COMPRESSIVE AND TENSILE STRENGTH STUDIES ON CEMENT CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY FLY ASH AND FINE AGGREGATE BY GRANULATED BLAST FURNACE SLAG

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ABSTRACT-Globally construction industry has enormous growth year by year. This leads to increase in need for construction materials, which can be obtained from the natural resources. By this the natural resources have depleted at a faster rate and cement production leads to higher amount of CO_2 emission. This directly leads to the environmental hazards for human and aqua life. So there is a necessity for finding the alternative material in order to conserve the earth for future generation. The growth in industrial progress leads to the increased production of industrial waste. Hence industrial waste materials management too is a challenging problem. There by handling and disposal of industrial waste is a big issue in this contemporary world. Keeping all the above problems in view, in this present experimentation, an attempt has been done to utilize the industrial waste products such as fly ash and granulated blast furnace slag in cement concrete by way of replacing them to cement and fine aggregate in the production of concrete.

The percentage of replacement of sand by granulated blast furnace slag are 0%,20%, 40%, 60%, 80%,100% and keeping fly ash as 25% constant for cement. This research is focused on the combined behaviors of granulated blast furnace slag and fly ash in study some of the strength properties. It can be seen that the effective utilization of both the materials will lead to the restriction of environmental hazards.

In this paper we focused on hardened properties of concrete, i.e. compressive strength and tensile strength.

I. INTRODUCTION

The global use of concrete is next to water in this era. As the demand for concrete as construction material increases, the demand and scarcity has been raised to a peak.

There has been rapid increase in the waste materials and by products production due to exponential growth rate of population from last few decades the basic strategies to decrease solid waste disposal problems have been focused at the reduction of waste production and recovery of usable materials from the waste as raw materials as well as utilization of waste as raw materials whenever possible. The beneficial use of industrial waste or by-products in concrete has been well known for many years and significant research has been published with regard to use of materials such as coal fly ash, pulverized fuel ash, blast furnace slag and silica fume as partial replacement for Portland cement. Such materials i.e., industrial waste utilization in concrete not only enhances durability but gives good strength when compared to Portland cement. The other main advantage of using such materials is to reduce the cost of construction and environmental pollution

In present the demand and scarcity has been raised and hence according to its concern many researches are carried out for alternate material. Granulated blast furnace slag is a by-product material produced from the manufacturing of iron. It is totally inert and its physical and chemical properties are similar to natural sand. Granulated blast furnace slag is a by-product in the manufacture of pig iron. It consists of iron and slag that are obtained in same orders. The slag is a mixture of lime, silica, and alumina in same proportion. The composition of granulated blast furnace slag is determined by that of ores fining stone and impurities in the coke charged in to blast furnace. Similarly M-sand also used as fine aggregates. M-sand is processed from the crushed rock of gravel.

ADVANTAGES ON ADDITION OF FLY ASH IN CONCRETE

- Increased compressive strength (late)
- Increased workability
- Reduced heat of hydration (Canada found that 10 ft cubes had a temperature rise of Only 35^o Celsius vs. 65^0 using Portland cement).

SCOPE

Fly ash is becoming a major part of the mix design for the application of concrete. The primary objective of this report is to introduce the general behavior of concrete when a percentage of cement is replaced by fly ash.

OBJECTIVE

The main objective is to study the effect of utilization of GBF slag in concrete. Along with the use of fly ash. The fine aggregate is replaced by GBF slag in various levels and cement has been replaced by 25% fly ash as constant by weight. The GBF slag replacement is done in weight batching basis.

II. LITERATURE REVIEW

- KeunHyeok Yang, Jin Kyu Song, Jae-Sam Lee, [14] 2010 studied alkali activated mortars and concrete using light weight aggregates. Test results showed that the compressive strength of alkali activated mortar decreased linearly with the increase of replacement level of light weight fine aggregate regardless of the water Chen Meizhu, Zhou Mingkai, Wu Shaopeng, [9] 2007 worked on mortar made up of ground granulated blast furnace, gypsum, clinker and steel slag sand. The experimental results show the application of steel slag sand may reduce the dosage of cement clinker and increase the content of industrial waste product using steel slag sand.

