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Exprimental Study on Strength and Durability of Concrete by Partial Replacement of Fine & Coarse Aggregate using Copper Slag & Cuddapah Stone with Addition of Glass Fibers

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Abstract - *Nowadays we are facing most difficult protection problems related to environment. Many things which are invented for our luxurious life are responsible for polluting environment due to improper waste management technique. Copper Slag can be an economic alternative to the river sand, which is an industrial by-product obtained from the manufacturing of copper.The use of glass fibres in SCC improves the engineering properties such as tensile strength, ductility Main objective of this project is to reduce the usage of cement, fine aggregate and coarse aggregate and improve the strength of concrete by using glass fibers. In this study we will investigate on the characteristics strength of concrete with COPPER SLAG, and CUDDAPAH STONE and addition of GLASS FIBERS. In order to reuse the waste, the coarse aggregate is replaced by cuddapah stone and fine aggregate by copper slag in concrete mix of M25 and M30 grade of concrete in the proportions of 0%,5%,10%,15%,20% . Then the glass fibers will be added to the optimum % of COPPER SLAG, and CUDDAPAH STONE Mix concrete and to conventional concrete upto 2% by the weight of cement. Then the mechanical properties are studied for compressive, split tensile and flexure tests for 7, 14, 28 days. 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 and 90 days. The grade of concrete is M25&M30.*

Key Words: Copper Slag, Cuddapah Stone, Glass Fiber, Sulphuric Acid (H_2so_4)

1. INTRODUCTION

Concrete is a widely used man-made construction material. Concrete is manufactured by cementitious materials to bind themselves together, as well as with other materials to form a strong and solid mass. Cement industries releases huge amount of carbon dioxide during processes that effecting the environment and causing global warming And by large mining of river sand[fine aggregate], leads to decrease of water level present in the earth. For this reason, partially replacement of fine aggregate with copper slag. In addition to this materials coarse aggregate is also been partially replaced with waste produced from cuddapah stone floor slab cutting industry . Which can be used as a substitute for regular coarse aggregate. Using these materials will be bits of help in the reduction of the concrete cost. So then the fine aggregate replaced with copper slag, and coarse aggregate replaced with cuddapah stone in concrete.

2. MECHANICAL PROPERTIES

Mechanical properties can be referred as calculation of strength obtained by the concrete at an interval of 7,14 and 28 days of curing. Investigations will be carried out for Percentage loss in compressive, split tensile and flexural strengths.

3. DURABILITY PROPERTIES

Durability properties of concrete can be referred as to with stand of chemical and weathering actions. Investigations will be carried out for Percentage loss in compressive strength after immersed in acid for 28 and 90 days.

4. PROPERTIES OF MATERIALS

Table-1: Physical Properties of cement

Property	Value Obtained
Specific Gravity	2.929
Fineness	6%
Normal Consistency	33%
Initial setting time	80 minutes
Final setting time	180minutes

Table-2: Physical Properties of Fine Aggregate

Property	Value Obtained
Specific Gravity	2.68
Fineness modulus	2.6
Grading zone	II

Table-3: Physical Properties of Coarse Aggregate

Property	Value Obtained
Specific Gravity	2.88
Fineness modulus	7.65

Table -4: Physical Properties of Copper Slag

Property	Value Obtained
Specific Gravity	4.13
Fineness	4.55

Table-5: Physical Properties of Cuddapah Stone

Property	Value Obtained
Specific Gravity	2.70
Fineness modulus	7.24

Table -6: Physical Properties of Glass Fiber

Property	Value
Aspect Ratio	857
Diameter	12 microns

Table -7: Physical Properties of Water

Property	Value Obtained
pH	7

5. RESULTS & DISCUSSIONS

5.1 PHASE 1

Sand is replaced with copper slag of about 5%, 10%, 15%, and 20% respectively and compared with nominal (M25) and (M30) concrete mix(S).A_1, A_2, A_3, A_4 means replacement of copper slag in 5%,10%,15% and 20% respectively.

