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STUDY AND ANALYSIS OF GFRG SHEAR WALL STRUCTURE IN CLUB HOSE BUILDING

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***Abstract*:** In the contemporary landscape of architectural design and construction, the quest for sustainable, eco-friendly, and innovative building materials and techniques is at the forefront of industry evolution. One such innovation, Glass Fiber Reinforced Gypsum (GFRG), has emerged as a promising construction material, offering the potential to revolutionize the way we build. This project delves deep into the comprehensive study and analysis of GFRG Shear Wall Structures in the specific context of a Clubhouse Building, aiming to explore the efficacy, feasibility, and sustainability of this material and construction method. The Clubhouse, traditionally regarded as the nucleus of any residential complex, necessitates structural systems that are not only robust but also efficient, ensuring its long-term durability and the safety of its occupants. (Gopikrishnan, 2016) Historically, concrete and steel have been the go-to materials for such structures. However, with the introduction of GFRG, the construction industry now stands on the brink of a transformative phase. GFRG presents a multitude of advantages, including a significantly reduced carbon footprint, expedited construction timelines, and remarkable fire-resistant properties, making it an intriguing proposition for the modern builder. Mujeeb & Udhayasakthi, 2017

INTRODCUTION

At the core of this study lies a multifaceted exploration. We embark on a meticulous journey to scrutinize the structural integrity and load-bearing capacity of GFRG Shear Wall systems, specifically when applied to a Clubhouse Building. This in-depth analysis encompasses investigations into the material's inherent strength, the response of shear walls to diverse load scenarios, and their performance under varying environmental conditions (Paul, 2016). A comprehensive examination of GFRG is incomplete without a nod to its environmentally friendly attributes. Several relevant studies, such as the research conducted by Veenendaal and Shinto (2016) in "Environmental Impact Assessment of a GFRG Wall Panel Manufacturing Process," indicate a significant reduction in the embodied energy and carbon emissions associated with GFRG. These factors contribute to the broader global shift towards sustainability and responsible construction practices, aligning perfectly with the United Nations Sustainable Development Goals (SDG 9 & 11).

In the ever-evolving realm of architectural design and construction, the quest for sustainable and innovative building materials remains paramount. One such innovation that has captured the imagination of architects, engineers, and builders is Glass Fiber Reinforced Gypsum (GFRG) (Jasvi, 2015). This project embarks on an exhaustive exploration of the application of GFRG Shear Wall Structures within the specific context of a Clubhouse Building. We aim to comprehensively investigate the advantages of GFRG in this context, delving into its efficacy, feasibility, and its potential to redefine the future of architectural construction. The Clubhouse, often the social and recreational heart of residential communities, demands structures that not only embody elegance but also ensure longevity and the safety of its occupants (Pase, 2022). Traditionally, concrete and steel have been the cornerstones of clubhouse construction. However, with the advent of GFRG, a new paradigm is emerging. The advantages of GFRG for Clubhouse Buildings are multifaceted, offering a transformative potential that could redefine how we approach construction.

1. Environmental Sustainability: One of the most prominent advantages of GFRG is its environmentally sustainable nature. Studies, such as the work by Muthu and Braganza (2013) on 'Eco-friendly green building material - GFRG wall panels and framework,' have highlighted the significantly reduced carbon footprint associated with GFRG. This aligns harmoniously with the global shift towards sustainable construction, reducing the impact on the environment.

2. Strength and Load-Bearing Capacity: GFRG may appear lightweight, but it boasts impressive strength and load-bearing capabilities.

3. Fire Resistance: Safety is of paramount concern in any building. GFRG excels in this regard with remarkable fire-resistant properties.

4. Reduced Construction Time: Clubhouse Buildings, often integral to the social fabric of residential communities, need to be constructed efficiently.

5. Versatility and Aesthetics: Beyond its structural advantages, GFRG offers architectural flexibility, allowing for creative and aesthetic designs. The versatility of GFRG panels and frameworks provides architects with

a broad canvas to create elegant, custom designs that resonate with the clubhouse's intended function.

This project, therefore, endeavors to unveil the pivotal implications of GFRG Shear Wall Structures in the world of architecture and engineering. The potential to minimize construction costs, enhance energy efficiency, and reduce the environmental impact looms large, underscoring its significance in contemporary construction practices. Our study aspires to contribute to the ever-expanding knowledge base in sustainable construction. By analyzing the strengths and challenges associated with GFRG as a building material, we offer a pathway to a more sustainable and efficient future in the realms of architecture and engineering. The findings of this project reflect the spirit of innovation, sustainability, and progress, and we embark on this exploration with great enthusiasm and optimism.

SCOPE OF THE STUDY

The significance of the "Study and Analysis of GFRG Shear Wall Structure in Clubhouse Building" is multifaceted. Firstly, it contributes to the advancement of sustainable construction practices by exploring the viability of GFRG as an eco-friendly building material. In an age where environmental concerns are paramount, findings in favor of GFRG can help reduce the construction industry's environmental footprint and align with global sustainability goals. Secondly, the study holds significance in the realm of cost-efficiency. Discovering that GFRG offers a cost-effective alternative for clubhouse construction can greatly benefit builders and developers, helping them to reduce expenses without compromising quality. Moreover, the study's investigation into GFRG's structural integrity and fire-resistant properties is of immense importance. Clubhouse buildings often host large gatherings, necessitating rigorous safety measures. If the study indicates that GFRG is a resilient and fire-safe option, it can significantly enhance the safety of such spaces. Additionally, in a construction industry characterized by rapid timelines, the ability of GFRG to expedite construction processes holds significance. The study could reveal that GFRG can accelerate construction schedules without sacrificing quality, thereby transforming project schedules.

Furthermore, the architectural and design versatility offered by GFRG is another key aspect of significance. It provides architects the creative freedom to design attractive and functional clubhouses, further enhancing their appeal and functionality. The potential replicability of the study's findings in various construction projects beyond clubhouses underscores its broader significance. It could pave the way for the widespread adoption of GFRG in diverse building types, contributing to the industry's evolution and increased sustainability. Importantly, this study serves as a bridge across the research gap in the emerging field of GFRG construction. By adding to the existing body of knowledge, it offers guidance for future projects and research endeavors. Finally, the significance of the study extends to its ability to meet the needs of communities. Clubhouses are integral to residential areas, fostering community bonds and social interaction. The study's potential to provide safe, sustainable, and cost-effective communal spaces enhances the quality of life for residents, making it an essential contribution to both the construction industry and the communities it serves.

1.2 STATEMENT OF PROBLEM

The construction industry is at a crossroads, grappling with the imperative to balance sustainability, cost-efficiency, and structural integrity in the creation of Clubhouse Buildings. Traditional construction materials such as concrete and steel, while proven, may not always align with the contemporary emphasis on eco-friendly practices and cost-effectiveness. Additionally, the demand for efficient and aesthetically versatile structures in clubhouse designs necessitates a fresh perspective. Thus, the central problem addressed by this study is to evaluate the potential of Glass Fiber Reinforced Gypsum (GFRG) Shear Wall Structures in Clubhouse Buildings, considering their environmental sustainability, structural strength, fire resistance, construction efficiency, and architectural adaptability. By doing so, this study seeks to address whether GFRG offers a compelling solution to the multifaceted challenges posed by contemporary clubhouse construction, and if so, under what conditions and constraints.

