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EFFECT ON CONCRETE WITH PARTIALREPLACEMENT OF CEMENT BY FLYASH AND FINE AGGREGATE BY COPPER SLAG

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ABSTRACT

The amount and type of generated waste has grown as the world population increases. Many of the wastes produced today will remain in the environment for a long time. Some of the by-products like fly ash, silica fume and slag are being used into construction industry. Few investigations have studied the durability properties and performance characteristics of concrete with copper slag as fine aggregate. They have concluded that the copper slag performs similar or better compared to natural sand concrete. The detailed experimental investigation has been done to study the effect of partial replacement of cement by Fly Ash (FA,15%) and fine aggregate by copper slag (20%, 40%, 60% and 80%), in concrete. After investigation, it has been seen that a significant percentage of strength increases by using these by products up to certain percent.

Keyword: *generated waste, copper slag, fly ash.*

I. INTRODUCTION

A way has been find out that some of wastes can be use into various industries, which will lighten the burden on the environment. As fly ash, copper slag is a by-product from copper industry. It has been estimated that for every ton of copper production about 2.2 tons of slag is generated and, in each year, approximately 24.6 million tons of slag is generated from world copper production. Dumping or disposal of this slag causes wastage of metal values and leads to environmental problems. Rather than disposing, these slags can be use taking full advantage of its physio-mechanical properties. The concrete industry is constantly looking for supplementary cementitious material with the objective of reducing the solid waste disposal problems i.e Fly Ash (FA) are among the solid wastes generated by industry. Substantial energy and cost savings can result when industrial by-products are used as partial replacements for the energy intensive Portland cement. High quality sand is in short supply in India thus; an increased demand for cement and concrete can be met by partially replacing cement with fly ash (FA) and natural sand with quarry sand. This investigation attempts to study the feasibility of using locally available fly ash (FA) as partial replacements for cement and natural sand in concrete. The huge quantity of concrete is consumed by construction industry all over the world. In India, the conventional concrete is produced using natural sand from river beds as fine aggregate. Decreasing natural resources poses the environmental problem and hence government restriction on sand quarrying resulted in scarcity and significant increase in its cost. Normally particles are not present in river sand up to required quantity. Digging sand, from river bed in excess quantity is hazardous to environment. The deep pits dug in the river bed, affects the ground water level. In order to fulfill the requirement of fine aggregate, some alternative material must be found. The cheapest and the easiest way of getting substitute for natural sand is obtained from limestone quarries, lateritic sand and crushing natural stone quarries is known as manufactured sand. Concrete made with limestone filler as replacement of natural sand in concrete can attain more or less same compressive strength, tensile strength, permeability, modulus of rupture and lower degree of shrinkage as the control concrete. Fly ash is the finely divided mineral residue resulting from the combustion of ground or powdered coal in electric power generating thermal plant.

Fly ash is a beneficial mineral admixture for concrete. It influences many properties of concrete in both fresh and hardened state. Moreover, utilization of waste materials in cement and concrete industry reduces the environmental problems of power plants and decreases electricity generation costs. Cement with fly ash reduces the permeability of concrete and dense calcium silicate hydrate (C–S–H). Research shows that adding fly ash to concrete, as a partial replacement of cement (less than 35 percent), will benefit both the fresh and hardened states. While in the fresh

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state, the fly ash improves workability. This is due to the smooth, spherical shape of the fly ash particle. The tiny spheres act as a form of ball bearing that aids the flow of the concrete (Marotta, 2005). This improved workability allows for lower water-to-cement ratios, which later leads to higher compressive strengths (Mindess, et al., 2003). In the hardened state, fly ash contributes in a number of ways, including strength and durability.

II. LITERATURE REVIEW

Various journals and literatures were studied and findings obtained by them were used to identify the research area, summarization of literatures as follows for fly ash and copper slag : Abdullah Anwar et al (2015), "Investigating the Compressive Strength of Concrete by Partial Replacement of Cement with High Volume Fly Ash" their studies tell that Fly ash is rich in cementitious industrial wastes and has great potential to replace Portland cement. Their studies tell that 28 days compressive strength of Mix can be achieved with a replacement of 30% of fly ash with the cement. Aman Jatale et al (2013), "Effects on Compressive Strength when Cement is Partially Replaced by Fly Ash" studied the effects on compressive strength when cement is partially replaced by fly ash and observed that the use of fly ash slightly retards the setting time of concrete. It was also found that the rate of strength development at various ages is related to the w/c ratio and percentages of fly ash in the concrete mix. Moreover, the modulus of elasticity of fly ash concrete also reduced with the increase in fly ash percentage for a given w/c ratio.

