Scientific Journal of Impact Factor (SJIF): 4.72
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 8, August -2017

USE OF BLAST FURNACE SLAG IN CONCRETE

Anirudh Kumar

BRCM College, Haryana, India

ABSTRACT:- *Concrete is a composite material composed mainly of water, aggregate, and cement. Often, additives and reinforcements (such as rebar) are included in the mixture to achieve the desired physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that is easily molded into shape. Over time, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with many uses. 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 cheaper than cement and impart greater volume durability and stability to concrete. Primarily for the purpose of providing bulk to the concrete the aggregate is used. 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 the aggregate is used for 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 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.*

INTRODUCTION

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.

TYPES OF SLAG:

1) 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.
2) Steel Slag is the glass-like by-product left over after a desired metal has been separated (i.e., smelted) from its raw ore. Slag is usually a mixture of metal oxides and silicon dioxide. However, slag can contain metal sulfides and elemental metals. While slag are generally used to remove waste in metal smelting, they can also serve other purposes, such as assisting in the temperature control of the smelting, and minimizing any re-oxidation of the final liquid metal product before the molten metal is removed from the furnace and used to make solid metal.

USES: For producing Portland slag cement granulated blast furnace slag is used as a Pozzolanic material. For insulation purposes Blast furnace slag is used in making mineral wool. It is used as alternative raw material for clinker production and such use can reduce a cement plant's fuel consumption and overall emission of carbon dioxide per ton of cement. In slag dryer the granulated slag obtained from various steel plants is dried. The clinker is ground in ball mill with 6% gypsum 40-50% dry slag. The resultant product is Portland slag cement. Portland blast furnace slag cement contains up to 60% ground granulated slag from steel production processes. For other consuming sectors like land filling, ballasting and road making, the cooled slag is crushed by machines or broken manually by hammers into smaller pieces and supplied to the various consumers. The Blast Furnace slag in India is used mainly in the cement manufacture and in other unorganized work, such as, railway ballast and landfills. A small quantity is also used by the glass industry for making slag wool fibers.

LITERATURE REVIEW

Manufacturing Portland cement (PC) is a major contributor of greenhouse gases, responsible for about 5 % of all global carbon dioxide emissions .In comparison, the production of ground granulated blast-furnace slag (GGBS) requires less than a fifth of the energy and produces less than a tenth of the carbon dioxide emissions. It is well known that blast furnace slag cement (BFSC) has been manufactured by integrating GGBS with cement clinker or by separate grinding. For a long period of time, the application of GGBS was limited to the production of BFSC. Due to its less grind ability, the surface area of the produced BFSC was even lower than that of commercial PC and its reactivity was limited. With advancement in technology, finer GGBS (particle size less than 10 lm) with increased reactivity was produced. The secondary pozzolanic reactions can result in reduced pore connectivity in the concrete. Therefore, partial replacement of PC with GGBS can significantly reduce the risk of sulfate attack, alkali–silica reactions and chloride penetration and increase compressive strength Concrete carbonation is one of the most important phenomena affecting the durability of concrete. Concrete carbonation has been studied extensively over the last few decades. However, due to the time consuming process of carbonation, many researchers have used accelerated carbonation test to shorten the experimental time. Considering the complex process of carbonation and the number of parameters involved, there are always some uncertainties in the accelerated carbonation test results. Most importantly, the moisture content and moisture profile of the concrete before the carbonation test can significantly affect the test results. The CO2 from the environment will dissolve in the pore solution through the partially filled pore system and will react with the cement hydration products. If the concrete is fully saturated, carbonation will be slow. Based on the quality of concrete and the environmental conditions, concrete will achieve equilibrium moisture pro-file status after several months. To shorten this time, various preconditioning techniques were employed before the carbonation test. Oven drying is one of the most popular methods. However, the high temperature drying can damage the pore structure of concrete.

