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EFFECT OF WASTE STEEL SLAG AND SILICA FUME ON MECHANICAL PROPERTIES OF HIGH STRENGTH CONCRETE

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Abstract- *The aim of the present experimental research is to compare the properties of Self-compacting high strength concrete made with and without steel slag and silica fume, used as supplementary cementing material. Concrete samples of M60 grade using water/binder ratio 0.32, with varying percentage of steel slag (0 to 40%) in the interval of 10% and with optimum percentage of silica fume(10%) were casted and tested for mechanical and durability properties at the age of 7, 28 and 56 days. Replacement of fine aggregates with steel slag showed progressive increase in mechanical properties such as compressive strength (CS), splitting tensile strength (TS), flexural strength (FS) at all ages.*

Keywords— Steel Slag, Silica fume, CS, FS, TS

1. INTRODUCTION

Concrete is most favorite construction material readily available and mostly utilized with wide range of applications. Prof. Hajime Okamura [1] in 1997 proposed an idea about Self compacted concrete. However, Prof. Ozawa [2] initially investigated the model experimentally in 1988 in Japan. Alizadeh, et al. [3] replaced sand with industrial waste slag and described mechanical and durability properties in detail. ACI 363[4] declared concrete having compressive strength (28 days) greater than 41 MPa as HSC. Fly ash as Natural pozzolana and silica fume as SCM can be utilized to manufacture HSC of 69 MPa to 85 MPa at 28 days [5, 6]. Limbachiya et al. [7] replaced natural conventional aggregate by recycled concrete aggregate in producing HSC. Juan Manso et al. [8] had carried out study on electric arc furnace slag in Concrete. Zeghichi [9] reported the substitution of natural fine aggregates by waste foundry slag to discuss mechanical and durability properties of high strength concrete. In 2012, Nadeem and Pofale [10] had used waste steel slag as alternative material for natural sand in various applications either partially or fully. Sharma et al. [11] discussed the effect of waste foundry slag and Alccofine on durability properties of HSC. Mohammed Irshad et al. [12] experimentally studied the effect of Mineral admixtures like silica fume on HSC prepared with locally available aggregate. Sharma et al. [11] Predicted Compressive Strength of HSC using NDT techniques. In their study, Khaloo and Houseinian [13] (1999) investigated the influence of silica fume on compressive strength and durability of concrete.

2.0. EXPERIMENTAL PROGRAM

2.1 Materials

Portland Pozzolana Cement (PPC) of 2.91 specific gravity was used as per recommendations of IS: 1489-1991(Part I), crushed coarse aggregate(CA) of maximum size 20 mm and river sand of Zone-II transported from Khizrabad (Pb) India conforming to recommendations of IS: 383-1970[15] was used. Coarse Aggregate was obtained from Ultra-Tech Concrete Ltd. Mohali (Pb) India, waste slag(FD) was used as substitute of natural sand obtained from steel manufacturing plant at Kala Amb(HP) India. Physical properties of CA, FA and FD are shown in Table 1[11, 14].

Table 1.Physical Properties of Coarse and Fine Aggregates (IS: 383-1970) [11, 14]

Properties					
Materials	Color	Maximum Size (mm)	Specific Gravity	Fineness Modulus	Water Absorption
Coarse Aggregate	Grey	20	2.72	6.83	0.43
Fine Aggregate	Light Grey	4.75	2.65	2.86	3.2
Slag	Black	4.75	2.71	2.93	0.4

Chemical properties of waste steel slag(FD) are as shown in Table 2.

Table2. Chemical Composition of Slag [11]

Chemical constituents						
composition	SiO_2	Fe_2O_3	CaO	MgO	Al_2O_3	SIO_2
(% age) content	31.8	18.10	33.2	1.93	8.18	0.26

According to IS: 456-2000 recommendations, Laboratory Tap water from IGCE,Abhipur college laboratory was used for preparation and curing of concrete specimens. As per recommendations of IS: 9103-1999, Super plasticizer -BASF

8777 with Specific gravity of 1.18 at 20^0 C was used to produce high workability with less water contents, confirms to.Silica fume is a supplementary cementitious material (SCM) was used to produced dense concrete procured from from Ultra-Tech Concrete Ltd. Mohali (Pb) India . Physical and chemical properties of silica fume are given in Table 3[11, 14].

Table3. Properties of silica fume [11, 14].

