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Behavior of Concrete Using Copper Slag As A Strength Parameter in Low Cost Construction Work

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ABSTRACT

The value of concrete in present society cannot be underestimated. We can see concrete structures everywhere, such as buildings, roads, bridges, and dams. There is no escaping the impact concrete makes on your everyday life. 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 sand binder 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 utilization of these materials in concrete comes from the environmental constraints in the safe disposal of these products. Big interest is being focused on the environment and safeguarding of natural resources and recycling of waste materials. Various industries 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).

KEYWORDS: *HDPE, LDPE. UPVC, PPVC, UPS, PS, PP*

AIM

As the addition of waste materials in concrete increase the strength of concrete and reuse of waste material. The need of this research is to reduced the quantity of waste material required to produce the concrete of high strength as not to increase the amount of cement.

OBJECTIVES

To compare the various properties like compressive strength and density of modified concrete with partial replacement of Copper slag with conventional concrete.

- Preparation of cubes using different shapes of reinforcement and a normal cube of M25, M30, and M35 grades of concrete.
- To compare physical properties of natural coarse aggregate with Copper slag waste particles.
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- To investigate the effect of Copper Slag waste materials in concrete on its strength.
- To study the properties of fresh concrete prepared by replacement of copper slag particle material
- To produce lighter weight polymer concrete for its multidimensional use.

INTRODUCTION

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 buildings, roads, 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).

In the last 20 years, a lot of work concerning the use of several kinds of urban wastes in the building materials industrials process has been published. One of the new waste materials used in the concrete industry is recycled plastic. For solving the disposal of large amounts of recycled plastic material, reuse of plastic in the concrete industry is considered as the most feasible application. Recycled plastic can be used as coarse aggregate in concrete.

Concrete is one of the oldest and most common construction materials in the world, mainly due to its low cost, availability, its long durability, and ability to sustain extreme weather environments. The worldwide production of concrete is ten times that of steel by tonnage. On the other hand, other construction materials such as steel and polymers are more expensive and less common than concrete materials. Concrete is a brittle material that has a high compressive strength, but a low tensile strength. This reinforcement of concrete is required to allow it to handle tensile stresses. Such support is usually made out using steel.

TYPES OF CONCRETE

Some common and main types of concrete are:

A. Normal concrete
B. High Strength Concrete
C. High-Performance Concrete
D. Air-Entrained Concrete
E. Light Weight Concrete
F. Self Compacting Concrete
G. Shotcrete
H. Pervious Concrete
I. Roller Compacted Concrete

PROPERTIES OF CONCRETE

Concrete has many attributes that constitute it a popular building material. The correct proportion of ingredients, positioning, and curing are needed in parliamentary procedure for these attributes to be optimal.

Good-quality concrete has many advantages that add to its popularity. Foremost, it is economical when ingredients are readily usable. Concrete's long life and comparatively low maintenance requirements increase its economic benefits. Concrete is not equally likely to rot, corrode, or decay as other building materials. Concrete has the ability to be formed or cast into virtually any desired form. Construction of the casts and casting can occur on the worksite which reduces prices.

Concrete is a non-combustible material which makes it fire-safe and able with stand high temperatures. It is resistant to wind, water, rodents, and worms. Hence, concrete is often used for storm shelters.

Concrete does have some limitations despite its numerous advantages. Concrete has a relatively low tensile strength (compared to other building materials), low ductility, low strength-to-weight ratio, and is susceptible to cracking. Concrete remains the material of choice for many applications, regardless of these limitations.

The compressive strength of concrete is normally at least ten times its tensile strength, and five to six times its flexural strength. The main factors governing compressive strength are:

- Water-cement ratio is by far the most significant element.
- The age of the cured concrete is too significant. Concrete gradually builds strength after mixing due to the chemical interaction between the cement and the water. It is normally tested for its 28-day strength, but the strength of the concrete may continue to increase for a year after mixing.
- The character of the cement, curing conditions, moisture, and temperature. The greater the period of moist storage i.e 100% humidity and the higher the temperature, the greater the strength at any given age.

