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Study of Concrete by Replacing Natural Sand with Artificial Sand and Copper Slag and Cement with Copper Slag

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***Abstract:** Various industrial solid wastes are generating in countries day by day due to rapid growth in technologies and experimentations. Use of such waste materials can be advantageous in concrete. This paper presents the results of an experimental investigation to comparative study on the effects of replacing cement and sand with copper slag and artificial sand in combination to determine the changes in the various mechanical properties of concrete. There were total six mixes in which the cement was replaced at various proportions of 5%, 10% and 15% and sand was replaced by 45% artificial sand 5% granulated copper slag. Copper slag was first pulverized and sieved through 90mm sieve and 1.5% hydrated lime was added for pozzolanic activation since it contains low amount of CaO. The compressive strength, flexural strength, acid attack test (H_2SO_4) and workability tests were attempted to determine the optimum content of replacement. The results showed great increase in compressive strength of concrete due to higher amount of Fe_2O_3 while strength has adverse effects in acidic environment on concrete containing copper slag as a cement replacement.*

***Keywords:** Compressive strength, flexural strength, workability, PCS (Pulverized copper slag), GCS (Granulated copper slag), AS (Artificial sand), CC (Control concrete).*

I. INTRODUCTION

The main aim of the environmental protection agencies and the government are to seek ways and means to minimize the problems of disposal and health hazards of byproducts. Some of the industrial byproducts have been successfully used in the construction industry for the production of cement and concrete. The amount and type of generated waste has grown as the world population increases. Numerous waste materials result from manufacturing, sewage treatment plants, industries, households, and mining. Many of the wastes produced today will remain in the environment for a long time. Copper slag is one of the by-products which are generated in tremendous amount when copper is extracted. Around 2.2 to 3 million tones copper slag is generated for 1 million copper ore extracted. The disposal of such huge waste is a great problem for environment. Hence present study tries to reduce the potential adverse effect on environment by using copper slag in replacement of cement and sand.

Also the natural sand is getting costlier day by day due to its scarcity by rapid construction programs and hence a potential substitute is required for the sustainable production of concrete and reduction of construction cost. Artificial sand is manufactured sand at stone crusher plant which is crushed through VSI crusher in various gradations as per the requirement. Hence the quality of sand can be maintained and also available at very low prices and easily accessible at different locations.

M. Fadaee stated that compressive strength of concrete at 28 days age with a substantial percentage of the slag material was not significantly different from the SCC samples without slag [1]. D.M. Boakye discovered that sum of oxides present in copper slag is nearly 72% and hence can be categorized a class F-fly ash as per ASTM C618-99. It was seen that setting time increases with increase in copper slag content. On the other hand, workability is also improved by adding copper slag [2]. . Jardel Pereira showed that as copper slag has high specific gravity, the density of concrete increases with addition of copper slag. Absorption reduction was 13 to 24% lower than the control mix [3]. The Compressive strength of concrete for partial replacement of fine aggregate with copper slag increased by 17.5% with 40% partial replacement and decreased by 9.02% with 50% partial replacement while compared with control Specimen. K Aswani and P Rama Rao showed that the Compressive strength for partial replacement of cement with copper slag increased by 15.4% with 15% partial replacement and decreased by 3.86% with 20% partial replacement while compared with control specimen. The Flexural strength for partial replacement of cement with copper slag increased by 20.31% with 15% partial replacement[7].D. Brindha and basakaran observed from acid resistance test that the concrete containing copper slag was found to be slightly low resistant to the H_2SO_4 solution than the control concrete[8].

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II. EXPERIMENTAL INVESTIGATION

A. Materials Used

1) *Cement:* Standard OPC 53 grade cement was used in this study. The various properties of cement confirming to IS recommendations are as below,

Table 2.1: Physical properties of cement

PROPERTY	EXPERIMENTAL VALUE	STANDARD VALUE FOR OPC
Fineness of cement	1.5 %	-
Consistency	30 %	-
Initial setting time	40 min	>60
Final setting time	225 min	<600

2) *Copper Slag:* Copper slag is a by-product obtained from smelting and refining of copper ore extracted. The copper slag used in this study was obtained from Shreya blasting services, Mumbai. The material is heavier due to its high specific gravity and having shiny and round shaped particles.

