Copper Slag Partially Replaces Fine Aggregate in M 25 Concrete: A Comparative Study of Compressive Strength Responses

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Abstract: ***Due to boom in construction industry, natural sand and M sand are depleting at an alarming rate cause several environmental issues. At this stage copper slag , an industrial byproduct generated during smelting and refining of Copper can be a partial alternative for fine aggregate where its world annual generation is about 33 million tonnes. The project look through the use of copper slag as partial replacement to M sand and natural sand for the designed M 25 grade mix concrete. compressive strength responses of above alternatives performed, and observed maximum value at 40% copper slag replacement which up to 36% increment.***

Keywords: Copper slag, design mix M25 grade concrete, M sand , natural sand, partial replacement, compressive strength responses

1. Introduction

A huge amount of concrete is consumed by the construction industry. About 45% volume of concrete is comprised of sand. A good quality concrete is produced by careful mixing of cement, fine and coarse aggregates, water and admixtures as needed to obtain an optimum quality and economy. Now-a-days due to constant sand mining the natural sand is depleting at an alarming rate. Scarcity of good quality Natural River sand due to depletion of resources and restriction due to environmental consideration has made concrete manufactures to look for suitable alternative fine aggregate. One such alternative is “Manufactured sand”. Though manufactured sand has been in use in concrete manufacturing in India, the percentage of its contribution is still very negligible in many parts of the country.

Copper slag is a non ferrous slag obtained as a by-product during the matte (molten copper sulphide) smelting and refining of copper. Major constituents of a smelting charge are sulphides and oxides of iron and copper. As a result, copper-rich matte (sulphides) and copper slag (oxides) are formed as two separate liquid phases. The molten slag is discharged from the furnace at 1,000–1,300 _C. When liquid slag is cooled slowly, it forms a dense, hard crystalline product where a quick solidification by pouring molten slag into water provides amorphous granulated slag. Recycling, recovering of metal, production of value added products and disposal in slag dumps or stockpiles are the options for management of copper slag. It has been widely used for abrasive tools, roofing granules, cutting tools, abrasive, tiles, glass, road-base construction, railroad ballast, asphalt pavements, cement clinker and blended cement production. fine or coarse aggregate in the preparation of cement mortar Copper slag has been excluded from the listed hazardous waste category of the United States Environmental Protection Agency (USEPA). The United Nations (UN) Basel Convention on the Trans boundary Movement of Hazardous Waste and its Disposal also ruled that copper slag is not a hazardous waste. The slag was made of black glassy particles and granular in nature and has a particle size range similar to sand

At present about 33 million tons of copper slag is generating annually worldwide among that India contributing 6 to 6.5 million tones. 50 % copper slag can be used as replacement of natural sand in to obtain mortar and concrete with required performance, strength and durability. (Khalifa S. Al-Jabri et al 2011).

2. Literature Review

Copper slag is one of the materials that are considered as a waste material which could have a promising future in construction industry as partial or full substitute of either cement or aggregates. It is a byproduct obtained during the matte smelting and refining of copper. To produce every ton of copper, approximately 2.2–3.0 tons copper slag is generated as a by-product material. In Oman approximately 60,000tons of copper slag is produced every year.

Many researchers have investigated the use of copper slag as fine or coarse aggregate in the preparation of cement mortar and concrete. Copper slag has been excluded from the listed hazardous waste category of the United States Environmental Protection Agency (USEPA). The United Nations (UN) Basel Convention on the Trans boundary Movement of Hazardous Waste and its Disposal also ruled that copper slag is not a hazardous waste. The slag was made of black glassy particles and granular in nature and has a particle size range similar to sand

In India a study has been carried out by the Central Road Research Institute (CRRI) shown that copper slag may be used as a partial replacement for river sand as fine aggregate in concrete up to 50 % in pavement concrete without any loss of compressive and flexural strength and such concretes shown about 20 % higher strength than that of conventional cement concrete of the same grade .

3. Problem Definition

3.1 Aim

Aim of this project is the comparative study of the strength characteristics of M25 grade concretes prepared by natural sand and M-sand as fine aggregate respectively, in which both are partially replaced by Copper slag.

3.2 Objectives

1) To study the property and characteristics of M sand and copper slag
2) Collection of primary data
3) To compare the properties and characteristics of various materials used in mix designing with IS code
4) To carry out mix design by using m sand as fine aggregate.
5) To conduct tests and strength characteristics of concrete as freshly prepared and hardened stage based on the designed proportion
6) Obtain the strength characteristics of concrete with partial replacement of copper slag

4. Experimental Investigation

4.1 General

Concrete structure is designed for a certain intended design life. In its life cycle period it is exposed to different hostile climatic condition such as rapid wetting and drying, abrasion, chloride and sulphate attack, carbonation, freeze and thaw effect etc. A good concrete from durability point of view, gives a good resistance from these potential hazards and subsequently enhance the life of the structure. A concrete is said to be durable if it shows good resistance to the potential hazards from the climatic condition and successfully completes the intended life cycle for what it has been intended to. Durability parameters are important for the type of structures too.

