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EXPERIMENTAL STUDY OF BLAST FURNACE SLAG CONCRETE

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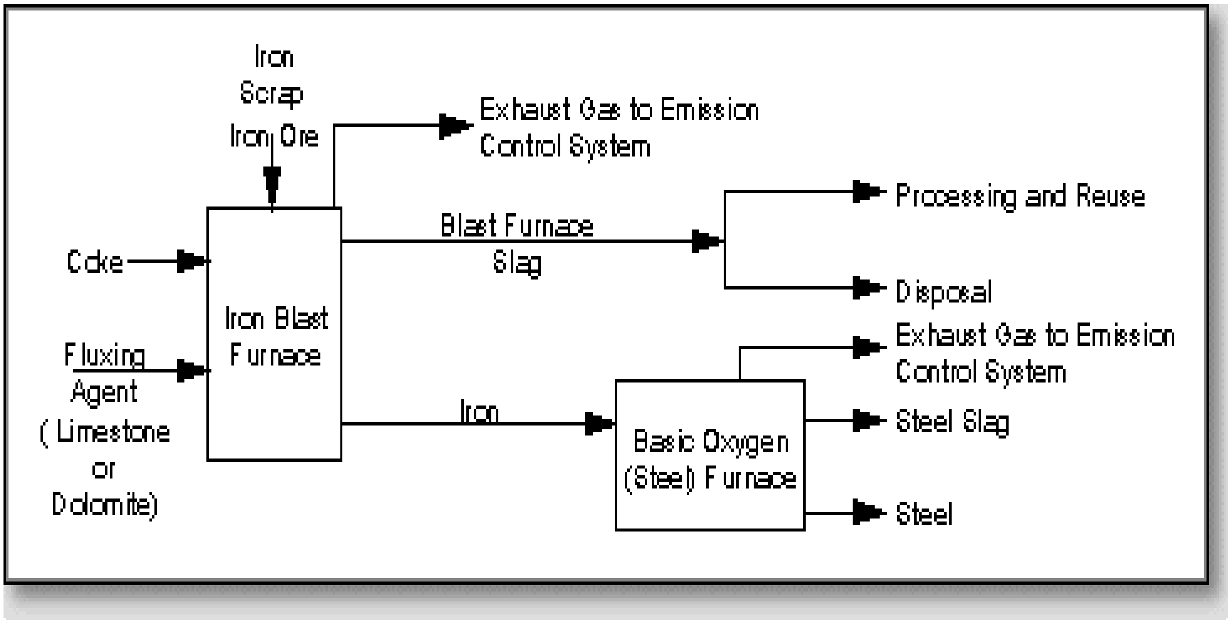
ABSTRACT
The study presents the experimental investigation carried out to evaluate effects of replacing fine aggregate with that of blast furnace slag on various concrete properties. The basic objective of this study was to identify alternative source of good quality aggregate because the natural stone quarries are depleting very fast due to rapid pace of construction activities in India .The effect of replacing natural fine 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 fine aggregate as a replacement of stone aggregate in various percentages of 0%, 20%, 40%, 60%, 80% 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.

KEYWORDS: Cement, Fine aggregate, Coarse aggregate, Blast Furnace Slag.

INTRODUCTION
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 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.

Blast furnace slag is a nonmetallic co-product produced in the process. It consists primarily of silicates, alumina-silicates, and calcium-alumina-silicates. The molten slag, which absorbs much of the sulfur from the charge, comprises about 20 percent by mass of iron production. Figure presents a general schematic, which depicts the blast furnace feed-stocks and the production of blast furnace co-products (iron and slag).



NEED OF PRESENT STUDY:-
In india the blast furnace slag can easily be meet in the earthquake and due to various causes. the industrial waste is also used in the blast furnace slag material. utilization of these are being encouraged in construction. in the present study the use of blast furnace slag as replacement of coarse aggregate has been discussed. as a replacement of stone aggregate partially or fully in making concrete therefore, the study introduced the effect of use of blast furnace slag. in the present study the flexural behavior of rcc beam casted with blast furnace slag have been observed.

