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NON CONVENSIONAL CONCRETE WITH COPPER SLAG AND SISAL FIBER

Ganesh Babu O[1], Saranya A[2], Sashikkumar M C[3], Sakthieswaran N[4]
[1]Department of Civil Engineering, University College of Engineering, Ramanathapuram.
Department of Civil Engineering, University College of Engineering, Nagercoil.
[2]Department of Civil Engineering University College of Engineering,Dindigul.
[3]Department of Civil Engineering, Regional Office, Anna University – Tirunelveli.

ABSTRACT

Natural resources are essential for the development of infrastructures in the construction industry. Nowadays there is more demand for the construction materials like aggregates. The wastes from the industries are also increasing day by day. In order to find better solution for this problem, we have to use the non-conventional, innovative materials and recycling of waste materials. By this, the industrial wastes can be utilized and it also reduces the consumption of natural resources. The increased industrial wastes cannot be controlled due to the increased growth of population. Moreover, the disposal of the industrial wastes is also a problematic one since the availability of land is very less. Therefore, we need to use the industrial wastes in an effective manner. In this Project used copper slag as a replacement for fine aggregateto study mechanical properties (compressive strength, tensile strength and flexural strength) of concrete.In such that, the concrete is also weak in tension, so to solute this problem natural fiber is used.

INTRODUCTION:

Large quantities of industrial by-products are produced every year by various industries. The main goals of environmental protection agencies and Governments are to seek wastes to minimize the dual problems of disposal and health hazards of these by products. Some of the industrial by-products are GGBS, fly ash, silver slag, steel slag, silica fume, etc.. Copper slag is one of the by product obtained during matte smelting andrefining of copper. It has been estimated that for every tonne

of copper production about 2.2 ton of slag is generated is generated and in each year, approximately 24.6 million tonne of slag is generated from world copper production.

The copper slag is obtained as a waste product after undergoing several industrial processes in Sterlite industries, Tuticorin. The copper business in India is held within Sterlite Industries (India) Ltd. There is some captive copper mining, but it is principally concerned in smelting and refining. Sterlite produces finished copper in the form of cathode some of which is then converted to copper rod. The initial process is carried out at the smelter, based at Tuticorin in southern India, and there are refineries and copper rod plants at Tuticorin and Silvassa, in western India. In May 2005 a new 300,000 tpa smelter was commissioned. This replaced the previous smelter which had capacity of 180,000 tpa. The final output of the refining process is in the form of copper cathode. In 2005 – 2006 production in India exceeded 273,000 tones of copper cathode. The production of copper produces several by-products, the most significant being phosphoric acid, used as fertilizer.

The use of sisal, a natural fiber with enhanced mechanical performance, as reinforcement in a cement basedmatrix has shown to be a promising opportunity. In recent years, a great deal of interest hasbeen created worldwide on the potential applications of natural fiber reinforced, cement basedcomposites. Investigations have been carried out in many countries on various mechanical properties,physical performance and durability of cement based matrices reinforced with naturally occurringfibers including sisal, coconut, jute, bamboo and wood fibers. These fibers have always been considered promising as reinforcement of cement based matrices because of their availability, low cost and low consumption of energy.

MATERIALS AND METHODS:

The methodology deals with the collection of materials from Sterliteindustry.Then the physical properties of the material are determined. The

copper slags are replaced by fine aggregate with various percentages and sisal fiber is used. The mix design can be arrived for each percentage ranging from 0% to 100% of copper slag. Then the specimens such as cube, cylinder, and prism were casted. After 28 days of curing, the specimens were tested to determine the durability of the concrete. Finally, the results are compared with the ordinary conventional concrete.

PHYSICAL PROPERTIES OF COPPER SLAG:

Physical properties	Sand	Copper slag
Particle shape	Irregular	Irregular
Appearance	Brownish yellow	Black & glassy
Type	River sand	Air cooled
Specific gravity	2.57	3.91
Percentage of voids %	33	43
Bulk density g/cc	1.71	2.08
Fineness modulus of copper slag	2.73	3.47
Angle of friction	45º	51º20’
Ultimate shear stress kg/cm^2	0.299	1.4106
Water absorption %	1.25	0.15 to 1.2
Moisture content %	0.5	0.1

Table 1: Physical properties of copper slag

CHEMICAL PROPERTIES OF COPPER SLAG AND OPC:

Component	OPC (%)	CS (%)

Silica (SiO_2)	20.85	33.05
Alumina (Al_2O_3)	4.78	2.79
Iron oxide (Fe_2O_3)	3.51	53.45
Calcium oxide (CaO)	6.06	63.06
Magnesium oxide (MgO)	2.32	1.56
Sulfuric anhydrite (SO_3)	2.48	1.89
Potassium Oxide (K_2O)	0.55	0.61
Sodium Oxide (Na_2O)	0.24	0.28
Titanium dioxide (TiO_2)	0.25	0
Manganese trioxide (Mn_2O_3)	0.05	0.06
CI	0.01	0.01
Loss on ignition	1.75	0
IR Insoluble residue	0.21	0
CuO	0	0.46
$Al_2O_3 + SiO_2 + Fe_2O_3$	29.14	89.29