Table-8: Compressive Strength of different mixes of Copper Slag (M25)

Mix Designation	Compressive strength (N/mm^2)		
	7days	14 days	28days
A	23	28.5	32.5
A1	20.5	28.5	32
A2	**22**	**30**	**33.5**
A3	19	26	29.4
A4	18.5	25	28

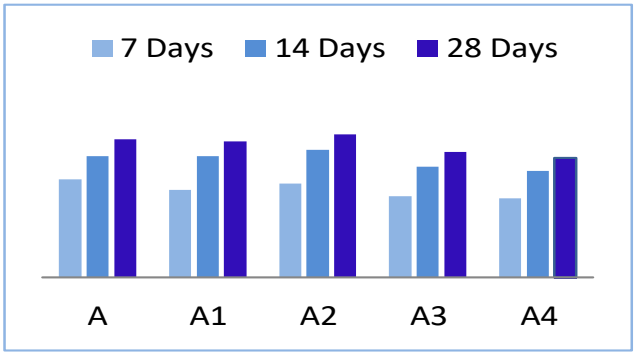


Fig1. Graph Showing The Compressive Strength Of Concrete With Partial Replacement Of Fine aggregate By Copper slag

Table-9: Split tensile Strength of different mixes of Copper Slag (M25)

Mix Designation	Spit Tensile Strength(N/mm^2)		
	7days	14 Days	28days
A	2.01	2.8	3.10
A1	1.86	2.62	2.86
A2	**2.08**	**2.93**	**3.2**
A3	1.52	2.11	2.21
A4	1.44	2.02	2.16

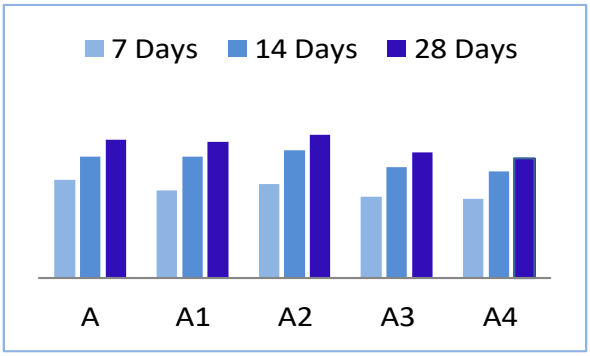
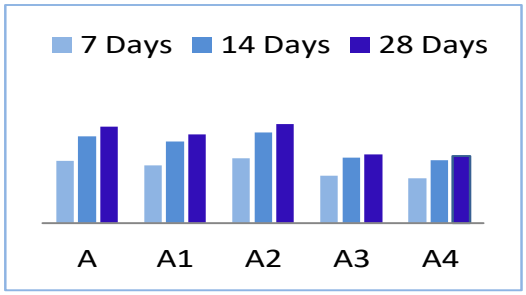


Fig2. Graph Showing the Split Tensile Strength of Concrete with Partial Replacement of Fine Aggregate by Copper Slag

Table-10: Flexural Strength of different mixes of Copper Slag in Fine aggregate (M25)

Mix Designation	Flexural strength (N/mm^2)		
	7days	14days	28days
A	2.53	3.17	3.82
A1	2.41	3.01	3.62
A2	**2.62**	**3.24**	**3.56**
A3	2.10	2.66	3.23
A4	1.95	2.46	2.98



5.2 PHASE 2

Coarse aggregate is replaced with cuddapah stone of about 5%, 10%, 15%, and 20% of mass of coarse aggregate with the obtained optimum % of Copper Slag in fine aggregate (M25) concrete mix(S) A5, A6, A7, A8 means replacement of Cuddapah stone in 5%, 10%, 15% and 20% respectively.

