AN EXPERIMENTAL STUDY ON COST REDUCTION OF BUILDING BY USING HOLLOW PANEL BOARDS

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ABSTRACT

Housing is one of the basic needs of society and is an essential component of the built environment. The Ministry of Rural Development estimated that the rural housing shortage in India stands at 44 million dwelling units. India's urban housing shortage is 18.78 million units, of which 96% belongs to Economically Weaker Section (EWS) and Low Income Group (LIG) type, as per the estimate of the Ministry of Housing and Urban Poverty

There is a huge growing requirement of building materials in India due to the existing housing shortage. To meet this challenge, India requires innovative, energy efficient building materials for strong and durable housing in fast track method of construction at affordable cost. The present research on replace of building materials by innovative low cost materials from foundation to slab. This study deals with the physical properties of GFRG (Glass fiber reinforced gypsum) Panel and finding out the suitable filler materials to strengthen it. Glass fiber reinforced gypsum panels (GFRG) are hollow panels made from modified gypsum plaster and reinforced with chopped glass fibers

KEYWORDS: Glass fiber, phosphoGypsum.

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 fibre reinforced phospho gypsum panel is a green product .They are made with modified gypsum plaster and reinforced withglass fibres rovins. 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, provide ductility and overall structure act as unity. These panels can be used as alternative

1.1 PHOSPHOGYPSUM: Phosphogypsum refers to the calcium sulphate hydrate formed as a by-product of the production of fertilizer from phosphate rock. It is mainly composed of gypsum ($CaSO_4 \cdot 2H_2O$). Although gypsum is a widely used material in the construction industry, phosphogypsum is usually not used, but is stored indefinitely because of its weak radioactivity. Phosphorus is a mineral critical to all life on Earth. As a requirement of all biological beings, it is a cornerstone of nutrition for plants, animals, and people. As such, it is widely used in fertilizers and animal feed products. This valuable and irreplaceable nutrient is derived from phosphate rock. Mined phosphate rock is first converted into phosphoric acid, which serves as the basis of phosphoric fertilizer and animal feed products (among other things). This is most frequently carried out via the *wet process*, in which dried phosphate rock is combined with sulphuric acid in a reaction yielding phosphoric acid and calcium sulphate, or phosphogypsum. For every ton of phosphoric acid produced, around 5 tons of phosphogypsum are produced, making this a substantial source of industrial waste.

Table 1. chemical properties of Phospo gypsum

SL.NO	CONSTITUENTS	PERCENTAGE (%)
1	CaO	30.45
2	SiO2	9.50

3	Al2O3	2.80
4	Fe2O3	0.90
5	SO3	42.9
6	MgO	0.3
7	K2O	0.1
8	P2O5	0.63
9	Loss on ignition	12.42

1.2 DIMENSIONS OF PANEL AND MATERIALS USED:

1.2.1 Raw Materials

1. Calcined Gypsum
i.Shall be more than 90% as Calcium Sulphate
ii. Combined moisture shall not be more than 6.2%
As per Standard
i.Once in a day
ii. Once in a shift
2. Ammonium Carbonate
Shall not be less than 99.14% as purity As per Standard Once on delivery at site
3. Glass Roving
4. BS-94 M the
5. Retarder D-50
These raw materials are performance based. Test Certificates provided by manufacturers are verified at the time of delivery.

1.3 HOLLOW PANEL DETAILS：

1.3.1 Standard Hollow Panel:

Panel is a factory manufactured walling product used in the construction industry to provide habitable enclosures for residential, commercial and industrial buildings. The 124mm thick hollow-core panels are machine-made using formulated gypsum-plaster reinforced with chopped glass-fibre. A typical cross-section and isotropic view of the wall panel shown below.

