Analyzing the Characteristics of Concrete with Steel Slag Hydrated Matrix

Arpit Singh[1], Prof. Sourabh Asange[2]

[1]*M.TECH Student, Department of Civil Engineering, TIT Bhopal, (M.P.)*
[2]*HOD, Department of Civil Engineering, TIT Bhopal, (M.P.)*

Abstract - *Iron slag and steel slag are the byproducts of the iron making and steelmaking processes. To date, these types of slag have been widely used in cement and as aggregate for civil works. A new product developed called Steel slag hydrated matrix (SSHM) which is made mainly from slag and absolutely free from natural aggregate. Steel slag hydrated matrix is made up of 100% recycled resources. It's strength performance is equivalent to ordinary concrete and a low alkaline dissolution. It has excellent wear resistance.*

In the present work basic properties such as compressive strength, flexure strength, workability were investigated of Steel Slag Hydrated Matrix in comparison with ordinary concrete. Mix proportion of fly ash, lime, ground granulated blast furnace slag, steel slag and water to achieve the required strength has been investigated.

Key Words: **Steel slag, Ground Granulated Blast Furnace Slag, Compressive Strength, Tensile strength, Flexural Strength**

1. INTRODUCTION

Global warming and environmental destruction have become manifest problems in recent years, heightening concern about global environmental issues, and a changeover from the mass-production, mass-consumption, mass-waste society of the past to a zero-emission society is now viewed as important. The iron and steel industry produces extremely large amounts of slag as byproduct of the iron making and steelmaking processes, and is therefore continuing to develop slag reduction and recycling technologies and intermediate treatment technologies. Iron and steel making slag are byproducts of the iron making and steelmaking processes. To date, these types of slag have been widely used in cement and as aggregate for civil works. Recently, steel slag hydrated matrix (SSHM) has been developed as a construction material for reducing environmental problems. Its main ingredients are steel making slag, blast furnace slag powder which are by products of steel making process, slaked lime and fly ash.

2. LITERATURE REVIEW

Many researchers have invested their time in experimenting steel slag with different materials and in different conditions and they come up with following results

1) **Qasrawi** et al. carried out Research work in Use of low CaO unprocessed steel slag in concrete as fine aggregate. Their conclusion is that regarding the compressive and tensile strength of concrete steel slag is more advantageous for concretes of lower strengths.

2) **Boukendakdji** et al. carried out Research work in Effect of slag on the rheology of fresh self- compacted concrete. Their conclusion is that slag can produce good self-compacting concrete.

3) **Wu** et al. carried out Research work in Utilization of steel slag as aggregates for stone mastic asphalt (SMA) mixtures. Their conclusion is that the test roads shows excellent performances after 2-years service, with abrasion and friction coefficient of 55BPN and surface texture depth of 0.8 mm.

4) **Maslehuddin** et al. carried out experimental work on comparison of properties of steel slag and crushed limestone aggregate concretes, finally concluded that durability characteristics of steel slag cement concrete were better than those of crushed limestone aggregate concrete. Some of physical properties were better than of crushed lime stones concrete.

5) **Toutanji and El-Korchi** carried out experimental work on Oxygen and water vapor transport in cement pastes, hence concluded that the increase in compressive strength of mortar containing silica fume as a partial replacement for cement, greatly contributes to strengthening the bond between the cement paste and aggregate. It was also demonstrated that super plasticizer in combination with silica fume plays a more effective role in mortar mixes than in paste mixes.

3. MATERIAL USED

3.1 STEEL SLAG

In our research program we have used the locally available steel slag. It was procured from the Rourkela Steel Plant, Rourkela. This material replaces the coarse aggregate in normal concrete. The different physical of steel slag are given below:

Table-1: Physical characteristics steel slag

NO.	MATERIAL	PROPERTIES	
1	Steel Slag	Specific gravity	2.98
2		Water absorption	3%
3		Los Angeles Abrasion	23%

3.2 GGBS

Table-2: Physical characteristics GGBS

NO.	MATERIAL	PROPERTIES	
1	GGBS	Specific gravity	2.71
2		Water absorption	1.4

3.3 FLY ASH

Table-3: Physical characteristics fly ash

NO.	MATERIAL	PROPERTIES	
1	Fly Ash	**Characteristics**	**Value**
2		Specific gravity	2.2
3		Moisture content	0.2%

