International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

Design of a Structure with Glass Fiber Reinforced Gypsum Panels

B. Siva Shankara Rao[1], B. Rama Krishna[2]
[1]M.Tech Student, [2]Asst.professor
M.Tech Structural Engineering,
AMRITA SAI INSTITUTE OF SCIENCE AND TECHNOLOGY
Amrita Sai Nagar, Paritala (Post), Kanchikacherla Mandal, 521180

Abstract—A global market for carbon credits is a promising instrument to reduce the impairment of adverse human activities on nature. As long as the problems which are related to the introduction of a global market for carbon credits (to achieve emission targets) have not been solved sufficiently, the initiative of people who are conscious about environmental conservation is needed. Unsustainable technologies have to be improved or replaced by sustainable substitute technologies, because virtually no one seriously suggests that mankind can continue to emit increasing amounts of CO2 into the atmosphere without any adverse consequences. Rapidwall, also called gypcrete panel is an energy efficient green building material with huge potential for use as load bearing and non load bearing wall panels. Rapidwall is a large load bearing panel with modular cavities suitable for both external and internal walls. It can also be used as intermediary floor slab/roof slab in combination with RCC as a composite material. Since the advent of innovative Rapidwall panel in 1990 in Australia, it has been used for buildings ranging from single storey to medium -high rise buildings. Light Weight Rapidwall has high compressive strength, shearing strength, flexural strength and ductility. It has very high level of resistance to fire, heat, water, termites, rot and corrosion. Concrete infill with vertical reinforcement rods enhances its vertical and lateral load capabilities. Rapidwall buildings are resistant to earthquakes, cyclones and fire.

Index Terms—Glass fiber, Gypsum panels, CO_2 emission, Green house and Rapidwall panel

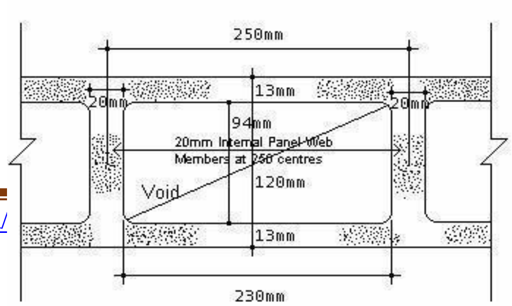
I. Introduction

The threat of climate change caused by the increasing concentration of greenhouse gases in the atmosphere is pushing the whole world into a catastrophic crisis situation with universal concern. The need of the 21st century is for energy efficient and eco-friendly products. The building industry accounts for 40% of CO2 emissions. Building construction causes CO2 emissions as a result of embodied energy consumed in the production of energy intensive building materials and also the recurring energy consumption for cooling and heating of indoor environment Highlighted. Herein the scope of environmental impacts caused through human behavior has been introduced. This was important on the one hand to create a general view about the role of the economy, with the aim of creating assets and progress and the awareness and conservation of nature on the other hand. Both are closely linked, where only a balanced emphasis is logical for ecologically sustainable development and human welfare. A few strategies and instruments for environmental conservation were mentioned. A global market for carbon credits is a promising instrument to reduce the impairment of adverse human activities on nature. As long as the problems which are related to the introduction of a global market for carbon credits (to achieve emission targets) have not been solved sufficiently, the initiative of people who are conscious about environmental conservation is needed. Unsustainable technologies have to be improved or replaced by sustainable substitute technologies, because virtually no one seriously suggests that mankind can continue to emit increasing amounts of CO2 into the atmosphere without any adverse consequences.

II. Production of Rapid wall

Preparation: Rapidwall is precast gypsum based walling panel produced by the company Rapid Building Systems. Rapidwall is manufactured off site in a Rapidwall production unit. The system, also called Rapid Building System, is a patented production process and therefore unique. The Rapid Building System streamlines the construction process by transferring the majority of on-site work to the Rapidwall factory. It is within the factory that the large single Spanning walls, roofs and ceilings are produced. These building components are then easily erected on site in a matter of hours rather than weeks.