Air entrainment, the introduction of very small air voids into the concrete mix, serves to greatly increase the final product's resistance to cracking from freezing-thawing cycles. Most outdoor structures today employ this technique.

CONVENTIONAL CONCRETE

Concrete is the conventional and one of the most durable building materials for most civil engineering works in the world. It provides superior fire resistance. Structures made of concrete can have a long service life. Reinforced concrete, pre-stressed concrete, and precast concrete is the most widely used types of concrete functional extensions in modern days.

Concrete is prepared from a mixture of coarse and fine aggregates, Portland cement, and water. Other additives such as fly ash and different types of admixtures such as air-entraining agents, accelerators, retarders, and plasticizers also may be used to improve the concrete's capabilities for workability or strength and their qualitative performances.

Conventional concrete is a particulate- strengthened the ceramic-matrix-composite material. The sand and stone are the dispersed particles in a multiphase matrix of cement paste. Reinforced concrete can then be considered a "fiber-reinforced" composite, with the reinforcing steel bar acting as the "fiber". One fundamental difference, however, between conventional concrete and other engineering composites is that the composition; and hence the properties, of the cement paste do not remain constant after processing but vary with time, temperature, and relative humidity. A second difference is a concrete porosity.

The pores of concrete are filled with a highly alkaline solution with a pH of between approximately 12.5.

INNOVATIONS IN CONCRETE:

Advances in concrete technology include the properties of concrete such as workability, strength, durability and so on. But this present scenario describes advances in concrete technology such as admixtures, plasticizers, super plasticizers, retarders. The use of these materials has become a lift for structural Engineers to bring down big constructions in usage in a smaller time. But in general, advances in concrete technology deals, with an increase in strength and durability of concrete and increasing the workability to the required time. 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 above-mentioned compounds are useful in not only increasing strength, durability and workability of concrete but they are also useful in giving protection to concrete, create bonds between the materials of concrete, and gives attractive colors to concrete and also they reduce water to a great extent which is a severe crisis in nowadays.

STRENGTH OF CONCRETE

The strength of concrete is very much dependent upon the hydration reaction just discussed. Water plays a critical role, particularly the amount used. The strength of concrete increases when less water is used to make concrete. The hydration reaction itself consumes a specific amount of water. Concrete is actually mixed with more water than is needed for the hydration reactions. This extra water is added to give concrete sufficient workability. Flowing concrete is desired to achieve proper filling and the composition of the forms. The water not consumed in the hydration reaction will remain in the micro-structure pore space. These pores make the concrete weaker due to the lack of strength-forming calcium silicate hydrate bonds. Some pairs will remain no matter how well the concrete has been compacted.

Low water to cement ratio leads to high strength but low workability. High water to cement ratio leads to low strength, but good workability. The physical characteristics of aggregates are shape, texture, and size. These can indirectly affect strength because they affect the workability of the concrete. If the aggregate makes the concrete unworkable, the contractor is likely to add more water, which will weaken the concrete by increasing the water to cement mass ratio.

Concrete's strength may also be affected by the addition of admixtures. Admixtures are substances other than the key ingredients or reinforcements which are added during the mixing process. Some admixtures add fluidity to concrete while requiring less water to be used. An example of an admixture which affects strength is superplasticizer. This makes concrete more workable or fluid without adding excess water. A list of any other admixtures and their functions is given below. Note that not all admixtures increase concrete strength.

Durability is a very important concern in using concrete for a given application. Concrete provides good performance through the service life of the structure when concrete is mixed properly and care is taken in curing it. Good concrete can have an infinite life span under the right conditions. Water, although important for concrete hydration and hardening, can also play a role in decreased durability once the structure is built. This is because water can transport harmful chemicals to the interior of the concrete leading to various forms of deterioration. Such deterioration ultimately adds costs due to maintenance and repair of the concrete structure. The contractor should be able to account for environmental factors and produce a durable concrete structure if these factors are considered when building concrete structures.

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 far the most important constituent of concrete, in that it forms the binding medium for the discrete ingredients. Made out of naturally occurring raw materials and sometimes blended or underground with industrial wastes. The cement used in this study was OPC 53 grades Ordinary Portland cement (OPC) conforming to IS-12269:1987.