Different sciences are developing fast in today's world. In recent decades, man has seen increased relationship of sciences in different fields and the more relationship has led to the appearance of the more new knowledge and technology. Nowadays, one of the most important problems of man are technical and engineering problems. The complexity of the most of the problems in this field has made the experts of this field use the new mathematical and modeling methods for solving this type of problems. Intelligent systems can be used as suitable tools for identifying complex systems, due to their ability of learning and adaptation. One of the complex problems in our world is the problem of the concrete. The main criterion for evaluating the compressive strength of concrete is the strength of the concrete on 28th day. The concrete sample is tested after 28 days and the result of this test is considered as a criterion for quality and rigidity of that concrete. Concrete is the most widely used structural material in constructions in the world. Massive Concreting in huge civil projects like dams, power plants, bridges and etc… usually is not practicable and it is necessary to be performed in several layers and the compressive strength of each layer should not be less than the specified compressive strength. Therefore one should wait 28 days to achieve 28-day strength of each layer of concrete. Thereupon if we have n layers of concrete we need 28×n days to complete the total project.

EXPERIMENTAL STUDY

(A) MATERIALS USED:

1) CEMENT (JP OPC): The cement used is 43 grades OPC of mark JP.

2) FINE AGGREGATES: 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

3) COARSE AGGREGATES (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,

4) BLAST FURNANCE SLAG AGGREGATES:

- **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 4.75mm.

Physical Properties of Slag Aggregate & Sieve Analysis of Fine Slag Aggregate

Physical tests	Values	Sieve	%age of wt. passing	Remarks
Specific gravity	2.3	4.75mm	99.98	slag aggregate as per IS: 383-1970
Max. size of coarse aggregate	20 mm	2.36mm	55.38	
Bulk modulus (compacted)kg/m^3	1.5	1.18mm	28.20	
Bulk modulus (loose) kg/m^3	1.2	600 µ	6.90	

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

- **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.

(B) <u>TESTING</u>

1) Compressive Strength of Cubes:

Compressive strength will increase on increasing the blast furnace slag concrete. The highest compressive strength of cubes was achieved with 100% replacement of slag, which was found about 38.25 M Pa. The compressive strength of cubes of control mix was found to be 35.44 M Pa. The average 28 days compressive strength of concrete mix for different mix proportion shown in below Table and its graphical representation is shown in Figure below:

Table: Compressive Strength of Cubes at 28 days

S.No	Replacement of slag (%)	Avg. compressive strength(MPa)	%age of increase in compressive strength
1	0	35.44	……….
2	20	35.80	1.005
3	40	36.15	1.96
4	60	37.25	4.86
5	80	38.10	6.98
6	100	38.25	7.35