Also the application of clay does not produce nearly the same volume of void space as Rapidwall where no loss in load bearing is accepted. The weight of Rapidwall is just 44 kg/m2, without any loss of durability and longevity in any weather condition. The bricks for a m2 average brick wall have a weight of approximately 140 kg, which is four times more than Rapidwall. The Rapid Building System has fire, moisture and sound resistance properties and is also secure against insects and would attack. A basic panel is manufactured commonly in the size 12 x 2.85 m (34.2 m2)



International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

on a casting table, which is the production unit for Rapidwall, and in a large enough size to form an entire wall of a building structure. It is cut easily either at the factory or site and can be tailored to a great variety of designs, including window and door requirements.

(a) *Figure 1: Cross section of Rapid panel and internal web members.*

Drying Method: Once a panel is removed from the table it is still too wet to be further processed. Panels gain their full product strength when they reach certain dryness. Rapid Building Systems has improved two different drying methods. During the production, a decision has to be made, which drying method is used, because as mentioned either Rapidwall 9100 or Silicon Rapid Water Repellent and Plaster Waterproofing Emulsion have to be added. Rapidwall 9100 needs to be heated above 50°C to activate its water repellent capability. This is only possible in the drying chamber (drying room).

Cutting of Rapidwall and Preparing for Dispatch: The Cutting Area is located directly next to the drying room. Cutting is essential in the manufacturing process of Rapidwall. A dried panel is ready for the construction of a dwelling, but in most cases has to be cut to size to match design applications of architects. Once drying is finished Rapidwall can be tailored to a great variety of designs. Most common are vertical or horizontal cuts by a circular saw on basic panels. Panels are cut to a smaller size or door and window cut-outs are performed. If diagonal or detailed cuts e.g. Rebate cuts, are necessary, a hand chain saw is used.

A Rebate is a connection between two panels on a wall, which are set up on site on an angle of 45or 90. It is the most common way to set up two walls on an angle, but setting up on an angle can also be done without a Rebate. To achieve a Rebate, 12 cm of one skin and One web member at the end of one panel is cut out vertically, leaving the other skin intact to create a joint to another wall.

III. Product Features and Applications

The construction of walls to enclose buildings is being carried out today, with few exceptions, almost the same way as it was done two hundred years ago. Although new construction methods, new[3] products and new look finishes have not been as readily accepted by designers and builders, attitudinal changes are occurring as building owners become more conscious of cost and environmental factors in building design, particularly in the area of energy savings.

Rapid Building System is a revolutionary building technology and innovative product, which will have a significant impact on future construction methods. The concept's strengths are extraordinary product features, such as suitability for single leaf, load-bearing construction of internal and external walls, ceiling, roofs and trusses. A Rapid Building

System panel by composition is environmentally friendly and is easily maintained and retains its characteristics through varying conditions.

- Gypsum naturally occurring worldwide abundant & very low cost.
- Low drying energy is needed for reasonable heat requirement
- Low cutting energy; easily cut either at factory
- Safe manufacturing process
- Lightweight modular building panel of 35 kg/m^2
- Very good load bearing capability
- Fire, moisture and sound resistant
- Secure against insect attack.

Design Criteria and Practice: The design capacities derived are based on ultimate strengths determined from tests. The ultimate strengths have been determined allowing a safety margin (mean strength divided by safety factor k) to account for the variations or scattering in the test results. Accordingly this provides a safety index of 3.0 for a confidence level of 90%.

For strength design a reduction factor K is further applied to the ultimate strength capacities obtained from the tests. This design strength reduction factor has been included in the various design charts presented. The strength reduction factors used are generally in Accordance with AS 3600-2001 but with some minor modifications to account for the differences between Rapid wall panel design and concrete structural design. Table 2.1 lists the design strength reduction factors K that are adopted in this thesis.

Table 2.1 Design strength reduction factors K.