PROPOSED ALGORITHM

Swami R.N. and Lambert G.H.
The primary effect of ground slag admixtures on the properties of the freshly mixed concrete are to provide better workability and finish ability. As a result, lower water-cement ratios may be used in many cases. Concrete mix proportioning for optimum performance with the slag can be accomplished in accordance with ACI Committee 211 recommendation s. The designs will usually indicate decreased amounts of water, fine aggregate, total cementations material, or a combination thereof, per unit volume of concrete compared to a mixture with Portland cement as the entire cementations material .The effects of partial replacement of Portland cement with ground slag on the properties of hardened concrete have been extensively investigated and reported in recent ye a r s. Both laboratory testing and field experience have shown that properly proportioned slag-port land cement concretes have the following properties compared to regular Portland mixes .

Tadao maehana Hirotoshi sawamura
Blast-furnace slag mixed fine aggregates: When the components of a blast-furnace slag mixed fine aggregate are to be added to the concrete mixer during concrete mixing, quality can be ensured by storing and controlling the quality of the blast-furnace slag fine aggregate and the ordinary fine aggregate separately. In the case of premixed blast-furnace slag mixed fine aggregate, quality control shall be maintained by the use of test certificates before and after aggregate premixing. The BFS mixing ratio and uniformity of mixing may be ascertained by conducting tests in accordance with the JSCE standard "Test Method for Blast-furnace slag Fine Aggregate Mixing Ratio in Blast-furnace slag Mixed Fine Aggregate (Draft),"if necessary.

Monshi A. et al.
Used slag from iron and steel industry as raw material for Portland cement production before firing. The slag from blast furnace and converter are mixed with limestone of six different proportions. The ground material is fired in rotary kiln having temperature of 1350˚C for I hour to have clinker which were crushed and mixed with gypsum of 3%. It

was observed that Cement prepared with 49% iron slag, 43% calcium lime and 8% steel slag gives the compressive strength of Type-1 ordinary Portland cement (OPC).

CONCLUSION OF LITERATURE REVIEW

It has been observed that on the basis of above literature review various researchers studied different types of slag in concrete in different forms i.e. fine aggregate, coarse aggregate, Ultra fine aggregate. Various strength parameters like compressive strength, flexural strength, split tensile strength etc. are evaluated and showed that by incorporating slag partially or fully in concrete, the mechanical properties of concrete can be improve. However, the use of blast furnace slag as a fine aggregate has not been studied yet. Hence, in the present study, blast furnace slag is used as fine aggregate in different proportion i.e. 0%, 20%, 40%, 60%, 80% and 100%. The compressive strength, split tensile strength and flexural behavior of reinforced beams are evaluated and compared with that the strength of control mix.
CEMENT (JP OPC): Cement used is 43 grades OPC of mark JP.

Table 3.1: Physical Properties of Cement

Sr. No.	Name of Test	Observed value	Standard value as per IS: 8112-1989
1.	Normal consistency (%)	29%	………
2.	Setting time in minutes (a) Initial setting (b) Final setting	 165 270	 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	25.18 36.20	Not less than 23 N/mm^2 Not less than 33 N/mm^2

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.

COARSE AGGREGATE (NATURAL STONE):-
The material which is retained on 4.75 mm sieve is known as coarse aggregate. Locally available coarse aggregate having average size of 20 mm was used in this study confirming to IS: 383-1970.

BLAST FURNACE SLAG AGGREGATE: -
The slag is black glassy particle and in the form of boulders. First, the slag is crushed manually and passing through a sieve of 4.75mm.

CONCRETE MIX PROPORTION:-
The concrete mix proportion for different slag ratio is

Table 3.10: Concrete Mix Proportion for M40 Grade

Mix proportion	**Percentage variation of blast furnace slag**					
	0%		0%		0%	
Cement	350	Cement	350	Cement	350	Cement
W/c ratio	0.40	W/c ratio	0.40	W/c ratio	0.40	W/c ratio
Coarse aggregate	1140	Coarse aggregate	1140	Coarse aggregate	1140	Coarse aggregate
Fine aggregate	896	Fine aggregate	896	Fine aggregate	896	Fine aggregate
slag aggregate	0	slag aggregate	0	slag aggregate	0	slag aggregate

CASTING OF SPECIMENS :-
Cubes, cylinders and beams moulds were cleaned thoroughly. To inner surface of the moulds oil thin layer was applied to avoid the adhesion of concrete with the inner side of moulds.

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Cube moulds of size 150×150×150 mm were used to determine the compressive strength. Same as to determine the split tensile strength, cylindrical moulds of diameter 150mm and length 300 mm were used and to determine the flexural strength, the beam specimen of size 700× 150× 150 mm were used. Limited quantity of specimen were casted to have strength at 28 days because of scarcity of material i.e. blast furnace slag.

