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AN EXPERIMENTAL STUDY ON STRENGTH AND DURABILITY PROPERTIES FOR UTILISATION OF COPPER SLAG, SEA SHELL POWDER AND CARBON FIBERS IN CONCRETE

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Abstract - *Main theme of the project is to reduce the usage of fine aggregate and cement and improve the strength by using fibers. In this work we will investigate on the strength characteristics and durability properties of concrete with Copper Slag (Cu) and Sea shell powder(S) and effectiveness Carbon Fibers. Replacement of copper slag is about 0%, 5%, 10%, 15% and 20% respectively by weight of Fine Aggregate. The obtained optimum % of Copper Slag concrete is investigated. Then with that optimum % of Copper Slag, Sea Shell powder is replaced about 5%, 10%, 15% and 20% respectively by the weight of Cement. After that optimum % of Copper Slag and Sea Shell powder is investigated. Then the carbon fibers will be added to the optimum % of copper slag and sea shell powder in the % of 0.5%, 1%, 1.5%, and 2% by the weight of cement. Mechanical properties at 28 days will be investigated. Then investigations will be carried out for Percentage loss in compressive, split tensile and flexural strengths, Percentage loss of weights by considering the Durability tests such as acid attack test and alkaline attack test at the age of 28, 56 and 90 days. The grade of concrete is* M_{25}.

Key Words: **Copper Slag, Sea Shell Powder, Carbon Fibres, Strength Properties, Durability.**

1. INTRODUCTION

Concrete is prime material for structures and used for various other applications. In order to reduce the usage of cement, now a day's the cement is being replaced by many admixtures. To reduce the use of fine aggregate copper slag is used as its replacement to safe guard the natural resources. Use of cement generate large amount of carbon dioxide which results in global warming and ozone layer depletion. Use of cement generate large amount of carbon dioxide which results in global warming and ozone layer depletion. Sea Shell Powder is the largest naturally available material whose production cost is very less compared to Ordinary Portland Cement (OPC).The naturally available material can solve the environmental damages for certain extend. To overcome the deficiencies of concrete, fibers are added to enhance the performance of concrete. This reduces the cracks and increases the strength of concrete.

1.1 DURABILITY

Durability of concrete is to with stand action of chemical, weathering and physical action is known as the corrosion to reinforcement in Flexure members. However the reduction of strength arises based on many aspects like cracks in members, corrosion of steel, alkali aggregate Durability of concrete.

1.2 HISTORY OF COPPER SLAG, SEA SHELL POWDER & CARBON FIBER

Copper-slag is a bi-product obtained during matte smelting& refining of copper. Copper slag is a black glassy particle and granular in nature like sand, produced during matte smelting and copper conversion.

Seashell also known simply as a shell is a hard, protective outer layer created by an animal that lives in the sea. The shell is part of the body of the animal empty seashells are often found washed upon beaches by beachcombers.

Chopped carbon fibers are predominantly produced from polyaczrylonitrile (PAN). Carbon fiber reinforced polymer, carbon fiber reinforced plastic, or carbon fiber reinforced thermoplastic is an extremely strong and light fiber - reinforced plastic which contains carbon fiber. Carbon fibers are expensive to produce but are commonly used wherever high strength-to-weight ratio and stiffness (rigidity) are required, such as aerospace, superstructure of ships, automotive, civil engineering, sports equipment, and an increasing number of consumer and technical applications.

2. PROPERTIES OF THE MATERIALS

The physical properties of the materials used in the work are as follows:

Table -2.1: Physical Properties of cement

S.no.	Property	Value Obtained
1	Specific Gravity	3.01
2	Fineness	6.3%
3	Normal Consistency	26%
4	Initial setting time	35 minutes
5	Final setting time	540 minutes

Table -2.2: Physical Properties of Fine Aggregate

S.no.	Property	Value Obtained
1	Specific Gravity	2.5
2	Fineness modulus	2.6
3	Grading zone	III

