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Evaluation strength and durability characteristic of concrete use steel slag

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ABSTRACT

In the present experimental study the various strength properties like compressive strength of concrete and also durability properties like Acid attack and capillary suction test on both ordinary concrete and steel slag Concrete, best steel slag concrete mix is carried out and compared with ordinary concrete mix for economic and ecological study. In this study different percentage of steel, slag is used. steel slag as a replacement of fine aggregate in concrete and replaced in the range of 0%, 10%, 20 %, 30%, 40% and 50% by weight of fine aggregate in concrete. Mix design has been carried out for M25 grade using relevant Indian Standard IS- 10262: 2009. It was found that with an increase in the amount of steel slag in concrete up to 30% with increasing compressive strength as well as the split tensile strength of concrete. It was also found that durability like acid resistance and alkalinity test conducted for long durability show that addition of steel slag up to 30% certain limit replacement to fine aggregate with less effect compare to control mix.

Keywords— *Steel slag, Silica fume, Admixture, Workability, Compressive strength, Acid resistance, CSAT*

1. INTRODUCTION

Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces. The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling. Virtually all steel is now made in integrated steel plants using a version of the basic oxygen processor in specialty steel plants (mini-mills) are using an electric arc furnace process. The open hearth furnace process is no longer used. In the basic oxygen process, hot liquid blast furnace metal, scrap, and fluxes, which consist of lime (CaO) and dolomitic lime (CaO.MgO or "dolime"), are charged to a converter (furnace). A lance is lowered into the converter and high-pressure oxygen is injected. The oxygen combines with and removes the impurities in the charge. These impurities consist of carbon as gaseous carbon monoxide, and silicon, manganese, phosphorus and some iron as liquid oxides, which combine with lime and dolime to form the steel slag. At the end of the refining operation, the liquid steel is tapped (poured) into a ladle while the steel slag is retained in the vessel and subsequently tapped into a separate slag pot. There are many grades of steel that can be produced, and the properties of the steel slag can change significantly with each grade. Grades of steel can be classified as high, medium, and low, depending on the carbon content of the steel. High-grade steels have high carbon content. To reduce the amount of carbon in the steel, greater oxygen levels are required in the steel-making process.

2. MATERIALS USED

2.1 Cement

Ordinary Portland cement (OPC) from a single lot was used throughout the course of the investigation. The physical properties of the cement are determined from various tests, conforming to Indian Standard IS: 1489-1991(Part-1) are listed in Table 3.1. All the tests were carried out as per recommendations of IS: 4031-1988. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture.

2.2 Course aggregate

Crushed angular granite metal from a local source was used as coarse aggregate. The specific gravity was 2.67; the coarse aggregate is defined as that retained on 4.75 mm IS sieve. To increase the density of the resulting concrete mix, the coarse aggregate is frequently used in 20mm sizes.

2.3 Fine Aggregate

IS 383-1970 defines the fine aggregate, as the one passing 4.75 mm IS sieve. The fine aggregate is often termed as a sand size aggregate. Locally available riverbed sand was used in the present study. The sand conforms to grading Zone – III as per IS 383 –

1970 respectively. The specific gravity was 1.78.

2.4 Steel Slag

Steel slag is a waste product obtained from the different steel industry and steel factories. The specific gravity was 2.50. The steel slag conforms to grading Zone – III as per IS 383 – 1970 respectively.

3. RESULT AND DISCUSSION ON EXPERIMENTAL TESTS

3.1 Workability of Concrete Mixes

The workability of concrete mixes was found out by slump test as per procedure is given in chapter 3. w/c ratio was kept constant 0.45 for all the concrete mixes. The workability results of different concrete mixes were shown in Table 1.

