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A STUDY ON MECHANICAL PROPERTIES OF M20 & M40 GRADE CONCRETES WITH FINE AGGREGATE PARTIALLY REPLACED WITH COPPER SLAG AND GGBS

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Abstract : Copper slag is a by-product obtained during matte smelting and refining of copper. The common management options for copper slag are recycling, recovering of metal, production of value added products such as abrasive tools, roofing granules, cutting tools, abrasive, tiles, glass, road-base construction, railroad ballast, asphalt pavements. Despite increasing rate of reusing copper slag, the huge amount of its annual production is disposed in dumps or stockpiles to date. One of the greatest potential applications for reusing copper slag is in cement and concrete production. By using the copper slag and GGBS in construction field, the chance of getting pollution due to copper slag AND GGBS will be reduced and it will be the cost effective method for any construction industry.

Introduction

In order to reduce reduction of natural total aggergates due to construction, artificially manufactured aggregate and some industrial waste materials can be used as alternatives. Copper slag (CS), is a material, produced during matte smelting and copper conversion was previously considered waste and disposed as landfill.The National Council for Cement has done pioneering work in the area utilization of industrial by-products for cement manufacture. The joint to utilize the copper slag as raw mix manufacture of OPCand as a blending material for PSC.Hence while designing the raw mixes, every effort was made to keep of utilization of copper slag to the maximum possible extent. The Central Electro Chemicals Research Institute, a Council of Scientific and Industrial Research, India had been consulted to confirm the character of copper slag and to obtain the recommendations from CECRI.

Among the metallurgical slags the most abundant and better known is basic granulated blast furnace slag produced as the by-product from the manufacturing of Pig Iron. Blast Furnace slag is formed by the combination of lime-stoned fluxes and the coke ash and residues from the reduction of iron. The blast furnace slag dosage is according to the expected performances. The properties of these cements will be more and more determined by the quantity of the blast furnace slag.

PROPERTIES OF COPPER SLAG AND GGBS

1. Copper slag, a copper production residue, shows in its chemical composition high contents of aluminium, silica and iron oxides, similar to that of cement.
2. Additionally, its hardness and gradation seems to indicate its suitability for use as alternative aggregate for applications in construction products.
3. Aggregate is the main material of concrete, usage is more than 70% of the concrete matrix.
4. Slag is used in Pavement Quality Concrete (PQC) in Dry Lean Concrete (DLC) mixes and its influence on workability (slump test), compressive strength, and flexural strength was determined.

LITERATURE SURVEY

Shanmugana than et al. (2008) carried out toxin and long term stability studies on CS and reported that the sediments samples are non-toxic and pose no environmental hazard also poor leach capability of the sediments essence assure long-term stability, indeed in extreme climates. The tests indicate that the heavy metals present in the slag are stable and are not likely to

dissolve significantly even through repetitious filtering under acid rain.Application of CS for operation similarly such as releif for FA in concrete has the binary benefit of bearing the costs of disposal and redution the cost of the concrete in some countries.

Shoya*et al.* (1999) plant no major differences in concrete compressive strength due to the use of CS as a relief for FA. Resend *et al*. (2008) reported a small reduction in concrete compressive and flexural strengths due to substitution of CS. Khanzadi and Behnood (2009) also explored the possibility of using CS as a replacement for coarse aggregate and reported an enhancement in the mechanical parcels of the high strength concrete mixture.

A. S. Arivalagan -This research work is an extinguished to develop a greenery concrete by using several industrial waste material in this report the M 35 mix design is used the GGBS replacement level is up to 40 % cement replacement, the maximum strength was obtained at the 20 % replacement at the age of 28 days. In this report the split tensile and flexure strength are also discussed at the replacement level of up to 40 % replacement and mechanical properties are compared with normal plain concrete.

VinayakAwasare, In this paper they have contemplated on the GGBS Blended bond cements for M 40 blend outline the compressive quality and flexure quality are resolved with expansion n of 20,30,50.% of GGBS with OPC 53 review cement. And they by reasoned that the standard concrete cement arranged by OPC bond and normal sand of M20 review.

