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Experimental Investigation of GFRG

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Abstract:
Glass fiber reinforced gypsum (GFRG) panels are new building materials made essentially of gypsum plaster reinforced with glass fibers. GFRG panels can be unfilled when used as partition walls, but when used as external walls, it is filled with M20 grade concrete (reinforced concrete filling) in order to resist the lateral loads.M20 grade is adopted in order to satisfy the durability requirements stipulated in the code IS 456:2000 rather than for strength .Concrete is the most important ingredient in the construction field. The increases quest for sustainable and eco-friendly materials in the construction industry has led to research on partial replacement of the conventional constituents of concrete by two selected waste materials. The attempt is made on replacing Silica Fume (SF) and Expanded Polystyrene (EPS) as replacement for cement and fine aggregate in the M_{25} and M_{30} grade concrete. In this project, ordinary portland cement (OPC) is replaced by 2.5, 7.5 and 10 percentage replacement of Silica Fume and 5, 10, 15 percentage of fine aggregate is replaced by Expanded Polystyrene in M_{25} and M_{30} grade concrete.

Keywords: GFRG Panels, Eco-Friendly Materials Silica Fume, Expanded polystyrene (EPS) Beads

I. INTRODUCTION

Building materials form the backbone of civil engineering construction Of all the modern building materials, concrete is one of the oldest and the most versatile building material used in any type of civil engineering structure. The advantages of using concrete include relatively good compressive strength, formability, general availability of its raw materials and adaptability to different environmental conditions. With the advancement of technology and increased field application of concrete and mortars, the density, strength, workability, durability and other characteristics of the ordinary concrete is continually undergoing modifications to make it more suitable for any situation. In order to meet the scarcity of cement and raw materials used in concrete, the use of recycled solid wastes, agricultural wastes and industrial by-products like silica fume, fly ash, blast furnace slag, silica fume, rice husk ash, Expanded polystyrene (EPS) beads etc. came into use. Concrete made with light weight materials are known as light weight concrete. Light weight concrete with density varying between 1400 to 2100 Kg/ m3 has been used for structural purpose for so many years. The benefit of using light weight concrete is that it leads to overall reduction in dead load of a structure. This results in the reduction of final cost and improved economy of structural elements. Glass fiber reinforced gypsum (GFRG) panels are machine made in less than one hour. All GFRG panels are 12 meters length and 3 meters height. The panels are cellular in form and are 124 millimeters thick. Construction using GFRG panels is very fast, low in cost and eliminates the need for bricks, blocks, sand, wall framing and plastering. The selection of structural systems, analysis and the design should be performed as per the Structural Design Manual prepared by IIT, Madras, India.
Expanded polystyrene (EPS) is a light weight cellular plastic material consisting of fine spherically shaped particles. These beads consist of 98% of polystyrene and 2% of air. It has a closed cellular structure and cannot absorb water.EPS beads are inert materials and do not contain chloroflurocarbon (CFC) and Hydrochloroflurocarbon (HCFC).

II. MATERIAL AND METHOD

Ordinary Portland cement, fine aggregates, coarse aggregates, silica fume, expanded polystyrene beads and water are used for making concrete mixes in this present study. Properties of constituent materials are tested as per the methods prescribed by the relevant IS codes.

A. *Cement*

Ordinary Portland cement (OPC) confirming to (53 Grade) was used for the experimental work. Laboratory tests were conducted on cement to determine standard consistency, initial setting time, final setting time, specific gravity, fineness, and compressive strength. The results are presented in table 1.

Table 1 properties of cement

Sl.No	Particulate	Value
1	Grade	OPC 53
2	Standard Consistency,%	31.5
3	Initial Setting Time, min	91
4	Final Setting Time, min	211
5	Specific Gravity	3.15
6	7 day Compressive Strength, N/mm^2	37
7	14dayCompressive Strength, N/mm^2	45
8	28dayCompressive Strength, N/mm^2	53

B. *Fine Aggregate*

M sand was used as fine aggregate. Laboratory tests were conducted on fine aggregate to determine the different physical properties .The test results are shown in the table 2.