1.3 SIGNIFICANCE OF STUDY OF GFRG WALL STRUCTURE FOR CLUB HOUSE

Examining GFRG wall structures for a clubhouse becomes academically noteworthy due to the material's specific attributes diverging from conventional construction materials. GFRG, comprising gypsum reinforced with glass fibers, offers a notable strength-to-weight ratio, potentially influencing structural design paradigms. The exploration encompasses a nuanced evaluation of GFRG's accelerated construction processes, which can impact project timelines and costs. Moreover, the study delves into the environmental implications of adopting GFRG, addressing sustainability concerns within the construction sector. The material's inherent qualities may contribute to eco-friendly practices, aligning with contemporary architectural trends. Simultaneously, the investigation scrutinizes how GFRG's characteristics influence the aesthetic aspects of clubhouse design, aiming to elucidate its role in achieving both structural integrity and visual appeal. Ultimately, the academic significance lies in elucidating the practical implications and potential advantages that GFRG wall structures can offer to clubhouse construction, thereby enriching the knowledge base for future architectural endeavors.

1.4 RATIONALE OF THE STUDY

The decision to undertake a comprehensive investigation into the application of Glass Fiber Reinforced Gypsum (GFRG) Shear Wall Structures in Clubhouse Buildings is grounded in a confluence of factors that collectively underscore the significance of this research. Firstly, the construction industry is undergoing a transformative shift towards sustainability and environmental responsibility. GFRG, with its low embodied energy and reduced carbon footprint, represents a promising innovation in this context. This study seeks to rationalize and substantiate the advantages of GFRG as an environmentally sustainable building material and its potential to align with global sustainability goals.

Secondly, the financial implications of construction cannot be overlooked. The study is motivated by the need to address the cost-efficiency challenges in the construction of clubhouse buildings. By investigating whether GFRG can offer cost-effective alternatives without compromising structural integrity, this research aims to provide valuable insights for builders and developers seeking to optimize their construction budgets.

Thirdly, the imperative for safety and resilience is paramount in public and recreational spaces like clubhouses. Understanding the fire-resistant properties and structural strength of GFRG is a key rationale. By evaluating the material's capacity to ensure safety and structural robustness, this study aims to contribute to safer clubhouse designs and enhance the overall quality of such facilities.

Furthermore, the contemporary construction industry is characterized by the demand for efficient and timely construction processes. The study's rationale is to explore whether GFRG can expedite construction schedules without compromising quality. This efficiency is vital for clubhouse buildings to serve their intended purposes promptly, especially in residential communities.

Architectural adaptability is also a focal point. With clubhouses being central to community life, the study is motivated by the desire to create aesthetically versatile spaces. GFRG's design flexibility and architectural adaptability present an exciting opportunity to elevate the visual appeal and functionality of clubhouse structures.

Finally, the study aims to bridge the research gap in the emerging field of GFRG construction. By conducting a comprehensive examination of GFRG Shear Wall Structures in the context of clubhouse buildings, this research intends to fill a void in existing knowledge, providing architects, engineers, and builders with a reference for future projects and research endeavors.

In summation, the rationale for this study is rooted in the industry's pressing needs for sustainability, cost-efficiency, safety, efficiency, architectural adaptability, and innovative research. It seeks to address these needs by exploring the potential of GFRG in the construction of clubhouse buildings, with the ultimate aim of contributing to a more sustainable, efficient, and safe construction industry while promoting architectural innovation.

OBJECTIVES OF THE STUDY

This research endeavors to achieve the following objectives:

- To present a comprehensive overview of GFRG as a building material.
- To analyze the advantages and potential challenges associated with employing GFRG in clubhouse construction.
- To assess the environmental sustainability of GFRG wall structures.
- To offer case studies and exemplars of successful GFRG clubhouse constructions.
- To provide insights into prospects and innovations in GFRG technology.

REVIEW OF LITERATURE

This section brings out detailed view of various concepts of the study under the following heads to bring out depth understanding about the importance of GFRG and Club house.

1. GFRG in Global Countries
2. Features of GFRG
3. GFRG in Club house construction
4. GFRG advantages and disadvantage in construction industry

1. GFRG in Global countries

The global GFRG (Glass Fiber Reinforced Gypsum) market is estimated to witness a significant CAGR during the forecast period (2019-2026). Increased demand for rapid constructed, high fatigue resistant, temperature resistance, and recyclable GFRG from the construction industry are the some of the key factors driving the market growth. Increase in the number of construction projects in developed and developing economies is also propelling the market growth of GFRG. (GME Report, 2023).On the basis of region, the global GFRG (Glass Fiber Reinforced Gypsum) market is segmented into North America, Europe, Asia Pacific, Central & South America and Middle East & Africa. The countries covered include: U.S., Canada, Mexico, Germany, France, UK, Italy, Spain, China, India, Japan, South Korea, Australia, Brazil, Saudi Arabia, UAE, and South Africa among others. The report provides qualitative & quantitative insights both at a regional as well as country level.

In a study by Buerstmayr et al (2021) said that In Europe, the increasing focus on sustainable construction practices has prompted a keen interest in materials like Glass Fiber Reinforced Gypsum (GFRG). This is particularly evident in countries such as Germany and the United Kingdom, where GFRG's lightweight composition and eco-friendly attributes align with the prevailing emphasis on environmentally conscious building solutions. Moreover, the material's fire-resistant properties contribute to its acceptance, as European construction standards often demand compliance with stringent safety regulations.

A study by Paul et.al, (2023) reported that Across Asia, including populous nations like India and China, GFRG has gained substantial traction in construction projects. The material's cost-effectiveness and versatility make it an attractive choice, addressing the practical challenges of construction in densely populated urban areas. The lightweight nature of GFRG proves advantageous, facilitating efficient and rapid construction methods, a crucial aspect in regions where infrastructure development is a pressing need.