4. EXPERIMENTS AND RESULTS

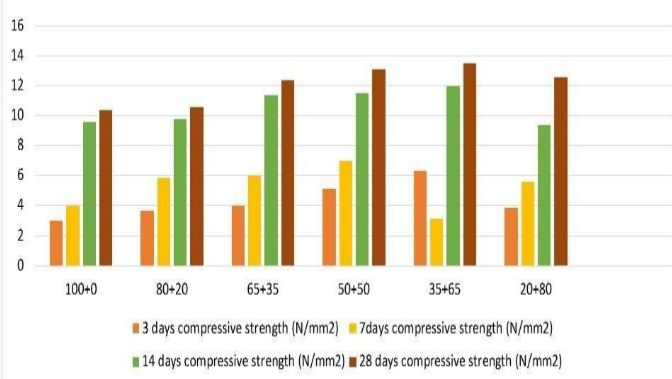
4.1 Mix proportions

- To get the consistency and setting times of the powder (lime + fly ash), six different types of mix were prepared by varying the lime and fly ash contents from 100% to 20%.
- For the mortar test the ratio of powder and GGBS (Ground granulated blast furnace slag) was taken to be 1:2 and six different types of specimen were prepared by varying the lime content.
- To prepare the SSHM (steel slag hydrated matrix), the mix proportion of powder, GGBS and steel slag was taken as 1:1.5:3. Here also six different types of specimen were prepared by using different lime and fly ash content.
- A specimen of normal concrete with the mix of 1:1.5:3 (cement: sand: aggregate) was prepared to compare with the new SSHM. The w/c ratio was taken to be 0.6.

Table -4: Compressive Strength of GGBS (values in N/mm^2)

Lime + Fly ash (%)	w/p	3 Day	7 Days	14 Days	28 Days
100+0	0.67	3	4	9.6	10.34
80+20	0.58	3.66	5.86	9.8	10.56
65+35	0.56	4	5.98	11.36	12.36
50+50	0.53	5.14	6.96	11.48	13.12
35+65	0.45	6.34	310.6	11.98	13.48
20+80	0.43	3.88	5.6	9.34	12.54

Chart-1: Compressive strength comparison Of GGBS (values in N/mm^2)

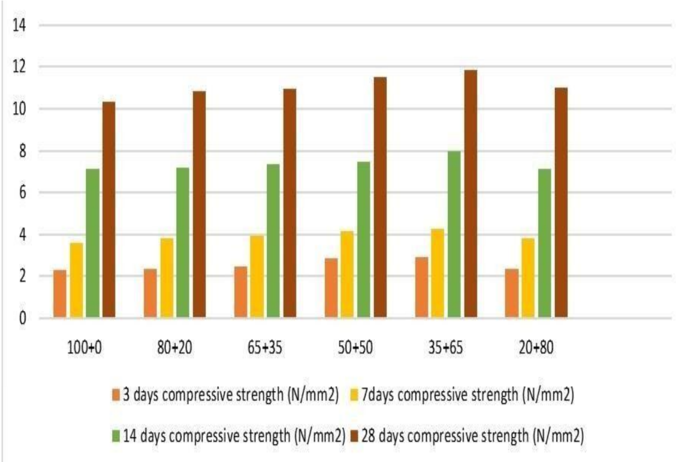


From above graph it is concluded that the mortar exhibit low early strength but shows considerable increase in strength with curing period. The low early strength may be due to the slow reaction between the powder and the water. But the reaction continues for a longer period hence more strength is gained age. It is little inconclusive in which way it changes with respect to different powder mix (lime+ fly ash).

Table-5: Compressive Strength of SSHM (values in N/mm^2)

Lime + Fly ash (%)	w/p	3 Days	7 Days	14 Days	28 Days
100+0	0.67	2.31	3.62	7.12	10.34
80+20	0.58	2.38	3.85	7.18	10.86
65+35	0.56	2.45	3.92	7.38	10.95
50+50	0.53	2.86	4.18	7.45	11.52
35+65	0.45	2.92	4.26	7.98	11.83
20+80	0.43	2.34	3.82	7.14	11.04

Chart-2: Compressive Strength Comparison of SSHM (values in N/mm²)



From the above graph it is evident that the strength of SSHM is less than the normal concrete. But the fact which is worth noticing that it is not at par with the strength shown by the GGBS mortar. It gives the idea that there might be some fault with the steel slag. Here also the low early strength is due to the fact that the reaction between the powder and water is slow. But the reaction continues for longer period and hence there is considerable gain of strength after 28 days.

