

Study of An Efficient Building Material: Rapid Wall

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Abstract - Urban & Rural India has shortage of 90 million housing units by 2015 also the projected population in India by 2026 will be 1,400 million. To fulfil this requirement an innovative efficient building materials option which has properties like energy efficient, strong, durable and fast track housing construction method for affordable cost and less time.

Gypsum Reinforced Rapid wall Construction is an innovative solution widely accepted and implemented in Australia, China and Oman. Rapid walls are used both architecturally and structurally as walls and slabs panel. It save energy and protect the environment hence known as a green product.

Rapid wall are prefabricated large gypsum panels with hollow cavities which filled with reinforced concrete produces another composite due to interaction between the concrete and the panels. As a result, the structural behaviour of rapid walls and the associated building system are more complicated than that of conventional structural system. They have already found wide applications, even without developed structural design codes because of their environmental friendliness. This paper mainly discussed the comparison between Rapid wall and block work wall construction's structural, architectural, Environmental and Economical aspects.

Keywords - GFRG; Rapid wall; Gypsum; Eco-friendly; Green

I. INTRODUCTION

Glass fiber reinforced gypsum (GFRG) is the name of a new building panel product. It is made essentially of gypsum reinforced with glass fibers and also known as Rapid wall. This product was originally developed and used since 1990 in Australia. It is suitable for rapid mass-scale building construction. Rapid wall 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. This product is not only eco-friendly or green, but also resistant to water and fire. Rapid wall panels are presently manufactured to a thickness of 124 mm, a length of 12m and a height of 3m, under carefully controlled conditions. The panel can be cut to required size. Although its main application is in the construction of walls, it can also be used in floor and roof slabs in combination with reinforced concrete.

The panel contains cavities that may be filled with concrete and reinforced with steel bars to impart additional strength and provide ductility. The panels may be unfilled, partially filled or fully filled with reinforced concrete as per the structural requirement. 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 and also as shear walls, capable of resisting lateral loads due to earthquake and wind. It is possible to design such buildings up to ten storeys in low seismic zones and to lesser height in high seismic zones. However, such construction needs

to be properly designed by a qualified structural engineer. Manufacture of GFRG panels with increased thickness (150 mm, 200 mm) with suitable flange thickness can facilitate design and construction of taller buildings.

Rapid wall panels can also be used as partition walls (non-load bearing) in combination with reinforced concrete (RC) framed columns and beams without any restriction on the number of storeys. Also, Rapid wall panels with embedded micro-beams and RC screed acting as T-beams can be used as floor or roof slabs.

It has significant flexural strength and has the lowest embodied energy rating of any load-bearing building system presently available in the world. A waterproofing system is added to the mix to make it suitable for internal or external use. Rapid wall is lightweight about 40kg/m^2 , approximately 12% of the weight of a concrete or brick wall and is stronger than conventional materials. Furthermore, it is load-bearing and can be used for external and internal walls as well as for roofs or floors in combination with reinforced concrete cavities.

Rapid wall is a system that has been proven in exhaustive scientific testing to withstand considerable loads and is therefore ideal in earthquake prone areas. It can be constructed to withstand high winds, such as cyclones and hurricanes using natural or 'waste' gypsum and is recyclable, can be used in load bearing buildings of up to 15 storeys. It is ideal for repetitive design construction and can be erected in a fraction of the time of other building methods. In present scenario Rapid wall has the potential to become the number one building material.

In India FACT & RCF, two fertilizer giants under public sector are together setting up Rapid wall product manufacturing plant at Ambalamugal using Rapid wall technologies of Australia called FACT RCF Building products Ltd. (FRBL). FACT has about 7 million tons of industrial by product gypsum. Glass fibre reinforced gypsum is made up of glass fibre and gypsum wastage from fertilizer industry.

II. PRODUCT DETAILS

A. Product Dimension

GFRG building panels, presently manufactured as Rapid wall, for the typical dimensions and material properties described in this manual. Typical dimensions of a GFRG building panel are $12.0\text{m} \times 3.0\text{m} \times 124\text{mm}$, as shown in Fig.1 (a). Each 1.0 m segment of the panel has four 'cells'. Each cell is 250 mm wide and 124 mm thick, containing a cavity $230\text{mm} \times 94\text{mm}$ as shown in Fig.1(b). The various cells are inter connected by solid 'ribs' of 20 mm thick and 'flanges' of 15 mm thick comprising gypsum reinforced with $300\text{mm} \times 350\text{mm}$ glass fibre roving, located randomly but centrally. The skin thickness is 15 mm and rib thickness is 20 mm.

