STRENGTH ANALYSING ON CONCRETE WITH PARTIAL REPLACEMNET OF FINE AGGREGATE BY M-SAND AND STEEL SLAG

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ABSTRACT

Now a day's huge quantity of concrete consumption is increased. The availability of natural sand is low and also use of large amount of natural sand, affect the environment. So we have to choose alternative material for fine aggregate for this paper. Study about the partial replacement of fine aggregate by using Steel slag and M- sand. The main objective of this investigation is to study experimentally the effect of partial replacement of fine aggregate by Steel slag and M-sand on the various strength properties of concrete by using the mix design of M30 grade. Test specimen with 0%, 10%, 20%, 30%, 40%, & 50% of partial replacement of fine aggregate by steel slag and similarly using M-Sand specimen is 0%, 10%, 20%, 30%, 40%, & 50% were cast and tested for compressive strength, Split tensile strength, & Flexural strength after curing period of 7 14 & 28 days. Sulphuric acid test, Sulphate attack test and Durability test were tested for the concrete specimens replacing of fine aggregate with 50 % of M-Sand and 50% of Steel Slag. Tests were carried out on five reinforced concrete beam specimens Size of 250 mm x 150 mm with M-Sand is varied up to 0%,10%,20%,30%,40%,50% and Steel Slag varied up to 0%, 10%,20%,30%,40%,50% of partial replacement of fine aggregate. Steel slag and M-Sand is available at free of cost, the cost of concrete decreases, when the percentage of replacement increases. So, more the percentage of replacement, higher will be the reduction in cost.

Keywords: M-sand, Steel Slag, RCPT TEST,

1. INTRODUCTION

Concrete plays a critical role in the design & construction of nation's infrastructure. The continues use of natural sand leads to the depletion of river beds results in to the ecological imbalance. Natural sand is replaced by Steel slag & M-Sand in various percentages. The economical and environmental purpose, it is important to think about and make use of the industrial waste by– products as the alternative materials in the construction activities. Utilizing the industrial waste by-product materials as the alternative materials it may reduce the cost of concrete production, reduce the pollution which helps in effective ways of utilization for our development. In this project work carried out in the preparation of partial replacement of fine aggregate by steel slag & M-Sand. Good strength is expected with these materials in concrete as a partial replacement in concrete with admixtures. In this project slag from steel industry is used to replace for fine aggregate. Steel slag is a byproduct obtained either from conversion of iron to steel in a Basic Oxygen Furnace (BOF), or by the melting of scrap to make steel in the Electric Arc Furnace (EAF). Like other industrial byproducts, slag actually has many uses, and rarely goes to waste. It appears in concrete, aggregate road materials, as ballast, and is sometimes used as a component of phosphate fertilizer. This substance is produced during the smelting process in several ways. Firstly, slag represents undesired impurities in the metals, which float to the top during the smelting process. Secondly, metals start to oxidize as they are smelted, and slag forms a protective crust of oxides on the top of the metal being smelted, protecting the liquid metal underneath. When the metal is smelted to satisfaction, the slag is skimmed from the top and disposed of in a slag heap to age. Aging material is an important part of the process, as it needs to be exposed to the weather and allowed to break down slightly before it can be used. M-sand is acquired in required grading to be used for construction purposes as a replacement for river sand, produced from crushing of granite stones. The sizes of M-sand can be controlled easily so that it meets the required grading for the given construction is an added advantage or otherwise the M-sand is defined as a purpose-made fine aggregate produced from quarry fines of certain types of rock through further screening and processing. Some of the general requirements of M-sand are: it should have particles with higher crushing strength, smooth surface texture and without organic impurities. In this study, therefore an attempt as been to study the effect of replacement of fine aggregate using Steel Slag and M-sand on Compressive strength , Split tensile strength, Flexural strength of concrete.

2. LITERATURE REVIEW

M. Mallesh , R.Suresh [2017] [1] in this study the use of GGBS and Steel slag as combined replacement of OPC and river sand respectively. M20 grade of concrete with W/C 0.5 is carried out with 5% of cement replacement by GGBS i.e, 5%,10%,15%,20%,25% along with the steel slag varied as 0%,10%,20%,30%,40%. For all mixes compressive strength are determined at 7 and 28 days of curing .Md.Zeeshan, Roshan S Gurav , Brij Bhushan S & Maneeth P D [2015][2] The study of partial replacement of natural fine aggregate by steel slag and natural coarse aggregate by waste lime stone aggregate in M20 grade of cement concrete .The compressive strength test is studied for 7 and 28 days of curing period and the split tensile and flexural strength is studied for 28 days of curing period.