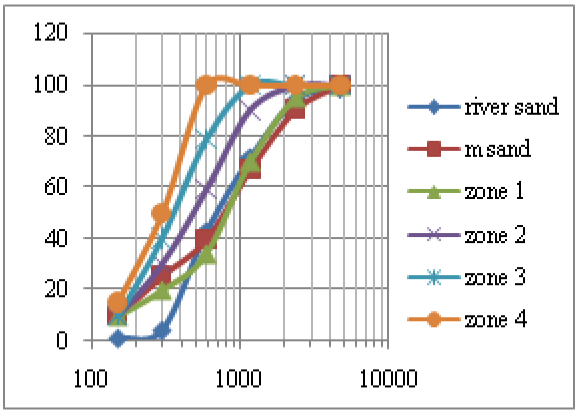
In this project experimental investigations were carried out on Physical and Mechanical properties of concrete made with M-sand, natural sand and copper slag concrete. Natural fine aggregate is completely replaced by M-sand and partially by copper slag. Compressive strength is evaluated and compared up to 28 days of ages. Specific properties of concrete materials and copper slag are also studied. The entire tests were performed as per specifications.

4.2 Sieve Analysis

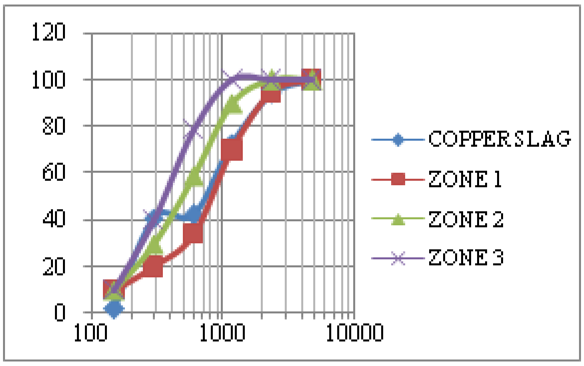
The test was conducted as per IS: 2386 (Part I) – 1963.The sample shall be brought to an air-dry condition before weighing and sieving. This may be achieved either by drying at room temperature or by heating at a temperature of 100^0 to 110°C. The air-dry sample shall be weighed and sieved successively on the appropriate sieves starting with the largest. Care shall be taken to ensure that the sieves are clean before use. Each sieve shall be shaken separately over a clean tray until not more than a trace passes, but in any case for a period of not less than two minutes. The shaking shall be done with a varied motion, back- wards and forwards, left to right, circular clockwise and anti-clockwise, and with frequent jarring, so that the material is kept moving over the .sieve surface in frequently changing directions. Material shall not be forced through the sieve by hand pressure, but on sieves coarser than 20 mm, placing of particles is permitted. Lumps of fine material, if present, may be broken by gentle pressure with fingers against the side of the sieve. Light brushing with a soft brush on the underside of the sieve may be used to clear the sieve openings. Light brushing with a fine camel hair brush may be used on the 150-micron and 75-micron IS Sieves to prevent aggregation of powder and blinding of apertures. Stiff or worn out brushes shall not be used for this purpose and pressure shall not be applied to the surface of the sieve to force particles through the mesh. On completion of sieving, the material retained on each sieve, together with any material cleaned from the mesh, shall be weighed.

Table 4.1: Sieve analysis result on aggregates (Cumulative % passing)

IS sieve	Cumulative % passing				%passing for single sized aggregates of normal sand (IS 383 –1970) zone ii
	C.A	River sand	M-sand	Copper slag	
4.75 mm	2.75	99.25	100	100	90 to 100
2.36 mm	0	93.50	90.7	94.2	75 to 100
1.18 mm	0	48.00	66.8	73	55 to 90
600 µm	0	21.00	39.8	42.2	35 to 59
300 µm	0	04.00	25.5	41.2	08 to 30
150 µm	0	0.05	9.9	1.8	0 to 10



Graph 4.1: Showing grading zone of m sand and river sand



Graph 4.2: Showing grading zone of copper slag

4.3 Fineness Modulus

Fineness Modulus (F.M) is a ready index of coarseness or fineness of the material. F.M is an empirical factor obtained by adding the cumulative percentage aggregate retained on each of the standard sieves and dividing this sum by an arbitrary number 100. the larger the figure , coarser is the material .

$$\text{Fineness modulus} = \sum \frac{\text{cumulative persentage retained}}{100}$$

Fine sand : Fineness Modulus : 2.2 - 2.6
Medium sand : F.M : 2.6 - 2.9
Coarser sand : F.M :2.9 - 3.2
Sand having fineness modulus more than 3.2 will be unsuitable for making satisfactory concrete.

