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Study on Strength Parameters of Concrete by using Copper Slag and Glass Powder as the Partial Replacement of Fine Aggregate for M30 Grade of Concrete

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Abstract: ***This paper deals with the experimental study of concrete by partial replacement of fine aggregate with copper slag and glass powder to increase the strength parameters such as compressive strength, split tensile strength, and flexural strengths of the M30 concrete. Here the fine aggregate partially replaced by copper slag (CS) and glass powder (GP) in CC,10%,20%,30%, & 40%. by weight of fine aggregate. Mix design was prepared for M30 grade of concrete. By replacement of copper slag and glass powder as fine aggregate we can reduce the digging of river sand or natural sand which effects the hydraulic structure stability and as well as we can reduce the open land fill and environmental pollution with copper slag usage it in concrete. Graphs are drawn strength vs. replacement with M Sand results are compared with normal concrete. Copper slag and glass powder GP are excellent by-product or waste material which retains its original properties. Due to its chemical composition which includes high iron, silica and aluminum oxide content, it can be used as a partial replacement for fine aggregate in concrete mixes. The cube, beam and cylindrical specimens were then prepared, demolded after 24 hours and properly cured. The specimens were subjected to compression testing, split tensile strength testing and flexural testing at 7 and 28 days.***

The addition of addition of copper slag increased the concrete strength gradually and the maximum strength was achieved at 40% replacement by Copper Slag with fine aggregate. The addition of glass powder increased the strength gradually till 30% replacement with fine aggregate and the strength decreased at 40%. The Copper slag seems to show better strength at 40% than the glass powder at 30%.

Keywords: Copper slag, Glass powder, Natural or M sand, Concrete, Compression and Flexural Strength and Replacement etc.

I. INTRODUCTION

The utilization of industrial waste or secondary materials has encouraged the production of cement and concrete in construction field. Newby-products and waste materials are being generated by various industries. Dumping or disposal waste materials causes environmental and health problems. Therefore, recycling of waste materials is a great potential in concrete industry. For many years, by products such as fly ash, silica fume, copper slag, glass powder and etc. were considered as waste materials. Concrete prepared with such materials showed improvement in workability and durability compared to normal concrete and has been used in the construction of power, chemical plants and under-water structures. Over recent decades, intensive research studies have been carried out to explore all possible reuse methods. Construction waste, blast furnace, steel slag, coal fly ash and bottom ash have been accepted in many places as alternative aggregates in embankment, roads, pavements, foundation and building construction, indirect tensile strength marginally decreased. Manufacture of ordinary Portland cement, without any further reuse or reclamation. Copper slag possesses the utilization of copper slag for applications such as fine aggregate or Portland cement replacement in concrete, or as raw material has the dual benefit of eliminating the cost of disposal and lowering the cost of the concrete. The use of copper slag in the concrete industry as a replacement for cement can have the benefit of reducing the costs of disposal and help in protecting the environment. Despite the fact that several studies have been reported on the effect of copper slag replacement on the properties of Concrete, further investigations are necessary in order to obtain a comprehensive understanding that would provide an engineering base to allow the use of copper slag in concrete. Laboratory investigations were carried out to assess the potential of the crushed recycled glass as Manufacturing sand or natural sand replacement using ratios of 0%,10%,30%, and 40%. The effects of glass sand replacement and materials replacement with powder glass on fresh and hardened concrete properties were assessed. It was concluded that with the incorporation of 45% of crushed glass as a natural sand replacement.

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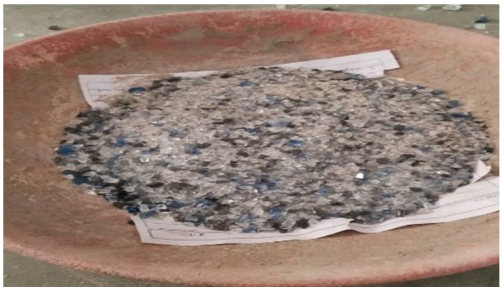
II. COPPER SLAG

Copper slag is a by-product material produced from the process of manufacturing copper. Copper slag is used in the concrete as one of the alternative materials. It is the waste product of copper slag a used as replacement of sand in order to obtain High-Performance Computing with good strength and durability properties. The copper settles down in the smelter, it has a higher density, impurities stay in the top layer and then are transported to a water basin with a low temperature for solidification. The end product is a solid, hard material that goes to the crusher for further processing. Copper slag used in this work was bought from Sri Srinivasa Metallizer's Hyderabad, Telangana, India.

III.GLASS POWDER

Glass powder is a waste material and it becomes granulated by sieving by means of sieves after they are crushed in the breaker and milled. Glass powders used as pozzolans are making strong gains in the concrete industry. There is no single chemical composition that characterizes all glass. Typical glass contains formers, fluxes, and stabilizers.

