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Performance Evaluation of GFRG Panels in High-Rise Structures: A Comparative Analysis on G+10 Buildings Using ETABS

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ABSTRACT
In recent decades, fiber-reinforced polymer building components have advanced significantly. Glass Fiber Reinforced Gypsum (GFRG) stands out for its fatigue strength, high strength-to-weight ratio, corrosion resistance, and moldability into diverse shapes. This study investigates how GFRG panels perform compared to Reinforced Cement Concrete (RCC) in terms of structural behavior, especially in seismic zones. Using ETABS software, a G+10 floor model explores scenarios with bare frame RCC, GFRG panels, composite GFRG panels, and GFRG panels with strut frames. Results show GFRG panels enhance structural performance, reduce costs, and improve seismic resilience, supporting their adoption for sustainable building solutions.
Keywords — GFRG, RCC, ETAB, Multi Storey Building, Construction, G+10 Building.

I. INTRODUCTION

In contemporary construction, the demand for innovative materials that enhance efficiency, sustainability, and performance is ever-growing. Among these innovations, Glass Fiber Reinforced Gypsum (GFRG) panels have emerged as a groundbreaking alternative to traditional building materials, particularly in high-rise structures. GFRG panels, made from gypsum reinforced with glass fibers, offer a unique combination of properties that make them well-suited for the demands of modern high-rise construction.

GFRG panels are celebrated for their exceptional strength-to-weight ratio, providing robust structural support while being significantly lighter than conventional materials such as Reinforced Cement Concrete (RCC). This lightweight characteristic not only facilitates easier handling and faster installation but also reduces the overall load on the building's foundation, contributing to enhanced structural efficiency.

One of the most compelling advantages of GFRG panels is their rapid construction capability. High-rise buildings, often complex and time-consuming projects, benefit greatly from the reduced construction timelines that GFRG panels offer. The panels can be prefabricated off-site and assembled quickly on-site, drastically cutting down labor costs and project durations.

Additionally, GFRG panels exhibit excellent fire resistance, a critical factor in high-rise structures where safety regulations are stringent. The panels can withstand high temperatures and prevent the spread of fire, enhancing the overall safety of the building. Moreover, their superior thermal insulation properties help maintain comfortable indoor temperatures, reducing the reliance on artificial cooling and heating systems, thereby promoting energy efficiency.

The environmental benefits of GFRG panels further solidify their role in sustainable construction practices. Made from natural gypsum and recyclable glass fibers, GFRG panels have a lower environmental impact compared to traditional construction materials. Their use contributes to greener building practices and aligns with the global shift towards sustainability in the construction industry.

In high-rise applications, GFRG panels are versatile, being used for interior partitions, load-bearing walls, and façade elements. Their ability to be molded into various shapes allows for innovative architectural designs, providing both functional and aesthetic benefits.

GFRG panels are crafted from gypsum plaster reinforced with glass fibers, combining lightweight properties with robust structural capabilities. This composition facilitates easier handling during construction, potentially lowering overall project costs by reducing transportation and labor expenses. Moreover, the rapid installation capabilities of GFRG panels expedite construction timelines compared to the more labor-intensive processes involved with RCC.

Conversely, RCC has long been favored for its exceptional strength and durability, attributes critical in multi-storey constructions where load-bearing capacity and seismic resilience are paramount. RCC's ability to withstand substantial loads and adverse environmental conditions has established it as a cornerstone of modern construction practices, albeit at a higher cost in terms of materials and labor compared to alternatives such as GFRG panels.

II. METHODOLOGY

In ETABS, a widely-used structural analysis and design software, response spectrum analysis is a key method for assessing the seismic performance of buildings and other structures. The process typically involves the following steps:

Model Creation: Begin by creating a structural model of the building or structure in ETABS. This step includes defining the geometry, materials, supports, and other relevant properties.

Load Assignments: Apply seismic loads to the model. For response spectrum analysis, these loads are defined using response spectrum functions. ETABS allows users to define these functions based on code-specific or user-defined response spectrum data.

Analysis Settings: Specify the analysis settings, including the type of analysis (e.g., static, modal, or time history), analysis options, solution controls, and output requests.

