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Experimental Investigation on Light Weight Concrete by Partial Replacement of Cement and Fine Aggregate with GGBS and EPS Beads

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ABSTRACT

In the present scenario, several buildings are being constructed ranging from ordinary residential buildings to sky-scrap structures. Invariably in all the structures, concrete plays a vital role in construction. Generally concrete is a mixture of cement, fine aggregate (River sand), coarse aggregate, water and type of admixtures used depends upon the situations. Now-adays good sand is extracted and transported from river bed being in a long distance. The extraction of sand has become a serious issue, posing environmental degradation, thereby causing serious threats of flood or diversion of water flow. Never the less the resources are also exhausting very rapidly and economical. To overcome from this crisis, partial replacement of cement with GGBS and fine aggregate with eps beads can be an economic alternative. This project focuses on investigating the characteristics of M25 grade of concrete with cement partially replace with GGBS 25%, 35% and fine aggregate replace with eps beads of 0.4%,0.6%, 0.8% respectively. The compressive strength of concrete is increases from 28.4 N/mm^2 to 35.6 N/mm^2 at 25% of fly ash and 0.6% of eps beads replacement; increases from 28.4 N/mm^2 to 34.1 N/mm^2 at 35% of fly ash and 0.6% of eps beads replacement.

Keywords: EPS beads, GGBS, M25.

1. INTRODUCTION

1.1 General

Now-a-days the most suitable and widely used construction material is Concrete. This building material, until these days, went through lots of development. The definition of Concrete is the mixture of cement, water, additives or sometimes superplasticizers. It is artificial material. In the beginning it is soft, ductile or fluid, and gradually will be solid. We can consider this building material as an artificial stone. The most important part of concrete is cement. The production process of this raw material produces a lot of CO_2. It is well known, that CO_2 emission initiates harmful environmental changes. Now-a-days researchers make efforts to minimize industrial emission of CO_2. The most effective way to decrease the CO_2 emission of cement industry is to substitute a proportion of cement with other materials. These materials called Supplementary Cementing Materials (SCM's). Usually used supplementary cementing materials are fly ash and GGBS. This is typically industrial by-product, hence the application of SCM's results less CO_2 during cement production. The SCM's provide other advantages and that is why the usage in the concrete technology is more and more general.

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Light weight concrete is an important and versatile material in modern construction. It has many advantages of dead load reduction, high thermal insulation; increase the process of building and lowers haulage and handling cost. It also lowers power consumption for extreme climate condition due to possessing property of low thermal conductivity. Nowadays lightweight concrete is commonly used in precast and prestressed components. Light weight concrete offers design flexibility and substantial cost savings by providing less dead load, improves seismic structural response, better fire rating, decreased storey height, smaller size structural members, lower foundation cost, and less reinforcing steel. The concrete made with light weight concrete exhibit lower thermal conductivity than of normal weight concrete. Therefore, light weight concrete provides more efficient fire protection than dense aggregates as it is less liable to spalling and has a higher thermal insulation. The LWC has been widely across other countries such as USA, UK and Sweden. Light weight concrete plays an important role in structural engineering and its use is steadily increasing. It is defined as a type of concrete which includes an expanding agent in that it increases the volume of mixture. It is lighter than conventional concrete with dry density of 300kg/m^3 up to 1840 kg/m^3. The reduction in weight by use of light weight concrete will be advantageous, especially for building structures.

1.2 Fly ash

Coal is the main ingredient in major industries worldwide. Coal has been used as a fuel for generating electricity, manufacturing of steel and in operating few automotive. On the burning of coal, ash is produced in small dark flecks known as “fly ash”. This fly ash is driven out through boilers together with flue gases. As it consists of fine particulate matter, it is also known as “pulverized flue ash”. While this fly ash is driven out from hot boilers, electrostatic precipitators quickly capture the fine particulate matter of ash pile up with some energy and the charged particles as the walls of precipitator are oppositely charged to the particles. In previous years for many industries, fly ash imposed a challenge in its disposal. They accustomed to dispose of it in a landfill far away from the industry. It created consequential environmental pollution as these lightweight particles of ash get muddled up with surrounding atmosphere causing dust or air pollution. And also, when it is disposed of in the landfill, it clogs the soil pores making the soil stale and unfit for use by causing soil pollution. Even its mix-up with groundwater by penetrating deep into soil pores causing water pollution. Therefore, the fly ash became a huge obstacle to either dispose or recycle.

1.2 GGBS

Iron and steel are the important materials used for construction industries. It is produced by processing hematite, calcium carbonate and coke substances in furnace by increasing the heat up to 1500 C. The GGBS is a by-product of iron. It is the most commonly used mineral admixture for manufacturing of concrete to obtain the high strength. In the industries, there is a step-by-step procedure for the manufacturing of iron using raw materials. The raw materials are converted into following two stages, such as,

1. Molten slag and
2. Molten iron

The density of the molten iron is high. Further process is necessary to obtain the required shape and size of products as per the requirement. Molten slag is the product which is mostly referred as the bottom product in evolution of GGBS. The GGBS has lesser density than a molten iron,

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therefore, a slag particle tends to float on the surface over the molten iron in blast furnace. The slag which is formed on the molten iron has rich number of silicates and alumina, because the raw products are produced by the combination of silica and other oxides. Processing of slag formed over the molten iron is also an important process, in which the temperature of molten slag is reduced by injecting water with high pressure through jets. The cooling process of molten slag is done rapidly to avoid the formation of particle size not more than 5mm. Due to rapid smoothening process, the most of the slag particles will attain granular shape. The formed ash particle mostly consists of non-crystalline calcium-alumina silicates. After the cooling process completed, the granulated slag is sent into the final processing unit, in which, the granulated slag is allowed to dry. After the moisture content is left, the granulated slag is allowed into grinding process to get the particle shape similar to the cementing materials. The final product after grinding the granulated slag in rotating ball mills is called as ground granulated blast furnace slag. The GGBS contains about 30-50% of Calcium Oxide, 28-38% of Silicon Dioxide, 8-24% of Aluminium Oxide and 1-18% of Magnesium Oxide.

