IMPACT AND FLEXURAL STRENGTH STUDIES ON REPLACEMENT OF FINE AGGREGATE AND CEMENT WITH INDUSTRIAL WASTE

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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. This paper gives the test results of hardened properties of concrete i.e. Impact strength test & Flexural test

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.

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

1. LunYunxia, Zhou Mingkai, Cai Xiao, Xu Fang, [11] 2008 used steel slag as fine aggregate for enhancing the volume stability of mortar. Experimental results indicated that powder ratio, content of free lime and rate of linear expansion can express the improvement in volume stability of different treated methods. Autoclave treatment process is found more effective steam treatment process on enhancement of volume stability of steel slag.

2. L. Zeghichi, [8] 2006 experimented on substitution of sand by GBF crystallized slag. Tests carried out on cubes of concrete showed the effect of the substituting part of sand by granulated slag (30%, 50%) and the total substitution on the development of compressive strength. Compressive strength test results at 3, 7, 28, 60 days and 5 months of hardening concluded that the total substitution of natural coarse aggregate with crystallized slag affects positively on tensile, flexural and compressive strength of concrete. The partial substitution of natural aggregate with slag aggregates permits a gain of strength at long term but entire substitution of natural aggregate.

3. Saud Al-Otaibi, 2008 studied use of recycling steel mill as fine aggregate in cement mortars. The replacement of 40% steel mill scale with that of fine aggregate increased compressive 40%, drying shrinkage was lower when using steel mill scale.

4.Sean Monkman, Yixin Shao, Caijun Shi, 2009 investigated the possibility of using carbonated LF slag as a fine aggregate in concrete. The slag was turned with CO_2 to reduce the free lime content while binding gaseous CO_2 into solid carbonates.

5.Tarun R Naik, Shiw S Singh, Mathem P Tharaniyil, Robert B Wendfort, 1996 investigated application of foundry by-product material in manufacture of concrete and masonry products. Compressive strength of concrete decreased slightly due to replacement of regular coarse aggregate with foundary slag however strengths were appropriate for structural concrete.

6. Dongshengshi, Yashihiromasuda and youngaran Lee, Advanced materials Research 2011 In their experimental study the potential use of blast furnace slag fine aggregate was that produced by 3 different steel factory in high strength concrete and mechanical properties of high strength concrete were studied.The concrete using the blast furnace slag fine aggregate is admitted the increase of compressive strength as well as the case of the river sand when the water cement ratio is reduced.

7.VenuMalagavelli et al. 2010 International Journal of Engineering Science and Technology in this investigation characteristics of concrete with partial replacement of cement with Ground Granulated Blast furnace slag and sand with the ROBO sand .The cubes and cylinders are tested for both compressive and tensile strengths. It is found that by the partial replacement of cement with GGBS and sand with ROBO sand helped in improving the strength of the concrete substantially compared to normal mix concrete.

8. Naoual Handel, J.Mater.Environ.Sci.2 (SI) 2011in this study we sought to use the Crushed Crystallized slag of blast furnace. It is used as aggregate in preparing slag concrete filling of steel columns. It is produced by totally orpartially replacing the calcareous gravel by crushed crystallized slag of blast furnace .The characterization of these concrete was made based on their mechanical properties.

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%

The final mix proportions are:

WATER	CEMENT	F.A	C.A
191.6	383.00	591.64	1146.00
0.50	1	1.54	2.99

SPECIMEN DETAILS

Standard specimens like impacts and beams are used to conduct the strength tests are taken according *to IS10086-1982*.

- The specimens having diameter of 150 mm and thickness of 75 mm are used for impact testing.
- Beam of 750X150X150mm are used to determine the flexural strength by subjecting them to two point loading

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 48 specimens have been cast and tested. Out of 48 specimens 36 impacts and 12 beams 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. Impact Test

2. Flexural Test

FRESH PROPERTIES

COMPACTION FACTOR TEST:

Compaction factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959.

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

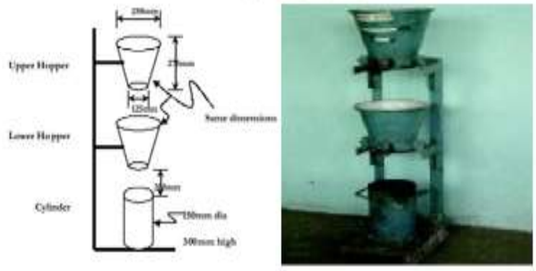


Fig: Compaction factor test

HARDENED PROPERTIES:

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:

IMPACT TEST

In this experimental work, concrete specimens were casted with 25% constant fly ash by the weight of cement and replacement of GBF slag in the place of fine aggregate varied by 0%, 20%, 40%, 60%, 80% and 100% respectively considered in this investigation. The nominal concrete does not contain fly ash and GBF SLAG. For each mix, 6 numbers of specimens were used to determine the Impact resistance of concrete for 7 days, 28 days. The impact resistance of the specimen was determined by using drop weight method of Impact test recommended by ACI committee procedures. The size of the specimen recommended by ACI-544 committee is 150 mm diameter and 75 mm thickness and the weight of hammer is 4.50 Kg with a drop of 457mm. The specimens placed on the base plate with the finished face up and positioned within four lugs of the impact testing equipment. The bracket with the cylindrical sleeve is fixed in place and the hardened steel ball is placed on the top of the specimen within the bracket. The drop hammer is then placed with its base upon the steel ball and held vertically. The hammer is dropped repeatedly. The number of blows required for ultimate failure to be recorded.

The impact energy delivered to the specimen are calculated by each impact is calculated as follows:

$$EI = Nmgh$$

Where EI is impact energy (N m),
N is the number of blows,
m is mass of the drop hammer (kg),
g is gravity acceleration (N/kg),
and h is height of drop hammer (m).

The energy absorption of Impact specimens are shown in Table. The comparisons of Percentage improvement of fly ash with 25% of cement and GBFS SLAG are of o various mixes of concrete at first crack are shown. Impact resistance of fly ash concrete and GBF SLAG with 0%, 20%, 40%, 60%, 80% and 100% respectively.

Fig: Test of specimens for Impact Test

FLEXURAL TEST

Testing of beams for flexural strength:

The loading arrangement to test the specimens for flexure is as follows. Two point loading is employed to determine the flexural strength. The element is simply supported over the span of 600 mm. The specimen is checked for its alignment longitudinally and adjusted if necessary. Required packing is given using rubber packing. Care is taken to ensure that two loading points are at the same level. The loading is applied using Universal Testing Machine (UTM). The load is transmitted to the element through the I-section and two 16 mm diameter rods placed at a distance of 200 mm from each support. That is at l/3 from each support. A 40KN load is applied gradually on to the specimen and the dial gauge reading is noted when the specimen fails. The flexural strength details are shown in 4.4 and the testing arrangement is shown in plate no-10

$f = \frac{M}{Z}$ in N/mm^2

Where M= Bending Moment in N-mm,

$Z = \frac{I}{y}$ = Section Modulus in mm

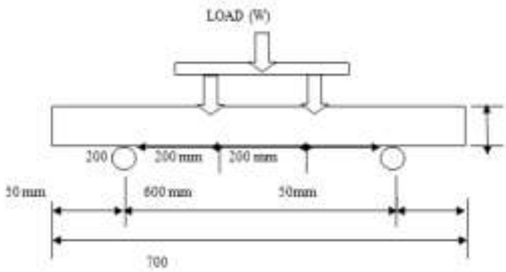


Fig: A line diagram showing the testing method is presented in figure

Fig: Specimen for flexural test a).Before testing b).After testing

V. TEST RESULTS

Impact Resistance

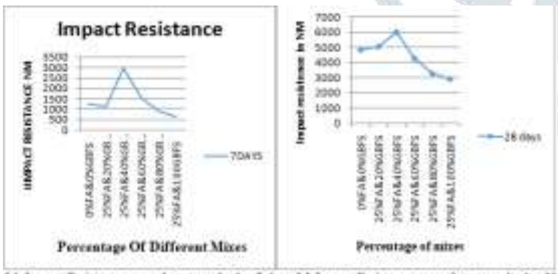
The 7 days and 28 days impact strength test results with natural sand being replaced by GBF Slag with various percentages and also keeping 25% replacement of cement by fly ash as constant are presented in table 5.5 and 5.6 and the graphical variations of impact strength verses 25% fly ash and various percentages of GBF slag as shown in fig 5.5 and 5.6 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. Coming to the 28 days impact strength it may be observed that with the replacement of GBF Slag up to 40 % the strength value increased and got maximum strength increases of 24.39% was obtained for 20 % GBF Slag the strength increased by 4.41 for 60% it is decreased to 11.44% and for 80 % it is decreased to 32.16 % and for 100% GBF Slag the strength decreases to 39.79%.