Fig 2.1 granular form

Fig 2.2 pulverized form

3) *Artificial Sand:* Artificial sand is made by crushing stones from quarries. The sand must be of proper gradation (it should have particles from 150 microns to 4.75 mm in proper proportion) and when fine particles are in proper proportion, the sand will have fewer voids. As a result of fewer voids, lesser cement will be required and such sand will be more economical. Only sand manufactured by *V.S.I. Crusher* is cubical and angular in shape, Sand made by other types of machines is flaky, which is troublesome in working. The properties are similar to natural sand.

Fig 2.3 artificial sand

4) *Natural Sand:* The sand particles should be free from any clay or inorganic materials and found to be hard and durable. The material which passes through BIS test sieve number 4 (4.75mm) is termed as fine aggregate usually natural sand is used as a fine aggregate at places where natural sand is not available crushed stone is used as fine aggregates

Table 2.2: properties of fine aggregates

PROPERTY	COPPER SLAG	ARTIFICIAL SAND	NATURAL SAND
Fineness modulus	4.115	3.17	3.76
Specific gravity	3.57	3.03	2.63
Bulking of sand	20%		28%
Water absorption	0.5%	2.3%	1.02%

5) *Coarse Aggregates:* Locally available coarse aggregate retaining on 4.75 mm sieve is used.
6) *Plasticizer:* Auramix -200 used is a high performance super plasticizer intended for applications where high water reduction and long workability retention are required. Plasticizer was added at 1.0% by wt. of cement to the mix.
7) *Hydrated Lime:* Hydrated lime was added with copper slag for the pozzolanic activation since copper slag contains low amount of CaO. Quantity of 1.5% was added by wt. of cementious material.

Table 2.3: chemical analysis (XRF scan) of copper slag and artificial sand

Component (%)	Natural sand	Copper slag	Artificial sand
Na_2O	0.59	0.52	2.45
MgO	0.47	0.99	4.19
Al_2O_3	15.39	3.74	13.07
SiO_2	73.79	27.94	49.21
P_2O_5	0.13	0.1	0.27
SO_3	0.50	1.26	0.09
K_2O	3.46	0.98	0.25
As_2O_3	-	0.18	-
ZnO	0.01	0.84	-
SrO	0.01	0.01	0.02
ZrO_2	0.03	0.01	0.02
BaO	-	0.07	-
PbO	-	0.05	-
Fe_2O_3	2.69	56.75	15.69
MnO	0.29	0.09	0.28
Cr_2O_3	0.19	0.03	0.01
CaO	1.79	3.55	9.86
TiO_2	0.34	0.5	2.35
Co_3O_4	-	0.11	-
CuO	-	1.61	0.03
LOI	0.37	Nil	1.8
MoO_3	-	0.22	-
Sb_2O_3	-	0.04	-
Cl	0.21	0.01	0.05

B. Methodology

In fresh state; the workability parameter such as slump value was studied. In hardened state; the strength tests such as compressive strength and flexural strength were studied. For compressive strength, 150 x 150 x 150 cube specimens were prepared in the moulds and were cured for 7, 28 and 56 days resp. and tested. For flexural strength results, 50 x 10 x 10 beam specimens were casted for 28 days curing and results were compared.

1) *Mix Design:* The mix proportion used for this study is given in Table 2.5. In this work, mix proportion of M-30 grade was chosen. Total 6 mixes were prepared for the study with different proportions of pulverized copper slag ranging from 5% to 15% as a partial replacement of cement and sand was replaced with 45% artificial sand and 5% granulated copper slag for the comparative study.

