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Replacement of Cement and Fine Aggregate by Ceramic Powder and Copper Slag in Concrete

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Abstract

Concrete, a homogeneous mixture of cement, fine aggregate, coarse aggregate and water is widely been used in construction activities. But cement and fine aggregate are becoming consequently costlier and their demand also increases every day. Meanwhile, industrial waste from manufacturing units also increases. On behalf ofutilization of industrial waste as well to minimize the construction material cost, some materials can replace the by-product of concrete. In this study we have chosen ceramic powder and copper slag as a replacement of cement and fine aggregate. More studies were carried out replacing cement but ceramic powder and replacing fine aggregate by copper slag separately. From the literature review we can to know maximum percentage of replacement of ingredients. In this study, different mix proportions were carried out by replacing different percentage of ceramic powder and copper slag. From the experimental results, it was observed that compressive strength was increased about 36%, when compared to conventional concrete.

Keywords: Ceramic Powder, Compressive Strength, Concrete, Copper Slag, Flexural Strength

1. Introduction

1.1 Concrete

Concrete is a homogenous mixture of Binder (Cement), Fine aggregate and Coarse aggregate with adequate water – cement ratio. It is one of the prime materials used for the construction. Concrete has good compressive strength and they are weak in tension, reinforcements are designed and added to improve the tensile properties of concrete.

Portland cement is most commonly used and they are the basic ingredient of concrete. Cement is manufactured through a closely controlled chemical combination of calcium, silicon, aluminium, iron and other ingredients. Portland cement gets its strength from chemical reactions between the cement and water. The process is known as hydration.

1.1.1 Fine Aggregates

Particles which pass by IS 4.75 mm sieve are considered to be fine aggregate. There are many type of fine aggregate particles used in construction. Sand is most commonly used in making concrete.

1.1.2 Sand

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt.

The most common constituent of sand, in inland continental settings and non-tropical coastal settings, is silica (Silicon dioxide or SiO_2), usually in the form of quartz, which, because of its chemical inertness and considerable hardness, is the most common mineral resistant to weathering.

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1.1.3 Coarse Aggregate

Particles which are retained on IS 4.75 mm are classified as coarse aggregate. Aggregate are granular material, derived from the most part from the natural rocks, crushed stones or natural gravels and sands. Aggregates occupy more volume in making concrete.

1.1.4 Water

Water used in making concrete should be free from impurities and pH of the water should be 6.5–8. It is important that water is added based on the water-cement ratio as adopted in mix design or standards.

1.2 Need for Alternatives

1.2.1 Cement

Carbon concentration in cement spans from approximately 5% in cement structures to approximately 8% in the case of roads in cement. Cement manufacturing releases CO_2 in the atmosphere both directly when calcium carbonate is heated, producing lime and carbon dioxide and also indirectly through the use of energy if its production involves the emission of CO_2.

The amount of CO_2 emitted by the cement industry is nearly 900 kg of CO_2 for every 1000 kg of cement produced. The liberation of CO_2 causes environmental hazards and replacement of cement by an alternative can reduce the impact considerably.

1.2.2 Sand

Sand which was once available abundance in nature has become scarce now. It has become important to find a suitable alternative for sand at the same time, it should be cost effective. Manufactured sand is being used off late for the replacement of sand and also Copper slag is being used in sand as well as partial replacements.

Ceramic powder and Copper slag, both are added as alternatives with varying proportions and tests are carried out to determine their properties, which are then compared with conventional concrete.

Table 1.

Constituents	Content (%)
Al_2O_3	45
SiO_2	52
Fe_2O_3	0.5
TiO_2	<1.5
CaO	<0.5
MgO	<0.3
K_2O	<0.1
Na_2O	<0.2
MnO_2	<0.004

1.3 Choice of Alternative

There are several alternatives being used and found to be effective for partial replacement of the scarce available construction materials and for cost effective construction.

We had chosen Ceramic powder for partial replacement of cement Since the availability is abundance (since they have been used in many forms), they also possess adequate properties and also they are cost effective material, which can be partially replaced with cement.

