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ANALYSIS OF CEMENT CONCRETE PREPARED WITH WASTE IRON SLAG

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ABSTRACT: In the present construction the replacement of natural resources in the production of cement and sand is the current issue. The environment problems are very common in India due to generation of industrial by-products. Due to industrialization enormous by-products are produced and to utilize these by-products is the main challenge faced in India. Due to advancement and the shortages of resources in the materials required for construction process many researches are in progress for the use of waste materials in the concrete technology. Iron slag is one of the industrial by-products from the iron and steel making industries. These Iron slag are materials which does not have a higher scrap value and are considered waste. Considering the specificity of physical and chemical properties of metallurgical slags, this research work demonstrates the possibilities of using iron slag as partial replacement of sand in concrete. In the present study an attempt has been made to prepare the concrete mix of grade M20 by mixing iron slag with various percentages in replacement with sand and studying the mechanical behavior of this concrete mix. Experimental study is conducted to evaluate the workability and strength characteristics of concrete, properties of concrete have been assessed by partially replacing sand with iron slag. The sand has been replaced by slag accordingly in the range of 0% (as a control mix) 10%, 20%, 30% , 40%, 50% and 60% by weight of sand for M20 mix. Concrete mixtures were produced, tested and compared in terms of compressive and split tensile strength with the conventional concrete.
Keywords: Concrete, Environment, Waste, Iron Slag, Mechanical Properties, Strength.

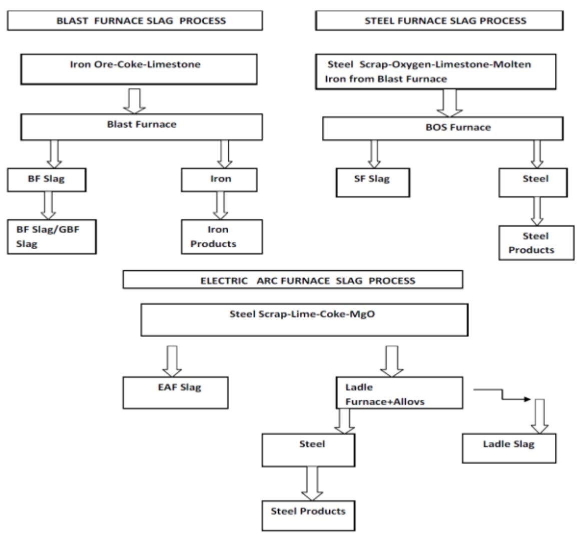
I. INTRODUCTION

As slag is an industrial by- product, its productive use grant an chance to relocate the utilize of limited natural resources on a large scale. Iron slag is a byproduct obtained in the manufacture of pig iron in the blast furnace and is produced by the blend of down-to-earth constituents of iron ore with limestone flux. Iron and steel slags can be differentiating by the cooling processing when removed from the furnace in the industry.

Consumption of natural sand is very high, due to the extensive use of concrete. In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructural growth, in this situation developing country like India facing shortage in good quality natural sand. Particularly in India, natural sand deposits are being depleted and causing serious threat to environment as well as the society. Increasing extraction of natural sand from river beds causing many problems, loosing water retaining sand strata, deepening of the river courses and causing bank slides, loss of vegetation on the bank of rivers, exposing the intake well of water supply schemes, disturbs the aquatic life as well as affecting agriculture due to lowering the underground water table etc are few examples. In past decade variable cost of natural sand used as fine aggregate in concrete increased the cost of construction. In this situation research began for inexpensive and easily available alternative material to natural sand.