Table 2.4: mix ratio for M-30 concrete

Cement	water	F.A.	C.A.
1	0.45	1.89	3.47

Table 2.5: various mix replacements (%)

MIX	CEMENT (%)	PCS (%)	NS (%)	AS (%)	GCS (%)	CA (%)
CONTROL MIX	100	-	100	-	-	100
MIX 1	100	-	50	50	-	100
MIX 2	100	-	50	45	5	100
MIX 3	95	5	50	45	5	100
MIX 4	90	10	50	45	5	100
MIX 5	85	15	50	45	5	100

Table 2.6: Mix proportions (Kg/m^{3})

MIX	WATER	CEMENT	PCS	F.A.			C.A.
				N.S	A.S	GCS	
C.C.	164.78	367.5	-	691	-	-	1278
Mix 1	171.5	367.5	-	345.5	389	-	1277
Mix 2	170.74	367.5	-	345.5	350	46.7	1277
Mix 3	170.6	349.1	18.3	344.5	349	46.6	1273
Mix 4	170.73	330.7	36.7	345	350	46.7	1275
Mix 5	170.73	312.3	55.1	345	350	46.7	1275

III. TESTS RESULTS AND DISCUSSIONS

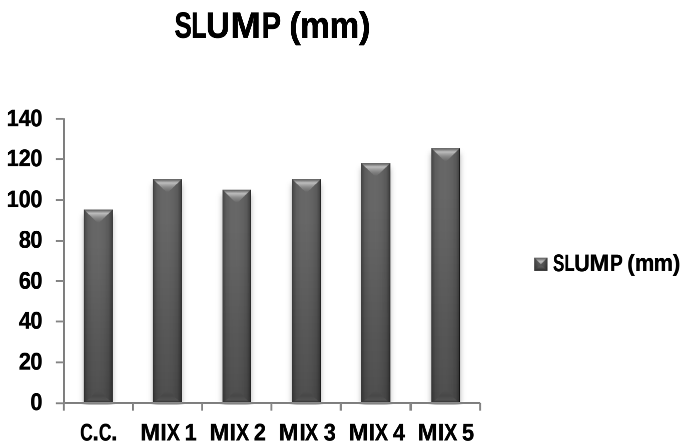
A. Workability

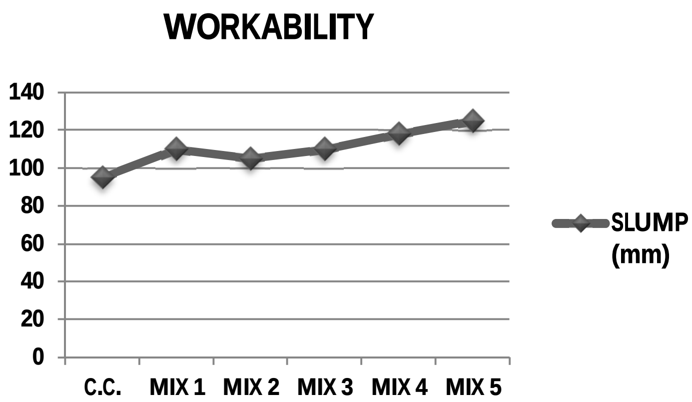
Workability is a measure of the ease with which a fresh mix of concrete or mortar can be handled and placed. For various mixes the concrete were prepared. In the fresh concrete, the slump cone test was carried out.

Slump cone test: The slump test result is a measure of the behavior of a compacted inverted cone of concrete under the action of gravity as per IS 1199. It measures the consistency or the wetness of concrete.