Table 1: Workability values for different concrete mixes

Mix No	Description	Slump (mm)
1.	100%FA+0% SS+5%SF	113
2.	90%FA+10% SS+5%SF	110
3.	80%FA+20% SS+5%SF	105
4.	70%FA+30% SS+5%SF	101
5.	60%FA+40% SS+5%SF	94
6.	50%FA+50% SS+5%SF	90

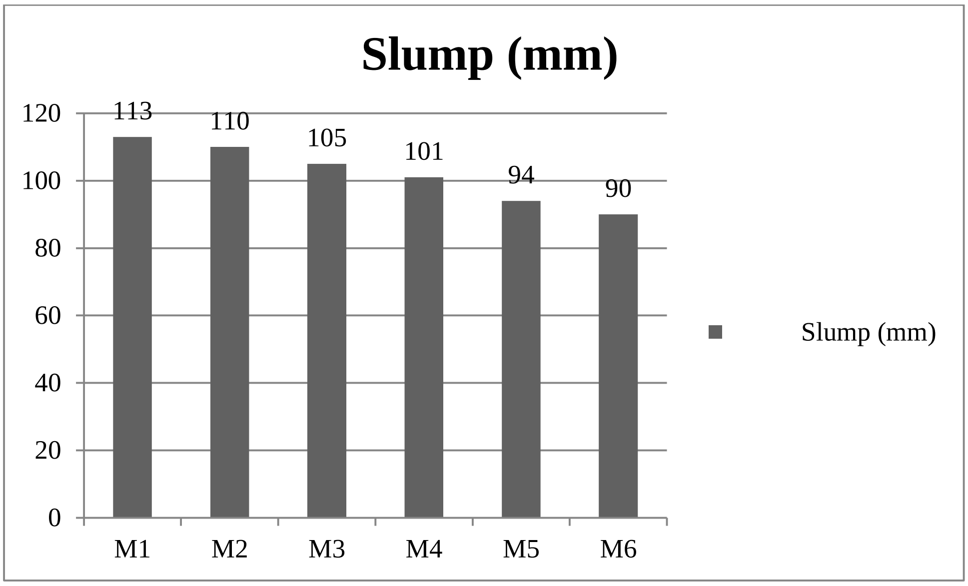

Fig. 1: Slump test results

Table 1 shows that as the addition of steel slag to concrete mix increases, the workability of the concrete mix was found to increase as compared to the control mix. The lowest value of slump was obtained with mix 50%FA+50% SS+5%SF and the highest value was obtained with 100%FA+0% SS+5%SF.

3.2 Compressive Strength

The results of the compressive strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The compressive strength test was conducted at curing ages of 7, 14, 28, 56 and 90 days. The compressive strength test results of all the mixes at different curing ages are shown in table 2. Variation of compressive strength of all the mixes cured at 7,14,28,56 and 90 days are also shown in figure 2.

Table 2: Compressive strength (MPa) results of all mixes of concrete at different curing ages

Mix no.	Description	7 Days	14 Days	28 Days	56 Days	90 Days
1.	100%FA+0% SS+5%SF	19.00	24.22	33.27	37.00	43.32
2.	90%FA+10% SS+5%SF	20.65	25.15	34.60	39.41	44.12
3.	80%FA+20% SS+5%SF	21.82	26.2	36.70	41.40	46.80
4.	70%FA+30% SS+5%SF	22.90	25.50	36.10	38.12	44.56
5.	60%FA+40% SS+5%SF	19.50	24.80	34.23	35.30	40.30
6.	50%FA+50% SS+5%SF	18.20	22.10	32.50	33.28	38.50