Table 2: Chemical properties of copper slag

PHYSICAL PROPERTIES OF SISAL FIBER

Physical properties	Sisal fiber
Specific gravity [Kg/m3]	1370
Water absorption [%]	110

Tensile strength [M Pa]	347-378
Modulus of elasticity [G Pa]	15

Table 3 : Physical properties of sisal fiber

MATERIAL USED:

Cement	**Coarse Aggregates**	**Fine aggregates**	**Copper Slag**	**Natural fiber**
Grade -53 Ordinary Portland cement from ultra cement Company India Limited	Coarse aggregates of 20mm size	Fine aggregate were taken of Zone-II were procured from Tuticorin District	Copper slag from Sterlite Industries India Limited, Tuticorin	Sisal fiber from Agave Sisalana

Table 4: Materials used in the concrete

MIX PROPORTIONS:

CEMENT	FA	CA	WATER	SF
1	1.51	2.87	0.45	2%

Table 5: Mix proportions for conventional concrete

% of copper slag	% of sisal fiber
0	0
20	2
40	2
60	2
80	2
100	2

Table 6: Mix proportions for non-conventional concrete

RESULTS AND DISCUSSION:

EFFECT OF COPPER SLAG SUBSTITUTE BASED ON WORKABILITY:

The workability of concrete is measured based on the slump of the fresh concrete. The effect of copper slag replacement as fine aggregates on the workability and density of high performance concrete for different proportions of copper slag will be noted. The workability of concrete increased with the increase of proportions of copper slag content in concrete mixes. With the 100% replacement of copper slag, the measures slump value is 160 mm. The workability increases with the increase of copper slag quantity with low water absorption characteristics. The increase in workability has more effect on concrete in the concrete mix with low water cement ratio. This gives good workability, greater strength and improved durability than the conventional concrete

PERCENTAGE REPLACEMENT	SLUMP VALUE (mm)
0	55
20	80
40	105
60	135
80	150
100	160

Table 7:Slump value for various percentage of copper slag & 2% of sisal fiber

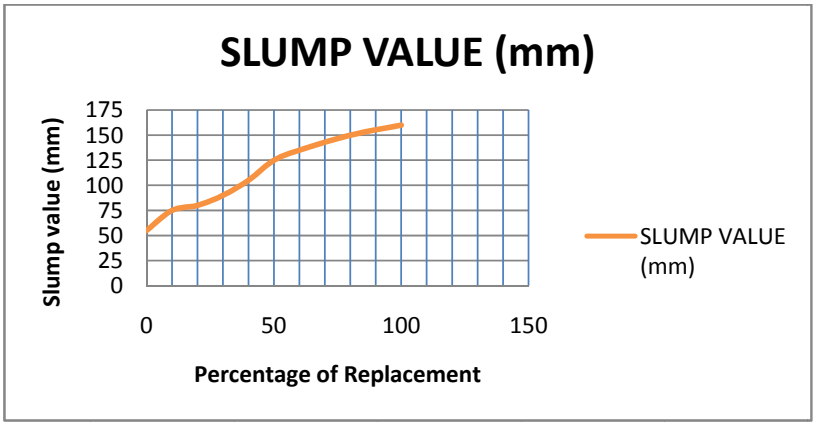

Fig 1: Slump value for various percentage of copper slag

Compressive Strength

In the study of strength of materials,the compressive strength is the capacity of a material or structure to withstand loads tending to reduce size.It can be measured by plotting applied force against deformation in a testing machine.It is a key value for

design of structure.It is measured on a universal testing machine, these range from very small table –top-systems to ones with over 53MN capacity.Concrete cubes of size 150 x 150 x 150 mm were cast with copper slag with various proportions and 2% sisal fiber. The maximum load at failure reading was taken and the average compressive strength is calculated.Here 0 to 100% (S20, S40, S60, S80, S100) of copper slag was replaced with fine aggregate and 2% of sisal fiber .The variation of 7days and 28 days compressive strength can be determined. Since optimum percentage of replacement is accepted for 40% to 60%replacement of copper slag with sand and sisal fiber . For normal conventional concrete the compressive strength was found to be 28.73 N/mm^2.

% of copper slag replacement	% of sisal Fiber	7 days Strength (N/mm^2)	14 days Strength (N/mm^2)	28 days strength (N/mm^2)
0	0	19.57	24.38	28.73
20	2	25.62	31.75	35.23
40	2	26.40	33.89	38.97
60	2	23.53	28.63	32.37
80	2	15.90	21.16	25.87
100	2	11.32	16.74	21.71

Table 8: Compressive strength test for various % of copper slag & 2% of sisal fiber