Marthong and T. P. Agrawal (2012), "Effect of Fly Ash Additive on Concrete Properties" studied the effect of fly ash additive on concrete properties and found that the normal consistency increases with increase in the grade of cement and fly ash content. It was also concluded that the use of fly ash improves the workability of concrete.Jayeshkumar Pitroda et al (2012), "Experimental Investigation on Partial Replacement of Cement with Fly Ash in Design Mix Concrete" studied the effect on compressive strength and split tensile strength with the partial replacement of cement with fly ash in the proportion of 10%, 20%, 30% & 40% by weight for the grade of M25 & M40. Research concluded that the compressive strength reduces when the cement is replaced with fly ash.

M. C. Nataraja, G. N. Chandan, Copper slag can be used as an alternative to natural sand in concrete. Compared to the control mix, there was a slight increase in the strength is due to copper slag. It was observed that up to 20% replacement of natural sand by copper slag, the split tensile strength of concrete was increased by 70% and flexural strength of concrete was increased by 50%.Naveed Shaikh, for lower grade of concrete 43.90% increase in strength of concrete is observed. Similarly 31.80% highest in the range for higher grade of concrete is noted for 40% replacement of copper slag.P. R. Wankhede & V. A. Fulari (2014), "Effect of Fly Ash on Properties of Concrete" studied an effect of fly ash on properties of concrete. The study has been carried out for M25 grade of concrete and tested for 7 days, 14 days, 28 days of curing. Cubes had been casted by replacing 0%, 10%, 20% & 30% cement with fly ash by weight. Concrete with 10% & 20% replacement of cement with fly ash shows good compressive strength for 28 days for 0.35 W/C ratio but in case of 30% replacement of cement with fly ash, compressive strength of concrete decreases.

III. MATERIALSAND METHODS

In order to explore the effect of copper slag as partial replacement to fine aggregates and fly ash as partial replacement to cement, we have used following materials:

Cement: The cement used was ordinary Portland cement 53 (OPC 53).All properties of cement were determined by referring IS 12269 - 1987. The specific gravity of cement is 3.15. The initial and final setting times were found as 55 minutes and 258 minutes respectively. Standard consistency of cement was 30%.

Coarse Aggregate: 20mm size aggregates-The coarse aggregates with size of 20mm were tested and the specific gravity value of 2.78 and fineness modulus of 7 was found out. Aggregates were available from local sources.

Fine Aggregate: The sand which was locally available and passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was 2.60.

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Water: The water used for experiments was potable water.

Fly Ash: Fly Ash is a by-product of the combustion of pulverized coal in electric power generation plants.
Chemical composition: Fly ash particles are generally spherical in shape and range in size from 0.5 µm to 100 µm. They consist mostly of silicon dioxide (SiO_2), which is present in two forms: amorphous, which is rounded and smooth, and crystalline, which is sharp, pointed and hazardous; aluminum oxide (Al_2O_3) and iron oxide Fly ashes are generally highly heterogeneous, consisting of a mixture of glassy particles with various identifiable crystalline phases such as quartz, mullite, and various iron oxides.

Table 1: Chemical Composition of Fly Ash.

Component	**Bituminous**	**Sub Bituminous**	**Lignite**
S_iO_2 (%)	20 – 60	40 – 60	15 – 45
Al_2O_3 (%)	5 – 35	20 – 30	20 – 25
Fe_2O_3 (%)	10 – 40	4 – 10	4 – 15
CaO (%)	1 – 12	5 – 30	15 – 40
Loss on Ignition LOI (%)	0 – 15	0 – 3	0 -5

Specific Gravity of Flyash
The specific gravity of fly ash is calculated and the result is as follows:

Table 2: Specific gravity of Fly ash

Materials	Weight of empty flask W1 (gm)	Weight of flask + ash W2 (gm)	Weight of flask + ash + water W3 (gm)	Weight of flask + water W4 (gm)	Specific gravity = [(W2-W1)/(W2-W1) – (W3 –W4)] x 0.79
Fly ash	32	31.4	78.8	72	2.68

Copper Slag: Copper slag is an individual by product material produce by copper smelting and refining processes. This has similar property of sand; hence copper slag can be replaced for fine aggregate. The physical Properties of natural sand and copper slag are as below.

