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Mechanical Properties of M30 Grade Concrete using Blast Furnace Aggregate- An Experimental Study

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***Abstract*—Cement concrete is the most widely used material for various constructions. Properly designed and prepared concrete results in good strength and durable properties. Even such well-designed and prepared concrete mixes under controlled conditions also have certain limitations because of which above properties of concrete are found to be inadequate for special situations and for certain special structures. Research for high strength and better performance characteristics of concrete are leading the researches for developing better structural concrete and new structural application techniques. New type of concrete have come in application in construction by using supplementary material like blast furnace aggregate for achieving better performance concrete than the normal concrete. Availability of mineral admixtures marked opening of a new era for designing concrete mix of higher and higher strength. As a result, the use of new mineral admixtures has considerably increased within the concrete industry. Lot of research is being carried on to find suitable coarse aggregate so that huge quantity of natural coarse aggregate needed to fulfill the increasing demand can be reduced, Thereby saving the rapid depletion of the natural resources i.e. rocks for coarse aggregate. Hence an attempt has been made in this investigation of partial replacement of Coarse aggregate with blast furnace aggregate.**
An experimental work was carried to know the various mechanical properties of M30 grade concrete replacing the natural coarse aggregate with Blast furnace aggregate. Cubes and cylinders were casted by partially replacing coarse aggregate with BFA at 10%, 20%, 30% and it was found that the compressive strength increased respectively by 15.70%,53.83% &and 21.12% respectively. Split tensile strength was found to be same as M30 Conventional concrete.

***Index Terms*— natural aggregate, blast furnace aggregate, compressive strength, split tensile strength, super plasticizer and workability.**

I. Introduction

Concrete is one of the versatile homogeneous materials, civil engineering has ever known. With the advent of concrete, civil engineering has touched highest peak of technology. Concrete is a material with which any shape can be cast and with equal strength or rather more strength than the conventional building stones. It is the material of choice where strength performance durability, impermeability, fire resistance and abrasion resistance are required. With the advancement of technology and increased field of application of concrete and motors, the strength, workability, durability and other characteristics of ordinary concrete can be made suitable for any situation. For this, definite proportions of cement, water, fine aggregate, coarse aggregate, mineral admixtures and chemical admixtures are required.

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Blast Furnace Slag is formed when iron ore or iron pellets, coke and a flux (either limestone or dolomite) are melted together in a blast furnace. When the metallurgical smelting process is complete, the lime in the flux has been chemically combined with the aluminates and silicates of the ore and coke ash to form a non-metallic product called blast furnace slag. It consists primarily of silicates, alumino silicates, and calcium-alumina-silicates. When ground to the proper fineness, the chemical composition and glassy (noncrystalline) nature of vitrified slags are such that when combined with water, these vitrified slags react to form cementitious hydration products Because of these cementitious properties, GGBFS can be used as a supplementary cementitious material either by premixing the slag with Portland cement or hydrated lime to produce a blended cement (during the cement production process) or by adding the slag to Portland cement concrete as a mineral admixture. Because of their more porous structure, blast furnace slag aggregates have lower thermal conductivities than conventional aggregates. Their insulating value is of particular advantage in applications such as frost tapers (transition treatments in pavement subgrades between frost susceptible and non-frost susceptible soils) or pavement base courses over frost-susceptible soils. LosAngeles test is also performed to find blast furnace slag aggregate's resistance to abrasion. Because of their more porous structure, blast furnace slag aggregates has lower thermal conductivities than conventional aggregates. Their insulating value is of particular advantage in applications such as frost tapers (transition treatments in pavement subgrades between frost susceptible and non-frost susceptible soils) or pavement base courses over frost-susceptible soils.

Photograph No. 1: Blast Furnace Slag

II. Experimental Program

Materials used for the casting of specimens are:

Cement: Ordinary Portland cement of 53 Grade from Ultra Tech conforming to I.S: 12269([6] is used.

