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Experimental Investigations on Properties of Concrete by Partial Replacement of Sand with Copper Slag

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Abstract: *The natural resources getting exhausted so construction technology is moving toward the utilization of industrial waste in our we utilize copper slag in partial replacement of sand from 0% to 20% by weight using design mix by satisfying quality parameter M 25 grades were prepared and the different strength parameters i.e. compressive strength ,split tensile , flexure strength are consider and comparative analysis where done between conventional concrete and replaced concrete and results were obtained from specimen testing were satisfactory up to given percentage of replacement. Copper slag is one of the materials which are considered as waste materials in the production of copper, which can be used as partial replacement of fine aggregates in concrete. This study presents the results of an experimental study on various durability tests on concrete containing copper slag as partial Replacement of sand. This Study presents the results of an experimental study on various durability tests on containing copper slag as a partial replacement.*

Keywords: Fine aggregate, Copper slag, Compressive strength, Tensile strength, Flexure strength.

Introduction

Concrete is a composite material which is made up of filler and a binder. Typical concrete is a mixture of fine aggregate (sand), coarse aggregate (rock), cement, and water. Cement and lime are usually used as binding materials, while the sandbinder is mixed as fine aggregates and crushed stones, gravel, broken bricks; clinker is employed as coarse aggregates. The concrete having cement, sand and coarse aggregates mix up in an appropriate percentage in addition to water is called cement concrete. In this kind of concrete, cement is used as a binding substance, sand as fine aggregates and gravel, crushed stones as coarse aggregates. An investigation relating to the use of byproducts to enhance the functions of concrete has been about for many years. In the recent years, the researchers have been made to use industry by-products such as fly ash, silica fume, ground granulated blast furnace slag, glass cullet, etc., in concrete production and civil applications.

The potential uses of industrial byproducts in concrete or as a partial aggregate substitution or as a partial cement substitution depending on their chemical composition and grain size, The usage of these materials in concrete originates from the ecological requirements in the protected transfer of these products. Enormous intrigue is being centered on the earth and shielding of common assets and reusing of waste materials. Various industry are producing a significant number of products which incorporate residues such as reclaimed aggregates, reclaimed asphalt pavement, foundry sand, copper slag, fly ash, glass cullet, polyethylene terephthalate, high density polyethylene (HDPE), unplasticized polyvinyl chloride (UPVC), plasticized polyvinyl chloride (PPVC), low density polyethylene (LDPE), polypropylene(PP), polystyrene (PS), expanded polystyrene (UPS).

Infrastructural improvement plays a significant task in the development and improvement of any country or society. This competence is accompanied by construction, remolding, maintenance and demolition of roads buildings, subways and other structural establishments. The buildings which are over their serviceability state are pulled down for safety motive. The waste generated from demolition was earlier used for landfills of ditches and trenches. But with time the quantity of structure and destruction, waste generated enlarged exponentially. It contains generally of inert and non-biodegradable resources such as wood, concrete, glass, plastic and steel. Many large project sites have heaps and piles of construction and demolition waste lying around on roads and highways causing inconvenience and accidents to traffic movement. It is estimated that in India construction industry generates nearly 10-12 million tons of waste annually (Thomas and Wilson 2013).

Over the most recent 20 years, a considerable measure of work concerning the utilization of a few sorts of urban squanders in the building materials industrials process has been distributed. One of the new waste materials utilized as a part of the solid business is reused plastic. For fathoming the transfer of a lot of reused plastic material, reuse of plastic in the solid business is considered as the most possible application. Reused plastic can be utilized as coarse total in concrete. Concrete is one of the most established and most regular development materials on the planet, essentially because of its ease, accessibility, its long sturdiness, and capacity to support extraordinary climate situations. The overall creation of cement is ten times that of steel by tonnage. Then again, other development materials, for example, steel and polymers are more costly and less basic than solid materials. Concrete is a fragile material that has a high compressive quality, however a low rigidity. This fortification of cement is required to enable it to deal with malleable anxieties. Such help is normally made out utilizing steel

The main advances in Concrete technology deals, with the action of:

- Plasticizers,
- Super plasticizers,
- Retarders,
- Accelerators,
- Air-entraining admixtures,
- Pozzolanic Admixtures,
- Damp-proofing Admixtures,
- Gas forming Admixtures,
- Workability Admixtures,
- Bonding Admixtures,
- Coloring Admixtures and
- Corrosion Inhibiting Admixtures.

