International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || REETA-2K16 ǁ PP. 825-834

A STUDY ON COMPRESSIVE STRENGTH OF CONCRETE REPLACEMENT OF COARSE AND FINE AGGREGETE BY STEEL SLAG AND QUARRY DUST

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Abstract: Global warming and environmental destruction have become the major issue in recent years. Use of more and more environmental friendly materials in any Industry in general and construction industry in particular, is of paramount importance. Crushed sand as a replaced material to natural sand has become beneficial and is common in the world. This helps in reducing the likely damage to the ecological balance due excessive sand lifting from river beds, affecting the ground water level. Preventing the depletion of natural resources and enhancing the usage of waste materials has become a challenge to the scientist and engineers. The world steel industry produces about 780 Mt of crude steel and an average of about 400 Kg of solid by products is generated in the steel industry per tonne of crude steel. The present investigation deals with usage of steel slag as a partial replacement coarse aggregate and quarry dust to fine aggregate respectively. Initially the optimum percentage steel slag and quarry dust to be replaced is found out by conducting 7days and 28 days compressive strength on cubes of size 150 mm x150mmx150mm with 20%, 40%, 60%, 80% and 100% replacement of coarse aggregate by steel slag and fine aggregate by quarry dust.

To study the strength loss, weight loss characteristics of concrete. Thus, needful conclusions have been drawn based on the experimental results. A new concrete composition is produced with replacing the natural coarse aggregate by ceramic waste aggregate at 20%, 40%, 60%, 80% and 100% replacement with both 5% and 10% Hcl. All test results of ceramic aggregate concrete are compared with reference concrete by which it concludes the suitability of ceramic aggregate into the concrete.

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 and now the per capita consumption is reached to more than 2 kg. 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 and effective economy.

By different ingredients of concrete, depending upon the purpose and use, the properties of concrete can also be changed or varied. It‗s usage in infrastructural development after independence in India was massive. Since the shielding ability and attenuation capacity are not influenced by the type of material and it depends on density of concrete, it is essential to increase the mass of concrete per the unit of the purpose of radiation attenuation and resistance to heavy machinery. Concrete has relatively high compressive strength but very low tensile strength. For this reason, it is usually reinforced with materials to makes strong in tension (often steel). Concrete can be damaged by many processes, such as the freezing of trapped water, permeability in concrete composition. To overcome the damage of concrete, proper quality of ingredients shall be used in the concrete composition. In this century, everywhere choosing concrete, so, due to its vast usage, concrete ingredients are in depleting stage. By this way quality of concrete production is quite difficult due to lower quantity of quality ingredients, so recycling, reuse and substitution of ingredients are one type of the solutions. Recycling is one of the better options and research work was stared on recycled aggregates. The strength of the concrete composite is based on the strength of different constituents used in the preparation of concrete. 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.

Materials and Methods

Cement

The Ordinary Portland Cement is generally classified into three grades, they are 33 grade, 43 grade and 53 grade. In this study OPC 53grade has been used. Brand used is Zuari cements OPC 53grade cement and its properties are,

Table1: properties of cement

S .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

Fine aggregate

Fine aggregate is defined as material that will pass through 4.75mm sieve and will for the most part, be retained on a 75µ sieve. For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent and its physical properties are,

Table 2: physical properties of Fine aggregate

S. No.	Property	Value
1	Specific gravity	2.62
2	Fineness Modulus	2.59
3	Grading	Zone –II

Coarse Aggregate

Coarse aggregate consists of crushed stone with particle size equal to or greater than 4.75mm. It shall comply with the requirements of [9]. In this research coarse aggregate of maximum size 10 mm for paver block and 20mm for cube was used and the specific gravity is 2.71.

Steel slag

Steel slag is an industrial by-product obtained from the steel manufacturing industry. It is produced in large quantities during the steel-making operations Steel slag can be used in the construction industry as aggregates in concrete by replacing natural aggregates. Fig.2 shows the induction furnace steel slag sample and table.1 shows the properties of steel slag.

