, hence concrete plays a vital role in present scenario of construction industries. Everyone has chosen concrete in infrastructural development because of its characteristics like strength and durability. The continuous usage of natural resources and the consequent energy requirement for this processing has a serious economic impact. More over in the alluvial plain area, where there is no availability of virgin aggregates, such as debris and rubble particles may be recycled and make it into use for new structural applications with variable.

Fig -1: Ceramic Waste after Crushing to 20 mm size

Some ceramics are composed of only two elements. For example, alumina is aluminum oxide, Al 2 O 3; zirconia is zirconium oxide, ZrO2 and quartz Ceramics are good insulators and can withstand high temperatures. A popular use of ceramics is in art work silicon dioxide, SiO2. Other ceramic materials, including many minerals, have complex and even variable compositions. For example, the ceramic mineral feldspar, one of the components of granite, has the formula KAlSi3 O 8. The chemical bonds in ceramics can be covalent, ionic, or polar covalent, depending on the chemical composition of the ceramic. When the components of the ceramic are a metaland a nonmetal, the bonding is primarily ionic; examples are magnesium oxide (magnesia) MgO, and barium titanate (BaTiO3). In ceramics composed of a metalloid and a nonmetal, bonding is primarily covalent; examples are boron nitride, BN, and silicon carbide, sic. Most ceramics have a highly crystalline structure, in which a three-dimensional unit, called a unit cell, is repeated throughout the material. For Example, magnesium oxide crystallizes in the rock salt structure. In this structure, Mg 2+ ions alternate with O 2− ions along each perpendicular axis.

II. LITERATURE REVIEW

Many scholars have conducted tests on effect of acid on ceramic aggregate concrete. Some of the results obtained are as follows:

B. Madhusudhan Reddy, H.SudarsanaRao and M.P.George (2012) studied on Effect of Hydrochloric acid on Blended Cement and Silica fume blended cement and their concreters. Based on the test results it was concluded that both initial and final setting times of BC and SFBC got retarded with an increase in hydrochloric acid concentration in deionised water. Compressive strength of BC and SFBC decreased with an increase in concentration of HCl.

Girardi F and Di Maggio (2011) proposed on resistance of concrete mixtures to cyclic sulfuric acid exposure and mixed sulfates. Six concrete pipes were casted according to the EN standards, Chemical test was conducted as cyclic immersion in the solution of sulfuric acid solution with pH value 2, the specimens showed a constant decrease in mass. The mass loss was due to the reaction of the acid solution with the alkaline substances in the concretes.

Said et al. (2010) reported on influence of natural pozzolana on the behavior of self compacting concrete under sulphuric and hydrochloric acid attacks. Self compacting concrete with lime stone filler addition of 30% and 50%, the specimens lost their cube shape when placed in 5% of HCl solution.

Pengfei Huang et al. (2005) studied on influence of HCl corrosion on the mechanical properties of concrete. The diffusion rate, of chloride ion had significant effect on the corrosion resistance of concrete to HCl. Based on the results, the diffusion coefficient of chloride ion decrease with increasing strength grade of concrete and implied that the normal strength concrete showed greater mass loss caused by HCl corrosion. Compressive strength was linearly varied with days of curing from 28 days to 360 days, these results are obtained without HCl impact. Based on the test results, strength loss increases with increasing the HCl content. Mass loss of the normal concrete was more serious than that of high strength concretes.

Kilinckale (1997) studied on the effect of $MgSO_4$ and HCl solutions on the strength and durability of Pozzolana cement mortars. Mortar specimens were cured in 5% $MgSO_4.7H_2O$ and in HCl (pH-2) by adding silica fume, rice husk ash, blast furnace slag, and fly ash content of 20% as pozzolana in cement mortars. Among the mortars stored in HCl solution, weight loss was observed for silica fume and fly ash mortars.

III. TEST ON MATERIALS

The present chapter deals with the properties of concrete materials used in the experimentation work and mix design procedure. The materials used for the experimentation is cement, fine aggregate, coarse aggregate, water and ceramic waste aggregate. This chapter emphasis on testing of all concrete materials, comparison with standard values and concluded whether the materials are suitable for usage into concrete or not.