- Isa Yuksel, Omer Ozkan, TurhanBilir, [5] 2006 experimented use of non-ground granulated blast furnace slag as fine aggregate in concrete. The study concluded that the ratio of GGBs/sand is governing criteria for the effects on the strength and durability characteristics.
- Juan M. Manso, et al.,[6] 2004 carried out work in laboratory to produce concrete with good properties using oxidizing GBF slag as fine and coarse aggregate. The concrete was tested for durability characteristics like soundness, leaching test, accelerated ageing test etc. The durability of the GBF slag concrete was found to be acceptable, especially in the geographical region for which its use was proposed, where the winter temperature hardly ever falls below 32˚F (0˚C). binder ratio.
- R.C. Sharma et.al [2] discussed the classified Indian fly ash basedss on the shape of particles as one of the parameters. According to him group fly ashes contained mainly spherical particles with the size range between 2-25m. The surfaces of glassy spheres in the group are predominantly smooth without any deposit, only some adherence was observed.
- U. Dayal et al [4] have reported the specific gravity of Indian ashes to range between 1.94 and 2.34 with a mean value of 2.16 and standard deviation of 0.21. The specific gravity of flyash decreases as the partial size increase. The specific gravity increases when the fly ash particles were crushed typical value of the surface of Indian fly ashes (3267 to 6842 cm^2/g) were comparable with that of the foreign ashes (2007 to 6073 cm^2/g).
- M.J. Shannag [5] studied the behavior of high strength concrete containing natural pozzolana. He designed for very high strength concrete with a compressive strength in the range of 69-110Mpa with locally available natural pozzolana. (Volcanic tuff from Jai Rimah region of north eastern jordan). He concluded that certain natural pozzolana combination can improve the strength of mortar more than the ordinary cement concrete.
- C Freeda Christy and D Tensing [15] They have investigated about the results of the cement mortar of mix proportion 1:3 , 1:4:5 and 1:6 cement mortar in which cement is partially replaced with class-F fly ash as 0%, 10%, 20%, 25%, and 30% by weight of cement .Richer the mix , higher the compressive strength has been obtained even with partial replacement of fly ash with cement.

III. MATERIALS AND PROPERTIES

CEMENT: Cement is the most important material in the concrete and it act as the binding material. Ordinary Portland cement of 43 grade manufactured by Penna cements is used in this investigation.

Fly Ash: The fly ash used in the present work is obtained from RTPP industry. MUDDUNURU, Kadapa Dist., It is used at constant percentage of 25 % replacing cement in all the mixes

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Aggregate: The basic objective in proportioning any concrete is to incorporate the maximum amount of aggregate and minimum amount of water into the mix, and thereby reducing the cementitous material quantity, and to reduce the consequent volume change of the concrete.

Coarse aggregate: Selection of the maximum size of aggregate mainly depends on the project application, workability, segregation, strength and availability. In this research aggregates that are available in the crusher nearby was used. The maximum size of aggregate was varying between 26 -12.5 mm. In this project 20mm size aggregate has been used.

Fine aggregate: The amount of fine aggregate usage is very important in concrete. This will help in filling the voids present between coarse aggregate and they mix with cementitous materials and form a paste to coat aggregate particles and that affect the compact ability of the mix. The aggregates used in this research are without impurities like clay, shale and organic matters. It is passing through 4.75mm sieve.

Granulated Blast furnace slag: Granulated Blast furnace slag is an industrial by-product obtained during the matte smelting and refining of pig iron. It has been estimated that approximately 300 to 540 kg per tonne of pig or crude iron is are produced. Although Granulated Blast furnace slag is used in many of the industries large amounts of the slag is still left out as dumping waste. In this project we are using the slag that had been produced in the GERDAU Steel Ltd. Tadipathri

Fly Ash:
Fly ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by electrostatic precipitator. It is most widely used pozzolanic material all over the world. The use of fly ash as concrete admixture not only extends advantages to concrete but also contributes to environmental pollution control.