1.3 EPS beads

Expanded Polystyrene (EPS) used in the project was in the form of 'EPS Beads' which is spherical in shape with size varying in between 4 mm to 6 mm in diameter. It is made up of pre-extended Polystyrene globules. It offers a non-hydroscopic and does not readily absorb moisture from the atmosphere. The Expanded Polystyrene is a stable, low-density Foam, which consists of 98% of air and 2% of polystyrene material. It has closed structure and cannot absorb water. It has good impact resistance. Polystyrene is packaging material in medical industry. Polystyrene is non-biodegradable material, so it creates disposal problems. Utilizing crushed polystyrene in concrete is good waste disposal method.

The polystyrene beads can be easily merged into mortar or concrete to produce lightweight concrete with a wide range of density. An application of polystyrene concrete includes walls, cladding panels, tilt up panels and composite flooring. Polystyrene concrete was used to produce load bearing concrete wall, also as the material of construction for floating marine structures. Expanded polystyrene beads concrete was popular through the ages. One of the main problems associated with the use of conventional lightweight aggregates produced from clay, slate and shale in concrete is that these porous aggregates absorb very large amount of the water mixed in concrete. This is affecting the performance of the concrete, apart from the fact that it is difficult to maintain specific water content during the casting. Also, this absorption of water by the aggregates will mean that the additional water will be required to maintain the slump at acceptable levels. These increased water contents require higher cement contents, even without any benefit. Hence, in this project, the fly ash (class F) and EPS beads have been considered as an alternative for cement and fine aggregate, respectively. This study aims to examine the effect of replacing both cement and fine aggregate with fly ash (25% & 35%) EPS beads (0.4%, 0.6% & 0.8%) in various predetermined proportions. The structural properties like compressive and split tensile strength of hardened concretes were determined and compared with controlled concrete with proper design mix at 28 days curing.

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2. LITERATURE SURVEY

2.1 GGBS in concrete

In the modern trends, the cement plays a vital role for the preparation of concrete in the construction industries. Therefore, the requirement of cement is important in the construction of civil engineering structures, like, industries, houses, bridges, water retaining structures, earth retaining walls, landing strips and road pavements. Hence, the production of cement is increased in the cement industry to meet such a demand in the construction industries. Carbon dioxide (CO_2) is emitted from cement industries during the process of calcinations of lime stone in dry process, combustion of fuels in the kiln and power generation. It contributes about 5% of global anthropogenic CO_2emission. Approximately, 1.25tonnes of CO_2 is emitted per tonne of cement production in the industries. Cement industries are one of the largest CO_2 producers when compared to other industries. The emission of CO_2 leads to environmental trouble for greenhouse effect, and it also increase the earth temperature to cause global warming. On the other side, the poor people are struggling to construct their own buildings in their locality due to the continuously increasing the cost of cement. These two bigger issues, such as Global warming and continuous raising the cost of cement have induced many scientists and researchers to identify the most appropriate alternative supplementary cementing materials for the replacement of cement. By considering these issues, our present research work was proposed to identify the effective way for the replacement of cement with waste materials disposed from agricultural and industries.

2.2 EPS Beads

Comprises of light weight and low-density aggregate which mix with a type of concrete mix which is known as light weight concrete i.e. In self -weight and dead loads it increases the volume of mixing simultaneously providing considerable decrement. Because of low density high volume aggregates the formation of voids with air entrapping takes place and as the thermal conductivity and low density in light weight concrete is the key point of attraction. .as compare to both, standard commercial concrete has more compressive strength than light weight concrete, In structural construction industry the light weight concrete trends because of increasing compressive strength achievement. By the densification of mixing strength can be increased and light weight concrete can be used in both structural and non-structural if there is an addition of superplasticizer and fibre.

Bengin M A Herki, et al (2020) Volcanic materials such as pumice are used in the production of concrete as partial replacement of natural aggregate concrete(LWAC)utilizing a locally available lightweight aggregate (LWA) called pumice aggregate (PA).This novel LWAC is made by partial replacement of coarse aggregate with different replacement levels of 10%, 20%, 30%, 40% and 50% of PA by volume. This study id focused to determine the mechanical and durability properties of LWAC to find the optimum replacement level of PA. The properties of PA were reported by conducting comprehensive series of tests on workability, compressive strength, density, and total water absorption and ultrasonic plus velocity (UPV). It is concluded that the LWAC has sufficient strength and adequate density.

Vandale Amar Diliprao, et al(2019) deals with the study of polystyrene foam are thermoplastic material obtain by Polymerization of styrene. In construction has lot of advantages by using of expanded polystyrene as compare use of conventional material which result in sustainable future. EPS is versatile durable material that offers excellent insulation property. As the structure of consist of 98% air its initial thermal properties are maintain throw out it's working life. It can be manufacture in a wide range of shape & sizes. The use expanded polystyrene in construction has lot of advantage compare with use of conventional material which result in sustainable future. EPS is use as lightweight aggregate to produced light weight concrete with unit weight less than 1000kg/m3 which make it as lightweight concrete coarse aggregate is measure contributor for heavy weight of concrete as replacing it with EPS beads result reduction of the density of concrete.