Formers make up the largest percentage of the mixture to be melted. In typical soda-lime-silica glass the former is silica (Silicon dioxide) in the form of sand. Glass powder used in this work was bought from Sri Laxmi Ganesh Minerals Hyderabad, Telangana, India.



IV.M SAND

Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. Manufactured sand is coming more economical. in which we are using waste material copper slag and glass powder into the replacement of fine aggregates. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm. M Sand which are also known as factory sand or artificial sand is a type of sand used as a replacement for natural sand in every construction industry today, Since it has become very difficult to get manufacturing sand cheaply, Because the construction of dams are taking place on every river hence these type of resources are washed away very quickly.

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V. SUPERPLASTICIZERS

Superplasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle segregation (gravel, coarse and fine sands), and to improve the flow characteristics (theology) of suspensions such as in concrete applications. Their addition to concrete or mortar allows the reduction of the water to cement ratio without negatively affecting the workability of the mixture, and enables the production of self-consolidating concrete and high-performance concrete. Another benefit of superplasticizers is concrete early strength enhancement (50 to 75%).

VI. NEED FOR PRESENT STUDY

The main focus of this project is to investigate the strength characteristics of concrete with inclusion of Copper Slag and Glass Powder as a partial replacement to fine aggregates at 0%, 10%, 20%, 30% and 40% Respectively. And to achieve economy in construction and to utilize such industrial wastes as an effective environmentally friendly material and to actually meet the scarcity of material in future. To give high performance concrete by using both copper slag and Glass Powder. In this investigation following aspects such as compressive strength, split tensile and flexural strength are studied. And the strength comparisons will be made and conclusions will be drawn.

VII. OBJECTIVES

A. To use industrial wastes such copper slag and glass powder as a stabilizing material and to solve the problem of waste disposal and economy while finding the optimum strength level.
B. To investigate the strength parameters such as compressive, split tensile and flexural strength for copper slag and glass powder replaced concrete.
C. To Study the Density and Water absorption of Concrete specimen after 28 days.
D. To compare the strength parameters of both copper slag and glass powder replaced concrete, making comparisons and drawing conclusions.

VIII. METHODOLOGY

A. The materials like Cement, M-Sand, Copper Slag, Glass powder, Natural Coarse Aggregate, and grade of concrete are selected and their characteristics has been thoroughly analyzed.
B. Using these materials, Design mix is done with required w/c ratio for M30 concrete grade.
C. The different proportions of copper slag and glass powder are replaced with fine aggregate is done. The cubes, beams and cylinders are casted and tested for different mix proportions.
D. Finally, with obtained results, comparison will be done and conclusions are drawn.

IX. TEST ON CEMENT

1	Specific Gravity	3.10
2	Standard consistency	31.5%
3	Initial setting time	57 min
4	Final setting time	4 hours
5	Soundness test (Le- Chatelier's test)	0.95mm

X. WATER

In the present investigation, potable water was used. Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely.
A lower water-to-cement ratio yields a stronger, more durable concrete, whereas more water gives a freer-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.
Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond together the individual sand and gravel particles and other components of the concrete to form a solid mass.

A. Reaction

Cement chemist notation: $C_3S + H \rightarrow C\text{-}S\text{-}H + CH$
Standard notation: $Ca_3SiO_5 + H_2O \rightarrow (CaO)\cdot(SiO_2) \cdot (H_2O)$ (gel) + $Ca(OH)_2$ Balanced: $2Ca_3SiO_5 + 7H_2O \rightarrow 3(CaO)\cdot 2(SiO_2) \cdot 4(H_2O)$ (gel) + $3Ca(OH)_2$

XI. PHYSICAL PROPERTIES OF COPPER SLAG

Copper slag is black glassy and granular in nature and has a similar particle size range like sand. The specific gravity of Indian slag lies between3.4 and 4.1. The bulk density of copper slag varies between 1.9 to 2.15 kg/m3which is almost similar to the bulk density of conventional fine aggregate. Table 4.4 shows physical properties of copper slag. The free moisture content present in slag was found to be less than 0.5%. Gradation test was conducted on copper slag and sand showed that both copper slag and sand had comparable particle size distribution as shown in Table 4.4 However, it seems that sand has higher fines content than copper slag.

Physical Properties copper slag	Copper
Particle shape	Irregular
Appearance	Black and glassy
Type	Air cooled
Specific gravity	3.91
Percentage of voids	% 35
Bulk density g/cc	2.08
Fineness modulus	3.47
Angle of internal friction	51° 20’
Ultimate shear stress kg/cm_2	0.4106
Water absorption %	0.16
Moisture content %	0.1
Fineness m_2 /kg (after grinding)	125

XII. CHEMICAL PROPERTIES ANALYSIS OF COPPER SLAG

Copper slag has high concentrations of SiO2 and Fe2O3 compared with OPC. In comparison with the chemical composition of natural pozzolans of ASTM C 618-99, the summation of the three oxides (silica, alumina and iron oxide) in copper slag is nearly 95%, which exceeds the 70% Percentile requirement for Class N raw and claimed natural pozzolans. Table 4.5 shows the chemical composition of copper slag which was obtained from National council for cement and building materials, Ballabgarh, India, 2010.

