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Experimental Study of Compressive Strength of Concrete by Partial Replacement of Fine Aggregate with Copper Slag

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Abstract: ***The innovation in the field of concrete technology can minimise the consumption of natural resources like river sand, aggregate and energy sources and lessen the burden of pollutants on environment. at present in mining and production of steel large amounts of Copper Slag are generated which gives an harm full impact on environment and humans. This assignment describes the feasibility of using the copper slag in concrete production. Dumping the waste materials to the environment directly may cause environmental problem. Hence it is highly required to reuse of waste material to save the environment. proper waste management can be employed to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. In order to utilize an alternative material to increase the strength of the concrete. Copper slag may be used as partial part of aggregate which is an environmental waste work as partial component without sacrifice the strength and durability of the concrete structure. In this research work the effects of replacing fine aggregate by copper slag is tested by performing the compressive strength. This work includes the determination of different properties of locally available copper slag and utilization of copper slag in concrete by replacing it in different composition ratio in aggregate by keeping the other parameters constant.***

Keywords: Copper Slag, Aggregate, M20 Grade, M25 Grade, Compressive Strength, Environmental Waste.

I. INTRODUCTION

A. General

The importance of cement concrete in present society can't be thought little of. Solid Structures of Concrete Presents in all places, such as structures, streets, bridges, and dams. There is no avoidance the effect of concrete utilization makes on your regular day to day existence. Concrete is a combined substance which is consisting of filler and a fastener. Regular concrete is a combination of F.A., C.A, cement, and water. Cement and lime are usually utilized as fastening 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 mixed as a fastening substance, sand as fine aggregates and gravel, crushed stones as coarse aggregates.

Concrete material is most common construction substance in the earth, mostly because ofits low charge, ease of use, its extendedstrength, and capacity tocarry onintenseweather atmosphere. The universal construction of concrete is 10 times that of steel by tonnage. On the other side, other constructionresourcesfor example steel and polymers are more costly and less common than concrete materials. Concrete is a fragile material that has a high compressive force, but a low tensile force. This reinforcement of concrete is required to allow it to handle tensile stresses. Such support is usually made out using steel.

B. Strength of Concrete

The concrete strength is very much dependent factor upon the hydration reaction. Water acting a vital function, particularly the amount used. The strength of concrete enlarges when a smaller amount of water is used to create concrete. The hydration effect itself graphs a specific amount of water. Concrete is essentially mixed with extra water than is wanted for the hydration responses. This additional water is mixed to provide concrete enough workability. Water to cement proportion gives to high strength but low workability. High water to cement ratio directs to small strength, but excellent workability. The objective distinctiveness of aggregates is form texture, and amount. These can ultimately affect strength.

C. Materials

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

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1) *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 IS12269-1987.
2) *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 w23mm and performance of concrete. The fine aggregate (sand) used was clean dry sand was sieved in 4.75 mm sieve to remove all pebbles.
3) *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.
4) *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. Potable water is generally considered satisfactory for mixing.

D. 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 Sterlite Industry Ltd., Tuticorin, and Tamilnadu. Nearly 4 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 1 ton of copper production. Concrete production with that material gives upgrading in workability compared to traditional concrete. Production of concrete has many environmental benefits for example waste recycling and resolve disposal problems.

E. 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, we use copper slag as a partial replacement for reducing the use of cement, 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.

F. 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.

G. Objectives

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

1) To investigate the effect of Copper Slag waste materials in concrete on its strength.
2) Used copper slag in place of sand during concrete construction.
3) To save the natural resource and cost optimization.

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II. LITERATURE SURVEY

A. Sukhoon Pyo et. al. [2016] they conducted analysis using a recently developed impact testing system that uses suddenly released strain energy to generate an impact pulse. Three fibre categories were measured, a warped fibre and two extra types of straight fibres. Sample effect reply was estimated in terms of first cracking power, post-cracking strength, energy inclusion power and strain power. The test outcomes specify that samples with warped fibres normally show fairly better mechanical functions than samples with straight fibres for the series of strain rates measured. All UHP-FRC sequence experienced demonstrate extra rate sensitivities in energy inclusion power, normally made much more energy dissipative under increasing strain rates.

B. B. Patnaik et .al. [2015] they studied about the force and toughness functions of concrete having copper waste as a fractional substitution of sand and results have been presented in this paper. Two different kinds of Concrete Grade (M20 & M30) were used with different proportions of copper slag replacement (0 to 50%) in the concrete. Strength & Durability properties such as Compressive Strength, Split Tensile Strength, Flexural Strength, Acid Resistivity and Sulphate Resistivity were evaluated for both mixes of concrete. test results explains that the strength functions of concrete has better having copper slag as a partial substitute of Sand (up to 40%) in concrete but in terms of stability the concrete found to be low resistant to acid attack and better resistance against sulphate attack.

