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CONCRETE STRENGTH EVALUATION BY USING COPPER SLAG INSTEAD OF AGGREGATES FOR M30 GRADE OF CONCRETE

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Abstract: Now a days, there is an imbalance in the ecosystem due to the over usage of some by-products. Here the major concern due to its harmful impact to environment. Several studies have been conducted to decrease severe effect on environment by using by products like copper slag as a replacing agent of fine aggregates. A complete review of studies has been discussed in this project for the chances of substitution of copper slag instead of fine aggregates in concrete. In this project we have discussed and investigated the impact of copper slag by substituting it with the fine aggregates at various levels of percentages. Here we evaluate the values of tensile strength, compressive strength .In this experiment, to determine the strength parameters, flexural strength and compressive strength, M30 grade concrete is used for curing of concrete in the duration of days of 3, 7 and 28.The results reveals that as there is an improvement in the Compressive Strength and Tensile Strength with the increase of content of copper, whereas the workability increases with improvement of copper slag percentage. Up to 35 % of replacement of copper slag with sand has a comparable strength with the control mix. But, additional replacement of copper slag leads to reduction in the strength.

Keywords:- **Copper slag, Compressive Strength, Tensile Strength, Flexural strength.**

I. INTRODUCTION

Concrete is a composite material with good flexibility as it is designed to resist against the harsh environments. Researchers are continuously examined to extent the limits to improve its performance by using innovative chemical admixtures and additional materials.

By using secondary materials or industrial waste has enhanced the production of cement and concrete in construction field. New by-products such as bottom ash, coal fly ash, steel slag and blast furnace are being generated in various industries. Disposing and dumping of waste materials which are generated as byproducts from various industries causes environmental problems. Recycling of by products is the best alternative to reduce the environmental impact. In many places construction waste, blast furnace, coal fly ash, steel slag and bottom ash are used as the alternative for fine aggregates in constructions.

From the manufacturing of copper, copper slag is produced as by-product. Approximately 25.6 million tons of copper slag is generated from the industries.

Copper slag has chemical and mechanical characteristics which makes the material is used as replacement of cement or fine aggregates. Copper slag has excellent soundness and good abrasion characteristics. Copper slag also shows the properties like pozzolana as it contains low amount of CaO. If the CaO is activated with NaOH, it shows cementitious properties. Then Copper slag is used as partial or full replacement of fine aggregates. This process reduces the cost of recycling and reduces the cost of the concrete. Replacement of copper slag can offer protection to the environment. Some reports states that the replacement of copper slag may causes side effects, despite of that fact, further researches are carried out to obtain the complete detailing about the usage of copper slag in concrete.

Fig 1: Copper slag Abrasive Grains

Table 1 Chemical analysis of copper slag

components	Copper Slag (%)
SiO_2	97.01
Al_2O_3	0.095
Fe_2O_3	1.05
CaO	1.064
MgO	0.118
SO_3	0.008
K_2O	0.028
Na_2O	0.118
TiO_2	0.120
Mn_2O_3	0.002
CuO	0.183
Sulphide Sulphur	0.082
Water Insoluble Residue	98.48
Chloride	0.350
Loss on Ignition	0.190

1.1 History- The manufacturer of world class refined copper, Sterlite Industries India Limited (SIIL), Tamil Nadu is the main producer of copper slag during the production of copper metal. Now, about 2600 tons of copper slag is produced per day. SIIL is a diversified and integrated FTSE 100 metals and mining company.

Table 2 Assumptions about copper slag:

S.No	Assumptions	In real
1.	Toxic	Non-toxic
2.	Durability	High durability
3.	Decreases concrete strength	Improves concrete strength
4.	Bleeding	No bleeding until 40-50% replacement
5.	Leaching	Leaching levels are insignificant

1.2 Manufacturing: Researchers stated that copper slag is a by-product generated during the matte smelting and refining of copper. It contains oxides like MgO,Al_2O_3 CaO and SiO_2 which are held in original concentration or adding as flux. The physical and chemical constitution of smelting system is influenced by Copper, Sulphur, Oxygen, Iron and their oxides. Due to this process, Copper slag and copper rich matte are formed as two separate liquids. We adding silica during smelting process, it creates strong bond of silicate anions with oxides.

