



“GFRG” A Sustainable, Affordable And Alternative Building Material

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Abstract- In our country, Economically Weaker and depressed section of the community miss out the opportunity of owning an own house, security, dignity and Governmental schemes. In this evolving world where land prices are reaching sky-high and the current methods of construction practiced i.e., RCC construction, which takes lots of time for construction, expensive and not environmentally friendly indicates for the use of alternative and good construction materials. One such material is GFRG-Glass Fiber Reinforced Gypsum Panels. This material is manufactured from waste gypsum a byproduct from fertilizer industry and perform better when compared to a RCC in many ways. To prove which method is more acceptable for today’s changing world especially from Economically Weaker Sections point of view, a comparative study had been made. The study comprises of comparisons drawn between the conventional RCC construction and GFRG construction in terms of their performance during exposure to loads, Cost of construction and timeline analysis. Research has found gypsum to be a durable material, and it is already heavily in use as partition walls. Experts predict that a building made of GFRG panels can have a life span of 60 years. And the material has been approved as green building material by the United Nations Framework Convention on Climate Change (UNFCCC).

Index Terms- Affordable, Conventional building, GFRG panels, Rapid walls.

I. INTRODUCTION

In India, the construction industry increasing rapidly which in turn increasing the requirement of building material in large quantities as the population growth is high especially in urban areas. Having an own house is every individuals dream to full fill their needs as we know it takes lot of money to construct a house or buy one. And most of us who buy the houses from their lifetime savings have to pay the EMIs till their retirement age. To overcome this housing hurdle, India needs innovative, high-efficiency building materials for strong and durable housing in an advanced mode of construction at an affordable cost. All these issues and concerns are required in sustainable and overall development. GFRG Panel provides speedy construction and contributes to environmental protection.

There have been a lot of efforts made earlier by the industry experts to find an alternative to existing construction technology to make it more affordable. Glass Fibre Reinforced Gypsum (GFRG) is one such technology in the construction field that could reduce the construction cost by 50% or more. Now, this method of construction is broadly accepted by a few Asian nations such as India, Saudi Arabia, Oman, and China.

Glass fibre reinforced gypsum (GFRG) panel or **Rapid wall** is a modern building element devised by the GFRG Building System Australia for mass-scale construction of houses in a very short span of time. A GFRG panel is basically calcined gypsum plaster,

reinforced with glass fibres which when filled with reinforced concrete in an appropriate proportion becomes strong enough to act as a load bearing and shear wall. GFRG panels can even resist the lateral loads due to earthquakes and wind. Not only the walls, but the roofs, sunshades, slabs, stair-case and the boundary walls can also be made by using GFRG panels. Due to its intensive advantages and benefits the technology grown rapidly mainly in southern parts of India (i.e., Kerala, Karnataka, Tamil Nadu and Andhra)

When it comes to mass scale housing this technology comes in handy which saves time and money. New technology advancements like these helps in the growth of the construction industry. This energy-efficient green building material is suitable to construct up to 8-storey building in the safest earthquake zone.

GFRG PANELS:

The Glass Fibre Reinforced Gypsum panels mainly comprises of gypsum which gives white shade to the panel and the panel have a smooth surface that can be painted or left alone. For the manufacturing of the gfrg panels skilled personnel are required.

The typical dimension of a GFRG building panel is 12.0m x 3.0m x 0.127m Each 1.0m segment of the panel contains four cells. Each cell is 250mm wide and 124mm thick. which weighs around 1.6 tons.

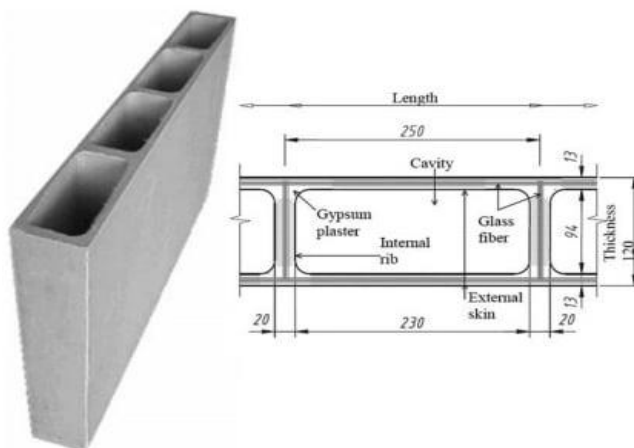


Fig-1 Details of a GFRG Panel

RAW MATERIALS OF GFRG:

Calcined gypsum, Glass fiber, White cement, D50(retarder), BS94(water repellent)

Calcined Gypsum

Gypsum partially dehydrated by heat (800-1100 0C); it is same like Plaster of Paris.

