EXPREMENTAL INVESTIGATION OF CONCRETE IN PARTIAL REPLACEMENT OF CEMENT AND FINE AGGREGATE USING GGBS AND M SAND

K.P.Ravikumar[1], A.Ayyappan[2], P.Ajith kumar[3], G.Jeya seelan[4], M.Manoj kumar[5], M. Mathan kumar[6]

[1,2]Assistant Professor, [3-6]UG students
Department of Civil Engineering,
Shivani Engineering College, Tiruchirappalli-620009.

***Abstract*: As we all familiar with the tern concrete that, it is a mixture of cement, fine aggregates, coarse aggregates and water. Cement manufacturing industries liberates about 1tonne of Co2 in the atmosphere while producing 1tonne of cement. Similarly fine aggregates i.e. natural sand is increasingly becoming scares and costlier day by day. In order to meet the demands, concrete industry is constantly looking for supplementary cementations materials and fine aggregates. Ground granulated blast furnace slag and manufactured sand are the industrial wastes and these materials can be used as supplementary to cement and fine aggregates by partially replacing it. In this experimental investigation, natural sand (NS) is partially replaced with manufactured sand (MS) and cement is partially replaced with GGBS. The experimental investigation is carried out in one phase, the phase M25 grade of concrete is produced by replacing 10%, 20%, 30% of GGBS and 25% of manufactured sand.**

***Keywords*: GGBS -Ground granulated blast furnace slag,MS-manufactured sand**

1. INTRODUCTION

1.1 GENERAL

Concrete is an artificial material in which the aggregates i.e. both fine and be coarse are bonded together by cement, when mixed water. Concrete can also be considered as a material which consists of a binding material within which there are embedded fragments of aggregates. The demand on concrete is likely to increase in future to match the requirement resulting from growing population, housing, transportation and other amenities. At present, there is scarcity ofConventional fine and coarse aggregates required for concrete making due to continuous demand, locally available waste materials, such as, ground granulated blast furnace slag replacing cement or aggregate can be used.

1.2 OBJECTIVE

The main objective of this is to studies on strength characteristics on utilization of GGBS as cement in concrete. To study the behavior of the concrete with replacing a part of coarse aggregate and fine aggregate. To investigate the effect on workability .to perform the specific gravity test. Sieve analysis, slump test under Indian standard method. **1.3 MATERIAL USED**

1.3.1 CEMENT

Portland cements are commonly characterized by their physical properties for quality control purposes. Their physical properties can be used to classify and compare Portland cements. The challenge in physical property characterization is to develop physical tests that can characterize key parameters. The cement which is used by us is 43 grade.

The physical properties of cement

1) Setting time
2) Soundness
3) Fineness
4) Strength

1.3.2 ORDINARY PORTLAND CEMENT (OPC)

Portland cement may be defined as a product obtained by finely pulverizing the clinker produced by calcining to fusion, an intimate & properly proportioned mixture of argillaceous & calcareous materials. The ordinary Portland cement has been classified as.

1) 33Grade (IS 269:1989)
2) 43 Grade (IS 8112:1989)
3) 53 Grade (IS 12669:1987)

We have to use 43 grade ordinary Portland cement (OPC) for this study program.

Chemical composition of (OPC)

Cao = 60-65%, Sio2 = 17-25%, Al2O3 = 3-8%, Fe2o3 = 0.5-6%, Mgo = 0.5-4%

1.3.3 COARSE AGGREGATE

1) Crushed granite coarse aggregate conforming to IS:383 1970 was used
2) Coarse aggregate passing through 20mm, having the specific gravity and fines modulus values 2.74 and 7.20 respectively were used.
3) Aggregate retained on 4.75mm sieve are identified as course. They are obtained by natural disintegration or by artificial crushing of rocks.
4) Coarse aggregate are obtained by crushing various types of granites, schist and gneiss, crystalline and lime stone and good quality sandstones.

1.3.4 FINE AGGREGATE

1) The fine aggregate conforming to zone-II as per IS: 383-1970 was used. Fine aggregate is smaller filler made of sand. A fineness modulus in the range 2.5-3.2 is recommended for concrete, to facilitate workability.

2) It may be obtained from bits, rivers, lake or sea shore, but it should free from clay and silt. The material passing through 4.75mm sieve are called fine aggregate. Natural sands are generally used as fine aggregate.