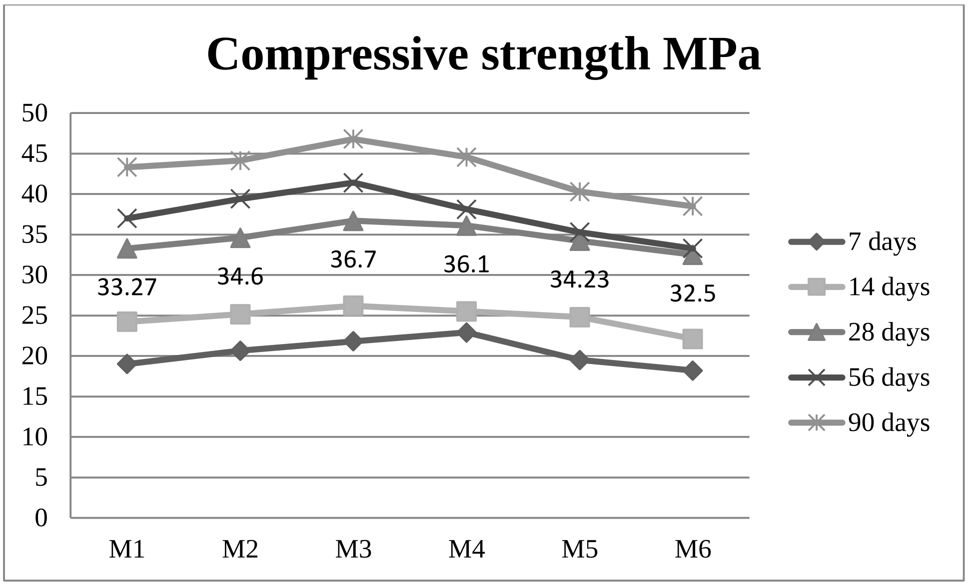

Fig. 2: Compressive strength results

Table 2 shows that addition of steel slag 50% replacement by weight of fine aggregate shows a decrease in compressive strength at 28 days concrete compared with control mix of concrete. It can also be observed from figure 2 that the maximum compressive strength at 28 days of curing was obtained for a mix containing 80%FA+20% SS+5%SF. The maximum compressive strength obtained at mix M3 value is 35.70 MPa it is increasing 12 % compared with normal mix concrete M1. Finally, addition of steel slag in concrete compressive strength increasing up to a certain limit after increasing amount of steel slag more than decreasing compressive strength respectively.

3.4 Split Tensile Strength Test Results

The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 7, 14, 28, 56 and 90 days. The splitting tensile strength test results of all the mixes at different curing ages are shown in table 3. Variation of splitting tensile strength of all the mixes cured at 7, 14, 28, 56 and 90 days is also shown in figure 3, the variation of splitting tensile strength of concrete mixes with respect to control mix (100%FA+0% SS+5%SF) after 7, 14, 28, 56 and 90 days respectively.

Table 3: Splitting tensile strength (MPa) results of all mixes of concrete at different curing ages

Mix no.	Description	7 days	14 days	28 days	56 days	90 days
1.	100%FA+0% SS+5%SF	2.41	3.18	4.48	5.23	5.71
2.	90%FA+10% SS+5%SF	2.72	3.28	4.88	5.25	5.60
3.	80%FA+20% SS+5%SF	2.98	3.45	4.98	5.30	5.52
4.	70%FA+30% SS+5%SF	2.84	3.43	4.20	4.50	5.38
5.	60%FA+40% SS+5%SF	2.61	3.21	3.72	4.29	4.89
6.	50%FA+50% SS+5%SF	2.50	2.89	3.24	3.88	4.00

