Experimental Investigation on Concrete By Partially Replacement In Cement And Aggregates With Micro Silica, Copper Slag And Insulator Waste

Rajendraprasad.S[1], Arthi.A[2], Anandhi.D[3], Auxiliarani.A[4], Rathimeena.A[5]
[1, 2, 3, 4] Dept of Civil Engineering
[5]Assistant Professor, Dept of Civil Engineering
[1, 2, 3, 4, 5] Achariya College of Engineering Technology, Pondicherry – 605 110.

Abstract- *The development of construction materials have problems and challenge that initiated worldwide research programs. The use of copper slag (CS) and insulator waste (IW) in concrete provides environmental as well as economic benefits for all related industries, particularly in areas where a considerable amount of CS and IW are available. The replacement of cement through some admixtures or other additives to increase the strength is in trend. Micro silica (MS), a very fine non-crystalline material is very good as filler material. CS is the waste material of smelting and refining of copper and IW is the waste material of transformer insulator bush. The basic materials required in the construction of buildings by using concrete are cement and aggregates. The project work deals with conventional concrete of M30 grade and compared with partial replacement of cement and aggregates by using admixture and industrial wastes. The result of concrete is obtained with replacement of MS and CS with cement and sand for various percentage ranging from MS-10% and 20%, CS- 30% and 40%, IW with coarse aggregate of 25% constant specimens where casted and cured for 7,14 and 28 days and tested for compressive strength and tensile strength. The integrated approach of working on safe disposal and utilization can lead to advantageous effects on the ecology and environmental issues.*

Keywords- Cement, Aggregates, Micro silica, Copper slag, Insulator waste, Compressive strength, Tensile strength.

I. INTRODUCTION

Micro silica is a by- product from the silica carbide and metallic industries where it is recovered from exhausts of electric furnaces. Silica fume is an ultrafine air borne material with spherical particles less than 1 µm in diameter, the average being about 0.1µm. silica fume increase the strength of concrete more 25%. Silica fume is much cheaper than cement therefore it is very important form economical point of view. Silica fume also decrease the voids in concrete. The consumption of ceramic materials has building up day by day in the form of tiles, sanitary fittings and other electrical goods like insulators. Crushed insulator bush scrap was used as a coarse aggregate in the present study. This insulator bush was used in manufacturing of transformer. This type of ceramic waste from industries is mounting day by day in processing, transporting and fixing due to its brittle nature. It is reported that toughness and soundness of recycled coarse aggregate is 30% less than the natural aggregate and loss of strength is about 30% as compared to the conventional concrete. Researchers developed waste management strategies to apply for advantages for specific needs. The use of copper slag in concrete provides environmental as well as economic benefits for all related industries, particularly in areas where a considerable amount of copper slag is produced. This work reports an experimental procedure to investigate the effect of using copper slag as partial replacement of sand. To produce every ton of copper, approximately 2.2 to 3 tons copper slag is generated as a by-product material. In Oman approximately 60,000 tons of copper slag is produced every year. Copper slag used in this work was brought from sterlite industries limited (SIL), Tuticorin and Tamil Nadu in India. Currently, about 2600 tons of copper slag is produced per day and a total accumulation of around 1.5 million tons.

II. MATERIAL USED

A. Cement:

Ordinary Portland cement 53 grade from Ramco Cement Company was used for this study. This cement is the most widely used one in the construction industry in India.

B. Coarse and fine aggregates:

Coarse aggregates of 20mm size and fine aggregate of Zone II.

C. Micro silica (MS)

Silica fume, also known as micro silica, is an amorphous (non-crystalline) polymorph of silicon dioxide. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm.

D. Copper slag (CS)

Copper slag from Sterlite Industries India Limited (SIIL), Tuticorinand Tamil Nadu in India was made use of.

E. Insulator waste Aggregate (IWA)

Insulator waste aggregate was collected from waste dump. Insulator bushes were used as a ceramic coarse aggregate as -insulator bushes can be crushed down to a size of 4.75 mm – 20mm.

F. Water

Locally available tap water is used. As per I.S: 456-2000.

III. PROPERTIES OF MATERIAL USED

A. Physical Properties of cement

Property	Value
Specific gravity	3.15
Initial setting time	40 minutes
Fineness of cement	3%

As per IS 269: 2013, the results are within maximum limits.

B. Physical properties of fine aggregate

Property	Value
Specific Gravity	2.31
Water Absorption	0.74%
Fineness Modulus	2.55

As per IS 383: 1970, the results are within maximum limits.

C. Physical properties of coarse aggregate

Property	Value
Specific gravity	2.64
Water Absorption	0.5%
Fineness modulus	2.298
Crushing value	12.42%
Abrasion value	14.5%
Impact value	11.2%

D. Micro Silica

Silica fume also known as micro silica is an amorphous (non-crystalline) polymorph of silicon dioxide as shown in Fig1. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm.

Physical Properties

S.no	Categories	Description
1	Size	Less than 1μ
2	Shape	Spherical

Chemical properties

Sl. no	Ingredients	Percentage
1	Silica	99.886%
2	Alumina	0.043%
3	Ferric oxide	0.040%
4	Calcium oxide	0.001%
5	Titanium oxide	0.001%
6	Potassium oxide	0.001%
7	Sodium oxide	0.003%

Mix Design

Mix Design is carried out by using Indian standard codes i.e. IS 456 -2000, & IS 10262-1982. In my dissertation work I am using M30 grade conventional concrete & the mix details are as follows.