This process produces copper slag and sulphide because of the low tendency to form the anion complexes. The structure of slag will get stable condition with the addition of alumina and lime at the furnace of 1100-1400ºC. After the liquid gets cool, it forms a dense, hard crystalline product is formed.

1.3 Advantages:

1. Reduction of heat of hydration.
2. Reduction in permeability.
3. Reduction in the demand for natural resources.
4. Reduction in cost of construction.
5. Altering of pore pressure.
6. Improvement in environment.

II. PAPERS REVIEWED

Some studies reveal the impact of cement by-pass dust replacements and copper slag on the strength of cement mortars. Generally 55% of ferrous content is present in copper slag. When altered with sand and cement in concrete, corrosion and durability factors should be find out. In the present research, replace 60% of fine aggregate with copper slag and 20% of cement with copper slag to form highly performed concrete. Here we use M20 grade concrete was used. It was additionally determined that using cement as an active material which shows better operating material than using lime.

Researchers examined the mechanical properties of high strength concrete Indicated that the strength of concrete which replaced with copper slag of percentage of up to 40% was equal to or higher than that of the control specimen. Results of the investigation on the mechanical properties of copper slag and reinforced concrete showed that the dynamic compressive strength usually increased with the increase in amount of copper slag up to 20% as compared to control concrete. To substitute the cementitious content, we use Micro silica with a specific gravity of 2.0 for strength requirement.

III. REPLACEMENT OF COMPONENTS

3.1 Replacement for Sand:

Researchers investigated the use of slag from copper smelting as a fine aggregate in concrete. Copper slag is also used as fine aggregate in concrete. The setting time, durability and strength of concrete mix made with copper slag. The replacement of copper slag and fly ash with fine aggregates were investigated. Up to 20 percent of copper slag and fly ash is used as fine aggregates can be used. The study investigated that maximum amount of slag does not considerably influence the amount of bleeding and the required plastic viscosity. This report mainly focused on the properties of copper slag and its impact on the engineering properties of mortars, concrete and cement. The results of the investigation on the mechanical properties of copper slag and reinforced concrete showed that the dynamic compressive strength usually increased with the increase in amount of copper slag up to 20% as compared to control concrete. After that limit, compressive strength will be reduced. The result of the investigation on the mechanical properties of high strength concrete indicated that the strength of concrete which replaced with copper slag of percentage of up to 40% was equal to or higher than that of the control specimen.

Concrete is replaced with copper slag of various proportions for the test groups. The series is 0%, 10%, 20%, 30%, 40%, 50%, 60%, 80% and 100%.

3.2 Replacement for Cement:

The investigation on the impact of copper slag on the hydration of cement –based materials revealed that up to 15% copper slag was used as cement replacement with hydrated lime. There is a considerable improvement in the compressive strength of hydration for 90 days. Also we can observe the increase in gel porosity and decrease in capillary porosity. Copper slag could be a suitable alternative to admixtures used in mortars and concrete.

The next part of the research was carried out about the application of copper slag as partial replacement of cement in concrete. Copper is partially replaced with Portland cement during the manufacturing of concrete and finely ground in ball mills. Various test series are used to perform the experiment. To increase the strength of concrete, hydrated lime is added and ½% of hydrated lime is added for five percent replacement of cement with copper slag.

3.3 Replacement for Both Sand And Cement:

In this part, copper slag is substituted for both sand and cement in concrete. Here optimum percentage replacement was 40% for aggregate and 15% for cement in concrete. So, first mix was prepared with replacement of copper slag 40% and replacement of copper slag 15%.

IV. MATERIALS AND METHODS

Cement: - Ordinary Portland cement (53 grade) was used for this experimental investigation.

Fig 2: Cement

Table 3: Properties of Cement

Property	Average value for OPC used in investigation	Standard value for OPC
Specific Gravity	3.55	-
Consistency	28%	-
Fineness by dry sieving	7.6%	<10%
Initial setting time(min)	46	>30
Final setting time(min)	246	<600
Soundness(mm)	3.6	<10
Compressive strength(N/mm^2)		
3-days	25.3	>23
8-days	34.91	>33
27-days	46.65	>43

Fine Aggregate: - Locally available river sand having density of 1483 kg/m^3 and fineness modulus of 4.19 was used. The specific gravity was found to be 2.23 and water absorption for fine aggregate 0.502 the fine aggregate was found to be confirming to zone-II as per Is 383:1970.