Chemical Component	% of chemical component
SiO_2	25.84
$Fe2O_3$	68.29
Al_2O_3	0.22
CaO	0.15
Na_2O	0.58
K_2O	0.23
Mn_2O_3	0.22
TiO_2	0.41
SO_3	0.11
CuO	1.20
Sulphide Sulphur	0.25
Insoluble residue	14.88

XIII. GLASS POWDER PYSICAL PROPERTIES

Property	Glass powder	Natural sand
Specific gravity	2.4-2.8	2.60
Bulk density	2.53	1.46
Moisture content (%)	Nil	1.50
Fine particles less than		
0.075mm (%)	12-15	0- 6
Sieve analysis	Zone-II	Zone-II

S. No	Material	Property details	
1.	Cement	Grade	43-OPC
		Consistency	34%
		Specific gravity	3.15
		Fineness	2%
2.	Natural sand	Grading Zone	Zone II
		Specific gravity	2.70
		Fineness	2.43%
3.	Glass powder	Specific gravity	2.66
		Fineness	3.36%
4.	Coarse Aggregate	Specific gravity	2.60
		Fineness	7.14%
5.	Water	Type	Potable

XIV. PREPARATION OF SPECIMENS

A. The standard size of specimens.
B. Cube 150 mm*150 mm*150 mm.
C. Cylinder Día = 150mm, Height = 300mm.
D. Beam 100mm*100mm*300mm.
E. The mould is metal preferable.
F. The concrete is made in proper proportion and fill the cube in proper layer.
G. Using manual mean the compaction is down.
H. After removed the specimen in the mould and stored in water for specified (7, 28days) curing days.

XV. WORKABILITY TEST

A. Slump Cone Test

Slump cone test is generally done to determine the workability of a fresh concrete which is done both at the site and laboratory. The apparatus required for conducting slump test are steel tamping rod of diameter 16mm and length of 0.6m with one end rounded, metallic plate and a metallic mould in the form of cone shape with following dimensions.

Height of the cone: 30cm

Bottom diameter of the cone: 20cm

Top diameter of the cone: 10cm

B. Standard Values of Slump

Workability	Slump (mm)
Very low	0-25
Low	25-50
High	50-100
Very high	100-175

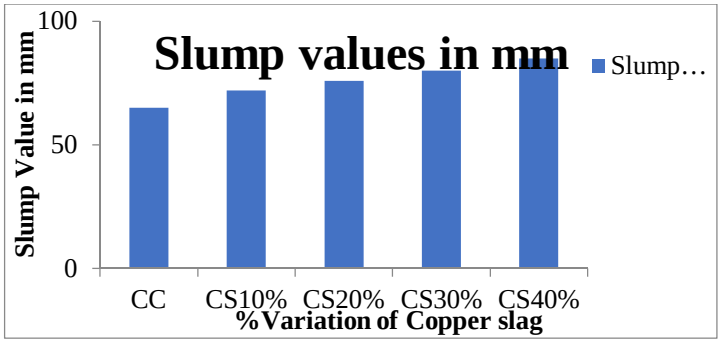
C. Slump Values of Copper slag

Partially replacement of CA	Slump values in (mm)
CC	65
CS10%	72
CS20%	76
CS30%	80
CS40%	85

D. Slump Values of Glass Powder

Partially replacement of CA	Slump values in (mm)
CC	65
GP10%	68
GP20%	74
GP30%	78
GP40%	82

E. Bar Chart Slump Values of Copper Slag



F. Discussion on Workability

Slump test was done for normal concrete by replacing Copper slag and Glass powder with fine aggregate partially at 0%, 10%, 20%, 30%, and 40% with fine aggregates keeping an optimum value for copper slag, glass powder and cement proportion at 10%. Slump was in increasing order; it might be due to the fact that industrial wasters of copper slag and glass powder plays a role in workability of concrete.