Table-11: Compressive Strenght of Different Mixs of Cuddapah Stone in Coarse Aggregate At 10% Copper Slag M25 Grade

Mix Designation	Compressive strength (N/mm^2)		
	7days	14 days	28days
A2	21.5	30	33.5
A5	21	29.5	33
A6	22	30.5	34
A7	**23**	**32**	**35.4**
A8	20.5	29	32

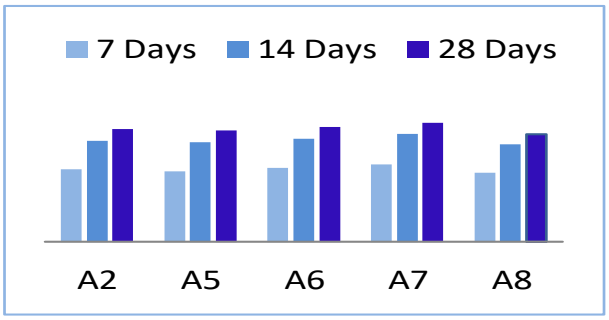


Fig4. Graph Showing The Compressive Strength Of Concrete With Partial Replacement Of Coarse aggregate By Cuddapah stone

Table-12: Split Tensile Strenght of Different Mixs of Cuddapah Stone in Coarse Aggregate At 10% Copper Slag M25 Grade

Mix Designation	Spit Tensile Strength(N/mm^2)		
	7days	14 Days	28days
A2	2.08	2.93	3.20
A5	2.13	2.95	3.28
A6	2.15	3.0	3.31
A7	**2.35**	**3.26**	**3.62**
A8	1.92	2.66	2.96

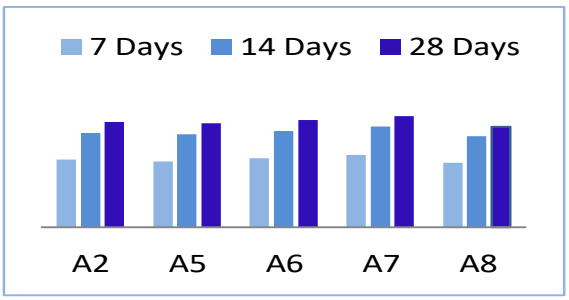


Fig5. Graph Showing The Split Tensile Strength Of Concrete With Partial Replacement Of Coarse aggregate By Cuddapah stone

Table-13: Flexural Strenght of Different Mixs of Cuddapah Stone in Coarse Aggregate At 10% Copper Slag M25 Grade

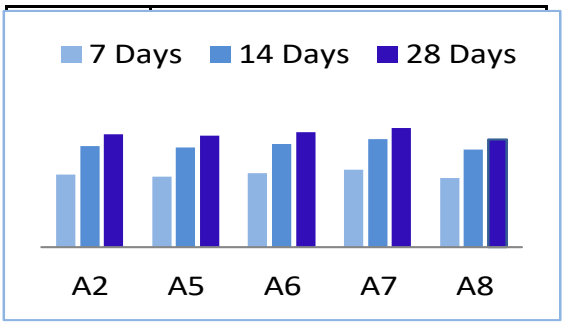


Fig6. Graph Showing The flexural Strength Of Concrete With Partial Replacement Of C.A By Cuddapah Stone

FOR M30 GRADE

5.3 PHASE 1

Sand is replaced with copper slag of about 5%, 10%, 15%, and 20% respectively and compared with nominal (M25) and (M30) concrete mix(S).B_1, B_2, B_3, B_4 means replacement of copper slag in 5%,10%,15% and 20% respectively.

Table-14: Compressive Strength of different mixes of Copper Slag (M30)

Mix Designation	Compressive strength (N/mm^2)		
	7days	14 days	28days
B	25.5	31.6	37.4
B1	**27.65**	**33.96**	**41.24**
B2	24	30	35
B3	22.3	26.45	31.85
B4	20	24.25	28

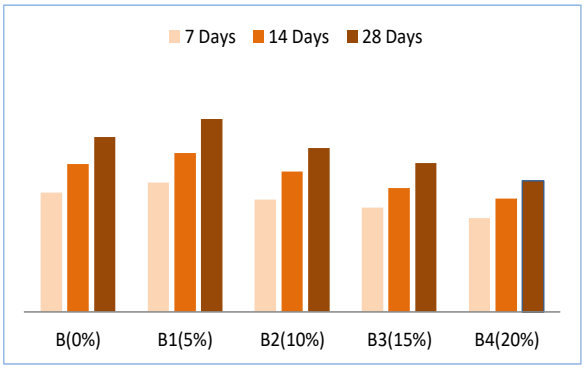


Fig7. Graph Showing the Compressive Strength of Concrete with Partial Replacement of Fine Aggregate by Copper Slag