K.A. Olonade, M.B.Kadiri and P.O.Aderemi [2015] [3] studied the concrete of mix ratio 1:2:4 was batched by weight with slag replacement levels of 0 to 100% of sand at

25/5 interval and the concrete specimens (cubes ,and beams) produced were cured in water 7,14,28and 56 days. Water demand, compressive strength as well as flexural strength of the concrete were determined.

B. Kaviya, K.Geetha [2014] [4] This investigation is to study experimentally the effect of partial replacement of fine aggregate by steel slag on the various strength properties of concrete by using the mix design of M 20 grade. Test specimen with 0,10,20,30,40,& 50% of partial replacement of fine aggregate by steel slag were cast and tested for compressive strength after curing period of 7 days & 28 days.

Ilangoan .R [2014] [5] has done a study on 100 % replacement of sand by quarry dust in concrete. The compressive strength of concrete with quarry dust has 40 % more strength than that of the concrete with sand

M.Shukala and AK Sachan (2013) [6] studied environmental hazardous stone dust utilization in building construction. It is found that partial replacement will not affected the strength and also solve the problem of disposal of stone dust. The workability of concrete reduces with the increase in stone dust and this can be improved by adding suitable admixtures.

Rajkumar et al (2012) [7] have concluded the concrete containing well graded quarry dust as fine aggregate along with plasticizer can be effectively utilized in the construction industry. Among the various percentages 1%, 2%, 3% and 4% of Triethanolamine and Diethanolamine added, the quarry dust replaced concrete with 2% addition of inhibitor shows maximum improvement in the compressive strength, split tensile strength, flexural strength, and bond strength when compared to the control specimen. By adding corrosion inhibitor permeability & water absorption properties were considerably reduced. Addition of the organic inhibitors to quarry dust replaced concrete, offered very good resistance against chemical attack and increases corrosion resistance by forming thin oxide layer to prevent outside agents and shielding the anodic sites. Considering strength as well as durability criteria, the optimum percentage of Triethanolamine and Diethanolamine to be added in concrete containing quarry dust as fine aggregate is 2% for delaying corrosion and to increase the strength and other durability characteristics.

Ganesha Mogaveera.G, Sarangapani and Anand .V .R [2011][8] have studied the effect of partial replacement of sand by quarry dust in plain cement concrete for different mix proportions. They have concluded that sand can be replaced effectively by means of quarry dust up to 20-25 %

Thaniya kaosal (2010)[9] has made study on the resuse of concrete waste as crushed stone for hollow concrete masonry units. The main objective was to increase the value of the concrete waste, to make a sustainable and profitable disposal alternative for the concrete waste. Attempts were made to utilize the concrete waste as crushed stones in the concrete mix to make hollow concrete blocks. Various percentage of crusted stone have been tried the amount (i.e. 0%, 10%

,20% ,50% and 100%). From the results they found concrete waste can used to produce hollow concrete block masonry units. Suitability of crushed granite fine (CGF) to replace river sand in concrete production was investigated

3. Experimental Result and Discussion

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Review of literatures

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Material collection

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Material studies

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MIX DESIGN (M30)

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Fresh concrete testes

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Workability test

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Casting of specimen

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Results

3.1 PRELIMINARY TEST

S.No	Material Properties	Steel Slag	M-Sand
1.	Specific gravity	2.93	2.84
2.	Fineness of modulus	3.54	2.765

3.2 FRESH CONCRETE

Following test were conducted on fresh concrete.

- Slump Test
- Compaction Factor Test

Table: 3.2.1 Slump Value

S.No.	Water cement ratio	Slump value (mm)
1	0.35	Nil
2	0.40	34
3	0.45	100

Fig 3.2.1 Concrete Filling in Cone

Fig 3.2.2 Slump Value

3.3 COMPACTION FACTOR TEST

Compaction factor value for control concrete is 0.92

3.4 HARDENED CONCRETE

Test which are conducted on hardened concrete are as follows,

- Compression test
- Splitting tensile test
- Flexural strength test

The test which conducted on hardened concrete are given below.

