Experimental Study on Glass Fiber Reinforced Gypsum (GFRG) Panels Filled with Alternate Concrete Mix Using Shredded Thermocol and Phosphogypsum

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Abstract—Glass fiber reinforced gypsum panels (GFRG) are hollow panels made from modified gypsum plaster and reinforced with chopped glass fibers. The hollow cores inside the walls can be filled with in-situ concrete/reinforced concrete or insulation material to increase the structural strength or the thermal insulation, respectively. GFRG panels can be unfilled when used as partition walls, but when used as load bearing walls, it is filled with M20 grade concrete (reinforced concrete filling) in order to resist the gravity and lateral loads. The study was conducted in two stages: First stage involves formulation of an alternate light weight mix to be used in the GFRG panels in lieu of M20 grade concrete by partial replacement of cement with phosphogypsum and fine aggregate with shredded thermocol and thereby conducting experimental investigations to obtain the optimum combination. In the second stage the above formulated mix is filled in GFRG panels and experimental investigations are conducted to evaluate the strength parameters and the results are compared with the panels filled with conventional M20 concrete mix. The results of the second stage of experimental investigations are presented in this paper

Index Terms—Hollow panels,Light weight, Low cost,Phosphogypsum, Shredded thermocol, Prefabricated, Green Product

1 Introduction

Concrete is considered as the second largest material consumed after water. Sustainable design and construction of structures using green material is an alternative to depletion of aggregates and increase in price of cement. Glass fiber reinforced gypsum (GFRG) panel is a green product .They are made with modified gypsum plaster and reinforced with cut glass fibers. They are manufactured to a thickness of 124 mm, a length of 12m and a height of 3m. Although its main application is in the construction of walls, it can also be used in floor and roof slabs in combination with the reinforced concrete. The panels contain cavities that maybe filled with concrete and reinforced with steel bars to impart additional strength and provide ductility. These panels can be used as alternative building material to replace bricks or concrete blocks. Various researches have been conducted by IIT Madras and they have developed a structural design manual for conducting the design of buildings made with GFRG.

Phosphogypsum is a byproduct of fertilizer industries. Apart from being used as a fertilizer, building material and soil stabilization agent, about 85% of phosphogypsum is dumped in the vicinity of phosphate factories, requiring large disposal areas .Thermocol is a type of polystyrene used for packaging .After its intended use it is being disposed as waste. It is one of the principle components of urban litter. They are not biodegradable and it takes several decades to hundred years for polystyrene to deteriorate in environment or in a landfill. Usually they are disposed in landfills by shredding it.

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Experiments have been conducted on the use of expanded polystyrene beads (EPS) for the production of light weight concrete .But EPS is a finished product rather than a waste material. Therefore this study focuses on the use of shredded thermocol in lieu of EPS beads for partial replacement of fine aggregates and phosphogypsum for partial replacement of cement thereby striving for a possible alternative to deal with these two materials and at the same time attempting to formulate an alternate light weight concrete mix. The alternate mixes thus formulated are filled in GFRG panels and the strength characteristics are studied here.

2 Objective of Work

The effective disposal of phosphogypsum is done by the manufacture of Glass Fiber Reinforced Gypsum (GFRG) panel, also known as Rapid wall. These can be used as load bearing as well as non load bearing structures. While using it as load bearing structures, it is being filled with M20 grade concrete so as to resist the gravity and lateral loads. M20 grade concrete is used in these panels inorder to satisfy the minimum requirements stipulated in IS 456:2000. In this work, phosphogypsum and shredded thermocol are used as partial replacement of cement and fine aggregates respectively and formulating an alternate light weight mix equivalent in strength to that of M20 grade concrete. The optimum percentage of phosphogypsum is found to be 10% in the first stage of experiment. Then shredded thermocol is added to replace fine aggregate in percentages of 5%, 10%, 15%, 20% and 25%. The mixes are then filled in the GFRG panels and compression testing is been

carried out.

3. Materials and Properties

Ordinary Portland cement, coarse aggregate, fine aggregate, phosphogypsum, shredded thermocol, water and super plasticizers are the materials used in making the concrete mixes. Their properties are tested according to the relevant IS codes.

Cement: Ordinary Portland cement of grade 43 confirming to IS 8112-2013 is used. The cement is tested for various properties as per IS 4031-1967(reaffirmed 1995). The specific gravity of cement is used is 3.2.

Fine aggregate: M sand was used as fine aggregate. Tests were conducted on fine aggregate as per IS 2386 (Part III)-1970. Zone II aggregate is used. The different properties of fine aggregate are: specific gravity 2.61, fineness modulus-2.67 and water absorption-1.02.