Bharath V B et.al 2020, They concluded that Experimental investigation has been carried out to determine utilization of the sugarcane bagasse ash and glass powder as cement replacement materials by making the cement concrete. Based on the results obtained from the experimental work the following conclusions can be drawn:

1. The compressive strength of concrete was higher than the conventional concrete for 10% sugarcane bagasse ash and 10% glass powder replacement by the weight of cement at 7, 14, & 28 days of curing ages. However further increase in replacement percentages lowers the compressive strength of concrete.

2. The split tensile strength of concrete in which cement was replaced by 10% SCBA & 10 & GP was higher than conventional concrete. However further increase in replacement percentages lowers the split tensile strength of concrete.

3. Glass powder and SCBA can be used as partial replacement for cement in concrete which helps in reduction of construction cost.

4. The optimum replacement of cement by SCBA and Glass Powder is 10% and 10%, further increase in the replacement percentages results in reduction of concrete strength.

3. OBJECTIVE OF THE STUDY

3.1 Aim

The aim of study is to evaluate the performance and suitability of replacement of EPS beads with fine aggregate and cement with GGBS in concrete manufacturing.

3.2 Objective

The objectives of experimental study are:

- Study on strength characteristics of M25 grade concrete with replacement of 25%, 35% cement by GGBS and replacement of 0.4%, 0.6%, 0.8% fine aggregate by EPS beads.
- To determine the workability by slump cone test & compaction factor test.
- To determine the compressive strength for 7, 14, 28days curing.
- To determine the split tensile strength for 28days curing

3.3 Methodology

1. Collect the GGBS (class F) and waste thermacoal or EPS beads.
2. If EPS beads are not passed from IS Sieve 4.75mm, then split into small pieces by manual method of splitting.
3. Choose the mix design and literature survey (for mix proportions and pending works from past researches).
4. Design mix design of M25 grade concrete.

5. Find out the mix proportions for different mix grades, those are mentioned below table 3.1.
6. Mixing of all dry materials for 2mintues and required quantity of water to add the dry mixed materials and mix it for 3-5mints.
7. Freshly prepared concrete test with slump cone test.
8. Cast the cube & cylinders moulds based on the requirement, those are mentioned below table 3.2.
9. Cure the sample in water for 7,14,28 days for cubes & 28days for Cylinders.
10. After curing ages, the samples tested. Compressive strength test for cubes and split tensile strength test for cylinders.
11. Results & discussions
12. Conclusions

Table 3.1: Experimental Program

Type of test to be conducted	Behaviour to be identified	Specimen	Size	No
Slump cone test	Fresh concrete properties	-	-	
Compression test	Compressive strength	Cube	150 X 150 X 150 mm	63
Tensile test	Split tensile strength	Cylinder	300 X 100 mm	21
Water absorption test	Water absorption	Cube	150 X 150 X 150 mm	21

4. MATERIALS AND MIX DESIGN

4.1 General

Good quality concrete is obtained by proper portioning of ingredients in concrete mix such as cement, fine and coarse aggregates. The appropriate proportion of materials provides homogenous mixture thus achieves designed strength and serves the service life. The nominal mix designs used for adequate strength are based on the fixed cement - aggregate ratio. This is not suitable for all grades of concrete. The estimation of essential quantities of materials in an optimum and economical way to achieve the target strength of concrete is considered as mix design. From the mix design, the suitable quantities of cement, fine aggregate, coarse aggregates and water are obtained. The mix design further depends on the properties of materials used. Material properties such as type of material, consistency, specific gravity, size, shape, texture, density, water absorption and gradation or particle size of aggregate greatly influence the mix design.

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4.2 Materials

The physical properties of cement, fine aggregate, coarse aggregate and water used in the investigation are presented in this chapter. The standard experimental procedures laid down in IS codes, which were adopted for the determination of normal consistency, initial and final setting times, specific gravity, bulk density, impact strength. The materials used in the experimental investigation include.

1. Cement
2. Coarse aggregate
3. Fine aggregate
4. Eps beads
5. fly- ash
6. Water

The properties of these materials are given in the following sub-sections.

4.2.1 Cement

Cement is anhydrous material with no reaction when it is in dry condition. The oxide form of silica, lime alumina reacts to form complex compounds. It has ability to bind the materials such as aggregates to maintain homogeneity of the mixture. On continuous reaction with water, it imparts strength and durability in hardened stage. When the cement mixed with water, reaction takes place and is called Hydration. The hydration process of cement with the compounds shows the strength of cement. Further, during this process, heat is liberated. Each compound produces different products when it hydrates. The strength of the hardened concrete gets affected, if the consistency of the cement paste is either extremely harsh or wet.

Initial experiments like initial setting time, final setting time, specific gravity and compressive strength test on mortar cubes were conducted on cement with regard to various water quality parameters. Ordinary Portland Cement (OPC) 53 grade was used in the present investigation corresponding to IS 12269 (1987). The summary of physical properties and various tests conducted on cement are presented in the Table 4.1.

Table 4.1 Physical Properties of Cement

Physical properties	Test result	Requirement as per IS 12269 (1987)
Specific gravity	3.14	-
Fineness (%)	3	Max 10%
Normal consistency	31%	-
Initial setting time (min)	92	Min. 30 min
Final setting time (min)	325	Max. 600 min

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4.2.2 Coarse aggregate

Crushed Granite stone aggregate of maximum size 20 mm, confirming to IS 383-1970 was used. The specific gravity and fineness modulus were found to be 2.7 and 3.28 respectively. Grading analysis is presented in table 4.2. Different properties of the granite coarse aggregate used in this experimental work are given in Table 4.3.