Table 2 properties of fine aggregate

Sl.No	Particulate	Value
1	Specific Gravity	2.33
2	Fineness Modulus	2.732
3	Effective Size	0.18mm
4	Uniformity Coefficient	3.83
5	Sand Type	Medium

C. *Coarse Aggregate*

In the construction of GFRG panels, maximum size of coarse aggregate used is 20mm. Laboratory tests were conducted on coarse aggregates to determine the different physical properties. The test results are shown in the table 3.

Table 3 properties of coarse aggregate

Sl.No	Particulate	Value
1	Specific Gravity	2.67
2	Void Ratio	0.77
3	Bulk Density	1.538
4	Porosity	0.44

D. *Silica Fume*

Silica fume, also known as micro silica .Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing silica-fume concrete require special attention on the part of the concrete contractor. The raw materials are quartz, coal, and woodchips. The smoke that results from furnace operation is collected and sold as silica fume, rather than being land filled. Perhaps the most important use of this material is as a mineral admixture in concrete. Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO2). The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Because of its fine particles, large surface and the high SiO2 content, silica fume is a very reactive pozzolan when used in concrete. The Properties of silica fumes are shown in table 4

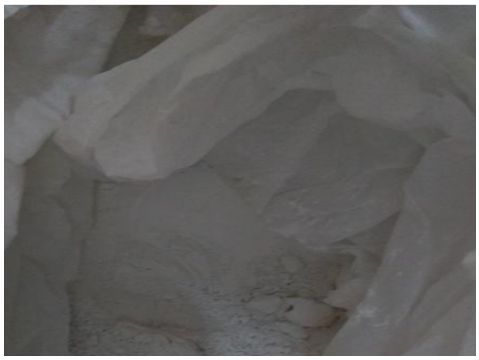

Fig: 1 Silica Fume

Table 4 properties of silica fume

SI.NO	Particulate	Value
1	Specific gravity	2.2
2	Mean grain size (µm)	0.15
3	Specific area cm2/gm	15000-30000
4	Colour	Light to dark grey

E. *Expanded Polystyrene (EPS) Beads*

Polystyrene is a waste material from packing industry. When processed in a special manner, polystyrene can be expanded and used as light weight concrete making material. The properties of EPS beads are shown in table 5

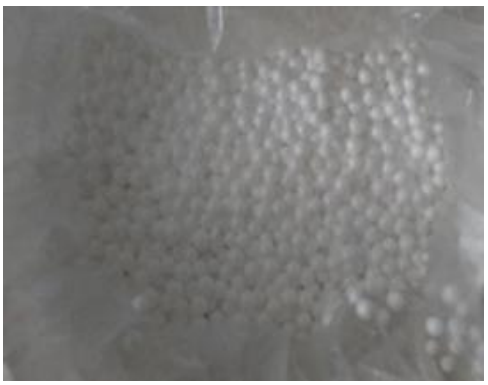

Fig: 2 Expanded Polystyrene (EPS) Beads

Table 5 properties of EPS beads.

Sl.No	Particulate	Value
1	Appearance	White emulsion
2	Specific Gravity	0.0075
3	Freeze/ the resistance	Excellent
4	Flammability	Non Flammability
5	Compatibility	Can be used with all types of Portland cement

F. *Concrete Mixes*

Mixes M25 and M30 grade concrete were designed as per IS 10262:2009. Several trail mixes were casted to arrive at the appropriate mix proportion. Table 6 and table 7 show the details of test specimen and mix proportioning of concrete.

Table 6 Detail of test specimen

Sl.No	Specimen	Size(mm)
1	Cube	150×150×150
2	Cylinder	150×300

Table 7 Mix Proportioning

Mix	Cement Kg/m^3	Fine Aggregate Kg/m^3	Coarse Aggregate Kg/m^3	Water $Litre/m^3$	W/C Ratio
M_{25}	383.6	785. 3	1048.84	191.58	0.5
M_{30}	425.73	770	1028.96	191.58	0.45