MIX PROPORTIONING

A concrete mix of M_{20} grade has been planned in this investigation. The mix proportions are 1:1.54:2.99 with water cement ratio 0.5. There are various methods of mix proportioning .Mix proportioning was based on the water cement ratio (water/cement) and the density of the concrete is considered as 2400kg/m^3. Quantity of water is taken according to slump of concrete 0.5 for economical purpose.
For the present investigation purpose the fine aggregate is replaced by Granulated Blast furnace slag and in percentages respectively 0, 20, 40, 60, 80 and 100 percent for the different mixes. The mix proportions for different mixes are presented below.

M1-	Fly Ash	0%,	GBFS 0%
M2-	Fly Ash	25%,	GBFS 20%
M3 -	Fly Ash	25%,	GBFS 40%
M4-	Fly Ash	25%,	GBFS 60 %
M5-	Fly Ash	25%,	GBFS 80%
M6-	Fly Ash	25%,	GBFS100%

SPECIMEN DETAILS

Standard specimens like cubes, cylinders, impact specimens and beams are used to conduct the strength tests are taken according *to IS10086-1982*.

- Cube Compression strength test was carried out on standard cube moulds of 150mmX150mmX150mm.
- For Split tensile strength test was carried out on cylindrical moulds of 150dia@300mm height are used.

CASTING OF SPECIMENS

Before placing the concrete inside faces of the mould are coated with the machine oil for easy removal afterwards after completion of the workability tests, the concrete has been placed in the standard metallic moulds in three layers and has been compacted each time by tamping rod. Before placing the concrete inside faces of the mould are coated with the machine oil for easy removal afterwards. The concrete in the moulds has been finished smoothly.

CURING

After casting the specimen the moulds were air dried for one day and then the specimens were removed from the moulds after 24 hours of casting of concrete specimens. Markings have been done to identify the different percentages of Granulated Blast furnace slag specimens. Then specimens were kept for normal water curing until testing age.

IV EXPERIMENTAL INVESTIGATION

In this present investigation, a total number of 72 specimens have been cast and tested. Out of 72 specimens 36 cubes, 36 cylinders, were cast and tested at 7and28 days of curing period.

The various tests conducted on different properties of concrete are listed below

- **FRESH PROPERTIES:**

1. Slump cone Test.
2. Compaction Factor test.

- **HARDENED PROPERTIES:**

1. Cube Compressive Strength Test
2. Split Tensile Strength Test

FRESH PROPERTIES

COMPACTION FACTOR TEST:

Compaction factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test.

$$\text{Compaction factor} = \frac{\text{weight of partially compacted concrete}}{\text{weight of fully compacted concrete}}$$

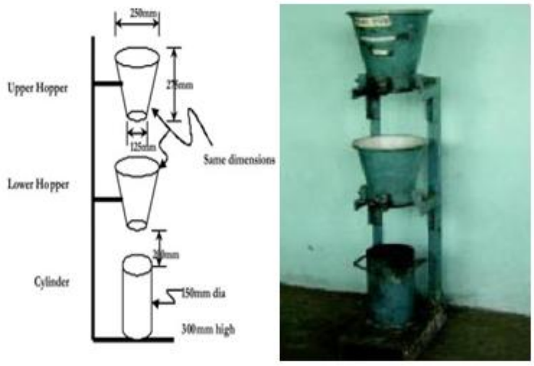


Fig: Compaction factor test

Preparation Module and Testing Procedure:

Mixing of concrete was done by hand mixing. All the ingredients of concrete were weighed and batched according to the mix proportions. The order of mixing the ingredients of concrete was first fine aggregate, slag, cement, coarse aggregate and finally water. The materials must be thoroughly mixed to obtain a good mix .After getting a mix, the moulds must be greased on to the inner surface of the mould to get cubes easily while demoulding. Concrete is poured in each mould in three layers. Each layer was tamped 25 times by using tamping rod, and then finally the mould was kept on vibrator to get a void less cube.

Testing Arrangement:

Cube Compressive strength details of specimen in KN/mm^2

All the cubes and cylinders cast were tested in the Compression Testing Machine for 7days and 28 days .The Maximum Capacity of the testing Machine is 2000KN. The cubes and cylinders were tested for compression and split tensile strength in a 2000KN CTM. The beams were tested for flexure in 40KN UTM.

