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Low Cost Housing by Using GFRG Panels

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ABSTRACT

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. A GFRG building does not require beams and columns. And the material has been approved as green building material by the United Nations Framework Convention on Climate Change (UNFCCC). The panel cavities can be partially or fully filled with reinforced concrete to provide additional strength. Buildings with load-bearing systems made of reinforced GFRG panels can go as high as 8-10 Storey's in low seismic zones. The panel cavities can also be used for electrical wiring and piping work. To demonstrate the technology; IIT has built a two-storied GFRG residential building on its campus.

Keywords: GFRG Panel, Affordable Housing, Economical Housing Techniques, Rapid Wall Construction.

I. INTRODUCTION

Low Cost Housing Importance:

- According to the 2011 census, the housing stock in urban India stood at 78.48 million for 78.86 million urban households.
- Urbanization has resulted in people increasingly living in slums and squatter settlements and has deteriorated the housing conditions of the economically weaker sections of the society.
- The group further estimated that 88% of this shortage pertains to houses for Economically Weaker Sections (EWS) and another 11% for Lower-Income Groups (LIG).For Middle- and High-Income Groups (MIG and HIG), the estimated shortage is only 0.04 million.
- There is a huge growing requirement of building materials in India due to the existing housing shortage of 24.7 million units (2007) mainly for the low income groups in urban India.
- Estimated urban housing shortage in 2012 is 26.53 million, while the housing shortage of rural India in 2012 is 42 million units.
- Thus total estimated housing shortage for Urban & rural India in 2012 is 68.53 million units.
- It is also important that housing and buildings are disaster resistant to protect the lives and properties of people.
- All these concerns are involved in sustainable and inclusive development.

Why Do We Need Low Cost Houses?

- Growing population day by day
- Affordable housing for BPL people
- We need a solution that is fast
- Easy to build
- Fulfills the needs of conventional houses

Recycling of Materials:

- Recycled materials adapted for low-cost housing include wood and rubber that are previously been used.
- Reprocessed into materials that are used in building walls and other parts of a house.
- Recycled glass and metal are also used on occasion.

Extensive Planning:

- In extensive planning, the more planning goes into a house, the less the actual construction will cost.
- Contractors should plan out exact dimensions and should gather facts.

- Contractors should look for the best materials at the cheapest prices so they can order exactly what they need.
- This saves money that would otherwise be wasted on unnecessary supplies and cleanup caused by littered materials.

Modular Planning

- Modular building is a type of construction where pieces of the home or typically whole rooms or major parts of rooms, are built off-site in large factories.
- This process allows the pieces to be built efficiently and exactly according to building standards.
- At the site, the pieces are connected to the house.

Infilling of Materials

- Infilling is the practice of going back through residential areas and building in areas that had previously been left empty.
- Now it's possible to build on because of resolved environmental concerns, space issues or other problems that have since been remedied.
- Infilling makes better use of existing space.
- It is less expensive for contractors overall.

Techniques to Reduce Cost of From Area

- Reduce plinth area by using thinner wall concept.
- Use locally available material in an innovative form like soil cement blocks in place of burnt brick.
- Use an energy efficiency material which consumes less energy like concrete block in place of burnt brick.
- Preplan every component of a house and rationalize the design procedure for reducing the size of the component in the building.

Foundation

- The foundation cost comes to about 10 to 15% of the total building
- Suggested to adopt arch foundation in ordinary soil for effecting reduction in construction cost up to 40%.

Wall

- Making use of Rat – trap bond wall & Concrete block wall.
- It is a cavity wall construction and leads to reduction in the quantity of bricks required for masonry work.
- By adopting rat-trap bond method one can create aesthetically pleasing wall surface and plastering can be avoided.

Concrete Block Walling

- In view of high energy consumption by burnt brick it is suggested to use concrete block which consumes about only 1/3 of the energy of the burnt bricks in its production.
- By using concrete block masonry the wall thickness can be reduced from 20 cms to 15 cms.

Lintel

The traditional R.C.C. lintels which are costly can be replaced by brick arches for small spans and save construction cost up to 30 to 40% over the traditional method of construction.

Roof

- Normally 5" thick R.C.C. slabs are used for roofing of residential buildings.
- By adopting rationally designed construction practices like filler slab and precast elements the construction cost of roofing can be reduced by about 20 to 25%.

Where and What?