Not only has this but these also included construction Chemicals such as:

- Concrete Curing Compounds,
- Mold Releasing agents,
- Non-shrink high strength Grout,
- Surface Retarders,
- Guniting Aid and
- Protective Coatings.

The previously mentioned mixes are helpful in not just expanding quality, strength and workability of cement yet they are additionally valuable in offering insurance to concrete, make bonds between the materials of cement, and gives alluring hues to concrete and furthermore they lessen water, all things considered, which is an extreme emergency in these days.

MATERIALS USED IN CONCRETE

The materials used in the projects for making concrete mixture are cement, fine aggregate, coarse aggregate, copper slag, are detailed describe below:

CEMENT: Cement is by a wide margin the most imperative constituent of cement, in that it shapes the coupling medium for the discrete fixings. Made out of normally happening crude materials and now and again mixed or underground with modern squanders. The bond utilized as a part of this examination was OPC 43 grades Ordinary Portland cement (OPC) fitting in with IS-12269:1987.

FINE AGGREGATE: Aggregates which possess about 70 to 75 percent volume of cement are some of the time saw as latent fixings in excess of one sense. Nonetheless, it is currently very much perceived that physical, compound and warm properties of totals considerably impact the properties and execution of cement. The fine total (sand) utilized was perfect dry sand was sieved in 4.75 mm sifter to expel all stones.

COURSE AGGREGATE: Coarse is utilized for making concrete. They might be as unpredictable broken stone or normally happening rock. Material which is expansive to be held on 4.75mm sifter estimate is called coarse totals. Its most extreme size can be up to 40 mm.

WATER: water assumes a critical part in the development of concrete as it takes an interest in a concoction response with bond. Because of the nearness of water, the gel is shaped which helps in increment of quality of cement. Water utilized for blending and curing might be spotless and free from damaging amounts of alkalies, acids, oils, salts, sugar, natural materials, vegetable development or other substance that might be malicious to blocks, stone, cement or steel. Compact water is by and large viewed as tasteful for blending. The pH estimation of water should not be not as much as the accompanying fixations speak to the greatest admissible esteems.

Limits of acidity: To neutralize 100 ml. sample of water, using phenolphthalein as an indicator, it should not require more than 5 ml. of 0.02 N NaOH. The details of the test shall be as given in IS-3025: Part 1:1987

Limits of alkalinity: To kill 100 ml. test of water, utilizing blended pointer, it ought not require in excess of 25 ml of 0.02 N H2SO4. The points of interest of tests might be as given in May be 3025: Part 1:1987.

Percentage of solids: Maximum permissible limits of solids when tested in accordance with IS-3025: Part 1:1987 shall be as under:

Water found satisfactory for mixing is also suitable for curing. However, water usedfor curing shall not produce any objectionable stain or unsightly deposit on the surface.

Sea water shall not be used for mixing or curing.

Water from each source shall be tested before the commencement of the work and thereafter once in every three months till the completion of the work. In the case of ground water, testing shall also be done for a different point of drawdown. Water from each source shall be got tested during the dry season before monsoon and again after the monsoon.

II. Literaure Review

Smithy Rajuet. al "Durability characteristics of copper slag concrete with fly ash DOI: https://doi.org/10.14256/JCE.1229,E-ISSN: 1031-1040, 2017.

An experimental investigation will be conducted to think about the properties of cement containing copper slag as a fractional substitution of fine totals in the solid blend plan. Different solidness tests will be directed on such cement of M30 review and M40 review to know the compressive quality, split elasticity, flexural quality by shifting extents of copper slag (CS) with fine totals by 0%, 5%, 10%, 15%, 20%,25%,30% and Egg shell powder (ESP) as bond by 0%, 5%, 10%, 15%, 20%, 25%, 30% by weight. The acquired outcomes will be contrasted and the ordinary cement, there by knowing the adjustments in the properties of cement containing copper slag as an incomplete substitution of fine total.

SukhoonPyo, Sherif El-Tawil, Antoine E. Naaman, "Coordinate pliable conduct of ultra superior fiber strengthened cement (UHP-FRC) at high strain rates", Elsevier 2016.