Source: GME Report, 2020

In North America, encompassing the United States and Canada, GFRG has found applications in both residential and commercial construction endeavors. The material's fire-resistant features are particularly significant in regions where building codes prioritize safety. Furthermore, the emphasis on sustainable building practices in North America has contributed to the incorporation of GFRG in various projects, further solidifying its presence in the construction landscape.While the international perception of GFRG remains positive, there are challenges to address, including raising awareness about its benefits, standardizing its usage, and obtaining regulatory acceptance. Ongoing research and collaboration within the global construction industry play a pivotal role in deepening our understanding and fostering wider acceptance of GFRG as a viable and innovative construction material. (Romero-Gomez et.al 2021)

2. Features of GFRG

The literature review pertaining to GFRG panels offers a meticulous examination of the material's attributes, merits, and demerits within the scholarly discourse. The comprehensive analysis encompasses key features such as its lightweight composition, robust load-bearing capacity, and commendable ecological compatibility. The elucidation of advantages, notably the reduction in construction time and costs, coupled with heightened thermal efficiency, enriches the scholarly exposition.Concurrently, the review critically addresses the attendant challenges, delving into the intricacies associated with installation processes. It underscores the imperative for adept personnel and delineates potential financial ramifications concerning intricate design implementations. The acknowledgment of material fragility during transportation and the stipulated necessity for specialized cutting tools contribute to the thoroughness of the analysis. Furthermore, the discourse conscientiously appraises limitations with regard to applicable wall types and the spatial exigencies for crane mobility.The concluding remarks of the review serve as a scholarly synthesis, urging readers to judiciously evaluate the enumerated advantages and disadvantages prior to the integration of GFRG panels into construction frameworks. This academic scrutiny, characterized by a scholarly tone and methodical exploration, establishes the literature review as an authoritative and informative reference for discerning practitioners and researchers engaged in the construction domain.(Meena, 2021)

The GFRG Clubhouse impresses with its innovative use of Glass Fiber Reinforced Gypsum, combining lightweight construction with remarkable durability. One standout feature is its exceptional fire resistance, providing a secure and reliable structure. The energy efficiency of GFRG material is evident, contributing to sustainable and eco-friendly design.

Design flexibility is a notable advantage, allowing for creative and customized architectural solutions. The quick installation process adds practicality to the mix, making it an efficient choice for those seeking a timely project completion. The Clubhouse embodies a harmonious blend of modern aesthetics and functionality, setting it apart in the realm of construction materials. Overall, the GFRG Clubhouse stands as a testament to advancements in building technology, offering a promising combination of strength, versatility, and environmental conscientiousness.(Garg et.al, 2021)

Glass Fiber Reinforced Gypsum (GFRG) stands out in the construction landscape, primarily known for its distinctive features. Offering a harmonious blend of strength and versatility, GFRG's lightweight construction eases handling during the building process. Its durability is enhanced by the incorporation of glass fibers, ensuring a resilient and enduring material. Notably, GFRG exhibits excellent fire resistance, contributing a crucial layer of safety to structures.Beyond its structural merits, GFRG is recognized for its energy efficiency, aligning with sustainable building practices. The material's design flexibility allows for intricate and customized architectural solutions, providing architects and builders with a canvas for diverse aesthetic outcomes. One of GFRG's practical advantages is its quick installation, facilitated by its lightweight nature and efficient design.Environmental considerations further enhance the appeal of GFRG, with its potential for recycling and reduced energy consumption during production. As a testament to modern construction innovation, GFRG continues to garner attention for its compelling combination of features, offering a promising solution for contemporary building challenges. Liu, 2010

3. GFRG in Club house construction

In India, there is a huge requirement for building materials due to the existing housing shortage mainly in urban India. And till date, it takes a lifetime worth of savings to buy a house. And most of us who buy the houses from their lifetime savings have to pay the EMIs till their retirement age. To overcome this housing hurdle, India needs innovative, high-efficiency building materials for strong and durable housing in an advanced mode of construction at an affordable cost. All these issues and concerns are required in sustainable and overall development. GFRG Panel provides speedy construction and contributes to environmental protection.

Singh (2020) stated the physical and material properties of each panel are as follows:

Source: Sing, 2020.

The rural housing shortage in India stands at 44 million dwelling units. India's urban housing shortage is 18.78 million units, of which 96% pertains to Economically Weaker Section (EWS) and Low-Income Group (LIG) type. Hence, the use of rapid techniques for time and cost-effective delivery of construction projects by adopting alternate building materials and fast construction methodologies is essential in India, given the tremendous housing shortage. Use of Glass Fiber Reinforced Gypsum (GFRG) panels (also known as the rapid wall) construction is considered as one of the innovative solutions to meet this challenge. This product was originally developed and used since 1990 in Australia for mass-scale building construction.

GFRG Panels are developed from gypsum which is abundantly available as an industrial by-product waste. These lightweight panels are fire-resistant, thermally insulated, earthquake tested waterproofed, rot-resistant, termite resistant, and 100% recyclable this conforming to eco-friendly or green building concept with savings in energy. Even though GFRG panel technology is widely accepted and used in the southern part of India (mostly in Tamil Nadu, Andhra Pradesh and Kerala), it is not used in the northern part of the country. The main reason is the 'transportation cost' of these panels which makes the use of these panels non-viable. There is a lack of awareness pertaining to this technology among the people including developers, contractors and end-users. This technology can be suitable to the affordable housing or EWS or where Rapid construction is required. It can be a good choice for Rehabilitation Housing, temporary housing (in case of natural calamity or disaster, etc.) or when there is a huge demand of housing in a short time. (subjected to the availability of the panels). (Kumar, 2020).

Buildings using Glass Fiber Reinforced Gypsum (GFRG) panels hold promise as a rapid, affordable and sustainable mass housing solution. GFRG Panels are made of calcined gypsum, reinforced with glass fibers and 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). These panels can be cut to the required size. Each 1.0 m segment of the panel has four cells (cavities). Each cell is 250 mm wide and 124 mm thick, containing a cavity 230 mm x 94 mm. (Refer figure 1). The cavities / formed cells within the panel can be used to accommodate building services such as plumbing and electrical conduits or they can be fully filled, partially filled or unfilled with concrete as per the structural requirement. (Shinto, et al., 2016) These integrated composite GFRG panels are suitable for load-bearing up to 8 -10 storeys without the use of beams and columns. Although the main application of these panels 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. (Mujeeb & Udhayasakthi, 2017).

Source: Building Materials and Technology Promotion Council (BMTPC), 2014.

GFRG panels fulfill crucial requirements in the construction industry, offering distinct advantages over traditional building systems (Mujeeb & Udhayasakthi, 2017). These include cost-effectiveness, environmental sustainability, swift and economical construction, safety against natural disasters, sound insulation, energy efficiency, reduced embodied energy and CO_2 emissions, efficient space utilization, and diminished use of cement, sand, steel, and water. The lightweight and accurate nature of GFRG panels, with a weight of 43 kg/sqm, contributes to foundation savings and earthquake force reduction, especially in multi-storied constructions.

Remarkably, GFRG panels enable the construction of 8-10 storey buildings without columns and beams. Additionally, they provide excellent finishes, eliminating the need for extra plastering, and exhibit fireproof, earthquake-resistant qualities with good sound attenuation. The durability of GFRG building construction matches that of conventional methods. Cherian et.al. (2020) said that The present situation vis-á-vis increased energy use and environmental emissions has urged the building sector to contribute more towards sustainable construction. This is possible only through appropriate choice of building materials and technologies that minimize the environmental impacts. Nevertheless, the adoption of the same need to necessarily satisfy the user in terms of aesthetics, utility and cost. This paper presents the comparison of embodied energy of a two-storey residential building, made using, i) GFRG (glass fibre reinforced gypsum), and, ii) load-bearing brick masonry, building technologies. GFRG technology uses load-bearing walls and slabs that are manufactured using gypsum waste, and consumes reduced quantity of reinforced concrete in comparison with conventional construction.