Table 3: Physical Properties of Natural Sand and Copper Slag

Physical properties		Natural sand	Copper slag
Particle shape		Irregular	Irregular
Appearance		Brownish yellow	Black and glassy
Specific gravity		2.61	3.91
Percentage voids %		Loose State	39
Bulk density g/cc		Compact state	34
Fineness modulus	1.45	1.84	42
	3.14	3.17	37
Angle of internal friction		45°	49.38°
Water absorption (%)		1.3	0.3
Moisture content (%)		0.43	0.095

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Table 4: Chemical Properties of Copper Slag

Chemical Component	Chemical Component (%)
S_iO_2 (%)	25.85
Fe_2O_3 (%)	68.29
Al_2O_3 (%)	0.22
Ca O (%)	0.15
Na_2O	0.58
K_2O	0.23
LoI	6.59
Mn_2O_3	0.22
TiO_2	0.41

Table 5: Sieve Analysis comparison between sand and copper slag

Sieve Size, mm	% Passing of River Sand	%Passing of Copper Slag	Zone II (As per IS383)
4.75 mm	95.32	99.6	
2.36 mm	85.41	97.9	75-100
1.18 mm	67.22	75.5	55-90
600 microns	41.95	35.3	35-59
300 microns	13.32	8.5	08-30
150 microns	3.88	0.3	0.-20
ZONE	ZONE-II	ZONE-II	

Adoption of standard replacement of fly ash as 15% - For testing of Compressive strength and split tensile strength, standard metallic cube molds of dimension 0.15x0.15x0.15 m and cylinder of diameter 0.15m and height of 0.3m are taken respectively. After 7 days, 14 days and 28 days of curing, these specimens are tested on Compressive Testing Machine (CTM) and Universal Testing Machine (UTM). Before testing, the molds were removed from the water and allowed to dry at room temperature.

Table 6: Experimental Results for different percentage of replacement

FLY ASH			
i) 0% Replacement			
CONTENT	7 DAY	14 DAY	28 DAY
CUBE(N/mm^2)	38.22	44	45
CYLINDER(N/mm^2)	2.48	2.97	2.99
ii) 10% Replacement			
CONTENT	7 DAY	14 DAY	28 DAY
CUBE(N/mm^2)	26.66	31.11	35.55
CYLINDER(N/mm^2)	1.64	2	2.16
iii) 15% Replacement			
CONTENT	7 DAY	14 DAY	28 DAY
CUBE(N/mm^2)	28	28.31	48
CYLINDER(N/mm^2)	1.71	2.02	2.85

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iv) 20% Replacement			
CONTENT	7 DAY	14 DAY	28 DAY
CUBE(N/mm^2)	22.22	31.11	40
CYLINDER(N/mm^2)	2.02	2.16	2.26