Type of action effect	Strength reduction factor K
Concentric or eccentric axially loaded walls	0.6
Bending without axial load	0.8
Shear strength	0.6
Flexural in-plane strength of walls	0.7
Compressive strength of wall cross-section	0.6
Tensile strength of wall cross-section	0.8

Product Dimensions: Rapidwall panel is world's largest loadbearing lightweight panels. The panels are manufactured with size 12 m lengths, 3m height and 124 mm thickness. Each panel has 48 modular cavities of 230 mm x 94 mm x 3m dimension. The weight of one panel is 1440 kg or 40 kg/sqm. The density is 1.14g/cm, being only 10-12% of the weight of comparable concrete /brick masonry.
Reinforcement in the form of 300-350mm long glass fiber roving's is located randomly but centrally within the panel faces and their connecting ribs.

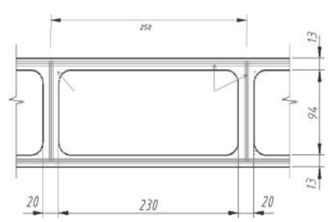


Fig. 2.2(a) cross section

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

Fig. 2.2(b) World largest load bearing lightweight panel being used in Australia

Figure 2.2 (b) indicates the various uses of the Rapidwall cells. Rapid wall panels are generally used structurally in six ways:-

1. As a lightweight load-bearing walling product in cottage construction- the panels can be used with or without non-structural core-filling such as insulation, sand, polyurethane or lightweight concrete.
2. As prefabricated lost-formwork for high capacity vertical and shear load-bearing structural walling- the panel’s cores are filled with concrete, either reinforced or not, to provide load-bearing walls in medium-rise residential constructions of up to twenty storeys.
3. As partitions- the panels can be insulated for use in hospitals and offices;
4. As fencing- the panels can be used from ground level with inserted SHS structural posts embedded into the ground. Alternatively the Rapidwall panels can be trenched and filled with sand without a need for foundations.
5. As cladding- for industrial buildings or sports facilities etc...
6. As suspended slab formwork- used in this way the panels become the flush plaster ceiling.

Basic Design Procedure for (P_{ud}- M_{ud}) Interaction Diagram Generation: Generation of the interaction diagram of a typical GFRG building panel is based on a simplified procedure; certain assumptions are made to develop the approximate interaction curve from the principles of mechanics. The cross section of a typical GFRG panel filled with concrete and reinforcement bars in each cell. The behavior of the GFRG panel infilled with concrete depends on the bond between the concrete and the GFRG panel. This is reflected in the variation of normal strain along the length of the wall.

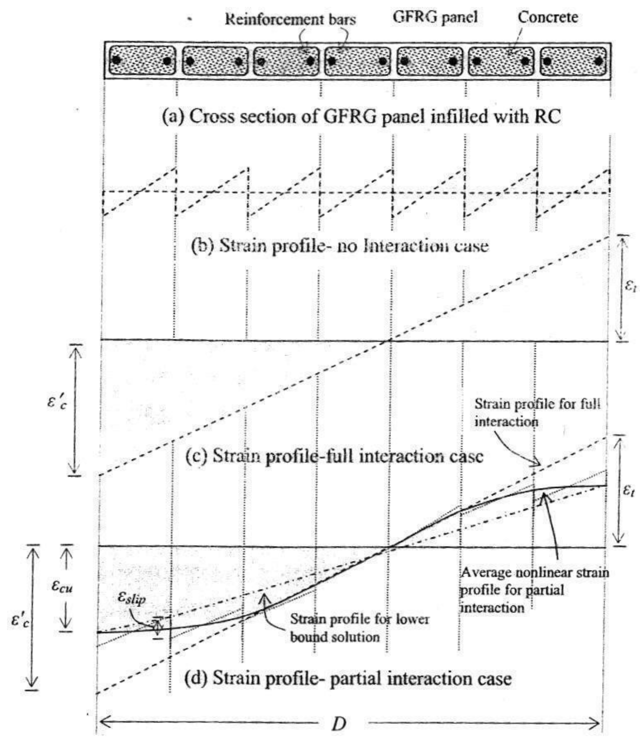


Fig. 3.4 Strain profiles for Nil, Full and partial interaction between GFRG panel and Concrete

If there is no bond, there would not be any interaction between them, resulting in small strain with multiple neutral axes, if it is assumed that the concrete cores are fully bonded to the GFRG panel, then the plane section remains plane assumption is valid for the entire section and the strain profile will be a straight line with a single axis, the probable strain profile can be assumed with the ultimate compressive strain ε_{cu}. The value of ε_{cu} is limited by the out of plane buckling strength of the panel and includes enhancement due to strain gradient for short wall lengths.