Fig 1: Steel slag sample

Table3: Comparison of coarse aggregate

S. No	Property	Steel slag Aggregate	Crushed aggregate (Granite)
1	Specific Gravity	3.6	2.68
2	Water absorption in %	0.18	0.10
3	Impact value in %	22	8.6
4	Crushing value in %	20	15.3
5	Abrasion value in %	19	14.25

Properties of quarry dust

The manufactured sand has required gradation of fines, physical properties such as shape, smooth surface textures and consistency which make it the best sand suitable for construction. These physical properties of sand provide greater strength to the concrete by reducing segregation, bleeding, honeycombing, voids and capillary. Thus required grade of sand for the given purpose helps the concrete to fill voids between coarse aggregates and makes concrete more compact and dense, thus increasing the strength of concrete. Fig 2 shows M sand.

Fig2: Quarry Dust

Table: 4 showing the physical properties of quarry dust and natural sand.

Property	**Quarry dust**	**Natural sand**	**Test method**
Specific gravity	2.62	2.60	IS2386(part III)
Bulk density	1750	1475	IS2386(part III)
Absorption	1.25	Nil	IS2386(part III)
Moisture content	Nil	1.5	IS2386(part III)
Fine particles lessthan0.075mm	13	6	IS2386(part III)
Sieve analysis	Zone-II	Zone-II	IS383-1970

Mix proportion

Mix proportion of 0.48: 1: 1.53: 2.88 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 grade of BHARATHI 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.

Table 5 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

RESULTS AND DISCUSSIONS

Workability of concrete

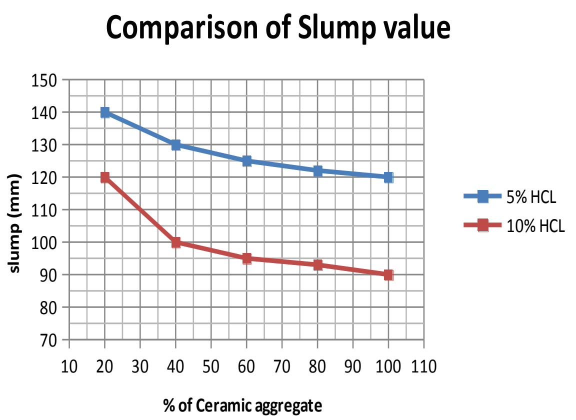
1) **Slump test**

Table 7: Test results of slump with different replacements for 5% Hcl

S. No	Nomenclature	% of Hcl	Percentage replacement of natural coarse aggregate with ceramic waste aggregate	Slump value in mm
1	**R**	5	0	150
2	**CWAC20**	5	20	140
3	**CWAC40**	5	40	130
4	**CWAC60**	5	60	125
5	**CWAC80**	5	80	122
6	**CWAC100**	5	100	120

Table 6 Test results of slump with different replacements for10% Hcl

SI.No	Nomenclature	% of Hcl	Percentage replacement of natural coarse aggregate with ceramic waste aggregate	Slump value in mm
1	**R**	10	0	130
2	**CWAC20**	10	20	120
3	**CWAC40**	10	40	100
4	**CWAC60**	10	60	95
5	**CWAC80**	10	80	93
6	**CWAC100**	10	100	90



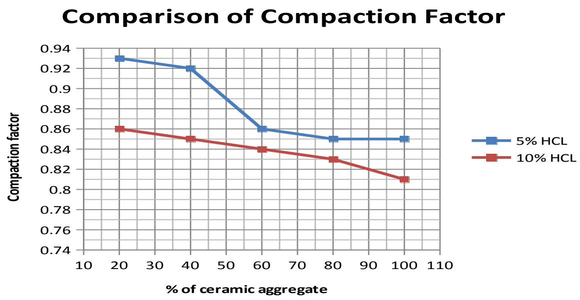
Graph1: Test results of compaction factor with different replacements for 5% Hcl

Table 8: Comparison of Compaction factor for 5%

SI. No	Nomenclature	% of Hcl	Percentage of replacement of natural coarse aggregate with ceramic aggregate	Compaction factor
1	**R**	5	0	0.93
2	**CWAC20**	5	20	O.93
3	**CWAC40**	5	40	0.92
4	**CWAC60**	5	60	0.86
5	**CWAC80**	5	80	0.85
6	**CWAC100**	5	100	0.85

Table 9: Test results of compaction factor with different replacements for 10% Hcl

SI. No	Nomenclature	% of Hcl	Percentage of replacement of natural coarse aggregate with ceramic aggregate	Compaction factor
1	**R**	10	0	0.89
2	**CWAC20**	10	20	0.86
3	**CWAC40**	10	40	0.85
4	**CWAC60**	10	60	0.84
5	**CWAC80**	10	80	0.83
6	**CWAC100**	10	100	0.81



Graph 2: Comparison of Compaction factor for 5% and 10% HCL

Comparison of test results with reference concrete

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 M_{20} 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%.