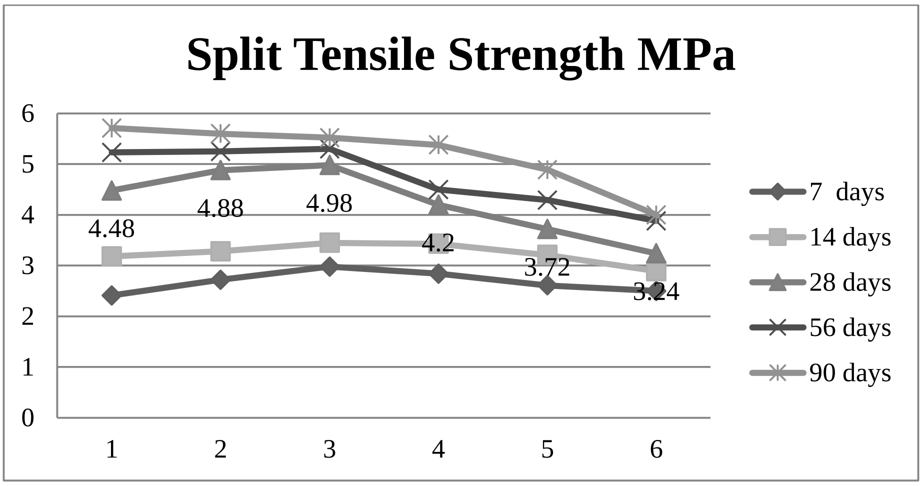

Fig. 3: Split tensile strength results

4. CAPILLARY SUCTION TEST (CSAT)

Sorptivity is defined as the rate of movement of a waterfront through a porous material under capillary action. Sorptivity test differs from the ISAT as the former measures the rate of capillary suction as opposed to the bulk effect of capillary suction in the latter at a specified time.

Table 4: Average IRA (mm/Sec$^{1/2}$) at 56 and 90 days of curing

Mix no.	Description	Average IRA (mm/Sec$^{1/2}$)	
		56 days	90 days
1.	100%FA+0% SS+5%SF	0.0195	0.0181
2.	90%FA+10% SS+5%SF	0.0155	0.0145
3.	80%FA+20% SS+5%SF	0.0141	0.0131
4.	70%FA+30% SS+5%SF	0.0171	0.0152
5.	60%FA+40% SS+5%SF	0.0191	0.0161
6.	50%FA+50% SS+5%SF	0.0230	0.0201

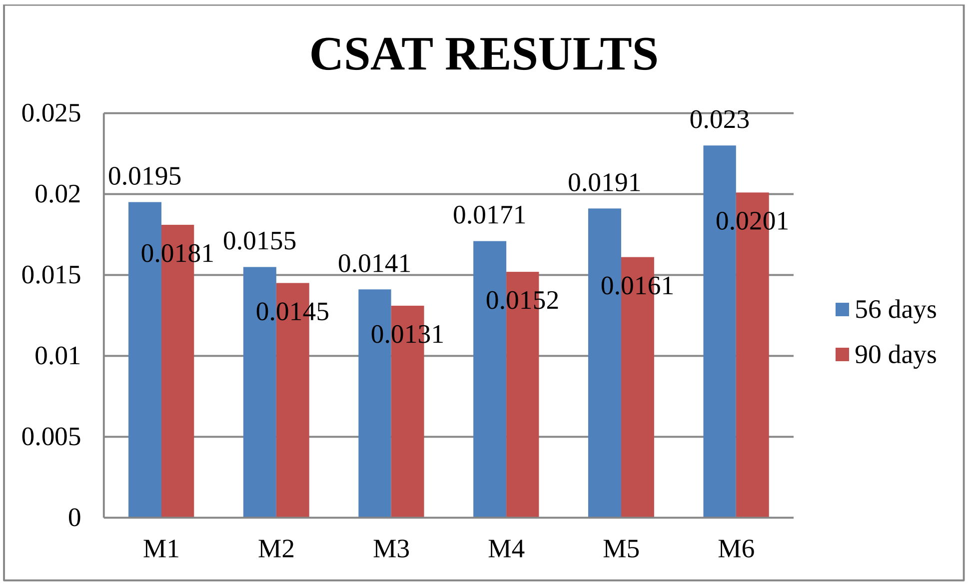

Fig. 4: CSAT results

The table shows the variation in the IRA value of concrete mixes at different curing ages. The lowest IRA value was obtained with a mix containing 80%FA+20% SS+5%SF for all curing ages, whereas mix containing 50%FA+50% SS+5%SF give the maximum value at all curing ages. This is because of the high absorption capacity of steel slag. Mix with 80%FA+20% SS+5%SF show less absorption value out of all and the mixes and mix with 50%FA+50% SS+5%SF show high absorption value at both 56 and 90 days. The lowest values of absorption (mm) observed with mix 80%FA+20% SS+5%SF are 0.0141 and 0.0131 at 56 days and 90 days respectively. The maximum value obtained from mix 50%FA+50% SS+5%SF are 0.0230 and 0.0201 at 56 days and 90 days respectively. Further, we obtained steel slag to replacement with fine aggregate up the certain limit to decreasing water absorption capacity and to increasing percentage of steel in concrete with an increasing water absorption capacity of steel slag concrete.