Fine aggregate**:** Fine aggregate is natural sand obtained locally. The physical property like specific gravity was determined in accordance with IS 2386.Fineness modulus was found based on sieve analysis results for fine aggregate.

Coarse aggregate**:** The crushed coarse aggregate of 20mm max size angular obtained from the local crushing point, at Hyderabad is used in present study. The physical property like specific gravity was determined in accordance with IS 2386.

Blast furnace slag**:** Blast Furnace Slag is obtained from a steel industry located at Musheerabad, Hyderabad. Table I is showing the slag activity index requirements of ASTM C989 **.**

Density =2.56 g/cm^3

Abrasion value=32.25%

Specific gravity = 2.9

Fineness modulus= 6.35

Water**:** Locally available portable water was used for mixing and curing which is portable and free from injurious substances that may be deleterious to concrete or steel.

Super plasticizer**:** The super plasticizer used in this investigation roofplast SP-45 from Armstrong chemicals Ltd.

III. Methodology

The properties of cement such as normal consistency, specific gravity, fineness etc., and the properties of fine aggregates, natural coarse aggregate and blast furnace aggregate like specific gravity, grain size, and water absorption are determined using the suitable test procedures. Mix design was carried out as per IS 10262-2009 for M30 grade of concrete and the mix ratio obtained was 1:1.89:3.45 with 0.45 of water cement ratio. The details of the M30 grade Concrete mix used are tabulated in Table I is arrived at as per IS: 10262[8]. Workability test on concrete with different water-cement ratio is carried out. Concrete cubes of size 150mm x 150mm x 150 mm are casted in standard as per obtained mix proportions for determining the compressive strength and cylinders of diameter 150mm and height 300mm casted for determining the split tensile strength, cured and tested following standard procedures. Specimens were tested on 7th and 28th day of curing.

IV. Discussion Of Results

Results for compressive strength, split tensile strength was obtained by testing the cubes and cylinders on Digital Compression testing Machine (CTM). Slump cone test was carried out to determine the workability of BFA infused Concrete and was found to be improved after the use of super plasticizer. The tabulated results of workability compressive strength split tensile strength and of blast furnace aggregate concrete specimens with10%, 20%& 30% BFA replaced with natural aggregate and specimens with are shown in Table III, Table IV& Table V respectively.

It can be clearly noticed from Figure1& Figure 2 with 10% BFA replacement, the strength at 28 days was found to be 41.65 N/mm2. i.e. 15.70% more than natural aggregate concrete. With 20% BFA replacement, the strength at 28 days was found to be 59.44 N/mm2. i.e. 56.83% more than natural aggregate. With 30% BFA replacement, the strength at 28 days was found to be 43.6 N/mm2. i.e. 21.12% more than natural aggregate.

Split tensile Strength of M30 grade concrete replacement, the strength at 28 days was found to be 3.82 N/mm2. i.e. 0.26% less than natural aggregate concrete. With 20% BFA replacement, the strength at 28 days was found to be 2.93 N/mm2. i.e. 23.49% less than natural aggregate. With 30% BFA replacement, the strength at 28 days was found to be 2.94 N/mm2. i.e. 23.23% less than natural aggregate.

Workability was found to be 100mm to 120mm for all batches of concrete.

Each batch of concrete was tested for consistency immediately after mixing, by one of the methods described in IS: 1199-1959. Care was taken to ensure that no water or other material was lost; the concrete used for the consistency test was remixed with the remaining of batch before making the test specimen. Fig.1 & Fig.2 variation of compressive strength and variation of Split tensile strength with respect to percentage replacement of BFA.