FINE AGGREGATE:

Aggregates which occupy nearly 70 to 75 percent volume of concrete are sometimes viewed as inert ingredients in more than one sense. However, it is now well recognized that physical, chemical and thermal properties of aggregates substantially influence the properties and performance of concrete. The fine aggregate (sand) used was clean dry sand was sieved in 4.75 mm sieve to remove all pebbles.

COARSE AGGREGATE:

Coarse aggregate is used for making concrete. They may be in the form of irregular broken stone or naturally occurring gravel. Material which is large to be retained on 4.75mm sieve size is called coarse aggregates. Its maximum size can be up to 40 mm.

WATER:

water plays an important role in the formation of concrete as it participates in a chemical reaction with cement. Due to the presence of water, the gel is formed which helps in increase of strength of concrete. Water used for mixing and curing shall be clean and free from injurious quantities of alkalies, acids, oils, salts, sugar, organic materials, vegetable growth or other substance that may be deleterious to bricks, stone, concrete or steel. Portable water is generally considered satisfactory for mixing. The pH value of water shall not be less than the following concentrations represent the maximum permissible values.

A. **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
B. **Limits of alkalinity:** To neutralize 100 ml. sample of water, using mixed indicator, it should not require more than 25 ml of 0.02 N H_2SO_4. The details of tests shall be as given in IS-3025: Part 1:1987.
C. **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 used for 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.

COPPER SLAG

Copper slag is a by-product of copper smelting and refining process. As refineries draw metal out of copper ore, they produce a large volume of non-metallic dust, soot, and rock. Copper slag which is an industrial waste obtained from smelting and refining process of copper from industry. Nearly four tons of copper is obtained as waste is disposed to lands cause's environmental impacts. So it can be reused as concreting materials. In refinery plants when copper metal produced by extraction process then copper slag is generated in a large amount in the production of copper metal. About 2-2.5 tons of copper slag produced for each one ton of copper production. Production of concrete has many environmental benefits for example waste recycling and resolve disposal problems. Concrete is wide utilized in the development of superior structures like high rise buildings, long-span bridges etc. So, it must have higher workability, it has superior mechanical properties than those of typical concrete. In order to produce concrete with good mechanical properties, fly ash and silica fume that are assume as waste materials used one of the most constituent. Concrete production with that material gives upgrading in workability compared to traditional concrete.

PROBLEM FORMULATION

Natural resources are decreasing in all over the world and increasing wastes from industries generated simultaneously. The eco-friendly and reliable development for construction consists the use of non-conventional and different waste materials and recycling of waste material for reducing emissions in environments and decreasing the use of natural resources. The mixture of concrete mainly consists fly ash for saving the cement also useful to maintain the heat of hydration temperature of concrete. A mixture of water, aggregate, sand and cement called concrete, it is a composite material that uses in constructions and developments. Therefore reducing the use of natural resources in construction like sand, we use copper slag as a partial replacement for reducing the use of sand because sand is a natural resource and it is not easily available everywhere, so copper slag is used in the concrete as one of the alternative materials. It is the waste product of copper produces from iron or steel plants. The construction industry is the only area where the safe use of Copper slag is possible. When it is introduced in concrete as a replacement material, it reduces the environmental pollution, space problem and also reduces the cost of concrete. In refinery plants when copper metal produced by extraction process then copper slag is generated in a large amount in the production of copper metal.

METHODOLOGY

The aim of the experiment was to assess the properties of concrete made with fine aggregates and copper slag to study the various important aspects such as compressive strength, flexural strength and split tensile strength of concrete cube prepared by using concrete materials and replacing copper slag with different percentage of replacements with cement and Fine aggregate respectively. In fresh state, the workability parameters such as slump cone test was studied. In hardened state, the strength tests such as compressive strength, split tensile strength and flexural strength were studied. The study was carried out for mix design of Grade of concrete-M25, M30, M35 and design IS-456:2000 & IS -10262:2009. In this study, total 270 numbers of concrete molds were cast. Out of which 180 cubes 150✕150✕150 mm and 45 cylindrical objects cast with dimensions diameter 150mm, height-300mm and a flexural beam of 45 molds cast by dimension 150✕150✕700 mm.