Table -1: Experimental results on Cement

SI .No	Tests	Experimented values	Suggested values as per IS specification
1	Fineness of cement	4%	< 10%
2	Normal consistency	30%	---
3	Specific gravity	3.05	< 3.15
4	Initial setting time	75 min	Min of 30 min
5	Final setting time	265 min	Max of 10 hrs

A. CERAMIC WASTE AGGREGATE

Ceramic waste aggregate is procured from waste dump at VV Electricals-Gudur. The properties of ceramic aggregate such as specific gravity, water absorption, impact value, crushing value, abrasion value are determined and the results are tabulated in Table-2.

Table -2: Physical Properties of Ceramic aggregate

Sl.No	Property	Value
1	Specific Gravity	2.50
2	Water absorption in %	0.18
3	Impact value in %	22
4	Crushing value in %	20
5	Abrasion value in %	19
	Fig. 2. Bulk density kg/m^3 Loose condition Dense condition	Fig. 3. 1069 1188

B. CERAMIC WASTE AGGREGATE

Based on the experimental results of available concrete ingredients surrounded by a Gudur town, design mix has been prepared as 0.45:1:1.5:3 and cubes were casted for evaluating the strength of ceramic concrete. From the above results of concrete materials, those are safe and allowable to use in concrete composition because of its properties.

IV. WORKABILITY OF CONCERETE

A. WORKABILITY

Workability of a concrete is a term which consists of the following four partial properties of concrete namely mix ability, transportability, mould ability, and compact ability. Cohesiveness and consistency both are concurrent properties of fresh concrete. Cohesiveness is a measure of the compact ability and finish ability of concrete. Consistency is requirement of water to mix the concrete properly.

B. TESTS ON WORKABILITY OF CONCRETE

Workability of concrete is determined by Slump cone test, Compaction factor test.

1) SLUMP CONE TEST

Workability of fresh concrete shall be carried out by performance of slump test. Slump value can be carried out according to the IS: 1199-1959. To determine the consistency or workability of ceramic concrete, slump cone test has been performed in the laboratory. Before conducting the experiment, apply demould agent i.e.., oil/grease inside the cone for avoidance of further sticking of the fresh concrete. Unsupported fresh concrete flows to the sides and a sinking in height takes place. The vertical settlement is known as slump. In this test, fresh concrete is filled into a cone of one third height and apply 25 blows uniformly on surface of the concrete according to the specifications. Blows are applied uniformly on the surface of the concrete mix to avoid unsettlement of mix. Remaining portion of cone is filled with fresh concrete and make the surface of the cone plain with tamping rod. Slump fall is measured when supporting cone is lifted up. If the mix is too wet, leads to collapse. A workable concrete should not show any segregation or bleeding. The slump cone apparatus is shown in fig.4.1 and measurement of slump is shown in fig.

Fig -2: Slump Cone Apparatus

Fig -3: Measurement of slump

2) COMPACTION FACTOR TEST

Workability of concrete is also determined by compaction factor. Generally, for low workability concrete it requires the compaction by vibrating. This test is originally meant for the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height, here in this experiment standard height is 20.3 cm between the upper and lower hoppers. Demoulding agent is applied inside the hoppers to skid the concrete without applying the force. Compaction factor is the ratio between partially compacted concrete and fully compacted concrete.

V. BEHAVIOUR OF CERAMIC

AGGREGATE CONCRETE UNDER COMPRESSION

A. MIX PROPORTION

Mix proportion of 0.45: 1: 1.5: 3 is chosen according to its ingredients i.e, water, cement, fine aggregate and coarse aggregate.

Water: Locally available bore well water was used for mixing and curing.

Cement: OPC 53 cement was used.

Fine aggregate: Locally available sand passing through 4.75 mm IS sieve and retaining on 2.36 mm IS sieve was used.

Coarse aggregate: Locally available coarse aggregate and ceramic aggregate of size 12 mm and 20 mm are used.

The quantity of materials used for the experimentation of work is tabulated.

