FLEXURAL STRENGTH OF BLAST FURNACE SLAG CONCRETE

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Abstract: The study presents the experimental investigation carried out to evaluate effects of replacing coarse aggregate with that of blast furnace slag on various concrete properties. The basic objective of this study was to identify alternative source of good quality aggregate because the natural stone quarries are depleting very fast due to rapid pace of construction activities in India .The effect of replacing natural coarse aggregate by slag on the compressive strength of cubes, split tensile strength of cylinders and flexural strength of beams are evaluated in this study. Use of slag – a waste industrial by product of iron and steel production provides great opportunity to utilize it as an alternative to normally available aggregate. The test results of concrete were obtained by adding slag to coarse aggregate as a replacement of stone aggregate in various percentages of 0%, 20%, 40%, 60% and 100%. All specimens were cured for 28 days before testing. From the study it has been observed that the blast furnace slag aggregate could be a good replacement of stone aggregate.

I. INTRODUCTION

Concrete is an age old material. It can be used easily in any shape and size of structural member. The main ingredients of concrete are cement, sand and aggregate. So concrete can be considered to be an artificial stone obtained by binding together the particles of relatively inert coarse and fine materials with cement paste. The aggregates are generally cheaper than cement and impart greater volume stability and durability to concrete. The aggregate is used primarily for the purpose of providing bulk to the concrete. The aggregate provides about 70-75% of the body of the concrete and hence its influence is extremely important. The stone aggregate produced by crushing of stone obtained from mountains. The quarrying of stone causes number of environmental problem. Hence to replace these aggregate by slag not only allow the use of waste product but also avoid environmental problem. Slag is a waste produced during manufacturing of pig iron and steel. It consists of oxides of calcium, magnesium, manganese, aluminum, nickel and phosphorous. The major component in the blast furnace slag is SiO2. The physical properties of slag depends upon change in process of cooling, however the chemical composition remain unchanged. The slag produced in blast furnace during pig iron manufacturing is called blast furnace slag and slag produced at steel melting plant is known as steel slag. Large amount of industrial waste produced every year in developing countries. Total world steel production crossed 1200 million metric tons. In India, Slag output obtained during pig iron and steel production is variable and depends on composition of raw materials and type of furnace. For ore feed containing 60 to 65% irons, blast furnace slag production ranges from about 300 to 540 kg per ton of crude iron produced. Lower grade ores yield much higher slag fractions, sometimes as high as one tone of slag per ton of pig iron produced. The slag is produced in large amount and creates problem to environment when it is dumped, like, it affect the permeability of soil and increases the water logging problem, It causes respiratory problem to nearby residents and pollute ground water and adversely affects the landscape of the area. The industries have to pay huge amount for the disposal of this material. Hence, Problem of disposing slag is very serious and can be sort out by using it in concrete.

Figure 1.1: Blast Furnace Slag

MATERIAL USED:-

CEMENT (JK OPC): The cement used is 43 grade OPC of mark JK. The various tests conducted are given in Table 1.1.

Table 1.1: Physical Properties of Cement

Sr. No.	Name of Test	Observed value	Standard value as per IS: 8112-1989
1.	Normal consistency (%)	30%	……
2.	Setting time in minutes Initial setting Final setting	170 270	Not less than 30 minutes Not more than 600 minutes
3.	Soundness(mm)	2mm	Not more than 10 mm
4.	Fineness (sieve method)	2%	Not more than 10 %
5.	Compressive strength(N/mm^2) At 3 days At 7 days	 26.25 37.20	 Not less than 23 N/mm^2 Not less than 33 N/mm^2

II. FINE AGGREGATE

The material which is passing through 4.75 mm sieve is known as fine aggregate. The fine aggregate was used in this study confirming to IS: 383-1970, with properties as given in Table 1.2.

Table 1.2: Physical Properties of Fine Aggregate

Physical Tests	Values
Specific gravity	2.65
Fineness modulus	3.40
Bulk modulus(compacted)	1.46 kg/m^3
Bulk modulus(loose)	1.7 kg/m^3

COARSE AGGREGATE (NATURAL STONE)

The material which is retained on 4.75 mm sieve is known as coarse aggregate. The crushed aggregate is generally used as coarse aggregate. Locally available coarse aggregate having average size of 20 mm was used in this study confirming to IS: 383-1970, with properties as given in Table 1.3

Table 1.3: Physical Properties of Coarse Aggregate

Physical tests	Values
Specific gravity	2.7
Fineness modulus	3.72
Maximum size of coarse aggregate	20mm
Bulk modulus(compacted)	1.5 kg/m^3
Bulk modulus(loose)	1.7 kg/m^3

WATER: The water which was used in this experimental work was free from salts and other impurities. Usually tap water is used for the mixing of concrete as per IS Code 456-2000

III. BLAST FURNACE SLAG AGGREGATE

PHYSICAL TESTS

The slag is black glassy particle and in the form of boulders. First, the slag is crushed manually and passing through a sieve of 20 mm and retained on sieve of 4.75 mm. The various tests conducted are given in Table 1.4

Table 1.4: Physical Properties of Slag Aggregate

Physical tests	Values
Specific gravity	2.3
Maximum size of coarse aggregate	20 mm
Bulk modulus(compacted)kg/m^3	1.5
Bulk modulus(loose) kg/m^3	1.2

Table 1.5 Sieve Analysis of Coarse Slag Aggregate

Sieve	%age of wt. passing	Remarks
20	100	slag aggregate as per IS: 383-1970
16	56.50	
12.5	27.20	
10	7.40	
4.75	0.15	

CHEMICAL TEST

The chemical properties of blast furnace slag have been found using X-ray fluorescence and shown in Table 3.9.From the chemical composition, it has been observed that the slag contains about 33% silica and 21% of calcium oxide. Similarly, it has been observed that it contain 23% of ferrous oxide. The slag content present in the slag can contribute to form silicates in the body of concrete and hence increases the strength.

Table 1.6: Chemical Properties of Blast Furnace Slag

Chemical components	%age of chemical components
MgO	0.8868
Al_2O_3	8.6925
SiO_2	33.6942
P_2O_5	0.4752
SO_3	0.9498
K_2O	0.8946
CaO	21.9869
MnO	2.4709
Fe_2O_3	23.7346
NiO	6.2144

IV. CONCLUSION

Concrete is an age old material. Mainly it is constituted of cement , sand and aggregate made up of natural stone. In the present study, natural stone coarse aggregate is replaced by blast furnace slag's aggregate in proportion of 0%, 20%, 40%, 60% and 100% in concrete. The various structural characteristics e.g. compressive strength, split tensile strength and flexural strength of concrete made up of blast furnace slag has been evaluated in this study. The flexural behavior of reinforced beam with different slag ratio has been studied and energy absorption capacity, first crack load, ultimate load, flexural toughness factor are observed experimentally and theoretically. The following conclusion has been made from the present study.

- The compressive strength of concrete made up op 100% slag aggregate has been increased upto 10% in comparison to conventional concrete having stone aggregate.
- The split tensile strength of cylinders with 40% slag aggregate has been decreased upto 48% in comparison to conventional concrete and further increase in quantity of slag beyond 40%, the split tensile strength increases about 10%.

FUTURE STUDY

The reinforced beam is analyzed theoretically with the help of limit state method. The ultimate load obtained is 116.4 KN. Actual span/depth ratio is also less than allowable span/depth ratio.

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