International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL INVESTIGATION ON STRENGTH PROPERTIES OF CONCRETE BY REPLACING NATURAL SAND BY MANUFACTURED SAND AND COPPER SLAG SUBJECTED TO CHLORIDE ATTACK

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Abstract - *In this project work the effect of concrete using copper slag and manufactured sand as natural sand replacement when subjected to with and without chloride attack for 58 days are studied. The concrete grade of M30 is selected and using IS 10262-2019 for concrete mix design. The properties of material for cement, coarse aggregate, natural sand, m-sand and copper slag are studied. Select water/cement ratio is 0.50. Based on weight of material ,the 0%, 20% and 60% replacement by using m-sand, 0%, 20% and 60% replacement by using copper slag and 10%+10%, 20%+20%, 30%+30%, 40%+40% and 50%+50% replacement by using m-sand and copper slag both. The workability of the concrete made by different replacement mixes are studied by slump cone test. The slump decreases as replacement by m-sand percentage increases in conventional concrete. The slump increases as replacement by copper slag percentage increases in conventional concrete. The strength tests like compressive strength test, split tensile strength test and flexural strength test are done on concrete specimens. The specimens are kept to curing under water and one more set is kept to curing under NaCl (5% concentration) solution mixed water. The 60% replacement of natural sand by m-sand got higher strength value. 40% replacement of natural sand by copper slag got higher strength value and 30%+30% replacement of natural sand by m-sand and copper slag got higher strength value when these are subjected to with and without chloride attack for 58 days. The chloride attack measures the durability of concrete for 58 days.*

Key Words: M-sand, Copper slag, Compressive strength, Tensile strength, Flexural strength, 5% NaCl solution, Chloride attack.

1. INTRODUCTION

Concrete is the most important material in the present days and used as construction material. It is essentially used for construction of structures like roads, buildings and bridges etc. Cement, Coarse aggregate, Fine aggregate and water are the basic ingredients of concrete. Cement is the binding material in concrete and it binds all material together in concrete when water is added to the concrete. Aggregates give mass to the concrete.

Now a days, most used construction material is concrete. Fresh concrete gives any shape and more advantageous over steel. In 19th century, the development of concrete takes place then it's got more importance and efficient material for construction. The steel bars were used with concrete and this gives more rigidity to the building. This composition is known as strengthen concrete. The developing industries are producing huge quantity of concrete. Fine aggregate is the important material in the concrete mix. Fine aggregate is nothing but natural sand that sand is obtained from river bed. Mining of sand reduces the self purifying capacity of river and subsequent effect on nature because of this reason; government has put limitation on mining of river sand. The manufactured sand was introduced to overcome the mining of river sand and this manufactured sand is also called as M-sand nothing but artificial sand. Day by day the production of concrete increases and the demand of river sand also increase. But the river sand takes many years for regeneration because of this; the manufactured sand is come in picture.

The alternative for river sand is to be finding and many by product wastes are used for replacing the river sand in concrete mix. The waste material or any by product wastes are available like foundary sand, washed bottom ash, quarry dust and copper slag etc.

In this investigation, the copper slag and m-sand are used as fine aggregate in concrete. Concrete is produced by replacing natural sand by manufactured sand and copper slag. The strength tests are conducted on this type of concrete and durability is check against chloride attack. The sodium chloride (NaCl) is used for chloride attack. The 5% concentration of NaCl is taken to mix with water. In this solution, the concrete specimens are kept for curing.

1.1 Manufactured Sand

Manufactured sand is produced by crushing of hard granite stone and the crushed stone is in form of grounded edges with cubical shape then it is separated and washed to make use full m-sand for construction. This m-sand replaces the natural sand in concrete mix. The plant for crushing of stone is established where more rock sources are available. Easily the required grain size can be produced.

1.2 Copper Slag

Copper slag is one of the waste materials and it is by product waste generated from copper smelting and copper refining hence difficulty in disposal of copper slag and this slag is effect on environment. There problems are overcome by using copper slag as the replacement of sand in concrete. The copper slag has same properties of sand. The copper slag is generated approximately 2.2 to 3.0 tons for one ton of copper production. The chemical constituents of copper slag are SiO_2 (25-50%), Free Silica (<0.5), Al_2O_3 (2-9%), Sulphates (0.2%), Chlorides (0.003%), Fe_2O_3 (45.55%), CaO_2 (2-9%), MgO_3 (1-5%) and CuO (0.75% max).