Table 3.1: slump values for various mixes

MIX	Slump value (mm)
Control mix	95
Mix 1	110
Mix 2	105
Mix 3	110
Mix 4	118
Mix 5	125



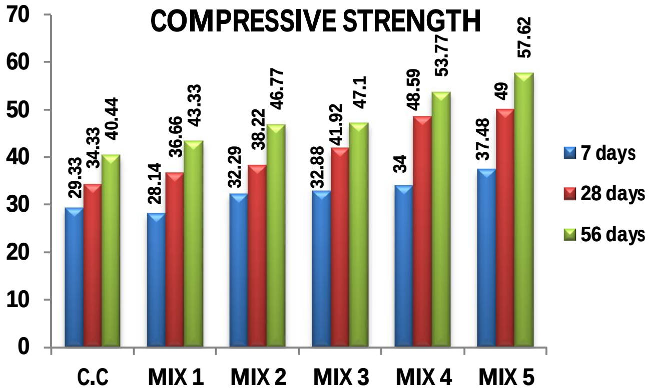


From the results, it was found that the workability of concrete was increased as the copper slag content in the mix was increased. The slump value for the control mix was 95 mm whereas the slump obtained for mix 5 was 125 mm. This considerable increase is due to the low water absorption characteristics of copper slag and its glassy surface compared with sand which caused surplus quantity of free water to remain after the absorption and hydration processes have completed. It should be noted that mixes with high contents of copper slag i.e. 15% showed signs of bleeding and segregation which can have detrimental effects on concrete performance.

B. Compressive Strength

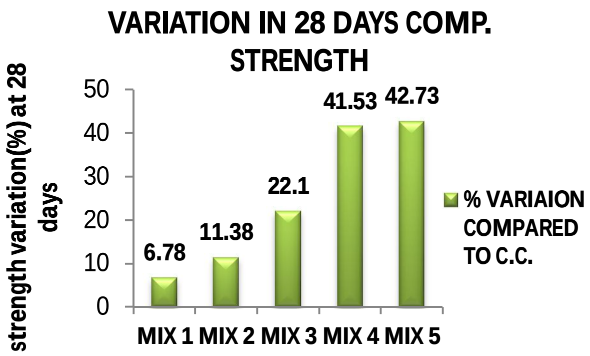
Table 3.2: average comp. strength of cubes for 7, 28 and 56 days

Mix	Average Compressive Strength (N/mm^2)		
	7 days	28 days	56 days
C.C	29.33	34.22	40.40
Mix 1	28.14	36.66	43.33
Mix 2	32.29	38.22	46.77
Mix 3	32.88	41.92	47.10
Mix 4	34	48.59	53.77
Mix 5	37.48	49	57.67



From the graph, the result of Mix 5 showed higher compressive strength as compared to all other mixes. The strength was gradually increased for each curing period. This may be due to the higher iron oxide (Fe_2O_3) content present in the copper slag and also due to the toughness of the material. The compressive strength of control mix at 7, 28 and 56 days were found to be 29.38, 34.33 and 40.44 N/mm^2 while Mix 5 has compressive strength of 37.48, 49 and 57.62 N/mm^2. The comp. strength of mix 5 was increased by 27.61% for 7days, 42.73% for 28 days and 42.48% for 56 days than control mix.

Variation in compressive strength of cubes at 28 days curing is shown in the graph below,



In the graph below, mixes with only sand replacement were compared. It was found that the 7 days strength of mix 2 is slightly lower than mix 3. The strength of mix 2 is increased by 10.09% for 7 days, 11.33% for 28 days and 13.74% for 56 days than control mix. The 7 days strength of mix 1 is reduced by 4.22% than control mix. When 5% GCS was added in the mix ,the strength of mix 2 was increased by 14.74% for 7days, 4.25 % for 28 days and 6.16% for 56 days than mix 1.

