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Study on Strength Properties of Concrete Using Lime Stone Powder As Cement & Copper Slag As Fine Aggregate

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Abstract
Nowadays most of the concrete applications utilize 15 to 20% of copper slag generated and remaining material is dumped as a waste. To reduce the accumulation of copper slag and to provide an alternative material for sand and cement approach has been done to investigate the use of copper slag in concrete for the partial replacement of sand and cement.
In this paper M_{30} grade concrete is used to determine various mechanical properties of concrete. The focus is on consists of substituting cement partially by lime stone powder and sand partially by copper slag in concrete. For cement replacement, four test groups including control mixture were constituted with replacement of 0% (control specimen), 10%, 15% lime stone powder with cement in each series sand replacement, and six test groups (including control mixture) were constituted with replacement of 0% (control specimen), 20%, 40%, 60%, 80% and 100% copper slag with sand in each series.
So, percentage of copper slag increases, the workability & density is increases. The utilization of limestone powder and copper slag in concrete provides additional environmental as well as technical benefits. Partial replacement of cement with lime stone powder and fine aggregate with copper slag reduce cost of making concrete.
Keywords: *Copper Slag, Compressive Strength, Split Tensile Strength, Flexural Strength.*

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I. Literature Review

1. Dr.K.Nirmalkumar, This study on the properties of concrete incorporated with various mineral admixtures-limestone powder and marble powder Observed that the general effect of Marble Powder is to retard the setting time of the cement. The replacement of OPC by Marble Powder influences the strength of the mortar. The Incorporation of Marble Powder in an enhanced flexural strength compared to the Conventional Concrete. The general effect of Marble Powder is to retard the setting time of the cement. The replacement of OPC by Marble Powder influences the strength of the mortar. The Incorporation of Marble Powder in an enhanced flexural strength compared to the Conventional Concrete. The slump of concrete relatively increases with higher values of the percentage of compensating of cement with Lime stone Powder.

2. Dr.G.Anusha, The results Optimization of Partially Replacement of Natural Sand & Ordinary Portland cement By M-Sand and Lime stone powder They concluded that Compressive strength, tensile strength and flexural strength is found to increase with age as for normal concrete. The 28 – day compressive, tensile strength and flexural strength is found 18.14, 10.76 -18.5 N/mm2 and 12.21- different mixes. The above strength properties the proportion of 50%-10% (M-Sand & higher values of compressive, tensile, and flexural strength. For the same proportion of 50% Sand & LSP) at 1:1:2 mixes and 0.50 water cement ratio. The water absorption is Conventional concrete specimen resulted to decrease of the wate and permeability of the concrete when compare to 50%-10% (M-Sand & LSP).

3. Tanveer Asif Zerdi, Investigated on Performance of Limestone Powder on Strength Properties as Partial Replacement of Fine Aggregate in Concrete Mix they concluded that, the compressive strength of concrete and water absorption test using lime stone powder are measured in the laboratory. Compressive strength is found to increase with age as for normal concrete. The 28 – day compressive 0%, 10%, 20% and 30% concrete 31.27, 24.97, 23.96 and 21.52 N/mm2 for different mixes. The above strength properties the proportion of limestone powder produced higher values of compressive strength. For the same proportion 0%,10%, 20% and 30% at 1:1.76:2.97 mixes and 0.50 water cement ratio.

4. Ramzi Taha, the author had clearly discussed about the effects of the copper slag in the concrete. The author had worked on M20 mix design and have incorporated the copper slag in percentages from (20 % to 60%). He has provided only the compression, split tensile & flexural strengths. He had concluded that the use of copper slag up to 60% increases the strength of concrete.