Fig 3(a) Casting of cubes

Fig 3(b) Compression testing of cubes

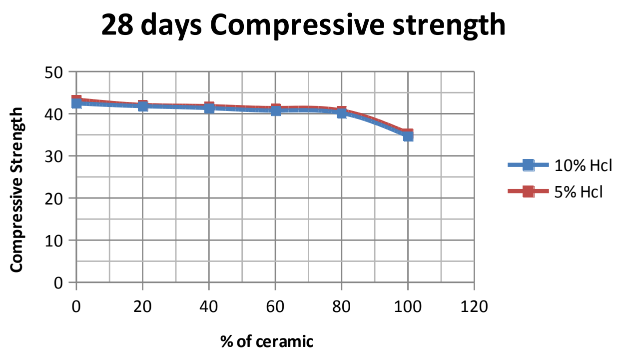
Help of hydraulic pumps until the dial gauge reading get reverses its direction of motion. The reversal of needle indicates the total failure of the specimen. The dial gauge reading is noted at the instant of failure, which is ultimate failure load of specimen. The compressive strength is calculated as,
Compressive strength = Maximum Load (N) /Plan area (mm^2).

Table 10: Compressive strength of Ceramic concrete with 5% acid for 28 days

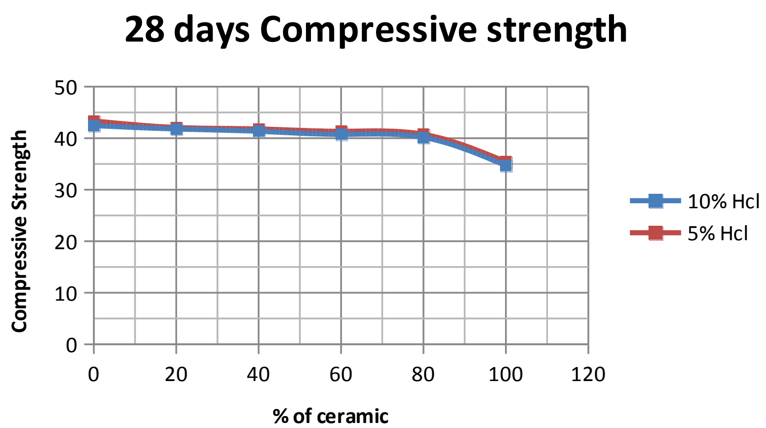
S. No	**% of Ceramic**	**% of Acid**	**Weight (gm)**	**Load(KN)**	**Compressive strength(MPa)**
1	0	5	8415	975	43.33
2	20	5	8395	945	42.07
3	40	5	8212	940	41.78
4	60	5	8138	930	41.33
5	80	5	8004	915	40.74
6	100	5	7889	795	35.41

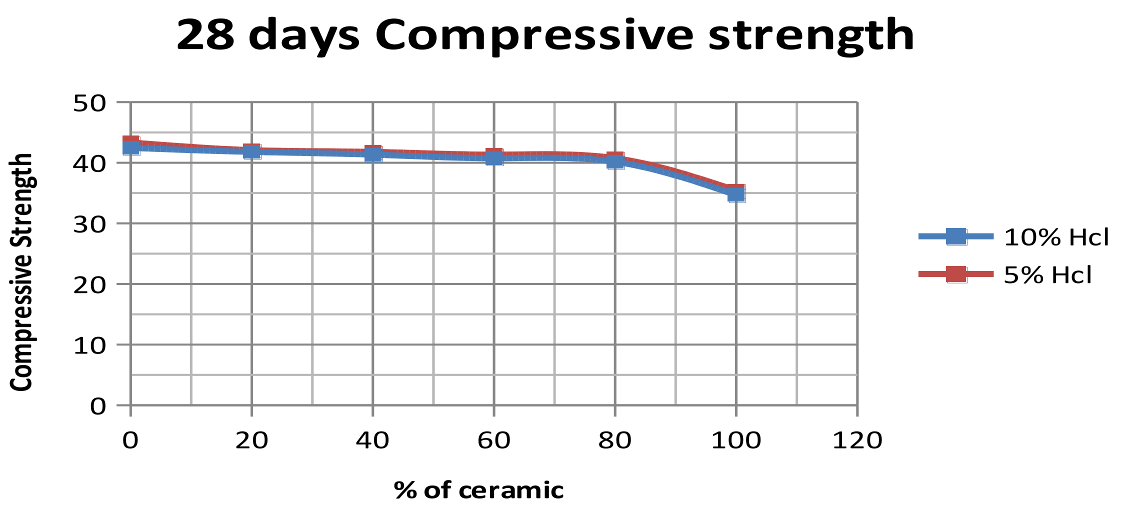
Table 11: Compressive strength of Ceramic concrete with 10% acid for 28 days