METHODOLOGY

We have chosen the replacement of fine aggregate with copper slag & GGBS by taking reference of several related research papers as 40%, 50% & 60 %. In concrete of mix proportion 1:1.5:3, 1:1.3:2.1 will be prepared by using OPC cement with different replacement percentage of copper slag & GGBS as partial replacement of fine aggregate. M20 & M40 mix proportions fine aggregate is replaced with 40%,50%,60% of copper slag & same with GGBS and tested concrete mixes will be tested for following strengths.

Replacement of fine aggregate with copper slag and GGBS

M20 MIX				
CEMENT	FINE AGGREGATE	COPPER SLAGAND GGBS	COARSE AGREEGATE	WATER
100	60	40	100	100
100	50	50	100	100
100	40	60	100	100

Similarly for M40 also.

- Compressive strength changes after, 7 days, 14 days & 28 days
- Split tensile strength change after,7 days,14 days & 28 days
- Flexural strength change after 7 days, 14 days &28 days are determined.

Compressive Strength Test

For each set, six standard cylinders were casted to determine 7-days and 28 days compressive strength after curing. Also six no. of cylinders were casted to know the compressive strength of concrete. The size of the cube is as per the IS 10086 – 1982.

Split tensile strength test

The tensile strength of concrete is used to know the capacity to resist cracking or breaking under tension. ... Studies indicate that conventional concrete's tensile strength varies **between 250 and 600 psi**, i.e.,

Flexural Test*:*

It is the ability of a beam or slab to support failure in bending. The flexural strength of concrete is 12 to 20 percent of compressive strength. But now a days flexural strength is not used to find field control ,only compressive strength is easy to judge the quality of concrete. Flexural strength = $PL/BD^{2.}$

P is load
L= Length
B = Breadth
D = Depth

Demoulded prisms

Demoulded & tested specimens

Showing flexural strength test

MIX DESIGN

MIX DESIGN OF M20 GRADE CONCRETE : An example of calculating the required quantities proportions is given below

Target mean strength = fm = f_{ck} + KS = 20+1.65*4
=26.6 N/mm.
W/C ratio = 0.50
Cement content = 405 kg/cu.m
Volume of concrete = 1 cu.m
Volume of water = 161 lit
content of coarse aggregates = 1220 kg
content of fine aggregates = 620 kg

Water	cement	Fine aggregate	Coarse aggregate
191.6 lit	405 kg	620 kg	1220 kg

Final Mix design
Hence the Mix is **1:1.53:3.01** (Designed for M20)

MIX DESIGN OF M40 GRADE CONCRETE : An example of calculating the required quantities proportions is given below

Target mean strength = fm = f_{ck} + KS = 40+1.65*5
= 48.25 N/mm.
W/C ratio = 0.38
Cement content = 473 kg/cu.m
Volume of concrete = 1 cu.m
Volume of water = 180 lit
content of coarse aggregates = 1039 kg
content of fine aggregates = 645 kg

Water	cement	Fine aggregate	Coarse aggregate
191.6 lit	473 kg	645kg	1039 kg

Final Mix design
Hence the Mix is **1: 1.3: 2.1** (Designed for M40)

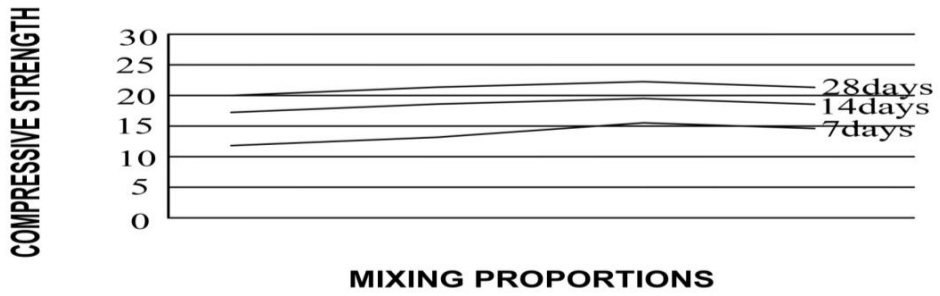
RESULTS AND DISCUSSIONS

Compressive strength

Table : 7, 14, 28 days compression test results M20 replaced with copper slag

STRENGTH OF CYLINDERS AT 7 , 14, 28 days			
MIX TYPE	**7 days**	**14 days**	**28 days**
M20	13.5	18.2	27.5
40%copperSlag	14.5	20.5	30.6
50%CopperSlag	15.3	22.2	33.7
60%CopperSlag	15.2	19.3	31.5

When F.A. is replaced with 40%,50% &60% 0f copper slag in m20 grade concrete increase in compressive strength of 11.2%,22.5%&14.5% respectively.