Test Procedure and Results:-

Test specimens of size 150 x 150 x 150 mm were prepared for testing the compressive strength concrete. The concrete mixes with varying percentages (0%, 10%, 20%, 30% 40%, and 50%) of steel slag as partial replacement of fine aggregate (sand) were cast into cubes and cylinders for subsequent testing.

3.4.1 COMPRESSIVE STRENGTH RESULT FOR M –SAND

Table: 3.4.1 Compressive Strength of Cube for M-Sand 7, 14, 28 Days

Mix (%) proportion	Compressive Strength (N/mm^2)		
	7 days	14 days	28 days
0	18.293	23.163	30.49
10	19.529	24.730	31.54
20	20.496	25.96	34.16
30	20.892	26.43	34.82
40	23.67	28.71	35.83
50	26.12	30.02	36.12

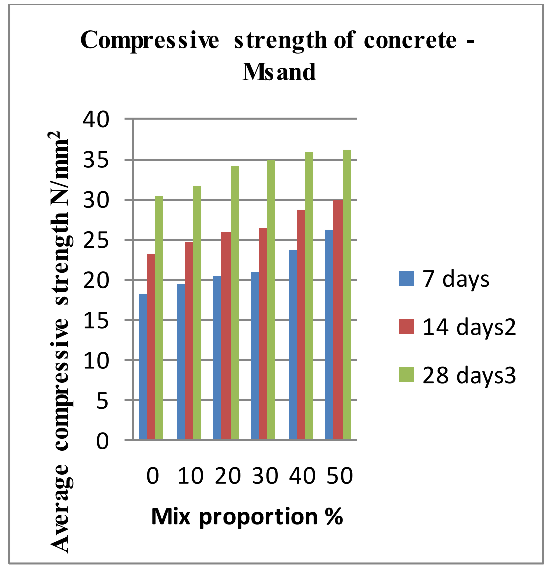

Fig 3.4.1

3.4.2 COMPRESSIVE STRENGTH RESULT FOR STEEL SLAG

Table: 3.4.2 Compressive Strength of Cube for Steel Slag 7, 14, 28 Days

Mix (%) Proportion	Compressive Strength (N/mm^2)		
	7 days	14 days	28 days
0	18.192	23.61	30.32
10	18.963	23.84	31.59
20	20.07	25.406	33.45
30	20.706	26.22	34.51
40	18.415	23.86	29.05
50	16.56	19.16	26.24

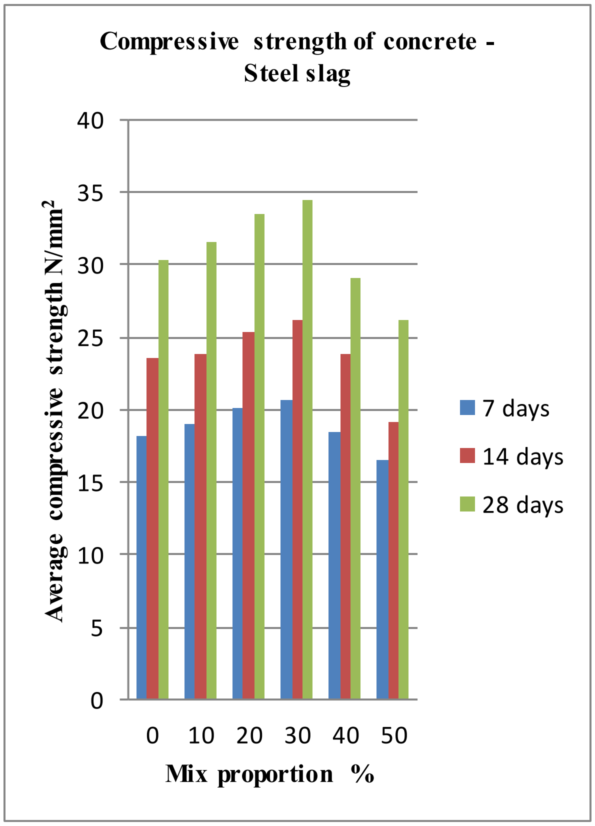

Fig 3.4.2

3.5 SPLIT TENSILE STRENGTH TEST

The splitting tensile strength of concrete cylinder was determined based on 516-1959. The load shall be applied nominal rate within the range 1.2 N/(mm^2/min) to 2.4/ (mm^2/min). The test was carried out on diameter of 150 mm and length of 300 mm size cylinder

$$\text{Split Tensile Strength} = \frac{2P}{\pi DL}$$

Where, P = Compressive Load in N

L = Length in mm

D = Diameter in mm

3.5.1 SPLIT TENSILE STRENGTH RESULT FOR M - SAND

Table: 3.5.1 Split Tensile Strength of Cylinder for M-Sand 7, 14, 28 Days

Mix (%) Proportion	Split tensile Strength (N/mm^2)		
	7 days	14 days	28 days
0	2.175	2.231	2.270
10	2.379	2.285	2.336
20	2.583	2.532	2.604
30	2.474	2.461	2.475
40	2.318	2.397	2.433
50	2.200	2.140	2.183