Table 4.2 Grading analysis for coarse aggregate – Sample - 5000gms

S. No.	IS Sieve size (mm)	Weight of retained (gms)	Cumulative weight retained (gms)	Cumulative % retained	% Passing
1	80	-	-	-	100
2	40	-	-	-	100
3	20	2940	2940	58.8	41.20
4	10	1040	3980	79.6	20.40
5	6.3	530	4510	90.2	9.80
6	4.75	490	5000	100	-
	total	5000		328.6	271.4

Fineness Modulus=328.60/100 = 3.28

Table 4.3 Properties of Granite coarse Aggregate

S. No	PARTICULARS	RESULTS	BIS SPECIFICATIONS (IS 2386-2013
1	Specific gravity	2.68	2.4 – 2.7
2	Fineness modulus	3.28	5 – 8
3	Flakiness index	13%	<40%
4	Elongation index	10%	<40%
5	Crushing value	12%	<45%
6	Impact value	14%	<45%
7	Water absorption	0.4%	<2%

4.2.3 Fine aggregate

The fine aggregate (sand) used throughout the experimental work was obtained from the river college CT laboratory. The specific particle size composition of the sand was prepared as per the IS Code 650-1966 and I.S. Code 383-1970. The properties of sand were analysed in accordance with the procedures laid down in I.S 2386 (Part I & Part III) – 1963 and were presented in Table 4.4 and 4.5.

Table 4.4 Properties of sand

S.No	PARTICULARS	RESULTS
1	Specific gravity	2.52
2	Fineness modulus	2.85
3.	Water absorption	0.5%

Table 4.5 Grading analysis for fine aggregate – Sample -1000 gms

S.No	IS Sieve size	Weight of retained (gms)	Cumulative weight retained (gms)	Cumulative % retained	% Passing
1	4.75 mm	8	8	0.8	99.2
2	2.36 mm	38	46	4.6	95.4
3	1.14 mm	230	276	27.60	72.4
4	600 microns	340	616	61.6	33.4
5	300 microns	295	911	91.1	8.9
6	150 microns	89	1000	100	0
	total	1000		285.7	309.3

Fineness Modulus=285.7/100 = 2.85

4.2.4 GGBS

In the present study, one of the source materials used in making concrete was GGBS. It was collected from Indian mart online shopping.

4.2.5 Eps beads

In the present study, one of the source materials used in making concrete thermacoal or eps beads. This are collected from local market.

4.2.6 Water

Potable water has been used for mixing as well as curing of concrete in the present investigation.

4.3 Mix design

One of the ultimate aims of studying the various properties of the materials of concrete and hardened concrete is to enable a concrete technologist to design a concrete mix design for a particular strength and durability. The design of concrete mix is not a simple task on account of the widely varying properties of the materials, the conditions that prevail at the site work in

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particular the exposure condition, and the condition that are demanded for a particular work for which mix is designed. Design of concrete mix design requires complete knowledge of various properties of these constituent materials, the implications in case of change on these conditions at the site, the impact of the properties of plastic concrete on the hardened concrete and the complicated inter-relationships between the variables. All these make the task of mix design more complex and difficult. Design of concrete mix needs not only the knowledge of material properties and properties of concrete in plastic condition, it also needs wider knowledge and experience of concreting. Even then the proportion of the materials of concrete found out at the laboratory requires modification and readjustments to suit the field conditions. Mix design can be defined as the process of selecting the suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The first objective is to archive the stipulated minimum strength and durability. The second objective is to make the concrete in the most economical manner. Cost wise all concretes primarily depends on two factors namely cost of the material and cost of material. Since the cost of cement is many times more than cost of other ingredients, attention is mainly directed to the use of as little cement as possible consistent with strength and durability.

Mix design calculations:

Cement grade = OPC 53

Specific gravity of cement =3.2

Specific gravity of fine aggregates=2.52

Specific gravity of coarse aggregates=2.68

Assuming Slump = 100mm

Zone ii sand confirming & Cement content: 350 kg/m^3 – 450 kg/m^3

The following procedure is followed to design the concrete

Step 1: Target Mean Strength

$$f'_{ck} = f_{ck} + 1.65 \times \sigma = 25 + 6.6$$

$$= 31.6$$

Step 2: W/C Ratio

- From the graph specified by IS10262-2019, w/c is taken as 0.47 for 31.6 N/mm^2 compressive strength of concrete.
- From the Table 5 of Is 456 - 2000, for moderate condition, w/c ratio is 0.45
- Hence, min of two values i.e., 0.45 is taken as w/c ratio.

Step 3: Water Content

From Table 4 of IS10262-2109, assume 20mm of aggregate is been used and hence max water content is 186 kg's, slum is assumed to be 100mm and hence water should be increases by 6%

Water content = $186 \times 1.06 = 197.16$

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Step 4: Calculation of Cement Content

$\frac{w}{c} = 0.45$ hence,

$c = \frac{197.16}{0.45} = 438.13$

from table of IS456,

min cement content = 320 and hence we use 438.13 Kg/m^3

Step 5: Calculation of Coarse Aggregate and Fine Aggregate

From IS 10262-2019, table 5: classified the zone of fine aggregate as Zone II and corresponding volume of coarse aggregate for 20mm size is 0.62 if w/c is 0.5 but our w/c is 0.45.

i.e., Volume of CA per unit volume of TA = 0.62 + (0.01 x 1)

= 0.63

Therefore, the volume of FA per unit volume of TA =1-0.63 = 0.37

Step 6: Mix Proportion

volume of concrete = 1m^3

volume of cement = $\frac{438.13}{(3.2 \times 1000)}$

= 0.136m^3

volume of water = 197.16

= 0.197m^3

Volume of air voids = 0.01 (from table 3 IS10262-2019)