Physical Properties		Chemical Properties	
Specific Gravity	2.1	CaO	31-33%
Density(Kg/m3)	675	Al_2O_3	23-25%
		SiO_2	33-35%

2.2 Mix Proportion

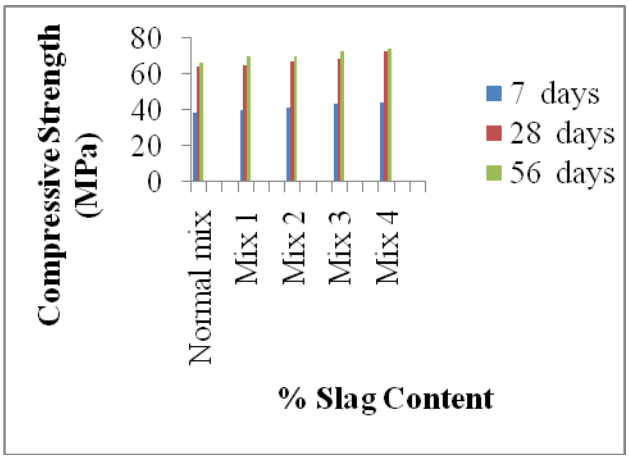
Quantity of silica fume was optimised by varying the silica fume content from 0% to 15% by weight of PPC for designing concrete mix of M60 grade, and was found to be 10%. Concrete mix was designed by EFNARC(2000);with a water binder ratio (w/b) of 0.239 and a targeted slump of 190 ± 35, by replacing fine aggregate with 10%, 20%, 30% and 40% of FD and10% silica fume (SF) contents was added in Portland pozzolanic cement. Concrete mixes prepared by replacing FA with0%, 10%, 20%, 30% and 40% of FD have been represented by (CTR), M10, M20, M30, M40 respectively (Table 4[11, 15]. 150mm x150mm x150 mm cubes(Set of 3 each) specimens for compressive strength, flexural tensile strength, splitting tensile strength, were casted, cured, dried and tested after the curing age of 7, 28and 56 days for compressive strength, flexural tensile strength, splitting tensile strength as per IS specifications.

Table4. Proportion of SCC Mixes [11, 15]

Mix design	Normal mix CTR	Mix 1 M10	Mix 2 M20	Mix 3 M30	Mix 4 M40
Cement (Kg/m^3)	450	450	450	450	450
Steal slag(kg)	0	45	90	144	180
Fine Aggregate(kg)	720	684	648	576	540
Coarse Aggregate(kg)	820	820	820	820	820
Super Plasticizer(ltr)	1.25%	1.25 %	1.25 %	1.25 %	1.25 %
Water(kg)	0.40	0.40	0.40	0.40	0.40
Silica fume(kg)	45	45	45	45	45

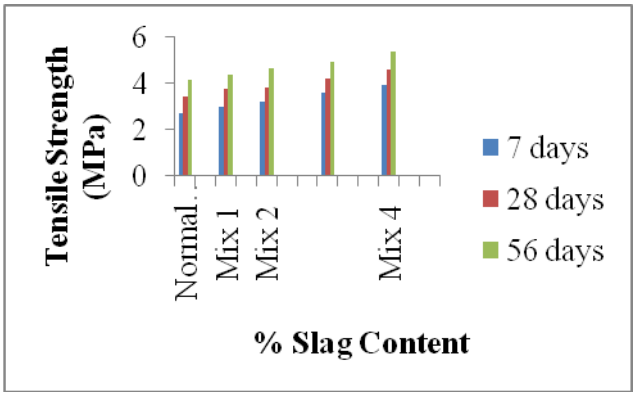
2.3 COMPRESSIVE STRENGTH

150 mm x 150 mm x 150 mm size cube specimens were casted and cured for compressive strength as per IS: 516-1959. A Test for Compressive strength test were carried out in a compression testing machine of maximum capacity 3000 KN after 7, 28 and 56 days of curing. The compressive strength tests results of SCC mixes are given in Table 4.2 and shown in Fig. 4.3. With the increase in Steel Slag content from 0 to 40% SCC mixes developed compressive strengths between 38.52 to 44.63 at 7 days, 63.99 to 72.70 at 28 days and 66.77 to 74.15 MPa at 56 days. The compressive strength increased with an Increase in the percentage of the Steel Slag [11, 16, 17, 18].



2.4 TENSILE STRENGTH

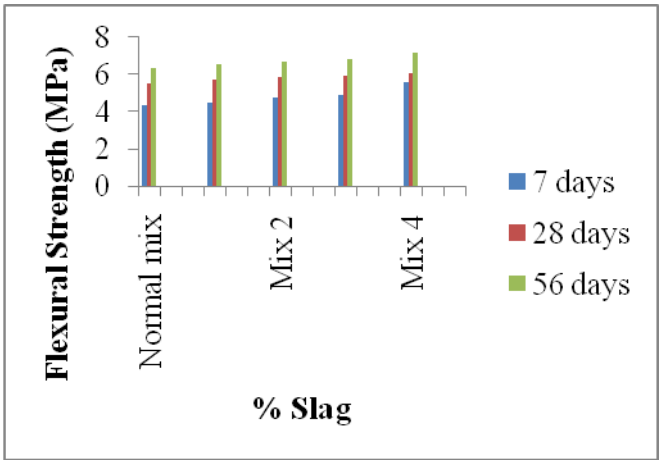
The Splitting Tensile strength tests results of SCC mixes are given in Table 4.2 and shown in Fig. 4.3. With the increase in Steel Slag content from 0 to 40% SCC mixes developed tensile strengths between 2.72 to 3.92 MPa at 7 days 3.45 to 4.61MPa at 28 days and 4.19 to 5.37 MPa at 56 days. The tensile strength increased with a Increase in the percentage of the Steel Slag[11, 16, 17, 18]..



