

GLASS FIBER REINFORCED GYPSUM

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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% pertains to Economically Weaker Section (EWS) and Low Income Group (LIG) type, as per the estimate of the Ministry of Housing and Urban Poverty Alleviation [1, 2]. The demand for conventional building materials used in the housing sector such as burnt clay bricks, cement and steel is growing every year. Reduction in the use of these energy intensive construction materials and speedy delivery of housing units at affordable cost are the key challenges faced in the mass housing sector today.

INTRODUCTION

Glass Fibre Reinforced Gypsum (GFRG) is a new building material and it is also known as Rapidwall building panel. Glass fiber reinforced gypsum panels (GFRG) are hollow panels made from modified gypsum plaster and reinforced with chopped glass fibers. The panel contains cavities that may be filled with concrete and reinforced with steel bars to impart additional strength and provide ductility and also it can be used for the construction of walls, floor and roof slabs.

The panel may be used generally in the following way, the panel may be used generally in the following ways:

- ❖ As lightweight load bearing walling in building (single or double storey construction) upto two storey construction: the panel may be used with or without non-structural core filling such as insulation, sand polyurethane or lightweight concrete.
- ❖ As high capacity vertical and shear load bearing structural walling in multi-storey construction: the panel core shall be filled with reinforced concrete suitably designed to resist the combined effect of lateral and gravity loading.
- ❖ As partition infill wall in multi-storey framed building: Panel may also be filled suitably. Such walls can also be used as cladding for industrial buildings or sport facilities etc.
- ❖ As Horizontal floor/ roof slabs with reinforced concrete micro beams and screed (T-beam action)
- ❖ As pitched (sloped) roofing
- ❖ As cladding for industrial building
- ❖ As compound wall.

This system can also be used in inclined configuration, such as staircase waist slab and pitched roofing

1.1 DEFINITION

Glass Fibre Reinforced Gypsum (GFRG) is a new building material and it is also known as Rapidwall building panel. Glass fiber reinforced gypsum panels (GFRG) are hollow panels made from modified gypsum plaster and reinforced with chopped glass fibers. The panel contains cavities that may be filled with concrete and reinforced with steel bars to impart additional strength and provide ductility and also it can be used for the construction of walls, floor and roof slabs.

1.2 PURPOSES

The panel may be used generally in the following ways:

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- As compound wall.
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2. TYPES OF GFRG PANELS

GFRG panel may be supplied in any of the following three grades:

- **Class 1- Water Resistant grade** – panels that may be used for external walls, in wet areas and/or as floor and wall formwork for concrete filling;

- **Class 2** – General grade -- panels that may be used structurally or non-structurally in dry areas. These panels are generally unsuitable for use as wall or floor formwork; and
- **Class 3** – Partition grade – panels that may only be used as nonstructural internal partition walls in dry areas only.



Fig.01 GFRG Panel

2.1 CHARACTERISTICS OF GFRG

- A thickness of 124mm under carefully controlled conditions to a length of 12m and height of 3m, contains cavities that may be unfilled, partially filled or fully filled with reinforced concrete as per structural requirement.
- GFRG panels, suitably filled with plain reinforced concrete possesses substantial strength to act not only as load bearing elements but also as shear wall, capable of resisting lateral loads due to earthquake and wind.
- GFRG panel can also be used advantageously as in-fills (non-load bearing) in combination with RCC framed columns and beams (conventional framed construction of multi-storey building) without any restriction on number of storeys.
- Micro beams and RCC screed (acting as T-beam) can be used as floor/ roof slab.
- Manufacture of GFRG Panels with increased thickness (150 mm – 200 m) with suitable flange thickness can facilitate design and construction of taller buildings.

Experimental studies and research have shown that GFRG Panels, suitably filled with reinforced concrete, possess substantial strength to act not only as load bearing elements, but also as shear wall, capable of resisting lateral loads due to

earthquake and wind. It is possible to design such buildings up to 10 storey in low seismic zone. (And to lesser height in high seismic zone).