Absolute weight of all materials except total aggregates = 1 - (0.136 + 0.197+0.01)

= 0.657

Mass of coarse aggregate = $0.657 \times 0.63 \times 2.68 \times 1000$

= 1109.27 kg/m^3

Mass of fine aggregate = $0.657 \times 0.37 \times 2.52 \times 1000$

= 612.58 kg/m^3

Step 7: Mix Ratio

438.13: 612.58: 1109.27

1:1.39:2.53

4.3.1 Mix Proportions

M25 grade of concrete is considered. Natural sand is replaced with EPS beads with various percentages 0%, 0.4%, 0.6%, 0.8%. Cement is replaced with GGBS by 25%, 35%. The mix design for concrete is carried out as per IS 10262-2019. Details of mix proportion for M25 concrete given below:

Volume of the cube = 1.1 X $(0.15)^3$ = 3.7125 X 10^{-3}

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Volume of the cylinder = $5.3014 \times 10^{-3} \times 1.1 = 5.83 \times 10^{-3}$

Table 4.9: Mix proportions for 1cube preparation

MIX	GGBS% – EPS beads %	CEMENT (gm)	GGBS (gm)	Fine aggregate (gm)	EPS beads (gm)	CA (gm)	WATER (ml)
M0	**0-0**	1626	0	2270	0	4120	732
M1	25 – 0.4	1219.5	406.5	2260.92	9.08		
M2	25 – 0.6			2256.38	13.62		
M3	25 – 0.8			2251.84	18.16		
M4	35 – 0.4	1056.9	569.1	2260.92	9.08		
M5	35 – 0.6			2256.38	13.62		
M6	35 – 0.8			2251.84	18.16		

Table 4.10: Mix proportions for 1cylinder preparation

MIX	GGBS% – EPS %	CEMENT (kg)	GGBS (gm)	FA (gm)	EPS (gm)	CA (kg)	WATER (lit)
M0	0-0	2.55	0	3571	0	6.46	1.15
M1	25 – 0.4	1.912	637.5	3556.72	14.28		
M2	25 – 0.6			3549.58	21.42		
M3	25 – 0.8			3542.44	28.56		
M4	35 – 0.4	1.657	892.5	3556.72	14.28		
M5	35 – 0.6			3549.58	21.42		
M6	35 – 0.8			3542.44	28.56		

5. EXPERIMENTAL INVESTIGATION

5.1 General

Generally, the fresh, mechanical and durability properties are the indicators of the performance of concrete. In the present experimental work, Pervious concrete is prepared with natural Fine aggregate and EPS beads in different proportions (0%, 0.4%, 0.6% and 0.8%) and cement with GGBS in different proportions (25% & 35%). Various specimens were cast according to standard provisions and cured. Various tests are conducted to determine, Slump cone test (workability), Compressive strength, Split tensile strength, and Water absorption test. The mixing, casting and curing of the specimens and the experimental procedures of tests are explained in the following sub sections.

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5.2 Mixing

All the required quantities of cement, fine aggregates and coarse aggregates weighed separately and mixed in dry condition. The obtained proportion of water is added to the composite mixture and mix thoroughly until a uniform mixture is formed. The same procedure is repeated for different mixes which includes the replacement of fine aggregate with EPS beads and cement with GGBS. The complete mixing is done by hand mixing. After the concrete is mixed, the fresh concrete tests are to be carried out to measure the workability. The detailed explanation of the slump test is reported below.

5.2.1 Slump test

Slump cone test is most simple and common test conducted to determine the workability of concrete mix. According to the IS 1199-1959, Slump test is carried out for every batch of mix. The apparatus is shown in the Table 5.1 and Fig.5.2.

Table 5.1 Apparatus for slump test

S.No	Name of the apparatus	Size of the apparatus
1	Slump cone – Frustum	h = 30 cm, Bottom dia = 20 cm and top dia= 10 cm.
2	Tamping rod with one end round	16 mm dia and 60cm long

Fig. 5.2: Slump cone apparatus

A sample of prepared concrete mix is taken for the test. The internal surface of the frustum of cone is cleaned and greased to avoid the adhesion of concrete. A non-porous base plate is placed on a uniform surface and the slump cone mould is fixed on it. Concrete mix is filled in three equal layers in the mould. The excess concrete is removed and levelled. Now, the cone is lifted in upward direction and the concrete slumps down. The slump (Vertical settlement) is measured in mm.

5.2 Casting and Curing

In the present work cubes and disc specimens were cast to conduct various tests.

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5.2.1 Casting of cubes

Totally 84 cubes were cast for conducting various tests. Among them 63 cubes for compressive strength test, 21 cubes for water absorption test. For the preparation of cube specimens, the mixed concrete is poured into the cube moulds made of steel of dimensions of 150 X 150 X 150mm. The moulds are cleaned and greased to avoid sticking of concrete to the moulds and tighten the bolts to prevent leakage of concrete. The concrete is put in layers into the moulds till the surface and levelled. The specimens are allowed to dry up for 24hrs.

5.2.2 Casting of cylinder

Total 21 number of cylinder specimens were cast for different tests. 21-cylinder specimens for split tensile strength test. The specimens are prepared by pouring the mixed concrete in the moulds of 150mm dia X 300mm height. The specimens are de-moulded after 24hrs.

5.2.3 Curing

The next stage is curing of the specimens. It is an important phase as the water for hydration is to be maintained in the specimens. Proper curing gives good strength to the concrete. So, after removing from the moulds the specimens are transferred to the curing tank containing water free from impurities and cured for 28 days.