Led investigation utilizing an as of late created affect testing framework that utilizations all of a sudden discharged strain vitality to produce an effect beat. Three fiber writes were viewed as, a turned fiber and two different kinds of straight filaments. Example affect reaction was assessed regarding first breaking quality, post-splitting quality, vitality ingestion limit and strain limit. The test outcomes show that examples with curved strands by and large display fairly preferable mechanical properties over examples with straight filaments for the scope of strain rates considered. All Ultra-High Performance Fiber Reinforced Concrete (UHP-FRC) arrangement tried indicated uncommon rate sensitivities in vitality retention limit, by and large ending up considerably more vitality dissipative under expanding strain rates. This trademark features the capability of Ultra-High Performance Fiber Reinforced Concrete (UHP-FRC) as promising bond based material for effect and impact safe applications.

Yuh-Shiou Tai, Sherif El-Tawil, Ta-Hsiang Chung, "Execution of twisted steel filaments implanted in ultra-elite cement subjected to different pullout rates" ,Elsevier 2016.

Explored the mechanical conduct of elite steel filaments installed in Ultra-superior cement (UHPC) at different pullout speeds the test factors were steel fiber compose, framework constituents, and pullout rates. Specifically, five kinds of high quality steel fiber were utilized and five pullout rates from semi static to affect rates were connected. Moreover, the impact of decreased measure of glass powder, as key network constituent, on pullout conduct was investigated. Trial comes about demonstrate that the pullout reaction of the majority of the fiber writes display dynamically expanding rate affectability as the pullout speed increments and winds up huge amid affect stacking. It is most unmistakable in the smooth and turned strands and slightest in the snared filaments. Moreover, checking electron magnifying instrument considers are introduced and used to clarify the system of rate upgrade from a tiny point of view.

AnjuRamesan, Shemy S. Babu, AswathyLal, "Execution of light weight concrete with plastic total", International Journal of Engineering Research and Applications, Vol. 5, Issue 8, August 2015, pp.105-110.

Learned about appropriateness of execution of light weight concrete with plastic total. the reasonableness of reused plastics (high thickness polyethylene) as coarse total in concrete by leading different tests like workability by droop test, compressive quality of 3D square and chamber, part elasticity trial of barrel, flexural quality of R.C.C and additionally P.C.C Beams, to decide the property and conduct in concrete. Impact of supplanting of coarse total with different rates of plastic total on conduct of cement was tentatively examined

and the ideal substitution of coarse total was discovered. The outcomes demonstrated that the expansion of plastic total to the solid blend enhanced the properties of the resultant blend.

Sahil Verma, Sahil Arora, "Substitution of Natural Sand in Concrete by Polyethylene Bottles" International Research Journal of Engineering and Technology (IRJET), Volume: 02 Issue: 01, Apr-2015.
Researched about the utilization the waste plastic squashed jugs of suitable size in concrete with fractional substitution of fine totals and it has the capability of discarding vast amounts of the disastrous waste usefully. The natural impacts can be significantly lessened by appropriate embodiment of these waste plastic jugs. The examination additionally gives the correlation of compressive quality of typical customary cement with the solid produced using the halfway substitution of totals with Polyethylene Terephthalate bottles. Subsequently concrete with squander Polyethylene Terephthalate (PET) fiber can be utilized as a compelling plastic waste administration hone in future.

Biaya Patnaik, Seshadri Sekhar.T, Srinivasa Rao, "Quality and Durability Properties of Copper Slag Admixed Concrete" International Journal of Research in Engineering and Technology, e-ISSN: 2319-1163, p-ISSN: 2321-7308, Volume 4, Issue 1, Feb 2015.
Learned about the quality and toughness properties of cement having copper slag as a fractional substitution of sand (fine total) and results have been introduced in this paper. Two various types of Concrete Grade (M20 and M30) were utilized with various extents of copper slag substitution i.e 0 to half in the solid. Quality and Durability properties, for example, compressive quality, Split Tensile Strength, flexural quality, corrosive resistivity and sulfate resistivity were assessed for both blends of cement. Test outcomes clarifies that the quality properties of cement has better having copper slag as a halfway substitute of Sand (up to 40%) in concrete yet as far as dependability the solid observed to be low impervious to corrosive assault and better protection against sulfate assault.