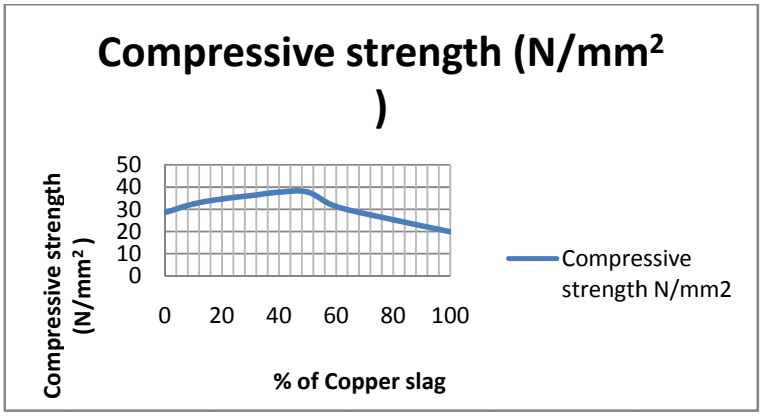

Fig 2: Variation in compressive strength of concrete for different % of copper slag and sisal fiber

Split Tensile Strength Test: Tensile strength is an important property of concrete because concrete structures are highly vulnerable to tensile cracking due to various kinds of effects and applied loading itself. However, tensile strength of concrete is very low in compared to its compressive strength. Cylindrical specimen of size 150 mm × 300 mm were cast using in the mix proportion 1:1.51:2.87 and W/C ratio is 0.45 with copper slag and 2% of sisal fiber.The specimen is loaded until failure occurs and failure load is noted. The average split tensile strength is calculated using the equation.

% of copper slag	% of sisal fiber	28 days strength (N/mm^2)
0	0	1.95
20	2	2.32
40	2	2.78
60	2	2.73
80	2	2.47

100	2	2.08

Table 9: Split tensile strength for various percentage of copper slag & 2% of sisal fiber

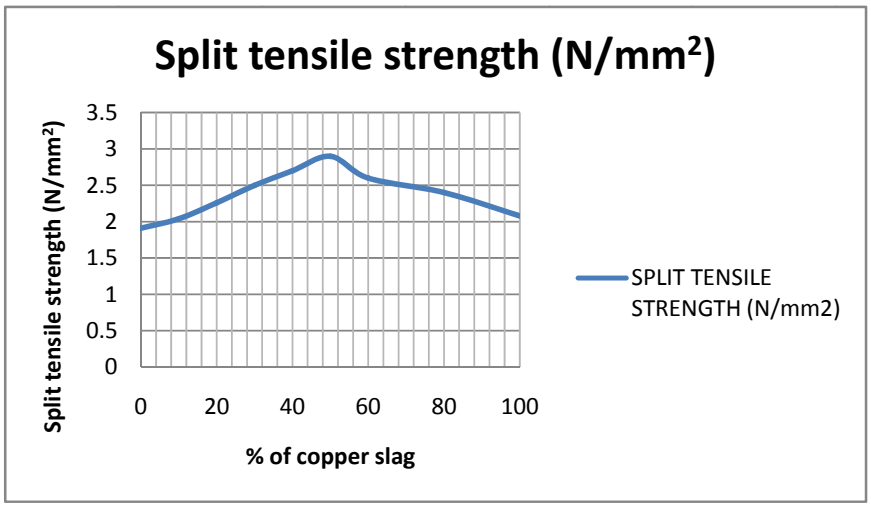

Fig 3: Variation in Tensile strength of concrete for different % of copper slag and sisal fiber

COMPARISON BETWEEN CONVENTIONAL CONCRETE AND COPPER SLAG REPLACED CONCRETE:

The various properties of copper slag compared with conventional concrete are listed below:

CONVENTIONAL CONCRETE	COPPER SLAG REPLACED CONCRETE
The slump value is 55 mm hence the workability is less	The slump value is 125 mm hence the workability is high
The compressive strength is 28.73 N/mm^2	The optimum compressive strength is 39.8 N/mm^2
The tensile strength is 1.95 N/mm^2	The optimum tensile strength is 2.99 N/mm^2
The cost of making concrete is costly	The cost of making concrete is comparatively less

The self weight of concrete is less	The self weight of concrete increased by 15 to 20 %

Table 10: comparison between conventional concrete and CS replaced concrete and sisal fiber

CONCLUSION:

- Compared to the control mix, the copper slag & sisal fiber based concrete showed an increase in the density up to 20%, whereas the workability was found to be often better
- Copper slag has lower absorption and higher strength properties than fine aggregate
- The highest strength obtained was 39.8 Mpa (50% replacement) and the corresponding strength for control concrete was 28.73 Mpa
- With higher level of replacements (100%) there was a slight bleeding tendency and it is recommended that up to 80 % of copper slag can be used as replacement of sand
- Replacement of copper slag increases the self weight of concrete specimens to the maximum of 15 to 20 %
- Replacement of copper slag in both fine aggregate and cement replacements reduces the cost of making concrete
- The utilization of copper slag in cement and concrete provides additional environmental as well as technical benefits for all related industries
- For higher replacement of copper slag in sand (greater than 50%) the compressive and split tensile strength decreases due to an increase of free water content in the mix
- The utilization of sisal fiber in concrete provides high tensile strength and prevent crack formations in concrete

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