Compressive Strength Test

Compression test is done confirming to IS: 516-1953. All the concrete specimens are tested in a 2000KN capacity Compression-Testing machine. Concrete cubes of size 150mm x 150mm x150mm were tested for crushing strength. Crushing strength of concrete was determined by applying load at the rate of 1400 N/cm^2/min till the specimens fail.

Fig: Test of specimens for compressive strength

Split Tensile Strength Test

All the concrete specimens were tested in a 2000KN capacity compression testing machine. Concrete cylinders of size 1500mm X 300mm height are tested for curing strength. This test method covers the determination of the splitting tensile strength of cylindrical concrete specimens. This method consists of applying a diametric compressive force along the length of a cylindrical specimen. This loading induces tensile stresses on the plane containing the applied load. Tensile failure occurs rather than compressive failure. Plywood strips are used so that the load is applied uniformly along the length of the cylinder. The maximum load is divided by appropriate geometrical factors to obtain. The splitting tensile strength by using the formula based on IS 5816 – 1970 and ASTM 496 splitting tensile strength of cylindrical concrete specimens.

The splitting tensile strength is calculated as below
Where
$F_t = 2P/\pi DL$
F_t=split tensile strength in N/mm^2,
P = Compressive load on the cylinder in N
L = Length of the cylinder in mm,
D = Diameter of the cylinder in mm.

Fig:Testing the specimen in split tensile strength

Split tensile strength has done for the mixes M1, M2, M3, M4, M5 and M6 of concrete for 7 days and 28 days. The test has conducted on the cylinder of 150mmX300mm.

V. TEST RESULTS

Cube Compressive strength

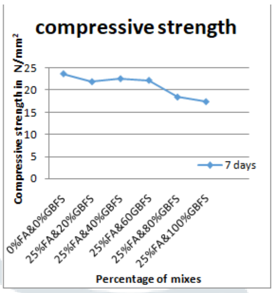
The 7 days and 28 days Cube compressive strength test results with natural sand being replaced by GBF Slag with various percentages and also keeping 25% replacement of cement by fly ash as constant are presented in table 5.1 and5.2 and the graphical variations of compressive strength verses 25% fly ash and various percentages of GBF slag as shown in fig 5.1 and 5.2 from the table and figures for 7 days of curing period ,the strength gain was lesser than the conventional mix . This may be attributed to the slower rate of strength gain due to the presence of fly ash because Pozzolanas give later strength .Coming to the 28 days compressive strength it may be observed that with the replacement of GBF Slag up to 80% to the fine aggregate the strength values increased and for 100 % replacement of GBF Slag the for fine aggregate the strength decreased .with the replacement of 40 % GBF Slag for fine aggregate the maximum strength increase of 24.49 % was obtained for 20 % GBF Slag the strength increased by 17.80 % , for 40% 24.49 %, and 60 % it was 15.32 % and for 80 % GBF Slag 2.80 % strength increases was noticed.

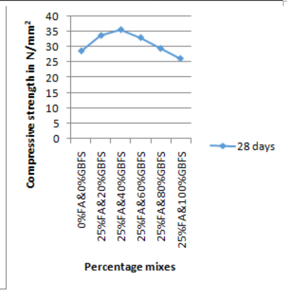
Table: Test results of cube compressive strength for specimensat 7 days

S.NO	MIX	% OF GBF SLAG	% OF FLY ASH	COMPRESSIVE STRENGTH IN M PA	%OF INCREASE/ DECREASE IN COMPRESSIVE STRENGTH
1	M1	0%	0%	23.629	----
2	M2	20%	25%	21.92	-7.23
3	M3	40%	25%	22.59	-4.39
4	M4	60%	25%	22.22	-5.96
5	M5	80%	25%	18.44	-21.96
6	M6	100%	25%	17.40	-26.36

Table: Test results of cube compressive strength for specimensat 28 days

S.NO	MIX	% OF GBF SLAG	% OF FLY ASH	COMPRESSIVE STRENGTH IN M PA	%OF INCREASE/ DECREASE IN COMPRESSIVE STRENGTH
1	M1	0%	0%	28.667	----
2	M2	20%	25%	33.77	+17.80
3	M3	40%	25%	35.69	+24.49
4	M4	60%	25%	33.06	+15.32
5	M5	80%	25%	29.47	+2.80
6	M6	100%	25%	26.14	-8.81





- Cube Compressive strength test results for 7 days.
- Cube Compressive strength test results for 28 days.

