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An Attempt of Green Building Construction Using GFRG Panels

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Abstract - Green construction involves more than just putting together a collection of the newest green technologies and materials. Rather, it is a process in which every aspect of the design is optimised first, followed by a re-evaluation, integration, and optimization of the impact and interplay of numerous different parts and systems inside the building and site as part of a whole building solution. India's rural housing need is estimated to be 44 million units. The urban housing shortfall in India is 18.78 million units, with 96 percent of them belonging to the Economically Weaker Section (EWS) and Low-Income Group (LIG) categories. As a result, given India's severe housing scarcity, rapid strategies for timely and cost-effective execution of construction projects, such as the use of alternate building materials and fast construction processes, are critical. One of the inventive methods to solve this difficulty is the use of Glass Fiber Reinforced Gypsum (GFRG) panels (also known as the fast wall). This product was developed and has been used for mass-scale building construction in Australia since 1990. GFRG Panels are made from gypsum, which is widely available as a waste product from the industrial sector. These lightweight panels are fire-resistant, thermally insulated, earthquake-tested waterproofed, rot-resistant, termite-resistant, and 100 percent recyclable, making them ideal for eco-friendly or green architecture.

This article compares the use of GFRG panels in the Indian building industry to traditional construction technologies on the basis of numerous functional, structural, and economic considerations, utilising Autodesk Revit Architecture to create a 3D model and Primavera to schedule the project. Preparation of an estimate using Microsoft Office Excel and a thorough drawing using Autodesk Autocad, as well as the installation of solar panels as a sustainable energy source and the creation of a vertical garden to enhance interior air quality.

Keywords - Green Building, Revit Architecture, GFRG Panels, Primavera, Autocad, MS Excel, Solar Energy, Vertical Garden.

I. INTRODUCTION

Every year, the need for traditional materials such as clay, sand, stone, gravels, cement, brick, block, tiles, distemper, paint, lumber, and steel, which are employed as important construction components in the housing sector, grows. The cost of construction materials is gradually rising. It is also vital to discover functional/innovative replacements for traditional building materials in the construction sector due to high transportation costs of these raw resources, demand, and environmental constraints. The key challenges facing the mass housing sector today are reducing the use of these energy-intensive construction materials and delivering housing units quickly and at a reasonable cost. Buildings made of green building material Glass Fiber Reinforced Gypsum (GFRG) panels hold promise as a quick, economical, and long-term mass housing solution. GFRG Panels are prefabricated to a size of 12 m length, 3 m height, and 124 mm overall thickness (with cavities) and are relatively light-weight (44 kg/m2). They are made of calcined gypsum and reinforced with glass fibres. They are prefabricated to a size of 12 m length, 3 m height, and 124 mm overall thickness (with cavities). These panels can be cut to any size needed. There are four cells in each 1.0 m segment of the panel (cavities). Each cell is 250 mm broad, 124 mm thick, and has a 230 mm x 94 mm hollow. The cavities / created cells within the panel can be utilised to house building services such as plumbing and electrical conduits, or they can be filled, partially filled, or left empty depending on the structural requirements. To enhance strength and ductility, the panel has chambers that may be filled with concrete and reinforced with steel bars.