Table-15: Split Tensile Strength of different mixes of Copper Slag in Fine Aggregate

Mix Designation	Spit Tensile Strength(N/mm^2)		
	7days	14 Days	28days
B	2.53	2.92	3.32
B1	**3.00**	**3.12**	**4.23**
B2	**2.92**	**3**	**3.47**
B3	2.50	2.75	3.12
B4	2.24	2.54	2

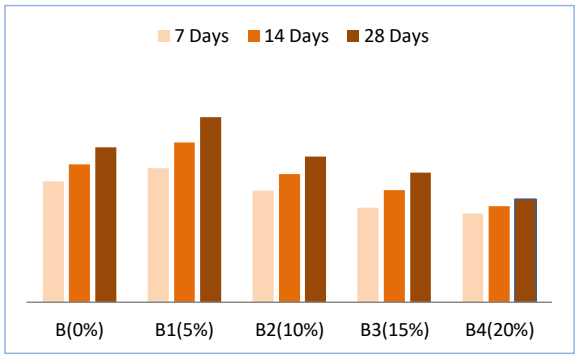


Fig8. Graph Showing the Split Tensile Strength of Concrete with Partial Replacement of F.A by Copper Slag

Table-16: Flexural Strength of different mixes of Copper Slag in Fine aggregate.

Mix Designation	Flexural strength (N/mm^2)		
	7days	14days	28days
B	3.21	3.66	4.12
B1	3.56	4.24	4.92
B2	2.96	3.41	3.87
B3	**2.52**	**2.98**	**3.45**
B4	2.36	2.55	2.74

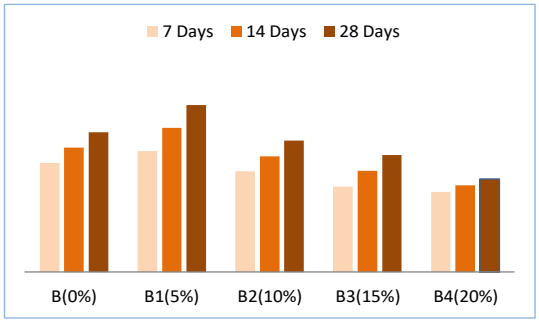


Fig9. Graph Showing the flexural Strength of Concrete with Partial Replacement of Fine aggregate by Copper slag

5.4 PHASE 2

Coarse aggregate is replaced with cuddapah stone of about 5%, 10%, 15%, and 20% of mass of coarse aggregate with the obtained optimum % of Copper Slag in fine aggregate (M30) concrete mix(S).B5, B6, B7, B8 means replacement of Cuddapah stone in 5%,10%,15% and 20% respectively.

Table-17: Compressive Strenght of Different Mixs of Cuddapah Stone in Coarse Aggregate at 5% Copper Slag M30 Grade.

Mix Designation	Compressive strength (N/mm^2)		
	7days	14 days	28days
B2	27.65	33.9	41.2
B5	28.1	34.0	41.5
B6	**29.45**	**34.5**	**43.2**
B7	27.5	30.4	38.2
B8	25.63	28.8	35.4

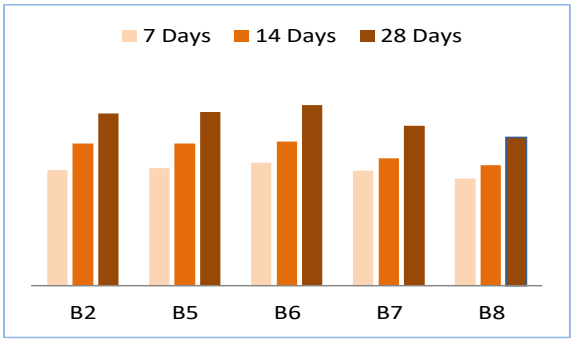


Fig10. Graph Showing the Compressive Strength of Concrete with Partial Replacement of Coarse aggregate by Cuddapah stone

Table-18: Split Tensile Strenght of Different Mixs of Cuddapah Stone in Coarse Aggregate at 5% Copper Slag M30 Grade.