Formula: $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$

Plaster of Paris is also 25 – 40 % cheaper than gypsum.

All gypsum panels are fire resistant.

COST:

One metric ton -1800/-

Packet (one kilogram)-25/-

Largest producer of gypsum in India:

Rajasthan, Gujarat, Jharkhand, Madhya Pradesh.



Fig: 2 Gypsum

GLASS FIBER:

Glass fiber is a material consisting of numerous extremely fine fiber of glass. Glass fiber made of 4 chemical compositions. Most Glass fiber are silica based (50-60%), and contain a host of other oxides of calcium, boron, sodium, aluminium, iron etc. Glass fiber really made of glass, glass fibers manufactured by heated the glass until melted then forced through superfine holes, this create glass fibers that are extremely thin. Fiber glass is stronger than steel (or) aluminum.

WHITE CEMENT:

White cement has essentially the same properties as grey cement, expect for colour. It is having a strong water proofing property without adding a waterproof coating with a compressive strength of 25 to 50 Mpa. In Comparison white cement had higher, compressive strength than normal grey cement. White cement is stronger(harder), move cohesive, sticky, and durable but it is expensive than the grey cement.

COST: packing size - 25kg-200/-
5kg-70/-
50kg-680/-

Largest producer of white cement in India- J k cement – Rajasthan, Birla White-Mumbai.

MANUFACTURING OF THE GFRG PANELS

The manufacturing process of the GFRG panels is done in the plant and it is done in the following steps:

1) Collection of the Raw Gypsum

The stock of waste gypsum of seven million tons of it with an addition of 2,000 tons every day piled up into a hill awaiting disposal in the fertilizer industry. This waste product of the fertilizer industry reprocessed by calcite to make gypsum plaster that forms the raw material for the GFRG panel.

2) Casting of the Panels

The panels are manufactured based on the technology transfer through. The panels are cast in three stages on a special table by pouring a paste of calcined gypsum and other chemical additives. Glass fibers are spread evenly onto the mix by means of a screening and rolling process. Next, special aluminium plugs are inserted on top of the finished first layer with 20mm gaps in between to form the hollow cavities in the panel. Now, the second pouring of the mix is done along with cut glass fibers with tamping to form the ribs of the hollow panel. In the third stage the process of the first stage is repeated to complete the top layer of the panel. After setting which takes 25 minutes the plugs are withdrawn and the costing table is rotated.

3) Drying of the Panels

Panels in their vertical position is taken out for drying by means of a special forklift. The drying of the panels is done in a dryer chamber in which hot air is circulated to dry the panel evenly for 90 minutes.

4) Cutting of panels

After drying, the panels are cut using a computer-aided and automated process tailor-made to the specified requirements for any building project. It is important that all this information is carefully planned in advance and furnished at the plant site by means of cutting drawings to be furnished by the architect or engineer.

CLASSIFICATION OF GFRG PANELS:

- 1) **Class-1- Water resistance grade-GFRG** panel for external walls, in wet areas and or as floors and wall frame work for concrete filling.

- 2) **Class-2- General Grade-** GFRG panels for structural application or non-structural application in dry areas. These panels are generally unsuitable for use as wall or floor formwork
- 3) **Class-3- Partition Grade-** GFRG panel as non-structural internal partition walls in dry areas only.

MECHANICAL PROPERTIES (unfilled panels)-based on test results:

Table:1

MECHANICAL PROPERTIES	NOMINAL VALUE
Unit weight	0.433 KN/m ²
Modulus of elasticity	7500 N/mm ²
Uni-axial compressive strength	1600 KN/m
Uni-axial tensile strength	34-37 KN/m
Ultimate shear strength	21.6 KN/m
Out-of-plane moment capacity, Rib parallel to span	2.1 KN/m
Out-of-plane moment capacity, Rib perpendicular to span	0.88 KNm/m
Mohr hardness	1.6
Out-of-plane flexural rigidity, EI, Rib parallel to span	3.5×10 ¹¹ Nmm ² /m
Out-of-plane flexural rigidity, EI, Rib perpendicular to span	1.7×10 ¹¹ Nmm ² /m
Co-efficient of thermal expansion	12×10 ⁶
Water absorption	1.0% 3.85%
Fire resistance Structural adequacy/Integrity/Insulation	140/140/140
Sound transmission class	40 db.