5. Prof. A. Nizad, studied on Strength and Durability Characteristics of Steel Fibre Reinforced Concrete Containing Copper Slag as Partial Replacement of Fine Aggregate", concluded that the strength and durability characteristics of steel fibre reinforced concrete containing copper slag as partial replacement of fine aggregate. Mix proportioning must be done for M20 normal concrete. Sand is replaced with copper slag in proportions of 0%, 10%, 20%, 30%, 40%, 50% & 60%. In all mixes, the proportion of steel fibre is kept constant i.e., 0.2% by volume of concrete. All hybrid mixes were tested and then found that Steel fibre reinforced concrete containing copper slag as 40 % Partial replacement of fine aggregate gives maximum strength and durability criteria.

II. Material Investigation

An OPC 53 Grade K.C.P Cement was used in this investigation. The quantity required for this work was assessed and the entire quantity was purchased and stored property in casting yard. The following tests were conducted in accordance with IS codes.

Specific gravity (Le- Chatelier flask) (IS: 1727-1967)
Slump test (Slump cone) (IS: 1199 – 1959)
Sieve analysis (IS: 2306 (Part-1)-1963)
Compressive strength test of concrete (IS: 516-1959)
Flexural strength test of concrete (IS: 516-1959)

The cement used in this study was ordinary Portland cement (OPC) purchased from K.C.P Cement Company. This cement is the most widely used one in the construction industry in Macharla.

Ordinary Portland Cement (OPC) is by far the most important type of cement. The OPC was classified into three grades, namely 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988. If the 28 days strength is not less than 33N/mm2, 43N/mm2 and 53N/mm2 it called 43 grade and 53 grade cement, respectively. Ordinary Portland cement of 53 Grade from K.C.P Cement brand conforming to IS: 8112-1989and IS 12269-1987 is used in this experimental work. The different property of cement is shown in below Table2.1. It conforms to various standard test as per IS recommendation.

Table2.1. Properties of Cement.

Properties	Avg. Values of OPC used in Current Experimental Work	Standard values for OPC
Specific gravity	3.15	-
Consistency	31.5%	-
Initial setting time	48 (min)	>30
Final setting time	225(min)	<600
soundness	2.8	<10
Fineness by Dry sieving	8%	<10%

2.1. Fine Aggregate:

The fine aggregate used in this investigation was clean river sand and the following tests were carried out on sand as per IS: 2386-1968. Fine aggregates (i.e. 10 mm) and fine sand were purchased from a nearby crusher in Guntur area, which are typically the same materials used in normal concrete mixtures. The gradation test conducted on aggregates showed that they met specifications requirements.

The aggregate size is lesser than 4.75 mm is considered as fine aggregate. The sand particles should be free from any clay or inorganic materials and found to be hard and durable. Silt test is carried out to specify the limits of presence of organic matter and silt in fine aggregates. It was stored in open space free from dust and water. It conforms to IS 383 1970 comes under zone II.Physical properties of a used fine aggregates workout in below Table2.2.

Table 2.2. Properties of Fine Aggregate.

Properties	Average values
Water absorption	2.52
Fineness Modulus	2.80
Specific Gravity	2.76
Silt content (%)	1.4
Organic matter	Nil

2.2. Coarse Aggregate:

The aggregate size bigger than 4.75 mm, is considered as coarse aggregate. It can be found from original bed Rocks. Coarse aggregate are available in different shape like rounded, Irregular or partly rounded, Angular, Flaky etc. It should be free from any organic impurities and the dirt content was negligible. There has been a lot of controversy on subject whether the angular aggregate or rounded aggregate will make Better concretes. They suggest that if at all the rounded aggregate is required to be used for economical Reason; it should be broken and then used. But the angular aggregate are superior to rounded aggregate from following two points.

1. It exhibits a better interlocking effect in concrete.
2. The total surface area of rough textured angular aggregate is more than smooth rounded aggregate for the given volume.

Dried angular coarse aggregate of 20 mm maximum sized and 10 mm minimum size locally available was used for experimental work.

Table.2.3. Properties of Coarse Aggregate.