XVI. COMPRESSIVE STRENGTH TEST

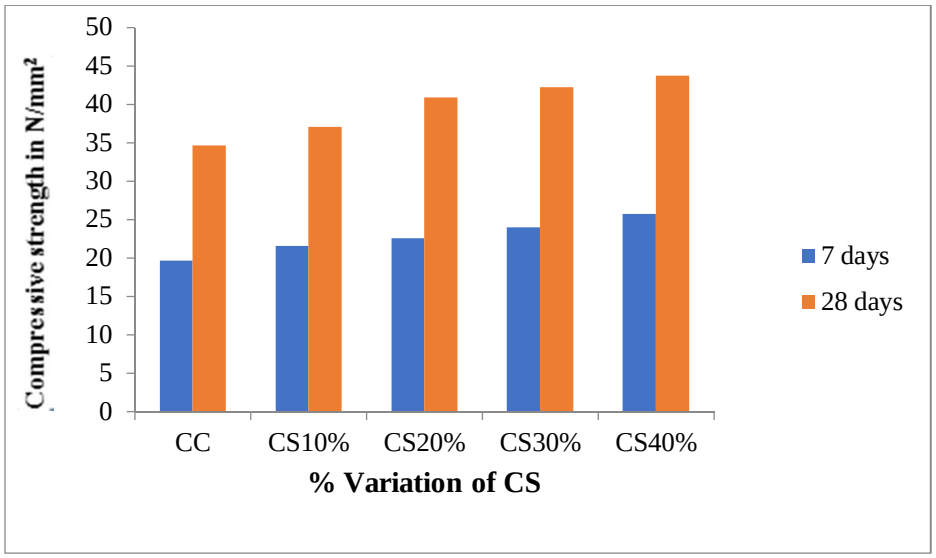
A. For concrete using Copper slag and Glass Powder

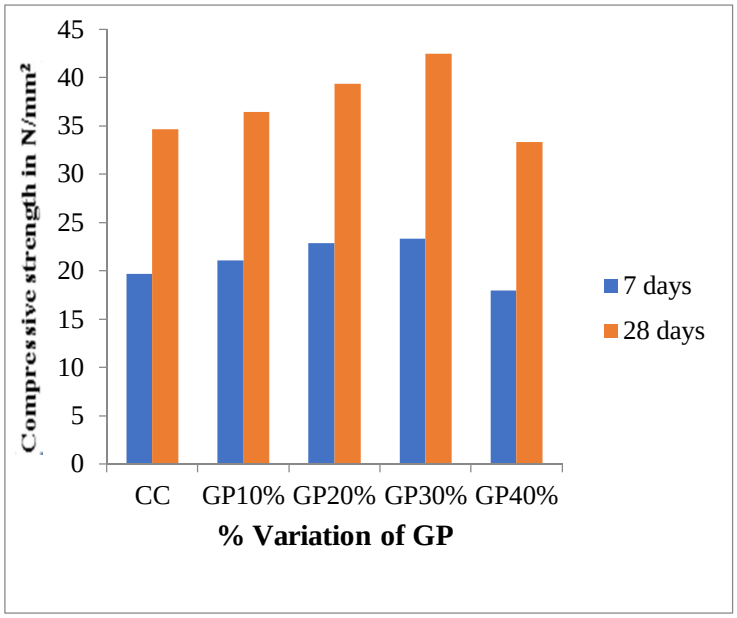
The compressive strength of normal concrete using copper slag was found out after 7 and 28 days of curing and the average of three specimens will be considered as the final compressive strength of the respective proportion. The cubes of standard size 150mm×150mm×150mm and then it was tested in Compression Testing Machine. The test is mainly done to determine the optimum values of copper slag and cement that can be used to produce concrete using copper slag the tests results are shown below are tabulated.

Sl. No.	%Copper slag Replacement With FA	Weight (Kg)	Ultimate Load (KN)	Compressive Strength For 7 Days (N/mm^2)
1	CC	8.20	430	19.11
		8.02	450	20.00
		8.00	410	18.22
		Average		19.7
2	CS10%	8.07	480	21.33
		8.32	450	20.00
		8.11	490	21.77
		Average		21.55
3	CS20%	8.00	490	21.77
		8.13	530	23.55
		8.05	510	22.66
		Average		22.60
4	CS30%	8.04	490	21.77
		8.10	530	23.55
		8.08	550	24.44
		Average		23.99
5	CS40%	8.03	590	26.22
		8.04	550	24.44
		8.02	570	25.33
		Average		25.77

Sl. No.	%Copper slag Replacement With FA	Weight (Kg)	Ultimate Load (KN)	Compressive Strength For 28 Days (N/mm^2)
1	CC	8.20	790	35.11
		8.03	740	32.88
		8.00	770	34.22
		Average		34.66
2	CS10%	8.05	850	37.77
		8.18	790	35.11
		8.03	820	36.44
		Average		37.10
3	CS20%	8.16	930	41.33
		8.15	910	40.44
		8.00	890	39.55
		Average		40.88
4	CS30%	8.04	950	44.00
		8.09	880	39.11
		8.08	910	40.44
		Average		42.22
5	CS40%	8.29	990	44.00
		8.18	980	43.55
		8.11	950	42.22
		Average		43.77

Bar chart % Variation of Copper slag With Respect to Fine Aggregate for 7 And 28 Days in N/Mm2





B. Discussion on Compressive Strength Result of Concrete Using copper slag and Glass Powder

The results of compression test, after completing the compression test, I concluded that the Optimum content of glass powder is 40% by volume replacement of glass powder with sand in M30 mix. Maximum Compressive strength of concrete decreased by 17.99 at 40% replacement of fine aggregate by glass powder at 7 days, and 22.0 at 40% replacement of fine aggregate by glass powder at 28 days.