S.No	**% of Ceramic**	**% of Acid**	**Weight (gm)**	**Load(KN)**	**Compressive strength(MPa)**
1	0	10	8423	955	42.44
2	20	10	8206	940	41.78
3	40	10	8198	930	41.33
4	60	10	8135	915	40.74
5	80	10	8018	900	40.15
6	100	10	7959	780	34.67



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

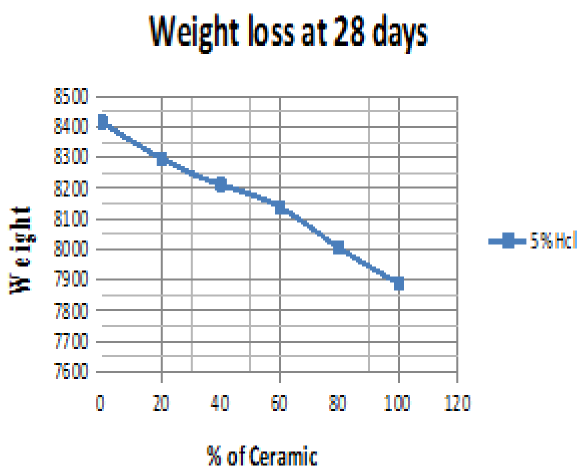




Weight Loss:

Table 12: Weight Loss of Ceramic concrete with 5% acid for 28 days

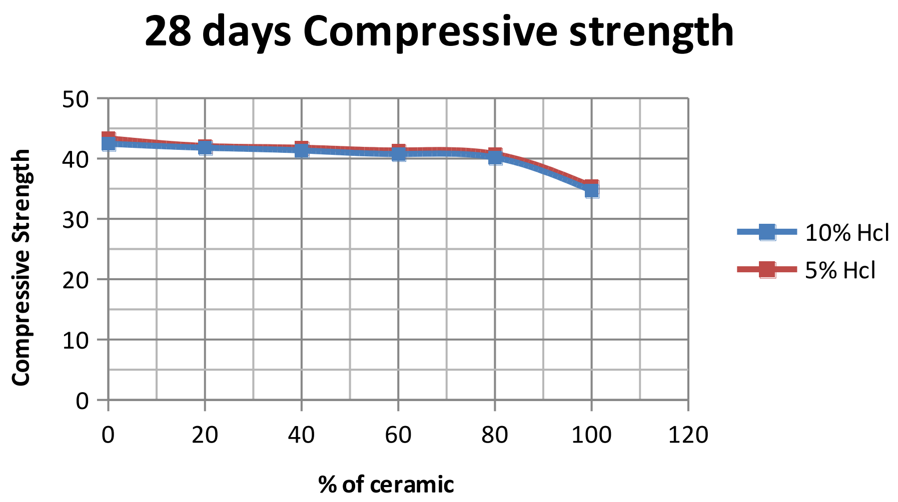
S. No	% of Ceramic	% of Acid	Weight (gm)
1	0	5	8415
2	20	5	8295
3	40	5	8212
4	60	5	8138
5	80	5	8004
6	100	5	7889