1.3 Chloride Attack

RC structures are exhibited to brutal situation and regularly anticipated that would last with zero repair or maintenance for longer period. The concrete structures under natural water resources like dams, canals and bridges etc. in that one of the natural fear is chloride attack that promotes consumption of steel and reduces quality and affects the structure because of this the damage of structure take place.

Chloride attack is the major factor that measures the durability of concrete. Chloride particles penetrate into the concrete. The chloride particles are from cement, aggregate, water and surrounding environment. Inside of concrete a carbon steels are placed. A thin layer is formed i.e. passive layer. Due to high alkalinity, diminishing of passive layer take place this causes the chloride attack.

2. OBJECTIVE OF THE EXPERIMENT

In this project work, an attempt is made to observe the workability and strength like compressive strength, tensile strength and flexural strength when subjected to with and without chloride attack for the replacement of natural sand by manufactured sand in conventional concrete in percentage like 20%, 40% and 60%. The replacement of natural sand by copper slag in conventional concrete in percentage like 20%, 40% and 60% and the replacement of natural sand by manufactured sand and copper slag like 10%+10%, 20%+20%, 30%+30%, 40%+40% and 50%+50%.

3. MATERIALS USED

Cement: 43 Grade of Ordinary Portland cement is used and having specific gravity 3.1.

Coarse aggregate: 20mm passing and 10mm retaining size aggregates are used.

Fine aggregate: Locally available river sand is collected as fine aggregate.

Manufactured sand: The m-sand is collected from local stone crusher.

Copper slag: It is collected from the star trace Pvt. Ltd, Chennai. It is black, glassy and irregular in size.

Table -1: Test Properties of natural sand, m-sand and copper slag

Properties	Natural sand	M-sand	Copper slag
Specific gravity	2.725	2.65	2.78
Fineness modulus	2.95	3.15	3.19
Grading	Zone II	Zone I	Zone I

Water: The portable water is used for concrete mix and same water is used for curing of concrete specimens.

Sodium chloride: The laboratory sodium chloride is used. It is mixed with water then the specimens are kept curing in that water for checking the chloride attack of the specimen.

4. MIX DESIGN AND METODOLOGY

4.1 Mix Design

The mix design for M30 grade of concrete has been carried out as per IS 10262-2019. The mix proportion gets as 1:1.76:3.06 and 0.50 water/cement ratio. The concrete is prepared by using this final proportion.

4.2 Methodology

The conventional concrete is prepared by using final mix ratio and constant w/c ratio is used for mixes. The three combinations are made by replacing natural sand by different alternative.

Combination I: The replacement of natural sand by m-sand in conventional concrete like 20%, 40% and 60%.

Combination II: The replacement of natural sand by copper slag in conventional concrete like 20%, 40% and 60%.

Combination III: The replacement of natural sand by m-sand and copper slag in conventional concrete like 10%+10%, 20%+20%, 30%+30%, 40%+40% and 50%+50%.

The workability of all combination of mixes is checked. The Cube of size 100mm100mm100mm, Cylinder of size 100mm diameter and 200mm height, Beam of size 100mm×100mm×500mm are prepared. The two sets of specimens are prepared for strength test. One set of specimens are kept curing under water for 58 days and another set is kept curing under water for 28 days after that

the specimens are transferred to 5% concentration of NaCl mixed with water and curing is done up to 30 days. The strength like compressive strength, split tensile strength and flexural strength tests are conducted on specimens to check 58 days strength test on concrete.

5. TESTS ON CONCRETE AND RESULTS

5.1 Slump Test

The workability of concrete is checked by slump cone test. The slump cone have internal diameter of 100mm on top 200mm bottom and 300mm height. This test is done on fresh concrete. The slump values are tabulated in table 2, table 3 and table 4.