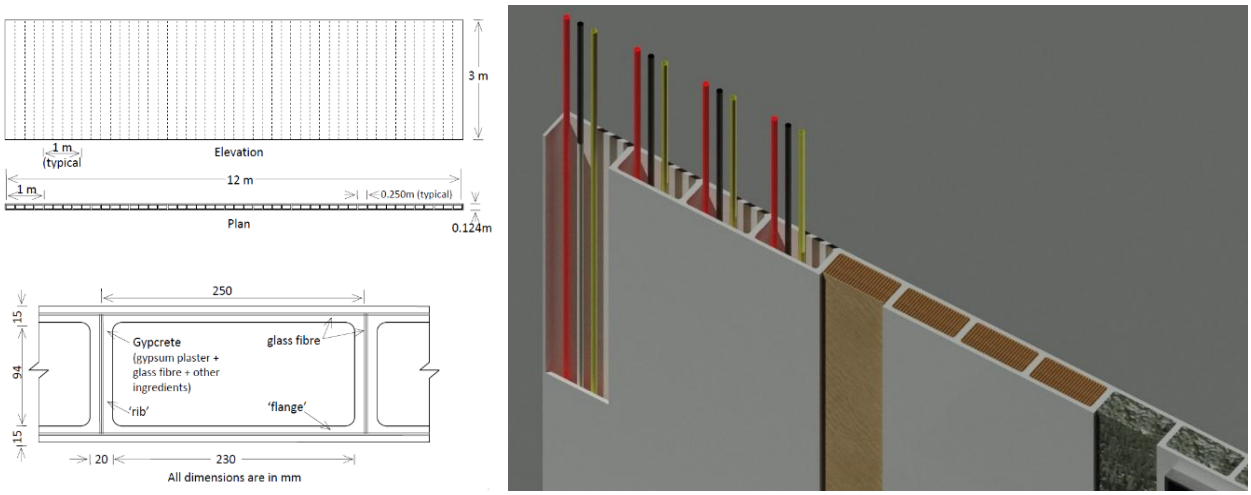


Figure 1 shows a typical GFRG panel cross-section & 3D Model Autocad 2D & 3D (all dimensions are in mm)

The load-bearing capacity of these integrated composite GFRG panels is up to 8-10 stories without the usage of beams and columns. Although these panels are most commonly utilised in wall construction, they can also be employed in floor and roof slabs when combined with reinforced concrete.

Monocrystaline solar panels are used. Monocrystalline silicon, also known as single-crystal silicon and abbreviated as mono c-Si or mono-Si, is the foundation material for silicon-based discrete components and integrated circuits found in almost all modern electronic equipment. Mono-Si is also used in the production of solar cells as a photovoltaic, light-absorbing material.

To preserve a healthy atmosphere both within and outside the building, a vertical garden has been built to the building's outside facades. Vertical gardens can build on this concept by 'naturally' blocking high-frequency sounds. With a layer of air between the plants and the wall, these walls act as additional insulation. They also have the ability to reduce noise levels by refracting, reflecting, and absorbing acoustic radiation.

II. AIMS & OBJECTIVES

The purpose of this research is to examine and evaluate the possibilities of GFRG wall panels in the Indian construction industry using performance metrics. To achieve this aim, the following are the objectives –

1. On the basis of the identified parameters, compare the GFRG panel construction system to the RCC frame construction system.

2. Estimates, scheduling, and detailed drawings were used to investigate the utilisation of the GFRG Panel system.

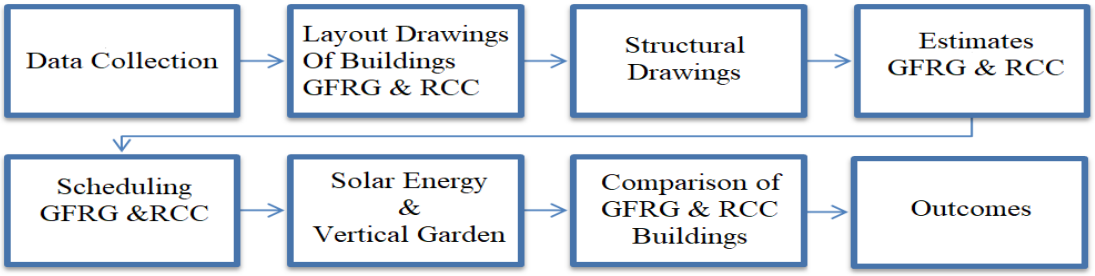
3. Installation of a solar energy system and a vertical garden system in the GFRG building on a budget that was saved When compared to traditional construction methods

III. AREA OF STUDY

The total planning, coordination, and control of a construction project from start to finish is known as construction management. It is a professional service that oversees the planning, design, and construction of a project from start to finish, employing specific project management techniques. Construction management's goal is to keep a project's timeline, budget, and quality under control. Time, quality, and cost are all factors that affect project management success. This triangle has spawned a slew of other building systems. In Australia, the GFRG system was one of these systems. It is a wall panel made of phospo gypsum, which is widely accessible as a waste product from chemical and fertiliser plants. Its goal is to achieve long-term growth. The goal of this project is to undertake a detailed research of GFRG panels in terms of construction management in terms of cost and time by detailed activity scheduling, as well as to compare these aspects to traditional buildings by implementing in a real-world setting.