The Iron slag is generally consists of, magnesium, aluminum, Silicates, calcium and manganese in various arrangements. Even though the chemical composition of slag same but the physical properties of the slag vary with the varying method of cooling. The slags can be used as cement major constituents as they have greater pozzolanic properties. The history of the use of iron and steel slag dates back a long way. European Slag Association (2006) has reported about the earliest reports on the use of slag, where in it is mentioned that Aristotle used slag as a medicament as early as 350 B.C. All through history use of slag has ranged from the novel to the usual including: cast cannon balls in Germany (1589), wharf buildings in England (1652), slag cement in Germany (1852), slag wool in Wales (1840) armored concrete in Germany (1892) slag bricks made from granulated slag and lime in Japan (1901) according to Iron and Steel (2007). In the past, the application of steel slag was not noticeable because enormous volumes of blast furnace slag were available. Through awareness of environmental considerations and more recently the concept of sustainable development, extensive research and development has transformed slag into modern industrial product which is effective and beneficial.

II. EVALUATION OF SLAG CREATION PROCESSES



CHEMICAL COMPOSITION OF SLAGS

In current years, growing thoughtfulness of environmental issues in our society has had an impact in improved utilization of slag. United with member companies identifying new opportunities for slag products are further urbanized .The typical chemistry of BFS, BOS and EAF Slags after exact conditioning and weathering are shown in table 1.2.

Constituents as Oxides	Symbol	BFS Slag (%)	BOS Slag (%)	EAF Slag (%)
Calcium Oxide	Cao	41	40	35
Free lime	-	0	0-2	0-1
Silicon oxide	Sio_2	35	12	14
Iron oxide	Fe_2o_3	0.7	20	29
Magnesium Oxide	Mgo	6.5	9	7.7
Manganese Oxide	Mno	0.45	5	5.7
Aluminum oxide	Al_2o_3	14	3	5.5
Titanium Oxide	Tio_2	1	1	0.5
Potassium Oxide	K_2o	0.3	0.02	0.1
Chromium Oxide	Cr_2o_3	<0.005	0.1	1
Vanadium Oxide	V_2o_5	<0.05	1.4	0.3
Sulphur	S	<0.6	0.07	0.1

EXPERIMENTAL PROGRAM & METHODOLGY

The physical properties of the cement as determined from various tests conforming to Indian Standard IS: 8112:1989 are listed in Table 3.1. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture. The various tests conducted on cement are initial and final setting time, specific gravity, fineness and compressive strength. The results of above said tests are given below in Table 3.1.

Sr. No.	Characteristics	Values Obtained Experimentally	Values Specified By IS 8112:1989
1.	Specific Gravity	3.12	-
2.	Standard Consistency, percent	29	-
3.	Initial Setting Time, minutes	147	30 (minimum)
4.	Final Setting Time, minutes	305	600 (maximum)
5.	Compressive Strength 3 days 7 days 28 days	 24.8 N/mm^2 37.5 N/mm^2 47.6 N/mm^2	 23 N/mm^2(minimum) 33 N/mm^2(minimum) 43 N/mm^2(minimum)

Fine Aggregates: The aggregates most of which pass through 4.75 mm IS sieve are termed as fine aggregates. The fine aggregate may be of following types:

i) Natural sand, i.e. fine aggregate resulting from natural disintegration of rocks.

ii) Crushed stone sand, i.e. fine aggregate produced by crushing hard stone.

iii) Crushed gravel sand, i.e. fine aggregate produced by crushing natural gravel.

Coarse Aggregates: The aggregate which is retained over IS Sieve 4.75 mm is termed as coarse aggregate. The coarse aggregates may be of following types:-

i) Crushed graves or stone obtained by crushing of gravel or hard stone.

ii) Uncrushed gravel or stone resulting from the natural disintegration of rocks.

iii) Partially crushed gravel obtained as product of blending of above two types.

WATER

Generally, water that is suitable for drinking is satisfactory for use in concrete. Water from lakes and streams that contain marine life also usually is suitable. When water is obtained from sources mentioned above, no sampling is necessary. When it is suspected that water may contain sewage, mine water, or wastes from industrial plants or canneries, , it should not be used in concrete unless tests indicate that it is satisfactory.

IRON SLAG

In this work, the Iron Slag is taken from the mandideep Iron and Steel industry located nearby bhopal. It is black in colour as shown in figure. The sieve analysis of iron slag is shown in Table 3.6.