Properties	Average values
Water absorption	2.03
Fineness Modulus	6.67
Specific Gravity	2.86
Organic matter	Nil

Water is an important ingredient of concrete, as it actively participates in the chemical reaction with cement. Since, it helps to form the strength giving cement gel and required workability to the concrete. The quantity and quality of water is required to be checked very carefully. Portable water is used in concrete

2.3. Copper SLAG:

Copper slag is a by-product material produced from the process of manufacturing copper. As the copper settles down in the smelter, it has a higher density, impurities stay in the top layer and then are transported to a water basin with a low temperature for solidification. The end product is a solid hard material that goes to the crusher for further processing. Copper slag used in this work was bought from Sri Srinivasa metalizers (Hyderabad), India.

Table2.4. Properties of Coper slag.

Properties	Typical Values
Colour	Black, Glassy
Gain Shape	Angular, Multifaceted
Specific Gravity at 25c	3.61
Bulk Density at 25 c	1.75tonnes/m^3
Ph	7.0
Conductivity at 25c	$4M_s$/m
Weight raise on ignition	4%
Moisture content	<0.1%

2.5. Chemical properties of Copper Slag:

Copper slag has concentrations of Sio2 and Fe2O3 compared with OPC. In comparison with chemical composition of natural pozzolans of ASTM C 618-99, the summation of the three oxides (silica, alumina and iron oxides) in copper slag is nearly 95%, which exceeds the 70% percentile requirement for class N raw and calcined natural pozzolans. Therefore, Copper slag is expected to have good potential to produce high quality pozzolans. Table shows the chemical composition of copper slag which was obtained from National Council for cement and building.

Table.2.5. Chemical composition of copper slag.

Constituent	Percentage
Silica ($S_{io)}$)	25-35%
Free Silica	<0.5%
Alumina (Al_2O_3)	2-9%
FerrousOxide (Fe_2O_3)	45.55%
CalciumOxide (C_aO)	2-9%
Magnesium Oxide (M_gO)	1-5%
CopperOxide (C_uO)	0.7%
Sulphates (S_{o3})	0.2%
Chlorides (Cl)	0.003%

III. Experimental Results

3.1 Specific Gravity

Table3.1. Specific Gravity test

Percentage of copper slag	Specific gravity
0	2.620
20	2.777
40	2.845
60	3.092
80	3.410
100	3.610

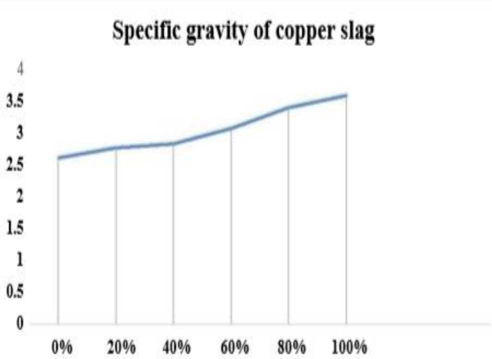

Fig.3.1 Specific gravity of copper slag.

3.2. Sieve Analysis:

Table 3.2. Sieve analysis test

Sieve size	Cumulative % of sand Retained
4.75mm	1.5
2.36mm	8.2
1.18mm	28.14
600µm	67.85
300µm	91.25
150µm	98.68

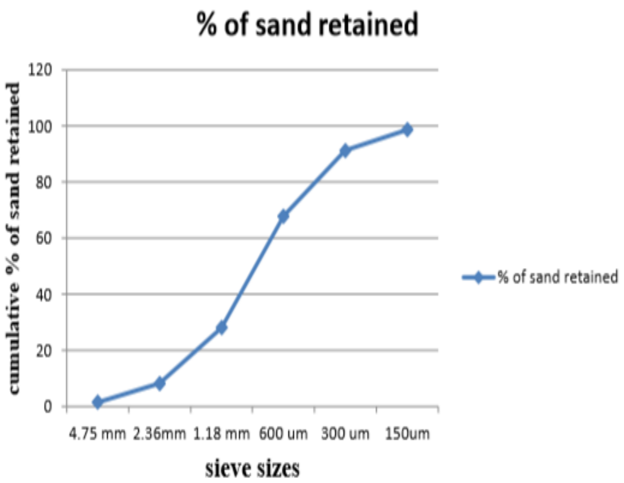

Fig.3.2. Sieve analysis for sand

3.3. Sieve Analysis of copper slag.

Table.3.3. Sieve test analysis of copper slag.