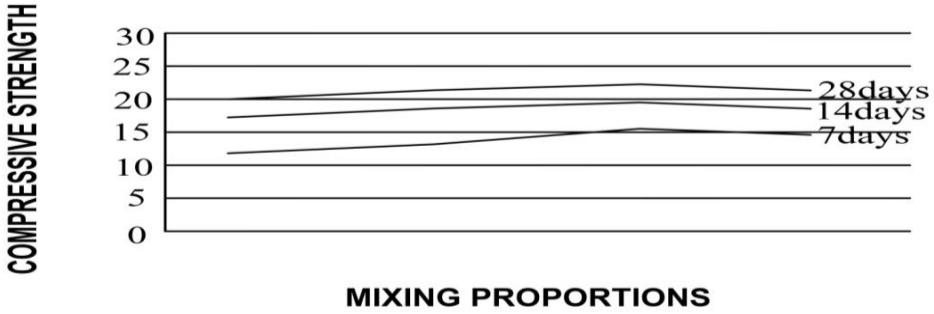


Graph : compression test for copper slag

Table : 7, 14, 28 days compression test results M40 replaced with copper slag

STRENGTH OF CYLINDERS AT 7 , 14, 28 days			
MIX TYPE	**7 days**	**14 days**	**28 days**
M40	24.2	36.2	45.7
40%copperSlag	27	38	49.5
50%CopperSlag	28.4	39.5	50.2
60%CopperSlag	27.5	38.85	49.5

When F.A. is replaced with 40%,50% &60% 0f copper slag in m40 grade concrete increase in compressive strength of 8%,27%&15% respectively



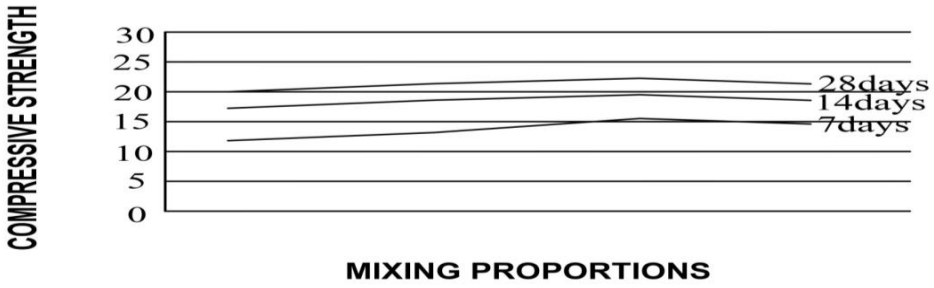
Graph : Compression test for copper slag

Compressive strength

Table : 7, 14, 28 days compression test results M20 replaced with GGBS

STRENGTH OF CYLINDERS AT 7 , 14, 28 days			
MIX TYPE	**7 days**	**14 days**	**28 days**
M20	13.5	18	27.5
40%GGBS	14.5	19.7	29.2
50% GGBS	15.8	21.2	30.5
60% GGBS	14.5	18.2	28.5

When F.A. is replaced with 40%,50% &60% 0f GGBS in m20 grade concrete increase in compressive strength of 6%, 10.9% & 3.6% respectively

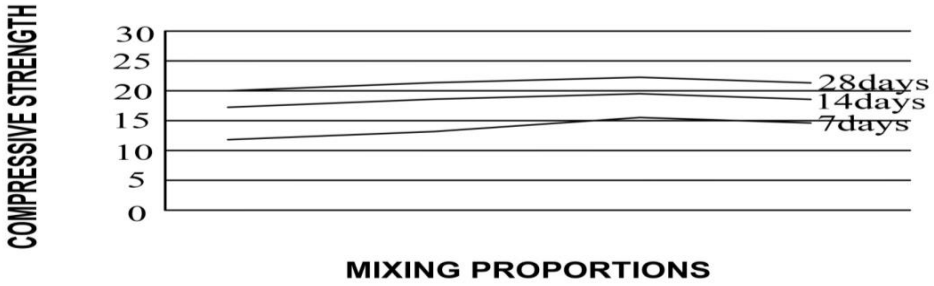


Graph : compression test for GGBS

Table : 7, 14, 28 days compression test results M40 replaced with GGBS

STRENGTH OF CYLINDERS AT 7 , 14, 28 days			
MIX TYPE	**7 days**	**14 days**	**28 days**
M40	24.2	36.2	45.7
40% GGBS	25.2	37.5	49.5
50% GGBS	26.4	38.8	50.8
60% GGBS	25.8	37.5	49.2