Table -2.3: Physical Properties of Coarse Aggregate

S.no.	Property	Value Obtained
1	Specific Gravity	2.75
2	Fineness modulus	7.17

Table -2.4: Physical Properties of Copper Slag

S.no.	Property	Value Obtained
1	Specific Gravity	3.4
2	Fineness modulus	4.76
3	Color	Black

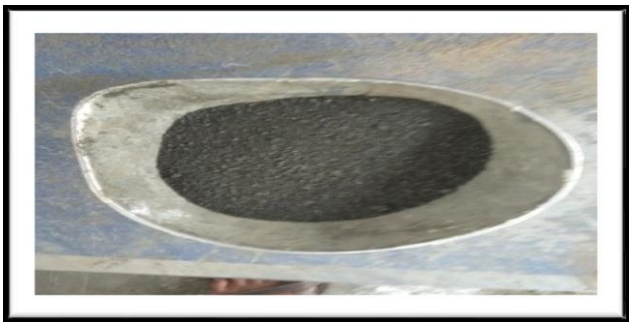

Fig -2.1: Copper Slag

Table -2.5: Physical Properties of Sea Shell Powder

S.no.	Property	Value Obtained
1	Specific Gravity	2.01
2	Fineness	7.3%

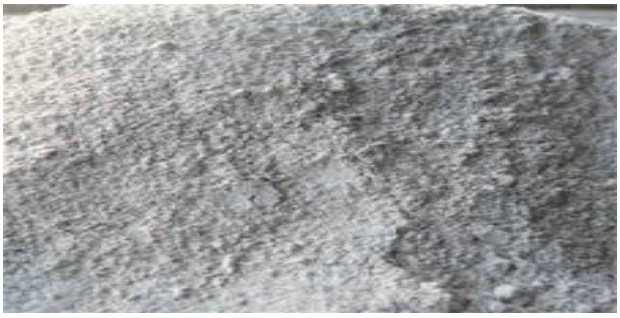

Fig -2.2: Sea Shell Powder

Table -2.6: Physical Properties of Carbon Fiber

S.no.	Property	Value
1	Aspect Ratio	150
2	Length	18mm
3	Diameter	0.12mm
4	Density	350g/lit
5	Color	black
6	Carbon Content	95%
7	Elongation	1.8%
8	Electric Resistivity	$1.6x10^{-3\Omega}$
9	Tensile Strength	430MPA
10	Tensile modulus	230GPA

Fig -2.3: Carbon Fiber

2.1 H_2SO_4 & NaOH

Sulphuric acid (H_2SO_4) is a mineral acid molecular is a colourless, odourless syrupy liquid that is soluble in water, in a reaction that is highly exothermic

Sodium hydroxide (NaOH) is a highly caustic substance that is used to neutralize acids and make sodium salts. At room temperature, sodium hydroxide is a white crystalline odourless solid that absorbs moisture from the air.

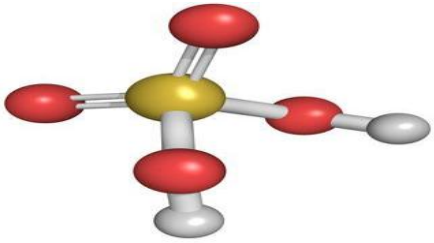

Fig -2.4: Structure of H_2SO_4

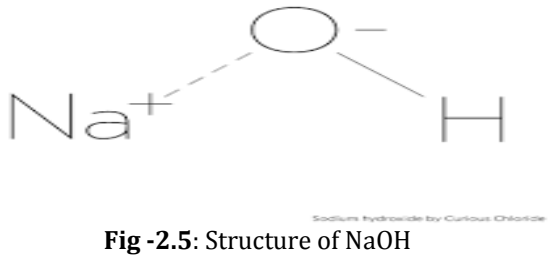

Fig -2.5: Structure of NaOH

These two solutions are used to find out the durability properties of the specimens.

3. MECHANICAL PROPERTIES

Fine aggregate is replaced with copper slag of about 5%, 10%, 15%, and 20% respectively and the comparison of nominal (M_{25}) concrete with copper slag based concrete.
Cu_5, Cu_{10}, Cu_{15}, Cu_{20} means replacement of copper slag with 5%, 10%, 15%, and 20% respectively.