Modal Analysis: Conduct a modal analysis to determine the natural frequencies, mode shapes, and modal participation factors of the structure. This step is critical for response spectrum analysis as it identifies the vibration modes that significantly influence the structure's response.

Response Spectrum Analysis: Perform the response spectrum analysis by applying the defined response spectrum functions to the model. ETABS calculates the structure's response to seismic loads based on the modal properties and response spectrum data.

Results and Design Checks: After completing the analysis, review the results to evaluate the structure's response to seismic loading. ETABS provides various output options for viewing and analyzing results, including displacements, accelerations, forces, and stresses. Engineers can also perform design checks to ensure the structure meets the required performance criteria and code provisions.

Response spectrum analysis in ETABS enables engineers to efficiently assess the seismic performance of structures and make informed decisions about design modifications or reinforcement measures to enhance seismic resistance.

A. *Define Materials and Model Geometry*

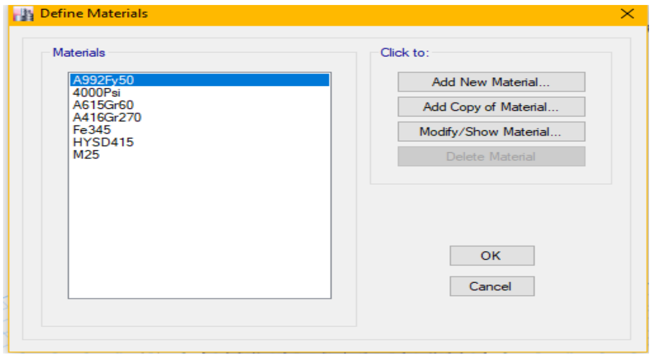


Fig 1. Define materials

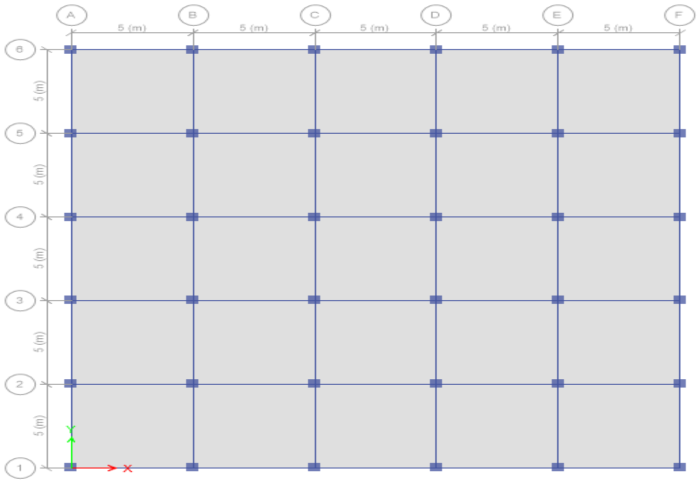
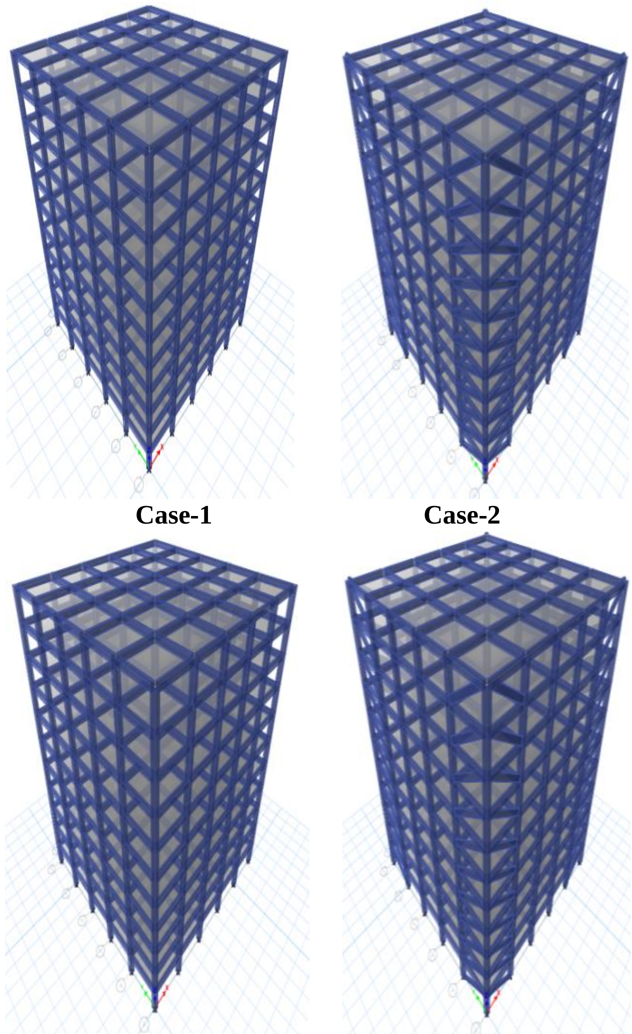