We have also opted for Copper slag as partial replacement for Fine aggregate, Copper slag can be considered as the left over particles after smelting process and which hardly have any further usage (waste material). They are cost effective and they possess good properties.

Tests results have proved that these alternatives have been good up to certain partial replacement and they have also been cost effective.

2. Ceramic Powder and its Properties

A ceramic is an inorganic, non-metallic solid comprising metal, non-metal or metalloid atoms primarily held in ionic and covalent bonds. Ceramics are generally made by taking mixtures of earthen elements, powders and water and shaping them into desired forms. Once the ceramic has been shaped, it is fired in a high temperature oven known as a kiln. Often, ceramics are covered in decorative, waterproof, paint-like substances known as glazes.

Powdered form of Ceramic raw materials is called as Ceramic Powder and there are several types of Ceramic powder that are available. Ceramic powder used in this project, as partial replacement of cement is KAOLIN (Ceramic Powder).

- Kaolin is one of the types of ceramic powder. It is also called as Aluminium Silicate Powder.
- Kaolin is obtained from Mineral called Kaolinite, group of common clay minerals that are hydrous aluminium silicates.

2.1 Properties of Kaolin

- The chemical formula for kaolinite as used in mineralogy is $Al_2Si_2O_5(OH)_4$.
- Appearance – White in colour.
- When added to concrete, it makes the paved surface less porous, which minimizes problems with moisture and freezing.
- It also makes concrete more fire resistant and helps to slow the spread of heat and flames.

3. Copper Slag and its Properties

- Copper slag is a by-product created during the copper smelting and refining process.
- The slag serves as a fine or binding agent, which helps hold the larger gravel particles within the concrete

Figure 1. Ceramic powder.

Figure 2. Copper slag.

Table 2. Chemical composition

Content	Percentage (%)
Al_2O_3	3.47
TiO_2	0.60
Fe_20_3	58
SiO_2	34.50
CaO	0.20
MgO	0.90
K_2O	1.02
Na_2O	0.95
Cu	0.42

Table 3. Physical properties

Specification	Content
Specific gravity	3.848%
Hardness	7 Mohr scale
Conductivity Ms/m	4.8
Chloride content	<0.0002
Bulk density	2.051 g/cc

Table 4. Test results compressive strength of cubes (conventional concrete)

Grade of Concrete	No. of Days	Load in (KN)	Compressive Strength (N/mm^2)
M25	7	375.45	16.68
	14	540.28	24.01
	28	630	28

Table 5. Compressive strength of cubes (basic ceramic powder test)

Specimen Identification	Days	Load in KN	Compressive Strength N/Mm^2	Average Compressive Strength N/Mm^2
A	7	633.05	28.13	28.5
		649.35	28.86	
B	7	645.95	28.7	21.85
		314.90	14.99	
C	7	420.35	18.68	21.65
		553.90	24.62	
D	7	477.70	21.23	20.96
		465.85	20.70	

together. When used in this manner, the slag helps to improve the properties of the concrete and also serves as a form of recycling.

- One of the primary advantages to copper slag is the low risk it poses to health and the environment.
- Copper slag also has a high strength-to-weight ratio, making it an effective option in concrete, or as a fill material under the roadway.

3.1 Properties

3.2 Variation of Compressive Strength for Various Proportion Mix of Ceramic Powder and Copper Slag for 7, 14, 28 Days

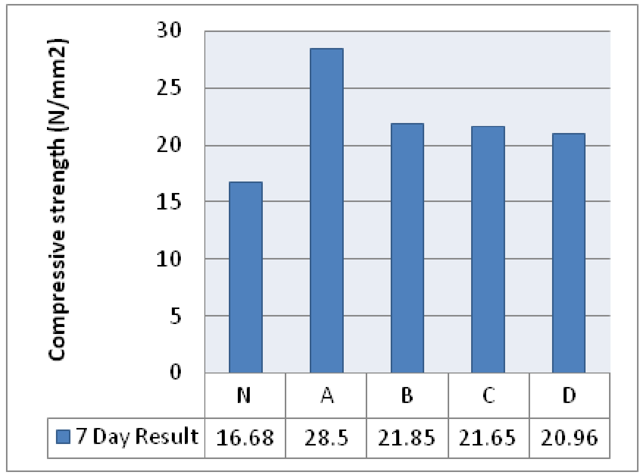

Figure 3. 7th day compressive strength of cubes (basic ceramic powder test).