Binaya Patnaik, Seshadri Sekhar.T, Srinivasa Rao, "Quality and Durability Properties Of Copper Slag Admixed Concrete" International Journal of Research in Engineering and Technology, e-ISSN: 2319-1163, p-ISSN: 2321-7308, Volume 4, Issue 1, Feb 2015.
Learned about the other of waterway sand by sand is conceivable in solid blend. For M 20 and M 25 review concrete, the ideal sand trade extent is by and large 20-25%. Also, by and large the sand can be supplanted till 30-40% by sand in material. The trading of sand by foundry sand in solid builds the compressive power, split malleable power, flexure power and modulus of adaptability. Typically the exploratory examination is completed for solid review. Assist examination ought to be discover in regards to M 35 and M 40 level solid, which could be valuable for multi-story structures, development of scaffolds, roads, and so forth where quality prerequisite is high.

Pranshu Saxena, Ashish Simalti, "Extent of Replacing Fine Aggregate With Copper Slag In Concrete" International Journal of Technical Research and Applications, e-ISSN: 2320-8163, Volume 3, Issue 4, August 2015, PP. 44-48.
Sudied about extent of substitution of fine total from copper slag in concrete. Copper slag speaks to a famous other option to sand as a shooting medium in modern cleaning. Utilizing impacting or high-weight showering systems, organizations are utilizing copper slag to clean vast refining hardware or heaters. Material like copper slag can be utilized as one which can decrease the cost of development. Their endeavor has been made to order the different investigations done on the substitution of copper slag in fine total to judge the quality of cement.

III. Material Used

CEMENT: is by a long shot the most essential constituent of cement, in that it frames the coupling medium for the discrete fixings. Made out of normally happening crude materials and here and there mixed or entomb ground with mechanical squanders. The cement used in this study was OPC 43 grades Ordinary Portland cement (OPC) conforming to IS 10262.

Figure 1: Cement.

The properties of cement used are given in Table.

Table1: Properties of cement.

Properties	Value
Fineness of cement	6%
Grade of Cement	OPC(43 grade)
Specific gravity of cement	2.90
Initial setting time	112
Final setting time	320
Normal Consistency	34%

FINE AGGREGATE: Aggregates which involve almost 70 to 75 percent volume of cement are at times seen as latent fixings in excess of one sense. In any case, it is currently all around perceived that physical, concoction and warm properties of totals generously impact the properties and execution of cement. The fine total (sand) utilized was perfect dry sand was sieved in 4.75 mm strainer to evacuate all rocks.

Figure 1: Fine Aggregate.

The Properties of fine aggregate are given in table

. **Table 2:** Properties of fine aggregate.

Properties	Value
Specific Gravity	2.44
Fineness Modulus	2.25
Water absorption	1.5%

3.2.3 COARSE AGGREGATE: are utilized for making concrete. They might be as unpredictable broken stone or normally happening rock. Material which are huge to be held on 4.75mm strainer measure are called coarse totals. Its most extreme size taxicab be up to 63mm.

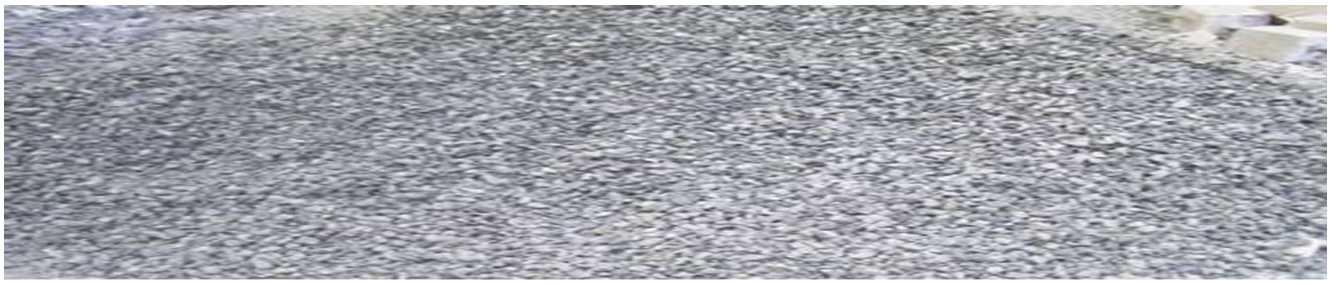

Figure 3: Coarse aggregate.

Properties of Coarse aggregate are given below in table.

Table 3: Properties of coarse aggregate.