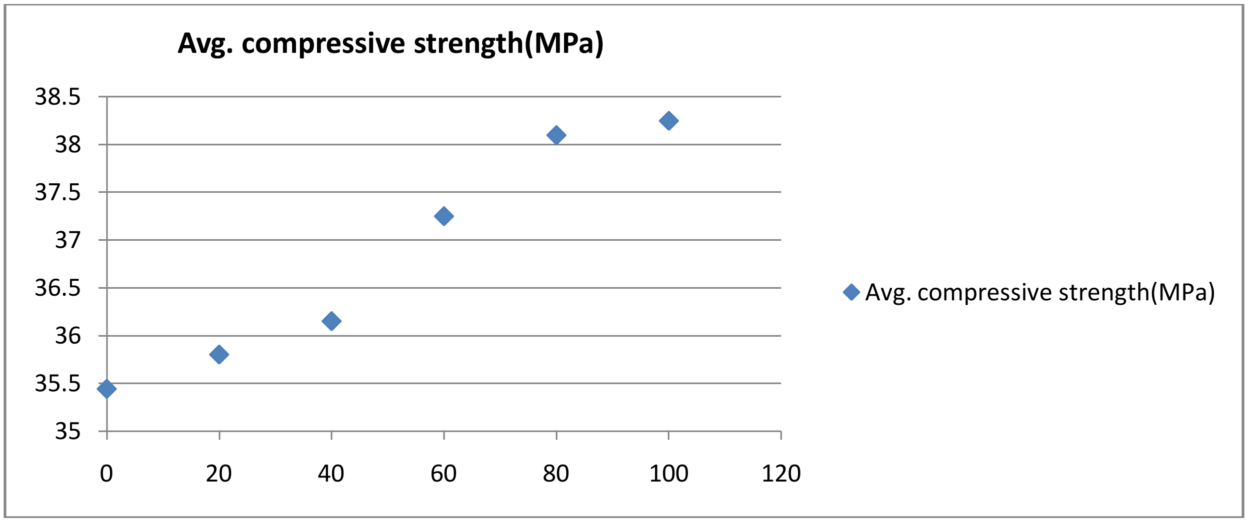

Figure: compressive strength V/s percentage of slag

2) Split Tensile Strength of Cylinders

As the slag mix the split tensile strength will decreases. The lowest value obtained when replacement of slag is 60% i.e. 0.76. Further on increase in the quantity of slag beyond 40%, the split tensile strength increases up to a small extent and on 100% replacement of slag strength is 0.91. The average split tensile strength of cylinders of different mix proportion is given in Table below and its graphical representation is shown in Figure below of table:

Table: Split Tensile Strength of Cylinders

S.No.	Replacement of % slag	Avg. Split tensile strength (M Pa)	%age of increase in strength
1	0	3.48	……….
2	20	2.18	-37.36
3	40	1.10	- 68.39
4	60	0.76	-78.16
5	80	0.93	-73.27
6	100	0.91	-73.85

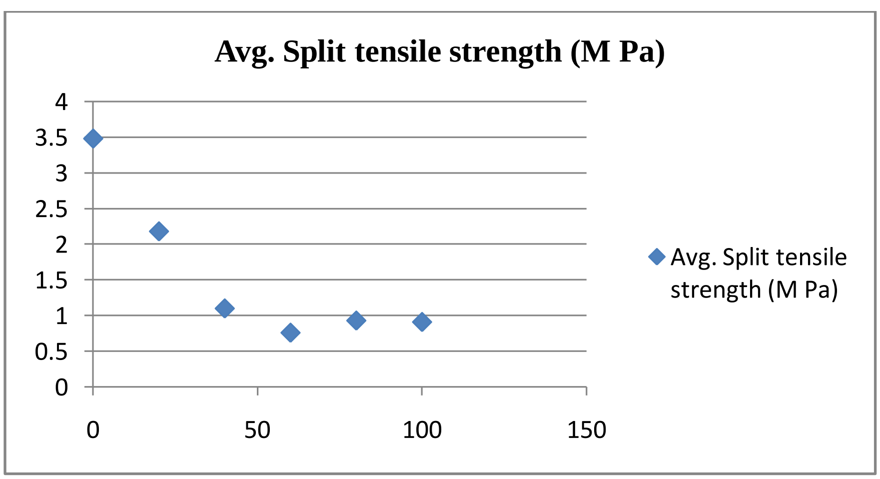

Figure: split tensile strength of cylinders V/s. percentage of slag

3) Flexural Strength of Beams

Flexural strength or ultimate moment (strength) for reinforced beams is defined as the moment that exists just prior to the failure of the beam. In order to evaluate this moment, we have to examine the strains, stress and forces that exist in the beam. The load v/s deflection curve is drawn for different beams with different percentage ratio of slag. The flexural strength of beams with different quantity of slag are calculated and compared with the beams of control mix. The flexural behavior of beams at 28 days is shown in above table and load v/s deflection curve for different beams are shown in fig. The first crack is also noticed for each beam.