2.5 FLEXURE STRENGTH

Rectangular beam samples of concrete of dimensions 100 mm X 100mm X 500mm were casted and cured for 7, 28 and 56 days to determine flexural tensile strength. The Flexural strength tests results of SCC mixes are given in Table 4.2 and shown in Fig. 4.3. With the increase in Steel Slag content from 0 to 40% SCC mixes developed flexural strengths between 4.33 to 5.62 MPa at 7 days, 5.51 to

6.05 MPa at 28 days and 6.35 to 7.15 MPa at 56 days. The flexural strength increased with an Increase in the percentage of the Steel Slag[11, 16, 17, 18]..



CONCLUSION

- Test results reported that there is rise in compressive strength, splitting tensile strength and flexural strength for M60 grade of concrete mix with inclusion of slag up to 40% replacement and 10% silica fume in addition to PPC.
- Compressive strength, splitting tensile strength and flexural strength of all concrete mixes showed a normal progression in strength with increase in curing age.

REFERENCES

1. Okamura,H .(1997). Self-Compacting High-Performance Concrete, Concrete International, pp.50-54.
2. Kazumasa Ozawa, Anura S.M.Nanayakkara and Koichi Maekawa, " Application of Multi-Phase Model to The Pipe Flow of Fresh Concrete"Proceedings of JSCE,No.466/V-19,pp.121-131,1993
3. Alizadeh, Chini, M., Ghods, P., Hoseini, M., Montazer, Sh., Shekarchi, M., "Utilization of Electric Arc Furnace Slag as aggregates in Concrete - Environmental Issue,"6th CANMET/ACI International Conference on Recent Advances in Concrete Technology. Bucharest, Romania, June 2003:451-464.
4. ACI Committee 363, 'State of Art Report on High Strength Concrete', ACI 363-92, ACI Manual of concrete practice: Part I, American Concrete Institute. Detroit, 2000.
5. Patel Y.,Patel P.J., Patel J., Patel H.S., Study on durability of High performance Concrete with Alccofine and Fly Ash, International journal of advanced engineering research and studies, 11(2013) 154-157.
6. Vatsal P, Niraj S.,A Survey of High Performance Concrete Developments in Civil Engineering Field, Open Journal of Civil Engineering, Vol.-3(2013), N0.-2, pp. 69-79.
7. Limbachiya M.C., Leelawat T., Dhir R.K., Concr. Mater. Struc.,33(2000)574.
8. Manso, J. M., Gonzalez, J. J., Polanco, J. A., 'Electric Arc Furnace Slag in Concrete', ASCE Journal of Materials in Civil Engineering.Vol. 16, No. 6, 2004:639- 645.
9. Zeghichi, L., 'The Effect of Replacement of Natural Aggregates by Slag Products on the Strength of Concrete'. Asian Journal of Civil Engineering (Building and Housing). Vol. 7, 2006:27-35.
10. Mohammed, N., Pofale, A. D., 'Replacement of Natural Fine Aggregate with Granular Slag - A Waste Industrial By-Product in Cement Mortar Applications as an Alternative Construction Materials', International Journal of Engineering Research and Applications (IJERA). Vol. 2, Issue 5, 2012:1258-1263.
11. Sharma Devinder, Sharma Sanjay, Goyal Ajay, "Utilization of Waste Foundry Slag and Alccofine in Developing High Strength Concrete,"International Journal of Electrochemical Science,11 (2016).
12. Muhamad I., "Effect of Mineral Admixtures on High Strength Concrete Made With Locally Available Materials," Jordan Journal of Civil Egg, Vol- 3(2009).
13. Khaloo, A. R., Houseinian, M. R. (1999). Evaluation of properties of silica fumes for use in concrete, International Conference on Concretes, Dundee, Scotland.
14. IS: 383-1970: Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standard, New Delhi-1970
15. IS: 10262-1982, 2009, 'Guidelines for Concrete Mix Design', Bureau of Indian Standards. New Delhi, India.
16. Sharma Devinder, Sharma, S. and Goyal, A., Prediction of High Compressive Strength of Concrete Using Waste Foundry Slag and Alccofine by NDT, International Journal of Research in Engineering and Technology, Vol.5,Issue 02(2016) 580-583.

17. Sharma Devinder, Sharma, S. and Goyal, A., Comparative Studies on Mechanical Properties of High Strength Concrete Using Foundry Slag and Alccofine, Concrete Research Letter.

18. Kapoor A., Sharma S., Sharma Devinder, "Waste Iron Slag and Alccofine as a Substitute Material for Fine Aggregate and Cement used in Concrete," Research Paper Published in International conference Organized by American Society of Civil Engineers (ASCE) in July 2016 at Hawai.