2.2 STANDARD DIMENSIONS: -

The current nominal manufactured dimensions of each GFRG panel are: -

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

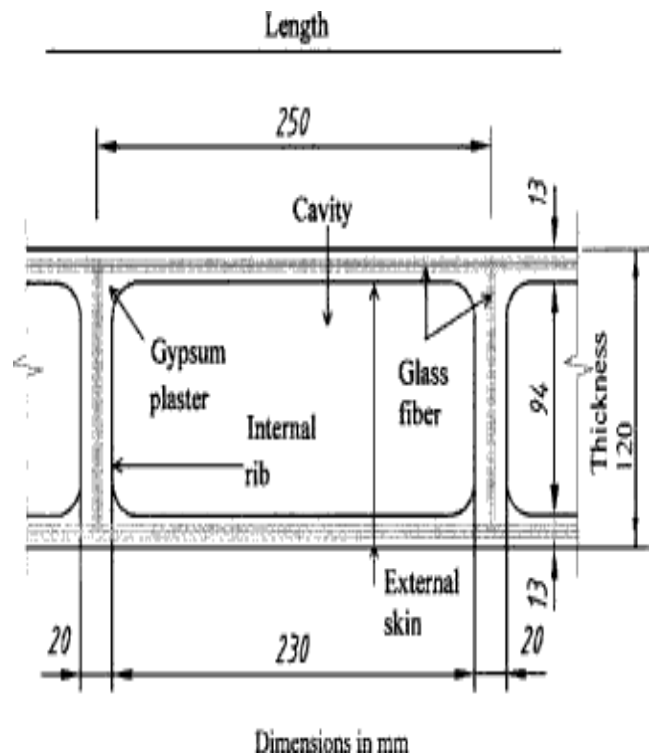


Fig.02 Cross-section of panels

3. MATERIALS AND MANUFACTURING PROCESS

3.1 MATERIALS: -

- **Phosphogypsum** – Shall be > 90% purity as CaSO4. Formed as an evaporite mineral and as a hydration product of anhydrite, gypsum is a crucial eco-friendly component used in the construction. Manufacture of GFRG (Glass Fibre Reinforced Gypsum) panels from the raw material gypsum, viz., natural gypsum, mineral gypsum, phosphor-gypsum or chemical gypsum, with purity more than 90 per cent, entails less energy in comparison to energy-intensive conventional building materials like, brick, concrete, etc. Increased thermal resistance of gypsum reduces the air conditioning load on the buildings, thus reducing the operational energy need in GFRG buildings.

- **Glass Fibre** – E glass shall be > 98% purity. Glass fibre is formed when thin strands of silica-based or other formulation glass are extruded into many fibres with small diameters suitable for textile processing. The most common types of glass fibre used is E-glass, which is alumina-borosilicate glass with less than 1% w/w alkali oxides, mainly used for glass-reinforced gypsum panels.
- **Ammonium Carbonate:** – Shall be of 99.14% purity as NH₄CO₃.
- **D50 Retarder:** - D50 Retarder is an admixture which is used to reduced the setting time of gypsum slurry.
- **BS94 Water Repellent:-** BS94 Water Repellent is used to reduced the extra water from the slurry.

3.2 MANUFACTURING PROCESS:-

The GFRG Panel is manufactured in semi-automatic plant using slurry of calcined gypsum plaster mixed with certain chemicals including water repellent emulsion and glass fiber roving’s, cut, spread and imbedded uniformly into the slurry with the help of screen roller. The panels are dried at a temperature of 275C before shifting to storage area or the cutting table. The wall panels can be cut as per dimensions & requirements of the building planned.