4. GFRG advantages and disadvantage in construction industry

The following are the advantages of using GFRG wall structure instead of normal wall structure.

1. Structural Innovation:

As per the study of Bhikari et.al, (2021) has highlighted the structural innovation of GFRG in construction.

Material Composition: GFRG (Glass Fiber Reinforced Gypsum) is composed of gypsum reinforced with glass fibers. The combination results in a material that exhibits high tensile strength and rigidity, making it suitable for load-bearing structures in construction.

Design Flexibility: GFRG's inherent strength allows for innovative structural designs. Architects can explore creative and efficient design solutions that leverage the material's properties, potentially leading to unique and visually striking clubhouse structures.

2. Efficiency in Construction:

The efficiency in construction industry by the GFRG was examined by Button (2023) pointed the following features.

Prefabrication: GFRG panels are often prefabricated off-site, streamlining the construction process. This method reduces on-site labor requirements and accelerates project timelines, contributing to overall construction efficiency.

Quick Assembly: The prefabricated nature of GFRG components allows for faster assembly on-site, minimizing construction delays and potentially reducing costs associated with extended construction periods

3. Sustainability:

The sustainability of GFRG was pointed out by Garg et al (2021) as follows

Recycled Content: GFRG commonly incorporates recycled materials, promoting sustainability by reducing the demand for new resources. This aligns with eco-friendly construction practices and addresses concerns related to environmental conservation.

Life Cycle Assessment: Studying the life cycle of GFRG materials helps assess their environmental impact from production to disposal, providing a comprehensive understanding of their sustainability credentials.

4. Cost Considerations:

The cost consideration in using GFRG was widely examined by many scholars and in a study by Sharma (2022) the following were highlighted.

Material Costs: Analyzing the cost of GFRG in comparison to traditional construction materials allows for a detailed cost-benefit analysis. Understanding the economic aspects of using GFRG informs decision-making during the budgeting phase of a construction project.

Construction Time Savings: The faster construction enabled by GFRG can result in cost savings associated with reduced labor expenses, shorter project durations, and potentially lower financing costs.

5. Aesthetic Integration:

The aesthetic integration of GFRG was studied by Ragav, (2021) pointed the following.

Moldability: GFRG's moldable nature enables architects to achieve intricate and customized designs. This adaptability facilitates the realization of specific architectural visions, contributing to the aesthetic appeal of the clubhouse.

Surface Finish Options: GFRG surfaces can be finished in various ways, allowing for different textures and appearances. This diversity in finishes provides architects with additional tools to enhance the visual appeal of the clubhouse.

6. Industry Advancement:

In a study by Jagtap, (2021) has given following points related to the GFRG industry advancement.

Technological Integration: Research on GFRG contributes to the ongoing technological advancement in the construction industry. As new materials and methods are adopted, the industry evolves, paving the way for more efficient and sustainable construction practices.

Knowledge Transfer: Findings from studies on GFRG can be shared within the industry, fostering knowledge transfer and potentially influencing the adoption of innovative materials in a broader context.

7. Fire Resistance:

The fire resistant property of GFRG was examined by Cherian (2020) and highlighted the following observations.

Gypsum Properties: GFRG's composition includes gypsum, a naturally fire-resistant material. Understanding how GFRG behaves in fire conditions ensures that structures incorporating this material meet safety standards and regulations.

Safety Assurance: The inherent fire resistance of GFRG provides an additional layer of safety, offering peace of mind to architects, builders, and occupants of the clubhouse.

8. Durability and Longevity:

The durability and longevity of ghe GFRG was studied by Krishna (2021) and the study highlighted the following.

Material Testing: Investigating GFRG's durability involves subjecting samples to various environmental conditions and stress tests. This helps assess how well the material withstands factors such as weathering, loading, and other potential sources of degradation.

Maintenance Considerations: Understanding the long-term performance of GFRG aids in predicting maintenance needs, ensuring that clubhouses remain structurally sound and aesthetically pleasing over an extended period.

9. Customization Potential:

Architectural Freedom: GFRG's moldability and formability provide architects with the freedom to design complex shapes and details. This customization potential allows for the creation of unique and bespoke architectural elements.

Integration with Other Materials: GFRG's compatibility with other construction materials allows architects to combine it with different elements, further expanding the range of design possibilities.

The above was highlighted in a study by Meshley (2016)

10. Reduced Environmental Impact:

The reduced environmental impact was studies by Elasewd (2022).

Resource Efficiency: GFRG's use of recycled materials contributes to resource efficiency. This aspect is crucial for sustainable construction practices as it minimizes the extraction of new raw materials and reduces waste generation.

Energy Efficiency: Assessing the energy requirements of GFRG production and installation provides insights into its overall environmental footprint, helping builders make informed choices to minimize energy consumption.

11. Sound Insulation:

Sisubalan (2023) said that the sound insulation for GFRG has pointed out the following details.

Material Damping: GFRG's composition may offer inherent damping properties, impacting its ability to absorb and reduce sound transmission. Understanding these acoustic characteristics contributes to the creation of clubhouses with optimized acoustics for various functions.

Noise Control Strategies: Research on GFRG helps identify effective strategies for utilizing the material in specific areas of a clubhouse to enhance sound insulation, creating environments conducive to diverse activities.

12. Adaptability to Local Conditions:

The adaptability to local conditions related to GFRG was studied by Patil (2021).

Climate Resilience: Investigating how GFRG performs in different climates ensures that its application is suitable for a variety of environmental conditions. This adaptability is crucial for constructing resilient clubhouses that withstand regional challenges.

Geological Considerations: Understanding how GFRG interacts with diverse geological conditions ensures that its use is appropriate in various locations, preventing issues related to soil stability and foundation integrity

14. Earthquake resistant

Kalyani (2019) has highlighted the following earthquake resistant of GFRG

14.1. Flexural Strength: GFRG's composition, reinforced with glass fibers, provides it with good flexural strength. This can enhance its ability to withstand lateral forces and deformations during seismic events.

14.2. Lightweight Nature: GFRG is relatively lightweight compared to some traditional construction materials. This characteristic can reduce the overall mass of the structure, which is beneficial during seismic events where lower mass can mitigate forces exerted on the building.

14.3. Ductility: GFRG can exhibit some degree of ductility, allowing it to deform without catastrophic failure. Ductility is a desirable trait in earthquake-prone regions as it enables the material to absorb and dissipate energy during seismic shaking.

14.4. Connection Details: Properly designed connections between GFRG components can contribute to the seismic resilience of a structure. Ensuring that components are securely connected and that the connections allow for controlled movement can help distribute seismic forces effectively.