Table -3.1: comparison of nominal, copper slag based concrete @ 28 days

Type of mix	Compressive Strength (N/mm²)	Split Tensile Strength (N/mm²)	Flexural Strength (N/mm²)
N	31.7	2.83	3.21
Cu_5	32.1	2.89	3.37
Cu_{10}	**34.6**	**4.02**	**4.97**
Cu_{15}	32.2	3.32	4.01
Cu_{20}	30.3	3.01	3.96

After obtaining the optimum % of copper slag i.e., Cu_{10}, to that copper slag based concrete, cement is replaced with sea shell powder of about 5%, 10%, 15%, and 20% respectively.
S_5, S_{10}, S_{15}, S_{20}, means sea shell powder with 5%, 10%, 15%, and 20% respectively.

Table -3.2: comparison of optimum of copper slag and sea shell powder based concrete @ 28 days

Type of mix	Compressive Strength (N/mm²)	Split Tensile Strength (N/mm²)	Flexural Strength (N/mm²)
Cu_{10}+ S_5	32.6	2.92	3.92
Cu_{10}+ S_{10}	**36.4**	**4.32**	**5.12**
Cu_{10}+ S_{15}	33.9	4.17	4.21
Cu_{10}+ S_{20}	34.3	4.02	4.46

Now with that optimum % of copper slag and sea shell powder concrete i.e., Cu_{10}+ S_{10}, carbon fibers are added by the weight of cement with the % of 0.5%, 1%, 1.5%, and 2% respectively.
$C.F_{0.5}$, $C.F_{1.0}$, $C.F_{1.5}$, $C.F_{2.0}$ means carbon fiber with 0.5%, 1%, 1.5%, and 2% respectively.

Table -3.3: comparison optimum of copper slag and sea shell powder with the addition of carbon fiber based concrete @ 28 days

Type of mix	Compressive Strength (N/mm²)	Split Tensile Strength (N/mm²)	Flexural Strength (N/mm²)
Cu_{10}+ S_{10}+ $C.F_{0.5}$	33.8	4.77	5.42
Cu_{10}+ S_{10}+ $C.F_{1.0}$	35.6	4.97	5.69
Cu_{10}+ S_{10}+ $C.F_{1.5}$	**37.2**	**5.39**	**5.96**
Cu_{10}+ S_{10}+ $C.F_{2.0}$	35.9	4.21	5.21

By the optimum % of copper slag, seashell powder and carbon fiber concrete the variations of strengths of compressive, split tensile and flexural strength are as shown in the tabular form.

Table -3.4: comparison of various mixes of concrete @ 28 days

Type of mix	Compressive Strength (N/mm²)	Split Tensile Strength (N/mm²)	Flexural Strength (N/mm²)
N	31.7	2.83	3.21
Cu_{10}	34.6	4.02	4.97
Cu_{10}+ S_{10}	36.4	4.32	5.12
Cu_{10}+ S_{10}+ $C.F_{1.5}$	**37.2**	**5.39**	**5.96**