Sieve size	Cumulative % of sand Retained
4.75mm	18
2.36mm	5.36
1.18mm	50.78
600µm	87.52
300µm	95.28
150µm	98.2

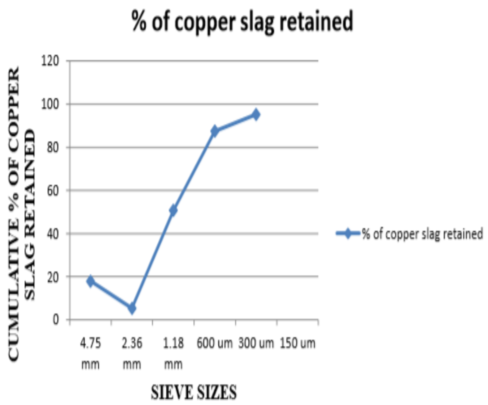

Fig.3.3. Sieve analysis for copper slag.

3.4. Slump Cone Test

Table. 3.4. Slump Cone test with different % of LP

%GES of Copper SLAG	SLUMP CONE TEST VALUES IN CM		
	10% LP	15%LP	20%LP
0%	28.7	29	28.6
20%	28.9	29.3	28.8
40%	29.4	29.3	29
60%	29.6	29.5	29.6
80%	30	30	30
100%	30	30	30

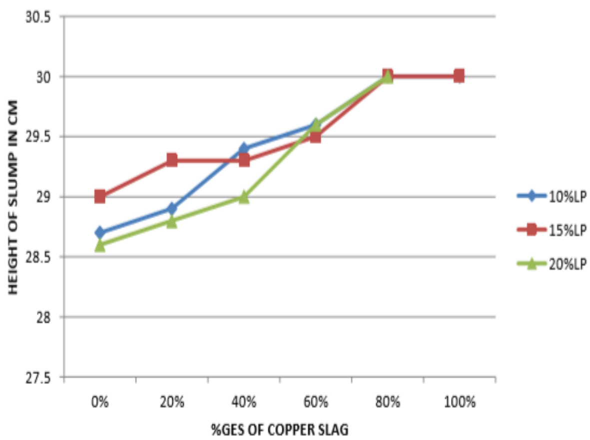

Fig. 3.4. Slum cone test values.

3.5. Soundness Test for Cement Additive Limestone Powder Standard Consistency

Take Cement content = 250g
Depth of plunger in cement paste=33 mm from top
% of water required to produce a cement paste of standard consistency = 80 ml

soundness test:

Water added = 0.78*standard consistency
% of water = 62.4 ml

Sample 1: 10% limestone powder replaced by cement
Cement content =180g
Limestone powder =20g
Distance between the indicator points after curing in water for 24 hrs=9 mm
Distance between the indicator points after boiling for 30 min=9mm
Soundness of cement additive limestone powder = 0 mm

Sample 2: 15% limestone powder replaced by cement
Cement content= 170 g
Limestone powder= 30g
Distance between the indicator points after curing in water for 24 hrs=9 mm
Distance between the indicator points after boiling for 30 min=10mm

Soundness of cement additive limestone powder = 1 mm
Sample 2: 20% limestone powder replaced by cement
Cement content= 160 g
Limestone powder= 40g
Distance between the indicator points after curing in water for 24 hrs=9 mm
Distance between the indicator points after boiling for 30 min=12mm
Soundness of cement additive limestone powder = 3 mm

3.6. Compressive Strength Test

Compressive strength for control concrete cube at 7 days=29.87N/mm2
For 28 days=41.65N/mm2

Table3.5. Compressive strength test at 7 & 28 days.