Properties	Values
Specific Gravity	3.125

Size of Aggregates	20mm
Fineness Modulus	5.96
Water absorption	2.0%
Impact Test	15.2%
Crushing Test	22.5%

3.2.4. WATER: water assumes an essential part in the arrangement of concrete as it takes part in compound response with bond. Because of the nearness of water the gel is shape which helps in increment of quality of cement. Any common water that is drinkable and has no articulated taste or smell can be utilized as blending water. Water from lakes and streams that contain marine life are likewise generally reasonable. Water utilized for blending and curing might be perfect and free from damaging amounts of alkalies, acids, oils, salts, sugar, natural materials, vegetable development or other substance that might be malicious to blocks, stone, cement or steel. Consumable water is for the most part thought to be attractive for blending.

The pH estimation of water should not be not as much as the accompanying focuses speak to the most extreme admissible esteems (of malicious materials in water):

- Limits of acridity: To kill 100ml example of water, utilizing phenolphthalein as a pointer, it ought not require more than 5ml of 0.02 typical NaOH. The subtle elements of test might be as given in IS 3025.
- Limits of alkalinity: To kill 100ml example of water, utilizing blended pointer, it ought not require more than 25ml of 0.02 typical H2SO4. The points of interest of tests should be as given in IS 3025.

IV. Results and Discussion

1. WORKABILITY TEST

In this work the workability is tested by slump test. When the concrete is freshly mix then it is tested by filling the fresh concrete in the slump cone. The workability is measured by removing the slump cone and measured the subsidence of the concrete this value is called the slump value of the concrete.

The slump value for the M 25 grade of the concrete with using copper slag are shown in the Table 4. There graphical representations are shown in the Figure 4.

Table 4: Slump Value of the Different mix M-25 Concrete.

Percentage replacement	Ingredients				Slump Value in (mm)
	Coarse Aggregate %	Fine Aggregate %	Copper slag %	Cement %	
0%	100	100	0	100	88
5%	100	95	5	100	87
10%	100	90	10	100	84
15%	100	85	15	100	81
20%	100	80	20	100	78

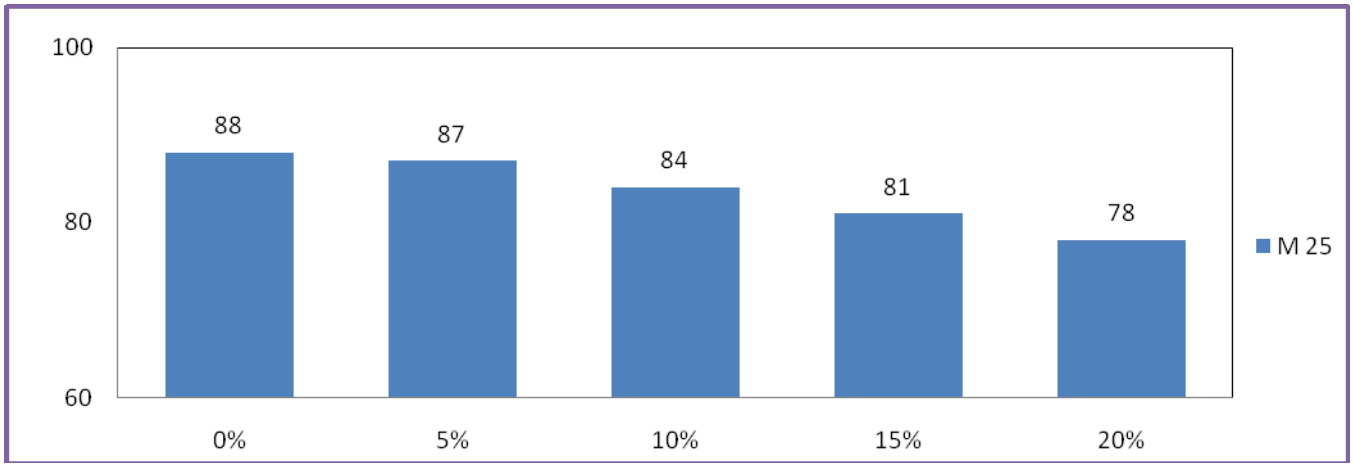

Figure 4: Slump Value of the Different mix M-25 Concrete.

2. COMPRESSIVE STRENGTH TEST

In this investigation the designed concrete was subjected to different tests to evaluate the quality and different properties of the casted concrete. The fundamental point of the examination is to screen the created strength attained by the concrete at different testing days from curing. Generally proper casting and curing of concrete will expand the quality of the concrete. For this project each test is done with 3 tests for each mix proportion and tried at required curing time. At that point the normal esteems are utilized for the investigations. The result of the compressive strength with partial replacement of copper slag for 7, 14, 28 and 56 days are shown in the Table 5 for M-25 concrete and their graphical representation is shown in the Figure 5.