5. CONCLUSIONS

- It was observed that as the addition of steel slag to concrete mix increases, the workability of the concrete mix was found to decreasing as compared to the control mix. The lowest value of slump was obtained with mix 50%FA+50% SS+5%SF and the highest value was obtained with 100%FA+0% SS+5%SF.
- It was observed that the addition of steel slag in concrete with increasing compressive strength as well as tensile strength as compared to control. Further steel slag replacement with fine aggregate up to 10-20% at obtained better results compare to another mix. The percentage of steel slag increasing with decreasing compressive strength as well as tensile strength.
- It was observed that in concrete containing more steel slag was found to absorb more water compared to ordinary concrete. It was observed that at optimum dosage that is at 10-20% replacement of steel slag with fine aggregate concrete is minimum water absorption capacity of concrete compare to control mix finally increasing percentage steel slag in concrete water capacity is more compared to control mix.
- The durability of concrete from the aspect of resistance to acid attack on concrete increases by adding steel slag in concrete.The optimum value of steel slag for resistance to acid attack was 10-20% by weight of the fine aggregate.
- The concrete containing 10-20% steel slag by weight of fine aggregate shows a less capillary rise in concrete.

6. REFERENCES

[1] J. Saravanan and N.Suganya (2015). Mechanical Properties of Concrete Using Steel Slag Aggregate. International Journal of Engineering Inventions E-ISSN: 2278-7461, P-ISSN: 2319-6491 Volume 4, Issue 9 [May 2015] Pp: 07-16.

[2] Hardeep Singh and Jaswinder Singh Saluja (2016). Effect of Steel Slag as a Replacement of Fine Aggregate in M40 Grade of Concrete. International Journal of New Innovations in Engineering and Technology.

[3] Anurag Jain, Sandeep Gupta and Mayank Gupta (2018).Steel Slag as Replacement of Fine Aggregate In Terms Of High Strength Concrete. International Journal of Engineering Sciences and Research Technology.

[4] B. Kaviya and K. Geetha (2014). Experimental Study on Partial Replacement of Fine Aggregate by Steel Slag. International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 11, November 2014.

[5] P.S.Kothai and R.Malathy (2014). Utilization Of Steel Slag In Concrete As A Partial Replacement Material For Fine Aggregates .international Journal Of Innovative Research In Science, Engineering And Technology (An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 4, April 2014.

[6] Anil, Mukesh Kumar, and Pankaj, Pardeep Kumar (2017). Effect of Steel Slag as Partial Replacement of Fine Aggregate in M35 Grade of Concrete. Imperial Journal of Interdisciplinary Research (IJIR) Vol-3, Issue-9, 2017 ISSN: 2454-1362.

[7] Shriver Padha and Ravi Kumar (2016). Utilization of Steel Slag in Concrete as a Partial Replacement to Fine Aggregate Volume 4, Issue 07 July-2016, Pages-5542-5552, ISSN (E):2321-7545.

[8] V. Subathra Devia, B. K. Gnanavelb (2014). Properties of Concrete Manufactured Using Steel Slag. Procedia Engineering 97 (2014) 95 – 104.

[9] samdish Abrol, Puneet Sharma, Nitin Verma, Ismitpal Singh (2016).Effect Of Steel Slag in Concrete. ijce, Volume 3, Issue 2 (2016).

[10] Ansu John and Elson John (2015). Study on the Partial Replacement of Fine Aggregate Using Induction Furnace Slag. American Journal Of Engineering Research (Ajer) E-Iss n: 2320-0847 P-Iss n: 2320-0936 Volume-4 Pp-01-05

[11] K. Thangaselvi (2015). Strength and Durability of Concrete Using Steel Slag as a Partial Replacement of Coarse Aggregate in Concrete. International Journal Of Advanced Research Trends In Engineering And Technology (IJARTET) Vol. 2, Issue 7, July 2015