C. Pranshu Saxena et. al. [2015] they studied about scope of replacement of F.A. from C.S. in concrete. Copper slag represents an accepted substitute to sand as a blasting way in industrial cleaning. With explosion or aggressive spraying methods, companies are using C.S. to clean huge refining equipment or furnaces .Material like copper waste can be utilized as one which can decrease the cost of construction. Their effort has been completed to accumulate the different analyses completed on the substitution of copper waste in F.A. to observe the potency of concrete.

D. T. U. Ganiron et. al. [2014] they studied about the effects of thermoplastic when added to concrete cement and needs of the ecological sector in terms of recycling the waste plastic that harms not only the soil structure and the environment The plastic was grounded into pieces for concrete mixture, where it substitutes the 5% of the fine aggregate, which is the sand. It then undergoes to strength test that investigate whether it can pass or at least equal the standard specification of concrete mix for wall panel. The experimentation went through moisture content test, specific gravity test, slump test, sieve analysis, compressive test and flexural test.

E. Yi Zheng et. al. [2013] they analysed structural concrete strength rapid detection methods, which mainly include rebound method, Ultrasonic-rebound combined method, and drilled core method were compared and analysed. Application of each method was analysed. Based on current detection technical specification, ultrasonic-rebound combined method for testing concrete strength was analysed. Actual concrete bridge as a platform for a compressive test, ultrasonic-rebound combined method test was carried out.

III. MATERIAL AND METHODOLOGY

A. Methodology

The aim of the experiment was to assess the properties of concrete made with Fine aggregates, cement, and coarse aggregate and copper slag to study the various important aspects such as compressive strength of concrete Cube prepared by using Concrete materials and replacing copper slag with different percentage of replacements with cement. In fresh state; the workability parameters such as slump cone test was studied. In hardened state; the strength tests such as compressive strength was studied. The study was carried out for mix design of Grade of concrete-M20, M25. In this study, concrete cubes were casted and Dimensions of cubes were 150✕150✕150 mm.

B. Materials Used

1) 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 inter-ground with industrial wastes. The cement used in this study was OPC 53 grades Ordinary Portland cement (OPC) ultratech conforming to IS 10262.



Figure 1. Cement

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Table 3.1: Properties of cement

Properties	Value
Grade of Cement	OPC(53 grade)
Specific gravity of cement	3.15
Initial setting time	35 min
Final setting time	330min
Normal Consistency	32%

2) *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.



Figure 2: Fine Aggregate

Table 3.2 - Properties of fine aggregate

Properties	Value
Specific Gravity	2.60
Fineness Modulus	3.75
Water absorption	0.6%

3) *Coarse Aggregate:* Coarse aggregate are used for making concrete. They may be in the form of irregular broken stone or naturally occurring gravel. Material which are large to be retained on 4.75mm sieve size are called coarse aggregates. Its maximum size can be up to 63mm.



Figure 3 - Coarse aggregate

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Table 3.3: Properties of coarse aggregate

Properties	Values
Specific Gravity	2.94
Size of Aggregates	20mm
Fineness Modulus	7.07
Water absorption	0.219
Aggregate Impact value	15.2%
Aggregate Crushing value	22.5%

4) *Water:* Water plays an important role in the formation of concrete as it participates in chemical reaction with cement. Due to the presence of water the gel is form which helps in increase of strength of concrete. Almost any natural water that is drinkable and has no pronounced taste or odor can be used as mixing water. Water from lakes and streams that contain marine life are also usually suitable. 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. Potable water is generally considered satisfactory for mixing.

5) *Copper Slag:* Copper slag is a by-product during 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.



Figure 3: Copper slag

Table 3.4: Chemical properties of copper slag

Chemical Component	% of chemical Component
SiO2	37.26
Fe2O3	47.45
Al2O3	3.95
CaO	2.38
Na2O	0.65
K2O	2.62
Mn2O3	0.086
TiO2	0.33
SO3	2.75
CuO	1.12

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C. Tests

1) *Tests on Fine Aggregate:* In this project, the river sand, which was available in saturated surface dry condition was used as fine aggregate and the following tests were carried out on sand as per IS:2386-1968

a) Sieve analysis
b) Density
c) Specific gravity
d) Water absorption

2) *Tests on Coarse Aggregate*

The coarse aggregate are tested for the following

a) Impact value
b) Sieve analysis
c) Density
d) Specific gravity
e) Water absorption

3) *Tests on Copper Slag*

The copper slag is tested separately for the following

a) Sieve analysis
b) Density
c) Specific gravity
d) Water absorption

4) *Sieve Analysis Test:* Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregate. This is done by sieving the aggregates as per IS: 2386 (part I) 1963. In this we use different sieves as standardized by the IS code and then pass aggregate through them and collect different sized particles left over different sieves.