- We have chosen a building in the Kotha Navarasapuram Village which is a Panchayat building and was constructed by a Kerala based company SHEGHRAM NIRMANPVT LTD, Kerala.
- We have observed the construction procedure and techniques are being used for GFRG panels construction, complete cost and estimation of building, relevant procedures used for panel manufacturing, analysis and duration of the every element of building.
- We have done a detailed case study of comparison between the conventional building and GFRG panel building in the two main aspects
  1. Cost
  2. Time

Location: Kotha Navarasapuram Village, West Godavari District, A.P.

Type of Building: Public Building (Panchayat raj)

Type of Construction: Rapid wall construction with GFRG panels

Area: 935.09Sq.ft

No of Rooms:

- 2 Office rooms,
- Common Entrance Hall
- Store room

Dimensions of Construction Elements:

Door Dimensions

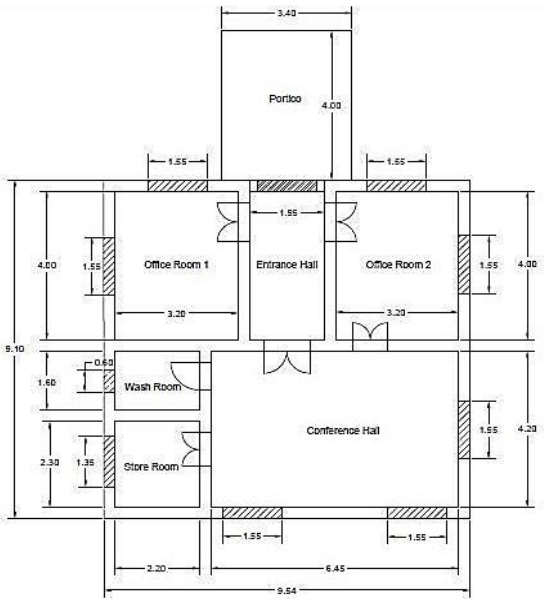
- D1 – 1.55×2.1
- D2 – 1.20×2.1
- D3 – 1.07×2.1
- D4 – 0.90×2.1
- D5 – 0.75×2.1

Ventilator Dimensions

- V – 0.6×0.4

Window Dimensions

- W1 – 1.55×1.35
- W2 – 1.35×1.25



II. METHODS AND MATERIAL

India is the developing country and in the economy of country construction projects and industries play a vital

role. Time and cost are two main concerns in a construction and they are used for planning a project.
This has increased the importance of time and Cost optimization in construction projects is necessary to estimate the cost and time of each activity through which the whole duration and total cost of the project are determined to complete the planning task.

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**

More Advantages 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 this 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.

Durability:

- The durability of this rapid wall system is same as the RCC construction.

USE OF THE GFRG PANELS ANDLIMITATION:

The panel may be used generally in the following ways:

As lightweight load bearing walling in building (single or double storey construction) up to two storey construction: the panel may be used with or without non-structural core filling such as insulation, sand polyurethane or light weight 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.

As Horizontal floor/ roof slabs with reinforced concrete micro beams and screed (T-beam action)

Brief Description of GFRG Panels:

- Glass Fiber Reinforced Gypsum (GFRG) Panel branded as Rapid wall is a building panel product, made of calcined gypsum plaster, reinforced with glass fibers, for Mass-scale building construction, was originally developed and used since 1990 in Australia.
- The panel, manufactured to a thickness of 124mm under carefully controlled conditions to a length of 12 m and height of 3m, contains cavities that may be unfilled, partially filled or fully filled with reinforced concrete as per structural requirement.
- Experimental studies and research in Australia,

China and India have shown that 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 stories micro-beams and RCC screed (acting on T-beam) can be used as floor/ roof slab.

GFRG Panal

GFRG Panel Dimensions:

- Thickness – 124mm
- Height – 3m
- Length – 12m

About GFRG Panels

- GFRG Stands for "Glass Fiber Reinforced Gypsum".
- Each panel has 48 modular cavities of 230mm x94 mm x 3m dimension.
- The weight of one panel is 1440 kg or 40 kg/Sq.m
- The density is 1.14g/cm^3, being only 10-12% of the weight of comparable concrete /brick masonry.