Fig 3: sieving

Table 4 sieve analysis of sand

I.S sieve size in mm	%of wait retained	%of wait passing
10	0	100
4.75	1.4	98.60
2.36	8.3	91.7
1.18	28.14	71.86
0.60	67.83	32.17
0.30	91.27	8.73
0.15	98.65	1.35
0.075	100	0

Copper Slag: It was taken from the local manufactures and conducted several tests on copper slag and also conducts the tests on replacement of fine aggregate with copper slag with different proportions. Fineness modulus for copper slag of 4.19 and water absorption for copper slag 0.1.

Table 4 values of sieve analysis for copper slag.

I.S sieve size in mm	%of wait retained	%of wait passing
10	0	100
4.75	5.40	94.60
2.36	17	83
1.18	50.74	49.26
0.60	87.52	12.48
0.30	95.22	4.78
0.15	98.5	1.5
0.075	100	0

Table 5 sieve analysis (90% sand &10% copper slag)

I.S sieve size in mm	%of wait retained	%of wait passing
10	0	100
4.75	0	100
2.36	5.3	94.70
1.18	23	77
0.60	51.4	48.60
0.30	52.2	47.80
0.15	97.20	2.80
0.075	100	0

Table 6 sieve analysis (80% sand &20% copper slag)

I.S sieve size in mm	%of wait retained	%of wait passing
10	0	100
4.75	0	100
2.36	4	96
1.18	23.4	76.6
0.60	53.18	46.82
0.30	89.60	10.40
0.15	96.4	3.60
0.075	100	0

Table 7 sieve analysis (70% sand &30% copper slag)

I.S sieve size in mm	%of wait retained	%of wait passing
10	0	100
4.75	0	100
2.36	5.3	94.7
1.18	28.6	71.4
0.60	64	36
0.30	94.2	5.80
0.15	98.30	1.70
0.075	100	0

Table 8 sieve analysis (60% sand &40% copper slag)

I.S sieve size in mm	%of wait retained	%of wait passing
10	0	100
4.75	0	100
2.36	4.8	95.2
1.18	29.5	70.5
0.60	65	35
0.30	94.6	5.40
0.15	99.5	0.5
0.075	100	0

Table 9 sieve analysis (50% sand &50% copper slag)

I.S sieve size in mm	%of wait retained	%of wait passing
10	0	100
4.75	0	100
2.36	5	95
1.18	31.90	68.10
0.60	67	33
0.30	94.20	5.80
0.15	97.60	2.40
0.075	100	0

Table 10 sieve analysis (40% sand &60% copper slag)

I.S sieve size in mm	%of wait retained	%of wait passing
10	0	100
4.75	0	100
2.36	06	94
1.18	31.80	68.20
0.60	68	32
0.30	95.4	4.60
0.15	97.6	2.40
0.075	100	0

Table 11 sieve analysis (30% sand &70% copper slag)

I.S sieve size in mm	%of wait retained	%of wait passing
10	0	100
4.75	0	100
2.36	5.4	94.6
1.18	33.4	66.6
0.60	71.6	28.4
0.30	95	5
0.15	96.4	3.6
0.075	100	0

Table 12 sieve analysis (20% sand &80% copper slag)

I.S sieve size in mm	%of wait retained	%of wait passing
10	0	100
4.75	0	100
2.36	6.7	93.3
1.18	34.5	65.5
0.60	72.3	27.7
0.30	95.5	4.5
0.15	98.4	1.6
0.075	100	0

Table 13 sieve analysis (10% sand &90% copper slag)

I.S sieve size in mm	%of wait retained	%of wait passing
10	0	100
4.75	0	100
2.36	6.5	93.5
1.18	34.9	65.1
0.60	72.4	27.6
0.30	95.6	4.4
0.15	98.8	1.2
0.075	100	0

Coarse Aggregate: - Natural granite aggregate having density of 1520 kg/m^3 and fineness modulus (FM) of 7.35. The specific gravity was found to be 2.67 for 10mm and 2.75 for 20mm aggregate and water absorption for coarse aggregate 0.128

Table 14 sieve analysis of Coarse Aggregates

I.S sieve size in mm	%of wait retained	%of wait passing
20	3.6	96.4
16	14.3	85.7
12.5	19.80	80.20
10	47.30	52.70
4.75	91.40	8.60
2.36	99.01	0.09
1.18	100	0
0.60	100	0
0.30	100	0