5) *Density:* The density of both fresh and hardened concrete is of interest to the parties involved for numerous reasons including its effect on durability, strength and resistance to permeability. Hardened concrete density is determined either by simple dimensional check followed by weighing and calculation or by weight in air water buoyancy method.

D. Preparation Of Materials

All materials were brought to room temperature before commencing the results. The cement samples, on arrival at the laboratory, were thoroughly mixed dry either by hand in such a manner as to ensure the greatest possible blending and uniformity in the material, care is being taken to avoid the intrusion of foreign matter. The cement was stored in a dry place.



Figure 5: Preparation of material

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E. Casting of Concrete Cubes

First of all, lubricating oil is applied to all the moulds so that during opening time after 24 hrs will open mould easily without damaging the concrete cube and before pouring ensures that all the bolts of cubes are tight, this prevents the leakage of concrete mix and help in setting of perfect cube shape (150 mm × 150 mm × 150 mm).The concrete mix of M-20, grade was designed to. All the concrete mixes were mixed in Institute laboratory. From each mix three 150 mm cubes were cast for determination of compressive strength, 100mm×100mm×700mm beam were cast for the determination of flexural strength.



Figure 6: Casting of Concrete

F. Curing Of Cubes

After opening the cubes, cubes will be named for their specification by the help of water resistant paint & paint brush taken to the curing tank and rested there for 7th day, 14th day & 28_{th} day with the cover of fresh and clean water. Specification denotes the cube specimen name; type of reinforcement shape used, and date of casting. During time period of curing of cubes, always watch the curing tank that water level does not reaches below the cubes due to concrete heat releasing property and then fill the tank to cover the cubes. The water for curing should be tested every 7 days and the temperature of water must be at 27°C.

G. Compressive Strength Test

The compressive strength on each 150×150×150 Cubic specimen was determined in accordance with Compression testing machine. The two ends of each specimen were ground before testing to ensure uniform distribution of load during test. The diameter of each specimen was taken before the compressive strength test. The testing was hydraulic controlled with a maximum capacity of 2000 KN. Load was applied to the specimen at a constant loading rate of 0.5 N until complete failure occurred. The outputs of the load cell from the testing machine were connected to a data acquisition system, which records the data during the test. The maximum load is recorded and the compressive stress computed by dividing the maximum load by the cross sectional area of the specimen. The type of fracture was also recorded.



Fig 7- Compression testing machine

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IV. RESULT AND DISCUSSION

A. *Introduction*

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 2 samples for every mix ratio and tested at required curing time. Then the average values are used for the investigations.

B. *Compressive Strength Test*

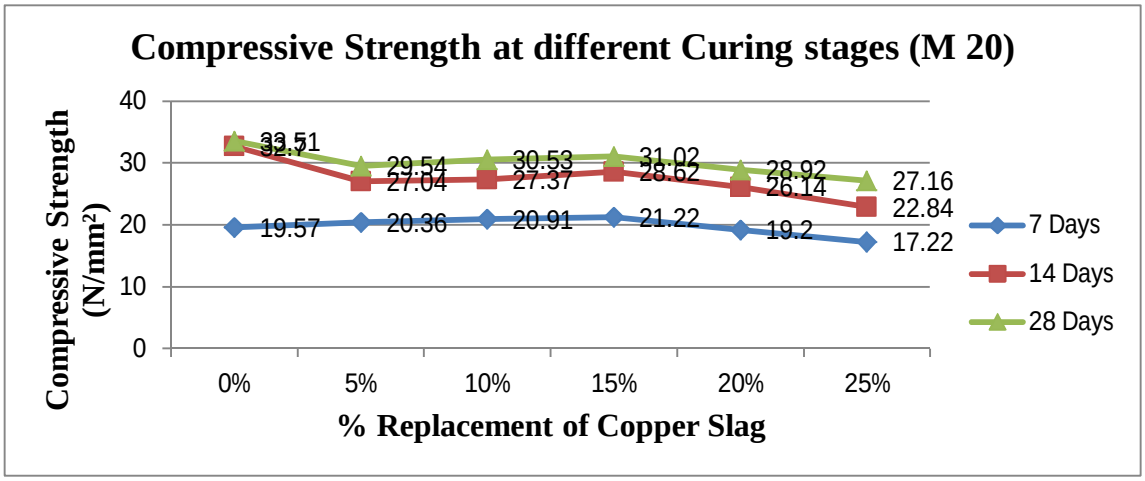
Concrete is weak in tension and strong in compression so the concrete should be strong to attain high compression. In this study for each mix 2-samples were tested and the average strength is compared with nominal mix of M20 & M 25 Mix. Compressive strength test finds out the high amount of compressive load a material can bear below facture limit. The results of compressive strength at the age 7th day, 14th day & 28th day are shown in table 4.1.