Table 4.2: Sieve analysis result showing fineness modulus

Is Sieve	Cumulative % Retained			
	Coarse Aggregate	River Sand	M Sand	Copper Slag
20	0.7	0	0	0
16	4.15	0	0	0
12.5	15.85	0	0	0
10	48.75	0	0	0
4.75 mm	97.25	1.17	2	0
2.36 mm	0	5.68	9.3	5.8
1.18 mm	0	28.14	33.8	27
600 µm	0	57.07	60.2	57.8
300 µm	0	95.39	74.5	58.8
150 µm	0	98.68	90.1	98.2
Fineness modulus	**5.32**	**2.87**	**2.69**	**2.47**

4.4 Specific Gravity Bulk Density Void Ratio Absorption and Surface Moisture Content

Specific Gravity – the ratio of the mass, in air, of a volume of a material to the mass of the same volume of gas-free distilled water at a stated temperature. The specific gravity of solid particles (Gs) is defined as the ratio of mass of given volume of solids to the mass of an equal volume of water at 4^0C, determined by Pycnometer.

Bulk density: Bulk density shows how densely the aggregate is packed when filled in a standard manner. The bulk density depends on the particle size distribution and shape of the particles. One of the early methods of mix design makes use of this parameter bulk density in proportioning of concrete mix. The higher the bulk density, the lower is the void content to be filled by sand and cement. The sample which gives the minimum voids or the one which gives maximum bulk density is taken as the right sample of aggregate for making economical mix.

Absorption: The increase in the mass of aggregate due to water being absorbed into the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry mass. The aggregate is considered "dry" when it has been maintained at a temperature of 110 ±5°C (230 ±9°F) for sufficient time to remove all uncombined water.

Surface moisture content: Saturated Surface Dry (SSD) – condition of an aggregate particle when the permeable voids are filled with water, but no water is present on exposed surfaces.

Table 4.3 Specific gravity, Bulk density and void ratio Absorption and surface moisture of aggregates

Property	*River Sand*	*M-Sand*	*Copper Slag*	*Coarse Aggregate*
Specific Gravity	2.65	2.69	3.6	2.77
Bulkdensity Kg/Litre	1.69	1.85	2.08	1.58
Void Ratio	0.64		0.43	
Surface Moisture In %	3	5.4	2.51	2
Absorption In %	1.75	1.96	1.84	.7

5. Mix Design

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. the purpose of designing as can been seen from the above definition is two-fold .the first object is to make the concrete in the most economical manner. Cost wise all concrete depend primarily on two factors; namely cost of material and cost of labour. Labour cost, by way of formworks, batching, mixing, transporting, and curing is nearly same for good concrete and bad concrete. Therefore attention is mainly directed to cost of material. since the cost of cement is many times more than the cost of other ingredients, attention is mainly directed to the use of as little cement as possible consistent with strength and durability.

5.1 Factors to Consider for Mix Design

- The grade designation giving the characteristic strength requirement of concrete.
- The type of cement influences the rate of development of compressive strength of concrete.
- Maximum nominal size of aggregates to be used in concrete may be as large as possible within the limits prescribed by IS 456:2000.
- The cement content is to be limited from shrinkage, cracking and creep.
- The workability of concrete for satisfactory placing and compaction is related to the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.

Procedure

1) Determine the mean target strength f_t from the specified characteristic compressive strength at 28-day f_{ck} and the level of quality control.
   $f_t = f_{ck} + 1.65\ S$
   where S is the standard deviation obtained from the Table of approximate contents given after the design mix.
2) Obtain the water cement ratio for the desired mean target using the empirical relationship between compressive strength and water cement ratio so chosen is checked against the limiting water cement ratio. The water cement ratio so chosen is checked against the limiting water cement ratio for the requirements of durability given in table and adopts the lower of the two values.

3) Estimate the amount of entrapped air for maximum nominal size of the aggregate from the table.
4) Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) from table.
5) Determine the percentage of fine aggregate in total aggregate by absolute volume from table for the concrete using crushed coarse aggregate.
6) Adjust the values of water content and percentage of sand as provided in the table for any difference in workability, water cement ratio, grading of fine aggregate and for rounded aggregate the values are given in table.
7) Calculate the cement content from the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.
8) From the quantities of water and cement per unit volume of concrete and the percentage of sand already determined in steps 6 and 7 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations:

$$V = \left[W + \frac{C}{S_c} + \frac{1}{p}\frac{f_a}{S_{fa}}\right] \times \frac{1}{1000}$$

$$V = \left[W + \frac{C}{S_c} + \frac{1}{1-p}\frac{C_a}{S_{ca}}\right] \times \frac{1}{1000}$$

Where,
V = absolute volume of concrete
= gross volume ($1m^3$) minus the volume of entrapped air
S_c = specific gravity of cement
W = Mass of water per cubic metre of concrete, kg
C = mass of cement per cubic metre of concrete, kg
p = ratio of fine aggregate to total aggregate by absolute volume
f_a, C_a = total masses of fine and coarse aggregates, per cubic metre of concrete, respectively, kg, and
S_{fa}, S_{ca} =specific gravities of saturated surface dry fine and coarse aggregates, respectively

9) Determine the concrete mix proportions for the first trial mix.
10) Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size and test them wet after 28-days moist curing and check for the strength.
11) Prepare trial mixes with suitable adjustments till the final mix proportions are arrived at.