Table 15 Sieve analysis of Coarse aggregate, Fine Aggregate and Copper slag

IS sieve size(mm)	Coarse Aggregate	Fine Aggregate	Copper Slag
	Cumulative % retained	Cumulative % retained	Cumulative % retained
20	3.4	0	0
16	15.4	0	0
12.5	18.5	0	0
10	46.8	0	0
4.75	92.45	1.5	18
2.36	99.32	8	5.86
1.18	100	28.54	50.5
0.60	100	67.5	87.57
0.30	100	91.75	95.32
0.50	100	98.63	98.5
Fineness modulus	7.35	4.19	5.45

V. MIX DESIG & TEST RESULTS

Mix Design: -Mix design for M30 grade of concrete and test results are conducted for different proportions for copper slag.

Table 16 Mix Proportions (Kg/m^3) and Mix Ratios

Cement	Fine Aggregate(sand)	Coarse Aggregate(20mm)	Water
419	733.25	984.65	188.55
1	1.75	2.35	0.45

Workability Test: -Workability test for M30 grade of concrete.

Table 17 Workability Test (slump Test)

Mix	W/C ratio	Slump(mm)
CS 10%	0.45	26
CS 20%	0.45	29
CS 30%	0.45	30
CS 40%	0.45	32
CS 50%	0.45	34
CS 60%	0.45	35
CS 80%	0.45	39
CS 100%	0.45	41

Preparation of Specimens:- A preliminary study on comprehensive strength, Flexural strength and Split tensile strength using different proportions of copper slag in varying proportions of copper slag 10%,20%,30%,40%,50%,60%, 70%,80%,90%, and 100%by weight of fine aggregate is carried. In the present study, experimental concrete cubes of size 150mm x 150mm x 150 mm, and beam dimensions of each specimen (700mm x 150mm x 150mm) and cylinder of diameter 150mm and height of 300mm. with experimental is conducted and tested for compression & tensile strengths for 7 and 28, 56 days of curing and flexural strength for 7 and 28, 56 days of curing. Concrete cubes of size 150mm x 150mm x 150mm were casted and tested for compressive strength for 7 days and 28, 56 days.

Compressive Strenghth: The concrete cube specimens of size150mm x 150mm x 150mmwere placed in the compression testing machine and loaded. Loading at constant rate was applied on the specimen. The failure load obtained is the strength of the specimen. The average strength of set of three samples was taken as cube strength.

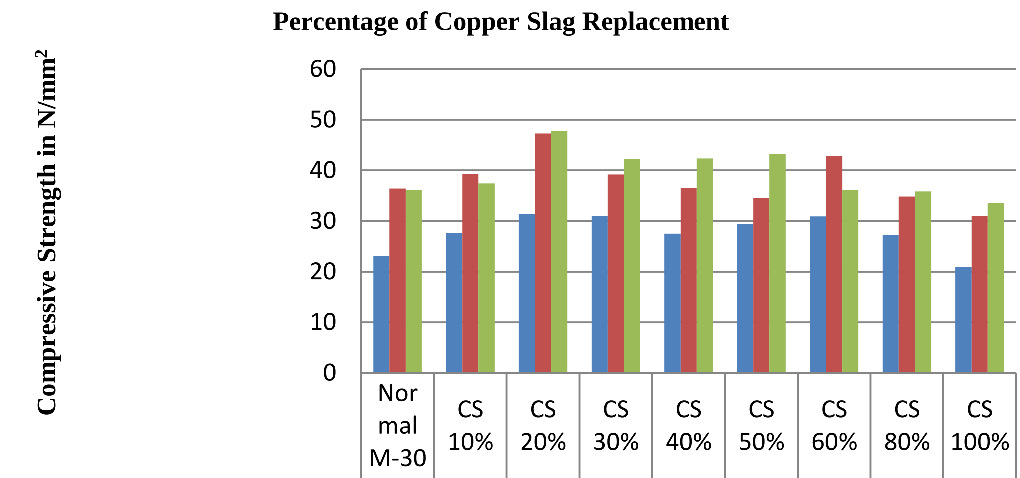
Fig 4 Compressive Strength Testing Machine