XVII. SPLIT TENSILE STRENGTH TEST

A. For Concrete using Copper slag and Glass Powder

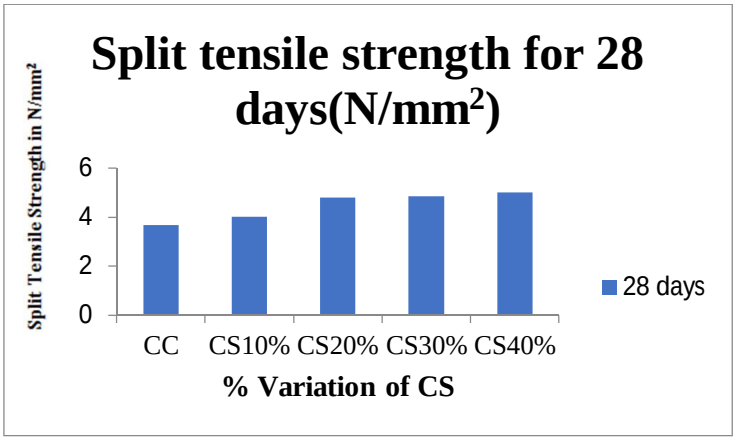
The split tensile of normal concrete and using copper slag as a replacement was determined at 28 days of curing by considering the average of two specimens. The cylinders of standard size 300mm × 150mm were casted and then later tested in compression testing machine by keeping it horizontally.

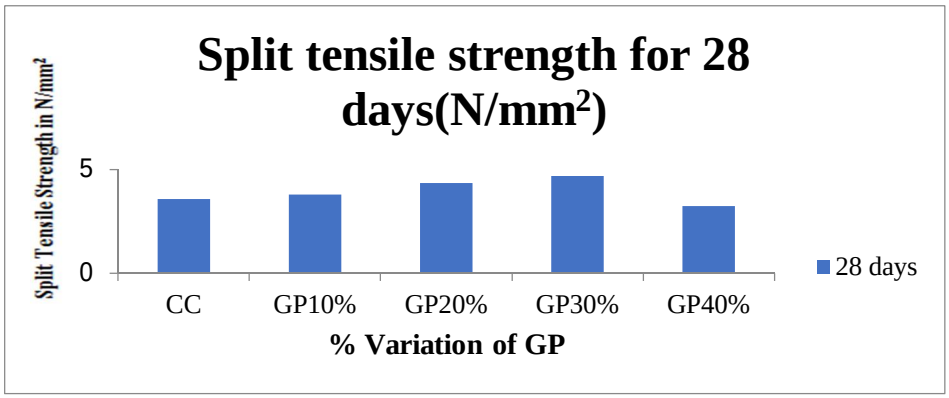
Split tensile strength is defined as a method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter. The effect of copper slag substitution as a fine aggregate on split tensile strength of concrete.

Sl. No.	% Copper slag Replacement With FA	Weight (Kg)	Ultimate Load (KN)	Split Tensile For 28 Days (N/mm^2)
1	CC	13.92	250	3.53
		13.22	270	3.81
		Average		3.67
3	CS10%	12.08	290	4.10
		12.92	280	3.96
		Average		4.03
4	CS20%	12.46	330	4.68
		13.45	350	4.95
		Average		4.81
5	CS30%	12.29	320	4.52
		12.23	370	5.23
		Average		4.87
6	CS40%	12.88	360	5.09
		12.22	350	4.95
		Average		5.02

Sl. No.	% Glass Powder Replacement With FA	Weight (Kg)	Ultimate Load (KN)	Split Tensile For 28 Days (N/mm^2)
1	CC	13.03	240	3.39
		13.33	270	3.81
		Average		3.60
3	GP10%	12.80	280	3.96
		12.52	260	3.67
		Average		3.81
4	GP20%	12.12	320	4.52
		12.52	300	4.24
		Average		4.35
5	GP30%	12.08	330	4.66
		12.02	340	4.81
		Average		4.7
6	GP40%	12.77	220	3.11
		12.16	240	3.39
		Average		3.25

Bar Chart % Variation of Copper Slag with Respect to Fine Aggregate for 28 Days in N/mm2





B. Discussion on Split Tensile Strength Result of Concrete Using Glass Powder

The results of split tensile test, after completing the split tensile test, we concluded that the Optimum content of glass powder is 40% by volume replacement of glass powder with sand in M30 mix. Maximum split tensile strength of concrete decreased by 3.25 and at 40% replacement of fine aggregate by glass powder at 28 days.