5.2 Sample Preparation of Cubes

This project entailed subjecting the designed concrete mixes to a series of tests to evaluate the strength, and other properties. For this project, it was important to monitor the strength development with time to adequately evaluate the strength of each concrete mix. For each test, either 3 samples from each mix were tested at each curing age, and the average values were used for analysis. The following sections present the procedures used for the various tests.

5.3 Performance of Fresh Concrete Workability Test

Workability is defined as the property of concrete which determines the amount of useful internal work necessary to produce full compaction. as per IS code 10262:2009, the property which for measuring the performance of fresh concrete is "slump test"

Slump Test

Slump is a measure of indicating consistency or workability of concrete and also slump gives an idea of water cement ratio needed for different works. Unsupported concrete when it is fresh flow to sides and shrinkage in height will takes place. The vertical settlement is known as slump. Slump increases if w/c ratio increases.

5.4 Performance of Hardened Concrete Compressive Strength Test

One of the most important properties of concrete is the measurement of its ability to withstand compressive loads. This is referred to as a compressive strength and is expressed as load per unit area. One method for determining the compressive strength of concrete is to apply a load at a constant rate on a cube (150×150×150 mm), until the sample fails. The compression tests performed in this project were completed in accordance with IS standard 516 “Methods of Tests for Strength of Concrete”. The apparatus used to determine the compressive strength of concrete in this project was a testing machine. For this study samples were tested for compression testing at 7, 28, days of curing. Calculated using the Equation:

To determine compressive strength of concrete we use Cube mould of 15cm side, vibrating machine, water measuring jar, compression testing machine etc The test is carried out to study the quality of cement from compression strength point of view The test consist of determining compression strength of 7and 28 days. Compression strength of cement is the property that most decides the qualities of strength of concrete.

$$fa = \frac{P}{A}$$

Where,
Fc = Compressive Strength of Concrete,
P -Maximum load applied (KN), and
A -the cross-sectional area of the sample (mm2

5.5 Mix Design Results for M sand

Table 5.1 obtained results of mix design for M sand

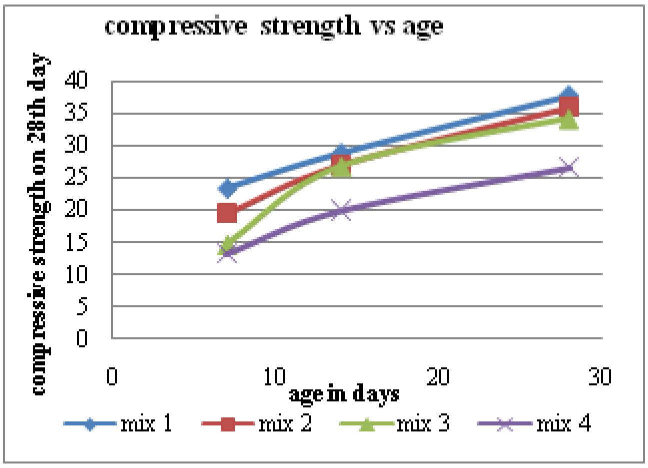
Mix proportion used	W/c ratio	7th day compressive strength	14thday compressive strength	28thday compressive strength n/mm^2	Slump In mm
1:1.19:2.58	.425	23.5	28.9	37.8	60
1:1.296:2.75	.45	19.55	27.1	36	75
1:1.235:2.815	**.45**	**17.4**	**26.78**	**34.22**	**55**
1:1.515:3.076	.5	13.33	20	26.66	90

International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

It is recommended that the properties of aggregates should be tested frequently, since variations in the properties of aggregates affect the strength of concrete and the strength obtained above is without using any admixtures

5.5.1 Selection of the Most Economical Trial Mix Proportion

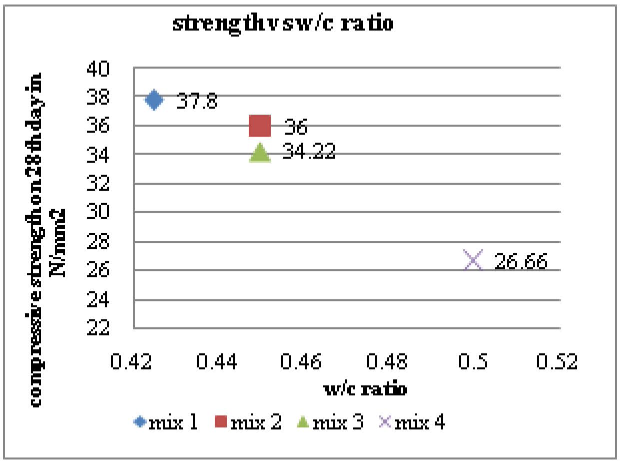
Selected M 25 grade concrete mix is MIX 3 **1:1.235:2.815** , from the remaining design mixes for further project proceedings, for which following studies will strengthen.