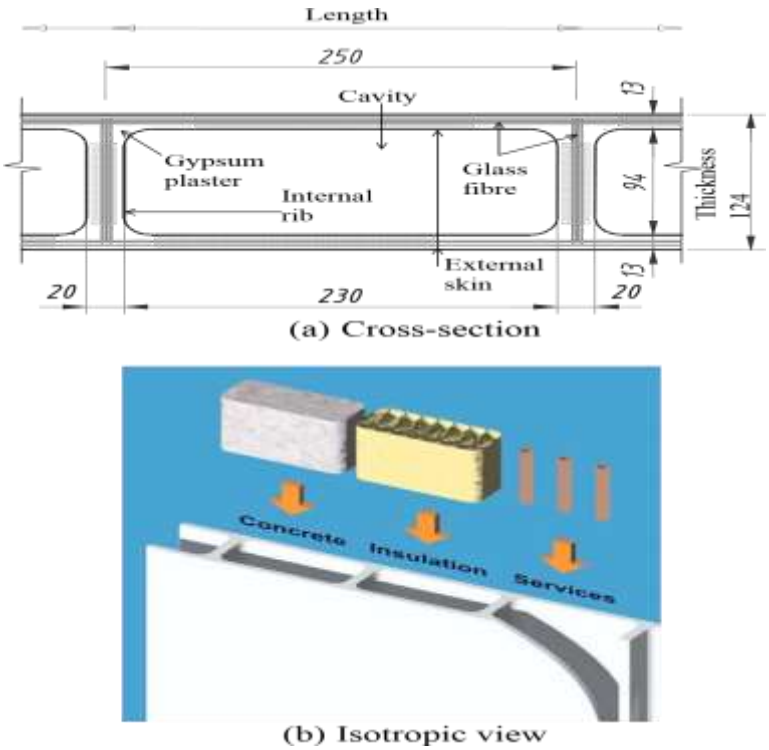

Figure 1 cross section of hollow panels

1.3.2 STANDARD DIMENSIONS:

The current nominal manufactured dimensions of each GFRG panel are:

- Length 12,020 mm
- Height 3050 mm, and
- Thickness 124 mm

Table 2. comparison with conventional walls

FACTORS	CONVENTIONAL	GFRG
Cost	Higher than GFRG	Can save 20-30%
Eco friendly	No	Yes
Fire resistant	Melts in 1000 degrees	Can withstand 1000 degrees for 4hours
Cooling effect	No cooling effect	Cooler up to 4 degrees
Time(for G+1)	6 months	30 days
Life	50 years	80 years

2. LITERATURE REVIEW :

MagantiJanardhana et al.(2004) Studied about behaviour of Glass Fiber Reinforced Gypsum wall panels. In a high seismic intensity zone, resistance of buildings to earthquakes is often ensured by adopting structural systems where seismic actions are assigned to structural walls (shear walls), designed for horizontal forces and gravity loads while columns and beams are designed only for gravity loads..

A Meher Prasad(2013) Focused on new building panel product, made of gypsum plaster reinforced with glass fibres. It is also known as Rapid wall in the industry. GFRG is of particular relevance to India, where there is a tremendous need for cost-effective mass-scale affordable housing, and where gypsum is abundantly available as an industrial by-product waste. The product is not only eco-friendly or green, but also resistant to water and fire. The panel contains cavities that may be filled with concrete and reinforced with steel bars to impart additional strength and provide ductility. - **DevdasMenon[2014]**Discussed about a demo building constructed in IIT Madras. The building is constructed using GFRG Panels which is made out of gypsum, largely available in form of Phosphogypsum, a waste by product of fertilizer industry and Glass fibre as reinforcing agent which enhances the strength of the panels. The building panels are suitable.

3. TESTS CONDUCTED ON GYPSUM PLASTER: for affordable mass housing, with the advantages of cost-effectiveness and rapid construction

3.1 INITIAL SETTING TIME:

Collect a sample of gypsum plaster from casting table. Place it into a standard mould and remove the mould. The gypsum plaster spreads into a circle on the table. Use the tool called as Initial hilmor (200g) and place the tip of it on the sample. Note the time at which the impression just disappears.

3.2 FINAL SETTING TIME:

Now use the tool called as Final hilmor (4800g) and places the tip of it on the sample. Note the time at which the impression just disappears is noted.

3.3 CUBE TEST:

Prepare a test specimen of standard size (50 cm2 face area). Remove the mould after 24 hours. Place the cube on Compression testing machine. Apply the load gradually and note the load at which the specimen fails.

TABLE 3. TIME MANAGEMENT

S. No.	Item of Work	RCC (in Days)	GFRG (in Days
1	Earthwork Excavation	2-4	2-4
2	C.C Bed 1:4:8	2-3	2-3
3	Brickwork in Foundation	5-7	5-7
4	Plinth Beam with DPC	2-4	2-4
5	Columns	9-10	-
6	Walls (Brick / GFRG)	10-15	2-4
7	Beams	15-18	-
8	Lintels and Sunshades	4-5	2-3
9	Slab	28	14
10	Plastering	10-12	-
11	White Wash	3-4	-
12	Colour Wash	2-3	2-3
13	Flooring	3	3
	Total Duration	98-120	34-44

TABLE 4. COST COMPARSION

Materials/items	Rapid wall building	Conventional building	Savings in %
Cement	16 tons	32.55 tons	50.8
Steel	1800 kg	2779 kg	35.2
Sand	20 cum	83.87 cum	76
Granite	38 cum	52.46 cum	27.56
Brick	-	57200	
GFRG panel	500 sqm	-	
Water	50000 ltr	200000 ltr	75
Labour	389 man days	1200 man days	67.59
Construction time	21 days	120 days	82
Wt. of superstructure	170 tons	490 tons	65
Construction cost	Rs. 13.25 lakhs	18.27 lakhs	61.5