Grade and Type

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;

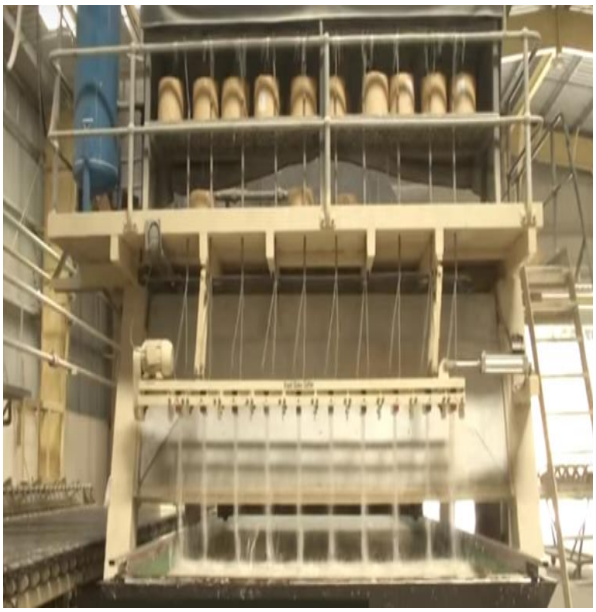
Class 2 – General grade - panels that may be used structurally or non-structurally in dry areas. These panels are generally unsuitable for use as wall or floor formwork.

Class 3 – Partition grade - panels that may only be used as non- structural internal partition walls in dry areas only.

Manufacturing process:

1. Phosphors gypsum which is a byproduct of phosphoric acid plant is calcined in calciner at 140-150^0 C at the rate of 15MT/hr. of calcined plaster. This calcined plaster is stored in product silo having capacity of250MT.
2. The plaster is then transferred to batch hopper by screw conveyors and through Entoleter in wall panel manufacturing area.
3. 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.
4. 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.
5. 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.
6. 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 275^{O}C for 60minutes.
7. 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.
8. The liquid effluent generated during manufacturing process is recycled back in the system for manufacturing of new wall panels.
9. 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.

10. 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 6tables.
11. Flow diagram of the system showing the manufacturing process is attached herewith.
12. The manufacturing machine is as shown in figure.



GFRG Panel Manufacturing

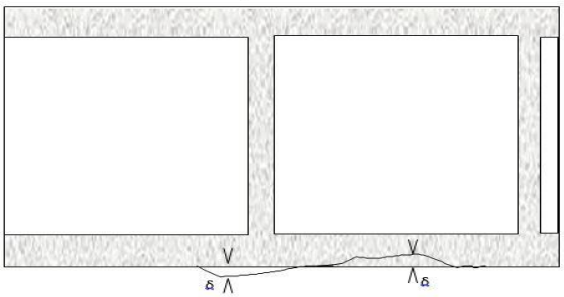
Properties of GFRG Panels

- Axial load capacity - 160 KN/m (16 Tons/m)
- Compressive strength - 73.2 Kg/cm^2
- Unit Shear strength - 50.90 N/m^2
- Flexural strength - 21.25 Kg/cm^2
- Tensile Strength - 35 KN/m
- Ductility - 4
- Fire resistance - 700-10000°C
- Thermal Resistance (R) - 0.36 K.W
- "U" Value - 2.85W/M2K
- Thermal conductivity - 0.617
- Elastic Modulus (E) - 3000-6000Mpa
- Sound transmission (STC) - 40
- Water absorption - < 5%
- Coefficient of thermal expansion- 12×10^{-6}mm/°C

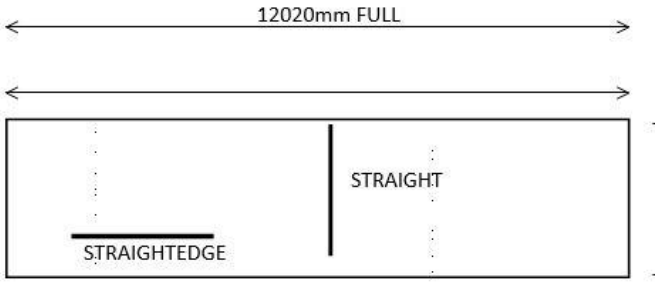
Flatness of the Panel:

The flatness of the panel shall satisfy the following: -

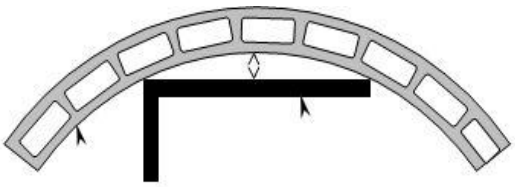
- The maximum local unevenness of protruding or recessing belessthan1mmon the A side and 3mm on the B side.
- For the overall curvature of the surface the deviation of any point on the panel face from a 2.5m straight edge shall not exceed k=3mm in any part of the panel and in both of the two orthogonal directions.