Copper slag %GES	COMPRESSIVE STRENGTH IN N/mm^2					
	10%LP		15%LP		20%LP	
	7 days	28 days	7 days	28 days	7 days	28 days
0%	21.10	27.24	22.10	31.62	20.14	29.61
20%	22.19	28.72	23.94	32.88	23.09	27.70
40%	25.80	30.96	26.80	35.61	24.37	29.44
60%	31.75	38.10	32.75	48.89	30.18	35.22
80%	26.14	33.78	28.14	35.82	25.03	31.43
100%	25.65	34.38	26.87	32.68	23.65	30.18

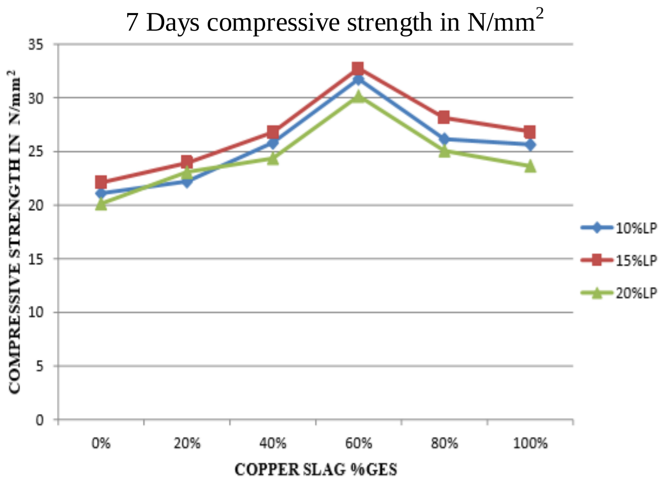

Fig.3.5. Shows variation of compressive strength (7 days) at different %ges of copper slag.

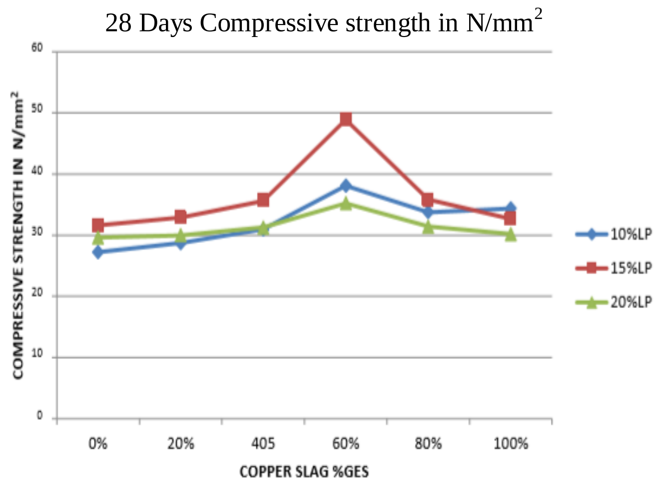

Fig.3.6. Shows variation of compressive strength (28 days) at different %ges of copper slag.

3.7. Flexural Strength

Flexural strength for control concrete beam at 28 days=5N/mm^2.

Table3.6. Flexural strength test

Copper SLAG %GES	FLEXURAL STRENGTH IN N/mm^2		
	10% LP	**15%LP**	**20%LP**
0%	4.53	4.62	4.17
20%	4.90	5.08	4.65
40%	5.14	5.48	4.94
60%	5.78	6.12	5.62
80%	6.19	6.60	5.84
100%	4.7	4.31	4.99

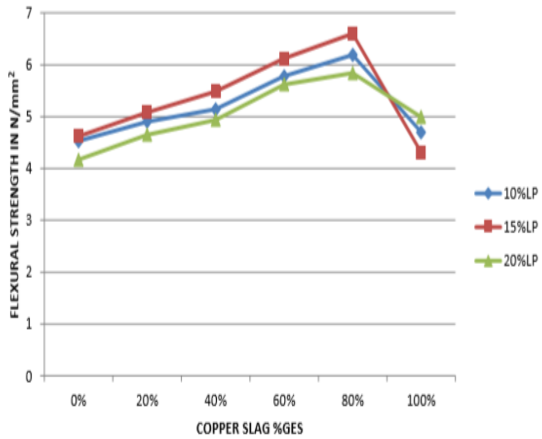

Fig.3.7 shows variation of flexural strength at 28 days for different %GES of copper slag.