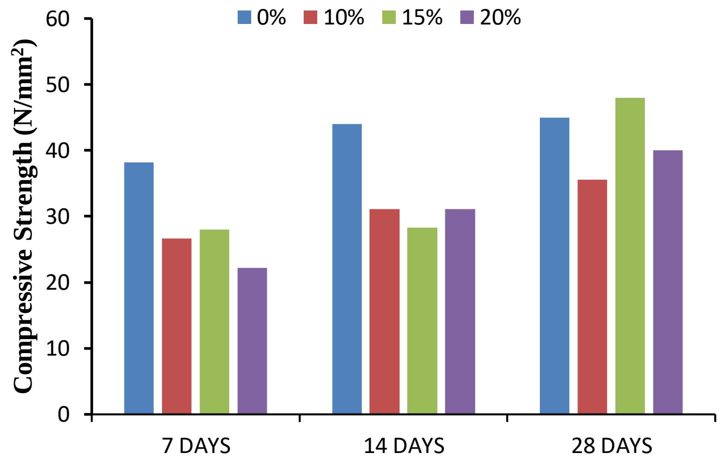

Fig 1: Graph Showing Compressive Strength of cubes

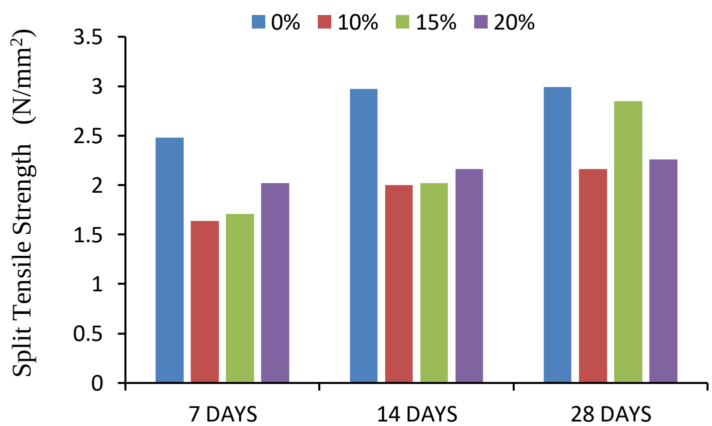

Fig2: split tensile strength

Based on the above Practical and Analytical results, the following conclusions are drawn.
Concrete with 15% replacement of cement with fly ash shows good compressive strength and split tensile strength for 28 days of curing as compared to 10% and 20% of replacement.

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IV. TESTS ON CONCRETE

4.1Fresh Concrete

4.1.1Workability of concrete

Workability is the ability to work with the fresh concrete. Slump test and compacting factor tests are the most widely used workability tests for concrete. The degree of workability of concrete depends on the values of test results obtained from slump test and compacting factor tests. Slump of the concrete was found to be 80mm.

4.2Hardened Concrete Test:

4.2.1 Compression Test: -

This test is done to determine the compressive strength of concrete specimens as per IS 516 – 1959)Tests have been done at recognized ages of the test specimens i. e. 7, and 28 days.

Table 7: Compressive Strength Test Results of the Specimen

Sl. No	Particular of Specimen	Replaced Flyash (%)	Replaced Copper Slag(%)	Date of Casting	Date of Testing	Age of Specimen	Compressive Strength
1	C0-F0	0%	0%	24/01/2018	1/2/2018	7	17.8
2	C0-F0	0%	0%	24/01/2018	1/2/2018	7	16.6
3	C0-F0	0%	0%	24/01/2018	1/2/2018	7	15.8
4	C20-F15	15%	20%	24/01/2018	1/2/2018	7	14.1
5	C20-F15	15%	20%	24/01/2018	1/2/2018	7	18.6
6	C20-F15	15%	20%	24/01/2018	1/2/2018	7	20.9
7	C40-F15	15%	40%	25/01/2018	2/2/2018	7	23.8
8	C40-F15	15%	40%	25/01/2018	2/2/2018	7	21.7
9	C40-F15	15%	40%	25/01/2018	2/2/2018	7	25.9
10	C60-F15	15%	60%	29/01/2018	6/2/2018	7	17.4
11	C60-F15	15%	60%	29/01/2018	6/2/2018	7	20.6
12	C60-F15	15%	60%	29/01/2018	6/2/2018	7	21.4
13	C80-F15	15%	80%	9/2/2018	16/2/2018	7	17.6
14	C80-F15	15%	80%	9/2/2018	16/2/2018	7	18
15	C80-F15	15%	80%	9/2/2018	16/2/2018	7	19.2
16	C0-F0	0%	0%	24/01/2018	23/02/2018	28	29.8
17	C0-F0	0%	0%	24/01/2018	23/02/2018	28	29.5
18	C0-F0	0%	0%	24/01/2018	23/02/2018	28	29.6
19	C20-F15	15%	20%	24/01/2018	23/02/2018	28	33
20	C20-F15	15%	20%	24/01/2018	23/02/2018	28	39
21	C20-F15	15%	20%	24/01/2018	23/02/2018	28	36
22	C40-F15	15%	40%	25/01/2018	24/02/2018	28	44.5
23	C40-F15	15%	40%	25/01/2018	24/02/2018	28	44
24	C40-F15	15%	40%	25/01/2018	24/02/2018	28	42
25	C60-F15	15%	60%	29/01/2018	2/3/2018	28	36.3
26	C60-F15	15%	60%	29/01/2018	2/3/2018	28	26.8
27	C60-F15	15%	60%	29/01/2018	2/3/2018	28	34.2
28	C80-F15	15%	80%	9/2/2018	17/02/2018	28	31.39
29	C80-F15	15%	80%	9/2/2018	17/02/2018	28	33
30	C80-F15	15%	80%	9/2/2018	17/02/2018	28	30.33