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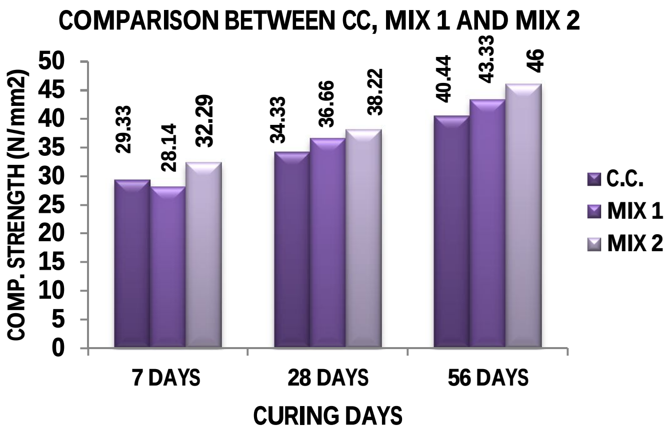
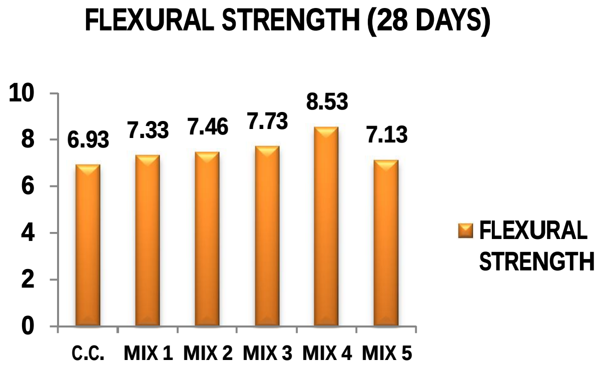
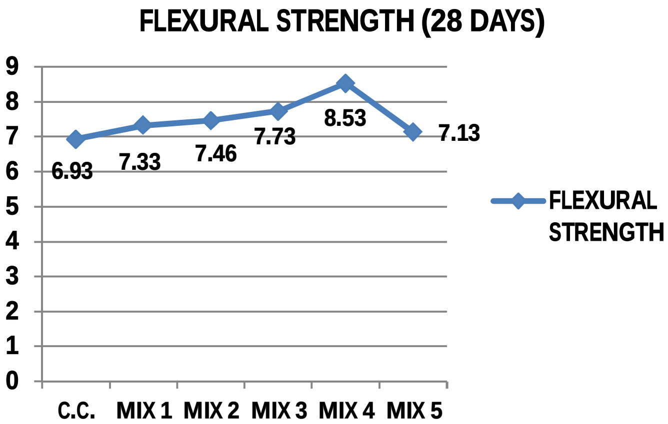


C. Flexural Strength

100 x100 x500 mm beam samples were casted for the test and were cured for 28 days. It has been seen that the optimum content of copper slag in the mix is 10% i.e., Mix 4 which showed higher flexural strength. After that strength was reduced as CS content increased in the mix. Control mix showed the average flexural strength of 6.93N/mm2 whereas strength of 8.53 N/mm2 was obtained from Mix 4. The strength for mix 4 was increased by 23.08% than control mix. After that there was significant reduction in strength. Results are shown in the graph below,





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D. Acid Attack Test

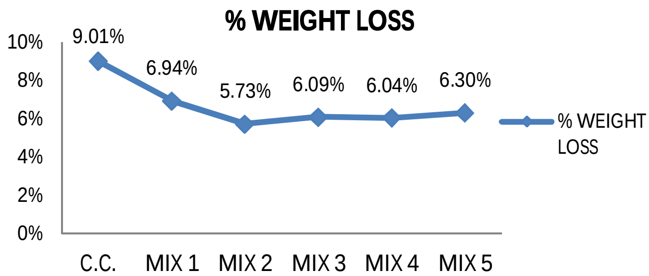
Acid attack test was done as per specifications according to ASTM C 267-97. Standard H_2SO_4 solution was used for the test. Acid was added at 3% by vol. of water. 150x150x150mm cube specimens were casted and cured for 28 days and after 24 hrs. Drying, specimens were kept in acid curing tank. Initial weight of cubes was taken. The cubes were cured in acid for 60 days and final weight was taken after 24 hrs. Dry curing. The compressive strength of cubes was checked and compared with that of cubes with water curing.