Mix Designation	Spit Tensile Strength(N/mm^2)		
	7days	14 Days	28days
B2	3.00	3.12	4.23
B5	3.12	3.21	4.51
B6	**3.53**	**3.72**	**4.82**
B7	3.12	3.52	4.25
B8	2.95	3.00	3.45

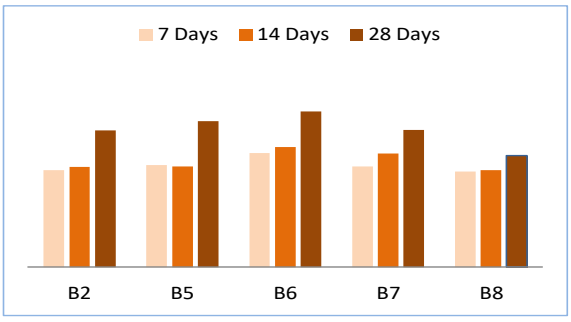


Fig11. Graph Showing the Split Tensile Strength of Concrete with Partial Replacement of Coarse aggregate by Cuddapah stone

Table-19: Flexural Strenght of Different Mixs of Cuddapah Stone in Coarse Aggregate at 5% Copper Slag M30grade

Mix Designation	Flexural strength (N/mm^2)		
	7days	14days	28days
B2	3.56	4.24	4.92
B5	3.72	4.36	5.00
B6	3.89	4.5	5.11
B7	**3.25**	**3.95**	**4.65**
B8	2.92	3.38	3.85

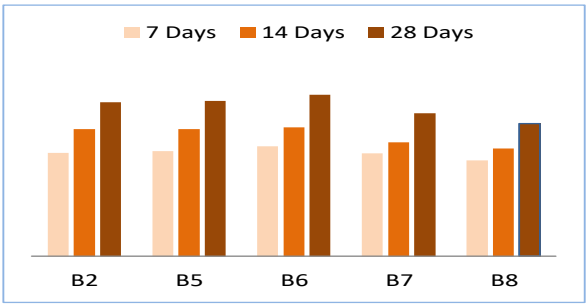


Fig12. Graph Showing the Flexural Strength of Concrete with Partial Replacement of Coarse aggregate by Cuddapah stone

5.5 PHASE-3

M25 GRADE

The 2% addition of Glass fibres to optimum gained mix obtained at replacing 10% of Copper slag in Fine aggregate + 15% of Cuddapah stone in Coarse aggregate in the concrete mix.

Table-20: Compressive Strenght of Addition of 2% of Glass Fibers to Optimum for M25 Grade.

Mix Designation	Compressive strength (N/mm^2)		
	7days	14 days	28days
A7	23	32	35.4
A9	24.5	34	45.8

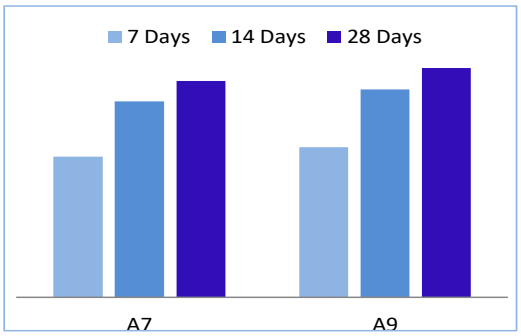


Fig13. Graph Showing the Compressive Strength Of % Addition Of Glass Fibers

Table-21: Split Tensile Strength of optimum of %Addition of Glass Fibers

Mix Designation	Split Tensile strength (N/mm^2)		
	7days	14 days	28days
A7	2.35	3.26	3.62
A9	2.59	3.58	3.98

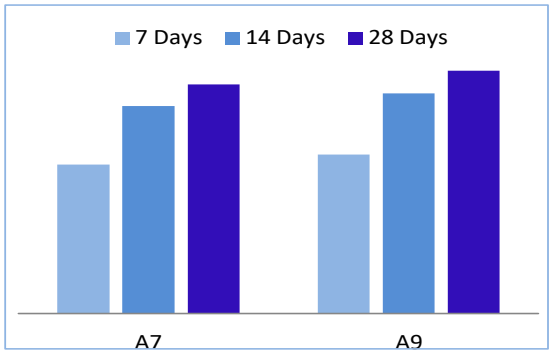


Fig14. Graph Showing the Split Tensile Strength of Concrete with % Addition of Glass Fibers

Table-22: Flexural Strength of Optimum of % Addition of Glass Fibers.