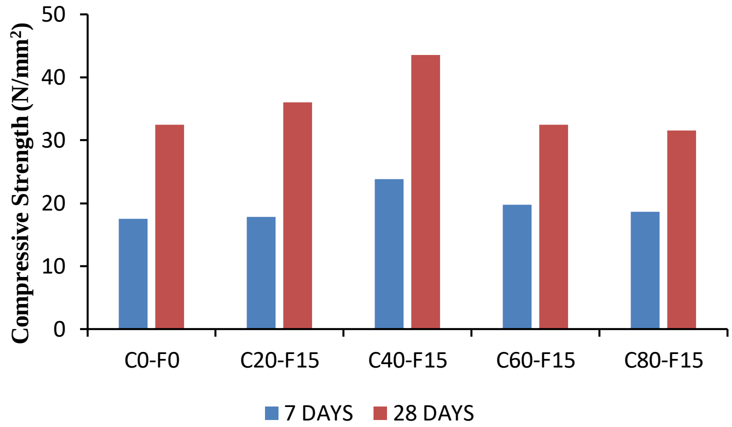

Fig 3:Bar Graph showing Compressive strength results for various proportions

4.2.2 Split-Tensile Strength Test

This test has been done to determine the slit tensile strength of concrete specimens as per IS 516 – 1959) Tests have been done at recognized ages of the test specimens i. e. 7, and 28 days.

Table 8: Split Tensile Strength Test Results of the Specimen

Sl. No	Particular of Specimen	Replaced Flyash (%)	Replaced CopperSlag(%)	Date of Casting	Date of Testing	Age of Specimen	Tensile Strength ($^{N}/_{mm^2}$)
1	C0-F0	0%	0	24/01/2018	23/02/2018	7	1.5
2	C0-F0	0%	0	24/01/2018	23/02/2018	7	1.8
3	C20-F15	15%	20	24/01/2018	23/02/2018	7	4.24
4	C20-F15	15%	20	25/01/2018	24/02/2018	7	3.99
5	C40-F15	15%	40	25/01/2018	24/02/2018	7	6.6
6	C40-F15	15%	40	25/01/2018	24/02/2018	7	8.1
7	C60-F15	15%	60	29/01/2018	2/3/2018	7	8.157
8	C60-F15	15%	60	29/01/2018	2/3/2018	7	6.99
9	C80-F15	15%	80	29/01/2018	2/3/2018	7	4.33
10	C80-F15	15%	80	24/01/2018	23/02/2018	7	5.44
11	C0-F0	0%	0	24/01/2018	23/02/2018	28	2.41
12	C0-F0	0%	0	24/01/2018	23/02/2018	28	2.35
13	C20-F15	15%	20	25/01/2018	23/02/2018	28	7.8
14	C20-F15	15%	20	25/01/2018	23/02/2018	28	8.99
15	C40-F15	15%	40	25/01/2018	23/02/2018	28	13.1
16	C40-F15	15%	40	29/01/2018	23/02/2018	28	13.8
17	C60-F15	15%	60	29/01/2018	23/02/2018	28	8.157
18	C60-F15	15%	60	29/01/2018	23/02/2018	28	9.5
19	C80-F15	15%	80	29/01/2018	23/02/2018	28	6.2
20	C80-F15	15%	80	29/01/2018	23/02/2018	28	6.8

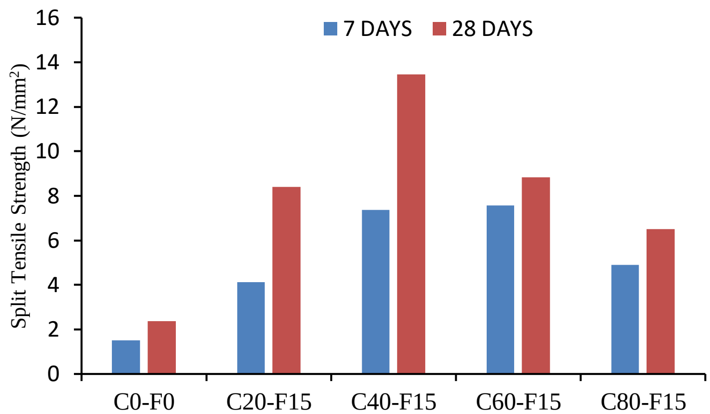

Fig 4: Bar Graph showing tensile strength for various proportions

V. EFFECT OF REPLACEMENT OF COPPER SLAG AND FLY ASH

Slump

For lower percentage replace of copper slag workability is lower than higher percentage replacement.
As percentage of copper slag replacement increases workability is also increases comparatively for 35 to 45 percentage replacement of copper slag, ,moderate workability is observed.