5.3 Experimental Procedure

In this section, the test setup and experimental procedure for conducting various tests are discussed.

5.3.1 Compressive strength test (IS 516-1989)

Compressive strength of concrete is the most important characteristic and it is an indexing property as concrete is designed to carry compressive loads. This test is conducted to determine the variation of strength of the specimens with varying ratios of coarse aggregate and reduction in fine aggregate content. Compressive strength test machine (CTM) with 2000KN capacity is used to conduct the test on cubes. After placing the cube between the plates in the CTM, load is applied until the crack is observed on the specimen. The load at the point of cracking is considered as failure load and it is noted. The compressive strength is calculated by

Compressive Strength (σ) = Failure load / Cross sectional area of specimen

5.3.2 Split tensile Strength of Concrete (IS:516-1959)

The cylinder specimens were tested on compression testing machine to create a tensile cracking. Align the specimen so that the lines marked on the ends are vertical and cantered over the bottom plate. Apply the load continuously without shock at a rate of approximately 14-21 kg/cm^2/minute (Which corresponds to a total load of 9.9 ton/minute to 14.85 ton/minute).

Tensile strength = $2P / \pi L D$

Here; P = peak load

L = length of cylinder = 300mm

D = diameter of cylinder = 150mm

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5.3.3 Water absorption test

The test is conducted as per ASTMC 642-97[36] to determine the increased resistance towards water penetration in concrete. Cubic moulds of 150 mm size were prepared with and without bacteria. The specimens are cured for 28 days. After curing, the surfaces of the samples were allowed to dry and their saturated surface masses were determined after immersion. For this purpose, the specimens were oven dried at 115±5^{o}C and water absorption of the specimens was calculated using the following formula:

Absorption after immersion (%) = ((B-A) / A) *100

Where;

A is the mass of oven dried sample in air.

B is the mass of the sample after immersion with a dry surface.

6. RESULTS AND DISCUSSION

6.1 Fresh properties of concrete (Slump cone test)

The slump Values of the concrete for replacement of sand with EPS beads by 0, 0.4, 0.6, 0.8% and cement with GGBS 25, 35% are graphically represented in Fig 6.1. It is observed that there is increase in the workability of the concrete the sand replacing with EPS beads and cement replacing with GGBS. Based on the observations, all of the slump values are in the medium workability range.

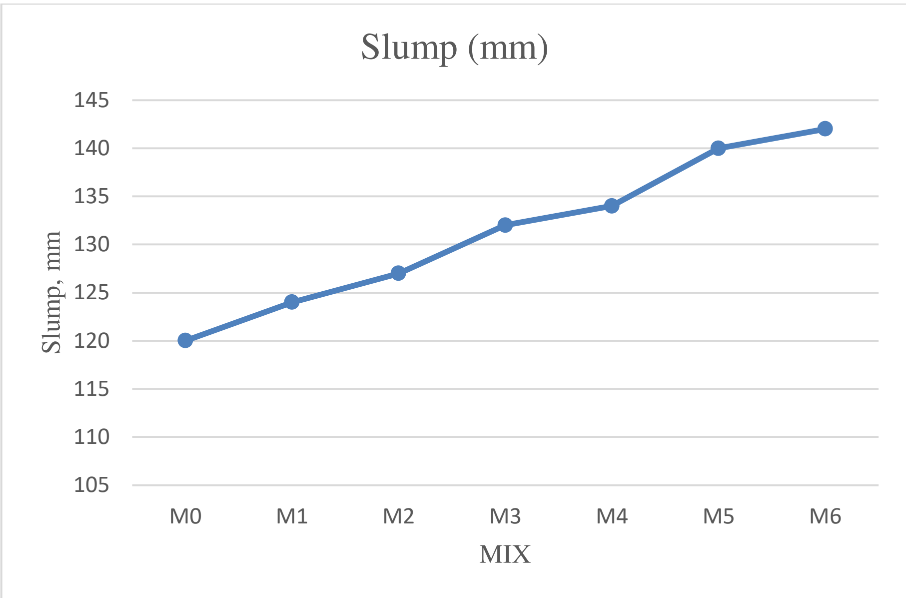

Fig 6.1 Slump Values Vs % MIX

6.2 Compressive strength test

The compressive strength values of the concrete for replacement of fine aggregate with EPS beads by 0, 0.4, 0.6, 0.8% and cement with GGBS 25, 35% are graphically represented in Fig 6.2 (a & b). It is observed that there is increase in the compressive strength of the concrete when the fine aggregate with EPS beads by 0, 0.4, 0.6, 0.8% and cement with GGBS 25, 35%. The

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percentage increase of compressive strength (28days) values for M1, M2, M3, M4, M5, M6 replacement of Fine aggregate with EPS beads – cement with GGBS is 7.04%, 25.35%, 10.56%, 5.28%, 20.07%, 0.7% respectively. Based on the observations, all of the compressive strength values are higher for EPS & GGBS replacement in the concrete. The optimum dosage of GGBS replacement in cement and EPS beads replacement in natural fine aggregates is 25% & 0.6% (M2 mix).