Mix Designation	Flexural strength (N/mm^2)		
	7days	14 days	28days
A7	2.67	3.39	4.11
A9	3.40	3.96	4.52

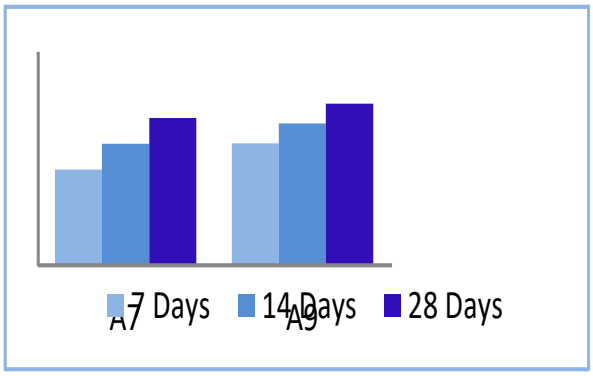


Fig15.Graph Showing theflexural Strength of Concrete with% Addition of Glass Fibers

M30 GRADE

The 2% addition of Glass fibres to optimum gained mix obtained at replacing 5% of Copper slag in Fine aggregate + 10% of Cuddapah stone in Coarse aggregate in the concrete mix.

Table-23: Compressive Strenght of Addition of 2% of Glass Fibers to Optimum for M30 Grade.

Mix Designation	Compressive strength (N/mm^2)		
	7days	14 days	28days
B6	29.4	34.5	43.2
B9	31.0	37.2	45.8

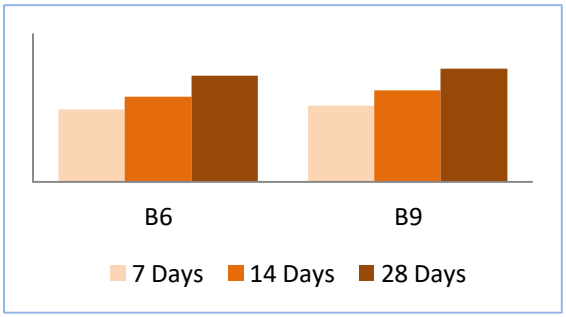


Fig16. Graph Showing The Compressive Strength Of % Addition Of Glass Fibers

Table-24: Split Tensile Strength of optimum of %Addition of Glass Fibers.

Mix Designation	Split Tensile strength (N/mm^2)		
	7days	14 days	28days
B6	3.53	3.72	4.82
B9	3.59	3.82	5.12

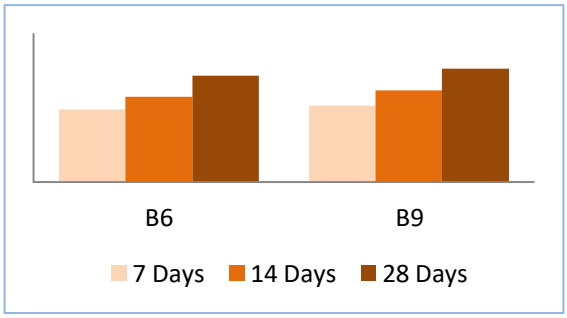


Fig17. Graph Showing the Split Tensile Strength of Concrete with % Addition of Glass Fibers

Table-25: Flexural Strength of Optimum of % Addition of Glass Fibers.