Table 5: Compressive Strength of M-25 concrete Mix at Different curing stages.

Percentage replacement	Compressive Strength in N/mm^2				Ingredients			
	7 Days	14 Days	28 Days	56 Days	Coarse Aggregate %	Fine Aggregate %	Copper slag %	Cement %
0%	17.20	22.70	29.10	39.67	100	100	0	100
5%	16.72	20.00	28.77	35.25	100	95	5	100
10%	15.59	19.75	26.75	33.50	100	90	10	100
15%	14.75	17.50	26.00	31.90	100	85	15	100
20%	13.50	16.00	24.90	31.25	100	80	20	100

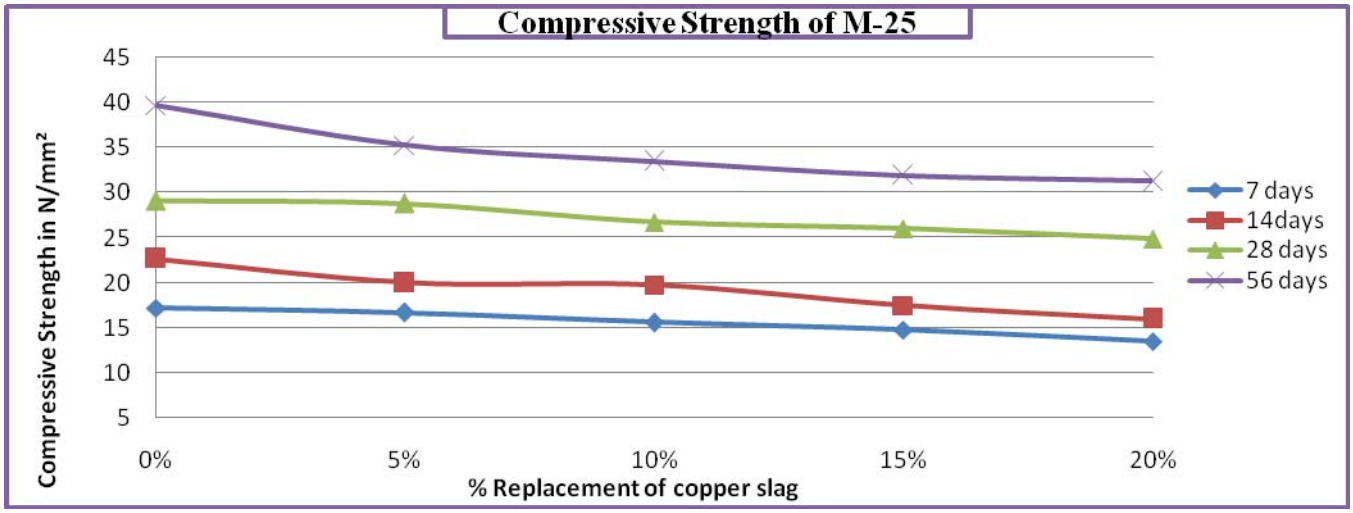

Figure 5: Compressive Strength of M25 Mix cubes at different curing stages.

3. FLEXURE STRENGTH TEST

Flexural strength also called as modulus of rupture. In concrete flexure is the bending moment caused by the applied load, in which a concrete beam has compression at top and tensile stress at the bottom side. Beams on testing will flop in pressure because of its property and shear will show up on concrete. In this exploratory

works absolutely 60-beams of size 700 x 100 x 100 mm are casted of M-25 grades concrete and other percentage of replacements as for 5%, 10%, 15% and 20% by weight of copper slag with sand. The consequence of the flexure quality with halfway substitution of copper slag for 7, 14, 28 and 56 days are shown in the Table 6 for M-25 concrete and their graphical representation in the Figure 6 for M-25 concrete.

Table 6: Flexure Strength of Different Mix of M-25 Concrete.

