ASSESSMENT OF STRENGTH FEATURES OF STEEL SLAG HYDRATED MATRIX

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Abstract - *Present day construction industry devours enormous measure of cement and concrete is the limiting material utilized for making concrete. Regarding these focuses, construction industry has concocted a substitute for concrete, famously known as 'Steel Slag Hydrated Matrix'(SSHM). It comprise of steel making slag, ground granulated impact heater slag, fly ash, lime and water. In the current study, tests are completed in two stages. In the major period of tests, the amount enhancement of raw materials like fly ash and lime is made in order to get a best restricting material that looks like the customary fastener, the concrete. The lime content in the lime-fly ash blend was shifted to various percentages. The compressive strengths of these cubes were determined after 3days, 7days 28 days and 60 days of curing period. From the above series of tests, the optimum mix was found out. In the second phase of tests, concrete specimens were prepared with taking steel slag as coarse aggregate, ground granulated blast furnace slag as fine aggregate and binder that is found to best performance from the test of phase one. The compressive strength, flexural strength and tensile strength were determined adopting conventional testing procedure. The compressive strength of SSHM after 28 days of curing was found to vary from 8N/mm² to 15N/mm².*

Key Words: Steel Slag Hydrated Matrix, Fly ash, compressive strength, Concrete, GGBS

1. INTRODUCTION

Forestalling the consumption of characteristic assets and improving the use of waste materials has become a test to the researcher and designers. Various investigations have been led concerning the security of characteristic assets, counteraction of natural contamination and commitment to the economy by utilizing this waste material. The two significant results of industry are slag and fly debris. In India, the yearly creation of fly debris is around 170 million tons, however around 35% of the complete is being used, which is exceptionally low. Attributable to its ultra-fineness, pozzolanic commitment and different properties, the utilization of fly debris makes an expense of removal and to diminish natural contamination, it is a basic to expand the amount of fly debris usage. Essentially, the Steel business in India is delivering around 24 million tones of impact heater slag and 12 million tones of steel slag. Concrete is the most liked and the single biggest structure material utilized by the construction business. Concrete is fundamentally made of totals, both fine and coarse, stuck by a concrete glue which is made of concrete and water. Every one of these constituents of cement has a negative natural effect and offers ascend to various supportability issues. The momentum solid development practice is impractical on the grounds that, not just it devours gigantic amounts of stones, sand, and drinking water, yet in addition one billion tons every time of concrete, which isn't a climate cordial material. For creation of concrete tremendous measure of energy is required and around 8 % of CO_2 is delivered to environment during concrete creation. Indeed, numerous results and strong squanders can be utilized in concrete blends as totals or concrete substitution, contingent upon their synthetic and actual portrayal, if sufficiently treated. The steel business slag having alluring characteristics and can be utilized as coarse totals in solid development..The consolidation of fly ash and impact heater slag in solid prompts numerous specialized benefits. At the point when two mineral admixtures are utilized together, better outcomes can generally accomplish. The utilization of such modern side-effect or waste material having alluring characteristics can bring about saving of energy and regular materials. With increment in populace, the interest for development of private and public structures is likewise expanding. The iron and steel industry delivers very a lot of slag as result of the iron making and steelmaking measures. As helpful reused materials, iron and steel making slag are principally utilized in fields identified with structural designing, for instance, in concrete, roadbed material, and solid total. Their reusing proportion is near 100%, making a significant commitment to the making of a reusing focused society. Nonetheless, public works projects, that is emphatically identified with reused fields, will in general be diminished as of late and, in addition, other reused materials, for example, reused roadbed materials and fly debris, become contender of slag in the fields. Hence, the advancement of new application advances has gotten a pressing matter.

2. METHODOLOGY

In this present study, a series of experiments have been done to evaluate the characteristic strength of steel slag hydrated matrix. The objective of this study is to prevent the exhaustion of natural resources and enhancing the usage of waste materials, concern about global environmental issues, and a change over from the mass-production, mass-consumption, mass- waste society to a zero-emission society. The physical and chemical properties of the raw materials have been studied to characterize the raw materials. In addition to this tests have been conducted in two phases. In first phase of tests the optimum percentage of lime is determined by testing mortar cubes prepared from lime+ fly ash as binder and GGBFS as fine aggregate in ratio of 1:2 and 1:3 with 20, 35, 50, 65, and80 percent lime in the binder. In the second series of tests concrete specimens were prepared by mixing lime +fly ash binder, GGBFS and steel slag in the ratios of 1:1.5:3. The compressive strength, flexural strength and split tensile strength of these samples were determined after 7 and 28 days.

3. CHEMICAL ANALYSIS AND MATERILAS USED

3.1 Chemical composition

Fly ash consists of silica, alumina, oxides of iron, calcium and magnesium and toxic heavy metals like lead, arsenic, cobalt, and copper. The chemical composition of fly ash is given in the Table 1. The permissible value as per IS: 3812-1981 and ASTM standard also shown here.