SPLIT TENSILE STRENGTH

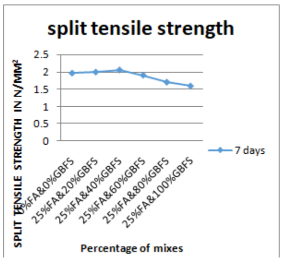
The 7 days and 28 days split tensile strength test results with natural sand being replaced by GBF Slag with various percentages and also keeping 25% replacement of cement by fly ash as constant are presented in table and the graphical variations of split tensile strength verses 25% fly ash andvarious percentages of GBF slag
as shown in fig from the table and figures for 7 days of curing period, the strength gains lesser than the conventional mix. This may be attributed to the slower rate of strength gain due to the presence of fly ash. coming to the 28 days split tensile strength it may be observed that with thereplacement of GBF Slag up to 100 % tothe fineaggregate the strength increases with the replacement of 40 %. GBFSlag for fine aggregate maximum strength increases of 33.63 % was obtained for 20%, 2.72% and 60 % it was 17.27 % and for 80 % 19.54 % and for 100 % 15 % strength was noticed.

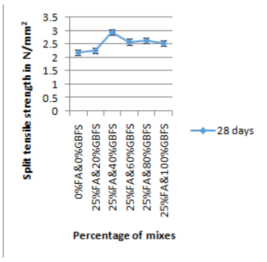
Table: Test results of split tensile strength for specimensat 7 days

S.NO	MIX	% OF GBF SLAG	% OF FLY ASH	SPLIT TENSILE STRENGTH TEST IN N/mm^2	% OF INCREASE/ DECREASE IN SPLIT TENSILE STRENGTH
1	M1	0%	0%	1.96	—
2	M2	20%	25%	1.99	+1.53%
3	M3	40%	25%	2.05	+4.59%
4	M4	60%	25%	1.90	-3.06%
5	M5	80%	25%	1.70	-13.26%
6	M6	100%	25%	1.59	-18.87%

Table: Test results of split tensile strength for specimensat 28 days

S.NO	MIX	% OF GBF SLAG	% OF FLY ASH	SPLIT TENSILE STRENGTH IN N/mm^2	% OF INCREASE/ DECREASE IN SPLIT TENSILE STRENGTH
1	M1	0%	0%	2.20	—
2	M2	20%	25%	2.26	+2.72
3	M3	40%	25%	2.94	+33.63
4	M4	60%	25%	2.58	+17.27
5	M5	80%	25%	2.63	+19.54
6	M6	100%	25%	2.53	+15





VI. CONCLUSIONS

There is a great potential for usage of the abundantly available environmental pollutants like GBF Slag fly ash in the structural Engineering.

It is observed that the Cube Compressive strength increases with replacement of Fine Aggregate with GBF Slag up to 80% and also keeping 25 % replacement of cement by fly ash as constant, for 100 % replacement the strength decreases. The maximum strength is obtained at 40 % replacement fine aggregate with GBF Slag. And it has increased by 24.49 % compared to that of conventional concrete.

- It is observed that split tensile strength increases with increase of replacement of fine aggregate with GBF Slag and also keeping 25% replacement of cement by fly ash as constant .The split tensile strength increases up to 100 % replacement of fine aggregate with GBF Slag .The maximum strength attains at 40 % replacement of fine aggregate with GBF slag, and it has increased by33.63 % compared to that of conventional concrete.
- GBF Slag is found to be 18.94 %. When compared to the conventional concrete mix.
- Finally it can be conclude that the partial replacement of fine aggregate with GBF Slag and with 25 % fly ash replacement for cement there is a gain in cube compressive strength, split tensile strength.

SCOPE FOR FUTURE WORK:-

The durability analysis can be carried out before implementing in the construction field.

The same investigation can be carried out for different mineral and chemical admixtures with different water cement ratios.

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