4. Conclusion

The above experimental data shows that addition of the ceramic powder and Copper slag improves the physical and mechanical properties. These results are of greater importance because this kind of innovative concrete requires large amount of fine particles. As cement cost is going on increasing trend and fine aggregate demand is increasing day by day, the replacement of ceramic powder and copper slag for cement and fine aggregate proves to be economical and an also provides an efficient utilization industrial waste. From the above study, it is concluded that the ceramic powder and copper slag for cement and fine aggregate may be used as a replacement material.

The replacement of cement and fine aggregate with ceramic powder and copper slag gives an excellent result in strength aspect and quality aspect. In this study, the percentage of cement and percentage of fine aggregate is replaced with ceramic powder and Copper slag with different proportions. From the result it was found to be very effective in compression strength and flexural strength when compared with nominal concrete.

The results shows for the above replacement, there is an increase in compressive strength achieved by 36 % of nominal mix (M25).

From the experimental studies, it is suggested that replacement of cement and fine aggregate by ceramic powder for 20% and Copper slag for 40% is effective and can be used in the construction activities.

Table 6. 7 day compressive strength of cube

Specimen Identification	Average Compressive Strength (N/Mm²)
N	23.98
A1	26.44
B1	24.06
C1	24.39
D1	26.24
E1	20.74
F1	24.07
G1	31.42
H1	27.92
I1	29.6
J1	24.05
K1	24.65
L1	32.30

Table 7. 14 day compresive strength of cube

Specimen Identification	Average Compressive Strength (N/Mm²)
N	16.64
A1	19.77
B1	17.83
C1	17.64
D1	20.79
E1	16.13
F1	16.9
G1	26.94
H1	24.51
I1	20.335
J1	22.78
K1	19.30
L1	22.71

Table 8. 28 day compresive strength of cube

Specimen Identification	Average Compressive Strength (N/Mm²)
N	27.99
A1	30.6
B1	26.72
C1	28.74
D1	28.89
E1	26.28
F1	26.73
G1	33.42
H1	36.04
I1	31.19
J1	26.26
K1	24.57
L1	38.02

Table 9. 7 day flexural strength of PRISM

Specimen Identification	Load in KN	Flexural Strength N/Mm²
N	11.5	5.75
A	10	5
B	9.5	4.75
C	13	6.5
D	12	6
E	9	4.5
F	6.5	3.25
G	12	6
H	11	5.5
I	9	4.5
J	12	6
K	12.5	6.25
L	12	6

Table 10. 28 day flexural strength of beam

Specimen Identification	Load in KN	Flexural Strength N/Mm^2
N	14.5	7.25
A	16.5	8.25
B	15	7.5
C	15.5	7.75
D	14	7
E	12	6
F	18.5	9.25
G	16.5	8.25
H	12.5	6.25
I	18.5	9.25
J	18.5	9.25
K	16.5	8.25
L	18.5	9.25

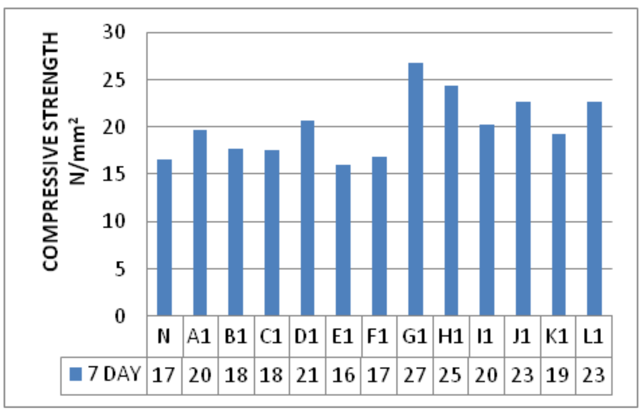

Figure 4. 7th day compressive strength of different proportions.