GFRG VS CONVENTIONAL BUILDING:

In the current society and rapid urbanization made the rcc constructions a prior and present ruling the construction industry although the conventional system having advantages and popularity it also causes some disadvantages and lacks in certain areas when compared to other methods. This can be overcome by the gfrg panels construction. When choosing the alternative material, it should outstand the conventional one. The GFRG panels outstands the conventional method in Energy consumption during manufacturing process, Natural resource and raw materials consumed, Recycling and safe disposal, Impact on environment, and Long-term sustainability and mainly it uses industrial waste as its raw material which is a key factor. The conventional method uses concrete, steel, plastics and bricks as a major construction material which causes environmental pollution in their manufacturing process with no scrap value and also the extensive use of these materials can drain the energy resources and adversely affect the environment. On the other hand, it is becoming very difficult to meet the on-growing demands. The main factor which differs these two construction methods are cost of construction and time of construction. Research says that gfrg construction could reduce the construction by 50% or more and also it saves the construction time as it is pre-fabricated.

Comparison between materials of conventional house and GFRG house:**Table-2**

Materials/items	Rapid wall building	Conventional	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	50000lit	200000 lit	75
Labour	389-man days	1200-man days	67.59
Construction time	21 days	120 days	82
Weight of superstructure	170 tons	490 tons	65
Construction cost	Rs.13.25 lakhs	18.27 lakhs	61.5

The use of cement, steel rebar, and sand is reduced by 25%, 36%, and 44% respectively.

WHY GFRG?

There are many other alternative materials out of all why gfrg makes it mark and why do we have to choose this one as a alternative material? Because the panels bore many advantages and qualities such as it is green building material which have low carbon or pollutant emission during the manufacturing and the way of construction too similar as conventional one and it completely avoids the usage of the brick material which can result in conservation of fertile topsoil of arable land which is used in bricks manufacturing and also the construction can be of high speed.

ADVANTAGES OF GFRG BUILDING OVER CONVENTIONAL BUILDING:

- High speed of construction.
- Less built-up area for the same carpet area: wall panels are only 124 mm thick.
- Less embodied energy and carbon footprint: significant reduction in the use of cement, sand, steel and water; recycling of industrial waste gypsum.
- Lower cost of structure: savings in materials and labour input.
- Lesser building weight (panels weigh only 44 kg/m²), contributing to savings in foundation and reduction in design for earthquake forces in multistoried construction.
- Buildings up to 6 - 10 storeys can be constructed using this load-bearing system, without the need for beams and columns.
- Excellent finishes of prefabricated GFRG panels – used for all the walls, floors and staircases, with minimal embedded concrete: no need for additional plastering.
- UNFCC approval under Clean Development Mechanism (CDM) of Kyoto protocol for carbon trading.
- Satisfactory performance under the event of fire.
- Good thermal comfort: indoor is cooler in summer and warmer in winter – ideal for tropical climates.
- Rot and termite resistant.
- Recyclable.

LIMITATIONS OF THIS TECHNOLOGY:

- In this load bearing wall system, the same floor plan has to be replicated in all floors, in multi-storeyed constructions.
- Precast constructions, especially on a mass scale, calls for meticulous planning and preparation, prior to start of construction.
- All the prescribed guidelines for cutting of panels, transportation, erection, joints, application of primer and waterproofing need to be strictly followed to ensure fault free performance of this prefab building system.
- Spans exceeding 5m are not advisable.
- Building height is restricted to 6 to 10 floors depending on seismic zonation.
- Walls and slabs are required to be planar, not allowing for curvature.
- The electrical/plumbing fittings should be planned in such a way that most of the pipes pass through the cavities in order to facilitate minimum cutting of panels).

FEW BUILDINGS CONSTRUCTED IN INDIA ARE:

- Demo building at IIT Madras campus.
- Residential building-Manipal, Udipi. Hastha Pvt.Ltd, Bangalore.
- Luxury Villa near Bangalore University. Hastha Pvt.Ltd, Bangalore.

- Mass housing project at Nellore, Andhra Pradesh. Hastha Pvt.Ltd, Bangalore.
- Residential building- Chitpady, Udupi.

CONCLUSION

Construction using GFRG (Glass Fibre Reinforced Gypsum) panels has been identified as a potential solution addressing the problem of housing shortage. GFRG building system and method of construction have been adapted to suit the Indian conditions, with compatible structural design. The problem is lack of awareness and the manufacturing companies was very limited as of now only one company is in working condition in the entire country which increases the construction cost and making unavailable to the people of northern India. With government involvement and increasing in number of manufacturing units can result in good production of this gfrg panels and surely it can a solution for the housing shortage in the coming days.

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