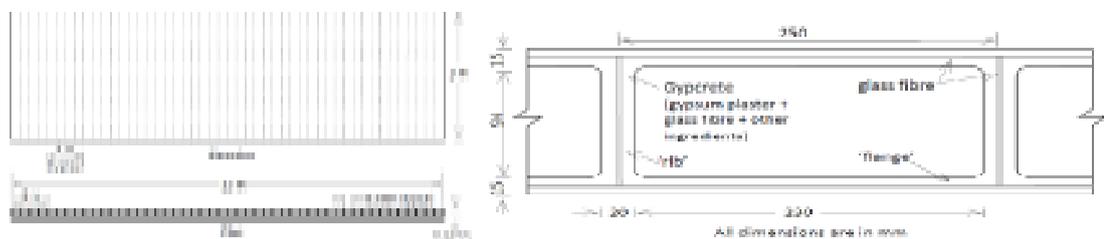


Figure 1. a) Typical Cross Section of GFRG Panel, b) Enlarged View of Typical Cell.

B. Grades and Types

- **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.

C. Manufacturing process

Phosphogypsum is a byproduct of phosphoric acid plant is calcined in calciner at 140-1500 °C at the rate of 15MT/hr. This calcined plaster product is stored in silo of having capacity 250MT.

With the help of screw conveyors this plaster is transferred to batch hopper and through Entoleter in Rapid wall panel manufacturing area. This area consists of casting tables having dimensions of 3m x 12m. One crab having mixer and glass roving delivery system is for delivering slurry and glass roving. The chemically added water is used to form Gypsum 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.

The casted panel is lifted to ACROBA frame and shifted to dryer for drying. The wall panel is dried at a temperature of 275⁰ C 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



Figure 2. a) Rapidwall Manufacturing Panel



b) Stillage



c) Final Product

dimensions supplied by the client and the cut pieces are transferred to stillages which are specially made for transporting wall panel.

The waste liquid effluent generated during manufacturing process can be recycled back in the system for manufacturing of new wall panels, also the solid waste which is generated during manufacturing process is recycled to the calciner after crushing and separating plaster and glass roving in recycle plant.

D. Definitions

Standard Rapidwall Panel- Rapidwall 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.

Water Resistant Rapidwall Panel- Water resistant GFRG panels are the same as ordinary GFRG panels in appearance. However the ingredients of the water resistant GFRG are modified specifically to provide water resistance when used externally or in wet areas such as bathrooms or laundries, etc.

External Skin- The two 13mm thick faces making up the panel are collectively defined as external skin.

Internal Rib- The 20mm thick ribs inside the panel connecting the two external skins are called internal rib.

Cavity- The internal hollow cores inside the panel are called the cavity.

Panel Length- The panel length is the maximum horizontal dimension of a single wall without vertical joint.

Panel Thickness- The panel thickness is the distance between the external faces of the two external skins.

Panel Height- The panel height is the maximum vertical dimension of a single wall without a horizontal joint.

III. PHYSICAL AND MECHANICAL MATERIAL PROPERTIES

Table 1. Physical Properties of Rapidwall

Material/items	Rapidwall Building
Weight- light weight	40 kg/sqm
Axial load capacity	16 tons/m
Compressive strength	73.2 kg/cm ²
Unit Shear strength	50.90 kN/m
Flexural strength	21.25 kg/cm ²
Tensile Strength	35 kN/m
Ductility	4
Fire resistance	4 hr rating withstood 700-1000 °C
Thermal Resistance	0.36 kw
“U “Value	2.85 w/m ² k
Thermal conductivity	0.617
Elastic Modulus	3000-6000 Mpa
Sound transmission {STC}	40
Water absorption	< 5 %

Table 2. Mechanical Properties of Rapidwall

Type of Panels	Property name	Value	Note
Unfilled Rapidwall panels	Uni-axial compressive strength ϕR_u	100 kN/m	Strength obtained from longitudinal compression/tension tests with ribs extending in the longitudinal direction
	Uni-axial tensile strength ϕR_u	28.8 kN/m	
	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	
	Unit weight	40 kg/m ²	
	Thermal expansion coefficient	12×10^{-6} mm/mm/°C	
Rapidwall panels filled with 25 MPa concrete in all the cores	Uni-axial compressive strength ϕR_u	890 kN/m	Obtained from longitudinal compression tests with ribs in the longitudinal direction