Mix Designation	Flexural Tensile strength (N/mm^2)		
	7days	14 days	28days
B6	3.89	4.50	5.11
B9	3.92	4.61	5.30

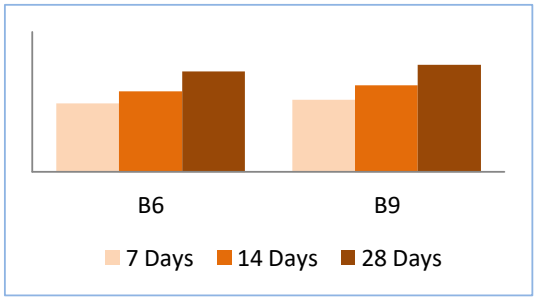


Fig18. Graph Showing theflexural Strength of Concrete with% Addition of Glass Fibers.

5.6 DURABILITY RESULTS

To check the Acid resistance of concrete Sulphuric Acid (H_2SO_4) is selected. The concentrations of acids in water are taken as 2% & 4% to water and tested after 28 & 90 days of immersion(FOR M25&M30GRADE MIX)

FOR M25 GRADE

Table-26: Compression Strength Results when Cubes Cured in 2% in H_2SO_4

Mix Designation	Compressive strength (N/mm^2)	
	28 days	90days
A	26.5	20.2
A7	29.4	23
A9	31.5	25.7

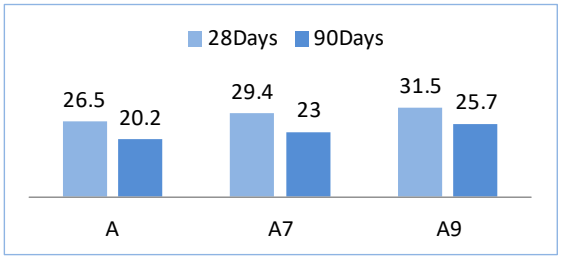


Fig22. Graph showing compression strength results when cubes cured in 2% H_2SO_4

Table-27: Compression Strength Results when Cubes Cured In 4% in H_2SO_4

Mix Designation	Compressive strength (N/mm^2)	
	28 days	90days
A	25	19
A7	28	22
A9	30.2	24.8

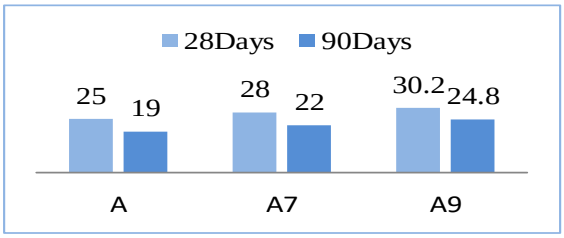


Fig23. Graph showing compression strength results when cubes cured in 4% H_2SO_4

FOR M30 GRADE

Table-28: Compression Strength Results when Cubes Cured in 2% in H_2SO_4

Mix Designation	Compressive strength (N/mm^2)	
	28 days	90days
B	31.4	25.6
B6	37.2	31.5
B9	39.8	33.4

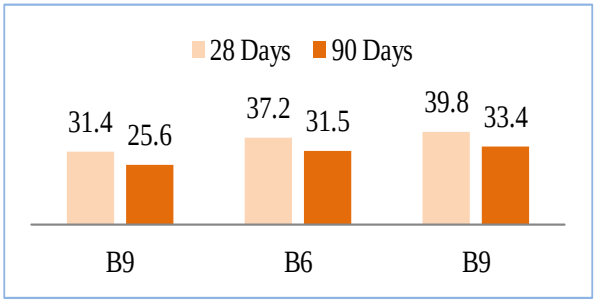


Fig24. Graph showing compression strength results when cubes cured in 2% H_2SO_4

Table-29: Compression Strength Results When Cubes Cured in 4% in H_2SO_4

Mix Designation	Compressive strength (N/mm^2)	
	28 days	90days
B	30	24.2
B6	36	30.3
B9	38.2	32