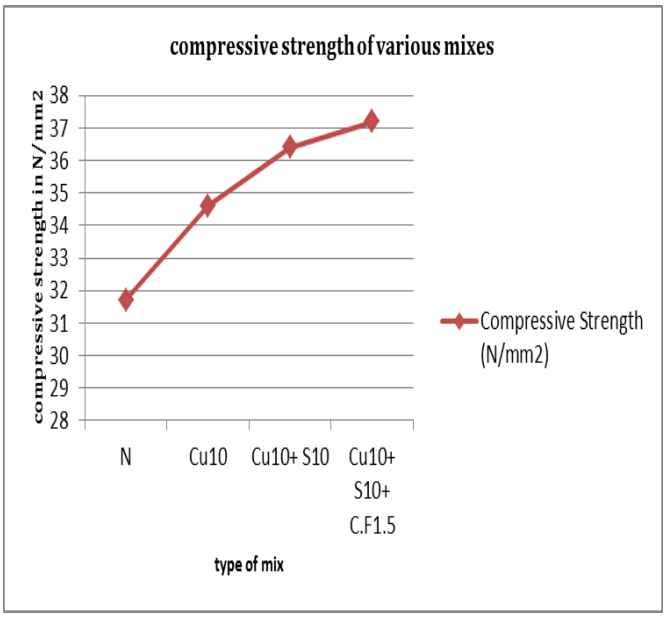

Chart -3.1: compressive strength of various mixes

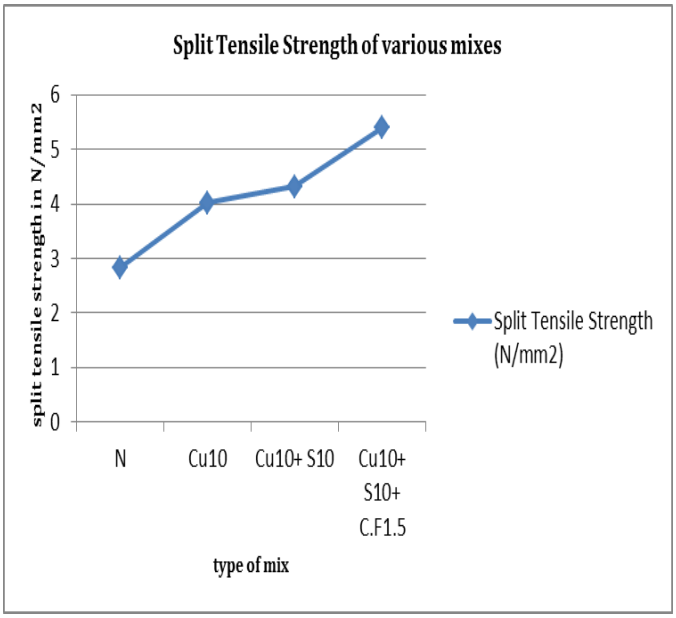

Chart -3.2: split tensile strength of various mixes

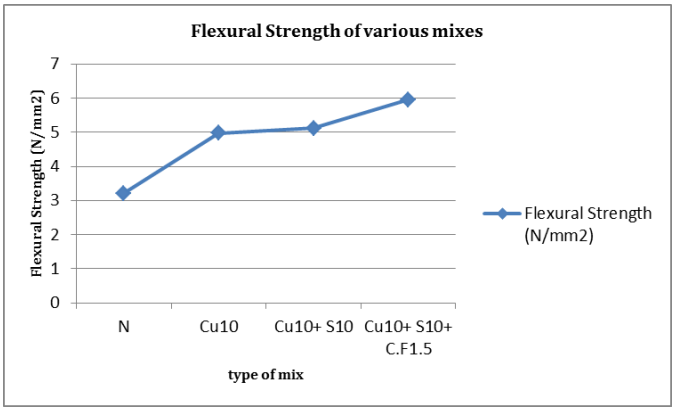

Chart -3.3: flexural strength of various mixes

4. DURABILITY PROPERTIES

Acid and alkaline attack tests are conducted on the specimens of optimum of copper slag, sea shell powder and carbon fiber. These tests are conducted by using solutions of H_2SO_4 & NaOH respectively. The solutions are mixed 5% by the weight of water which is used for curing. Then the cubes are immersed in acidic and alkaline water continuously for 28, 56 and 90days. The acidity and alkalinity should be maintained throughout the test period.