When F.A. is replaced with 40%,50% &60% 0f GGBS in m40 grade concrete increase in compressive strength of 5%, 15% & 9% respectively



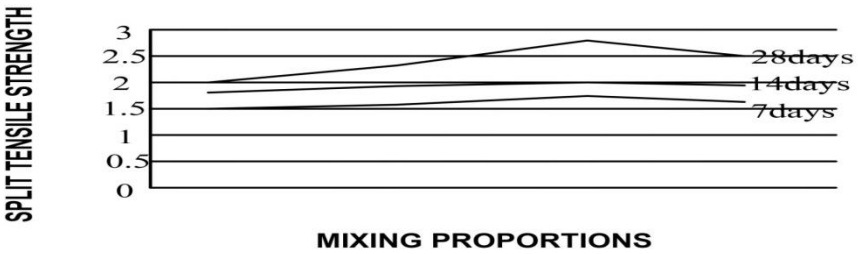
Graph : compression test for GGBS

Split tensile strength

Table : 7.7, 14, 28 days split tensile test results M20 replaced with copper SLAG

STRENGTH OF CYLINDERS AT 7 , 14, 28 days			
MIX TYPE	**7 days**	**14 days**	**28 days**
M20	1.54	2.1	3.12
40%copperSlag	1.6	2.2	3.24
50%CopperSlag	1.8	2.32	3.5
60%CopperSlag	1.7	2.22	3.2

When F.A. is replaced with 40%,50% &60% of copper slag in M20 grade concrete an increase in split tensile strength of 3%,12%,&2.5% respectively is obtained.

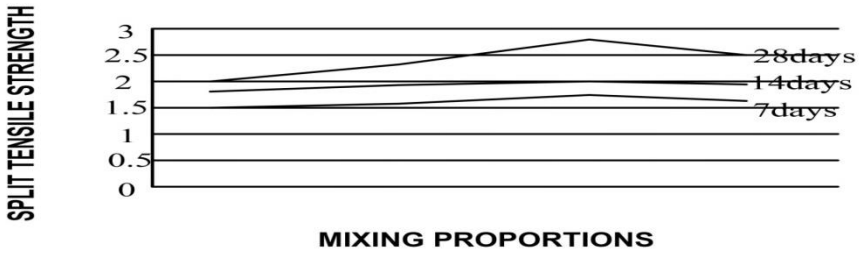


Graph : Split tenslie test for copper slag

Table : 7.7, 14, 28 days split tensile test results M40 replaced with copper slag

STRENGTH OF CYLINDERS AT 7 , 14, 28 days			
MIX TYPE	**7 days**	**14 days**	**28 days**
M40	1.6	2.2	4.42
40%copperSlag	1.75	2.20	4.4
50%CopperSlag	1.9	2.50	4.98
60%CopperSlag	1.82	2.35	4.5

When F.A. is replaced with 40%,50% &60% of copper slag in M40 grade concrete an increase in split tensile strength of 4%,18%,&5% respectively is obtained.



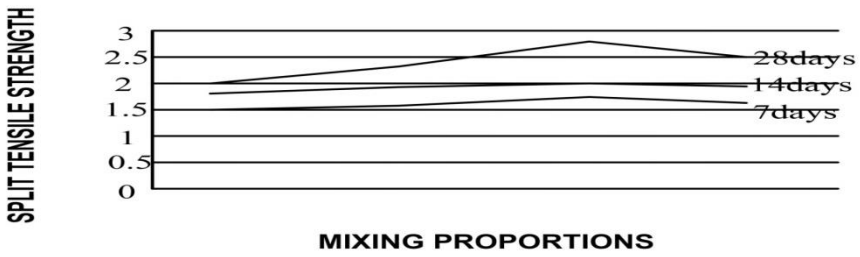
Graph : Split tenslie test for copper slag

Split tensile strength

Table : 7.7, 14, 28 days split tensile test results M20 replaced with GGBS

STRENGTH OF CYLINDERS AT 7 , 14, 28 days			
MIX TYPE	**7 days**	**14 days**	**28 days**
M20	1.54	2.1	3.12
40% GGBS	1.6	2.12	3.15
50% GGBS	1.8	2.25	3.3
60% GGBS	1.7	2.2	3.2

When F.A. is replaced with 40%,50% &60% of GGBS in M20 grade concrete an increase in split tensile strength of 3%,5.7%,&2.5% respectively is obtained.