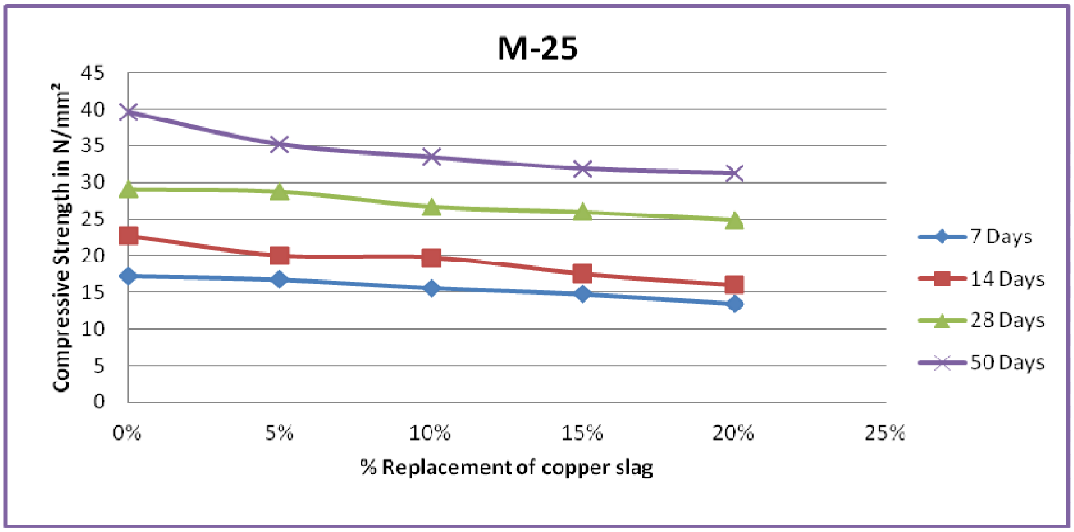
RESULTS AND DISCUSSION

Compressive Strength Test

In this study the designed concrete is subjected to various tests to estimate the strength and other properties of the casted concrete. The main aim of the study is to monitor the developed strength attained by the concrete at various testing days from curing. Generally proper casting and curing of concrete will increase the strength of the concrete. For this project each test is carried out with 3 samples for every mix ratio and tested at required curing time. Then the average values are used for the investigations. The Compressive Strength values taken from experimental analysis are described below.

Table 1: Compressive Strength of M-25 concrete Mix at Different curing stages

Compressive Strength (N/mm^2)				
Grade:M-25				
Percentage replacement	**7 Days**	**14 Days**	**28 Days**	**50 Days**
0%	17.207	22.70233	29.101	39.6896
5%	16.72067	20	28.77373	35.25
10%	15.59	19.75	26.75	33.5
15%	14.75	17.5	26	31.9
20%	13.5	16	24.9	31.2493