1.3.5GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Ground Granulated Blast furnace Slag (GGBS) [1] is a by product from the blast furnaces used to make iron. These operate at a temperature of about 1500 degrees centigrade and are fed with a carefully controlled mixture of iron ore, coke and limestone. The iron ore is reduced to iron and the remaining materials from a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching optimises the cementitious properties and produces granules similar to coarse sand. This „granulated‟ slag is then dried and ground to a fine powder.

(a)CHEMICAL PROPERTISE

Chemical Composition of GGBS The chemical composition of a slag varies considerably depending on the composition of the raw materials in the iron production process. Silicate and aluminate impurities from the ore and coke are combined in the blast furnace with a flux which lowers the viscosity of the slag. In the case of pig iron production the flux consists mostly of a mixture of limestone and forsterite or in some cases dolomite. In the blast furnace the slag floats on top of the iron and is decanted for separation.

(b)Chemical composition:

Calcium oxide = 40%, Silica = 35%, Alumina = 13%, Magnesia = 8%

The glass content of slag’s suitable for blending with Portland cement typically varies between 90- 100% and depends on the cooling method and the temperature at which cooling is initiated. The glass structure of the quenched glass largely depends on the proportions of network-forming elements such as si and Al over network-modifiers such as Ca, Mg and to a lesser extent Al. Increased amounts of network-modifiers lead to higher degrees of network DE polymerization and reactivity. It is a granular product with very limited crystal formation, is highly cementitious in nature and, ground to cement fineness, and hydrates like Portland cement.

(c)Physical properties:-

- Colour : off white,
- Specific gravity : 2.9
- Bulk density : 1200 Kg/m3
- Fineness : 350 m2/kg

(d)Applications of GGBS

GGBS is used to make durable concrete structures in combination with ordinary Portland cement and/or other pozzolanic materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years. Two major uses of GGBS [2] are in the production of quality-improved slag cement, namely Portland Blast furnace cement (PBFC) and high-slag blast-furnace cement (HSBFC), with GGBS content ranging typically from 30 to 70% and in the production of ready-mixed or site-batched durable concrete. Concrete made with GGBS cement sets more slowly than concrete made with ordinary Portland cement, depending on the amount of GGBS in the cementitious material, but also continues to gain strength over a longer period in production conditions. This results in lower heat of hydration and lower temperature rises, and makes avoiding cold joints easier, but may also affect construction schedules where quick setting is required.

Fig.1.Ground granulated blast furnace slag

(e)Uses of GGBS

1) Better workability, making placing and compaction easier.
2) Lower early age temperature rise, reducing the risk of thermal cracking in large pours.
3) High resistance to chloride ingress, reducing the risk of reinforcement corrosion.
4) High resistance to attack by sulphate and other chemical.

(f) Advantage of (GGBS)
Ground granulated blast furnace slag (GGBS) is a hydraulic binder, i.e. a cement, which has been known and used for 150 years.

1) It improves the quality of concrete
2) Its production virtually CO2 free
3) Improves the durability of concrete

1.3.6 MANUFACTURED SAND

(a)General Requirements:

1. All the sand particles should have higher crushing strength.

2. The surface texture of the particles should be smooth.

3. The edges of the particles should be grounded.

4. The ratio of fines below 600 microns in sand should not be less than 30%.

(b)MSAND:
Manufactured sand is popularly known by several names such as Crushed sand, Rock sand, Green sand, Ultra Mod Sand, Robo sand, Poabs sand, Barmac sand, Pozzolan sand etc. recognizes manufacture sand as Crushed Stone Sand.

(c)Natural Sand:
1) Excessive and illegal quarrying of Natural sand at river beds, resulting into soilerosion and danger to the reservoir structures.
2) Scarcity due to ban on quarrying activities near the river bed by the Govt. to prevent depleting of natural resource.
3) No control on silt content.
4) Very long distance transportation resulting into volume loss on the quantity of sand received at site.
5) Adulteration with filter sand (Unfit to be used in concrete) No guarantee on gradation.
6) Huge inventory cost during monsoon for non availability.
7) Fear of not getting sand, if rejected for quality.
8) Additional manpower for removal of pebbles & boulders while loading into batching plant to avoid pump choke up No mechanism on pricing.