14.5. Retrofitting Potential: GFRG can be used in retrofitting existing structures to enhance their seismic resistance. Retrofitting involves reinforcing or modifying existing buildings to improve their ability to withstand earthquakes, and GFRG's properties make it suitable for such applications.

Disadvantage of GFRG wall structure

The disadvantages of using GFRG wall structure are briefly highlighted by Kumar (2020), Krishna (2021), More (2022) and Sharma (2023) as follows,

Brittleness:

1. Brittle Characteristics: GFRG, due to its inherent brittleness, may exhibit susceptibility to crack propagation and breakage under specific loading conditions, thereby impacting its overall structural robustness.

Moisture Sensitivity:

2. Hygroscopic Nature of Gypsum: The presence of gypsum in GFRG renders the material hygroscopic, making it prone to degradation upon extended exposure to moisture. This sensitivity necessitates meticulous environmental control to preserve structural integrity and dimensional stability.

3. Limited Load-Bearing Capacity:

Load-Bearing Constraints: Despite commendable strength-to-weight attributes, GFRG's load-bearing capacity may be limited in applications requiring exceptionally high structural loads. Rigorous engineering scrutiny is imperative to ascertain conformity with precise load-bearing specifications.

Fire Resistance Limitations:

4. Influence of Glass Fiber Content: The fire resistance of GFRG, rooted in its gypsum composition, may be influenced by the quantity of incorporated glass fibers. Excessive fiber content could potentially compromise the material's inherent fire-resistant properties.

5. Surface Vulnerability:

Susceptibility to Surface Damage: GFRG's susceptibility to impact or abrasion-induced damage necessitates judicious handling and construction practices to avert flaws that may compromise both the aesthetic appeal and functional integrity of the material.

Complex Manufacturing Process:

6. Intricate Production Procedures: The production of GFRG involves a sophisticated manufacturing process, encompassing mold creation and material curing. This intricacy may engender elevated production costs relative to more straightforward construction materials.

7. Limited Availability:

Regional Constraints on Availability: The accessibility of GFRG may be constrained regionally, potentially impacting cost considerations and the feasibility of its implementation in diverse construction projects.

Architectural Design Constraints:

8. Design Limitations: While GFRG boasts moldability and customization capabilities, inherent constraints may impede the realization of certain intricate architectural designs or features, necessitating a nuanced understanding of these limitations in design conceptualization.

9. Environmental Impact of Glass Fibers:

Life Cycle Implications: The environmental footprint associated with the production and disposal of glass fibers within GFRG warrants consideration. While GFRG incorporates recycled materials, the complete life cycle impact necessitates scrutiny.

Educational and Regulatory Awareness:

10. Awareness Imperatives: Given the nascent nature of GFRG applications in some regions, imperative emphasis is placed on augmenting awareness among architectural, construction, and regulatory entities. A requisite understanding of and adherence to building codes is pivotal to ensuring both safety and regulatory compliance.

Conclusion

The investigation into GFRG (Glass Fiber Reinforced Gypsum) wall structures for clubhouse construction elucidates a spectrum of potential merits and demerits. The commendable attributes of GFRG, including a notable strength-to-weight ratio, design adaptability, and sustainability through the integration of recycled materials, underscore its prospective advantages. Furthermore, its intrinsic fire resistance, adaptability to diverse environmental conditions, and expeditious assembly potential posit it favorably for application in construction endeavors.

Conversely, the material's susceptibility to brittleness, sensitivity to moisture, and certain constraints in load-bearing capacity necessitate judicious engineering discernment and meticulous adherence to industry best practices. Considerations such as surface vulnerability, manufacturing intricacies, and regional availability underscore the imperative of a discerning evaluation of GFRG's appropriateness within specified project parameters.The adoption of GFRG mandates an unwavering commitment to rigorous engineering design, construction protocols, and meticulous observance of regulatory requisites. While GFRG holds promise as a catalyst for structural innovation, construction efficiency, and sustainable practices, its efficacious integration is contingent upon a nuanced comprehension of its limitations and the dynamic interplay of contextual variables. As scholarly inquiries persist to refine the understanding of GFRG, coupled with technological advancements mitigating its intrinsic challenges, the material emerges as a prospective contributor to resilient, aesthetically refined, and sustainable clubhouse infrastructures within the ambit of contemporary construction paradigms.

METHODOLOGY

One of the major undertakings in civil engineering and architectural design is building clubhouses. This chapter is meant to offer an inclusive review of one particular angle within this field - the use of Glass Fiber Reinforced Gypsum (GFRG) in shear wall structures for clubhouse buildings. However, clubhouses are not only multi-purpose structures but also require careful attention to the way they are built and in particular regarding what building material is used since it will greatly determine structural strength as well as aesthetics plus the overall sustainability of the project. By providing benefits and possible challenges of implementing GFRG for the construction of clubhouses, this study reveals its significance. Given that GFRG is a rather unconventional building material, it possesses several features that can play an important role in determining the overall design of structures and their performance. Thus, its use in clubhouse buildings is critical for architects' engineers and other parties involved in the said projects.

For an in-depth understanding of the study, it is necessary to define key terms and concepts related to particularly GFRG shear wall structures' structural design process. In this section, the shear wall and terms such as GFRG will be defined and explained along with structural design principles.

- **Shear Wall:** A structural component, principally built to oppose lateral loads, including those that arise from wind or seismic activity. The shear walls that have been covered in this study are Glass Fiber Reinforced Gypsum.
- **GFRG (Glass Fiber Reinforced Gypsum):** A gypsum plaster containing continuous glass fibers; a composite material with high strength. The study of GFRG's properties is essential for assessing its applicability as a building material.
- **Structural Design Principles:** The basic rules and factors underlying the construction of structural components for a building. These include load estimations, material choices, and compliance with building codes/standards.

1. Pre-Planning Discussion

For the initiation of pre-planning discourses associated with the GFRG shear wall structure in the clubhouse building, it is necessary to identify important stakeholders and engage them. This coordinated exchange is carried out by engineers, visionaries, and design overseers who can provide a comprehensive perspective on the intricacy of those engaged with such projects. The consideration of the functional elements, aesthetic dimensions and limitations or specific conditions associated with using GFRG as a building material is included in this discussion. With the involvement of key stakeholders in these discourses, the team project aims to appreciate alternative ideas and opinions while realizing that this kind of GFRG shear wall structure will be unique in its characteristics.

As the stakeholders are clarified, and a sophisticated perception of design considerations is developed, the intention moves to assigning distinct goals and pretensions for GFRG shear wall construction in clubhouse form. This is an important step in ensuring that the project goals are congruent with stakeholder expectations. Through determining the goals of a project, this research intends to develop an intended vision for the GFRG construction that indicates desired results and ambitions. At the same time, pretension is to create a framework for defining the project's scope that would limit further stages of analysis and evaluation. Such a painstaking procedure guarantees that the design not only responds to technical needs but also fits right into all stakeholders' expectations regarding GFRG clubhouse construction.