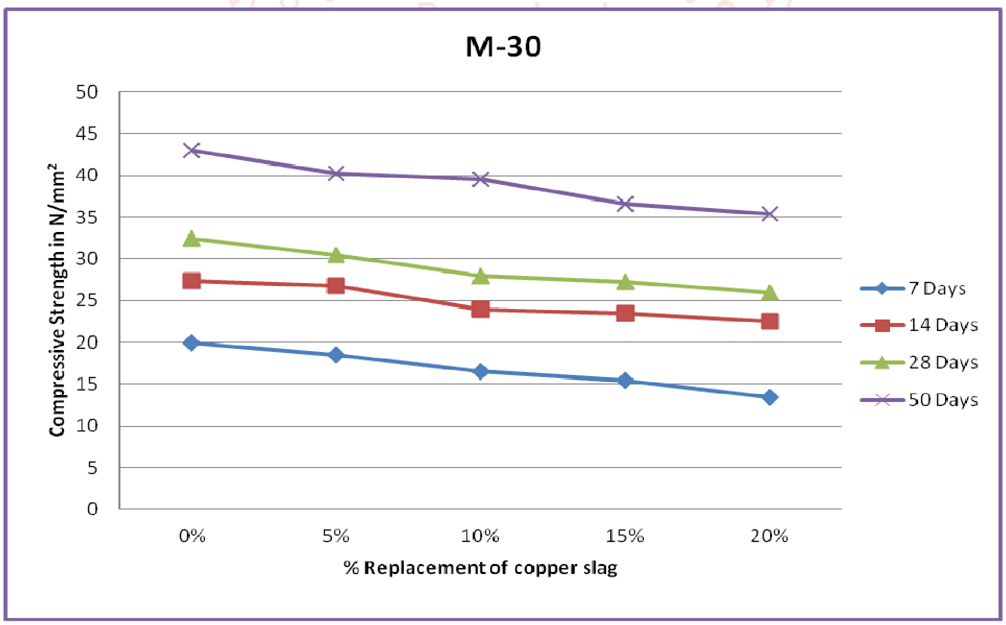


Graph 1: Compressive Strength of M25 Mix cubes at different curing stages

The three cubes were specimens were tested using Compressive Strength machine. The results of compressive strength test and a variation in strength of cubes shows in graph.

Table 2: Compressive Strength of M-30 concrete Mix at Different curing stages

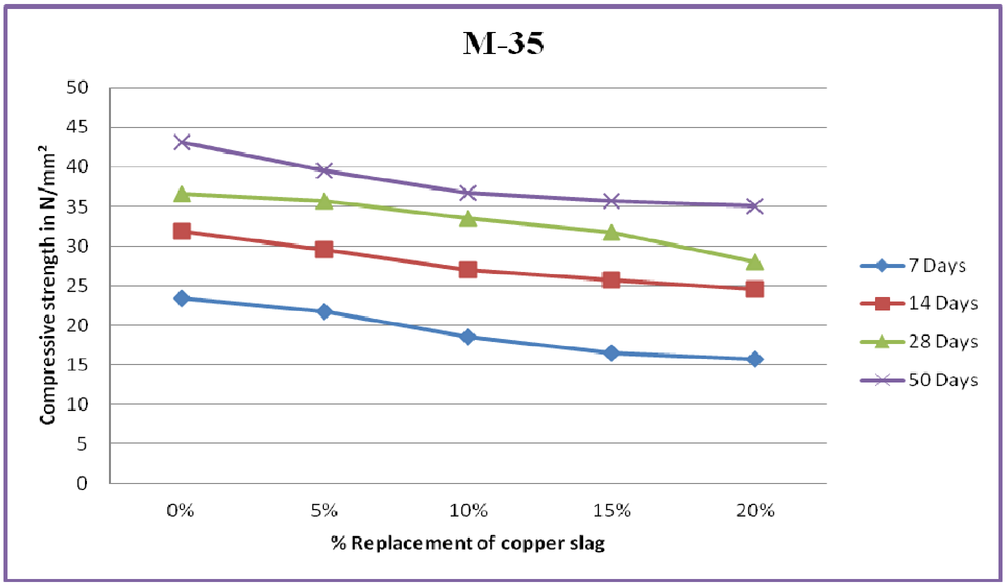
Compressive Strength (N/mm^2)				
Grade:M-30				
Percentage Replacement	7 Days	14 Days	28 Days	50 Days
0%	19.949	27.42193	32.433	42.9733
5%	18.5	26.75	30.5	40.1999
10%	16.5	24.001	28.005	39.59
15%	15.5	23.5	27.25	36.59
20%	13.5	22.5	25.99	35.36



Graph 2: Compressive Strength of M30 Mix cubes at different curing stages

Table 3: Compressive Strength of M-35 concrete Mix at Different curing stages

Compressive Strength (N/mm^2)				
Grade:M-35				
Percentage Replacement	7 Days	14 Days	28 Days	50 Days
0%	23.434	31.893	36.635	43.175
5%	21.755	29.5	35.75	39.5
10%	18.505	27	33.5	36.75
15%	16.54	25.75	31.75	35.75
20%	15.75	24.5	28.057	34.999



