

Affordable Rapid Mass Housing Using GFRG Panels

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Abstract- In the present Indian scenario, there is a huge growing requirement of building materials in India due to the existing housing shortage. As per the current Census estimated urban housing shortage is 19 million, while the housing shortage of rural India is about 44 million units. The National Real Estate Development Council estimates that total housing requirement in India will increase to 114 million units by 2022 from 63 million units as of now.

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 construction of building systems using Glass Fibre Reinforced Gypsum (GFRG) panels is a very promising and emerging building technology.

GFRG buildings can completely avoid cement plastering, and uses much less quantities of steel, cement sand and water compared to conventional buildings. GFRG buildings consume much less embodied energy (less carbon footprint) and recycles industrial waste gypsum, contributing to sustainable development. It has been approved as a green building material by the United Nations Framework Convention on Climate Change (UNFCCC).

In this paper we did a detailed study on GFRG Panels which includes dimensions, grade, design and construction of building based on construction manual prepared by IIT Madras to suit Indian situation. The later part deals with analysis of GFRG construction with respect to conventional construction.

I. INTRODUCTION

GFRG is the abbreviation for glass fibre reinforced gypsum. It is the name of a new building panel product, made essentially of gypsum plaster, reinforced with glass fibres, and is also known in the industry as Rapid wall. This product, suitable for rapid mass-scale building construction, was originally developed and used since 1990 in Australia. 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 aim of project work is to study the step by step process of construction and design using this GFRG panel. We also did an analysis of benefits of GFRG construction versus the conventional construction.

II. DEVELOPMENT OF LOW COST HOUSING

In recent years, there has been considerable debate over the definition of low cost housing. Without falling into any further debate on the issue, in plain terms, low cost housing may be defined as provision of housing which caters to the minimum requirements of masses within their income capabilities, without sacrificing the quality of construction.

Premier R&D institutions engaged in the field of building technology like the Central Building Research Institute (CBRI), Roorkee; the Structural Engineering Research Centre (SERC), Madras; the National Council for cement and Building Materials (NCB) Ballabgarh; and the Regional Research Laboratories, etc. have played important role in the development of cost-effective construction techniques and materials. On the other hand, organisations like the National Building Organisation (NBO), New Delhi; the Building Materials and Technology Promotion Council (BMTPC), New Delhi; HUDCO have been instrumental in the promotion of the innovative construction techniques evolved by the aforesaid research institutions in the country.

III. DIMENSION OF GFRG PANEL

- Thickness – 124mm
- Height- 3.0m
- Length- 12.0m

IV. GRADE OF PANELS

Class – 1 – Water resistant grade

GFRG panel for external walls, in wet areas and /or as floor and wall formwork for concrete filling

Class – 2 – General Grade

GFRG panels for structural application or non-structural application in dry areas. These panels are general unsuitable for use as wall or floor formwork

Class – 3 – Partition Grade

GFRG panel as non-structural internal partition walls in dry areas only

V. DESIGN, CONSTRUCTION & WORKMANSHIP

GFRG buildings are designed as load bearing systems. Hence, all the walls have to be started from the foundation or plinth beam till the terrace. Ideally, the same floor plan has to be replicated for all floors in multi-storey buildings. Buildings can be designed up to ten storeys in low seismic zones, using GFRG panels (and to lesser height in high seismic zones), without conventional columns and beams. In this building system, the foundation is conventional, while the entire structural elements in super structure is constructed using GFRG panels.

Limit states design procedures are used for the design of GFRG buildings, considering the ultimate limit state for strength design, as well as serviceability requirements as recommended in IS 456: 2000. Earthquake resistant design is carried out in compliance with the requirements of international codes (in India IS 1893 (Part 1): 2002), where the response reduction factor (R) is taken as 3.0 for seismic load calculations.

The construction of GFRG building is different from the conventional method. It requires special type of equipment, tools and tackles such as appropriate crane for loading, unloading and erecting the panels, lifting jaws and spreader bar for lifting the panels and adjustable later props for supporting wall panels after erection.

Rapidwall enables fast track method of construction. Conventional building construction involves various cumbersome and time consuming processes, like:

- masonry wall construction

- cement plastering requiring curing
- casting of RCC slabs requiring cantering and scaffolding and curing
- removal of cantering and scaffolding
- plastering of ceilings

VI. COST ANALYSIS OF GFRG PANEL CONSTRUCTION

The main component that goes into construction of GFRG Panels is a powder that is a residual of many fertilizer industries and is available at very cheap rate in market. Apart from the cost, it is easier to assemble and does not require curing time (like normal concrete). It therefore decreases the duration of construction and hence labour cost involved. To summarize the GFRG technique saves money by:

- Providing cheaper substitute than Concrete and Bricks for construction
- Reducing the duration of overall construction and hence saving labour cost

As the panels are prefabricated, they can be cut to require sizes based on room sizes, and used thus giving way to rapid construction.

