Evaluation of Compressive Strength by Utilization of Steel Slag in Concrete

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Abstract **- As production of steel products are increasing in India, dumping of wastage of steel industries has always been an issue. In India, a huge amount of steel slag is available in different forms due to different methods of manufacturing. To make concrete structures more cost effective as well as to provide prompt compressive strength, steel slag is utilized in concrete. Steel slag is an industrial by product which is obtained from the Steel manufacturing industry. The steel slag used in this research are lightweight as well as tough. That is the reason why Steel slag are used in concrete by replacing coarse aggregate in M30 grade of concrete. The compressive strength has been rigorously analyzed in this paper with different replacement percentages to find out the best for incorporation of steel slag.**

1.INTRODUCTION

Industrial by products create problems of storage and also creates environmental pollution; therefore, numerous studies have been conducted to investigate its use. So, construction industry has proved that it is a good place for consumption of industrial by products in which concrete is the major area where it can be used. Steel slag is a byproduct formed during the Steel making process from the iron and steel making industry. Use of Steel slag reduces the need of coarse aggregate/natural rock as a construction material. Slag is useful in making ecofriendly material. Maximum utilisation of by product, waste materials for economic and environmental reasons. It leads to rapid development in slag utilisation.

1. Steel slag can be used in normal concrete to improve its mechanical, chemical and physical properties.
2. Use of Steel slag by replacing coarse aggregate is most promising concept.

2. INVESTIGATION OF MATERIAL PROPERTIES: -

Material used for making concrete mix are Cement, Sand, Aggregate, Steel Slag and Water. The new mix of M30 are.

1. M30 Concrete with 0% replacement of coarse aggregate.
2. M30 Concrete with 40% replacement of coarse aggregate.
3. M30 Concrete with 60% replacement of coarse aggregate.

A. Fine Aggregate

Locally available clean river sand is preferable. Passing the sand through the IS-480 sieves have been used. The sand which is passed to 4.25mm used for making the concrete. The results of sieve analysis conducted as per the specification of code IS 383-1970.River sand having density of 1460 kg/m3 and fineness Modulus (FM) of 2.51 was used.

B. Cement

OPC 53 grade been used in the study. Specific gravity of cement was tested IS 8112-1989 and it was found to be 3.15. In this research, cement used was OPC 53 grade confirming to IS 8112-1989. It has the cohesive and adhesive properties which makes necessary bond with aggregate. 53 Grade OPC provides high strength and durability because of its optimum particle size distribution and superior crystallized structure.

C. Coarse Aggregate

The coarse aggregate used is crushed (angular) aggregate. Aggregates are commonly obtained by

crushing the natural rocks. Mximum size of aggregate considered is 20 mm IS sieve passing and minimum size of aggregate considered is 12.5 mm IS sieve passing. The fineness modulus of coarse aggregate is 5.82. Specific gravity of coarse aggregate is 2.69. The normal maximum size is gradually 10 mm to 20 mm however particle sizes up to 40 mm as per its requirement from the application of the concrete. The fineness modulus of aggregate is 6.80 which is used and its density 1700 kg/cubic meter.

D. Water

For this research, the water used for curing and also for mixing purpose was clean. It is going to effect the setting time of the cement. Concrete mixture water is used to provide the workability of concrete and to ensure cement hydration. Cement requires up to 25% of its weight for hydration. Water used more than this amount is only for the purpose to increasing its workability. The Water is of the potable standard having pH value 7. Water cement ratio is kept upto 0.5.

E. Steel Slag

Steel slag is the by-product of steel & Iron industries, which form during reduction process of iron melting. The chemical composition changes depending on the melting procedure. Its mineralogical composition also varies based on the cooling and melting procedure. Physical, mechanical and chemical compositions are studied. It is obtained from conversion of iron to Steel in a Basic Oxygen Furnace (BOF) or by the melting of scrap to make still in the Electric Arc Furnace (EAF). The Electric Arc Furnace (EAF) does not use hot metal like the Basic Oxygen Furnace (BOF) but uses cold steel scrap. We managed Steel slag from local foundry industries and casting industries. The used steel slag for the making of concrete mix is from electric arc furnace process. The size of steel slag aggregate preferred as per the replaced material (course aggregate) size. We used 20 mm passing and 16 mm Retaining Steel Slag. Table-1 and Table-2 are for properties of steel slag provided by vendor and properties measured by us respectively.

Property	Value
Los Angeles Abrasion	20 – 25
Sodium Sulphate Soundness Loss	< 12
Hardness	6-7

Table -1 Properties of Steel slag

Property	Value
Specific Gravity	3.2 – 3.6
Dry rodded unit weight	1600-1920 kg/m^3
Water Absorption	Up to 3%

Table -2 Properties Steel Slag Measured

3.EXPERIMENTAL PROGRAMME

A. Casting Procedure

- Cubes are cast in three-layer and each layer's thickness is nearly 50 mm.
- But strokes for each layer had been between 35 to 45 no more difference for accurate results.
- Cubes are cast at Temperature of 27±2°.
- After casting 9 numbers of trial cubes, place the casted cubes on a plane and firm platform.
- Leave it for 24 hours.
- After 24 hours, trial cubes were demoulded the and identification was given by a permanent marker.
- Trial cubes were placed in the water tank immediately for curing.

B. Equipment for casting

- Casting cube mould size of 150 mm x 150 mm x 150 mm
- Electronic weighing balance.
- G.I.sheet.
- Compaction rod.