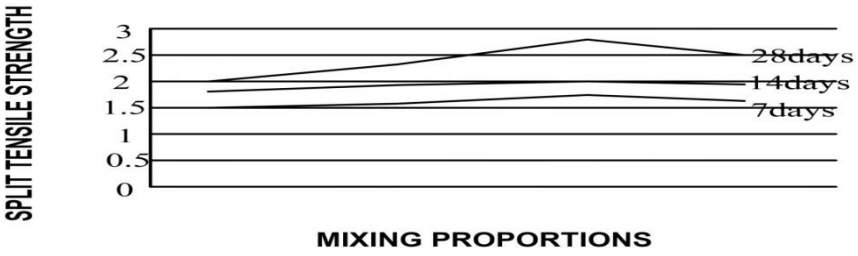


Graph : Split tenslie test for GGBS

Table : 7.7, 14, 28 days split tensile test results M40 REPLACED WITH GGBS

STRENGTH OF CYLINDERS AT 7 , 14, 28 days			
MIX TYPE	**7 days**	**14 days**	**28 days**
M40	1.6	2.2	4.2
40%GGBS	1.75	2.20	4.3
50%GGBS	1.9	2.50	4.85
60% GGBS	1.82	2.35	4.4

When F.A. is replaced with 40%,50% &60% of GGBS in M40 grade concrete an increase in split tensile strength of 4%, 15.4% ,&4.8% respectively is obtained.



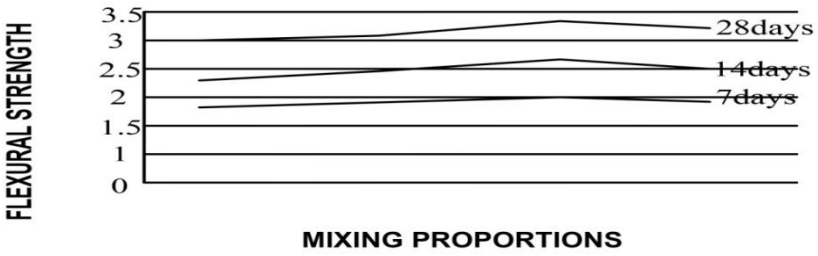
Graph : Split tenslie test for GGBS

Flexural strength

Table : 7, 14, 28 days split tensile test results M20 replaced with copper slag

STRENGTH OF CYLINDERS AT 7 , 14, 28 days			
MIX TYPE	**7 days**	**14 days**	**28 days**
M20	1.6	2.2	4.2
40%copperSlag	1.75	2.20	4.3
50%CopperSlag	1.9	2.50	4.85
60%CopperSlag	1.82	2.35	4.4

When F.A. is replaced with 40%,50% &60% of copper slag in M40 grade concrete an increase in split tensile strength of 4%,15.4%,&4.8% respectively is obtained.

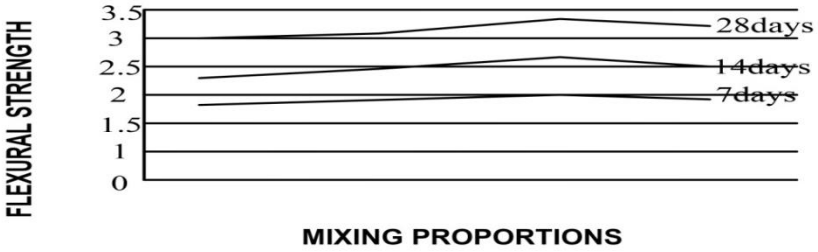


Graph : Flexural strength test for copper slag

Table 7, 14, 28 days split tensile test results M40 replaced with copper slag

STRENGTH OF CYLINDERS AT 7 , 14, 28 days			
MIX TYPE	**7 days**	**14 days**	**28 days**
M40	1.85	2.4	3.95
40%copperSlag	1.9	2.54	4.3
50%CopperSlag	1.98	2.9	4.64
60%CopperSlag	1.92	2.7	4.4

When F.A. is replaced with 40%,50% &60% of copper slag in M40 grade concrete an increase in split tensile strength of 8.8%,17%,& 9.5% respectively is obtained.