Table -2: Slump value

Type	Percentage Variation	Slump in mm
COMBINATION I (Natural sand+M-sand)	100%+0%	30
	80%+20%	26
	60%+40%	22
	40%+60%	18
COMBINATION II (Natural sand+Copper slag)	80%+20%	32
	60%+40%	34
	40%+60%	36
COMBINATION III (Natural sand+M-sand+Copper slag)	80%+10%+10%	30
	60%+20%+20%	32
	40%+30%+30%	35
	20%+40%+40%	33
	0%+50%+50%	30

5.2 Compressive Strength Test

The compressive strength test on concrete is done as per IS 516:1959 (Reaffirmed 1999). The cube of size 100mm×100mm×100mm is used for this test. 58 days compressive strength is found and subjected to with and without chloride attack. The results are tabulated in table 3.

Table-3: Compressive strength of concrete for all combinations subjected to with and without chloride attack for 58 days (5% NaCl concentration).

Type of mix	Percentage Variation (%)	Compressive Strength at 58 days in N/mm²	
		Without Chloride attack	With Chloride attack
Combination I (Natural sand+M-sand)	100+0	39.33	36
	80+20	46.33	45
	60+40	51	48.33
	40+60	55	51
Combination II (Natural sand+Copper slag)	80+20	44.66	42
	60+40	47	45
	40+60	42	39
Combination III (Natural sand+M-sand+Copper slag)	80+10+10	47	43.33
	60+20+20	53	49
	40+30+30	56	53.66
	20+40+40	51	48
	0+50+50	49.33	46.33

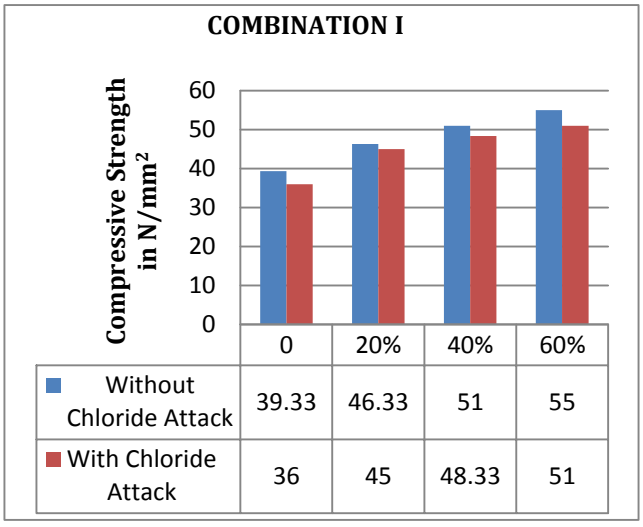

Chart -1: Comparison of compressive strength subjected to with and without chloride attack for 58 days for combination I.

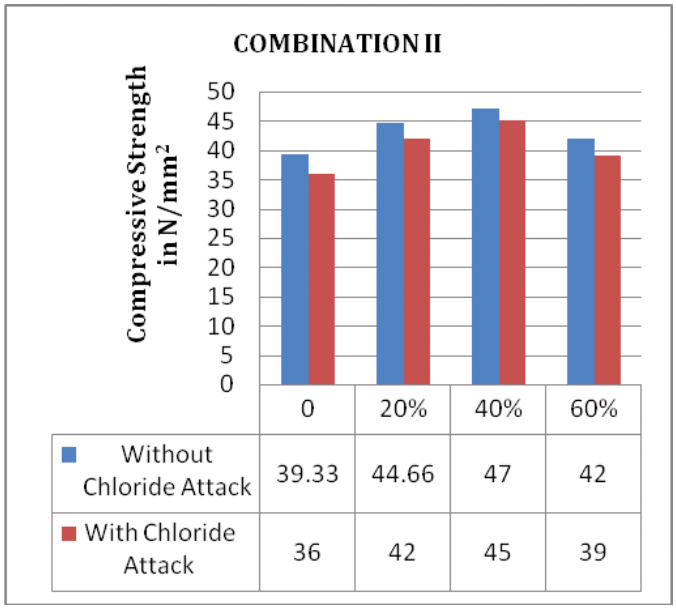

Chart -2: Comparison of compressive strength subjected to with and without chloride attack for 58 days for combination II.