Table 1 Chemical composition of fly ash

Type	Fly ash (Present study) (%)	ASTM requirement C-618 Class F (%)	I.S. specifications (%)
SiO2	56.04	-	
Al_2O_3	33.85	-	
Fe_2O_3	3.9	-	
SiO_2 + Al2O3 + Fe2O3	93.84	70.00 minimum	70.0 (minimum)
CaO	0.73	-	
MgO	0.68	5.00 maximum	5.0 (maximum)
K2O	1.22		
Na_2O	0.19	1.50 maximum	1.5 (maximum)
TiO_2	2.69	-	
MnO_2	0.31	-	
SO_3	0.05	5.00 maximum	3.0 (maximum)
L.O.I (900°C)	1.4	6.00 maximum	5.0 (maximum)

The fly ash meets the general requirements of ASTM C-618 Class F fly ash and as per IS: 3812- 1981 found suitable as a pozzolanic material.

3.2 Steel slag

This is the main ingredient of steel slag hydrated matrix (SSHM). In our research program we have used the locally available steel slag. The steel slag had grayish white colour. The chemical, morphological, mineralogical and physical data for the above steel slag is presented as follows. The tests on steel slag were carried out as per IS: 1727-1967. The specific gravity of fly ash is 2.98 and it comes under Zone-II (by IS: 12020-1982). This material replaces the coarse aggregate in normal concrete. The different physical and chemical properties of steel slag are given below.

Table 2 Physical properties of coarse aggregate

Aggregates	Absorption (%)	Bulk Specific Gravity	Los Angeles Abrasion (%)
Lime Stone	0.4	2.73	38
Steel slag	0.6	2.98	36

Steel Slag is found in the form of big pebbles. It is crystalline in microstructure and non- hydraulic in nature. The microstructure and distribution of steel slag was studied.

Table 3 Chemical composition of Steel slag

Composition	Steel slag Present study (%)
Fe	19
Cao	35
SiO	16
MgO	3
Al_2O_3	5
P_2O_5	4
MnO	4

3.3 Ground granulated blast furnace slag (GGBS)

The Ground granulated blast furnace slag had off white color. The chemical, morphological, mineralogical and physical data for the above ground granulated blast furnace slag is presented as follows. The tests on ground granulated blast furnace slag were carried out as per IS: 12089-1987.The different physical and chemical properties of ground granulated blast furnace slag are given below.

Table 4 Physical properties of fine Aggregate

Fine Aggregate	Water absorption (%)	Specific Gravity
Ground granulated Blast furnace Slag	1.4	2.17
Natural sand	0.96	2.7

Table 5 Chemical Composition of GGBS

Composition	GGBS Present Study(%)
Fe	0.3
CaO	37
SiO_2	34
MgO	6
P_2O_5	12
Al_2O_3	12
MnO	0

4. RESULT AND DISCUSSION

The results obtained from the testing of mortar prepared from hydrated lime, fly ash and GGBS and strengths of steel slag hydrated matrix are presented. The conventional procedure followed to characterize the quality of cement is adopted in the first phase of tests and best raw material composition was arrived at. In the second phases, concrete specimens were prepared with taking steel slag as coarse aggregate ground granulated blast furnace slag as fine aggregate and binder that is found to best performance from the test of phase one. The composition of above raw materials was varied to study the effect of raw material compositions on compressive strength, flexural strength and tensile strength adopting conventional testing procedure. The effect of curing period on strength was also studied and reported. Comparison is also made between the Steel slag hydrated matrix and the conventional concrete.

4.1 Compressive Strength of Concrete

The compressive strength of steel slag aggregate concrete decreased with the proportion of lime content. The compressive strength varied from 12.5MPa, for concrete with 20% lime content10MPa, to 12.5MPa for concrete with 35% lime content. The Steel slag Hydrated Matrix Concrete was compared with Normal concrete and the compressive strength of Normal concrete was 24.2MPa. The compressive strength of steel slag aggregate concrete is less than the normal concrete. The steel slag was full of impurities particles like coal, burnt soil lumps and some other materials and also presences of excess lime .These have swelled after coming in contact with water and consequently creating cracks in the Steel slag hydrated matrix. Further, for steel slag hydrated matrix and normal concrete compressive strength at 7 days and 28 days were calculated given in table 6. The comparison between compressive strength of steel slag hydrated matrix and normal concrete is in Fig 1.