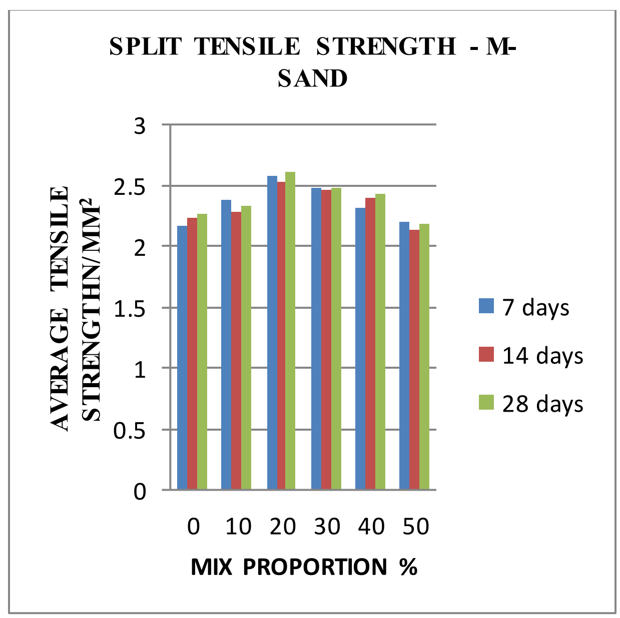

Fig 3.5.1

3.5.2 SPLIT TENSILE STRENGTH RESULT FOR STEEL SLAG

Table: 3.5.2 Split Tensile Strength of Cylinder for Steel Slag 7, 14, 28 Days

Mix (%) proportion	Split tensile Strength (N/mm^2)		
	7 days	14 days	28 days
0	2.185	2.274	2.276
10	2.412	2.302	2.347
20	2.578	2.538	2.600
30	2.470	2.480	2.483
40	2.387	2.409	2.438
50	2.245	2.155	2.193

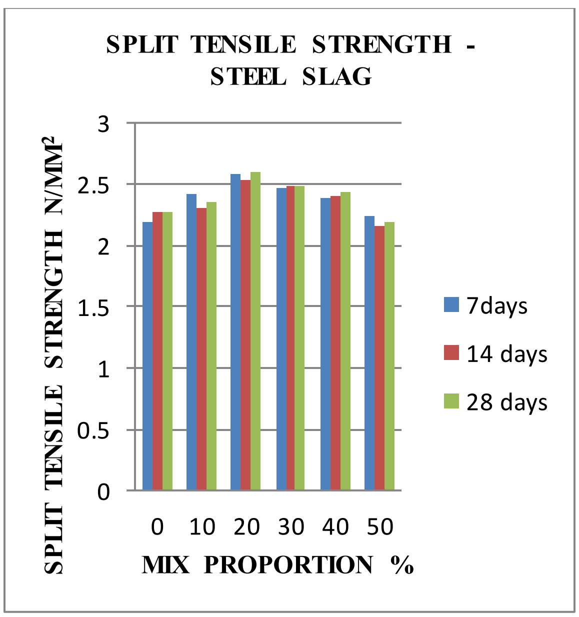

Fig 3.5.2

3.6 FLEXURAL STRENGTH TEST

The flexural strength of concrete prism was determined based on IS: 516 –1959. Place the specimen in the machine in such a manner that the load is applied to the upper most surface as cast in the mould along two lines spaced 13.3 cm a part. Apply load without shock and increase continuously at a rate of 180 kg/min and it is increased until the sample fails. Measure the distance between the line of fracture and nearest support.