Percentage replacement	**Flexure Tensile Strength in N/mm^2**				**Ingredients**			
	7 Days	14 Days	28 Days	56 Days	Coarse Aggregate %	Fine Aggregate %	Copper slag %	Cement %
0%	2.97	3.19	3.67	3.89	100	100	0	100
5%	2.8	2.98	3.46	3.63	100	95	5	100
10%	2.6	2.68	3.3	3.42	100	90	10	100
15%	2.38	2.56	3.16	3.34	100	85	15	100
20%	2.32	2.48	3.1	3.28	100	80	20	100

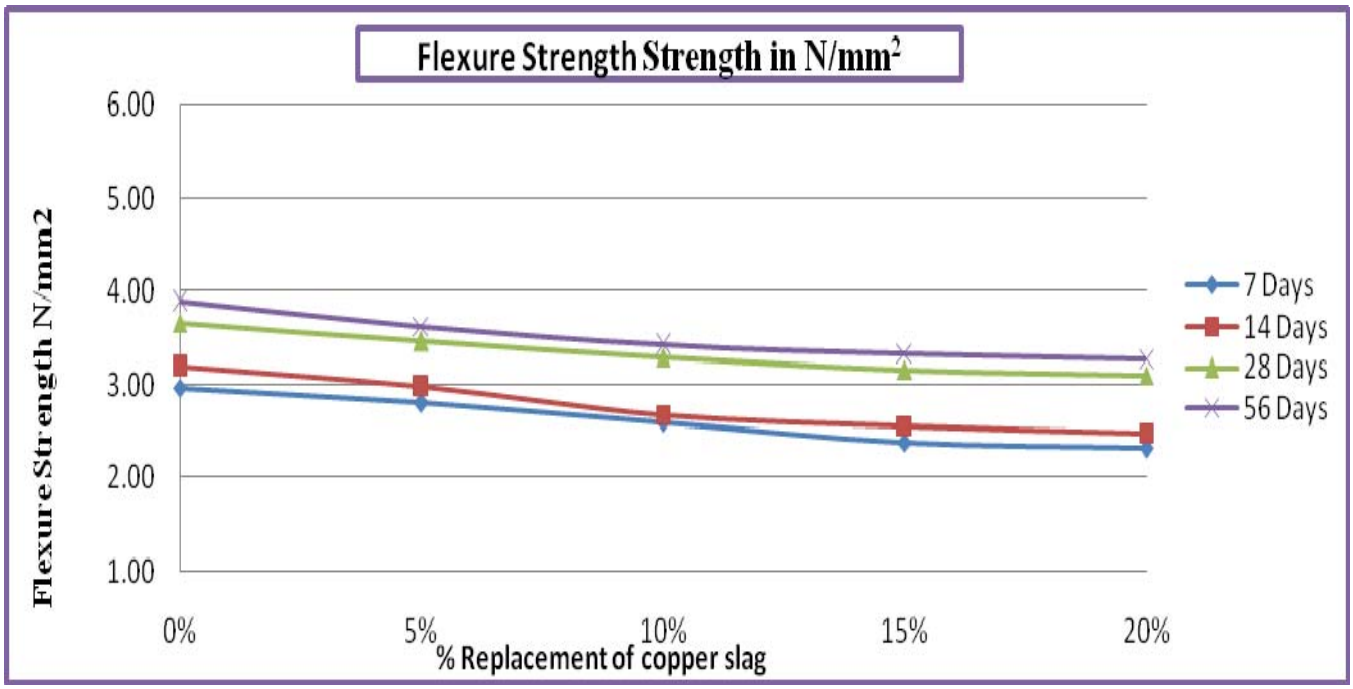

Figure 6: Flexural Strength of M25 Mix cubes at different curing stages.

V. Conclusions

As per investigational analysis following conclusions can be drawn.

- The utilization of copper slag in concrete provides additional environmental as well as technical benefits for all related industries
- Partial replacement of copper slag in fine aggregate reduces the cost of making concrete because which is used for mass concreting (gravity dam). Replacement of copper slag with sand increases the self weight of concrete specimens to the maximum of 15-18%.
- A Copper slag is a type of waste used as a substitute to natural sand in concrete.
- From this investigation, the copper slag particles are waste of low cost material which would help to resolve solid waste disposal problem and protect environment from pollution.
- Cost of Concrete production reduces when Copper Slag is used as a fine aggregate in concrete.
- Copper Slag acts like River Sand as it contains Silica (SiO2) like sand.
- Addition of Copper Slag builds the thickness of cement along these lines expanding the Self-weight.
- The Compressive Strength of Concrete with incomplete supplanting of Sand with Copper to 20% can be comparable with conventional Concrete.
- Partial substitution of Copper waste in concrete with shows good resistance to sulphate attack

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