Graph 5.1: Compressive strength v/s age in day

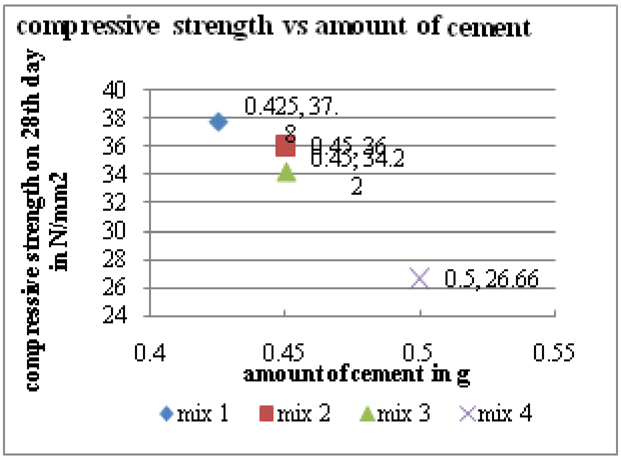
Objectives of concrete mix design To determine the most economical and practical combination of available materials (ie, aggregates cements, water, admixtures etc)to produce a concrete that will satisfy the performance of requirements

- Design considerations
- acceptable workability of concrete
- adequate durability and strength of hardened concrete
- uniform appearance of hardened concrete
- economy
- most important factor affecting workability : water content
- most important factor affecting strength : water-cement ratio
- most important factor affecting durability : water cement ratio and cement content
- most important factor affecting appearance : proportioning of fine and coarse aggregate



Graph 5.2: Showing compressive strength vs w/c ratio.

In this graph 4 lines indicates 4 mixes with different ratios. here the mix 4 provides the better performance , which gives more preferable values of strength with most economical proportion. Here the graph shows that as the w/c ratio increases compressive strength decreases. From this it is understood that, can't take mix with higher w/c ratio.



Graph 5.3: Compressive strength Vs amount of cement

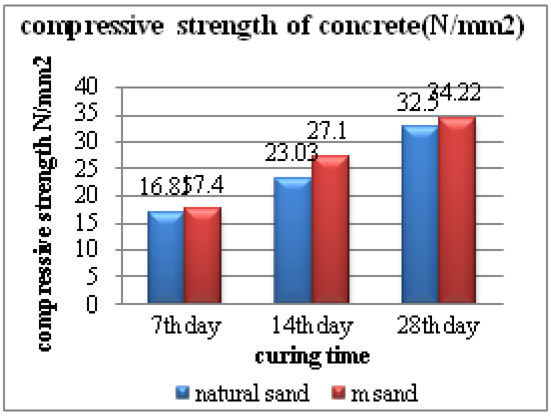
The mix proportion that is used throughout the project which related to M sand is the **MIX 3**

5.6 Mix Proportion Details of Concrete Using Natural Sand

Concrete batches were prepared as previous and compressive strength of concrete with natural sand as fine aggregate determined for7, 14, 28th days of age, and obtained 32.5 N/mm^2 for 28th day compressive strength.

Table 5.2: Mix proportion of components in concrete using natural sand

Material	M 25 Using Natural Sand	
	Quantity(kg/m^2)	Mix Ratio
Cement	425.78	1
Fine aggregate	685	1.6
Coarse aggregate	1209	2.8
Water	191.6	.45



Graph 5.4 Strength attaining with age.

This graph comparing the compressive strength of natural and river sand at 7th, 14th and 28th compressive strength. The graph indicates that compressive strength of M sand is higher than river sand at 3 stages and 28th day strength increases more than 10%.

5.7 Copper Slag As A Partial Replacement Of 5.7.1. Fine Aggregate

Sample preparation

Concrete mixtures with different proportions of Copper slag used as a partial or full substitute for fine aggregates were prepared in order to investigate the effect of Copper slag substitution on the strength of normal concrete. Concrete mixtures were prepared with different proportions of Copper slag. The proportions (by weight) of Copper slag added to concrete mixtures were as follows: 0%(for the control mix) 20%, 40%, and 60%, . The control mixture was designed to have a characteristic 28 day compressive strength of 25 N/mm2 (M- 25), using a water-to-binder ratio of 0.45. The mix proportion chosen for this study is given in Table.