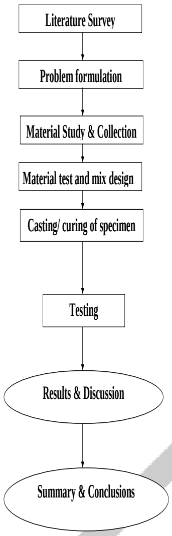
(d)M sand
1)100% replacement to Natural sand &it is one of the bi-product of aggregates.
2) No scarcity, as the Govt. is encouraging thebusiness to garner un-tapped revenue.
3) Govt. has identified the places and accorded the sanction for carrying out quarrying and crushing activities without compromising on any environmental issues.
4) Sand washing machine to ensure 0% silt content, benefiting best economized concrete with possibilities of reduction in cement content.
5) Uninterrupted supply even during rainy season, which in turn facilitating timely completion of the project.
6) No adulteration. World class Machine is employed to get the Top-Quality-Graded aggregates meeting both BIS and Customer requirement, the Consistency on the required gradation is guaranteed. No fear, the quality is the main focus. No additional

manpower is required to remove boulders or pebbles, which is again cost saving.Transparency in pricing, as the manufacturing facility is legal and ethical.

1.3.7 WATER

1) Water used for mixing and curing shall be clean and free from injurious amounts of oils alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete.
2) If should free from organic matter and the pH value should be between 6 to7.
Portable water is generally considered satisfactory for mixing concrete.
3) Water found satisfactory for mixing is also suitable for curing concrete.
4) The amount of water must be limited to produce concrete of the quality required for job. Water also used for washing aggregates and curing.

2. METHODOLOGY



3. TEST OF MATERIALS

3.1 GENERAL

The experimental on partial replacement of cement and fine aggregate using by ground granulated blast furnace slag and manufactured sand were carried out by the following methodology: the collection of data is studied on concrete by using GGBS and M sand partial replacement in the first stage of the project. Then after collection, the grade of concrete as M25 was selected for this project. The mix design for M25 grade is calculated and quantities are arrived for the materials by using Indian standard method. The properties of materials are determined by conducting various tests on cement, fine aggregates and coarse aggregate. The concrete is prepared for the grade M25. After the preparation of concrete, the property study is carried out for fresh concrete and hardened concrete. For the fresh concrete, the workability test is carried out by using slump cone test and for hardened concrete the compressive strength, split tensile strength and flexural strength is determined for the consequent mix. Was GGBS and manufactured sand is partially added to the concrete in various percentages. Then workability test is done by slump cone. Then concrete is casted into the moulds in the form of cubes of size 150mm X 150mm X 150mm, cylinders of size 150mm diameter and 300mm height and beam of size 500mm X 100mm X 100mm . After 24 hours from casting the cubes, cylinders and beams are de moulded and they are allowed for curing, for a period of 7 days, 14 days and 28 days.

3.2 MATERIAL TESTING

To investigate the properties of the materials that were used for casting the specimens, various laboratory tests were performed; following the IS codes 2386:1963 and IS 383:1970.

3.2.1 CEMENT

Standard consistency test

For finding out initial setting time, final setting time and soundness of cement and strength parameter known as standard consistency has to be used,the standard consistency of a cement paste is defined as that consistency which will permit a vicar plunger having 10mm diameter and 50mm length to penetrate a depth of 33-35mm from the top of the mould

Standard Consistency of cement = 30%

3.2.2Fineness of Cement Test

100gm of cement taken and sieved in a standard IS no 90µ. The air which get lump is broken down and the material was sieved continuously for 15 minutes using sieve shaker. The weight of residue left on the sieve is noted.

3.2.3Initial setting time test

Lower the needle (c) gently and bring it in contact with the surface of the test block quickly release. Allow it to penetrate into the block. But after some times when the paste starts losing its plasticity needle may penetrate only to a depth of 33-35mm from the top.

The period elapsing between the times when water is added when the water is added to the test block to a depth equal to 33-35mm form the top is takenas initial setting time.

Initial setting time of the cement used = 30 Minutes

3.2.4Final setting time of cement test

Replace the needle (c) of the Vicat apparatus (F). The cement shall be considered as finally set when , upon , lowering the attachment gently cover the surface of the test block, the center needle makes an impression, while the circular cutting edge of the attachment fails to do so . In other words the paste more than 0.5mm. Replace the needle of the vicat apparatus by a circular attachment. The cement shall be considered as finally set when , upon lowering the attachment gently cover the surface of the test block , the center needle makes an impression , while the circular edge of the attachment fails to do so.