Table: Flexural Behavior of Beams at 28 Days

Specimen in %	Load (KN)	
	First crack load	Ultimate load
0	62	158.6
20	66	165
40	68	180.6
60	72	192
80	74	196
100	49.86	142.8

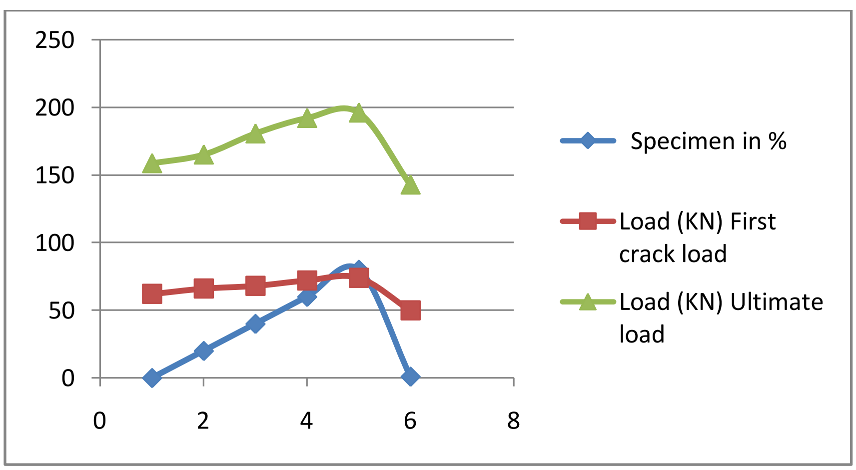

Figure: Variation of Toughness Index of Reinforced Beam

CONCLUSION

1. 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.
2. 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%.

3. 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.
4. 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.

REFERENCES

1. Atul Dubey, Dr. R. Chandak, Prof. R.K.Yadav Effect of blast furnace slag powder on compressive strength of concrete International Journal of Scientific & Engineering Research, Volume3, Issue8, August-2012 1ISS2229-5518.

2. Bahador Sabet Divsholi, Tze Yang Darren Lim, and Susanto Teng (June 2014), Durability Properties and Microstructure of Ground Granulated Blast International Journal of Concrete Structures and Materials Vol.8, No.2, pp.157–164.

3. Blast-furnace slag as a mineral admixture for concrete publication #C820448 Copyright © 1982, The Aberdeen Group All rights reserved

4. Dhanasri , Kishore Kumar "Performance of Concrete by replacing Coarse Aggregate and Fine Aggregate with Blast Furnace Slag and Crusher Dust" Vol. 2, Issue 12, December 2013.

5. Guo L.P., Sun W., Zheng K.R., Chen H.J., Liu B. (2007) "study on flexural fatigue performance and fractal mechanism of concrete with high proportion of ground granulated blast furnace slag" cement and concrete research vol. 37 pp-242-250

6. IS 2386 (Part-1): 1963(Reaffirmed 2007), "Methods of tests for Aggregate for concrete" Part 1 particle size and shapes, Bureau of Indian standards, New Delhi, India.

7. IS 383: 1970 (Reaffirmed 2002), "Specification for coarse and fine aggregate from natural sources for concrete ", Bureau of Indian Standards, New Delhi, India.

8. IS 4031 (Part 4): 1988 (Reaffirmed 2005), "Methods of Physical Tests for Hydraulic Cement", part 4 Determination of consistency of standard cement paste, Bureau of Indian Standards. New Delhi, India.

9. IS 456:2000, "Plane and Reinforced Concrete- code of practice (Fourth Revision), Bureau of Indian Standards, New Delhi, India.

10. IS 516: 1959(Reaffirmed 2004), "Methods of Tests for Strength of concrete", Bureau of Indian Standards. New Delhi, India

11. Khanzadi M. and Behnood Ali (2009) "mechanical properties of high strength concrete incorporating copper slag as coarse aggregate" construction and building materials vol.23 pp-2183-2188

12. Lee N.K. and Lee H.K. (2013) "setting and mechanical properties of alkali-activated fly ash/slag concrete manufactured at room temperature" construction and building materials vol. 47 pp- 1201-1209.