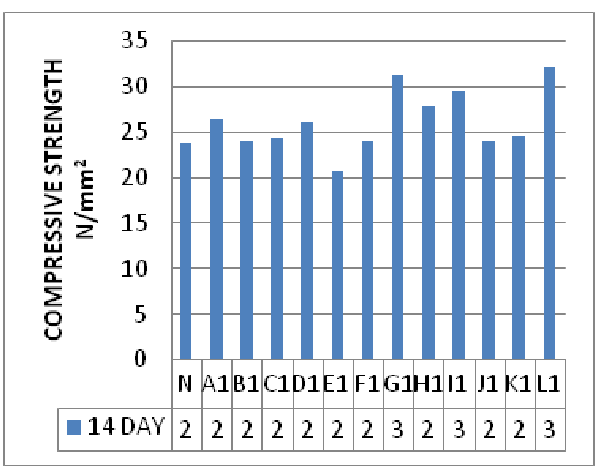

Figure 5. 14th day compressive strength of different proportions.

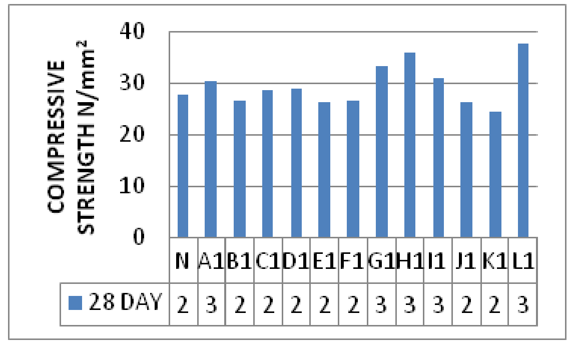

Figure 6. 28th day compressive strength of different proportions.

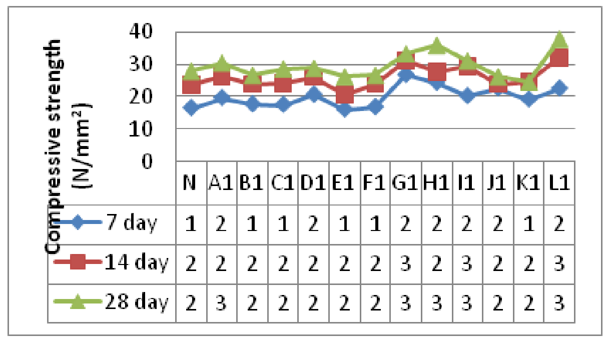

Figure 7. Comparsion of 7, 14 and 28 day compressive strength of different proportions.

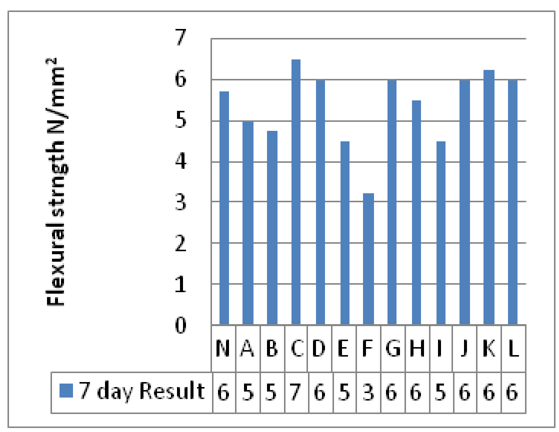

Figure 8. 7th day compressive strength of different proportions.

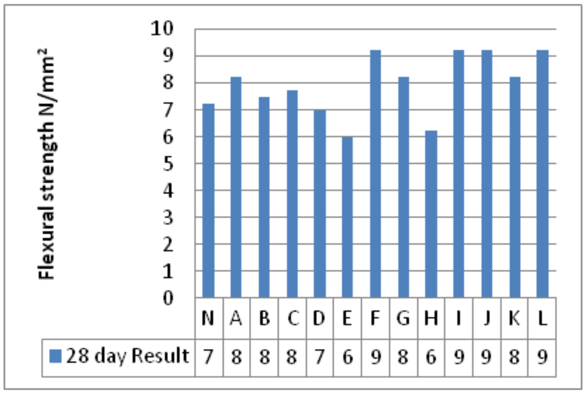

Figure 9. 28th day compressive strength of different proportions.