Figure-1 Concrete cubes with green concrete

C. Testing Procedure

- 27 cube specimen has been casted for all 3 mix designs mentioned above and as shp,
- After taking out and drying of the cubes, they were added to the compressive testing machine.
- Before starting the test, Approximate rate of loading in the compression testing machine (CTM) was kept about 5 kN per second.
- Cubes were placed carefully in the centre position of compression testing machine so that the load can be distributed uniformly.
- Ultimate load readings were notes down.
- Different batches of specimen were casted for 7 days, 14 days and at 28 days testing.

Figure-2 Concrete cubes while casting

4. COMRESSIVE STRENGTH

Compressive strength was achived by performing the test on cubes (150×150×150mm) in CTM (compression testing machine).

- This test was conducted to calculate an average compressive strength of 3 cubes which were containing the same proportion of materials in it.
- M30 Concrete with 0% replacement of coarse aagregate.
- M30 Concrete with 40% replacement of coarse aggregate.
- M30 Concrete with 60% replacement of coarse aggregate.

There was total 9 batches and each of them owned 3 cubes. The test were done at 7 day,14 day and 28 day after casting process.

Compressive strength of concrete at 7 day.			
Sr no.	Percentage of replacement	Compressive strength at 7 day (MPa)	Average Compressive strength at 7 day (Mpa)
1	0%	24	22.81
		22.22	
		22.22	
2	40%	20	21.03
		24.44	
		18.66	
3	60%	20	20.36
		22.22	
		18.88	

Table-3 Test results

Figure-3 Concrete cubes while testing

Compressive strength of concrete at 14 day.			
Sr no	Percentage of replacement	Compressive strength at 14 day (MPa)	Average Compressive strength at 14 day (MPa)
1	0%	28.88	25.62
		24.88	
		23.11	
2	40%	25.33	26.07
		27.11	
		25.78	
3	60%	26.66	22.96
		20	
		22.22	

Table-4 Test results at

Figure-4 Failed Cube Specimen

Compressive strength of concrete at 28 day.			
Sr no	Percentage of replacement	Compressive strength at 28 day (Mpa)	Average Compressive strength at 28 day (Mpa)
1	0%	22.22	29.26
		32.22	
		33.33	
2	40%	31.11	32.22
		32.22	
		33.33	
3	60%	31.11	26.29
		22.22	
		25.55	

Table-5 Test Results

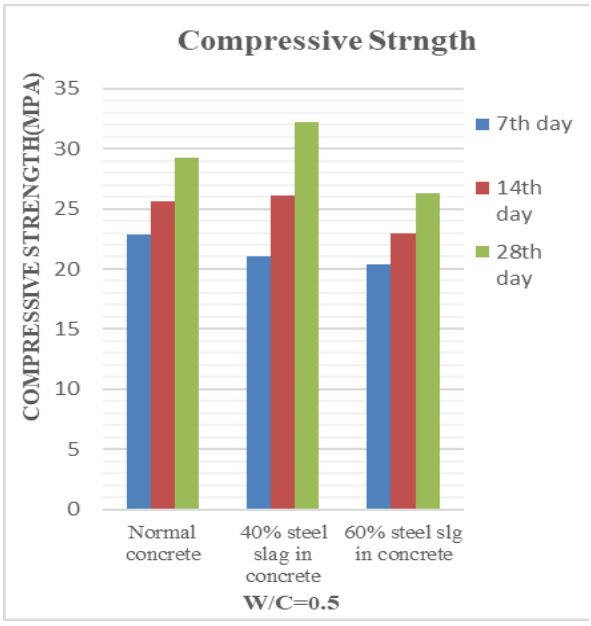

Figure-5 Compressive Strength Graph

Figure-6 Slag in failed specimen

5.RESULTS AND DISCUSSIONS

- Testing was done after curing process for 7 days,14 days and 28 days and results are presented in tabular form in table-3, 4 and 5, respectively.
- The results in Table 3 are providing the typical strength gain of M30 concrete with 0% replacement. M30 concrete replacement with 40% is giving better strength gain at 7 days and M30 concrete replacement with 60% is giving reduced strength gain compared with 0% replacement.
- Similar behavior is observed in the Table-4 and Table-5. It clearly says that strength development in M30 concrete with 60% replacement is reduced compared to M30 concrete with 0% replacement.
- We can say that 40% steel slag in concrete is the best possible replacement in term of getting good strength and very economical as compared to normal concrete.

6.CONCLUSION

In observation of strength gain, M30 concrete with 0% replacement (Normal Concrete) has been taken as a base and Other two replacement (i.e. 40% & 60%) are compared.

1. At 7 days, The M30 concrete with 40% replacement is having 92.2% and M30 concrete with 60% replacement is having 89.3% compared to M30 normal concrete.So, Initial strength gain is highest of Normal concrete.

2. At 14 days, The M30 concrete with 40% replacement is having 101.8% and M30 concrete with 60% replacement is having 89.6% compared to M30 normal concrete.So, After Initial strength gain M30 concrete with 40% replacement exceeds other two.
3. At 28 days, The M30 concrete with 40% replacement is having 110.1% and M30 concrete with 60% replacement is having 89.8% compared to M30 normal concrete.So,at 28 days when it is usually believed that concrete will gain its full strength, the M30 concrete with 40% replacement with steel slag has achieved more strength compared ot normal concrete.

The overall study suggests to use M30 concrete with 40% replacement of Steel slag to gain Best compressive strength. Moreover, cost for the concrete will be reduced in the above concrete.

7.FUTURE SCOPE OF STUDY

- There are scope of more research in this direction with percentage replacement variations in concrete.
- The different mix can be tried for compressive strength as well as tensile strength and also for flexure.
- Further through radiography the concrete can be analysed.

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