TABLE I. SLAG ACTIVITY INDEX REQUIREMENTS OF ASTM C989

Chemical constituent as oxides	Type I cement	Type C Fly ash	Type F Fly ash	GGBFS
SiO_2	21.1	33.5	43.4	40.0
Al_2O_3	4.6	22.9	18.5	13.5
CaO	65.1	27.4	4.3	39.2
MgO	4.5	4.6	0.9	3.6
Fe_2O_3	2.0	6.1	29.9	1.8
SO_3	2.8	2.2	1.2	0.2

TABLE II. QUANTITY OF MATERIALS FOR GRADE M30

S.NO.	Material (Kg/m^3)	Quantity of Material (Kg)
1	Cement	360
2	Fine aggregate	681.4
3	Coarse Aggregate	1244
4.	water	158
5.	water cement ratio	0.45
6.	Workability	100mm-120mm
7.	Super Plasticizer	0.4%

Cement: fine aggregate: coarse aggregate is **1: 1.89: 3.45**
with w/c ratio **0.42**

TABLE III SHOWING WORKABILITY IN TERMS OF SLUMP

S.No	Mix ID	Slump in mm
1	G1 (0% BFA)	110
2	G2 (10% BFA)	100
3	G3(20% BFA)	105
4	G4(30%BFA)	108

TABLE IV SHOWING COMPRESSIVE STRENGTH OF M30 GRADE

S.No.	Mix ID	Compressive strength at 28 days(N/mm^2)
1	G1 (0% BFA)	36
2	G2 (10% BFA)	40.27
3	G3(20% BFA)	57.40
4	G4(30%BFA)	43.6

TABLE V SHOWING SPLIT TENSILE STRENGTH OF M30 GRADE

S.No.	Mix ID	Split tensile strength at 28 days(N/mm^2)
1	G1 (0% BFA)	3.83
2	G2 (10% BFA)	3.81
3	G3(20% BFA)	2.92
4	G4(30%BFA)	2.94

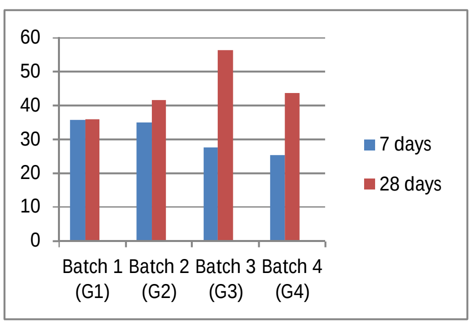

Fig.1 variation of compressive strength with respect to percentage replacement of BFA

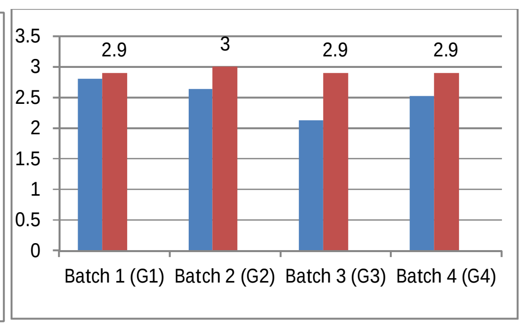

Fig..2 variation of Split tensile strength with respect to percentage replacement of BFA

V. CONCLUSIONS

Blast furnace slag is a by product and using it as aggregates in concrete will might prove an economical and environmentally friendly solution in local region. The demand for aggregates is increasing rapidly and so as the demand of concrete. Thus, it is becoming more important to find suitable alternatives for aggregates in the future. The results showed that it has properties similar to natural aggregates and it would not cause any harm if incorporated into concrete. The main purpose of concrete is to provide compressive strength to the structure and from the research work done; we found compressive strength of concrete made with 20% BFA is 59.44% more than conventional concrete of same grade. The results were encouraging, since they show that using blast furnace slag as coarse aggregates in concrete has no negative effects on the short term properties of hardened concrete.
Therefore it can be concluded that blast furnace aggregate is found to be excellent replacement as an aggregate for increasing compressive strength. But the Split tensile strength is found to be decreasing beyond 10% replacement. This may be because of its sharp, angular shape which may not give proper bondage with other aggregate.

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