A STUDY ON USE OF CERAMIC AGGREGATE IN CONCRETE WITH HCL

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Abstract - *This project reports the experimental investigation made to study the strength characteristics of ceramic aggregate concrete and effect of acid on ceramic aggregate concrete in fresh and hardened state. Due to the vast usage of concrete, the ingredients of concrete are depleting stage. And the wastage is rapidly increasing due to increasing of industries. So, interest mounting up to use waste materials as alternative aggregates. The main aim of the project is to use ceramic waste effectively as a replacement of natural aggregate.*

This research mainly focus on examine of aggregate properties of ceramic waste and also comparison of properties with natural aggregate. The conclusions which are needed have been taken based on experimental results. Concrete composition is produced with replacing the regular coarse aggregate by crushed ceramic waste with an regular interval of 20% from 0 to 100%. All test results are compared with reference concrete to study the suitability of ceramic aggregate. Also hydrochloric acid is used as replacement of water by 5 and 10 percentages. Finally results are compared with normal concrete.

Key Words: Ceramic waste, Natural aggregate, Strength Characteristics, Hydrochloric Acid, Effect of Acid

1. INTRODUCTION

Concrete is the most commonly used building materials. Concrete is a versatile material that can easily be mixed to meet a variety of special needs and formed to virtually any shape. Around five billion tones of concrete have been used around the world wide every year. 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. In this century, due to its vast usage, concrete ingredients are in depleting stage. So recycling, reuse and substitution of ingredients are one type of the solutions. The use of secondary materials, such as recycled aggregates, might not create a major source of aggregate but if secondary materials were used in demanding situations, the quantity of natural aggregate required by construction industry would be reduced. The use of secondary materials may not completely remove the problem of the resulting shortage of aggregate but it could alleviate it. By substitution of waste material in the preparation of concrete is a new concept for diminution of waste.

From the last decade, construction industry has been conducted research on the utilization of waste products in concrete. Some of waste products are fly ash, rice husk ash, discarded tires, plastic, glass rock, steel slugs, stone dust and ceramic waste. Each waste product has its specific effect on properties of fresh and hard concrete. The use of waste products in concrete not only makes it economical but also solves some of the problems. there is exhaustion of coarse aggregate has been takes place, so, to preserve the natural coarse aggregate, the use of crushed ceramic aggregate can be used to produce lightweight concrete without affecting strength.

Fig -1: Crushed Ceramic Waste

A ceramic material is an inorganic, non-metallic, often crystalline oxide, nitride or carbide material. Some elements, such as carbon or silicon, may be considered ceramics. Ceramic products are part of the essential construction materials used in most buildings. Some common manufactured ceramics include wall tiles, floor tiles, sanitary ware, household ceramics and technical ceramics. Among these, ceramic waste aggregate was generated in huge quantity because of its higher quantity usage. This ceramic waste was produced from ceramic industries, construction demolition waste. About 30% of waste is generated in ceramic industries during the manufacturing, transportation and usage. The amount of quantity of wastage is more due to its brittle nature. Ceramic coarse aggregate originated in the industrial waste and ceramic blocks crushing presents a shape coefficient similar to that of coarse aggregate obtained in the crushing of limestone. The main aim of our work is to effectively use crushed ceramic waste as a replacement. Concrete containing ceramic waste as coarse aggregate offers dual advantage of replacement of natural aggregates and helps to dispose unwanted waste material.

2. LITERATURE REVIEW

E.Arunakanthi, H.SudarsanaRao and **I.V.Ramana Reddy** (2012) studied on effect of Hydrochloric Acid in mixing and curing water on strength of high-performance metakaolin concrete. Ordinary Portland cement is partially replaced by 20% of metakaolin by weight and aggressive chemical environment is simulated by subjecting the concrete to different concentrations of Hydrochloric acid in deionised water during mixing and curing. It was observed that the compressive strength increased with replacement of cement by Metakaolin and compressive strength decreased continuously with increase in concentration of HCl.