The results of split tensile test, after completing the split tensile test, I concluded that the Optimum content of copper slag is 40% by volume replacement of copper slag with sand in M30 mix. Maximum split tensile strength of concrete increased by 5.02 at 40% replacement of fine aggregate by copper slag at 28 days.

XVIII. FLEXURAL STRENGTH TEST

A. For concrete Using Copper Slag and Glass Powder

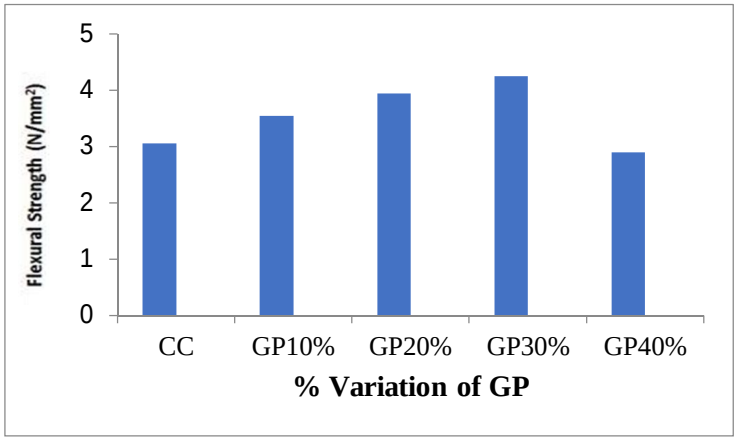
In order to study the effect on flexural strength, the beams containing different proportion of copper slag were prepared and kept for curing for 28 days. The test was conducted on U.T.M as per I.S.516-1959.

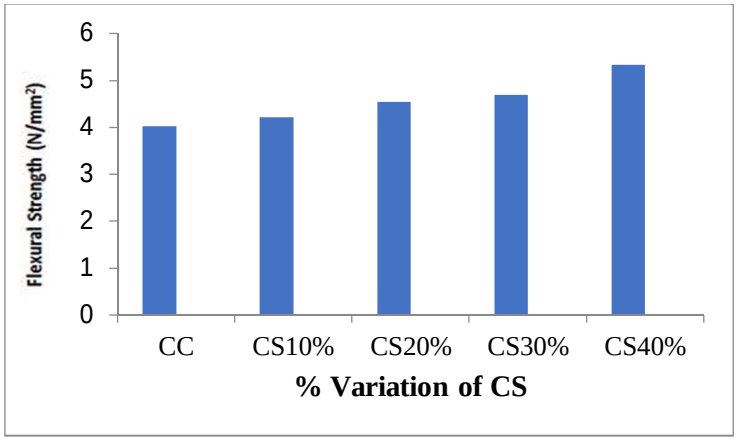
Flexural Strength of M30lConcrete Grade Using copper slag for 28lDays in N/Mm2

Sl. No.	Mix Proportions	Flexure Strength after 28 days(N/mm^2) for CS
1	CC	4.03
3	CS10%	4.22
4	CS20%	4.55
5	CS30%	4.70
6	CS40%	5.34

Flexural Strength of M30lConcrete Grade Using glass powder for 28lDays in N/Mm2

Sl. No.	Mix Proportions	Flexure Strength after 28 days(N/mm^2) for GP
1	CC	3.06
3	GP10%	3.55
4	GP20%	3.95
5	GP30%	4.25
6	GP40%	2.90





XIX. DENSITY TEST

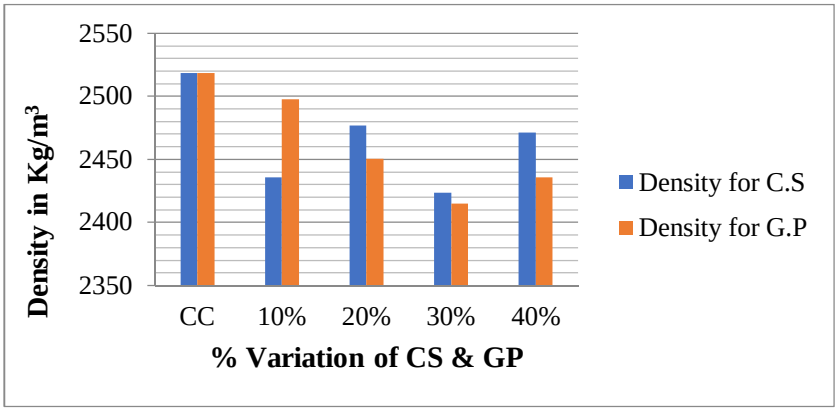
In order to study the density of Concrete we are going to weigh the concrete cube specimen after 28 days of curing and Volume of the cube will be determined and Density will be calculated by dividing mass of the concrete specimen with its volume.