III. EXPERIMENTAL PROCEDURE

A. *Preparation of Mixes*

M25 grade concrete mix is taken as the reference mix and designated as MR. The optimum percentage replacement of cement with silica fume was found by preparing samples with various replacement levels of 0%, 2.5%, 7.5%, and 10%.Water cement ratio of the reference mix was kept at 0.5. The optimum percentage of silica fume was found to be 5%. This mix with optimum percentage of silica fume is used further to find the optimum percentage of EPS beads. Fine aggregate is replaced with 0%, 5%, 10%, 15%, 20% and 25% EPS beads to find the optimum percentage. Silica fume is replaced in terms of its weight and EPS beads in terms of its volume. The details of the mix proportioning for optimum percentage of silica fume and optimum percentage of EPS beads is furnished in table 8 and table 9 respectively.

IV. EXPERIMENTAL WORK

A. *Compressive Strength*

Concrete cube (150×150×150mm) of M25 & M30 grade concrete have been casted, the conventional cubes and the cubes with replacement of cement by 0%, 2.5%, 7.5%, 10% Silica fume and replacement of fine aggregate by 0%, 5%, 10%, 15% Expanded polystyrene have been tested .The results have been given below,

Fig: 3 Compressive strength test

Table 8 Compressive strength result for M_{25}

Mix	Compressive strength (N/mm^2)		
	7^{th} day	14^{th} day	28^{th} day
M_0	19.62	23.24	27.02
M_1	18.66	20.84	23.72
M_2	19.36	21.29	24.36
M_3	19.54	21.48	24.74

M0 – Conventional mix
M1 – 2.5% Silica fume and 5% Expanded polystyrene.
M2 – 7.5% Silica fume and 10% Expanded polystyrene.
M3 – 10% Silica fume and 15% Expanded polystyrene.

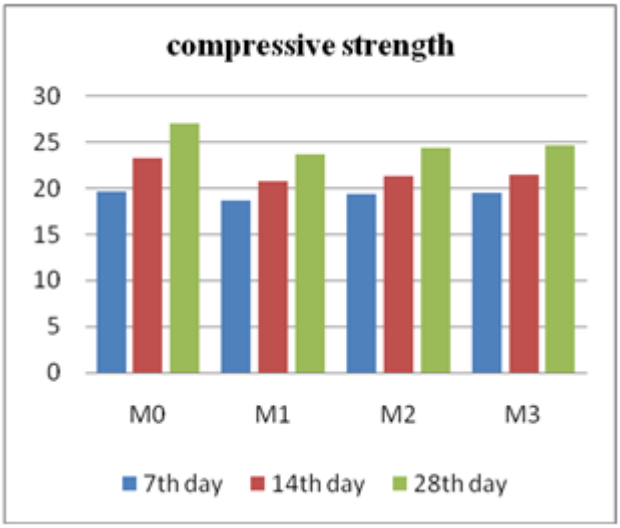

Fig: 4 Compressive strength Vs Mix for M_{25}

Table 9 Compressive strength result for M_{30}

Mix	Compressive strength(N/mm^2)		
	7^{th} day	14^{th} day	28^{th} day
M_0	23.72	26.15	28.67
M_1	23.11	24.92	27.79
M_2	23.78	25.21	28.09
M_3	24	25.37	28.22

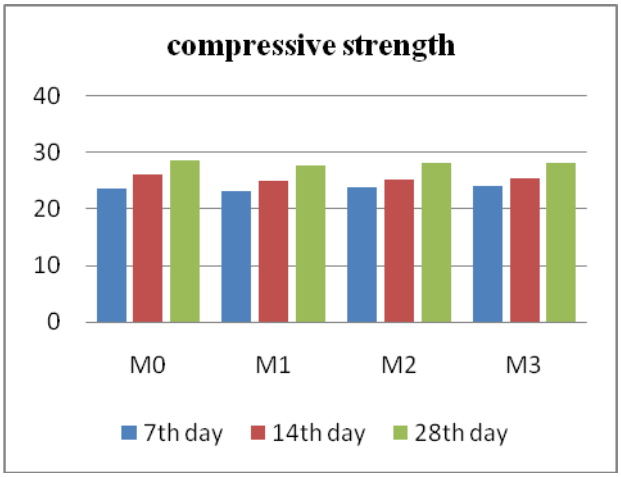

Fig: 5 Compressive strength Vs Mix for M_{30}

B. *Split tensile strength*

Concrete cylinder (dia-150mm, height-300mm) of M_{25} & M_{30} grade concrete have been casted, the conventional cylinders and the cylinders with replacement of cement by 0%, 2.5%, 7.5%, 10% silica fume and replacement of fine aggregate by 0%, 5%, 10%, 15% expanded polystyrene.