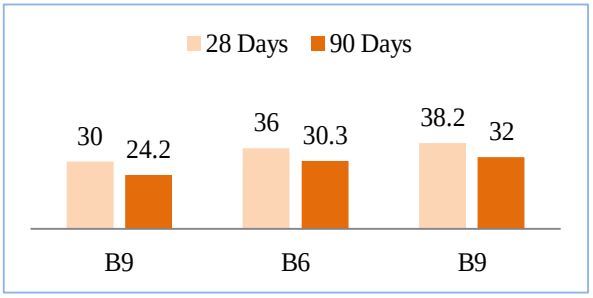


Fig25. Graph showing compression strength results when cubes cured in 4% H_2SO_4

6. CONCLUSIONS

FOR M25 GRADE

At the phase 1

1. It is observed that at 10% replacement of Fine aggregate with Copper slag the mechanical properties of concrete shows maximum results.
2. It is observed that at 10% replacement of Fine aggregate with Copper slag the mechanical properties of concrete shows maximum results.
3. We noticed that the further increment of Copper slag in Fine aggregate leads to decreasing the Mechanical properties of concrete.
4. The test results are compared to conventional mix concrete 10% replacement of Copper slag in Fine aggregate is observed as optimum.
5. Compressive, split tensile, Flexural strength are observed for getting the maximum values at 10% replacement.
6. Maximum compressive strength of 33.5 N/mm^2 is obtained at 10% replacement of Copper slag in Fine aggregate at the age of 28 days.
7. Maximum split tensile strength of 3.2 N/mm^2 is obtained at 10% replacement of Copper slag in Fine aggregate at the age of 28 days.
8. Maximum flexural strength of 3.86 N/mm^2 is obtained at 10% replacement of Copper slag in Fine aggregate at the age of 28 days.
9. As per the study, it is observed that the workability property increases as the % replacement of Copper slag in Fine aggregate increases.
10. **At the phase 2** by replacing Coarse aggregate by Cuddapah stone in optimum mix i.e. at 10% replacement of Copper slag in Fine aggregate the mechanical properties were observed.
11. We have found that optimum strength gained at 15% replacement of Cuddapah stone in Coarse aggregate in the optimum mix (10% Copper slag).
12. **At the phase 3** by addition of (2%) Glass fibres to OPTIMUM mix the mechanical properties were found to be increased.
13. As per the study, it is observed that the mechanical properties increased and getting the maximum value by addition of Glass fibres to OPTIMUM mix.

In durability study at 2% and 4% H_2SO_4 for 90 days curing the strength will be decreased up to 5 to 7 % **FOR**

M30 GRADE
At the phase 1

14. It is observed that at 5% replacement of Fine aggregate with Copper slag the mechanical properties of concrete shows maximum results.
15. We noticed that the further increment of Copper slag in Fine aggregate leads to decreasing the Mechanical properties of concrete.
16. The test results are compared to conventional mix concrete 5% replacement of Copper slag in Fine aggregate is observed as optimum.
17. Compressive, split tensile, Flexural strength are observed for getting the maximum values at 5% replacement.
18. Maximum compressive strength of 41.24 N/mm^2 is obtained at 5% replacement of Copper slag in Fine aggregate at the age of 28 days.
19. Maximum split tensile strength of 4.23 N/mm^2 is obtained at 5% replacement of Copper slag in Fine aggregate at the age of 28 days.
20. Maximum flexural strength of 4.92 N/mm^2 is obtained at 5% replacement of Copper slag in Fine aggregate at the age of 28 days.
21. As per the study, it is observed that the workability property increases as the % replacement of Copper slag in Fine aggregate increases.

22. **At the phase 2** by replacing Coarse aggregate by Cuddapah stone in optimum mix i.e. at 5% replacement of Copper slag in Fine aggregate the mechanical properties were observed.
23. We have found that optimum strength gained at 10% replacement of Cuddapah stone in Coarse aggregate in the optimum mix (5% Copper slag).
24. **At the phase 3** by addition of (2%) Glass fibres to OPTIMUM mix the mechanical properties were found to be increased.
25. As per the study, it is observed that the mechanical properties increased and getting the maximum value by addition of Glass fibres to OPTIMUM mix.
26. In durability study at 2% and 4% H_2SO_4 for 90 days curing the strength will be decreased up to 5 to 7 %

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