Fig 2. Plan view of G+10 storey model



Case-1 **Case-2**

Case-3 **Case-4**

Fig 3. 3D views of G+ 10 structures in different cases

III. RESULTS AND ANALYSIS

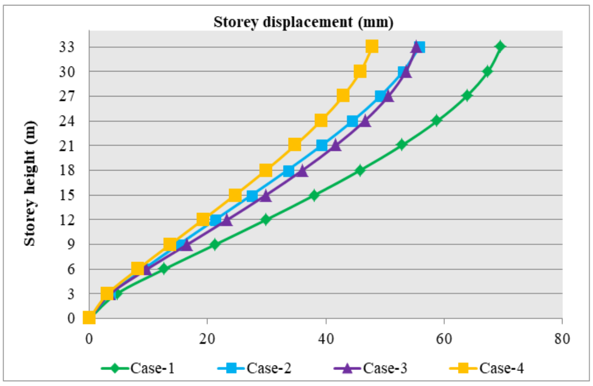


Fig 4. Storey displacement of G+10 storey building in various cases

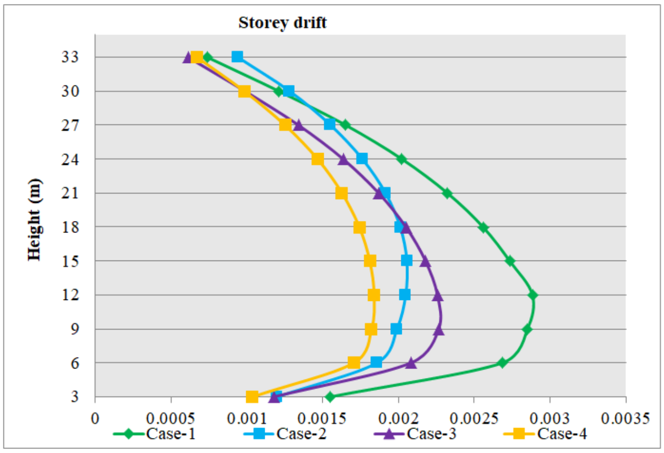


Fig 5. Storey drift of G+10 storey building in various cases

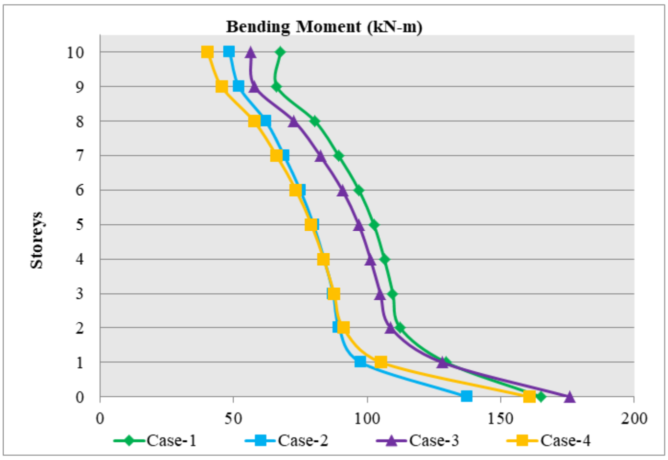


Fig 6. Bending moment in G+10 storey building in various cases

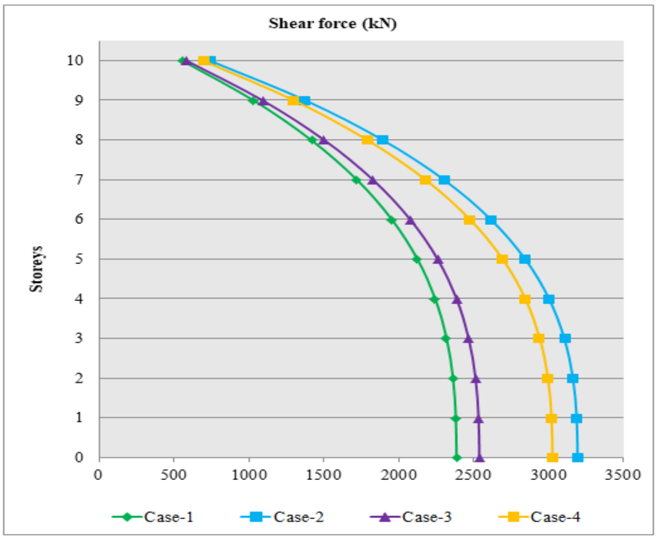


Fig 7. Shear Force in G+10 storey building in various cases

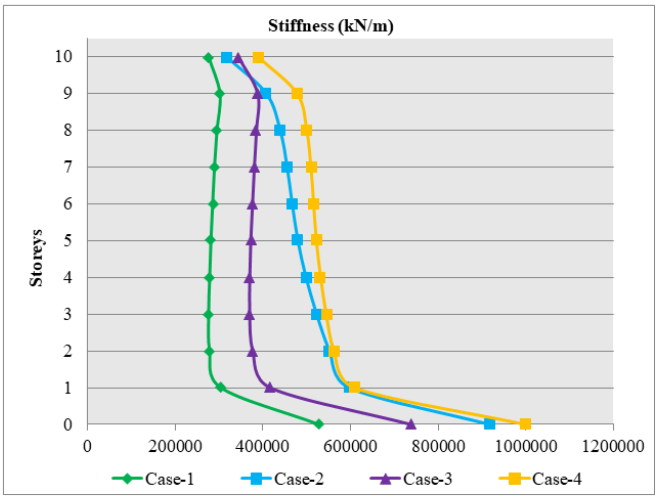


Fig 8. Stiffness in G+10 storey building in various cases

IV. CONCLUSIONS

The adoption of Glass Fiber Reinforced Gypsum (GFRG) panels in high-rise construction marks a significant advancement in building materials, driven by the need for enhanced efficiency, sustainability, and performance. GFRG panels, composed of gypsum reinforced with glass fibers, offer a compelling alternative to traditional materials such as Reinforced Cement Concrete (RCC) due to their superior strength-to-weight ratio, ease of handling, rapid construction capabilities, and excellent fire resistance.

Our study, conducted using ETABS software for response spectrum analysis, highlights several key findings that underscore the benefits of GFRG panels in seismic applications. The analysis involved creating a G+10 floor model and comparing various design scenarios, including RCC structures and those incorporating GFRG panels, with and without shear walls. The results indicate that GFRG panels reduce parameters like story displacement, drift, and bending moments, while increasing shear forces, stiffness, and base reactions. This demonstrates their effectiveness in enhancing structural performance and seismic resilience.

Moreover, the environmental advantages of GFRG panels, made from natural gypsum and recyclable glass fibers, contribute to greener building practices and align with global sustainability goals. The cost analysis further reveals that GFRG panels are more economical than traditional RCC, making them a viable option for modern construction projects, particularly in economically disadvantaged areas.

In conclusion, the study affirms that GFRG panels are not only a sustainable and cost-effective alternative but also a material that enhances the structural integrity and safety of high-rise buildings. As the construction industry continues to evolve, the integration of GFRG panels is poised to play a crucial role in meeting the demands for sustainable, efficient, and resilient building solutions. These findings support the continued exploration and adoption of GFRG panels, paving the way for innovations in construction methodologies and architectural design..

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