Table 4.1 Compressive Strength at different Curing stages (M 20)

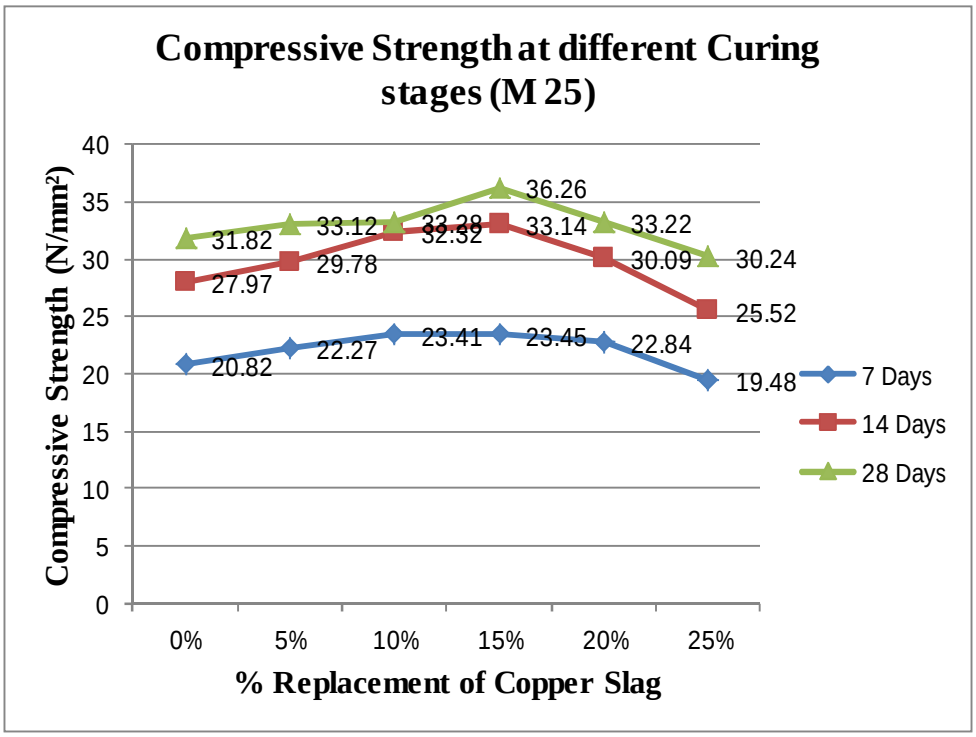
Percentage Replacement of Copper Slag	Compressive Strength (N/mm²)		
	7 Days	14 Days	28 Days
0%	19.57	32.70	33.51
5%	20.36	27.04	29.54
10%	20.91	27.37	30.53
15%	21.22	28.62	31.02
20%	19.20	26.14	28.92
25%	17.22	22.84	27.16

Table 4.2 Compressive Strength at different Curing stages (M 25)

Percentage Replacement of Copper Slag	Compressive Strength (N/mm²)		
	7 Days	14 Days	28 Days
0%	20.82	27.97	31.82
5%	22.27	29.78	33.12
10%	23.41	32.32	33.28
15%	23.45	33.14	36.26
20%	22.84	30.09	33.22
25%	19.48	25.52	30.24



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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 Days.

V. CONCLUSION & FUTURE SCOPE

A. Introduction

Based on the test results obtained from the experimental program of this work the following major calculations are arrived.Based on the experimental investigation following assumptions are as follows:

1) A Copper slag is a type of waste used as a substitute to Cement in concrete.
2) Cost of Concrete production reduces when Copper Slag is used as Cement in concrete.
3) After 7 days curing from the experimental test results, the compressive strength of concrete mix of cube having 15% of copper slag has the higher strength of 21.22Mpa(M20) and 23.45Mpa(M25).
4) After 14 days curing from the experimental test results, the compressive strength of concrete mix of cube having 15% of copper slag has the higher strength of 28.62Mpa(M20) and 33.14Mpa(M25).
5) After 28 days curing from the experimental test results, the compressive strength of concrete mix of cube having 15% of copper slag has the higher strength of 31.02Mpa(M20) and 36.26Mpa(M25).