Table -3: Quantity of Materials used

Materials (kg)	**Replacement of C.A by Ceramic aggregate**					
	0%	**20%**	**40%**	**60%**	**80%**	**100%**
Cement	10	10	10	10	10	10
Fine aggregate	15.3	15.3	15.3	15.3	15.3	15.3
Natural crushed aggregate	28.8	23.04	17.28	11.52	5.76	0
Ceramic aggregate	0	5.76	11.52	17.28	23.04	28.8

B. CASTING OF CUBES

Mix proportion of 0.45:1:1.5:3 is chosen according to its ingredients i.e, water, cement, fine aggregate, coarse aggregate. For every mix, 6 cubes are prepared to test, each 3 cubes for 7 days and 28 days after curing. Mix the cement and sand with trowel on non-porous plate until uniform colour is achieved. Place the coarse aggregate in the flat surface and place the cement sand mix upon the aggregates and mix the entire materials thoroughly. Then add water to the mixture. The water/cement ratio used in this mix is 0.45.Water is replaced by Hydrochloric acid accordingly in proportions of 5% and 10% respectively. The time of mixing shall be in any case not less than 3 to 5 minutes. Mixing time is the time elapsed between the water is added to the mix and casting of cubes.

1. Apply thin layer of oil to the interior faces of the mould and firmly hold in position by means of suitable clamps.
2. Place the entire quantity of concrete in the cube moulds and compact the concrete for three layers using tamping rod and place the moulds in the vibratory machine for a period of about 1 minute.
3. At the end of vibration, remove the mould together with the base plate from the machine and finish the top surface of the cube mould by smoothing the surface with the blade or trowel. Make identification mark on cubes.
4. Keep the filled moulds in the atmosphere of at least 90% relative humidity for 24 hours in the humidity chamber after completion of vibration.
5. Remove the cubes from the moulds and immediately submerge them in clean fresh water and keep there until taken out just prior to testing.

Fig -4: Cube moulds on Vibratory machine

C. CASTING OF CUBES

Curing is the process of controlling the rate and extent of moisture loss from concrete during cement hydration. Since the hydration of cement does take time days and even weeks rather than hours-curing must be undertaken for a reasonable period of time if the the concrete is to achieve its potential strength and durability. Curing may also encompasses the control of temperature since this effects the rate at which cement hydrates.

Fig -5: Cube moulds allowed drying in moisture for 24 Hours

Fig -6: Curing of concrete specimens in water

D. TESTING OF CONCRETE SPECIMENS

The concrete specimens after curing in water are tested for 7 days and 28 days strength by using Compressive testing machine of 2000 KN capacity.

Compression test is the most common test conducted on hardened concrete, partly because it is easy test to perform and most of desirable characteristic properties of concrete are qualitatively related to its compressive strength. Compression test is carried out on specimens of cubical shape. The size of specimen is 15 x 15 x 15 cm. The cube specimens after curing were placed at the center of the testing machine and the load is to be applied at a rate of 20 KN per minute until the concrete specimen fails under compression. The compressive strength of concrete is calculated by dividing the maximum load at failure by the average cross sectional area.