Table 18 Compressive Strength

Mix	Compressive Strength(Mpa)		
	7 days	28 days	56 days
Normal M-30	23.07	36.45	36.16
10%	27.62	39.27	37.46
20%	31.45	47.28	47.75
30%	30.99	39.21	42.24
40%	27.48	36.58	42.38
50%	29.40	34.50	43.26
60%	30.92	42.85	36.20
80%	27.27	34.84	35.85
100%	20.93	31.00	33.58

Table 19 Strength Gained

Mix	Compressive strength 7 days	Strength Gained days	Compressive strength 28 days		Compressive strength 56 days	
Normal M-30	23.07	100	36.45	100	36.16	100
10%	27.62	115.29	39.27	108.35	37.46	103.65
20%	31.45	135.94	47.28	130.81	47.75	132.19
30%	30.99	129.40	39.21	108.49	42.24	120.37
40%	27.48	126.18	36.58	118.64	42.38	119.86
50%	29.40	123.58	34.50	106.58	43.26	117.30
60%	30.92	115.12	42.85	102.38	36.20	116.74
80%	27.27	113.82	34.84	100.14	35.85	100.24
100%	20.93	86.42	31.00	85.45	33.58	92.22



	Normal M-30	CS 10%	CS 20%	CS 30%	CS 40%	CS 50%	CS 60%	CS 80%	CS 100%
7 days compressive strength	23.07	27.62	31.45	30.99	27.48	29.4	30.92	27.27	20.93
28 days compressive strength	36.45	39.27	47.28	39.21	36.58	34.5	42.85	34.84	31
56 days compressive strength	36.16	37.46	47.75	42.24	42.38	43.26	36.2	35.85	33.58

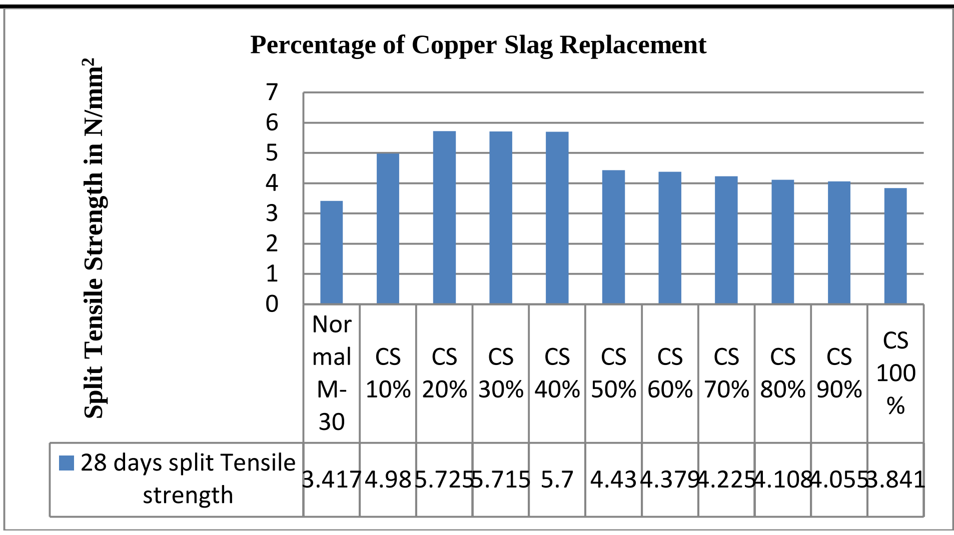
Graph 1 Compressive Strength

Split Tensile Strength Test: - The concrete cylinder of 150mm diameter and depth 300mm was casted. The cylinder was placed and loaded in compression testing machine. The load was applied gradually till the cylinder got failed. The failure load obtained was taken as the strength of the specimen. The average strength of the two samples was taken as cylinder strength.

Fig 5 Testing of cylinder

Table 20 split Tensile Strength at 28days

Replacement of copper slag	Average split tensile strength at 28days(N/mm^2)	Increase in split tensile Strength (%)
Normal M-30	3.417	00.00
10%	4.980	67.54
20%	5.725	67.25
30%	5.715	66.81
40%	5.700	26.71
50%	4.430	26.17
60%	4.379	25.22
70%	4.225	23.46
80%	4.108	20.22
90%	4.055	18.67
100%	3.841	12.40