Distribution of Strain at Ultimate Limit State: Fig. 3.1 depicts how the value ε_{cu} is to be computed depending on the location of the neutral axis x_u (from the extreme compression location), which in turn depends on the eccentricity of loading.

$$e = M_{ud}/P_{ud}$$

Case 1: Pure Compression

Under pure compression, ($e = 0$, $X_u=\infty$) $\varepsilon_{cu} = P/E$

$E = Ec\ Ac + Eg\ Ag/Ac + Ag$

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

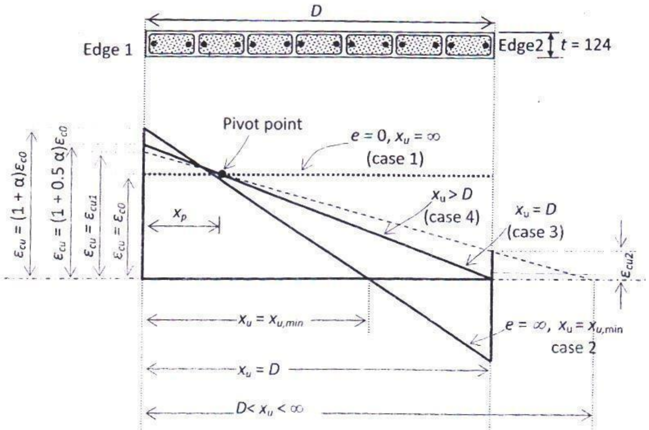


Figure 3.5 recommended strain profile

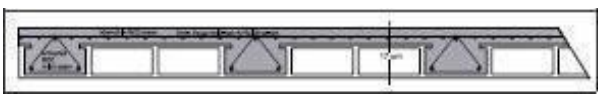


Fig. 3.9 GFRG –recomposed slab system can be used efficiently in floor slabs and Roof slabs.

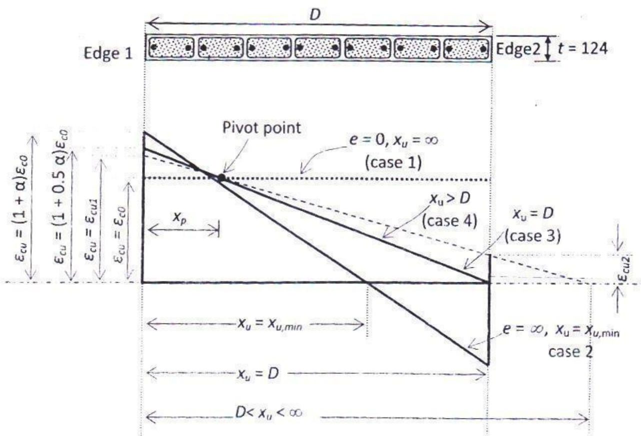


Fig. 3.5 recommended strain profile

DESIGN OF FOUNDATION

Design of Stem Wall

Assume, width of stem = 200mm

The vertical load per meter length of the wall = 100KN Design vertical load = 100x1.5 =150KN

Bearing strength fbr = 0.45 fck =0.45x20 = 9Mpa

Limiting bearing resistance = 9x1000x200 1800KN > 150KN

Hence, a minimum reinforcement of 0.25 percentage of gross cross sectional area may be provided in each direction (IS13920, cl.9.1.4).