IV. USES OF RAPID WALL

The most valuable use of Rapid wall is its use as load bearing wall in multi storey construction in combination with RCC. Rapid wall can also be used as non load bearing and partition wall in RCC framed structures. IIT Madras has recently developed method of fixing panel in between RCC columns, beams and floor slab with clamping system. By this panel can be fixed to floor slab and panel at bottom using screws, which will be embedded within flooring and skirting. At top clamps will be fixed to panel and ceiling slab or beam. On sides also clamped at bottom to RCC column, floor slab and panel. Plastering of walls can also be saved thereby saving time and cost. If this is taken into account at design stage itself, dead load reduction of more than 50% can be made. This will save in foundation, RCC columns and beams, in turn steel and concrete. This will make substantial savings in cost of construction.

V. CASE STUDY

A residential demonstration house in India of 130 m² built-up area is constructed with Rapid wall panels and compared with Conventional block work gives the following results mentioned in table 2.

Table 3. Construction comparison of Rapidwall and Conventional Building

Material/items	Rapidwall Building	Conventional Building	Saving in %
Cement	16 tons	32.55 tons	50.80
Steel	1800 kg	2779 kg	35.20
Sand	20 cum	83.37 cum	76.00
Granite	38 cum	52.46 cum	27.56
Bricks	-	57200	-
GFRG panel	500 sqm	-	-
Water	50000 liter	200000 liter	75.00
Labor	389 man days	1200 man days	67.59
Construction time	21 days	120 days	82.00
Weight of superstructure	170 tons	490 tons	65.00
Construction cost	Rs 13.25 lakhs	Rs 18.27 lakhs	61.50

VI. EMBODIED ENERGY

Energy required to manufacture products is known as Embodied energy. It is including energy consumption of all associated processes such as mining, transport and manufacturing. Conventionally, the energy embodied in a building includes the energy used directly to construct the building as direct energy and the energy used indirectly in the manufacture of building materials as a indirect energy. The main reason for recognizing indirect energy is that a construction process can be very energy efficient, whereas the materials that are used are very inefficient in energy consumption, thus a holistic view is preferable to a limited view of parts of a manufacturing chain. The measurement of embodied energy is joule (J).

As per research on embodied energy rates by Dr. P. S. Chani for 1 sqm brickwall and Rapid wall is 194.38 kWh and 35.59 kWh respectively and the calculated values are as follows

Table 4. Embodied Energy Calculations

Energy	Conventional Building	Rapidwall Building
Estimated embodied energy	136908 kWh	26275 kWh
Saving /reduction of energy	-	110633 kWh
saving of % embodied energy	-	80%

VII. CONCLUSIONS

Rapidwall provides fast track building construction methodology by utilizing the benefits of pre-fabricated, light weight large panels with modular Cavities. By this process, man power, cost and time of construction is reduced. The use of scarce natural resources like river sand, water and agricultural land is significantly reduced. Rapid wall panels have reduced embodied energy and require less energy for thermo-regulation of interiors.

Rapidwall fulfilled the following industrial requirements which are present need of construction industry.

- Cost effective Innovative/Alternative construction Material for affordable Housing
- Sustainable against natural disasters like earthquakes, cyclones and fire
- Energy efficient, strong & durable
- Environmentally friendly
- Which gives Easy, fast & Economical construction
- Have the ability to be recycled
- Have little or no CO₂ emissions

REFERENCES

- [1] Wu, Y. F., 2004. "The effect of longitudinal reinforcement on the cyclic shear behavior of glass fiber reinforced gypsum wall panels: Tests". Engineering Structures, ELSEVIER, 26 (11):1633-1646.
- [2] IS : 1905-1987, Code of Practice for Structural use of Unreinforced Masonry, Bureau of Indian Standards, New Delhi, India.

- [3] IS : 456-2000, Plain and Reinforced concrete - Code of Practice, Bureau of Indian Standards, New Delhi, India.
- [4] Paulay T., and Priestley M.J.N., 1992. Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley & Sons, New York, USA.