Final setting time of cement = 540 min

3.3 PROPERTIES OF CEMENT

S.NO	Characteristics	Relevant code	Result
1	Type	-	OPC
2	Specific gravity	IS : 4031-1988 Part 2	3.16
3	Fineness modulus	IS : 4031- 1996 Part 1	10%
4	Initial setting time	IS : 4031- 1988 Part 5	30 minutes
5	Final setting time	IS : 4031-1988 Part 5	540 minutes

3.4FINE AGGREGATE

The following experiment were conducted to fine out properties of fine aggregate as per IS-2386, **Table**

3.4.1Specific gravity test

The specific gravity of aggregate is made use of in design calculation of concrete mixes. Specific gravity of aggregate is also required calculating the compaction factor in connection with the workability measurement. The specific gravity is determined by pycnometer method.

Specific gravity of sand =dry weight of sand / weight of equal volume of water.

The above table represented in specific gravity of fine aggregate results is 2.67. This test are mentioned above table. Average specific gravity of the fine aggregate various from 2.6 to 2.8.

The results of tests done on fine aggregate are presented in table and all the parameters were within the permissible limits.

3.5 COARSE AGGREGATE

3.5.1Water absorption test

The coarse aggregate for the work should be river gravel or stone. The maximum size of aggregate is generally limited to 20mm. aggregate of 10 to 20mm is desirable for structures having congested reinforcement. Well graded cubical or rounded aggregates are desirable aggregates should be of uniform in size for this project 20mm size aggregate were used.

3.5.2Specific gravity test for coarse aggregate

The specific gravity of aggregate is made use in design calculation of concrete mixes. Within the specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Similarly specific gravity of aggregate is required to be considered when we deal with light and heavy weight concrete.

3.5.3Ground granulated blast furnace slag

Specific gravity test of GGBS

Specific gravity of GGBS =W5 (W3-W1)/ ((W5+W3-W4) (W2-W1)

Weight of empty bottle (w1) = 69.8gm

Weight of bottle + Water (w2) = 191gm

Weight of bottle + Kerosene (w3) =168gm

Weight of bottle +GGBS + Kerosene (w4) =208gm

Weight of GGBS (w5) =55.3gm

S = 55.3(168-69.8)/ (55.3+208-208) (191-69.8)

S = 2.95

3.6CONSISTENCY TEST OF GGBS:

Water content	**Sample of GGBS (gm)**	**Value of consistency**
100	400	42
108	400	41
116	400	40
124	400	39
132	400	38
		Avg = 40

4. MIX DESIGN

a. Characteristics compressive strength required in the field at 28 days grade designation - M_{25}

b. Nominal mix size of aggregate = 20mm

c. Shape of coarse aggregate = Angular

d. Degree of workability required at site = 75 mm

e. Degree of workability require at = As per IS: 456

f. Type of cement = Ordinary Portland cement

Test data of material (to be determined in the laboratory)

a. Specific gravity of cement = 3.16

b. Specific gravity of fine aggregate = 2.7

c. Specific gravity of coarse aggregate = 2.71

d. Fine aggregate confirm to Zone ɪɪ of IS - 383

Procedure for concrete Mix design of M25 Concrete

Step - 1 Determination of Target strength

$f_{target} = f_{ck} + 1.65 \times S$

$= 25 + 1.65 \times 4$

$= 31.6\ N/mm^2$

Where,

S = Standard deviation in N/mm^2 = 4 (as per table -1 of IS 10262 - 2009)

Step - 2 Selection of water content

From Table 5 of IS: 456, (Page no20)

Maximum water cement ratio of Mild exposure condition = 0.55

Based on experience, adopt water - cement ratio as 0.45

0.45 < 0.55, hence Ok.

Step - 3 Selection of water content

From Table 2 of IS 10262 - 2009,

Maximum water content = 186 Kg (for nominal maximum size of aggregate - 20 mm)

Estimate water content = 186 + (3/100) × 186 = 191.6 Kg/ m^3

Step - 4 Selection of cement content

Water cement ratio = 0.45

Corrected water content = 191.6 Kg/m^3

Cement content - From Table 5 IS: 456,

Minimum cement content for mild exposure condition = 300 Kg/m^3

383.2 Kg/m^3> 300 Kg/m^3, hence Ok.

This value is to be checked for durability requirement from IS: 456

As per clause 8.2.4.2 of IS: 456

Maximum cement content = 450 Kg/m^3.

Step - 5 Estimation of coarse aggregate proportion

For Table 3 of IS: 10262- 2009,

For nominal maximum size of aggregate = 20mm,

Zone of fine aggregate = Zone II

And for water content = 0.45

Volume of coarse aggregate per unit volume of total aggregate = 0.62

NOTE 1: For every ±0.05 change in w/c, the coarse aggregate proportion is to be changed by 0.01. If the w/c ratio less than 0.5 (standard value), volume of coarse aggregate is required to be increased to reduce the fine aggregate content.