Fig -7: Compression testing machine of 2000KN

Fig -8: Concrete Specimens after testing

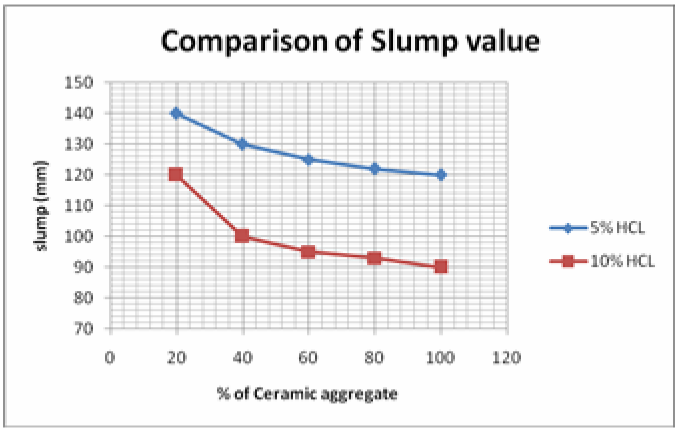
VI. RESULTS & DISCUSSIONS

A. WORKABILITY OF CONCRETE

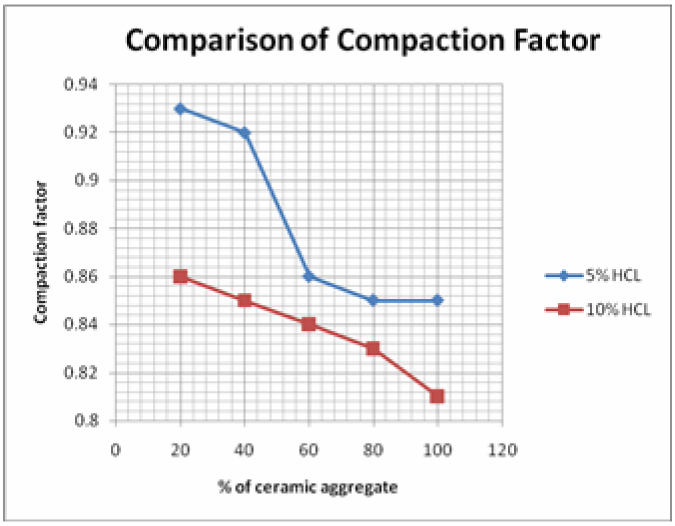
Workability of a concrete is a term which consists of the following four partial properties of concrete namely mix ability, transportability, mould ability, and compact ability. Cohesiveness and consistency both are concurrent properties of fresh concrete. Cohesiveness is a measure of the compact ability and finish ability of concrete. Consistency is requirement of water to mix the concrete properly. Workability of concrete depend not only the properties of concrete but also the nature of application. A very dry concrete seems to be have low workability and too wet condition seems to have high workability, both of these are not enough to improve the good characteristics of concrete. Test results and slump and compaction factor with different replacements of ceramic aggregate and acid.

Table -4: Test results of compaction factor with different replacements for 10% HCl

SI. No	Type of specimens	% of HCl	%replacement of natural coarse aggregate with ceramic aggregate	Compaction factor
1	**NA**	10	0	0.89
2	**CA20**	10	20	0.86
3	**CA40**	10	40	0.85
4	**CA60**	10	60	0.84
5	**CA80**	10	80	0.83
6	**CA100**	10	100	0.81



APH-1: Comparison of slump for 5% and 10% HCL for table 4



GRAPH-2: Comparison of Compaction factor for 5% and 10% HCl for table for 4

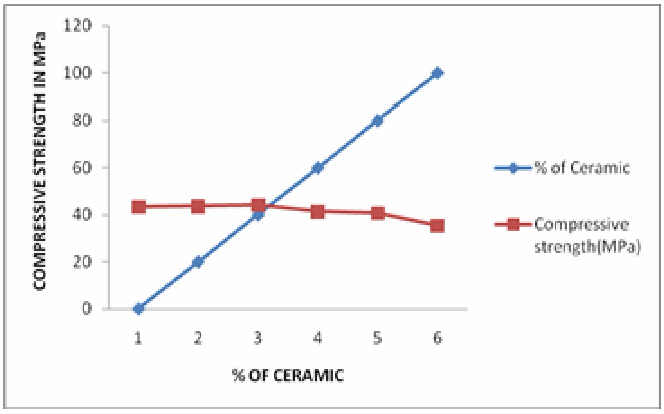
Workability of concrete is determined by its shape, size, surface texture and water absorption. Ceramic waste aggregate possess angular shape and has smooth surface which in turn possess rough surface on crushing. The maximum size of aggregates used is 20 mm. Ceramic aggregate exhibits higher water absorption capacity. Ceramic waste aggregate exhibited 0.18% of water absorption and natural crushed granite aggregate exhibited 0.10% of water absorption. Ceramic concrete exhibited higher moisture content and by which gel pores and cavities could not be filled with sufficient cement paste as compared with reference concrete. The cohesiveness of ceramic aggregate in concrete composition is dipping when the replacement has been increased. Due to the higher angularity, water absorption and surface area of ceramic waste aggregate the slump values decreased. Due to these factors the workability factors such as Slump value and Compaction factor decreased gradually with increase in replacement of natural coarse aggregate with ceramic waste aggregate as well as Hydrochloric acid.