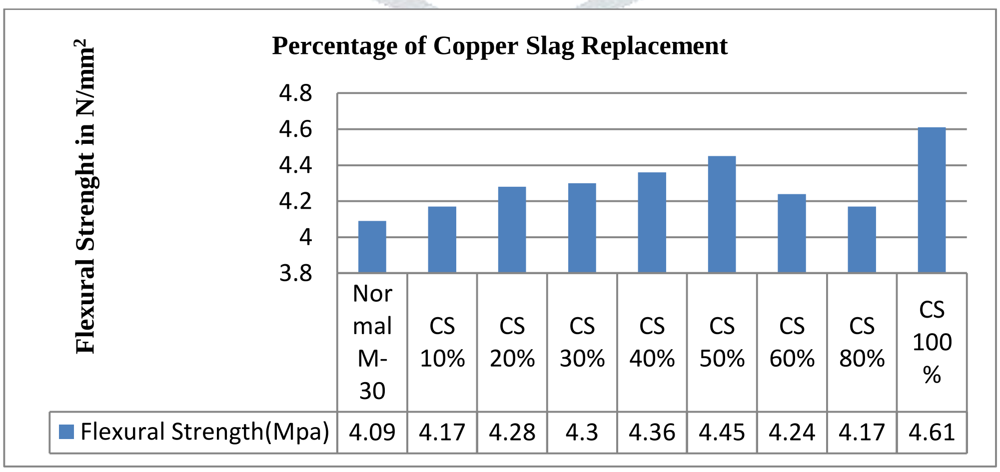
Graph 2 Average Split Tensile Strength for 28 Days

Flexural Strength Test: - The concrete beams were placed and loaded in the Universal Testing Machine. The beams were testes at the age of 28 days for the flexural strength. The beam dimensions were 700mm X 150mm X 150mm. The load was applied gradually till the beam got failed. The failure load obtained was taken as strength of the specimen.

Fig 6 Universal Testing Machine

Table 21 Flexural Strength

Mix	Flexural Strength(Mpa)
Normal M-30	4.09
10%	4.17
20%	4.28
30%	4.30
40%	4.36
50%	4.45
60%	4.24
80%	4.17
100%	4.61



Graph 3 Flexural Strength

VI. CONCLUSION

1) Workability increases by percentage increase of copper slag.
2) Compressive strength is increased by 30% by substituting fine aggregate with copper of 21%.concrete get more strength than normal strength of concrete.

3) By replacing 21% of natural sand with copper slag, the split tensile strength of concrete is improved by 68.25%.This improvement which is replaced by copper slag is higher than normal mix.
4) By replacing 21% of natural sand with copper slag, the flexural strength of concrete improved by 60% .This flexural strength which is obtained by replacing with copper slag has more strength than normal mix.
5) Due to high toughness of copper slag, compressive and flexural strength is increased.
6) It also reduces the cost of making concrete.
7) Reduces the cost of recycling of copper slag.
8) It also reduction of heat of hydration, permeability, in the demand for natural resources, Altering of pore pressure.
9) It improves the environmental conditions by reduce the adverse effects caused by disposal of copper slag.

REFERENCES

1) AL Alnuaimi (2011), "Effects of Copper Slag as a Replacement for Fine Aggregate on the Behavior and Ultimate Strength of Reinforced Concrete Slender Columns", Qaboos University, Vol.9, pp.90-102.
2) Antonio U. Arino and BarzinGobasher (1998), "Effect of Ground Copper Slag on Strength and Toughness of Cementitious Mixes", ACE Materials Journal, V.96, No.1, pp.68-74.
3) Barnett Stephanie Y.MariosH.soutsos, Jhon K. Bungey, Steve T.Millard(2008),"Fast track construction with slag cement concrete: Adiabatic strength development and strength prediction", ACE materials journal.V.104,NO.4,pp 388-398.
4) Binod Kumar, (2013), properties of pavement quality concrete and dry lean concrete with copper slag as fine aggregate ", International journal of pavement Engineering, vol.1, pp 1-7.
5) BrindhaV.AndP.Nagan, (2012),"Durability studies on copper slag admixed concrete",Asian journal of civil Engineering(Building and Housing),Vol.12,No.5,pp563-578.
6) Brindha L., Baskaran.R,Nagan.F, (2011) "Assessment of corrosion and durability characterstics of copper slag admixed concrete", International journal of pavement Engineering, vol.1, No.2, pp 192-211.
7) Baskaran H.nagan.s,(2011)," Assessment of corrosion and durability characteristics of copper slag admixed concrete", International journal of pavement Engineering,vol.12 ,pp 192-215.

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