NOTE 2: For pump able concrete or congested reinforcement the coarse aggregate proportion may be reduced up to 10%.

Hence,

Volume of coarse aggregate per unit volume of total aggregate

= 0.62× 90% = 0.558

Volume of fine aggregate = 1- 0.558 = 0.442

Step- 6 Estimation of the mix ingredients

a. Volume of concrete = 1m^3

b. Volume of cement = (Mass of cement/Specific gravity of cement) ×

(1/1000)

= (425.7 / 3.15) × (1 / 1000)

= $0.1352m^3$

c. Volume of water = (Mass of water / Specific gravity of water)× (1/1000)

= (191.6 / 1) × (1 / 1000)

= $0.1916m^3$

d. Volume of aggregate = Volume of concrete−(Volume of cement + Volume of water)

= 1−(0.1352 + 0.1916)

= $0.6732m^3$

e. Mass of coarse aggregate = 0.6732 × 0.558 × 2.84 × 1000

= 1066.8 Kg /m^3

f. Mass of fine aggregate = 0.6732 × 0.442 × 2.64 × 1000

= 746.4Kg /m^3

Concrete mix proportion

Cement = 425.7 Kg /m^3

Water = 191.6 Kg /m^3

Fine aggregate = 746.4 Kg /m^3

Coarse aggregate = 1066.4 Kg /m^3

For casting Mass of ingredients required will be calculated for 3 numbers cube assuming 5% waste.

Volume of concrete required for 3 cubes = 3 × (0.15^3 × 1.05)

= $0.010631m^3$

Cement = (425.7 × 0.10631)

= 4.5 Kg

Water = (191.6 × 0.010631)

= 2Kg

Fine aggregate = (746.4 × 0.010631)

= 7.9 Kg

Coarse aggregate = (1066.4 × 0.010631)

= 11.3 Kg

Table

Water Content Kg /m^3	Cement Kg /m^3	Fine aggregate Kg /m^3	Coarse aggregate Kg /m^3
191.6	425.7	746.4	1066.4
0.45	1	1.7	2.5

5. GENERAL

Testing of hardened concrete plays an important role in controlling and confirming the quality of concrete of concrete works. One of the purpose of testing hardened concrete is to confirm that the concrete used at the site has developed the required strength.

5.1 MOULD PREPARATION

5.1.1Cube

The cube moulds are screwed tightly to avoid leakage; oil was applied on inner surface of the moulds. The Concrete after mixing was poured into moulds in three layers by tamping with a tamping rod.

5.1.2Cylinder

The cylinder moulds are screwed tightly to avoid leakage; oil was applied on inner surface of the moulds. The Concrete after mixing was poured into moulds in three layers by tamping with a tamping rod.

5.2 MIXING OF CONCRETE

5.2.1Hand mixing

The mixing shall be continued until there is a distribution of the materials and the mass is uniform in colour and consistency. The mixing time shall be at least 2 minutes. The object of mixing is that the concrete mass becomes homogeneous& uniform in color & consistency.

5.3 COMPACTING AND CURING

Compaction

1) Concrete should be thoroughly compacted and fully worked around the reinforcement, around embedded fixtures and into corners of the formwork.
2) Concrete is compacted using compacting rod (hand compaction)
3) Over compaction or under compaction of concrete are harmful and should be avoided.
4) Compaction of very wet mixes should also be avoided.

Curing

1) Curing is the process of preventing the loss of moisture from the concrete.
2) Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas, hessian or similar materials.
3) Concrete should be kept constantly wet for at least seven days from the date of placing concrete in case of OPC and at least 10 days where admixtures or blended cements are used.

We maintained the curing process for 28 days.