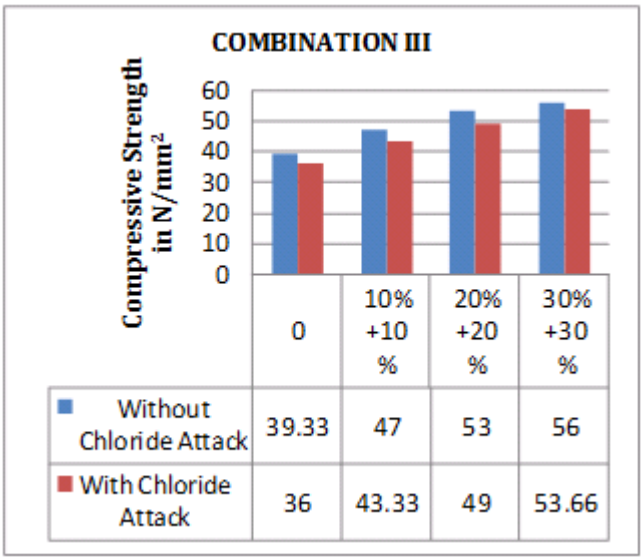

Chart -3: Comparison of compressive strength subjected to with and without chloride attack for 58 days for combination III.

5.2 Splite Tensile Strength Test

The tensile strength test is done on cylinder of size 100mm diameter and 200mm height. 58 days tensile strength is found when subjected to with and without chloride attack. The test results are tabulated in table 4.

Table -4: Tensile strength of concrete for all combination subjected to with and without chloride attack for 58 days (5% NaCl concentration).

Type of mix	Percentage Variation (%)	Tensile Strength at 58 days in N/mm²	
		With Chloride Attack	Without Chloride Attack
Combination I (Natural sand+M-sand)	100+0	2.12	1.8
	80+20	2.44	2.33
	60+40	2.75	2.54
	40+60	2.86	2.75
Combination II (Natural sand+Copper slag)	80+20	2.22	2.12
	60+40	2.65	2.44
	40+60	2.54	2.23
Combination III (Natural sand+M-sand+Copper slag)	80+10+10	2.86	2.75
	60+20+20	3.08	2.97
	40+30+30	3.39	3.08
	20+40+40	2.97	2.65
	0+50+50	2.65	2.44

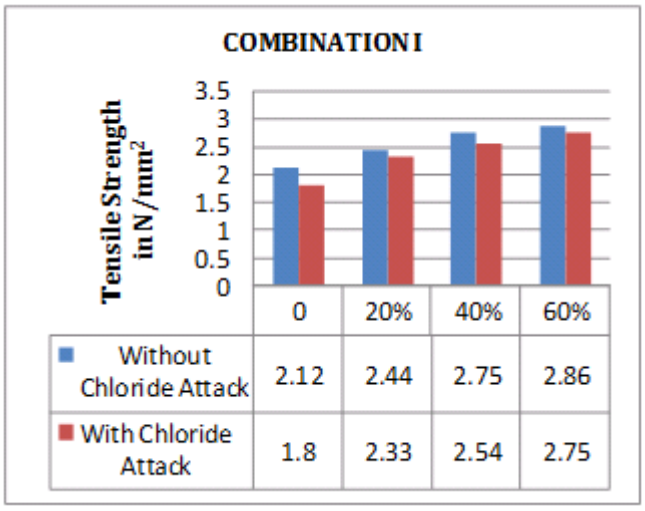

Chart -4: Comparison of tensile strength subjected to with and without chloride attack for 58 days for combination I.

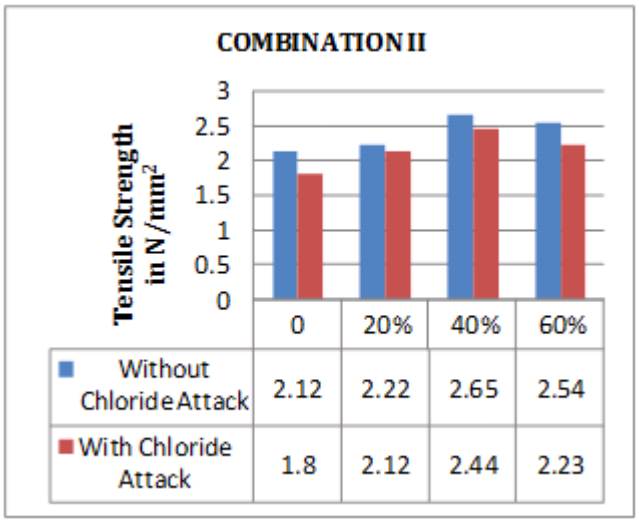

Chart -5: Comparison of tensile strength subjected to with and without chloride attack for 58 days for combination II.