Fig : 6 Split Tensile strength test

Table 10 Split tensile strength for M_{25}

Mix	Split tensile strength(N/mm^2)		
	7^{th} day	14^{th} day	28^{th} day
M_0	2.42	2.90	3.29
M_1	2.25	2.52	2.76
M_2	2.30	2.67	2.87
M_3	2.34	2.83	3.19

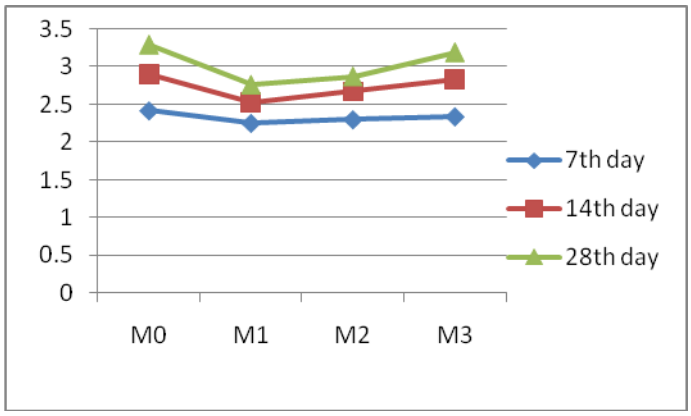

Fig: 7 Split Tensile test Vs Mix M_{25}

Table 11 Split tensile strength result for M_{30}

Mix	Split tensile (N/mm^2)		
	7th day	14th day	28th day
M_0	2.45	2.67	3.11
M_1	2.40	2.76	3.10
M_2	2.53	2.84	3.18
M_3	2.55	2.97	3.25

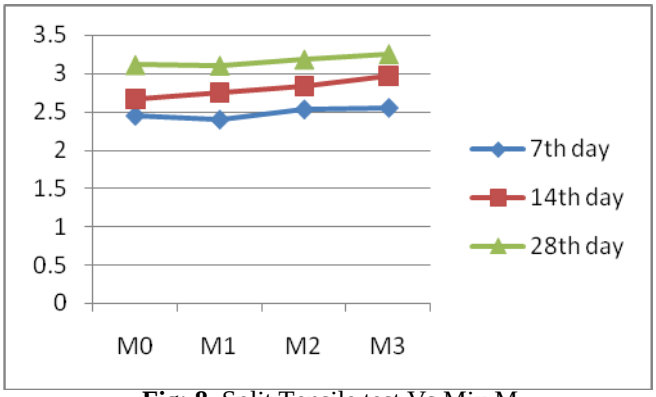

Fig: 8 Split Tensile test Vs Mix M_{30}

V. CONCLUSION

The following conclusions are made based on the experimental investigations on compressive strength, split tensile strength:

1. The compressive strength increases up to 10% replacement of cement by Silica fume and 15% replacement of fine aggregate by expanded polystyrene.

2. The split tensile strength also increases up to 10% replacement of cement by Silica fume and 15% replacement of fine aggregate by expanded polystyrene.

3. The compressive strength and tensile strength increases due to good packing nature of Silica fume

4. 15% replacement of fine aggregate by expanded polystyrene does not cause any decrease in strength since the replacement level is low.

5. Increase in the EPS content in concrete mixes reduces the density of concrete.

6. Workability increases with increase in EPS beads content.

7. The replacement by using EPS has shown a positive application as an alternate material in building non-structural members, and it also serves as a solution for EPS disposal.

8. Obtained results suggest that expanded polystyrene concrete has scope for non- structural applications, like wall panels, partition walls, etc.

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