If a > 13.3cm then

3.6.1 FLEXURAL STRENGTH RESULT FOR M – SAND

Table: 3.6.1 Flexural Strength of beam for M-Sand 7, 14, 28 Days

Mix (%) Proportion	Flexural Strength (N/mm^2)		
	7 days	14 days	28 days
0	1.602	2.426	3.204
10	1.692	2.535	3.385
20	1.735	2.595	3.462
30	1.829	2.723	3.604
40	1.919	2.865	3.829
50	2.014	3.016	4.028

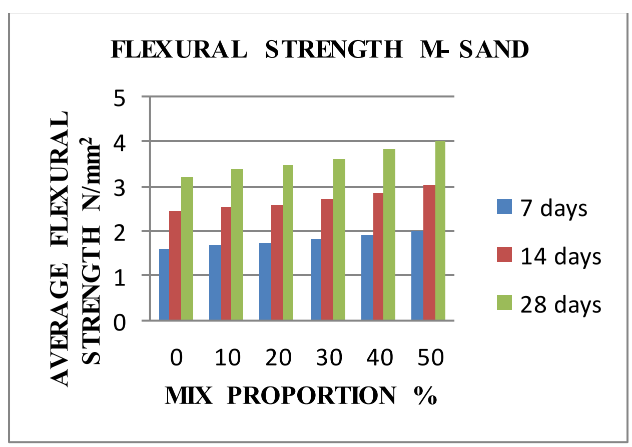

Fig 3.6.1

3.6.2 FLEXURAL STRENGTH RESULT FOR STEEL SLAG

Table: 3.6.2 Flexural Strength of beam for Steel Slag 7, 14, 28 Days

Mix (%) proportion	Flexural Strength (N/mm^2)		
	7 days	14 days	28 days
0	1.676	2.514	3.352
10	1.728	2.593	3.457
20	1.905	2.851	3.801
30	2.09	3.137	4.183
40	1.987	2.980	3.974
50	1.932	2.898	3.864

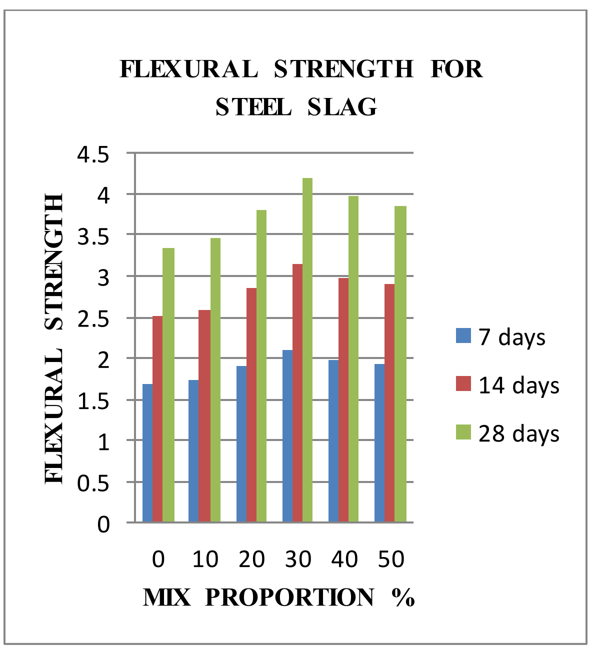

Fig 3.6.2

3.7 ACID ATTACK TEST

3.7.1 SULPHURIC ACID TEST

The acid resistivity of concrete was studied by immersing the specimens in acid solution. The test has been conducted for the conventional concrete and concrete specimens replacing fine aggregate with 50 % of M-Sand and 50% of Steel Slag. The Specimen size 150 x 150 mm x 150 mm were casted and cured in water for 28 days. After 28 days of curing the specimens were removed from the curing tank and their surfaces were cleaned with a soft nylon brush to remove weak reaction production and loose material from the specimen. The initial waits where measured and the specimen were immersed in 5% in sulphuric acid solution for next 28 days of acid exposure, specimens were tested for compressive strength and compare with the strength of concrete specimen which were not exposed to acid attack. The result are tabulated

Table: 3.7.1 Weight loss and compressive strength loss

MATERIAL	WEIGHT LOSS (%)	COMMPRESSIVE STRENGTH LOSS (%)
Normal sand	2.65	9.73
M-Sand (50 %) Replacement	2.36	9.54
Steel Slag (50 %) Replacement	2.17	9.01

3.7.2 SULPHATE ATTACK TEST

The sulphate resistivity of concrete was studied by immersing the specimen in sulphate solution. The test has been conducted using conventional concrete and concrete specimen replacing fine aggregate with 50 % of M-sand and 50 % of Steel Slag. The specimen sizes 150 x 150 x 150 mm were casted and cured in water for 28 days. After 28 days of curing the specimens were removed from the curing tank and their surfaces were cleaned with a soft nylon brush to remove weak reaction products and loose materials from the specimen. The initial weight were measured and the specimens were immersed in 5% sodium sulphate solution for the next 28 days of sulphate exposure, specimen were tested for compressive strength and compared with the strength of concrete specimens which were not exposed to acid environment.