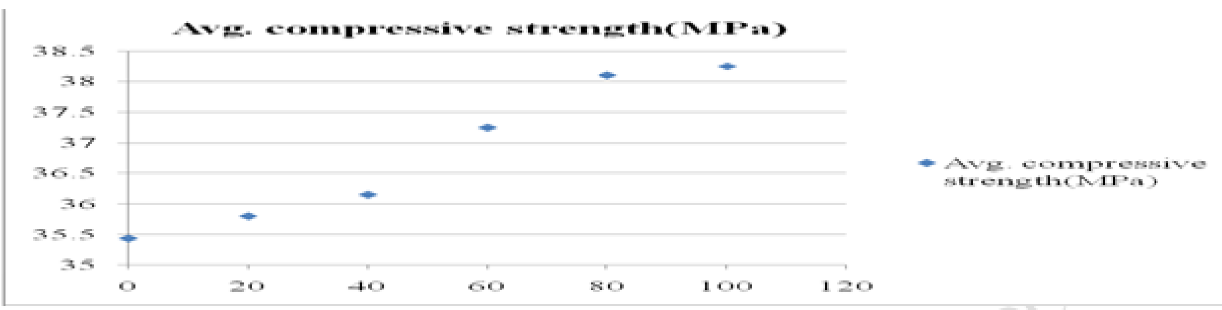
TESTING :-

1. **COMPRESSION TEST OF CUBES:-** Compression testing machine (CTM) of 300 tones capacity . Compressive strength of concrete cubes of size 150× 150 × 150 mm was determined.
2. **SPLIT TENSILE TEST OF CYLINDERS: -** Split tensile test is an indirect method to determine the tensile strength of concrete. The tests consist of applying compressive line loads along the opposite generators of the concrete cylinder placed with its axis horizontal between the platens. The cylinder of size 150mm diameter and 300 mm height was cast to check the splitting tensile strength of concrete.
3. **FLEXURAL STRENGTH TEST OF BEAMS: -** At which the concrete member may crack Flexural strength is essential to estimate. The specimen cast for this test was of size 700 ×150× 150mm as shown in figure. Universal testing machine (UTM) of capacity 100 tones was used to obtain the flexural strength of beams. Two point loading system was adopted for the test. The specimens were tested at 28 days of casting.

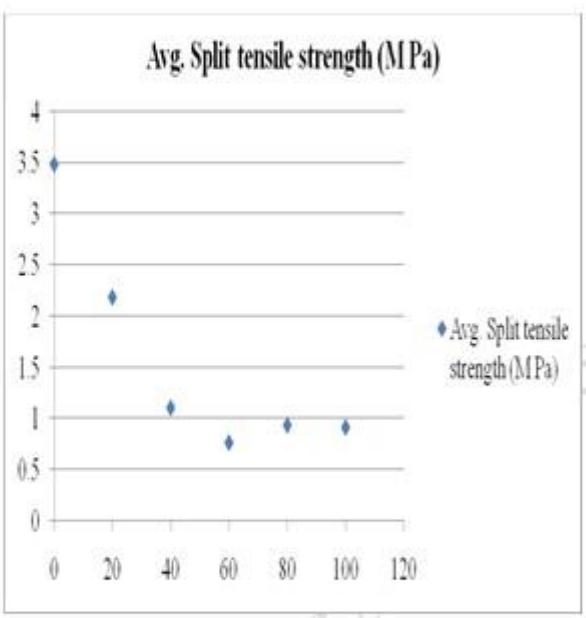
EXPERIMENT AND RESULT

All the Specimens were casted and tested after 28 days. The compressive strength split tensile strength, first crack load, ultimate load. Flexural behavior of reinforced beams is studied by load deflection curve.