Table: Test results of impact test for specimens at 7 days

S.NO	MIX	% OF GBF SLAG	% OF FLY ASH	IMPACT ENERGY IN N-m	%OF INCREASE/ DECREASE IN COMPRESSIVE STRENGTH
1	M1	0%	0%	1240.00	—
2	M2	20%	25%	1140.00	-8.06%
3	M3	40%	25%	2972.40	+22.00%
4	M4	60%	25%	1574.50	-26.93%
5	M5	80%	25%	882.85	-28.80%
6	M6	100%	25%	640.00	-48.38%

Table: Test results of impact test for specimens at 28 days

S.NO	MIX	% OF GBF SLAG	% OF FLY ASH	IMPACT ENERGY IN N-m	%OF INCREASE/ DECREASE IN COMPRESSIVE STRENGTH
1	M1	0%	0%	4850.00	—
2	M2	20%	25%	5064.00	+4.41%
3	M3	40%	25%	6033.00	+24.39%
4	M4	60%	25%	4295.00	-11.44%
5	M5	80%	25%	3290.00	-32.16%
6	M6	100%	25%	2920.00	-39.79%



5.1 Impact Resistance strength test results for 7 days 5.2 Impact Resistance strength test results for 28 days

Flexural strength:

The 28 days flexural 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 5.7 and the graphical variations of flexural strength verses 25% fly ash and various percentages of GBF slag as shown in fig 5.7 from the tables and figures for 28 days flexural strength it may be observed that with the replacement of GBF Slag up to 80 % of fine aggregate the strength increases . For 100 % replacement of GBF Slag for fine aggregate the strength decreased. For 40 % replacement the strength increases 18.94 % and got maximum strength and for 20 % 11.80 % increases and for 60 % 13.35 % increases and 80 % 7.70 % and for 100 % 1.242 % decreased.

Table: Test results of Flexural strength test for specimens at 28 days

S.NO	MIX	% OF GBF SLAG	% OF FLY ASH	FLEXURAL STRENGTH IN N/mm²	%OF INCREASE/ DECREASE IN COMPRESSIVE STRENGTH
1	M1	0%	25%	6.44	—
2	M2	20%	25%	7.20	+11.80%
3	M3	40%	25%	7.66	+18.94%
4	M4	60%	25%	7.30	+13.35%
5	M5	80%	25%	6.90	+7.70%
6	M6	100%	25%	6.36	-1.242%

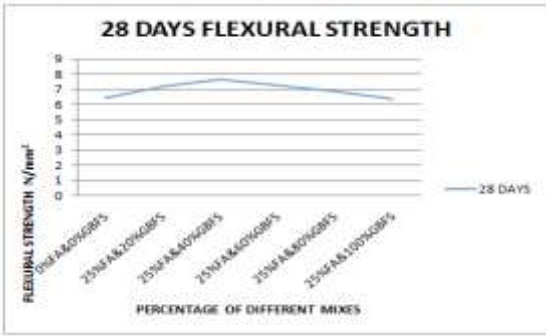


Fig: Flexural tensile strength test results for 28 days

THEORITICAL VALUE OF MODULUS OF ELASTICITY OF CONCRETE:

The theoretical value of modulus of elasticity has been calculated using is code formula

$$E=5000\sqrt{fck}$$

From the 7 days and 28 days compressive strength test results with natural sand being replaced with GBF slag with various percentages, replacements of cement with Fly ash theoretical value of modulus of elasticity is calculated.

TABLE: THEORETICAL VALUE OF MODULUS OF ELASTICITY OF CONCRETE

S.NO	MIX	f_{ck} in N/mm²	MODULUS OF ELASTICITY E(N/mm²)	% OF INCREASE/DECREASE IN MODULUS OF ELASTICITY
1	M1	28.60	$2.67x10^3$	--------
2	M2	33.77	$2.90x10^3$	8.80%
3	M3	35.69	$2.98x10^3$	11.60%
4	M4	33.06	$2.84x10^3$	7.49%
5	M5	29.47	$2.71x10^3$	1.65%
6	M6	26.14	$2.55x10^3$	-4.49%

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 impact resistance increased up to 40 % with replacement of fine aggregate with GBF Slag and also keeping 25% replacement of cement by fly ash as constant. After that a decrease is observed at the replacement level of 60 % to 100 % with reference to conventional concrete. The maximum impact energy attains at 40 % replacement of fine aggregate with GBF Slag.
- It is observed that the flexural strength increased with replacement of fine aggregate with GBF Slag up to 80 % and also keeping 25 % replacement of cement by fly ash as constant. After that for 100 % replacement of fine aggregate with GBF Slag a slight decrease of 1.24 % observed. The maximum flexural strength attains at 40 % replacement of fine aggregate with 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 , impact resistance , flexural strength and modulus of elasticity of concrete. The use of GBF Slag and

fly ash in conventional concrete has proved to be advantageous because of social benefits, cost reduction and usage of waste material in to usable product.

SCOPE FOR FUTURE WORK:-

- The same investigation can be carried out for different mineral and chemical admixtures with different water cement ratios.
- The work can be carried out by using recycled aggregate.
- For this same investigation fibers (both natural and artificial) may be used and strength characteristics may be studied.

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