B. Scope Of Future Work

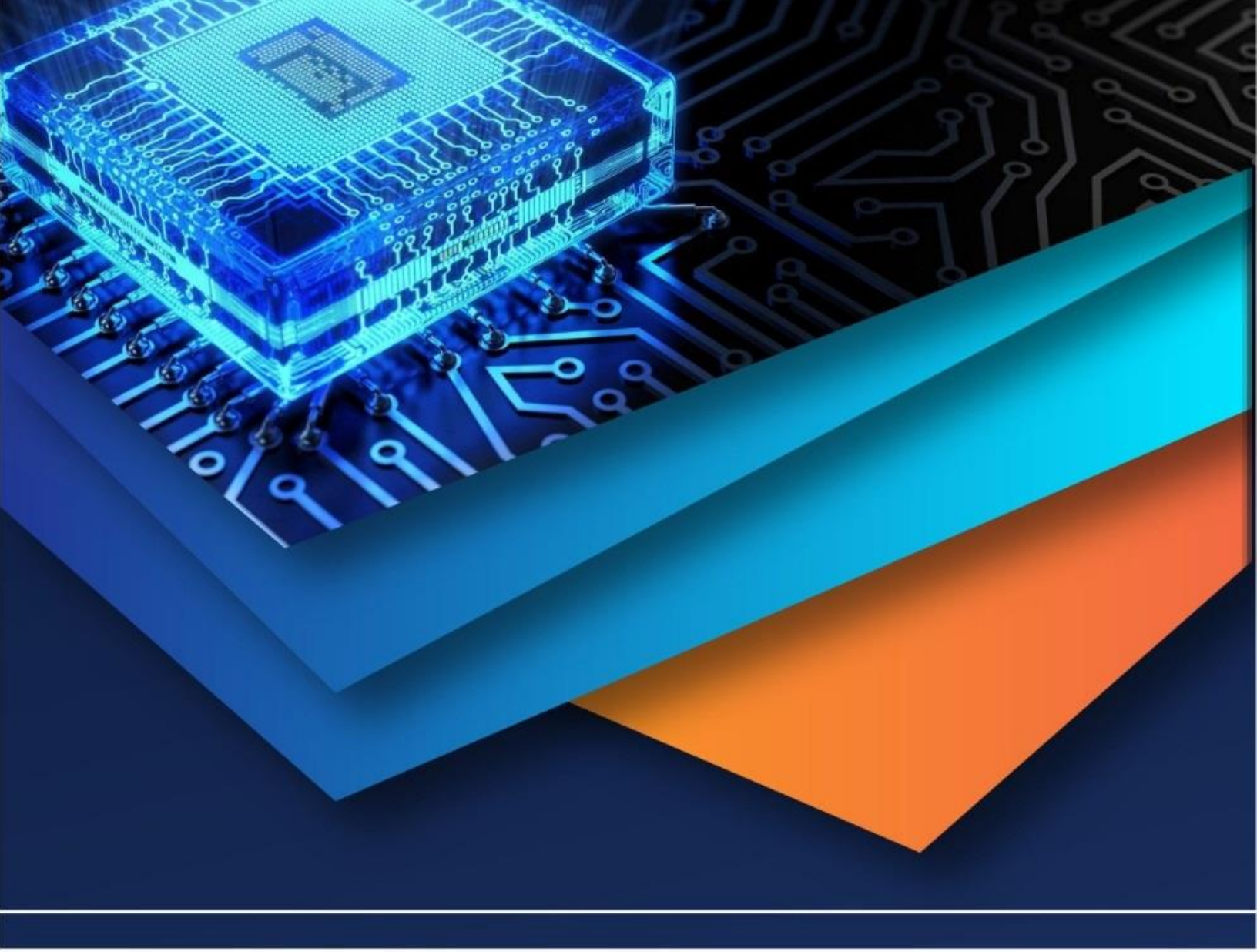
1) This research was intended to examine the influence of copper slag additions in concrete for M20 & M 25 mixes. The same word can be extended to higher grades of concrete mixes with varying water/cement ratio.
2) Copper slag can be effectively replaced in making bricks, hollow blocks and pavement blocks.
3) Since copper slag has higher shear strength value it can be used for soil stabilization.
4) Copper slag can be replaced along with fly ash, silica fume and granulated blast furnace slag in concrete and RCC members which can be tested for mechanical performances.

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