The mix proportions chosen for this study is1:1.235: 2.815 with 0.45 water/cement ratio for M-sand replacement and 1: 1.6: 2.8 with 0.45 water/cement ratio for river sand. Concrete mixtures with different proportions of copper slag ranging from 0% (for the control mix) to 60% for both M sand and natural sand replacement were considered. Six concrete mixtures were prepared with different proportions of copper slag as shown in Table 4. The materials were mixed in a rotating pan and compacted using vibrating table. The slump of the fresh concrete was determined to ensure that it would be within the design value and to study the effect of copper slag replacement on the workability of concrete. The specimens were remolded after 24 hr, cured in water and then tested at room temperature.

5.7.2 Concrete Mix Design Details (M-Sand)

Table 5.3 Replacement of M-Sand using copper slag

Cement Kg/m3	% of slag Added	F.A Kg/m3	Slag Kg/m3	C.A Kg/m3	Water L/m3
425.77	10	473.38	52.6	1172.7	191.6
425.77	20	420.6	105.19	1172.7	191.6
425.77	30	383.19	157.79	1172.7	191.6
425.77	40	315.59	210.39	1172.7	191.6
425.77	50	262.99	262.99	1172.7	191.6
425.77	60	210.39	315.59	1172.7	191.6

5.7.3 Concrete Mix Design Details (River Sand)

Table 5.4 Replacement of river sand using copper slag

Cement kg/m^3	% of Slag Added	F.A Kg/m^3	Slag kg/m3	C.A kg/m3	Water l/m3
425.78	10	616.5	68.5	1209	191.6
425.78	20	548	137	1209	191.6
425.78	30	479.5	205.5	1209	191.6
425.78	40	411	274	1209	191.6
425.78	50	342.5	342.5	1209	191.6
425.78	60	274	411	1209	191.6

6. Test Results and Discussions

6.1. Compressive Strength of cubes

A total of 36 cubical specimens of standard dimensions 150 x 150 x 150 mm were tested in each proportion. The samples were cast in 16 batches. M25 grade of concrete was used for all. The percentage replacement of fine aggregate by slag was 0, 10,20,30,40,50 and 60. A constant water cement ratio of 0.45 was adopted for making concrete mixtures. The mix proportion used was 0.45:1:1.235:2.815(for M-sand replacement) and 0.45:1:1.6:2.8(for natural sand replacement). The aggregate used for this study was crushed stone from quarry with the nominal size of 20mm. The cube specimens were tested at 7 days and 28 days. Table 5.3 gives concrete mix designs details(M sand and copper slag as fine aggregate).Table 6.1(M sand replacement) and 6.2(River sand replacement) gives the compressive strength response of concrete at 7th day and 28th day of age.

$$\text{Compressive strength (N/mm)} = (\text{Ultimate load in N})/(\text{Area of crosssection } (mm^2))$$

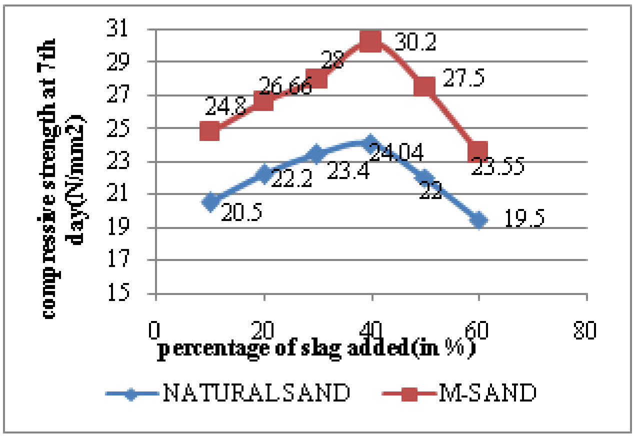
Here 0 to 60% of copper slag was replaced with M sand and river sand. The optimum percentage of replacement was obtained at 40% replacement of copper slag with both river sand and M sand. For control concrete the compressive strength was found to be 34.22 N/mm^2 and 32.5 N/mm^2 for M sand and river sand respectively used as fine aggregate.

Table 6.1 Compressive strength response of copper slag with M-Sand

Replacement of F.A%	Slag kg/m3	At 28 Days (N/mm^2)	% Increase in	at 7Days (N/mm^2)	% Increase in
0	_	34.22		17.4	_
10	52.6	42.66	24.7	24.8	26.85
20	105.20	43.11	26	26.66	36.46
30	157.79	44	29	28	43.22
40	210.39	46.6	36.1	30.2	54.47
50	262.99	40	10.1	27.5	40.66
60	315.59	30.2	_	23.55	20