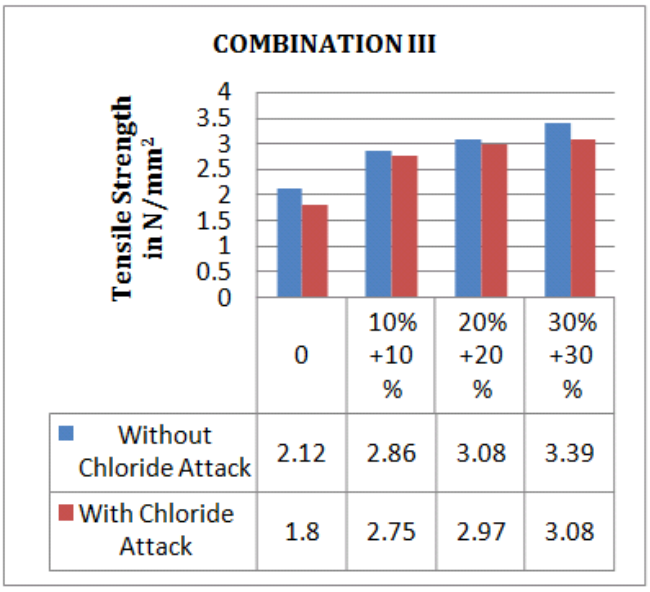

Chart -6: Comparison of tensile strength subjected to with and without chloride attack for 58 days for combination III.

5.4 Flexural Strength Test

The flexural strength test on concrete is on beam of size 100mm×100mm×500mm. 58 days flexural strength is found and subjected to with and without chloride attack. The results are tabulated in table 5.

Table -5: Flexural strength of concrete for all combinations subjected to with and without chloride attack for 58 days (5% NaCl concentration).

Type of mix	Percentage Variation (%)	Flexural Strength at 58 days in N/mm²	
		Without Chloride Attack	With Chloride Attack
Combination I (Natural sand+M-sand)	100+0	4.97	4
	80+20	5.42	5.2
	60+40	5.94	5.76
	40+60	6.08	5.91
Combination II (Natural sand+Copper slag)	80+20	6.8	4.24
	60+40	7.08	4.72
	40+60	6.21	4.16
Combination III (Natural sand+M-sand+Copper slag)	80+10+10	5.4	4.58
	60+20+20	6.21	5.16
	40+30+30	7.08	6.96
	20+40+40	5.77	5.48
	0+50+50	5	4.97

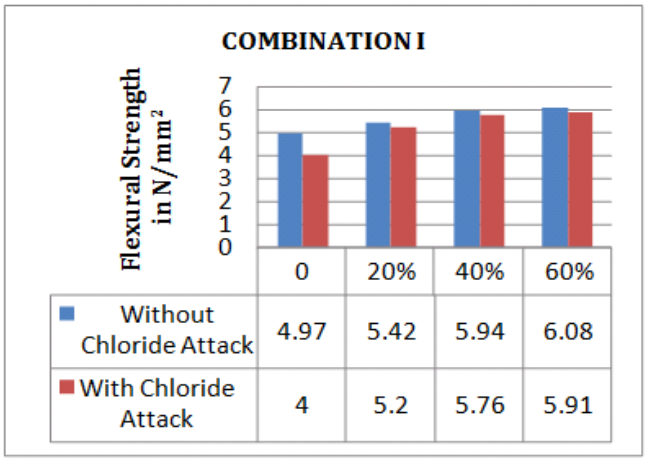

Chart -7: Comparison of flexural strength subjected to with and without chloride attack for 58 days for combination I.