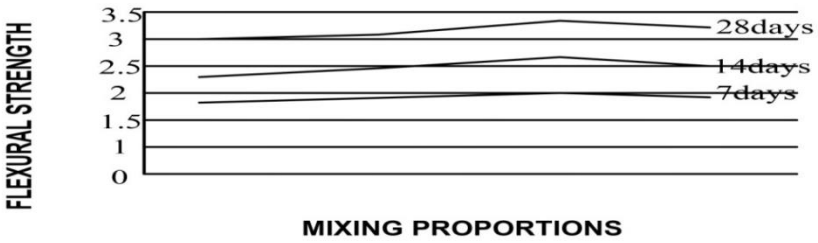
Graph : Flexural strength test for copper slag

Flexural strength

Table 7, 14, 28 days split tensile test results M20 replaced with GGBS

STRENGTH OF CYLINDERS AT 7 , 14, 28 days			
MIX TYPE	**7 days**	**14 days**	**28 days**
M20	1.8	2.30	3.01
40% GGBS	1.82	2.40	3.10
50% GGBS	1.92	2.55	3.20
60% GGBS	1.89	2.45	3.15

When F.A. is replaced with 40%,50% &60% of GGBS in M40 grade concrete an increase in split tensile strength of 4%,15.4%,&4.8% respectively is obtained.

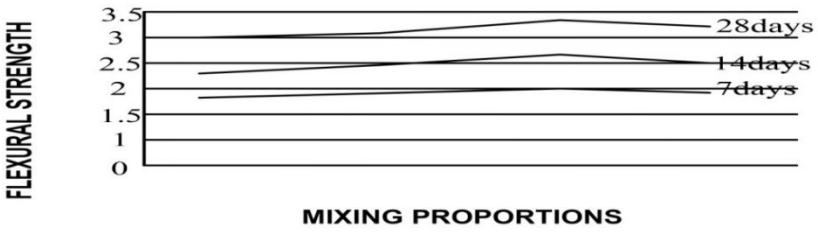


Graph : Flexural strength test for GGBS

Table 7, 14, 28 days split tensile test results M40 replaced with GGBS

STRENGTH OF CYLINDERS AT 7 , 14, 28 days			
MIX TYPE	**7 days**	**14 days**	**28 days**
M40	1.85	2.4	3.95
40% GGBS	1.95	2.45	4.2
50% GGBS	1.91	2.7	4.5
60% GGBS	1.89	2.6	4.3

When F.A. is replaced with 40%,50% &60% of GGBS in M40 grade concrete an increase in split tensile strength of 8.8%,17%,& 9.5% respectively is obtained.



Graph : Flexural strength test for GGBS

CONCLUSIONS

- Compressive strength is increase of 22.5% is observed when fine aggregate is replaced with 50% copper slag in M20 grade and in M40 grade concrete an increase 27 % is observed.
- compressive strength is increase of10.9% is observed when fine aggregate is replaced with 50% GGBS in M20 grade concrete and in M40 grade concrete an increase 14% is observed.
- An increase in tensile strength of 12 % is observed when fine aggregate is replaced with 50% copper slag in m20 grade concrete and in m40 grade concrete an increase 18% is observed.
- An increase in tensile strength of 5.7 % is observed when fine aggregate is replaced with 50% GGBS in M20 grade concrete and in M40 grade concrete an increase 15.4 % is observed.
- Flexural strength increases of 7.3 % is observed when fine aggregate is replaced with 50% copper slag in M20 grade concrete and M40 grade concrete an increase 17 % is observed.
- An increase in flexural strength of 6.3% is observed when fine aggregate is replaced with 50% GGBS in M20 gradeand M40 grade concrete an increase 13 % is observed.
- As replacement of fine aggregate with copper slag are showing increased values of stresses in compressive strength, split tensile strength & flexural, copper slag can be used as replacement of fine aggregate in making concrete.
- Usage of industrial waste like copper slag reduces the usage of natural sand and hence reduces environmental problems.
- It gives a solution for wastage of industrial waste which reduces environmental pollution.

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