Optimum specimens-(opt spc) - **Cu_{10}+ S_{10}+ $C.F_{1.5}$**

Table -4.1: Acid Attack Test (H_2SO_4)

Type of mix	Compressive Strength (N/mm^2)	Split Tensile Strength (N/mm^2)	Flexural Strength (N/mm^2)
opt spc	37.2	5.39	5.96
opt spc @28 days	30.28	3.32	4.24
opt spc @56days	23.14	2.56	3.45
opt spc @90days	16.44	1.67	2.79

Table -4.2: Alkaline Attack Test (NaOH)

Type of mix	Compressive Strength (N/mm^2)	Split Tensile Strength (N/mm^2)	Flexural Strength (N/mm^2)
opt spc	37.2	5.39	5.96
opt spc @28 days	33.46	4.01	4.36
opt spc @56days	28.75	3.54	4.01
opt spc @90days	25.95	3.27	3.69

Fig -4.1: Specimens of acid and alkaline attack

Table -4.3: comparison of mechanical properties of acid and alkaline attacked specimens

Type of mix	Compressive Strength (N/mm^2)		Split Tensile Strength (N/mm^2)		Flexural Strength (N/mm^2)	
	Acid attack	Alkaline attack	Acid attack	Alkaline attack	Acid attack	Alkaline attack
opt spc @28 days	30.28	33.46	3.32	4.01	4.24	4.36
opt spc @56days	23.14	28.75	2.56	3.54	3.45	4.01
opt spc @90days	16.44	25.95	1.67	3.27	2.79	3.69

4.1 LOSS OF WEIGHT OF SPECIMENS

Type of mix	% loss of weight of cube		% loss of weight of cylinder		% loss of weight of beam	
	Acid attack	Alkaline attack	Acid attack	Alkaline attack	Acid attack	Alkaline attack
opt spc @28 days	11.8	9.9	11.98	11.9	11.5	12.75
opt spc @56days	26.3	19.64	25.9	21.19	24.5	23.67
opt spc @90days	30.21	26.78	31.47	29.67	31.2	30.67

5. CONCLUSIONS

By replacement of fine aggregate up to 10% with copper slag there is an increase of mechanical properties and there after decreasing pattern is observed. The copper slag based concrete has an increase of compressive strength of about 9.14%, split tensile strength of about 0.42 times, flexure strength of about 0.54 times when compared to nominal concrete.

By replacement of cement with sea shell powder up to 10% to the 10% optimum copper slag concrete there is an increase of mechanical properties and there after decreasing pattern is observed. The copper slag and sea shell powder based concrete has an increase of compressive strength of about 14.82%, split tensile strength of about 0.52 times, flexure strength of about 0.59 times when compared to nominal concrete.

By the addition of carbon fibers up to 1.5% to the optimum copper slag and sea shell powder based concrete there is an increase of mechanical properties, there after decreasing pattern is observed. The copper slag, sea shell powder and carbon fiber based concrete has an increase of compressive strength of about 17.35%, split tensile strength of about 0.9 times, flexural strength of about 0.85 times when compared to nominal concrete.

Compressive strength of copper slag, sea shell powder and carbon fiber based concrete specimens are immersed in 5% of H_2SO_4 solution is reduced 18.62 % at 28 days, 37.79 % at 56days and at 55.80% 90 days.

Split tensile strength of copper slag, sea shell powder and carbon fiber based concrete specimens are immersed in 5%

of H_2SO_4 solution is reduced 38.40 % at 28 days, 52.5 % at 56 days and 69.01 % at 90 days.

Flexural strength (N/mm^2) of copper slag, sea shell powder and carbon fiber based concrete specimens are immersed in 5% of H_2SO_4 solution is reduced 29.00 % at 28 days, 42.11% at 56 days and 53.4 % at 90 days.

Loss of weight is 11.76% at 28 days, 25.5% at 56 days and 30.96 % at 90 days when copper slag, sea shell powder and carbon fiber based concrete specimens are immersed specimens are treated with H_2SO_4.

Loss of weight is 11.51% at 28 days, 21.5% at 56 days and 29.04 % at 90 days when copper slag, sea shell powder and carbon fiber based concrete specimens are immersed specimens are treated with NaOH.

Finally by the above results and conclusions of durability study to the optimum percentage of copper slag, sea shell powder and carbon fiber based concrete it is concluded that the acid attack is more when compared to alkaline attack.

The loss of strength and loss of weight of acid attacked specimens is more when compared to alkaline attacked specimens

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