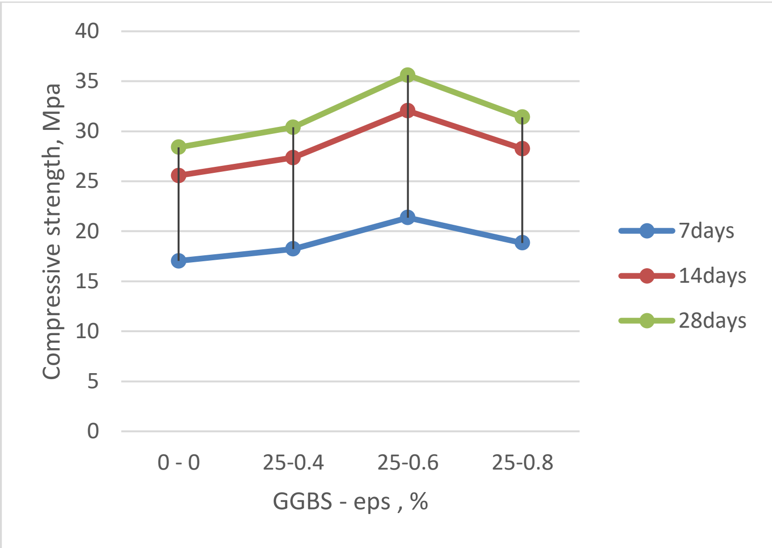

Fig 6.2(a) Compressive strength Vs % (GGBS – EPS %)

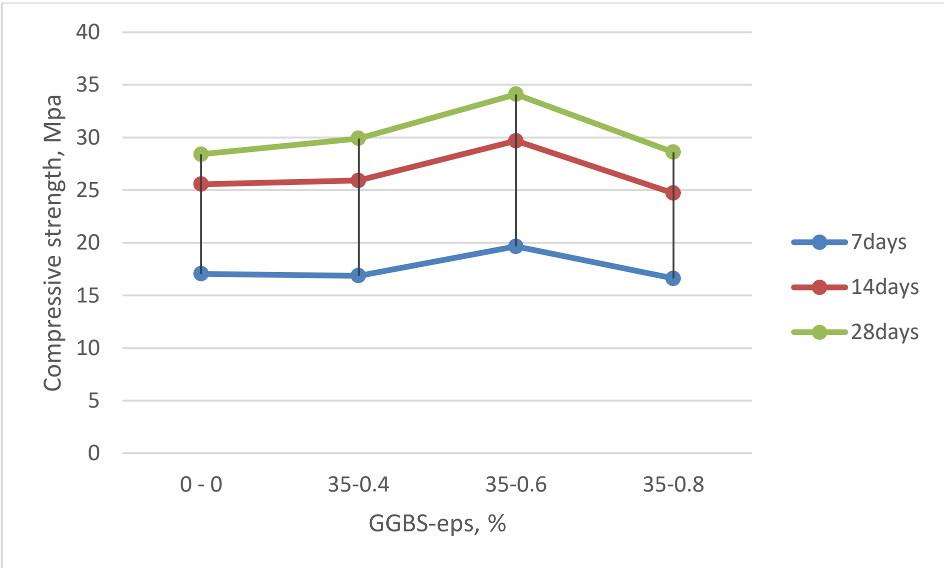

Fig 6.2(b) Compressive strength Vs % (GGBS – EPS %)

6.3 Split tensile strength test

The Split strength values of the concrete for replacement of fine aggregate with EPS beads by 0, 0.4, 0.6, 0.8% and cement with GGBS 25, 35% are graphically represented in Fig 6.3 (a & b). It is observed that there is increase in the tensile strength of the concrete when the fine aggregate with EPS beads by 0, 0.4, 0.6, 0.8% and cement with GGBS 25, 35%. The percentage increase of

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tensile strength (28days) values for M1, M2, M3, M4, M5, M6 replacement of Fine aggregate with EPS beads – cement with GGBS is 7.1%, 26.76%, 8.27%, 4.75%, 18.83%, 0.058% respectively. Based on the observations, all of the tensile strength values are higher for EPS & GGBS replacement in the concrete. The optimum dosage of GGBS replacement in cement and EPS beads replacement in natural fine aggregates is 25% & 0.6% (M2 mix).

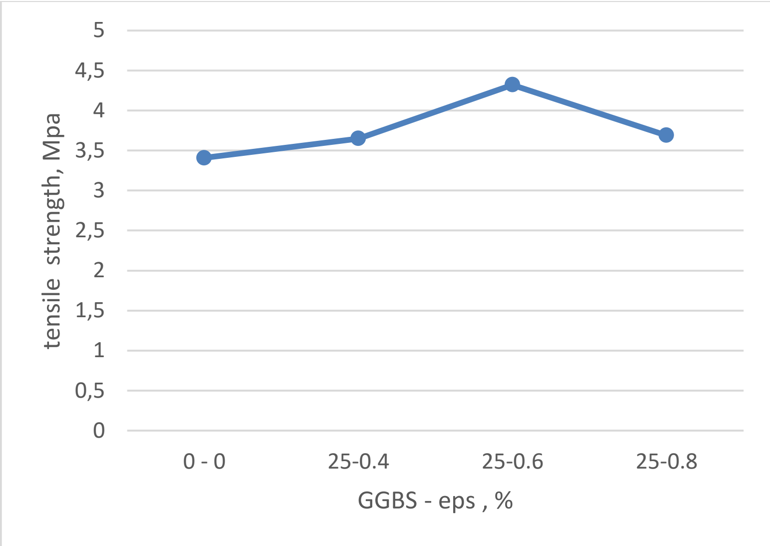

Fig 6.3(a) Tensile strength Vs % (GGBS – EPS %)