Milica et al. (2011) experimented on durability of sulfur concrete in various aggressive environments. Sulfur concrete specimens were prepared with sulfur, aggregate, and various fillers with talc and micro silica. Specimens were cured in 10% of HCl, after 60 days of curing period, mass loss was increased 20% and similarly for the progress of curing period, subsequently compressive strength loss was more when samples were cured in HCl as compared with H2SO4.

Ilangovana R et al. (2008) reported on Strength and durability properties of concrete containing quarry rock dust as fine aggregate in concrete composition. The durability of rock quarry dust concrete under sulphate and acidic action was more inferior to the conventional concrete.

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.

Soon-Do Yoon and **Yeon-Hum Yun** (2008) studied on chemical durability of glass - ceramics obtained from waste glass and fly ash, the specimen was immersed into 20 ml of acid solution for a period of 48 hrs and tested the compressive strength values, that could be varied as 236.4 to 279.7 MPa, before immersion into the HCl and after immersion in acid the values were 192.1 to 248.6 MPa. Bending strengths were 72.8 to 94.9 Mpa before and after immersion it was 55.3 to 72.6 MPa.

Nevi Yalcin et al. (2000) suggested on utilization of bauxite waste in ceramic glazes. The resistance to 3% of HCl solution of the glazed sample was positive. Few glazes protected their colors and glosses. All glazes were resistant to a test made with 3% NaOH solution and no change was observed in color and glazes.

3. EXPERIMENTAL STUDY

3.1 Materials

Cement: In this investigation, Ordinary Portland cement 53 grade conforming to IS:12269 was used. It was tested for physical properties according IS: 8112 – 1989.

Fine Aggregate: The locally available sand conforming to grading as zone-II according to the IS: 383-1970 which passes through in between 4.75mm to 2.36mm IS sieve has been used as Fine aggregate for this experimentation.

Natural Coarse Aggregate: Crushed granite aggregate available from local sources has been used .The size of coarse aggregate is in between 12mm to 20mm has been used as Coarse aggregate for this experimentation.

Water: Locally available bore well water is used for the experimentation and curing purpose. The water is free from any contamination, substance and other organic matter.

HCl: Hydrogen chloride, also known under the name HCl. Hydrogen chloride is a monoprotic acid, which means it can dissociate(i.e., ionize) Hydrochloric acid is a strong corrosive acid. It is formed by dissolving hydrogen chloride in water. It has a pH value less than 7.

Crushed Ceramic Aggregate: Crushed Ceramic 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-1

3.2 Mix Proportion

Table -1: Comparison of Coarse Aggregate

Sl. No	Property	Crushed Ceramic Aggregate (Insulator bush)	Crushed aggregate (Granite)
1	Specific Gravity	2.50	2.68
2	Water absorption in %	0.18	0.10
3	Impact value in %	22	18.6
4	Crushing value in %	20	15.3
5	Abrasion value in %	19	14.25
6	**Bulk density kg/m³** Loose condition Dense condition	 1069 1188	 1219 1425

Mix design was prepared for M20 grade concrete according to the IS: 10262-2009 and its proportion was 0.45: 1: 1.5: 3 of Water, Cement, Fine Aggregate and Coarse

Aggregate by weight. In the preparation of concrete, natural coarse aggregate was replaced with crushed ceramic waste aggregate at 0, 20, 40, 60, 80 and 100%. The quantity of materials used for the experimentation of work is tabulated in table-2.

Table -2: Quantity Of Materials Used In Kg

Materials		Cement (in Kg)	Fine Aggregate (in Kg)	Coarse Aggregate (in Kg)	Ceramic Aggregate (in Kg)
Replacement of Coarse Aggregate by Ceramic Aggregate	0%	10	15.3	28.8	0
	20%	10	15.3	23.04	5.76
	40%	10	15.3	17.28	11.52
	60%	10	15.3	11.52	17.28
	80%	10	15.3	5.76	23.04
	100%	10	15.3	0	28.8

3.3 Casting of Cubes

Mix proportion is chosen according to table. For every mix, 6 cubes are prepared to test. On this 6 cubes, 3 for 7 days and remaining 3 for 28 days curing. Mix the cement and sand on non-porous plate until uniform colour is achieved and then take the coarse aggregate in the flat surface and place the cement sand mix upon the aggregates. 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.