Fig 3.1 cubes after removing from acid tank

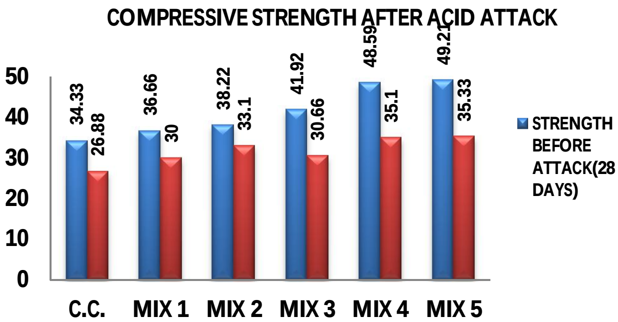
1) Weight Reduction After Acid Curing

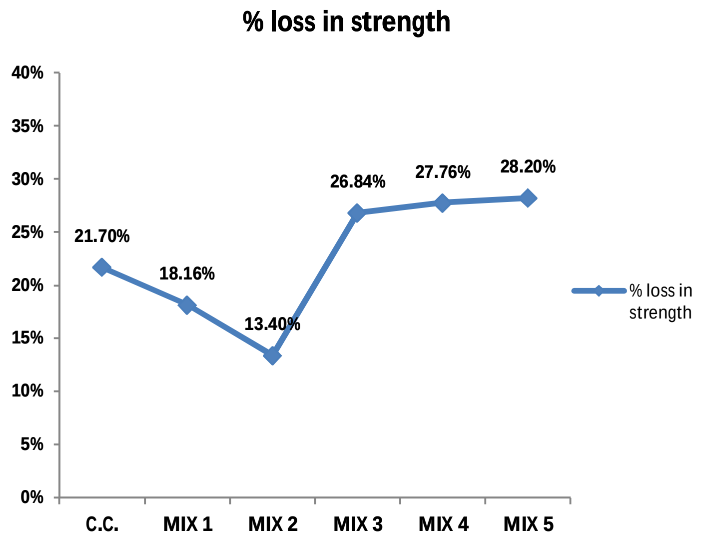
Table 3.3 weight reduction after acid attack

MIX	WT. BEFORE ATTACK (Kg)	WT. AFTER ATTACK (Kg)	% WT. LOSS
C.C.	8.875	8.075	9.01 %
MIX 1	8.995	8.37	6.94 %
MIX 2	8.985	8.47	5.73 %
MIX 3	8.86	8.32	6.09 %
MIX 4	9.1	8.55	6.04 %
MIX 5	9.04	8.47	6.3 %



2) Compressive Strength After Acid Attack





From the results, it was seen that the reduction in weight of all the mixes was lesser as compared to the control mix. The least affected mix in every aspect was MIX 2 which has shown the weight loss of 5.73% and reduction in compressive strength by 13.40% which is less than all other mixes. While mix containing copper slag as cement replacement showed slight more weight reduction than mix 2.

Also the compressive strength reduction was least for MIX 2 i.e. 13.4% and that for mix 5 is greatest i.e. 28.2% which is more than control mix. It may be due to the dispersion of C-S-H gel which got dispersed in acid by cement acid reaction which formed calcium sulphate on the surface of concrete which formed cracks in concrete. Hence, copper slag as cement showed least resistance to acid attack as compared to control concrete.

IV. CONCLUSION

From the detailed study of results, it is concluded that use of both the materials copper slag and artificial sand plays an important role in sustainable production of concrete. By using copper slag in concrete, its effect on environment can be reduced to a greater extent. Also artificial sand is found to be feasible material in replacement of sand for sustainable production of concrete. The materials can be greatly involved in the reduction of the materials cost in construction. There is a scope of copper slag which can also be replaced as a fine aggregate in concrete.