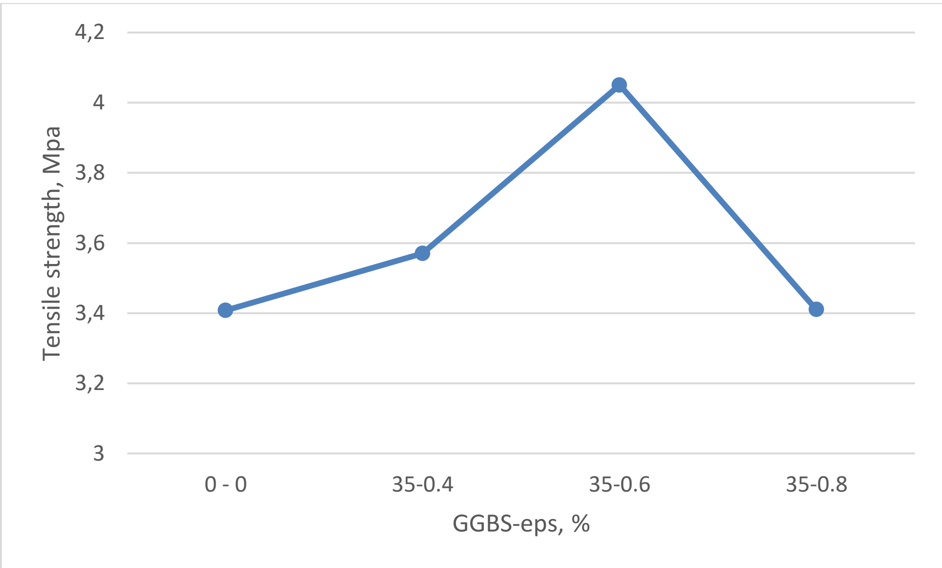

Fig 6.3(b) Tensile strength Vs % (GGBS – EPS %)

6.4 Water absorption test

The water absorption values of the concrete for replacement of fine aggregate with EPS beads by 0, 0.4, 0.6, 0.8% and cement with GGBS 25, 35% are graphically represented in Fig 6.4. It is observed that there is increase in the water absorption of the concrete when the fine aggregate with EPS beads by 0, 0.4, 0.6, 0.8% and cement with GGBS 25, 35%. The percentage decrease of water absorption values for M1, M2, M3, M4, M5, M6 mixes replacement of Fine aggregate with

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EPS beads – cement with GGBS is 23%, 28.2%, 35.89%, 48.7%, 53.84%, 56.4% respectively. Based on the observations, all of the water absorption values are lesser for EPS & GGBS replacement in the concrete. The least water absorption of GGBS replacement in cement and EPS beads replacement in natural fine aggregates is 35% & 0.8% (M6 mix).

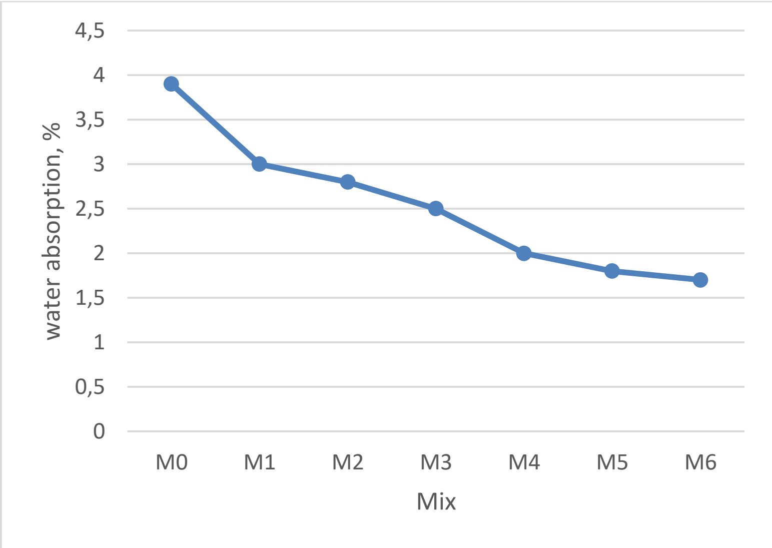

Fig 6.4 Water absorption Vs % Mix

7. CONCLUSIONS

- As we have conducted different types of tests on lightweight concrete we found various results. By conducting compressive and split tensile strength test on concrete cubes and cylinders, we found that compressive , tensile strength is slightly improved by partially replacing the cement with GGBS and combine aggregate with Eps beads. In this whole process we are trying to increase the strength of concrete and for that we are using mix aggregate cement of GGBS.
- The workability increases with increasing GGBS and eps replacement in concrete. The eps beads were light weight and specific gravity was less than 1%, it occupies the more spaces and finally it's light weight. This also called light weight concrete.
- The cement replacing 25% with GGBS and fine aggregate with eps beads with 0.6% given the higher compressive and split tensile strength compare to the all-other mixes including control mix (0% replacement). The percentage increment of compressive and tensile strength is 25.35% and 26.76%.
- The cement replacing 25, 35% with GGBS and fine aggregate with eps beads with 0.4, 0.6, 0.8 % given that, increasing replacement the water absorption value decreases. The least water absorption value for compressive and split tensile strength compare to the all-other mixes including control mix (0% replacement). The percentage increment of compressive and tensile strength is 25.35% and 26.76%.
- The cement replacing 25, 35% with GGBS and fine aggregate with eps beads with 0.4, 0.6, 0.8 % given that, increasing replacement the water absorption value decreases. The least water absorption value for 35% replacement cement with GGBS and 0.8% replacement fine aggregate with EPS beads.

- By doing this project we could gave a contribution to the society by making the environment eco-friendlier by utilizing the GGBS scientifically. Thus, by adopting replacement method we can overcome problems such as waste disposal crisis.
- Utilization of GGBS and its application for the sustainable development of the construction industry is the most efficient solution and also address the high value application of such waste. By using the replacement materials offers cost reduction and can overcome few environmental hazards.

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