Minimum vertical reinforcement, Asst min = 0.0025x1000x200 = 500mm2 Spacing of 12 mm reinforcement on each of stem wall, in vertical direction

= 1000x113/(500/2)>300mm (provided)

Spacing of 8 mm reinforcement on each face of stem wall, in horizontal direction =1000x50/(500/2) = 200mm

Hence provide 12mm diameter bars at 300mm spacing along vertical direction, and 8mm diameter bars at 200mm a pacing along horizontal direction on each side of stem wall

Size of Footing: The vertical load per meter length of the foundation = 100KN x 1.1= 110KN A strip footing can be selected as the type of foundation.

Area of the footing per meter length = 110KN/100KN/m = 1.16m Width of the footing = 1.2m

Thickness of Footing: The uniform pressure at bottom of slab = 100x1.5/1.3 = 0.119N/mm2 Shear force at a distanced' from face = 0.119x1000x(500-d) Permissible shear stress for Pt = 0.25 and M20 concrete, is 0.36MPa Shear resistance = 0.36x1000xd

Equating equations d, = 124.2 mm Overall depth D= 125+75+16/2 = 210mm

Check for Gross Soil:

Pressure: Gross Soil Pressure

qmax =[110+24x(1.1x0.2+0.4x1.3)+18x1.1x1.2]=10.55kn/m2 <110 kn/m2.

Hence, ok

IV. CONCLUSION

- The selected engineering models for GFRG panels in roof slabs, lintels, wall columns have been discussed in a rational way under different loading conditions and the results have been found accordingly.

- The design panels have been found suitable as per the conventional concrete building.

- This thesis has introduced GFRG walls and the associated building system, with the structural characteristics of that system de-scribed.

- The experimental and theoretical investigations undertaken since 2002 have been presented from the structural element and overall building performance points of view.

- The accurate calculation of the in-plane flexural strength of GFRG walls is a difficult, if not impossible, task due to the relative slips between the infill concrete cores and the GFRG panel.

- Lower bound solutions for the in-plane flexural strength have been presented, of which the lower bound solution is most suitable for design use.

- Based on the results of the experimental and theoretical investigations and on a rational analysis of the existing design frameworks, a methodology and associated procedure for the design of GFRG buildings has been offered.

V. REFERENCES

[1] Omahen R. Ecologically sustainable development: approaches in the construction industry. Master of economics thesis, Faculty of Economics, University of Regensburg: Regensburg, Germany; 2002.

[2] Wu YF. Development of the structural design theory for Rapid

wall building system. Construe Des Project 2004:189(1):47–51 [in Chinese].
[3] CSIR.Evaluation of seismic performance of gypcrete buildingpanels. Structural Engineering Research Centre, Chennai, India; August 2002. Project no. CNP 053241/2.
[4] Liu K, Wu YF, Jiang X. Shear strength of concrete filled glass fiber reinforced gypsum walls. Mater Struct 2008:41(4):649–62.
[5] Wu YF, Dare MP. Axial and shear behaviour of glass fiber reinforced gypsum wall panels: tests. J Compos Construe ASCE 2004:8(6):569–78.
[6] Wu YF. The effect of longitudinal reinforcement on the cyclic shear behavior of glass fiber reinforced gypsum wall panels: tests. Eng Struct 2004:26(11): 1633–46.
[7] Wu YF, Dare MP. Flexural and shear strength of composite lintels in glass fiber reinforced gypsum wall constructions. J Mater Civil Eng ASCE 2006:18(3):415–23.
[8] Priestley MJN, Verma R, Xiao Y. Seismic shear strength of reinforced concrete columns. J Struct Eng ASCE 1994:120(8):2310–29.
[9] Jiang X, Gou Y. Cyclic behavior of fiber-reinforced plasterboard with core concrete composite shear walls. In: Proceedings of the ninth Canadian conference on earthquake engineering, Ottawa, Ontario, Canada; June 2007. p. 1234–42.
[10] Zhang X, Liang M, Zhao K. Experimental study on seismic behavior of reinforced rapid-wall. J Shangdong Jianzhu Univ 2007:22(2):93–8.