3.8. Split Tensile Strength Test

Split tensile strength for control concrete cylinder at 28 days=2.95 N/mm^2.

Table3.7. Split Tensile test at different % of Lime stone powder.

Copper SLAG %GES	SPLIT TENSILE STRENGTH IN N/mm^2		
	10% LP	**15%LP**	**20%LP**
0%	1.98	2.08	1.76
20%	2.02	2.19	1.89
40%	2.26	2.42	2.16
60%	2.48	2.79	2.35
80%	3.15	3.56	2.90
100%	2.53	2.87	2.49

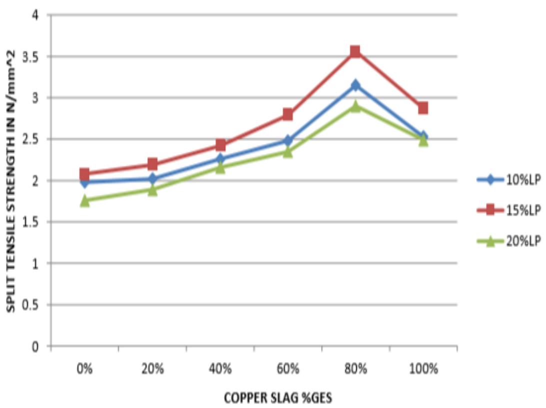

Fig.3.8. Shows variation of split tensile strength at 28 days for different %GES of copper slag.

3.9. Water Absorption Test

Water absorption test was carried out for control concrete mix and 15% lime stone powder and different %GES of copper slag.

Table.3.8. Water absorption test

%GES of copper slag	10%LP			15%LP			20%LP		
	Dry weight	**Wet weight**	**Water absorption %**	**Dry weight**	**Wet weight**	**Water absorption %**	**Dry weight**	**Wet weight**	**Water absorption %**
0%	8.150	8.467	3.90	8.180	8.49	3.88	8.230	8.55	3.97
20%	8.255	8.54	3.48	8.308	8.56	3.153	8.52	8.79	3.26
40%	8.45	8.71	3.19	8.490	8.73	2.87	8.63	8.895	3.08
60%	8.710	8.93	2.57	8.915	9.04	1.41	8.98	9.24	2.98
80%	9.05	9.33	3.1	9.140	9.42	3.08	9.18	9.47	3.16
100%	9.18	9.49	3.48	9.270	9.57	3.25	9.30	9.62	3.54

IV. Conclusion

As the percentage of copper slag increases, workability & density increases. Compressive strength of concrete increases as % ge of copper slag increases up to 60% and limestone powder increases up to 15% and then decreases. (Fig 5.4). Using 60% copper slag and 15% limestone powder Compressive strength is recovered, which is more than control concrete (Fig 5.4). The %ge increase in compressive strength of concrete mix with 60% copper slag and 15% limestone powder compared with control concrete is 17.38. Thus saving of fine aggregate & cement by replacing with 60% copper slag and 15% lime stone powder. This is the optimum percentage used in concrete. Flexural and split tensile strength of concrete increases as the %ge of copper slag increases up to 80% and limestone powder increases up to 15% and then decreases. The %ge increase in flexural strength of concrete mix with 80% copper slag and 15% limestone powder compared to control concrete is 32. The %ge increase in split tensile strength of concrete mix with 80% copper slag and 15% limestone powder compared to control concrete is 20.67. The utilization of lime stone powder and copper slag in concrete provides additional environmental as well as technical benefits. Partial replacement of cement with lime stone powder and fine aggregate with copper slag reduce cost of making concrete.

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