Strength test

Copper slag is a very good alternative material for fine aggregate it can be replaced up to 40% with fine aggregate so that it gives highest strength at 28 days compare to normal concrete with M20 mix. Strength of Concrete is increased due to the bulkiness provided by the copper slag replaced. At 40% replacement of copper slag ideal adhesion of all the materials can be seen.

VI. CONCLUSION

- ✓ From the observations and results obtained, 40% replacement of copper slag gives highest strength.
- ✓ By replacing fine aggregate with 40% of copper slag gives the strength 40.72% more than the reference with conventional concrete at 28 days for compression strength and split tensile strength respectively.
- ✓ It contributes to natural sand conservation. By using copper slag as fine aggregate as we can make environment more sustainable.

REFERENCES

1. *Abdullah Anwar, Sabih Ahmad, Syed Aqeel Ahmad, Juned Ahmad and Syed Mohd. Ashraf Husain, "Investigating the Compressive Strength of Concrete by Partial Replacement of Cement with High Volume Fly Ash", ISSN 2347 – 5161, Vol.4, No.6, pp 4162 – 4166.*
2. *Aman Jatale, K. Tiwari, S. Khandelwal, "Effects on Compressive Strength when Cement is Partially Replaced by Fly Ash", IOSR Journal of Mechanical and Civil Engineering, ISSN 2278-1684, Volume 5, Issue 4, Jan.-Feb. 2013, pp 34-43.*
3. *C. Marthong, T. P. Agrawal, "Effect of Fly Ash Additive on Concrete Properties", International Journal of Engineering Research and Applications, ISSN 2248-9622, Volume 2, Issue 4, July-August 2012, pp 1986-1991.*
4. *Izhar Ahmed, Dr S.S.Jamkar Department of Applied Mechanics, Govt, Engg. college, Aurangabad. "Effects of Fly Ash on Properties of Concrete"as Per Is: 10262-2009‖ IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN: 2278-1684 Volume 4, Issue 2 (Nov-Dec. 2012), PP 01-05*

5. *J. Anne Mary "An Experimental Investigation On Copper Slag As Replacement Of Fine Aggregate In Concrete".International Journal of Civil Engineering and Technology (IJCIET) Volume 7, Issue 6, November-December 2016, pp. 282–289.*
6. *JayeshkumarPitroda, Dr. L. B. Zala, Dr. F.S. Umrigar, "Experimental Investigation on Partial Replacement of Cement With Fly Ash in Design Mix Concrete", International Journal of Advanced Engineering & Technology, Volume-03/Issue 04/ Oct.- Dec., 2012/ 126-129.*
7. *M. C. Nataraja1, G. N. Chandan ,T. J. Rajeeth "Concrete Mix Design Using Copper Slag As Fine Aggregate" IJCIETVolume 5, Issue 9, September (2014), pp. 90-99*
8. *M. V. PatilY.D.Patil,Effects of "Copper Slag as Sand Replacement in Concrete'International Journal of Engineering and Technology (IJET)p-ISSN : 2319-8613 Vol 8 No 2 Apr-May 2016*
9. *Naveed A Shaikh "A Partial Replacement of Fine Aggregate by Copper Slag In Concrete".International Journal Of Engineering And Computer Science ISSN: 2319-7242 Volume 5 Issue 12 Dec. 2016, Page No. 19809-19812*
10. *P. R. Wankhede, V. A. Fulari, "Effect of Fly Ash on Properties of Concrete", International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 4, Issue 7, July 2014*
11. *Pranshu Saxena, Ashish Simalti, "Scope Of Replacing Fine Aggregate With Copper Slag In Concrete"IJTRA. Volume 3, Issue 4 (July-August 2015), pp. 44-48*
12. *Rahul Bansal, V. Singh, R. K. Pareek, "Effect on Compressive Strength with Partial Replacement of Fly Ash", International Journal of Emerging Technologies, ISSN 2249-3255, Volume 6, Issue 1, 2015, pp 1-6.*
13. *ShantmurtiUpadhyaya, R. Chandak, "Effect of Fly Ash on Compressive Strength of M20 Mix Design Concrete", International Journal of Advancements in Research & Technology, ISSN 2278-7763, Volume 3, Issue9, September 2014.*
14. *T. Sama, D. Lalwani, A. Shukla, A. Sofi, "Effect of Strength of Concrete by Partial Replacement of Cement with Fly Ash and addition of Steel Fibres", Journal of Civil Engineering and Environmental Technology, ISSN 2349-8404, Volume 1, Number 1, August 2014, pp 5-9.*