Graph 3: Compressive Strength of M35 Mix cubes at different curing stages

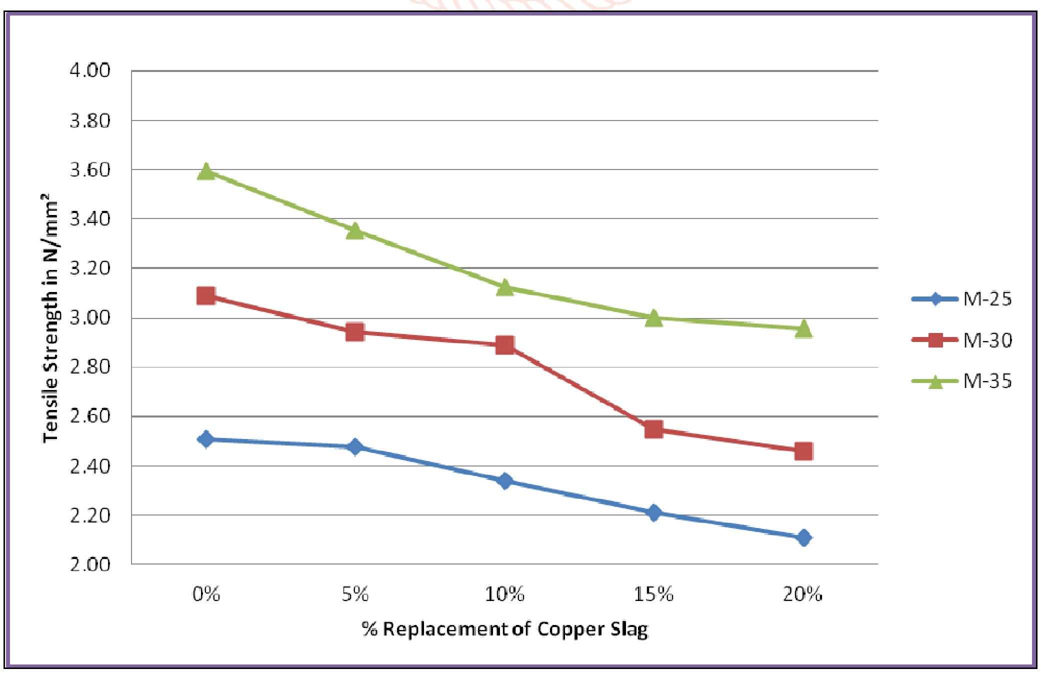
Most concrete structures are designed assuming that concrete processes sufficient compressive strength. The compressive strength is the main criteria for the purpose of structural design. To study the strength development of concrete in comparison to Conventional concrete, compressive strength tests were conducted at the ages of 7, 14, 28 & 50 days. Graphs show compressive strength variations when Replacement of fine aggregates and cement by copper Slag.

Split Tensile Strength Test

The split tensile strength of concrete is tested by casting cylinder of size 150mm x 300mm and is continuously cured for 28 days testing. Totally 45 cylinders were casted for normal M25, M30, M35 grade and for 5%, 10%, 15% and 20% by weight partial replacement of copper slag for sand & cement. Three samples are tested and the average values are taken as tensile strength of concrete. The values of split tensile strengths are shown in table.

Table 4: Split Tensile Strength of Concrete at 28 Days

Percentage Replacement of Copper Slag	Split Tensile Strength (N/mm^2)		
	M-25	M-30	M-35
0%	2.51	3.088	3.592
5%	2.479	2.944	3.356
10%	2.34	2.89	3.125
15%	2.21	2.547	3
20%	2.11	2.458	2.957