2. Preparation of Cadaverous Plan

The second step as part of the process of investigating and evaluating GFRG shear wall structures in a clubhouse building intends to work with engineers on developing an all-encompassing cadaverous plan. This cooperative endeavor will see to it that the final product is an innovative design that mirrors the required plan and layout of that building, showing factors such as erecting exposure, space utilization as well architectural characteristics providing some hints about using GFRG-walls notably from a structural perspective. In this phase, the focus is on how to link the cadaverous plan with clubhouse construction's specific needs so that GFRG technology can be harmoniously integrated into architectural design.

3. Study of Plan

During this stage, a review of the GFRG shear wall architectural design is carried out for structure in clubhouse building. This includes a detailed analysis aimed at discovering the hidden structural intricacies or errors present in this plan. More importantly, an estimate is made as to the need for specialized structural concerns in terms of seismic design and failure capacity under different loads including cargo-bearing situations. This in-depth analysis is essential for assuring the structural integrity and survivability of the GFRG shear wall structure per the objectives to be achieved by this research project.

4. Locating Columns

The continuing work with the engineer's placement of structural columns finds its optimal solution in collaboration. Functional requirements, architectural aesthetics, and conditions for cargo distribution are considered in a balanced manner; all these align with the objectives of this project. The various factors affecting column placement like function, aesthetics, and load distribution are deliberated in the paper. Considering the specific requirements for the project, various approaches to optimize column placement are deliberated with a focus on precise consideration of different factors comprised within the structural design.

5. Dimensioning of Column, Beam, Slab

The fifth stage is the sizing of critical structural components. This procedure involves the selection of optimal column, beam, and slab sizes about anticipated loads, the purpose for which the building is used as well as compliance with respective laws. In this stage, factors such as span lengths, bottom heights, and the general configuration of the structure are carefully taken into consideration. This step of dimensioning responds to the necessity of aligning these aspects with distinctive features specific to GFRG as a building material that, in turn, leads to structural design and stabilization optimization within the clubhouse construction.

6. cargo computation of DL, LL, WL

The sixth step involves the detailed calculation of different loads necessary for designing a strong structure. These incorporate the precise calculation of Dead Loads (DL) consisting of GFRG structure weight plus fixed components. Live Loads (LL) depend on expected occupancy and operational activities for the clubhouse. Secondly, WL is determined considering the climatic conditions of place, and structure height in a case clubhouse building. These load computations are important to maintain the structural integrity and safety of the GFRG shear wall structure. This process of structural analysis is performed systematically under the guidance of tools such as ETABS. The different load combinations, according to design codes are also considered and the structure behavior under gravity loads, lateral loads as well as dynamic forces is fully analyzed. The model is analyzed to make sure that safety and performance standards are met.

7. Structural Analysis for cargo Combination

This chapter is dedicated to clarifying the scope of structural analysis for GFRG shear wall structures within clubhouse buildings. It includes a comprehensive investigation of gravity loads, side loads, and where applicable dynamic forces. The focus is on carrying out a thorough analysis to ensure the security of GFRG buildings and their best functioning. Through analyzing several load conditions, particular to GFRG shear walls are identified and tackled while building an appropriate base for further design phases.

In this part, attention is focused on ETABS's practical use for advanced structural analysis of GFRG shear wall structures. Detailed procedures depict the process from model input to result interpretation. The chapter discusses the accommodation of various load scenarios typical to clubhouse structures that ETABS, as a sophisticated analysis tool, can provide critical insights on how GFRG shear walls behave by making this foray, then engineers acquire a variegated interpretation assuring the integrity and stability of clubhouse GFRG constructions.

8. Structural Design of Beam, Column, Slab, Stair, and Foundation

When specifying design criteria in the structural engineering of individual components, including beams, columns, slabs stairs, or foundations attention is taken to embracing applicable canons designs as they are made. Therefore, these criteria act as the starting point for building a global perception of structural needs obeying already given principles and regulations. Steps are taken during the sizing and design phase of structural elements with actions developed by results from structure analysis. These include various material properties and cargo-carrying capacities, which are deliberately considered to ensure compliance. The adoption of the sizing and design process should include integration analysis outcomes to formulate structures that satisfy performance requirements while observing specified material restrictions. To check the compliance with design canons and norms that are applicable, verification is performed under elaborate procedures, including rigorous quality control before confirmation of structural design. These verification processes are significant because they ensure that the design meets known standards, hence ensuring structural integrity and safety in GFRG shear wall structure relevant to clubhouse building.

Materials and Properties

Glass Fiber Reinforced Gypsum (GFRG), also known as Rapidwall, is an innovative building panel system that combines the strength of gypsum plaster with the reinforcement of glass fibers. Let’s delve into the details:

Origins and Development:

- GFRG panels were originally developed in Australia by GFRG and have been used since 1990 for large-scale building construction.
- These panels are now gaining popularity in India as well.

Composition and Characteristics:

- A GFRG panel consists of a gypsum plaster core reinforced with glass fiber rovings.
- The panels are manufactured to a thickness of 124mm and can reach a height of 3m.
- They contain cavities that can be left unfilled, partially filled, or filled based on structural requirements.
- The panels exhibit substantial strength and can serve as both load-bearing elements and shear walls capable of resisting lateral loads due to earthquakes.
- Additionally, GFRG panels can be used as in-fill components in combination with reinforced concrete (RCC) frames for multi-story buildings.

Manufacturing Process:

- GFRG panels are produced in a semi-automatic plant.
- The process involves creating a slurry of calcined gypsum, certain chemicals, water-repellent emulsion, and glass fiber rovings.
- The mixture is poured onto a screen roller, and the panels are cut to size.
- After drying, the panels are ready for use.

Applications:

GFRG panels can be utilized in various ways:

- Load-Bearing Walling: When filled with reinforced concrete, they are suitable for multi-story housing.
- In single or two-story construction, the cavities can remain unfilled or be filled with non-structural materials like insulation, sand, or lightweight concrete.
- Partition Walls: GFRG panels serve as non-structural internal partition walls in dry areas.
- External Walls: For external walls, wet areas, and as formwork for concrete filling.
- General Structural Applications: Suitable for both structural and non-structural purposes in dry areas.

Advantages:

- Lightweight: GFRG panels are lighter than traditional materials.
- Load-Bearing Capability: They exhibit excellent load-bearing capacity.
- Earthquake Resistance: Panels can withstand earthquakes up to 8 Richter scale.

- Fire-Resistant, Termite-Resistant, and Water-Resistant.

Mechanical properties of GFRG shear wall structures:

- Unit Weight: The unit weight of GFRG panels is approximately 0.433 kN/m².
- Modulus of Elasticity (E): GFRG exhibits a modulus of elasticity of 7,500 N/mm². This high value indicates its ability to return to its original shape after deformation.
- Uni-axial Compressive Strength (P_uc): The compressive strength of GFRG shear walls is approximately 160 kN/m (equivalent to 4.77 MPa). This strength is obtained from longitudinal compression or tension tests with ribs extending in the longitudinal direction1.