Take a cube mould of size 15 X 15 X 15 cm, apply thin layer of oil to the interior faces and firmly hold in position by means of suitable clamps. Fill the mould with concrete 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. At the end of vibration, remove the mould 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. Keep the filled moulds in the atmosphere of at least 90% relative humidity for 24 hours in the humidity chamber after completion of vibration. 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 -2: Casting of Cube Moulds

3.4 Curing 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 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. The curing period may depend on the properties required of the concrete, the purpose for which it is to be used. Here we are curing the cubes for 7 days and 28 days according to the tests.

Fig -3: Curing of Concrete Specimens in Water

4. RESULTS AND DISCUSSIONS

4.1 Workability

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

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. measurement of slump is shown in fig-4.

Fig -4: Measurement of Slump

Test results of slump with different replacements of ceramic aggregate and acid are shown in table-3.

Table -3: Test results of slump with different replacements for 5% and 10% of HCl

SI. No.	Type of specimens	Percentage replacement of natural aggregate with ceramic aggregate	Slump value in mm	
			5% Hcl	10% Hcl
1	NA	0	150	130
2	CA20	20	140	120
3	CA40	40	130	100
4	CA60	60	125	95
5	CA80	80	122	93
6	CA100	100	120	90

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.

Test results of Compaction factor with different replacements of ceramic aggregate and acid are shown in table-4.

Table -4: Test results of Compaction Factor with different replacements for 5% and 10% of HCl

SI. No.	Type of specimens	Percentage replacement of natural aggregate with ceramic aggregate	Compaction factor	
			5% Hcl	10% Hcl
1	NA	0	0.93	0.89
2	CA20	20	0.93	0.86
3	CA40	40	0.92	0.85
4	CA60	60	0.86	0.84
5	CA80	80	0.85	0.83
6	CA100	100	0.85	0.81

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 turns possess rough surface on crushing. The maximum size of aggregates used is 20 mm. Ceramic aggregate exhibits higher water absorption capacity..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.

4.2 Compressive Strength

Compression test is the most common test conducted on hardened concrete. Compression test is carried out on specimen of 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 -5: Testing of Concrete Specimen

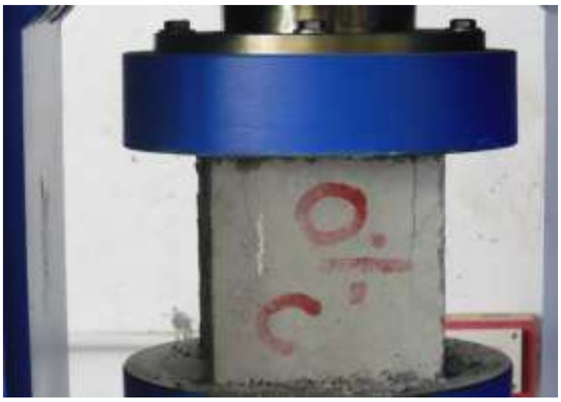


Fig -6: Failure of Concrete Specimen

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-5,6.

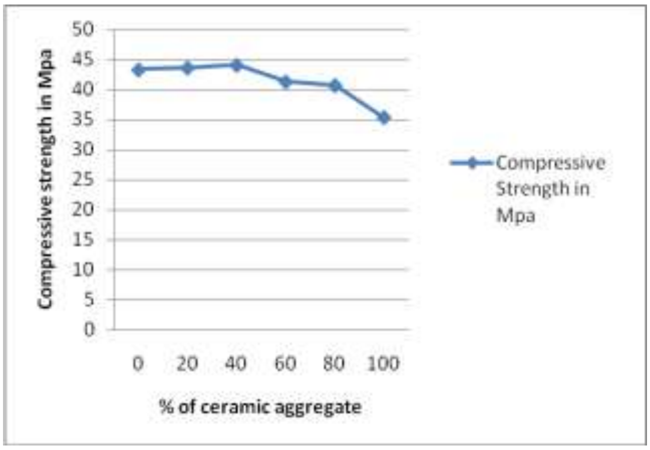
Table -5: Compressive strength of Ceramic concrete with 5% acid for 28 days