B. COMPRESSIVE STRENGTH

In order to study the behavior of ceramic waste aggregate concrete produced with waste ceramic coarse aggregate in presence of hydrochloric acid by replacing the natural coarse aggregate design mix is prepared for M20 grade. Total 72 cube specimens are casted, among these 12 specimens are casted with natural coarse aggregate (local available machine crushed-Granite) of which 6 specimens are with 5% HCl and 6 specimens with 10% HCl. Remaining samples are casted by replacing natural coarse aggregate with waste ceramic aggregate as 20, 40, 60, 80 and 100% replacement with both 5% and 10% Hcl.6 specimens were casted for each specimen. Ordinary port land cement of 53 grade (Bharathi) from single batch has been used as a binding material in concrete composition. The various parameters like strength of ceramic waste aggregate concrete are studied as per the design mix proportion of 0.45:1:1.5:3. The compressive strength of concrete specimens for 7 days and 28 days was tested and the results are tabulated in table.

Table -5: Compressive strength of Ceramic concrete with 5% acid for Compressive strength of Ceramic concrete with 5% acid for 28 days

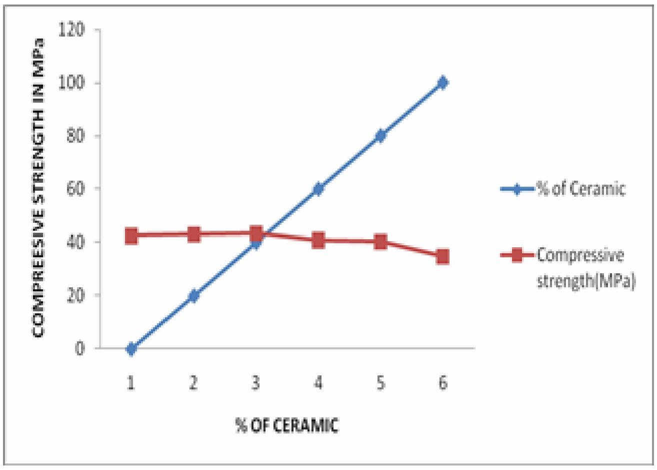
SI.No	% of Ceramic	% of Acid	Compressive strength(MPa)
1	0	5	43.33
2	20	5	43.64
3	40	5	44.08
4	60	5	41.33
5	80	5	40.74
6	100	5	35.41



Graph 3: compressive strength at 5% of HCl for table table 5

Table 6: Compressive strength of Ceramic concrete with 10% acid for 28 days

SI.No	% of Ceramic	% of Acid	Compressive strength(MPa)
1	0	10	42.44
2	20	10	42.88
3	40	10	43.33
4	60	10	40.74
5	80	10	40.15
6	100	10	34.67



GRAPH 4: Compressive strength of Ceramic concrete with 10% acid for 28 days for table 6

CONCLUSIONS

Workability of ceramic aggregate concrete is decreased when the aggregate is replaced with ceramic waste and when the normal water is replaced with hydrochloric acid.

• The slump value has been decreased from 150 mm to 120 mm at 5% addition of HCl. At 10% addition of HCl , the slump has been decreased from 130 mm to 90 mm.

• Compaction factor has been decreased from 0.93 to 0.85 at 5% addition of HCl. At 10% addition of HCl the compaction factor has been decreased from 0.89 to 0.81.

• When normal aggregate is replaced with ceramic aggregate at 20%, 40%, 60%, 80% and 100%, the compressive Strength shows as 43.33 ,43.64, 44.08, 41.33, 40.74 ,35.41 MPa. These values show that compressive strength is reduced to 35.41% at 100% replacement with ceramic waste.

• When normal aggregate is replaced with ceramic aggregate at 20%, 40%, 60%, 80% and 100%, the compressive strength shows as 42.44, 42.88, 43.33, 40.74, 40.15, 34.67Mpa. These values show that compressive strength is reduced to 34.67% at 100% replacement with ceramic waste.

• The average 28 days compressive strength of reference mix at 5% HCl is 44.08 MPa.

• The average 28 days compressive strength of reference mix at 10% HCl is 43.33 MPa.

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