TABLE 5. STRENGTH PARAMETERS

S.No.	Parameters	Test Method	Requirement	Results Obtained
1.	Dimensions Length Height Thickness	BMBA PC-3:2011 Clause 10.4.2	 12.02m 3.05m 124mm	 Within specified tolerances
2.	Water Content	Clause 10.4.3	Less than 1%	Satisfactory
3.	Weight	Clause 10.4.4	40 kg/m^2	44.10 kg/m^2

4.	Water absorption	Clause 10.4.5	Max. 5% by weight	3.85% (Avg.)
5.	Compressive strength	Clause 10.4.6	Min. 160 kN/m	161.3 kN/m (Avg.)
6.	Flexural strength	Clause 10.4.7/10.4.8	Min. 2.1 kN/m	2.14 kN /m (Avg.)
7.	Fire resistance	Clause 10.4.10	4 hr rating withstood 700-1000^{o}C	Satisfactory

4. EXPERMENTAL PROCEDURE

4.1 Manufacturing of hollow panel:

1.Our project members were collect list of materials from different sources for making a proto type model of hollow panel.

2.To made a hollow panel below mentioned materials are required

4.2 Materials used :

- Raw phosphogypsum
- White cement
- Water
- Retardant(D50)
- Water emulsion(BS94 M)
- Glass fiber

4.3 Raw Phosphogypsum:

1.Phospho gypsum is a by-product of chemical and fertizer industry it also comes from cement manufacturing industry as we collect 50 kg's of phospho gypsum from “SAGAR CEMENT" Cement manufacturing industry at bayyavaram.

Figure.2 Phosphorus panel board

Figure.2 Phosphorus panel board

4.4 White cement: White Portland cement is used in combination with white aggregates to produce white concrete for prestige construction projects and decorative work. White concrete usually takes the form of pre-cast cladding panels, since it is not economical to use white cement for structural purposes. White Portland cement is also used in combination with inorganic pigments to produce brightly colored concretes and mortars. Ordinary cement, when used with pigments, produces colors that may be attractive, but are somewhat dull. With white cement, bright reds, yellows and greens can be readily produced. Blue concrete can also be made, at some expense. The pigments may be added at the concrete mixer. Alternatively, to guarantee

4.5.1 Panel making process :

- Collected raw gypsum will be heated at 180°C-200°C.by heating raw gypsum calcination will process will be done.
- After calcination of raw gypsum it transform as fine powder look like cement powder

- Taking all the material into a pan and mixing of material will be done according to design proportions. To form a gypsum plaster
- To test the gypsum plaster a 15×15 cm cube will becasted. Compressive strength and water absorption rate will be checked.

figure. 4 panel cube mould

figure. 5 panel cube

- To cast a panel a rectangular pan will be need and the pan should be uniform and apply grease or oil to its inner surface. The gypsum plaster will be poured as layer with a thickness of 2.5 cm.athalf of 1st layer glass fiberrovins are split over the pan area then remain depth will be covered with plaster. After drying 1st layer imperious sheets thicknes of 3cm are to be placed at certain interval to form hollow cavities for panel
- Next again pour the plaster between the gaps of imperious sheets at dry it for 30 min.
- Then after the top layer will be layed.here also after pouring the plaster to its half of depth glass fiberrovins are spread over the surface and remaining depth covered.

- After casting panel leave it for 1 day to drying of panel.after drying panel will be gain its strength.

figure. 6 hollow panel boards

CONCLUSION

1. The hollow panel technology made to reduce the cost of construction.
2. The key advantages of rapidity, affordability and sustainability have generated interest in this technology.
3. Several such buildings (up to four storeys) are now being built across the country.
4. The use of hollow panels for construction of residential buildings results in significant increase in the construction speed, reduction in the labour requirement and construction cost, reduction in the use of energy intensive construction materials and promotion of reuse of industrial by-product waste generated by fertilizer industries in large magnitudes.
5. Moreover, the use of light weigh hollow panel minimizes the building self-weight significantly, which makes the hollow building technology appropriate for use in higher seismic zones.
6. The whole building, made out of concrete infilled GFRG panels, avoids the use of bricks (with multiple joints and weak locations) and reduces the use of concrete significantly.
7. The excellent surface finish of hollow panels eliminates the need for plastering. At least one-fifth of the construction cost can be saved due to the use of this technology.
8. From the durability point of view, the life of GFRG buildings can be expected to be not less than that of similar conventional buildings.
9. There is great potential to utilize this technology for affordable mass housing projects in India. Housing using GFRG is an ideal solution for mass housing which can be rapidly built, which addresses sustainability and delivers quality houses with low cost of construction.

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