Table: 3.7.2 Weight loss and compressive strength loss

MATERIAL	WEIGHT LOSS (%)	COMMPRESSIVE STRENGTH LOSS (%)
Natual sand	1.78	6.98
M-Sand (50%) Replacement	1.60	6.74
Steel Slag (50 %) Replacement	1.32	6.25

3.8. DURABILITY TEST

3.8.1 RAPID CHLORIDE PERMEABILITY TEST

Chloride penetration in concrete is mainly affected for concrete structures subjected to sea water or ground water environment containing high concentration of chloride salts dissolved in it. The RCPT is an indication of the permeability of chloride ions in the concrete. The rapid chloride penetration test was conducted as per ASTMC 1202-1997

The Rapid Chloride Penetration Test (RCPT) is used to determine the electrical conductance of concrete to provide a rapid indication of its resistance to the penetration of chloride ions. The RCPT is performed by monitoring the amount of electrical current that passes through concrete discs of 50mm thickness and 100mm diameter for a period of six hours. A voltage of 60 V DC is maintained across the ends of the specimen throughout the test. One lead is immersed in a sodium chloride (NaCl) solution (3%) and the other in a sodium hydroxide (NaOH) solution (0.3M). The total charge passed through the cell in coulomb has been found in order to determine the resistance of the specimen to chloride ion penetration.

Average current flowing through one cell is calculated by;

$Q = 900 \times 2 \times I$ Cumulative coulombs.

$$I_{CUMMULATIVE} = I0 + I30 + I60 + I90 + I120 + I150 + I180 + I210 + I240 + I270 + I300 + I330 + I360$$

Where

I_0 = Initial current reading in mA.

I_t = Current reading at t minutes in mA.

.

Figure 3.8.1 Rapid chloride permeability test

Table: 3.8.1 Rapid chloride permeability values

Materials	Charge passed in coulombs	Chloride permeability
Normal sand	2887.15	Moderate
M-Sand (50 %)	1989	Low
Steel Slag (50 %)	670	very low

4. CONCLUSION

The strength characteristics of concrete mixtures have been computed in the present work by replacing 0, 10, 20, 30, 40, & 50% of M-Sand and Steel Slag with the sand. On the basis of present study, following conclusions are drawn.

M-SAND:

The compressive strength, & flexural strength of M-Sand is gradual increase in strength by replacement of fine aggregate by 0%, 10%, 20%, 30%, 40%, and 50%. The split tensile strength increases with increase in percentage of M-Sand by 20% by weight of fine aggregate. The split tensile strength decrease in percentage of M-Sand by above 20% by weight of fine aggregate. From the results of compressive strength, & flexural strength of 7, 14 and 28 days curing, 50% replacement of fine aggregate by M-Sand is the optimum percentage of replacement of M30 grade concrete and split tensile strength decreases above 20% in further replacement of M-Sand in concrete

STEEL SLAG:

The compressive strength, and flexural strength increases with increase in percentage of steel slag by 30% by weight of fine aggregate. The split tensile strength increases with increase in percentage of steel slag by 20% by weight of fine aggregate. The compressive strength, and flexural strength decreases at above 30% replacement of Steel Slag. The split tensile strength decrease at above 20% replacement of steel slag. From the results of compressive strength, & flexural strength of 7, 14 and 28 days curing, 30% replacement of fine aggregate by steel slag is the optimum percentage of replacement of M30 grade concrete and decreases considerably in further replacement of steel slag in concrete.

Comparatively, M-Sand gives more strength in compressive strength and flexural strength then the replacement of steel slag. Eco-friendly and Mass utilization of waste material is possible in construction by using steel slag and M-Sand as partial replacement material for partial replacement in concrete. . From the result of acid attack test M Sand (50%) undergoes low loss in weight compared to the steel slag (50%). From the result of rapid chloride permeability test chloride permeability value for the M sand(50%) is Low and for the Steel Slag (50%) is Very low

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