Density of M30lConcrete Grade Using Copper Slag

Sl. No.	%age of Copper Slag	Weight($W_{1)}$ kg	Density(kg/m^3)
1	CC	8.50	2518.5
2	CS10%	8.22	2435.55
3	CS20%	8.36	2477.04
4	CS30%	8.18	2423.7
5	CS40%	8.34	2471.11

Density of M30lConcrete Grade Using Glass Powder

Sl. No.	%age of Copper Slag	Weight(W_1) kg	Density(kg/ m^3)
1	CC	8.50	2518.5
2	GP10%	8.43	2497.7
3	GP20%	8.27	2450.4
4	GP30%	8.15	2414.8
5	GP40%	8.22	2435.5



Discussion on Density Result of Concrete Using Copper Slag and glass powder

The Density test was conducted after 28 days of curing of concrete using both copper slag & glass powder and graphs were plotted Density vs Percentage variation of CS & GP, from the results it was observed that the concrete made using GP & CS seems to have lower densities than the conventional concrete.

XX. WATER ABSORPTION TEST

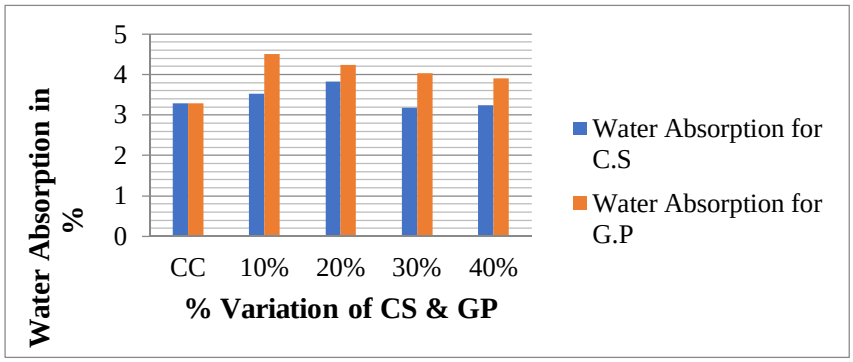
In order to study the water absorption of Concrete using CS & GP, the specimens are dried in an oven for a specified time and temperature and then placed in a desiccator to cool. Immediately upon cooling the specimens are weighed. The material is then emerged in water at agreed upon conditions, often 23°C for 24 hours or until equilibrium.

Water Absorption of M30lConcrete Grade Using Copper Slag

Sl. No.	%age of Copper Slag	Dry Weight(W_1) kg	Weight of Specimen after Immersion in Water(W_2) kg	%age Absorption
1	CC	8.50	8.78	3.29
2	CS10%	8.22	8.51	3.52
3	CS20%	8.36	8.68	3.82
4	CS30%	8.18	8.44	3.18
5	CS40%	8.34	8.61	3.24

Water Absorption of M30lConcrete Grade Using glass powder

Sl. No.	%age of Copper Slag	Dry Weight(W_1) kg	Weight of Specimen after Immersion in Water(W_2) kg	%age Absorption
1	CC	8.50	8.78	3.29
2	GP10%	8.43	8.81	4.50
3	GP20%	8.27	8.62	4.23
4	GP30%	8.15	8.48	4.04
5	GP40%	8.22	8.54	3.90



Discussion on Water absorption Result of Concrete Using Copper Slag and Glass Powder

The water absorption test was conducted after 28 days of curing of concrete using both copper slag & glass powder and graphs were plotted water also vs Percentage variation of CS & GP, from the results it was observed that the concrete made using GP & CS seems to have increased water absorption at certain point then later decrease.

XXI. CONCLUSION

On the basis of the experimental investigations made and analysis of the results, following are the conclusions which are made.

In the present scenario, the use of copper slag and glass powder are increasing day by day both in research as well as in the construction industries. Since, the physical and mechanical properties of copper slag and glass powder have maximum advantages. Therefore, replacement or reuse of it can be done in several manners. The well-defined scope in the future studies of copper slag and glass powder are that it can also be replaced by cement and fine aggregate very easily and has an application in concrete as an admixture.

A. Maximum compressive, tensile and flexural strength is obtained when copper slag is replaced with fine aggregate up to 40%. With such important properties of copper slag, and glass powder maximum compressive, tensile and flexural strength is obtained when glass powder is replaced with fine aggregate up to 30% and glass powder replaced with fine aggregate that the strength will be decreased at 40% of glass powder. further research is advised to analyze the scope of replacement extensively.

B. From the results of compressive strength, split tensile strength and flexural strength, the concrete shown higher value at 40% replacement of fine aggregate using copper slag. So, it is recommended that 40% of fine aggregate can be replaced by copper slag.

C. From the results of compressive strength, split tensile strength and flexural strength, the concrete shown higher value at 30% replacement of fine aggregate using glass powder. and the concrete shown lower value at 40% replacement of fine aggregate So, it is recommended that 40% of fine aggregate can be replaced by Copper Slag.