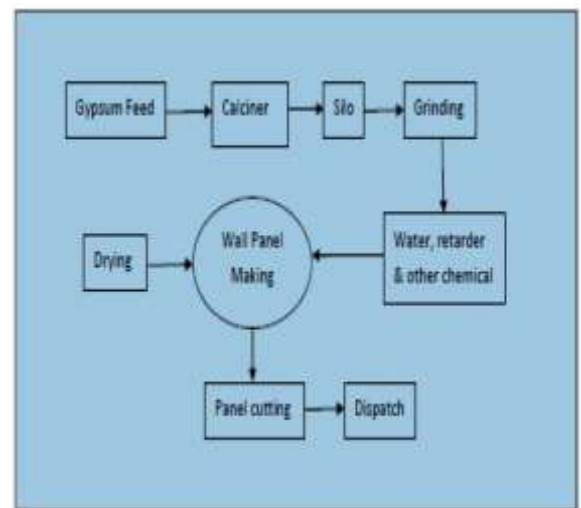
- Phosphogypsum which is a byproduct of phosphoric acid plant is calcined in calciner at 140-1500 C at the rate of 15MT/hr. of calcined plaster. This calcined plaster is stored in product silo having capacity of 250MT.
- The plaster is then transferred to batch hopper by screw conveyors and through Entoleter in wall panel manufacturing area.
- This area consists of 6 casting tables having dimensions of 3m x 12m, one crab having mixer and glass roving delivery system is for delivering slurry and glass roving for three tables. The chemicals are added in water & mixed and then plaster is added & mixed to form slurry.
- One layer of slurry is laid on the table by the crab followed by a layer of glass roving. This glass roving is embedded in to the slurry with the help of screen roller.
- Another layer of slurry is poured followed by a layer of glass roving this layer is pushed inside the ribs with the help of temping bar. Finally a layer of glass roving is laid for the top face of the wall panel.
- After getting final Gilmore wall panel is lifted from the casting table to ACROBA frame and shifted to

dryer for drying. The wall panel is dried at a temperature of 2750C for 60 minutes.

- After drying, the wall panel is either shifted to storage area or on the cutting table. The wall panel is cut as per dimensions supplied by the consumer and the cut pieces are transferred to stillage’s which are specially made for transporting wall panel.
- The liquid effluent generated during manufacturing process is recycled back in the system for manufacturing of new wall panels.
- The solid waste which is generated while manufacturing wall panels is recycled back to the calciner after crushing and separating plaster & glass roving in recycle plant.
- The above system is a batch process. Six wall panels can be manufactured in eight hour shift per table. Similarly, 36 wall panels can be manufactured in eight hour shift with 6 tables.



Fig.03 GFRG panel casting table



GFRG manufacturing process table

4. RECOMMENDATIONS:-

1. *This research aims to study direct cost for GFRG, it neglects the indirect cost for this system. For further cost analysis, future research needs to study the indirect cost which will result for more accuracy calculation of GFRG cost during design phase for the project.*

2. *The future research needs to study the Risk analysis for using of GFRG system in repetitive project; this will help the owner/ designer to anticipate the cost for GFRG system during design phase.*

3. *Future research needs to inspect new techniques to decrease the cost for GFRG system with same performance for system.*

4. *Environmental aspects can be addressed in future researches to study environmental performance for spaces using GFRG system.*

5. *Future studies can address the quality procedures for installation inspection for GFRG system on site.*

5. References

- ❖ *Use of Glass Fibre Reinforced Gypsum (GFRG) Panels in Buildings, Structural Design Manual ", Structural Engineering Division IIT Madras*
- ❖ *Geethu S, Renjith R, "Formulation of an Alternate Light Weight Concrete Mix for Concrete Filled Glass Fibre Reinforced Gypsum (GFRG) Panels", International Journal of Science and Research, Vol 4, Issue7 (2015)*
- ❖ *Devdas Menon, A Meher Prasad (2013) "Development of Building Systems using Glass Fibre Reinforced Gypsum (GFRG) Panels" The masterbuilder Janardhana M., Cyclic behaviour of glass fibre reinforced gypsum wall panels, Thesis submitted to Indian Institute of Technology Madras for PhD, IITM*