Direct cost was concluded to be divided into 6 categories. The categories for the direct cost are:

- GFRG panels,
- Panel accessories
- Electric hand tools
- Crane cost
- Labours cost
- Reinforced concrete cost

VII. ADVANTAGES OF GFRG PANELS

Major advantages of GFRG Panel construction are mentioned as under:

1. Higher speed of construction.
2. More carpet area for the same built-up area: thickness of wall panels is only 124mm.
3. Less embodied energy and carbon footprint significant reduction in use of steel, cement, sand and water, recycling of industrial waste gypsum.
4. Less cost of construction: savings in materials; no cement plastering.
5. Less building weight (panels weigh only 44 kg/m²), thereby reduction in design for seismic

forces and savings in foundation, especially in multi-storeyed buildings.

6. 8 to 10 storeyed buildings can be designed using GFRG panels, without the need of conventional RC beams and columns.
7. Very good finishes of GFRG buildings: use of factory made panels for all the walls, floors and staircases.
8. Less CO2 emission compared to other conventional building materials.
9. Better thermal comfort inside GFRG building compared to conventional buildings.
10. Since gypsum is a hard material there is no creep in the GFRG panel so it is major asset of this type of construction.

VIII. LIMITATION OF GFRG CONSTRUCTION

Although theoretically there are no drawbacks of using this technology, a few practical issues do arise

1. We need some expertise in order make a house using this technology. The handing, fixing and equipment requirement for these panels is fairly different from conventional style. Although it is not very difficult to learn the right techniques, it will eventually take time for becoming and industry trend
2. The Panels are customized according the design and drawings of your house when manufactured. Unfortunately, you cannot make a lot of changes during fixing stage. Hence planning is important. Also the doors, windows and other openings are made by cutting through the panels, hence the planning for placing doors and windows also needs to be extensive.
3. In India, if you looking to do a construction in a normal populated area, it is very likely that your plot is already surrounded by built house. The GFRG technique needs empty space around the plot so that cranes can be placed while fixing panels. Also the panels need special care while storing them and need more space as compared to cement/blocks. These 2 factors make it difficult for a full scale implementation in India .Empty space to store and move Panels is needed.

IX. GFRG vs CONVENTIONAL CONSTRUCTION

Comparison of Construction Time between RCC and GFRG Construction:

S.No	Item of Work	RCC (Duration in Days)	GFRG (Duration in Days)
1	Earth work 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		98-115 Days	34-44 Days

Advantages of GFRG over the Conventional RCC Concrete:

Creep

Since gypsum is a hard material there is no creep in the GFRG panel so it is major asset of this type of construction

Shrinkage in concrete

In the Rapid wall system, there is no volume change even at high temperatures.

Dampness

The movement of moisture through concrete structures is dampness. There is no dampness problem in GFRG panel wall system.

Comparison of Construction Material used between Conventional and GFRG Construction:

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

- [2] Building Materials & Technology Promotion Council Ministry of Housing & Urban Poverty Alleviation, Government of India.
- [3] Madhuri Reddy, Rakhi Wagh, Yogiraj deshmkh” GFRG Panels over Conventional Construction” IJETSR Volume 4, Issue 10, October 2017
- [4] Building materials and construction by RANGWALA
- [5] BMTPC, and IIT Madras, “GFRG/Rapidwall building structural design manual”, New Delhi, India, 2013
- [6] Cost Model For Using GFRG Mohamed Said Meselhy Elsaheed International Journal of Development and Economic Sustainability Vol .4, No.3, pp.33-47, June 2016

X. CONCLUSION

From this we conclude that conventional buildings are more costlier when compare to panel system. The panels has good life span as same as concrete structures. Nowadays the use of panels for construction evolves gradually. But still most of the people are not aware about this type of construction practices for residential buildings. From this project we can create some awareness about the construction of panel systems about the cost, time management, resource allocation and quality and quantity of GFRG.

GFRG Panels provides a new method of building construction in fast track, fully utilising the benefits of prefabricated, light weight large panels with modular cavities and time tested, conventional cast-in-situ constructional use of concrete and steel reinforcement.

This will also contribute to achieve the goal of much needed social inclusive development due to its various benefits and advantages with affordability for low income segments also. Fast delivery of mass dwelling/ housing is very critical for reducing huge urban housing shortage in India. Rapidwall panels will help to achieve the above multiple goals.

REFERENCES

- [1] IIT Madras GFRG panels demonstration building.