M30 Grade	Cement (kg)	FA (kg)	CA (kg)	Water
Quantity	438.1	654.4	1135.1	186
Proportions	1	1.49	2.59	0.38

% of Replacement

Micro silica	Copper slag	Insulator waste
10%	30%	25%
20%	40%	

% of Trial mixes

Trial Mix	Micro silica	Copper slag	Insulator waste
Trial 1	10%	30%	25%
Trial 2	10%	40%	25%
Trial 3	20%	30%	25%
Trial 4	20%	40%	25%

IV. TESTING RESULT

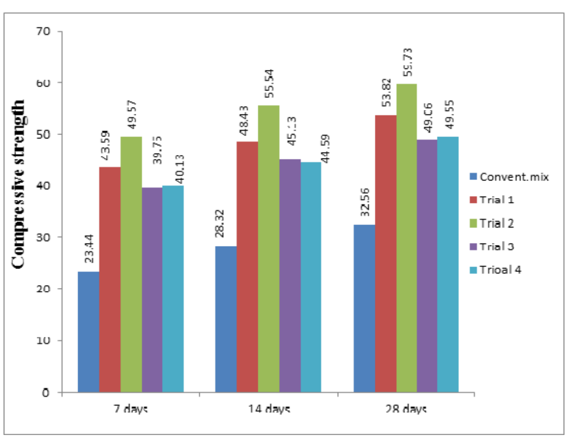
A. Compressive strength Test:

A compression testing apparatus is used to determine the compressive strength of the concrete. The cubes were tested and the ultimate loads were recorded.

Compressive strength = P/A

COMPRESSIVE STRENGTH (N/mm^2)

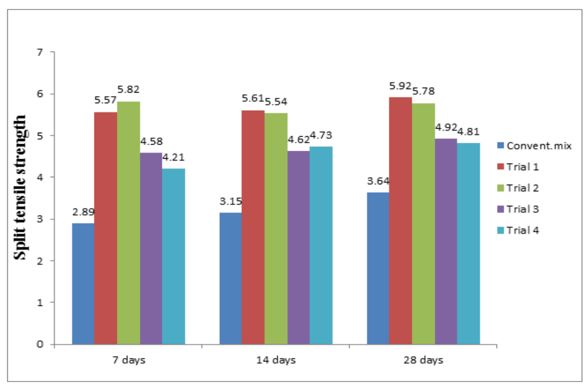
% of Replacement	7 days	14 days	28 days
CC mix	23.44	28.32	32.56
Trial 1	43.59	48.43	53.82
Trial 2	49.57	55.54	59.73
Trial3	39.75	45.13	49.06
Trial 4	40.13	44.59	49.55



B. Split tensile strength test:

To determine the behaviour of materials under axial loading, a split tensile test method is used.
Split tensile strength = 2P/πld

% of Replacement	7 days	14 days	28 days
CC mix	2.89	3.15	3.64
Trial 1	5.57	5.61	5.92
Trial2	5.82	5.54	5.78
Trial 3	4.58	4.62	4.92
Trial 4	4.21	4.73	4.81



V. CONCLUSION

The following conclusions were made based on experimental study:

1. Properties are studied by using MS as replacement for cement and CS as a replacement for FA and IW as a replacement for CA.
2. The various strength parameters such as compressive and tensile of normal concrete in different combination of MS, CS and IW are initially found out by using standard Indian codal provision.
3. Trail 1,2,3,4 mix compressive and split tensile strength was greater than conventional concrete.

4. Trial 2 mix shows higher compressive strength than conventional concrete as 83% and 62.6% in split tensile strength.
5. Further research work is done to check the flexural strength of these materials in their corresponding proportions.

REFERENCES

[1] Al-Jabri K and Makoto Hisada. “Copper slag as a sand replacement for high performance concrete cement and concrete components”, Vol 31, pp. 483 – 488, 2009.
[2] Arivalagan, S., (2013), “Experimental Study on the Flexural behaviour of reinforced concrete beams as replacement of Copper slag as Fine Aggregate”, *Journal of Civil Engineering and Urbanism*, Vol. 3, Issue 4, pp.176-182.
[3] Brindha D, Baskaran T, Nagan.S (2010), “Assessment of Corrosion and Durability Characteristics of Copper slag Admixed Concrete”, *International Journal of Civil and Structural Engineering*, Vol. 1, No. 2, pp – 192 -211.
[4] BinayaPatnaik, SeshatriSekhar T and Srinivasa Rao (2014), “An Experimental Investigation on Optimum usage of Copper slag as Fine Aggregate in copper slag admixed concrete”, *International Journal of Current Engineering and Technology*, Vol. 4, No.5.
[5] IS: 10262-1982(Reaffirmed2004): Recommended guidelines for concrete mix design, Bureau of Indian Standard, New Delhi-2004.
[6] IS:383-1970: Specification for coarse and fine aggregates from natural sources for concrete, Bureau of Indian standard, New Delhi -1970.
[7] IS: 2386(Part I,III)-1963: Methods of test for aggregate for concrete, Bureau of Indian standard, New Delhi-1963.
[8] IS:4031(Part4,5&6)-1988:Methods of physical test for hydraulic cement ,Bureau of Indian standard, New Delhi -1988.
[9] IS:8112-1989(Reaffirmed 2005):specification for 53 Grade ordinary Portland cement,Bureau of Indian standard, New Delhi -2005.