Weight of sample taken =1000 gm.					
Sr. No.	IS-Sieve (mm)	Wt. Retained (gm)	%age retained	%age passing	Cumulative % retained
1	4.75	14	1.4	98.6	1.4
2	2.36	28	2.8	95.8	4.2
3	1.18	94.5	9.45	86.35	13.65
4	600 µ	189.5	18.45	67.8	32.1
5	300 µ	329.5	32.95	34.95	65.05
6	150 µ	291.5	29.15	5.8	94.2
7	Pan	58	5.8		
	Total	1000.00		SUM	210.6

TEST METHODS

The procedure of methods used for testing cement, coarse aggregates, fine aggregate and concrete are given below:

(i) SPECIFIC GRAVITY

Specific gravity is ratio of the weight of a given volume of a substance to the weight of an equal volume of some reference substance, or equivalently the ratio of the masses of equal volumes of two substances.

(ii) SIEVE ANALYSIS FOR COARSE AND FINE AGGREGATES AS PER IS: 2386 (PART I) – 1963

The sieve analysis is used for the determination of particle size distribution of fine and coarse aggregates by sieving or screening.

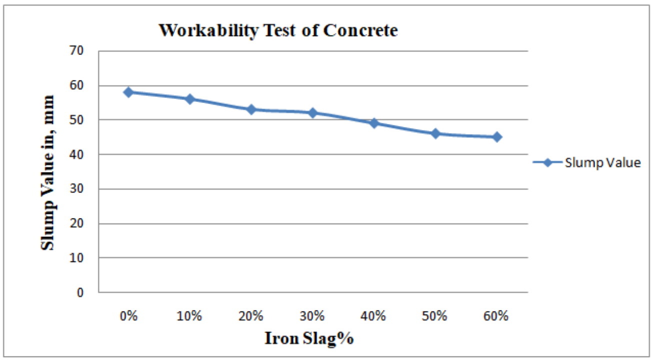
III. COMPRESSIVE STRENGTH OF CONCRETE:

Cube specimens of size 150 mm x 150 mm x 150 mm were taken out form the curing tank at the ages of 7, 28 and 56 days and tested immediately on removal from the water (while they were still in the wet condition). Surface water was wiped off, the specimens were tested. The position of cube when tested was at right angle to that as cast. The load as applied gradually without shock till the failure of the specimen occurs and thus the compressive strength was found.

IV. RESULTS AND DISCUSSION

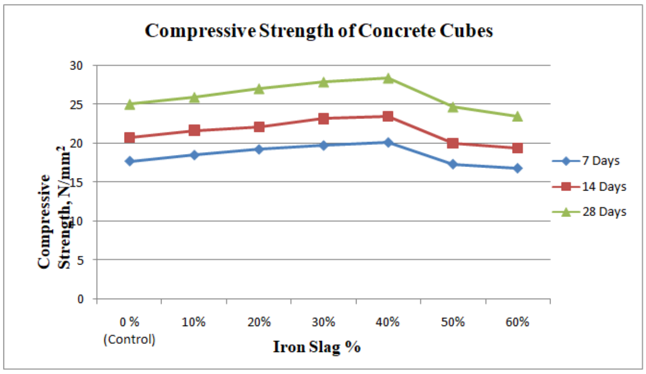
The experimental program included the following:

- Testing of properties of materials used for making concrete.
- Concerte mix (M20).
- Casting and curing of specimens.
- Tests to determine the compressive strength and split tensile strength and Flexural strength of concrete.