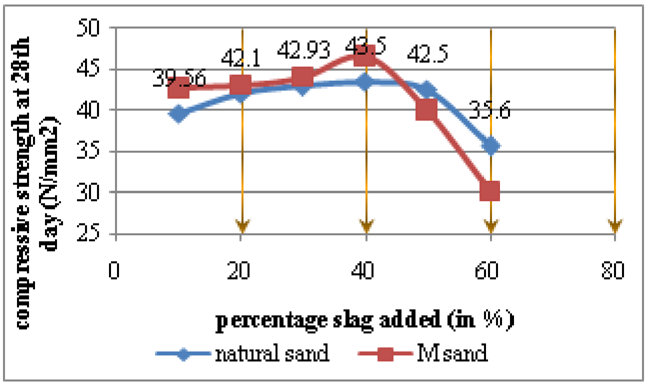
Table 6.2 Compressive strength response of copper slag with river sand

Replacement of F.A %	Slag kg/m3	Strength at 28 Days (N/mm2)	% Increase in Strength	Strength at 7 Days (N/mm2)	% Increase in Strength
0	_	32.5	_	16.52	_
10	68.5	38.56	22.67	20.5	24.24
20	137	41.1	29.53	22.2	34.24
30	205.5	41.93	32.09	23.4	41.81
40	274	42.5	33.84	24.04	45.69
50	342.5	41.5	30.76	22	33.30
60	411	34.6	9.53	19.5	18.18



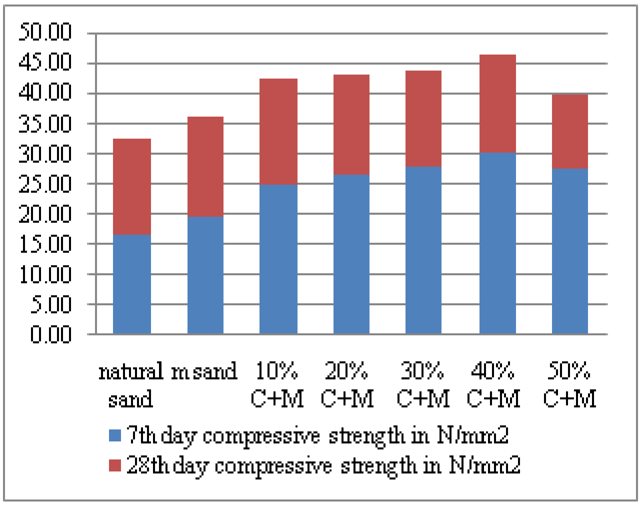
Graph 6.1 Compressive strength response of concrete with copper slag at 7th day

The graph indicates that as percentage of copper slag increases the 7th day compressive strength increases up to 40% and decreases thereafter. The concrete gets maximum 7th day compressive strength at 40%of copper slag replaced by weight of sand, and it is called as optimum dosage at .45water –cement ratio .Replacing copper slag in m sand has higher values when comparing with natural sand replaced with copper slag.

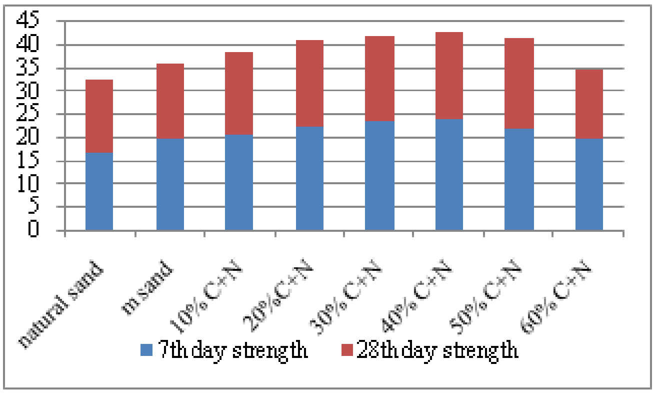


Graph 6.2: Compressive strength response with copper slag at 28th day

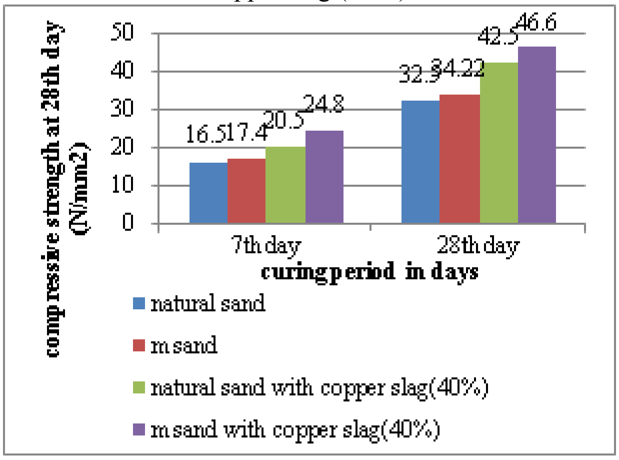
The graph indicates that as percentage of copper slag increases, the 28th day compressive strength increases up to 10% and then decreases. The concrete gets maximum 28th day compressive strength at 40% of copper slag replaced by weight of natural sand.