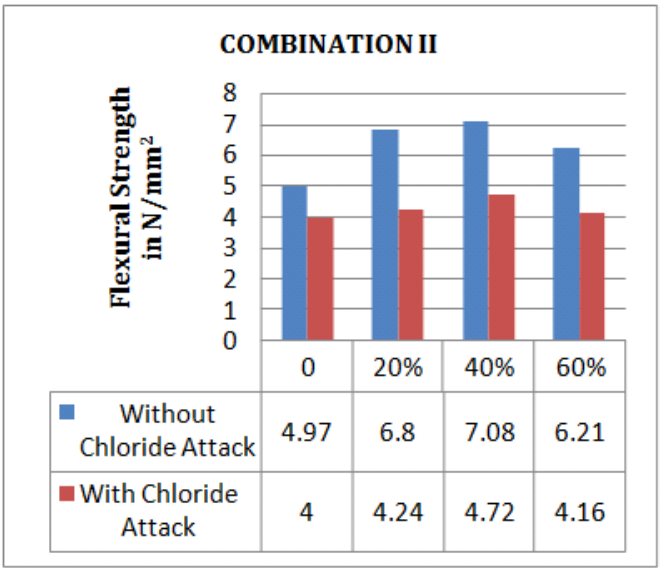

Chart -8: Comparison of flexural strength subjected to with and without chloride attack for combination II.

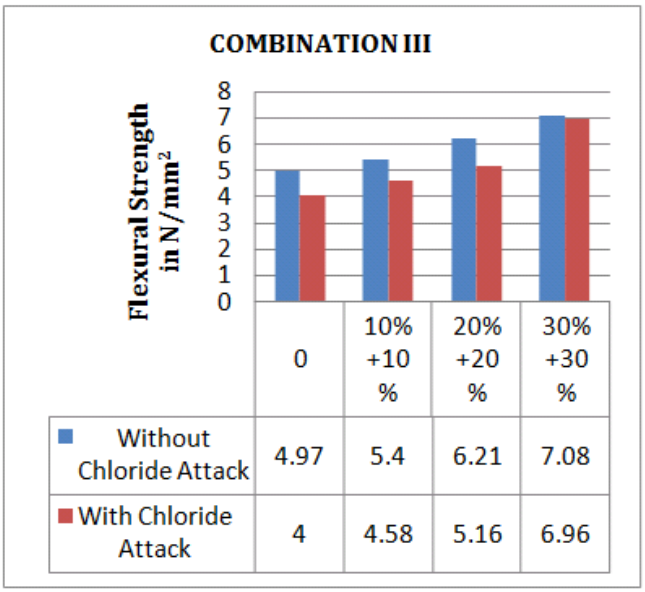

Chart -9: Comparison of Flexural strength subjected to with and without chloride attack for combination III.

6. CONCLUSIONS

The present investigation focuses on the replacement of natural sand by manufactured sand and copper slag subjected to with and without chloride attack and their effect on workability and durability characteristics of Natural sand+M-sand, Natural sand+Copper slag and Natural sand +M-sand+Copper slag are evaluated. The compressive strength, tensile strength and flexural strength for 58 days with and without chloride attack are observed. The following conclusions are made from this project investigation

- The workability of concrete made by replacing natural sand by m-sand is decreased with increasing the replacement percentage (m-sand) at constant water/cement ratio.
- The workability of concrete made by replacing natural sand by copper slag is increased with increasing the replacement percentage (copper slag) at constant water / cement ratio.
- The replacement of natural sand by m-sand (Combination I) subjected to with and without chloride attack gives higher compressive strength, higher tensile strength and higher flexural strength at 60% replacement. Thus the concrete can resist the chloride attack more effectively at 60% replacement.
- The replacement of natural sand by copper slag (Combination II) subjected with and without chloride attack gives higher compressive strength, higher tensile strength and higher flexural strength at 40% replacement. Thus the concrete can resist the chloride attack more effectively at 40% replacement.
- The replacement of natural sand by m-sand and copper slag (Combination III) subjected to with and without chloride attack gives higher compressive strength, higher tensile strength and higher flexural strength at 30%+30% replacement. Thus the concrete can resist the chloride attack more effectively at 30%+30% replacement.
- The 60% replacement by m-sand, 40% replacement by copper slag and 30%+30% replacement by m-sand and copper slag will under goes maximum pozzolanic reaction and fill all pores in concrete effectively so that the minimum number of chloride ions are penetrate in to the concrete.
- Due to using of m-sand and copper slag in concrete can reduced the mining of river bed for natural sand.

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