Local Unevenness



Measurement of curvature in both directions



Overall curvature

Water Content

The water content of panels measured immediately after the drying process (without moisture intake after drying) shall be less than 1% when tested.

Water Absorption Rate

The water absorption rate for water resistant grade GFRG panels shall not be greater than 5% by weight after 24 hours of immersion in water when tested. . No test is needed for other grades of GFRG panels

Measurement of Water Content

This test measures the loss of water of the specimen after drying in a standard oven. It is combined with the

measurement of density and water absorption tests. Should the samples after conditioning take up moisture then the panel was over cooked (calcined) in the dryer and fails the test.

Apparatus

Air circulating oven: The net space available inside the drying oven shall not be less than 200×300×360. The oven shall have a temperature control at 40±2°C and a humidity control at 50±2%.

Scale

With a capacity of 5 kg and an accuracy of 0.5g.

Test Procedure

- Weigh each original specimen and record their weights;
- Condition the specimen (or specimens) to constant weights, within 0.1% of the dried weight, at a temperature of 40±2°C, in an atmosphere having a relative humidity of 50±2%.
- This can be done by drying the specimen for 24 hours initially and weighing the specimen; then drying for another 4 hours each time and weighing the specimen until the difference of the two consecutive weights of the specimen is with 0.1% of the dried weight; and Weigh the dried weight *w* of each specimen to within0.5g.

III. RESULTS AND DISCUSSION

Calculation of Results:

The weight loss of the individual specimen in percent with respect to its dried weight (w) is the water content of the specimen.

Measurement of Water Absorption Rate:

Apparatus:

Water bath or container: enough room to immerse the three specimens and keep them separated and elevated from the bottom of the bath with minimum spaces of 25mm.

Test Procedure:

- Immerse the specimens flat in a bath of water at a constant temperature of 21±0.5°C with a head of 25 mm of water over the top of the sample. The sample should be positioned in the water bath elevated one inch above its base;
- Remove the specimens from the bath after 24 hours of immersion, wipe excess water from the surfaces and edges of the specimens and weigh immediately to within 0.5g.

Calculation of Results:

The percentage of weight gain with respect to the dried weight of each specimen calculated is the water absorption rate.

Wetting and Drying Test:

Put the panels through 20 cycles of wetting and drying at room temperature of 30^0C. Each cycle consist of 24 hours of wetting followed by 24 hours of drying. Measure the average compressive strength at the end of 20 cycles.

Salt Spray Test:

Embed a 12mm Ø, 250mm reinforcing rod in the concrete filled in cavity. After 7 days curing, hung the same in a salt spray chamber for 2 weeks. Observe any apparent damage to the panel and to the reinforcement.

Fire Resistance Test:

The fire resistance test on GFRG panel (Rapid wall) shall be conducted using a blow torch (burning kerosene as fuel). The blue flame temperature shall be measured and shall be in the range of 700^0 C to 1000^0C. The blower tip of the blow torch shall be kept at a distance of about 50 mm from one face of the building panel (size 300 x 300 x 124 mm) so that the blue flame shall directly hit the panel continuously. The panel shall be exposed to such a state for continuation duration of 4 hours. The other face of the panel shall be

pasted with a thermocouple to monitor the temperature continuously.

Record the temperatures (^{0}C) at 30 minutes interval during the test period of 4 hours for the hollow GFRG panel and the GFRG panel filled with M20 concrete the results.

At the end of the test, no damage or cracks should be observed beyond the spot where the flame was directly hitting the face of the panel.

IV. CONCLUSION

- In this project we have learnt about GFRG panel details, properties and tests on the GFRG panels
- We have learnt about the step by step procedure of a GFRG panel construction.
- We have how to study the layouts and structural plans of building components.
- We have learnt the procedure of estimating the quantity of materials for different building components, and thereby evaluating the total cost of the project.
- We have learnt how to design slabs, beams, columns based on the local conditions of the site.

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