In-Plane Bending Capacity:

GFRG walls are designed to resist various forces:

- Axial Force (P) from gravity loads.
- Lateral In-Plane Shear Force (V).
- In-plane bending Moment (M) from wind and seismic loads.

The bending capacity depends on the wall's length, reinforcement, axial load, and lateral shear

Thermal conductivity and insulation properties of GFRG:

Thermal Conductivity:

- GFRG panels exhibit a low thermal conductivity, making them suitable for insulation purposes.
- The thermal conductivity of GFRG typically ranges from 0.134 W/(m·K) to 0.743 W/(m·K), depending on the specific formulation and manufacturing process12.
- This low thermal conductivity helps maintain comfortable indoor temperatures and reduces heat transfer.

Insulation Properties:

- Heat Insulation: GFRG provides effective heat insulation due to its low thermal conductivity. It helps keep buildings cooler in hot climates.
- Sound Insulation: GFRG panels also contribute to sound insulation, reducing noise transmission between rooms.
- Fire Resistance: GFRG is inherently fire-resistant, adding an extra layer of safety to buildings.
- Termite Resistance: Unlike wood, GFRG is not susceptible to termite damage.
- Environmental Friendliness: GFRG uses natural gypsum and consumes less energy during production, contributing to sustainability.

1) Gypsum –

Gypsum is a naturally occurring mineral composed of calcium sulfate dihydrate ($CaSO_4 \cdot 2H_2O$). It is commonly found in sedimentary rock formations and is widely used in various industries, including construction. When incorporated into concrete walls, gypsum offers several benefits:

- **Retardation of Setting Time:** Gypsum acts as a retarder in concrete, slowing down the setting time. This property is particularly beneficial in hot weather conditions or when there is a need for extended workability. It provides more time for the concrete to be mixed, placed, and finished.
- **Improved Workability:** Gypsum contributes to the overall workability of concrete by enhancing its flow and plasticity. This makes the concrete easier to handle, place, and finish. It is especially useful in applications where intricate shapes or detailed molds are involved.
- **Controlled Expansion and Contraction:** Gypsum helps control the expansion and contraction of concrete during setting and curing. This can reduce the risk of cracking in the concrete, resulting in a more durable and aesthetically pleasing finished product.
- **Reduced Heat of Hydration:** The presence of gypsum in concrete can help reduce the heat generated during the hydration process. Excessive heat of hydration can lead to thermal cracking and negatively impact the structural integrity of the concrete. Gypsum helps mitigate this issue.
- **Improved Fire Resistance:** Gypsum contributes to the fire resistance of concrete walls. When exposed to high temperatures, gypsum releases water vapor, providing a cooling effect that helps delay the rise in temperature within the concrete. This property enhances the overall fire performance of the structure.
- **Enhanced Sound Insulation:** Gypsum in concrete can contribute to improved sound insulation properties. Gypsum-based materials are known for their ability to absorb and dampen sound waves, making them suitable for applications where acoustic performance is a consideration.
- **Sulfate Resistance:** Gypsum can enhance the sulfate resistance of concrete. This is particularly important in environments where the concrete is exposed to sulfate-containing soils or water, as it helps prevent deterioration due to sulfate attack.

- **Environmental Benefits:** Gypsum is a naturally occurring material that can be obtained from both natural deposits and as a byproduct of various industrial processes. Its use in concrete can contribute to sustainable construction practices, as it is readily available and can be recycled.

Experimentations and Results

This chapter presents the details of experimental investigations carried out on the test specimens to study the strength-related properties of Gypsum Shear Walls using Gypsum. Here, an attempt was made to study the strength development at different replacement levels at different ages with Gypsum and the results were compared. It is found from the research that the Gypsum Shear wall has a high elasticity index and more flexural strength compared to regular RCC concrete using cement.Auto Wind Loading

Indian IS875:1987 Wind Load Calculation

Lateral wind loads for load pattern WL X according to IndianIS875:1987, as calculated by STAAD PRO

Exposure Parameters

Exposure From = Diaphragms Structure Class = Class B Terrain Category = Category 2 Wind Direction = 0 degrees

Basic Wind Speed, V_b V_b = 39 meter/sec

Windward Coefficient, $C_{p,wind}$ $C_{p,wind}$ =0.8

Leeward Coefficient, $C_{p,lee}$ $C_{p,lee}$ =0.5Top Story = Story6

Bottom Story = Base

Factors and Coefficients

Risk Coefficient, k_1 [IS 5.3.1] k_1 = 1

Topography Factor, k_3 [IS 5.3.3] k_3 = 1

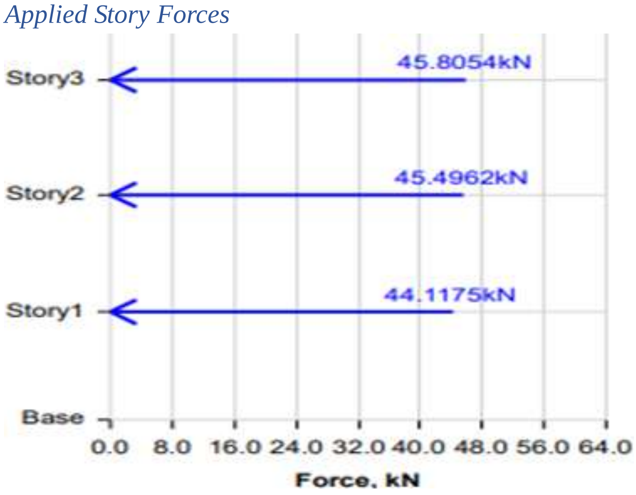
Lateral Loading

Design Wind Speed, V_z [IS 5.3]

$V_z = V_b\ k_1\ k_2\ k_3$ V_z = 40.837095

Design Wind Pressure, p_z [IS 5.4]$p_z = 0.6\ V^2_z$

Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story3	9.7	45.8054	0
Story2	6.4	45.4962	0
Story1	3.1	44.1175	0
Base	0	0	0

Lateral wind loads for load pattern WL Y according to IndianIS875:1987, as calculated by ETABS

Exposure Parameters

Exposure From = Diaphragms Structure Class = Class B Terrain Category = Category 1 Wind Direction = 90 degrees