Table: 6 Compressive strength of steel slag hydrated matrix

Mixture No	Maximum Diameter of steel making slag(mm)	Slump (mm)	Unit content(Kg/m³)					Compressive strength (N/mm2)	
			Water	BFS	Lime	Fly ash	Steelmaking Slag	7Days	28Days
A	20	40	255	716	98.6	393.5	1506	6.1	11.2
B	20	42	268	716	176	322	1506	6.49	13.1
C	20	51	286	716	247	248	1506	4.9	10.1
D	20	54	305	716	324	173	1506	4.66	9.12
E	20	49	313	716	394	98.3	1506	3.9	8.9

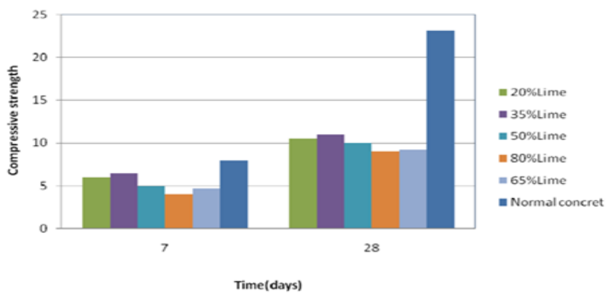

Fig-1: Comparison of Compressive strength of SSHM vs Normal concrete

Fig 1 shows the strength of SSHM is less than the normal concrete. One may observe at Fig 1 that SSHM is not equal with the strength shown by the GGBS mortar. It shows there might be some fault with the steel slag. At low early strength, the reaction between the powder and water is slow. The reaction continues for longer period which results to considerable gain of strength after 28 days as compared to normal concrete.

4.2 Flexural Strength

It is increased with proportion of decrease of lime content varying from 2.5 MPa, in the 35% lime content of concrete is the higher Flexural strength of 2.5 MPa .slag aggregate concrete. The flexural strength of Normal concrete was 4.3 MPa. These results indicate that the improvement in the flexural strength, due to the impurities of steel slag aggregate.

Table: 7 Flexural Strength of Steel Slag Hydrated Matrix with Normal concrete

SSHM			Normal concrete at 28Days in (MPa)
Flexural strength in MPa			
% Lime +Fly ash	7 Days	28 Days	
0.5	0.51	2.1	4.3
0.52	0.64	2.4	
0.63	0.44	1.9	
0.64	0.35	1.47	

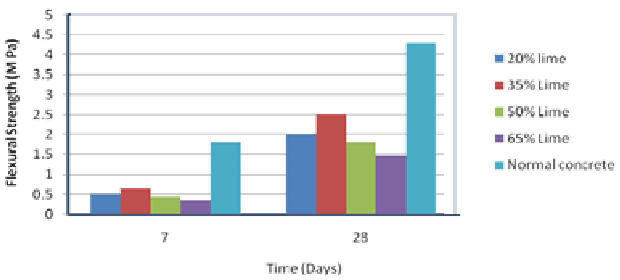

Fig- 2: Comparison of flexural Strength of SSHM VS Normal concrete

4.3 Split Tensile Strength

The split tensile strength of the Normal concrete was 2.22 MPa while it was in the range of 2.1 to 2.13 MPa in the steel slag aggregate concretes. The split tensile strength of the steel slag aggregate concrete was less than that of Normal concrete.

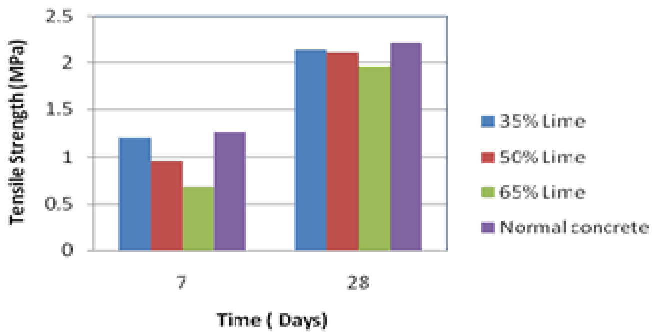

Fig- 3: Comparison of Tensile strength of SSHM vs Normal concrete

5. CONCLUSIONS

From the current investigations ensuing ends were drawn-The compressive strength of mortar Steel slag hydrated lattice was less during before phases of restoring, yet it has accomplished practically same strength as ordinary concrete mortar following 56 days. The 28 days compressive strength of cement of Steel slag hydrated framework is discovered to be not exactly the ordinary concrete cement. The compressive strength of SSHM following 28 days of restoring was found to differ from $8N/mm^2$ to $15\ N/mm^2$. Flexural strength after 28days of Steel slag hydrated framework is lower than ordinary concrete. Split Tensile strength following 28 days of Steel Slag hydrated Matrix is roughly same as the typical concrete. Steel slag hydrated matrix has the highlights like produced using 100% reused assets, same strength execution as customary concrete, great wear obstruction, low basic disintegration, and brilliant development living space for befouling life forms in marine conditions. In this task work, all endeavors have been made to get an elective material to solid utilizing generally byproducts of steel industry. It includes no consuming of petroleum derivatives, which is generally utilized for assembling of concrete, helps in emanation of CO_2 and secures ecological contamination.

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