A. There was a reduction in water demand of concrete when copper slag was added which resulted in improved workability of concrete.
B. The copper slag can be effectively replaced as cement up to 15% when sufficient amount of hydrated lime was added. Artificial sand is found suitable to replace partially with natural sand by 50% thus reducing the cost of construction.
C. The compressive strength was increased significantly by 42% when PCS was replaced with cement by 15% and 45% AS and 5% GCS with natural sand.
D. The optimum content of PCS for flexural strength of concrete to be increased by 23.08% was 10% by wt. of cement. The strength was reduced by further increase in PCS content.
E. The increase in strength was found to be due to the high percentage of Fe_2O_3 in copper slag and high toughness of materials.
F. Due to the toughness of copper slag, the material usually takes more time for the pulverization process
G. Copper slag as cement replacement has lesser resistance to acid attack than control concrete. This may be due to dispersion of C-S-H gel in concrete which formed cracks in concrete
H. Artificial sand and copper slag as sand replacement has shown great resistance to acidic environment than control concrete.
I. Proper care must be taken in acidic environment while replacing cement with copper slag in concrete.

REFERENCES

[1] M. Fadaee, R. Mirhosseini, R. Tabatabaei and M. J. Fadaee “INVESTIGATION ON USING COPPER SLAG AS PART OF CEMENTITIOUS MATERIALS IN SELF COMPACTING CONCRETE” Asian journal of civil engineering (bhrc) vol. 16, no. 3 (2015)

[2] R.Chitra1, S.J.Mohan2 “REPLACEMENT OF CEMENT AND FINE AGGREGATE BY COPPER SLAG AND CERAMIC POWDER” International Journal of Pure and Applied Mathematics Volume 116 No. 13 2017, 229-234 ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version)

[3] Meenakshi Sudarvizhi. S, Ilangovan “PERFORMANCE OF COPPER SLAG AND FERROUS SLAG AS PARTIAL REPLACEMENT OF SAND IN CONCRETE” international journal of civil and structural engineering Volume 1, No 4, 2011

[4] K. S. Al Jabri “COPPER SLAG AS FINE AGGREGATE FOR HIGH PERFORMANCE CONCRETE” Department of Civil and Architectural Engineering, Sultan Qaboos University, Sultanate of Oman 2006

[5] R.Chitra, S.J.Mohan “REPLACEMENT OF CEMENT AND FINE AGGREGATE BY COPPER SLAG AND CERAMIC POWDER”; Department of Civil Engineering BIST,Bharath Institute of Higher Education and Research (BIHER), Bharath University , International Journal of Pure and Applied Mathematics Volume 116 No. 13 2017, 229-234, SSN: 1311-8080 (printed version); ISSN: 1314-3395

[6] CONCRETE jardel pereira gonc¸alves moˆ nica batista leite lima “COPPER SLAG WASTE AS SUPPLEMENTARY CEMENTIOUS MATERIAL TO CONCRETE” (2007)

[7] K Aswani and P Rama Rao (2015) “AN EXPERIMENTAL STUDY ON THE BEHAVIOR OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT AND FINE AGGREGATE WITH COPPER SLAG” IJSRD - International Journal for Scientific Research & Development| Vol. 3, Issue 08, 2015 | ISSN (online): 2321-0613

[8] D.Brindha ,Baskaran.T , Nagan.s “ASSESSMENT OF CORROSION AND DURABILITY CHARACTERISTICS OF COPPER SLAG ADMIXED CONCRETE” international journal of civil and structural engineering Volume 1, No 2, 2010 ISSN 0976 – 4399

[9] Chandana Sukesh, Katakam Bala Krishna, P.Sri Lakshmi Sai Teja, S.Kanakambara Rao PARTIAL “REPLACEMENT OF SAND WITH QUARRY DUST IN CONCRETE” International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-2, Issue-6, May 2013

[10] K. Srinivas Reddy “REPLACEMENT OF NATURAL SAND WITH ROBO/ARTIFICIAL SAND IN SPECIFIED CONCRETE Mix” ISSN XXXX XXXX © 2016 IJESC Volume 6 Issue No.9

[11] Akshaykumar M. Bhoi , Yogesh D. Patil, Hemant S. Patil and Madhav P. Kadam “Feasibility Assessment of Incorporating Copper Slag as a Sand Substitute to Attain Sustainable Production Perspective in Concrete” Advances in Materials Science and Engineering Volume 2018, Article ID 6502890