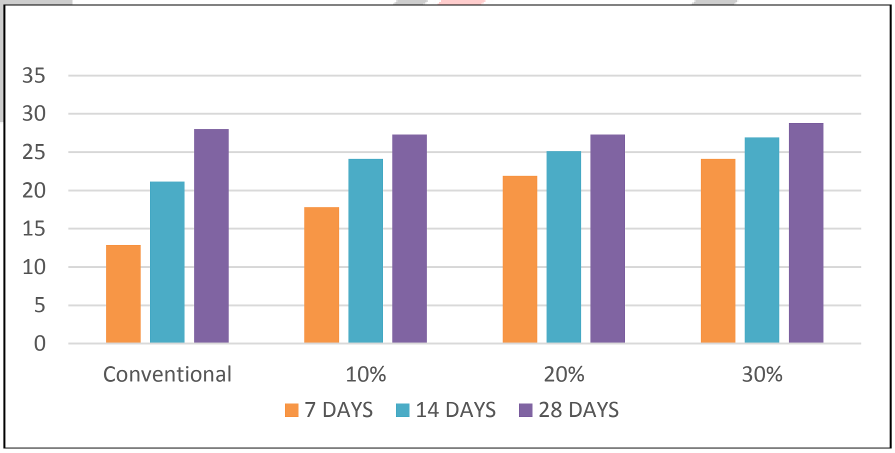
6. COMPRESSION STRENGTH TEST

i. The compressive strength of concrete is generally lower than that of normal weight higher strength concrete.
ii. To achieve higher strength, manufactured sand; to achieve even higher strength, similar aggregate can be used.
iii. Mix design is the major controlling the strength of concrete.
iv. The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load.
v. The testing machine may be equipped with two steel bearing platens with hardened faces.
vi. The specimen should be given sufficient time for hardening and then is should be cured for 28days.
vii. After 28 days, it should be loaded in the compressive test machine and testing for max load.
viii. Compressive strength should be calculate by dividing max load by the cross sectional area.
ix. Two series of test carried out to determine the compressive strength of concrete. In each series, both concrete with water proofing admixtures and plain concrete without admixtures are used.

Fig. 2 Compressive test

S.NO	%REPLACEMENT OF GGBS AND M SAND	7 DAYS (N/mm2)	14 DAY (N/mm2)	28 DAY (N/mm2)
1	Conventional	12.88	21.17	28
2	10%	17.8	224.13	27.3
3	20%	21.9	25.13	27.3
4	30%	24.13	26.9	28.8

COMPRESSIVE STRENGTH



7. SPILT TENSILE STRENGTH OF CONCRETE CYLINDERS

For Split tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length were cast. The split tensile strength of concrete is determined by casting cylinder of size 150mmx300mm.the cylinders were tested by placing them uniformly. Specimens were taken out form curing taken at age of 28 days of moist curing and tested after surface water dipped down form specimens. This test was performed on universal testing machine (UTM).

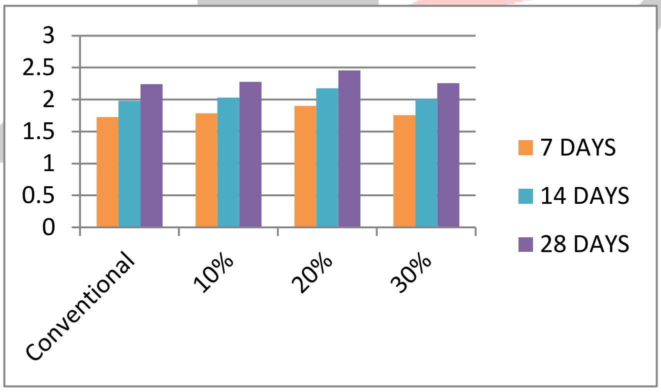
The magnitude of tensile stress (T) acting uniformly to the line of action of applied loading is given by formula.

$T_{sp} = 2P/\Pi dl$

Fig.3Tensile strength test

S.NO	% REPLACEMENT OF GGBS AND M SAND	7 DAYS (N/mm2)	14 DAYS (N/mm2)	28 DAYS (N/mm2)
1	Conventional	1.723	1.981	2.239
2	10%	1.785	2.03	2.275
3	20%	1.900	2.177	2.455
4	30%	1.755	2.005	2.256

SPLIT TENSILE STRENGTH



8. RESULT AND DISCUSSION

The above chart shows that compressive andtensile strength of concrete at 7 days and 14 daysdecreases gradually as the percentage of replacementincreases. However, replacement by 10% and 20% and 30% isfound to be more than the conventional concrete.

CONCLUSION

In this project we tried to replace the cement And fine aggregate partially by GGBS (10%, 20%, & 30%) and M Sand (25%) respectively to increase The strength of concrete. But the strength is same with The conventional concrete only at 10% and 20% Replacement of aggregate by GGBS .The strength isGradually increasing at 30% replacement of GGBS. So we conclude that the cement and coarse aggregate Replaced with GGBS at 30% and M Sand at 25% in Concrete is suitable for construction. Moreover it Reduces the construction cost by reducing the cost of Cement and coarse aggregate and it also reduces the Environmental pollution due to GGBS and M Sand.

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