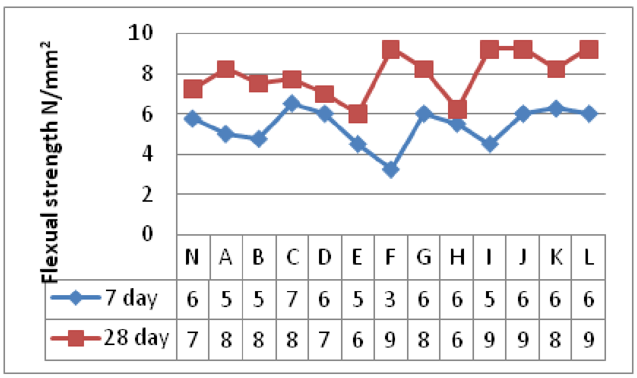

Figure 10. Variation of flexural strength for various proportion mix of ceramic powder and copper slag for 7 and 28 days.

5. References

1. Indian standard plain and reinforced concrete – Code of practice. (IS 456:2000).
2. Kanniga E, Selvaramarathnam K, Sundararajan M. Embedded control using mems sensor with voice command and CCTV camera. Indian Journal of Science and Technology. 2013 Jun; 6(S6):4794–6. ISSN : 0974-6846.
3. Indian standard code of practice for design loads (other than EQ) for building and structures. Part 1.
4. Indian standard code of practice for design loads (other than EQ) for building and structures. Part 2.
5. Indian standard code of practice for design loads (Other than EQ) for building and structures. Part 3.
6. Das MP, Jeyanthi Rebecca L, Sharmila S. Evaluation of antibacterial and antifungal efficacy of Wedelia chinensis leaf extracts. Journal of Chemical and Pharmaceutical Research. 2013 Feb; 5(2):265–9. ISSN: 0975 – 7384.
7. Concrete mix proportioning (IS 10262:2009).
8. Subhashini V, Ponnusamy S, Muthamizhchelvan C. Growth and characterization of novel organic optical crystal: Anilinium d-Tartrate (ADT). Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy. 2012 Feb; 87: 265–72. ISSN: 1386-1425.
9. International Journal of Innovative Technology Exploring Engineering. (LJITEE). 2013 Jul; 3(2): ISSN: 2278-3075.
10. Thomas J, Ragavi BS, Raneesha PK, Ahmed NA, Cynthia S, Manoharan D, Manoharan R. Hallermann-Streiff syndrome. Indian Journal of Dermatology. 2013 Sep-Oct; 58(5):383–4. ISSN: 0019-5154.
11. Subha Palaneeswari M, Ganesh M, Karthikeyan T, Manjula Devi AJ, Mythili SV. Hepcidin-mini review. Journal of Clinical and Diagnostic Research. 2013 Aug; 7(8):1767–71. ISSN: 0973 - 709X.
12. International Journal of Trends and Technology (IJETT). 2013 Jun; 4(6).
13. Kimio T, Natarajan G, Hideki A, Taichi K, Nanao K. Higher involvement of subtelomere regions for chromosome rearrangements in leukemia and lymphoma and in irradiated leukemic cell line**.** Indian Journal of Science and Technology. 2012 Apr; 5(1):1801–11.
14. Cunningham CH. A laboratory guide in virology. 6th ed. Minnesota: Burgess Publication Company; 1973.
15. Sathishkumar E, Varatharajan M. Microbiology of Indian desert. Ecology and Vegetation of Indian desert. Sen DN, editor. India: Agro Botanical Publ; 1990. p. 83-105.
16. Varatharajan M, Rao BS, Anjaria KB, Unny VKP, Thyagarajan S. Radiotoxicity of sulfur-35. Proceedings of 10th NSRP; India. 1993. p. 257–8.
17. 2015 Jan 01. Available from: http://www.indjst.org/index.php/vision