Sl. 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

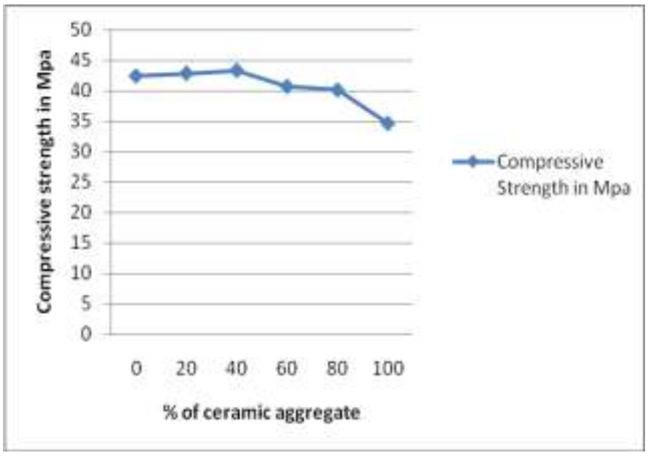
Table -6: Compressive strength of Ceramic concrete with 10% acid for 28 days

Sl. 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

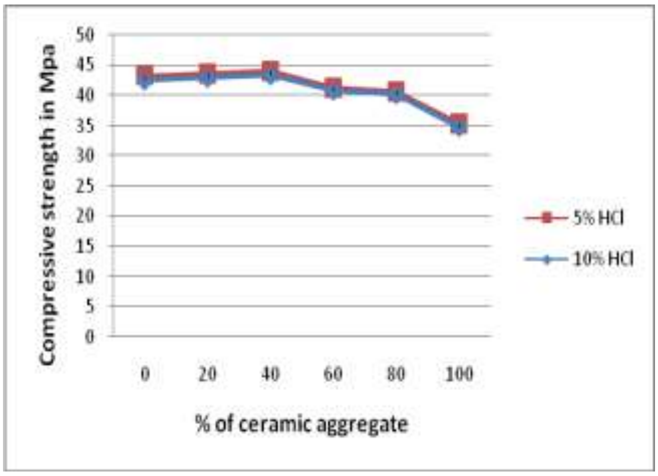
The graphs of compressive strength at various proportions of ceramic aggregate and acid are shown in graphs-1,2,3.



Graph -1: 28 Days compressive strength for 5% HCl



Graph -2: 28 Days compressive strength for 10% HCl



Graph -3: Comparison of 28 Days compressive strength for 5% and 10% HCl

Compressive Strength of concrete depends on strength of aggregate, strength of cement paste and bond strength between cement paste and aggregate. Generally concrete composition occupies 70 to 80% of volume by aggregates. Ceramic coarse aggregate exhibits higher values of impact value, crushing value and abrasion value than crushed granite aggregate. As the replacement of ceramic waste inclusion and acid in concrete preparation increases the compressive strength decreases. The decrease in compressive strength is due to its brittle nature, poor bonding between the cement paste and coarse aggregate.

5. CONCLUSIONS

When the aggregate is replaced with ceramic waste and when the normal water is replaced with hydrochloric acid the workability is decreased.

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

Compaction factor has been decreased from 0.93 to 0.85 at 5% addition of HCl. And from 0.89 to 0.81 at 10% addition of HCl.

The average 7 days compressive strength of reference mix at 5% HCl is 36.67Mpa. And at 10% HCl is 31.55Mpa.

The average 28 days compressive strength of reference mix at 5% HCl is 43.33Mpa. And at 10% HCl is 42.44Mpa.

When normal aggregate is replaced with ceramic aggregate at 20%, 40%, 60%, 80% and 100%. For 7 days,

- at 5% HCl that compressive strength is reduced to 32.32% at 100% replacement.
- at 10% HCl that compressive strength is reduced to 22.37% at 100% replacement.

When normal aggregate is replaced with ceramic aggregate at 20%, 40%, 60%, 80% and 100%. For 28 days,

- at 5% HCl that compressive strength is reduced to 15.83% at 100% replacement.
- at 10% HCl that compressive strength is reduced to 17.09% at 100% replacement.

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