IV. METHODOLOGY

Following steps were undertaken as an approach towards this study -



1.Data Collection - Desk research of the existing literature on GFRG panel system including manufacturing and the installation process, Properties (Physical & Chemical)

2.Layout Drawings of GFRG & RCC Building -Preparation of detailed layout drawings for GFRG building and RCC building by using Autodesk Autocad.

3.Structural Drawings- Preparation of structural drawings for GFRG building and RCC building by using Autodesk Autocad.

4.Estimate GFRG & RCC Building -Preparation of detailed estimate for GFRG building and RCC building by using MS Excel.

5.Scheduling GFRG & RCC Buildings – Preparation of detailed scheduling for GFRG building and RCC building by using Primavera.

6.Solar Energy & Vertical Garden - Provision of solar energy system and vertical garden system in GFRG building (Manual Calculation & Preliminary Estimate)

7.Comparison of GFRG & RCC Building - Comparison of GFRG building and RCC building with Various parameters.

8.Model Preparation- Using Autodesk Revit, created a 3D model of the GFRG building with a sustainable energy source and a vertical garden**.**

9.Outcomes – Results From the comparison of GFRG Building & RCC Building.

Figure 2 Shows Layout drawing & 3D Model of GFRG Building By Using Autocad & Revit

V. LITERATURE REVIEW

1. RAPID AFFORDABLE MASS HOUSING USING GLASS FIBRE REINFORCEMENT

Devdas Menon [2014] described a structure constructed at IIT Madras. The structure is built up of GFRG Panels, which are made up of mineral, usually in the form of phosphogypsum, a waste by-product of the fertiliser industry, and glass fibre as a reinforcing agent, which increases the panels' strength. The building panels are suitable for affordable mass housing, offering cost-effectiveness and speed of construction. GFRG panels have cellular chambers between the outer flanges and the interior ribs, which may be stuffed with concrete and reinforced with steel bars if necessary to achieve the requisite load-bearing capability. In low to moderately unstable zones, buildings designed using this technique with no columns and beams will go all the way up to 8 to 10 storeys, and in high unstable zones, to a lower height. Electrical wiring and alternate plumbing operations might be concealed in the vacant holes within the panels.

The use of GFRG Panels in building construction is a novel concept.This construction approach makes a major step towards sustainable living by lowering the negative environmental effect that is commonly associated to traditional construction technologies.

2. CRITICAL REVIEW OF USE OFGLASS FIBRE REINFORCEMNT GYPSUM [GFRG] PANELS IN HOUSING IN INDIA

Kuldeep Kumar [2020] described GFRG Panels are made from gypsum, which is widely available as a waste product from the industrial sector. These lightweight panels are fire-resistant, thermally insulated, earthquake-tested waterproofed, rot-resistant, termite-resistant, and 100 percent recyclable, making them ideal for eco-friendly or green architecture. the utilisation of GFRG panels in the Indian building sector by comparing them to traditional construction systems using a variety of functional, structural, and economic criteria.

3. PERFORMANCE EVALUATION OF VERTICAL GARDENS

Ratih Widiastuti [2016] describes A field measurement was taken with the objective of researching the effectiveness of using vertical gardens to reduce surface temperature in the inside of a building's facade. The initial study was based on measurements of the interior façade thermal efficiency of vegetated and bare facades of the Pertamina branch office building in Semarang.The results showed that the plant layer on the façade successfully decreased the inner surface temperature on the façade. The internal surface temperature of the vegetated façade was always lower than the naked façade, as can be observed. The thermal lag of the vegetated façade was similarly slower than that of the naked façade, indicating that it might be advantageous to minimise cooling demands during peak hours. When the air temperature climbed, the effective thermal resistance of a plant layer steadily reduced.

4. A POWER CASE STUDY FOR MONOCRYSTALINE AND POLYCRYSTALLINE SOLAR PANELS

According to **Ali Vardar [2016]**, Solar energy is most commonly employed in the form of polycrystalline and monocrystalline panels, each having its own set of characteristics and efficiency. Climate conditions, the type of solar cells employed, and other factors all affect the effectiveness of photovoltaic panels, according to this study. For monocrystalline and polycrystalline solar panels, the daily average efficiency was 6.65 percent and 5.38 percent, respectively. More study is needed to figure out which precise factors trigger each type of cancer.