Graph 6.3: Compressive strength response of concrete with natural sand, M-Sand and partial replacement of M-Sand by copper slag(C+M)



Graph 6.4: Compressive strength response of concrete with natural sand and partial replacement of natural sand by copper slag (C+N)



Graph 6.5: Compressive strength response of concrete with natural sand, m sand and 40% replacement by copper slag both in natural and m sand

This graph includes all the samples produced. 7th and 28th day compressive strength of four samples is given. Graph indicates that from all this samples m sand with 40% replaced copper slag provides a better performance.

6.2 Effect of M sand on compressive strength of concrete

The mix with M sand as 100% fine aggregate gives initial workability of 55mm; IS 456 code specifies a minimum slump of 50 mm for medium workability. M25 grade concrete mixes meet this requirement when M-sand is used as fine aggregate .Higher fineness modulus, particles grading, shape, texture and control of micro fines have contributed to better workability of manufactured sand. The fresh properties of concrete are certainly affected by the use of manufactured sand, but the hardened properties ie, compressive strength do not seem to be greatly affected by the gradation. Their particle size distribution helps in higher packing density which enhances the durability of the concrete. The high amount of fines, angular particle shape, and higher void content of the M sand will likely result in concrete with higher water demand for the same slump relative to a natural sand. Since the void content is higher there is a need for more paste to fill the voids. the fresh properties of concrete are certainly affected by the use of a manufactured sand, the hardened property, ie compressive strength do not seem to be greatly affected by the gradation.

Compressive strength of M25 grade concretes with M-sand as fine aggregate 3-15% higher when compared with the results using river sand as fine aggregate. The good physical properties of manufactured sand has enabled in reduction of free water as well. The standard mix with 100% manufactured sand has exhibited much higher compressive strength 34.22 Mpa. The standard mix with 100% of river sand has exhibited compressive strength of 32.5mpa, 5.3% lower than that of manufactured sand. The improved properties of ms by the entire process of manufacturing could have resulted in reduced surface area and better particle packing. This contributed to the better binding effect with the available cement paste and improved the compressive strength.

6.3 Effect of copper slag on compressive strength of cement concrete

Maximum Compressive strength of concrete increased by 36% at 40% replacement of fine aggregate by copper slag, Compressive strength is increased due to high toughness of Copper slag.

The use of copper slag as a replacement for fine aggregate is environmentally helpful due to the reduction in the waste produced from the copper manufacturing process. It also contributes to conservation of natural fine aggregate. Cubes measuring 150 mm x 150 mm x 150 mm with different percentages of copper slag as a replacement for fine aggregate were tested in this research. The compressive strength development of concrete containing different percent replacement of copper slag was conducted. According to the results obtained the compressive strength increased by using copper slag as fine aggregate replacing material. Due to the higher value of specific gravity its packing is more compact and also provides a better packing, leads to production of most efficient mix, the contents of cement, water, and coarse aggregate were kept constant while the percentages of copper slag as a replacement for fine aggregate varied from 0 to 60%. Results showed that replacement of 40% of fine aggregate with copper slag caused major changes on concrete strength, the strength increase about 36% .Further increasing the ratio of copper slag as fine aggregate reduced the concrete strength and increased concrete slump . It is possible that the reduction in strength resulting from increasing copper slag is due to increased voids due to the fact that copper slag possesses fewer fine particles than fine aggregate. It could also be due to the increase of the free water because the copper slag absorbs less water than the fine aggregate. It is recommended that the effect of copper slag change on total void volume and amount of free water content be studied separately.

7. Conclusion

Proportioning the concrete mix for type of job in hand is an essential part of any quality assurance plan. This can be done effectively with proper understanding of properties of constituent material of concrete. In this project river sand is replaced with M sand as fine aggregate material in concrete. And also in the selected mix, copper slag is partially replaced adorably from 10% up to 40% resulting a greater compressive strength than the nominal mix strength. And that the optimum percentage replacement of copper slag in fine aggregate is inferred as 40%. The comparative study result empowers the conclusion that all M sand mixes have higher compressive strength than mixes produced by using river sand. Being an industrial waste copper slag causes bad effects on environment and using it as a fine aggregate material in concrete this effects can be reduced and also can reduce the scarcity of good quality natural river sand due to depletion of resources and restriction due to environmental consideration has made.

8. Future Scope

It is possible to introduce a better alternative for natural sand. Also leads to a detailed study of properties of fine aggregate. Copper slag is an industrial waste, using it as a fine aggregate will leads to more future developments in this area. Scope of the project has wide application on construction field. The project is limited only to check compressive strength as strength characteristics.

9. Acknowledgement

We express our profound sense of gratitude to Mrs.Shaina Beegam N, Associate Professor, Al-Ameen Engineering College, Kulappully for her valuable guidance, encouragement and help given for us in the project. Also express our sincere thanks to all staff members of Civil department for their kind co-operation they have rendered.

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