Coarse Aggregate: In the construction of GFRG panels, maximum size of coarse aggregate used is 12.5mm. Tests on coarse aggregate were done as per IS 2386 (Part III)-1970.The different properties of coarse aggregate are: specific gravity-2.67, voidratio-0.73, porosity 0.42 and water absorption-0.6

Phosphogypsum :Phosphogypsum was collected from FACT-RCF building products Ltd, Kochi, Kerala. The specific gravity of phosphogypsum was found to be 2.26

Shredded thermocol: Shredded thermocol is obtained by shredding the polystyrene waste. Shredding machine with dust separator is used to shred the rejected thermocol scrap. The shredded thermocol was obtained from Mane Electricals, Pune. The specific gravity of shredded thermocol was found to be 0.033

Superplasticizer : Water reducing plasticizer SP Ceraplast 300 is used to optimize the workability, water cement ratio and hence the strength

4 Experimental Procedure

The first stage of work consisted of formulating an alternative mix equivalent to M20 grade concrete. Concrete mixes were prepared according to IS 10262:1982 and IS 10262:2009. The optimum percentage of phosphogypsum was found to be 10%. Then shredded thermocol was added in 5%, 10%, 15% and 20% .The concrete cubes, cylinder and beams were tested and the optimum percentage of shredded thermocol was found to be 15%.

Fig.8 GFRG panels

The second stage of work consisted of filling the panels with alternate mixes i.e concrete mixes with optimum percentage of phosphogypsum and varying percentages of shredded thermocol and testing of the specimens to study their strength characteristics. The compression test was carried out on GFRG specimens of size 300mm x 300mm x 124mm as shown in Fig. 1. The results of the test carried out on GFRG panels are explained in the results and discussion part.

5 Results and Disscusssion

5.1 Compression Test on GFRG Panels

The test was done for all the alternate concrete mixes for determining 7 and 28 day compressive strength. From the results obtained it is observed that the strength decreases with the addition of shredded thermocol. Replacement up to 15% shows strength greater than that of panels filled with M20 grade concrete. The results obtained are shown in the Figure 4. It was observed that the failure of web occurred first. This type of failure (Fig. 3) is mainly due to the weak connection existing between bottom flange and web of GFRG panels. At the time of manufacture, glass fibers are laid over the aluminium plug (which serves as a provision for providing hollow cavities in GFRG panels) and tamping rods with cutting edges are used to tamp the glass fibers to the rib portion. This step is carried out to ensure the continuity of glass fibers in GFRG panels. But the fibers inserted in such a manner create an improper bonding between the bottom flange and web of GFRG panels.

Fig.2 Concrete filled GFRG panels

Fig.3 Failure pattern of GFRG panel

5.2 Density

The density of the GFRG panels was found to be decreasing with the addition of shredded thermocol. The results obtained are shown in Figure 5. Density of concrerte filled panels decreased due to the light weight of the fine aggregates.

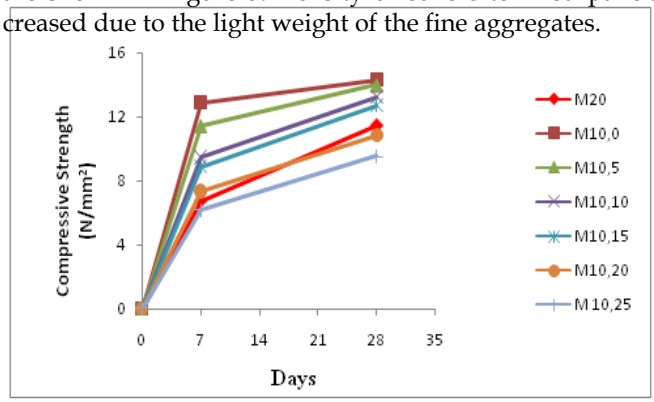

Fig. 4 Compressive Strength Vs Days

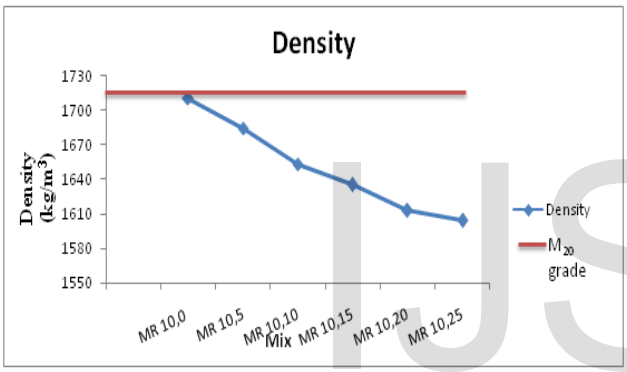

Fig.5 Density of panels

6 Conclusion

The optimum combination of phosphogypsum and shredded thermocol which can be used as an alternative to M20 mix which can be filled in GFRG panels was found to be 10% and 15% respectively.

The reduction in density of GFRG test specimens filled with alternate mix was about 4.08% when compared to that filled with M20 grade concrete.

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