D. The workability of concrete increased with the increase in copper slag and glass powder content of fine aggregate replacements at same water-cement ratio. The reason is copper slag and glass powder play roles in enhancing the workability.

E. According to literature review the workability should be between high to very high but in our experimental work also we found workability between high to very high.

F. Compressive, Tensile and Flexural strength were increased due to the high toughness property of Copper slag and glass powder.

G. As the percentage of Copper slag and glass powder in design mix as replacement increases, the density of harden concrete observed to be decreased.

H. The presence of Copper slag and Glass powder also seem to enhance the rate of water absorption of concrete for 10% of CS and 20% of GP then later reduced as the percentage of the CS & GP increased.

I. The replacement of fine aggregate using copper slag and glass powder in concrete decreases the density of concrete thereby reducing the self-weight of the concrete as compared to the conventional concrete.

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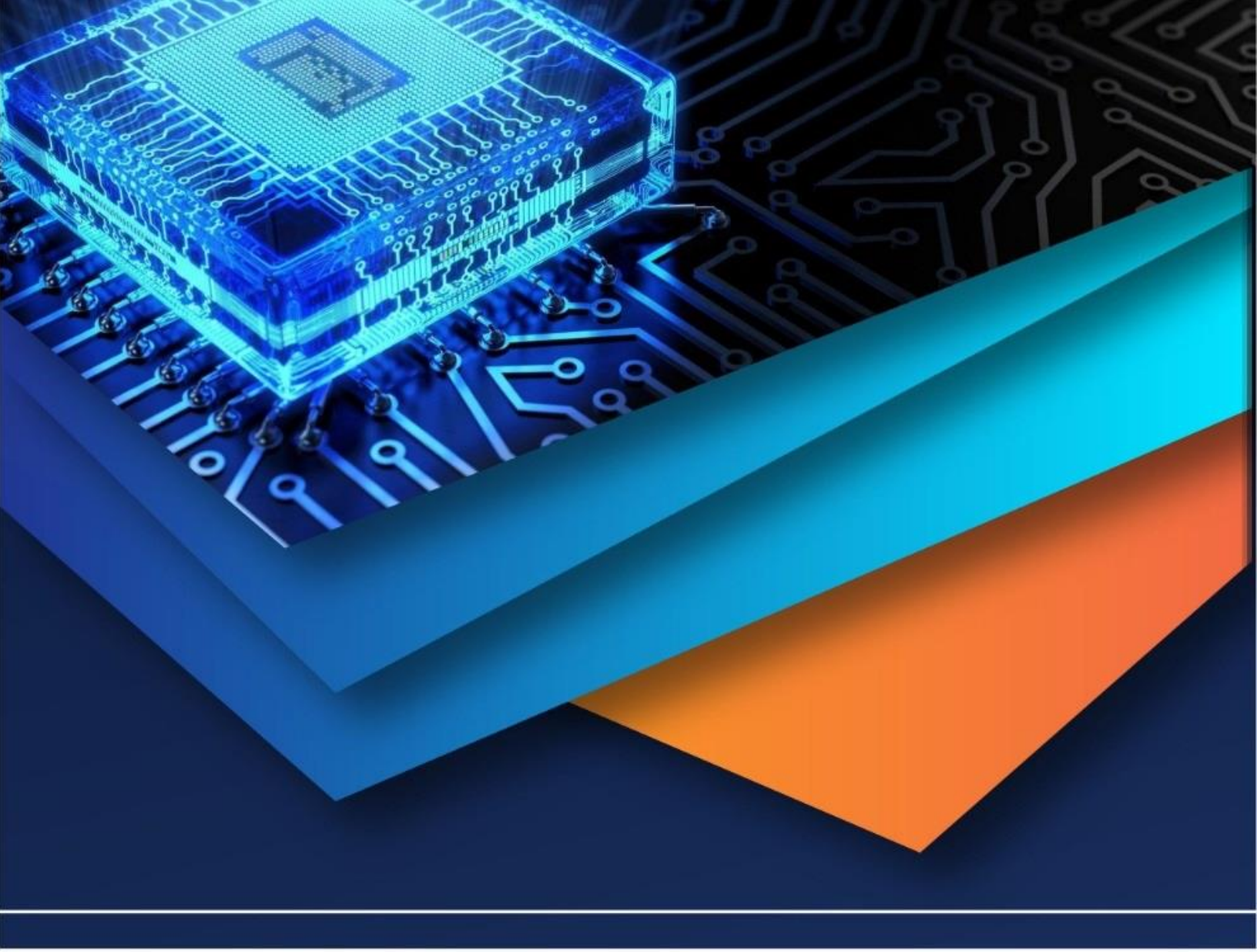

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