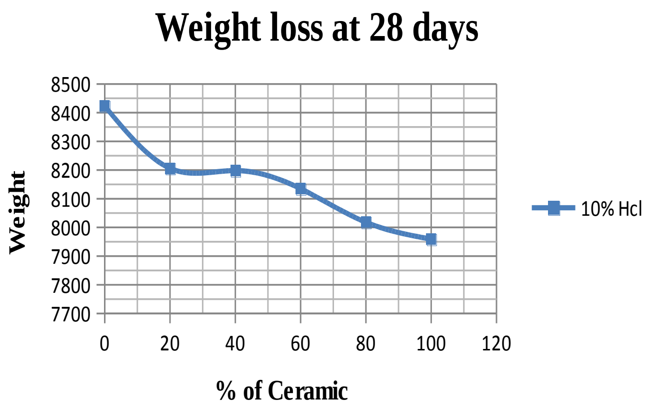


Graph 4: Weight loss of ceramic concrete with 5% Hal at 28 days

Table 13: Weight Loss of Ceramic concrete with 10% acid for 28 days

S. No	% of Ceramic	% of Acid	Weight (gm)
1	0	10	8423
2	20	10	8206
3	40	10	8198
4	60	10	8135
5	80	10	8018
6	100	10	7959





Graph 5: Weight loss of ceramic concrete with 10% Hal at 28 days

Conclusion:

Workability:

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.

Slump value

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

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.

7 days Compressive strength

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

At 5% Hcl

When normal aggregate is replaced with ceramic aggregate at 20%, 40%, 60%, 80% and 100%, the compressive strength shows as 35.11, 32.89, 29.04, 25.78 and 23.41 Mpa. These values show that compressive strength is reduced to 32.32% at 100% replacement with ceramic waste.

At 10% Hcl

When normal aggregate is replaced with ceramic aggregate at 20%, 40%, 60%, 80% and 100%, the compressive strength shows as 29.77, 28.14, 26.67, 24.74 and 23.11 Mpa. These values show that compressive strength is reduced to 22.37% at 100% replacement with ceramic waste.

28 days Compressive strength

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

At 5% Hcl

When normal aggregate is replaced with ceramic aggregate at 20%, 40%, 60%, 80% and 100%, the compressive strength shows as 42.07, 41.78, 41.33, 40.74 and 35.41Mpa. These values show that compressive strength is reduced to 15.83% at 100% replacement with ceramic waste.

At 10% Hcl

When normal aggregate is replaced with ceramic aggregate at 20%, 40%, 60%, 80% and 100%, the compressive strength shows as 41.78, 41.33, 40.74, 40.15 and 34.64 Mpa. These values show that compressive strength is reduced to 17.09% at 100% replacement with ceramic waste.

7.1.1 Weight loss

At 5% Hcl the weight loss of ceramic aggregate concrete at 7 days and 28 days was found to be 0.96% and 6.02% respectively. At 10% Hcl the weight loss of ceramic aggregate concrete at 7 days and 28 days was found to be 4.62% and 2.76% respectively.

References :

[1]. Ilangovana.R, et al., “Strength and durability properties of concrete containing Quarry rock dust as fine Aggregate” ARPN Journal of Engineering and Applied Sciences, 2008,3, 20-26.

[2]. Khidhair J. Mohammed, et al., “Using of steel slag in modification of concrete properties” Eng. & Tech. Journal, 2009, 27.

[3]. Mohanraj.E.K. et al., “Study on concrete using waste materials by partial replacement of aggregates to reduce global warming gases” Indian journal of science and technology, 2011, 4, 1899-1905.

[4]. Mohammed Nadeem and Arun D.Pofale ”Utilization of Industrial waste slag as aggregate in concrete applications by Adopting Taguchi‟s for Optimization” Open Journal of civil Engineering 2012, 2, 96-105.

[5]. Priyanka, et al., “ An Experimental investigation on the properties of concrete containing manufactured sand” International Journal of Advanced Technology, 2012,3,101-104.

[6]. Adams Joe .M, et al., “Experimental Investigation on the effect of M-Sand In High performance concrete” American journal of engineering research, 2013,2, 46-51.

[7]. Arivalagan. S “Evaluate the properties of concrete using Manufacturing sand as fine aggregate” World

[8]. Journal of Engineering Science, 2013,02, 166-175.

[9]. Chinnaraju.K, et al., “Study on concrete using steel slag as coarse aggregate replacement and eco sand as fine aggregate” International journal of research in engineering and advanced technology,2013, 1,1-6.

[10]. IS 383-1970 Indian standard specification for coarse and fine aggregates from natural sources for concrete.

[11]. IS 10262-2009 Indian standard concrete mix proportioning

[12]. IS 15658-2006 Indian standard precast concrete blocks for paving .