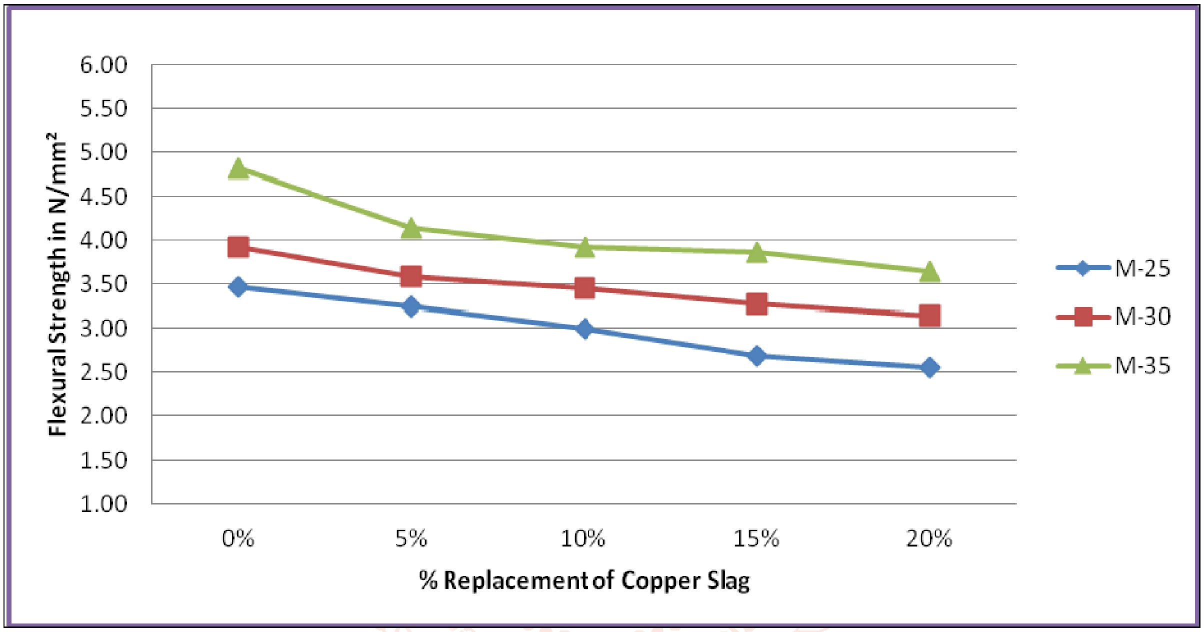
Graph 4: Split Tensile Strength at 28 Days

Flexural strength

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 fail in tension due to its property and shear will appear on concrete. In this experimental works totally 45-beams of size 700 x 100 x 100 mm are casted of M25, M30, M35 grades concrete and other percentage of replacements as for 5%, 10%, 15% and 20% by weight of copper slag with sand and cement. Then compare the values of both design mixes. The flexural values of various mixes are displayed in Table.5.

Table 5: Flexural Strength of Concrete at 28 days

Percentage Replacement of Copper Slag	Flexural Strength (N/mm^2)		
	M-25	M-30	M-35
0%	2.51	3.088	4.82
5%	2.479	2.944	4.14
10%	2.34	2.89	3.92
15%	2.21	2.547	3.86
20%	2.11	2.458	3.64



Graph 5: Flexural Strength at 28 Days

Waste Management

Copper slag is mixed in the concrete as replacement material of fine aggregate. It is the waste product of copper produces from iron or steel plants. The safe disposal of this waste is lack, Costly and causes environmental Pollution. The construction industry is the only area where the safe use of Copper slag is possible. When it is introduced in concrete as a replacement material, it reduces the environmental pollution, space problem and also reduces the cost of concrete. Many researchers had already establish, copper slag achievable use as a material in concrete. In this Experimental study Copper slag is used in concrete in the form of replacement material of fine aggregate. For this study, M25, M30 and M35 grade of concrete is prepared and the test are conducted for various substitute of fine aggregate and cement using copper slag as 0%, 5%, 10%, 15%, 20% in concrete prepared with fine aggregate.

Conclusion:

The Present Study investigated the effectiveness of using copper slag for partial replacement of sand, cement and combination of both in concrete elements. 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 and cement reduces the cost of making concrete.
- Replacement of copper slag with sand and cement 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 behaves similar to River Sand as it contains Silica (SiO2) similar to sand.
- Addition of Copper Slag increases the density of concrete thereby increasing the Self-weight.
- The Compressive Strength of Concrete with partial replacement of Sand with Copper Slag up to 20% can be comparable with conventional Concrete.
- Partial substitution of Copper waste in concrete with shows good resistance to sulphate attack

Utilization of copper slag as ordinary Portland cement replacement in concrete and as a cement raw material has the dual benefit of eliminating the costs of disposal and lowering the cost of the concrete.

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