TEST PROCEDURE AND RESULTS

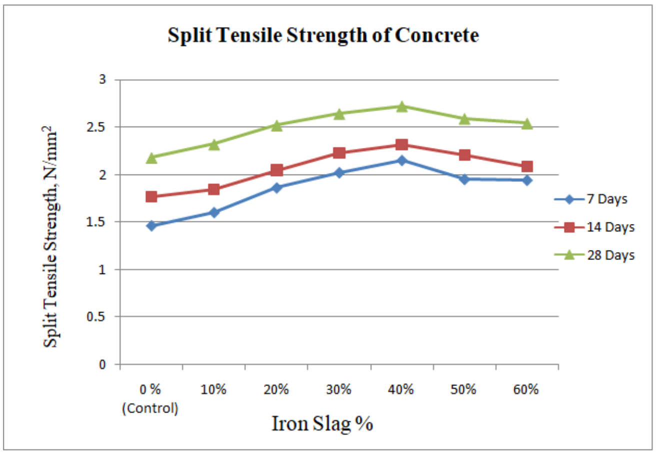
Mix	Compressive Strength (N/mm^2)			Average Compressive Strength (N/mm^2)		
	7 days	14 days	28 days	7 days	14 days	28 days
0 % (Control)	17.15	20.80	25.50	17.73	20.8	25.06
	17.85	21.10	24.70			
	18.20	20.50	25.00			
10%	18.40	21.35	25.90	18.51	21.75	25.95
	18.50	21.80	26.00			
	18.65	22.10	25.95			
20%	19.25	22.25	26.90	19.25	22.23	27.05
	19.10	22.15	27.00			
	19.40	22.30	27.25			
	19.65	23.10	27.60			
30%	19.70	23.40	28.00	19.76	23.25	27.90
	19.95	23.25	28.10			
40%	20.15	23.45	28.40	20.16	23.55	28.40
	20.10	23.50	28.30			
	20.25	23.70	28.50			
50 %	17.10	19.90	24.50	17.33	20.05	24.70
	17.70	20.15	24.60			
	17.20	20.10	25.00			
60%	16.50	19.45	23.10	16.80	19.46	23.53
	16.90	19.75	23.50			
	17.00	19.20	24.00			



Splitting tensile strength of concrete mixes with iron slag

Mix	Split Tensile Strength (N/mm^2)			Average Split Tensile Strength (N/mm^2)		
	7 days	14 days	28 days	7 days	14 days	28 days
CM	1.26	1.69	2.11	1.46	1.77	2.18
	1.45	1.78	2.18			
	1.67	1.85	2.25			
10%	1.45	1.95	2.30	1.60	1.85	2.32
	1.70	1.90	2.28			
	1.65	1.70	2.40			
20%	1.80	1.98	2.48	1.86	2.05	2.52
	1.86	2.05	2.55			
	1.92	2.12	2.54			
30%	1.95	2.20	2.60	2.02	2.23	2.64
	2.05	2.24	2.67			

	2.08	2.27	2.65			
40%	2.14	2.32	2.70	2.15	2.32	2.72
	2.17	2.35	2.75			
	2.15	2.30	2.73			
50 %	1.25	1.65	2.10	1.22	1.59	2.05
	1.20	1.60	2.05			
	1.22	1.53	2.02			
60%	1.18	1.62	1.96	1.17	1.54	1.94
	1.15	1.52	1.95			
	1.20	1.50	1.91			



CALCULATION OF OPTIMUM CONTENT FOR MIX

The test result conducted in different days with the different percentage of iron slag mix, it is observed that the optimum content of iron slag in concrete is 40 % with replacing by weight of sand. The variation of compressive and split tensile strength with the different percentage of mix can be concluded from the graph shown in graph 4.5. However at the same percentage of iron slag in the mix, the split tensile strength improvement is comparatively more.

S.NO	No. of Days	Iron slag	Compressive strength, %	Split tensile strength
1	28	10	3.42	6.03
2	28	20	7.35	13.49
3	28	30	10.17	17.42
4	28	40	11.76	19.85
5	28	50	-1.49	-6.34
6	28	60	-6.50	-12.37

RECOMMENDATIONS

- On the basis of this research work it can be concluded that the optimum percentage of iron slag is 40% and for the partial replacement with sand due to variations in the strength test.
- Result shows that the above percentage of iron slag can be used as a material to optimize the cost of cement concrete as iron slag is industrial waste material.
- In comparison with traditional concrete this material is more durable hence it gives better performance in the design life of structures.

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