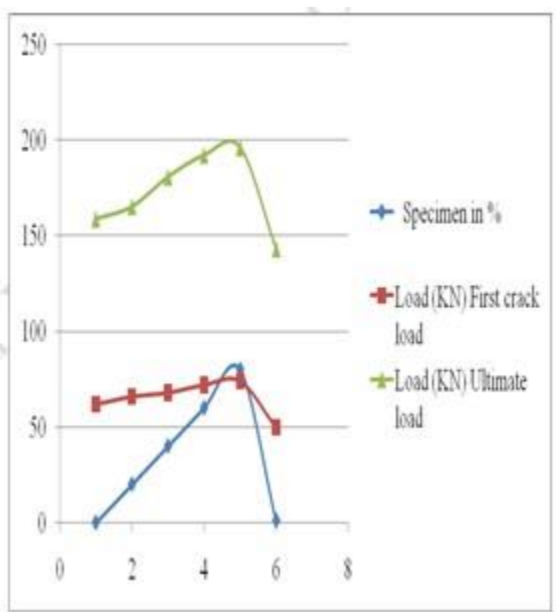
1.COMPRESSIVE STRENGTH OF CUBES



2.SPLIT TENSILE STRENGTH OF CYLINDERS



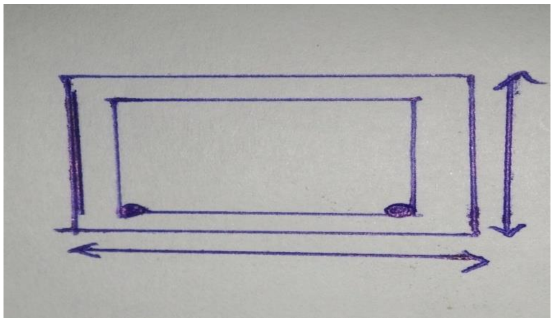
3. FLEXURAL STRENGTH OF BEAMS



THEORTICAL RESULTS:
The plain cement concrete have more compressive strength and minimum tensile strength. Normally, the tensile strength of concrete is about 10-15% of its compressive strength. Hence, if a beam is made of plain cement concrete, it has a very min load carrying capacity since its low tensile strength limits its overall strength. So, reinforcement is used to increase its tensile strength. The concrete reinforced by steel bars is called reinforced cement concrete. The joint action of steel and concrete section is dependent on the following important factors:

1. Bond development between concrete and steel bars.
2. Steel bar corrosion is absent here.
3. Equal expansion of concrete and steel bar

ANALYSIS OF R/F BEAM:-.



Cross Section of Beam
150×150 mm
b= 150mm, d= 125mm, d'= 25, M40, Fe 500
A_{st}= 226 mm^2 (12mm diameter)
A_{sc}= 226 mm^2 (12mm diameter

Solution by working state method

1. Design constant
   For M40, Fe500
   C=13N/$mm^{2,}$
   t=275N/$mm^{2,}$
   m=280/3c=7.18,
   $k=m_c/(m_c+t)=0.253$,
   j=1-k/3=0.916,
   R=0.5cjk=1.506
2. Type of reinforcement
   $n_c = k\,d$
   n_c =0.253*125=31.62
   B n*n/2= m A_{st} (d-n)
   $bn^2/2$ =7.18*226(125-n)
   $75n^2$=202835-1622.68n
   $75n^2$-1622.68n-202835= 0
   n^2- 21.63n -2704.46=0
   For value of n
   n=63.93
   Where $n_c<n$
   So, section is over reinforced

3.Lever arm
   Lever arm=d-n/3
   =125-63.93/3=103.69
4. Moment of resistance
   M_r=0.5 c n b(d-n/3)
   $M_r=0.5*13*63.93*150(103.69)10^{-6}$
   $M_r=6.4*10^{-6}$ KN-M
5. Max bending moment
   B.M= $wl^2/8$
   B.M= $w*(0.700)^2/8$
   $(6.4*8)/(0.700)^2=w$
   W=105.46KN

SUMMARY:-
The reinforced beam is analyzed theoretically with the help of working state method. The ultimate load obtained is 105.46 KN. Actual span/depth ratio is also less than allowable span/depth ratio

CONCLUSION
The following conclusion has been made from the present study.

- The compressive strength of concrete made up of 100% slag aggregate has been increased up to 7.35% in comparison to conventional concrete having stone aggregate.

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- The split tensile strength of cylinders with 40% slag aggregate has been decreased up to 40% in comparison to conventional concrete and further increase in quantity of slag beyond 40%, the split tensile strength increases about 10%.
- The maximum value of first crack load has been observed as 72KN with 60% replacement of slag correspondence to 61.67 KN in case of conventional concrete with stone aggregate.
- The ultimate flexural load was observed maximum with 60% slag aggregate i.e. 192 KN and the ultimate flexural load in case of conventional concrete beam with stone aggregate was observed as 156.8KN.
- The moment of resistance of reinforced beam is obtained analytically as $6.4*10^{-6}$.

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