VI. ADVANTAGES AND DISADVANTAGES

GFRG panels meet critical specifications that are currently fundamental demands in the building sector, resulting in several benefits of this product over traditional construction systems.

ADVANTAGES OF GFRG OVER CONVENTIONAL BUILDING SYSTEMS:

- Construction that is both sustainable and environmentally friendly
- Construction is simple, quick, and cost-effective.
- Natural calamities such as earthquakes, cyclones, and fire pose no threat to the structure.
- The structure provides excellent sound isolation.

- The building system based on GFRG is energy efficient, sturdy, and long-lasting.
- Less CO2 emissions and embodied energy.
- Significantly less cement, sand, steel, and water are used.
- The structure is light and precise (panel weight - 43 kg/sqm), resulting in foundation savings and reduced design for seismic stresses, especially in multi-story buildings.
- The GFRG building construction has the same durability as traditional construction.

DISADVANTAGES / LIMITATION OF GFRG BUILDING SYSTEMS:

- To build a house using this technology, you'll need a lot of experience. These panels require slightly different handling, mounting, and equipment than standard type panels.
- Because the Panels are customised to the design (including the openings), no adjustments may be made during the installation process.
- Equipment such as a crane is required to construct a building using the GFRG panel method. Furthermore, crane movement necessitates a large amount of area surrounding the plot.
- When storing the panels, extra caution is required. In addition, compared to cement/blocks, more room is required. This makes a full-scale adoption in India problematic (mass housing or affordable housing).
- Curved walls or domes are not suited for the panels. Use masonry/concrete for that specific location if it is required.

VII. RESULT

ESTIMATED COST OF BUILDINGS

RCC BUILDING	**Rs. 83,04000 /-**
GFRG BUILDING	**Rs. 60,98,250 /-**
TOTAL SAVING	**Rs. 22,05,750 /-**

Because the expected cost of a GFRG building is less than that of a conventional RCC structure, the GFRG Green building is more cost effective than a conventional RCC structure.

TIME REQUIRED FOR CONSTRUCTION

RCC BUILDING CONSTRUCTION	**5 Months**
GFRG BUILDING CONSTRUCTION	**Upto 3 Months**
TOTAL TIME SAVED	**2 Months**

Because the time necessary to create a GFRG construction is shorter than that required to construct a traditional RCC structure, this technology is more time efficient.

ESTIMATED COST OF SOLAR ENERGY AND VERTICAL GARDEN

SOLAR ENERGY SYSTEM	**Rs. 18,70,414 /-**
VERTICAL GARDEN	**Rs. 2,14,000 /-**
TOTAL COST	**Rs. 20,84,414 /-**

GFRG Building Construction is less expensive and takes less time than RCC Building Construction, GFRG Building Construction is more cost efficient and economical.

With the inclusion of a solar energy system and a vertical garden, the cost of the GFRG building is estimated to be **Rs. 81,82,664/-**, saving **Rs. 121336/-**

Even after factoring in the cost of a solar energy system and a vertical garden system, the cost of constructing a GFRG Building is less than the estimated cost of constructing an RCC building, demonstrating that GFRG Buildings are more sustainable, cost-effective, time-efficient, and environmentally friendly.

VIII. CONCLUSION

During this study, a thorough examination, assessment, and analysis of the GFRG Panel-based construction system was conducted, leading to the following conclusions:

Environmental Benefits: Reduce water waste, Protect biodiversity and ecosystems, Conserve natural resources, Improve air and water quality, Protect biodiversity and ecosystems

Benefits to the Economy: Lower operational expenses, Increase occupant productivity, Create a market for environmentally friendly products and services.

Benefits to society: Improve quality of life, Reduce demand on local infrastructure, Improve occupant health and comfort.

This method may be appropriate for low-cost housing or EWS, as well as situations where rapid construction is necessary. It's a suitable option for rehabilitation housing, temporary housing (in the event of a natural disaster, for example), or when there's a high need for accommodation in a short period of time.

Even if the dwelling units are ready (in a short time) in isolation, the entire project cannot be operational in the absence of external ancillary and supporting services, according to the completion of the overall project, which includes the infrastructure and external development required for a project to become operational (drainage, electrical supply, water supply, storm water, roads, etc.). As a result, if this technology is to be employed in large-scale housing developments where exterior development is critical, additional planning is necessary.

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