Table-6: Tensile Strength (values in N/mm²)

Lime +Fly ash (%)	**28 days tensile Strength**
100+0	0.3
80+20	0.33
65+35	0.37
50+50	0.38
35+65	0.43
20+80	0.34

Chart-3: Tensile Strength Comparison at 28 days (values in N/mm²)

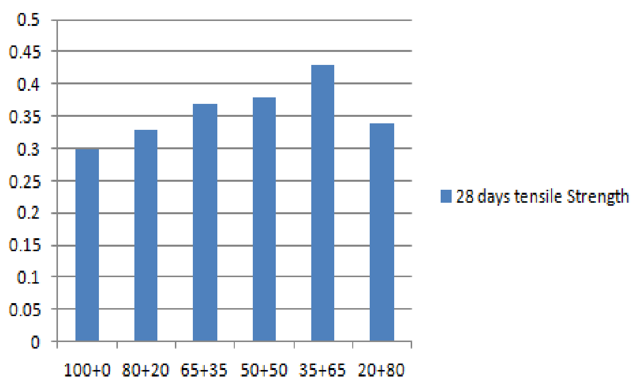
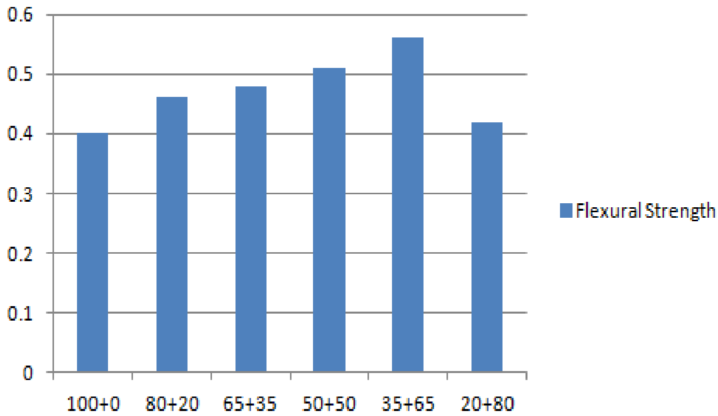


Table -7: Flexural Strength (values in N/mm²)

Lime + Fly (%)	**28 days Flexural Strength**
100+0	100+0
80+20	0.46
65+35	0.48
50+50	0.51
35+65	0.56
20+80	0.42

Chart-4: Flexural Strength Comparison at 28 days (values in N/mm²)



CONCLUSIONS

The new material called "Steel Slag Hydrated Matrix", consisting of mainly of steel making slag, ground granulated blast furnace slag, fly ash, and water matrix has a number of excellent features, including the following

1. Made from 100% recycled resources.
2. Considerable strength as ordinary concrete.
3. Excellent wear resistance and other physical properties.
4. Low alkaline dissolution.
5. Excellent growth habitat for biofouling organism in marine environment.
6. Economical.
7. Little adverse effect on environment.

The steel slag hydrated matrix has been used as material for artificial stone and cover blocks, confirming its ease of use in construction with conventional techniques. Test also confirms that it has low impact on the ecological system. A trial calculation shows that this material will make substantial contribution to reducing natural aggregate consumption and CO_2 emission.

REFERENCES

[1] Bernal, S., De Gutierrez, R., Delvasto, & Rodriguez, E. (2010). Performance of an alkali- activated slag concrete reinforced with steel fibers. Construction and Building Materials, 24(2), 208-214.

[2] Boukendakdji, O., Kenai, S., Kadri, E. H., & Rouis, F. (2009). Effect of slag on the rheology of fresh self-compacted concrete. Construction and Building Materials, 23(7), 2593-2598.

[3] Coastal Development Institute of Technology. Coastal Development Institute of Technology Library. no. 16, Manual on Steel Slag Hydrated Matrix. 2003-03.

[4] Gonen, T., & Yazicioglu, S. (2007). The influence of mineral admixtures on the short and long-term performance of concrete. Building and Environment, 42(8), 3080-3085.

[5] Japan Concrete Institute. Concrete Gijutsu no Yoten '01. 2001, p. 60.

[6] Maslehuddin, M., Sharif, A. M., Shameem, M., Ibrahim, M., & Barry, M. S. (2003).

[7] Comparison of properties of steel slag and crushed limestone aggregate concretes. Construction and building materials, 17(2), 105-112.

[8] Matsunaga.H, Kogiku.F, Takagi.M ,Tanishiki.K, Nakagawa.M, Environment Friendly Block Made From Steel Slag, SP- 221-27,pp. 457-469

[9] Ministry of the Environment. Heat Island Jittai Kaiseki Chousa Kento Iinkai Kentou-kekka.

[10] Parisara, Envis newsletter, Vol .2, No.6, Jan 2007