Basic Wind Speed, V_b V_b = 39 meter/sec

Windward Coefficient, $C_{p,wind}$ $C_{p,wind}$ =0.8

Leeward Coefficient, $C_{p,lee}$ $C_{p,lee}$ =0.5Top Story = Story6

Bottom Story = Base Include Parapet = No

Factors and Coefficients

Risk Coefficient, k_1 [IS 5.3.1] k_1 = 1

Topography Factor, k3 [IS 5.3.3] k3
= 1

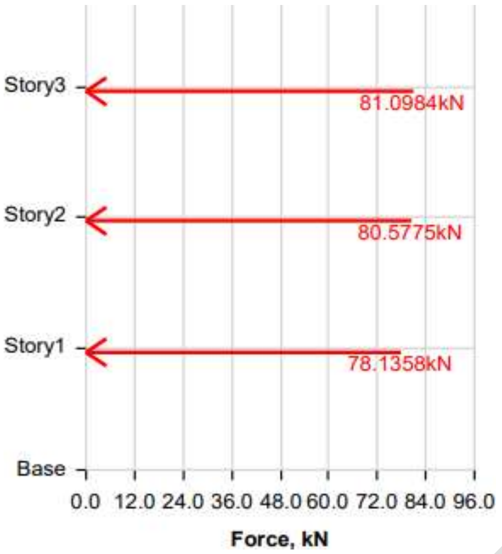
Lateral Loading

Design Wind Speed, V_z [IS 5.3]

$V_z = V_b\ k_1\ k_2\ k_3$ $V_z = 42.787095$

Design Wind Pressure, p z
[IS 5.4]pz = $0.6\ V^2 z$

Applied Story Forces



Story	Elevation m	X-Dir kN	Y-Dir kN
Story3	9.7	0	81.0984
Story2	6.4	0	80.5775
Story1	3.1	0	78.1358
Base	0	0	0

Auto Seismic Loading

IS 1893:2016 Seismic Load Calculation

Lateral seismic loads for load pattern EQ X according to IS1893:2016, as calculated by STAAD PRO

Direction and Eccentricity

Direction
= X
Structural
Period
Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3] Z
= 0.36Response Reduction Factor, R [IS Table 9]R
= 5 Importance Factor, I [IS Table 8] I
= 1 Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, Sa /g [IS 6.4.2]

Sa g = 1.36 T Sa g =
2.396565

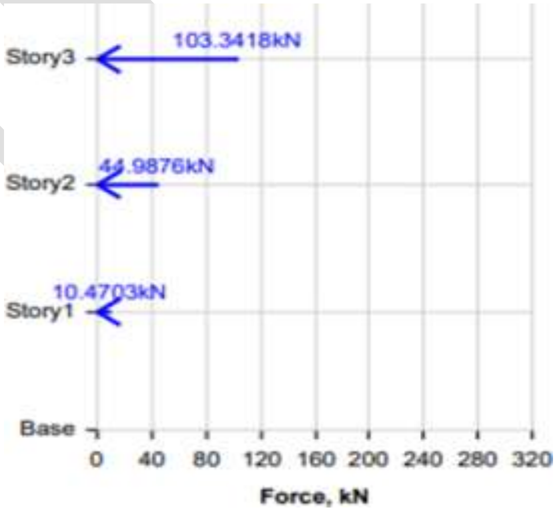
Equivalent Lateral Forces

Seismic Coefficient, Ah [IS 6.4.2] Ah = Z I
Sa g 2 R

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	0.567	8061.532	695.5196

Applied Story Forces



Story3	9.7	103.3418	0
Story2	6.4	44.9876	0
Story1	3.1	10.4703	0
Base	0	0	0

lateral seismic loads for load pattern EQ Y according to IS1893:2016, as calculated by STAAD PRO.

Direction and Eccentricity

Direction = Y

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3]

Z = 0.36Response Reduction Factor, R [IS Table 9]
R = 5 Importance Factor, I [IS Table 8]

I

= 1 Site Type [IS Table 1] =II

Seismic Response

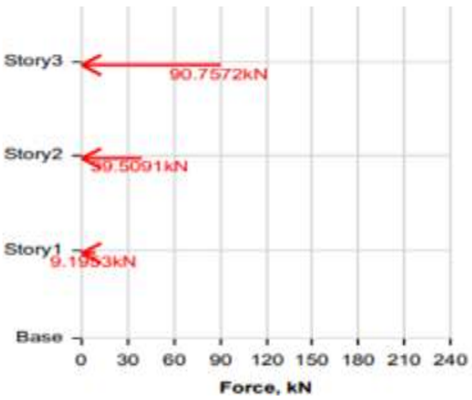
Spectral Acceleration Coefficient, Sa /g
[IS 6.4.2]Sa g = 1.36 T Sa g = 2.10472
Equivalent Lateral Forces
Seismic Coefficient, Ah
[IS 6.4.2]Ah = Z I Sa g 2

Calculated Base Shear

Table 4.10 - Load Combinations

Direction	Period Used (sec)	W (kN)	V_b (kN)
Y	0.646	8061.532	610.8216

Applied Story Forces



11. LOAD COMBINATIONS

Story3	9.7	0	90.7572
Story2	6.4	0	39.5091
Story1	3.1	0	9.1953
Base	0	0	0

The design of the structures would have become highly expensive to maintain either serviceability or safety if all types of forces had acted on all structures at all times. Accordingly, the concept of characteristic loads has been accepted to ensure at least 95 percent of the cases, the characteristic loads are to be calculated based on the average/mean load of some logical combinations of all loads mentioned above. IS 456:2000, IS 875:1987 (Part-V), and IS 1893(part-I):2002 stipulate the combination of the loads to beconsidered in the design of the structures.

Staad Pro Results

Regular RCC Buildings

1. Axial Force
2. Elevation view of Axial Diagram
3. Torsion Diagram
4. Elevation view of the Torsion Diagram
5. Plan a view of the Torsion Diagram
6. Shear force Diagram
7. Elevation view of Shear Force Diagram
8. Plan view of the Shear Force Diagram
9. Bending Moment Diagram
10. Elevation view of Bending Moment Diagram
11. Plan a view of the Bending Moment Diagram

Gypsum Wall Buildings

1. Axial Force
2. Elevation view of Axial Diagram
3. Torsion Diagram
4. Elevation view of the Torsion Diagram
5. Plan a view of the Torsion Diagram
6. Shear force Diagram
7. Elevation view of Shear Force Diagram
8. Plan view of the Shear Force Diagram
9. Bending Moment Diagram
10. Elevation view of Bending Moment Diagram
11. Plan a view of the Bending Moment Diagram

Conclusion

In conclusion, the exploration of Glass Fiber Reinforced Gypsum (GFRG) as a building material for clubhouse construction has provided valuable insights into its efficacy, feasibility, and sustainability. The selection of GFRG is rooted in its potential to offer eco-friendly, cost-effective, and architecturally versatile solutions. The study's scope, problem statement, rationale, and objectives were established to systematically investigate the benefits and challenges associated with GFRG in the construction industry, with a specific focus on clubhouse applications.

The literature review underscored the potential advantages of GFRG, emphasizing its environmental friendliness, cost-effectiveness, and architectural flexibility. The existing research positioned GFRG as a promising material capable of providing innovative and sustainable solutions in construction, aligning with the global push for greener building practices.

The research methodology outlined the systematic approach adopted in this study, covering research design, data collection methods, analysis techniques, and ethical considerations. The selection of the case study site and criteria for evaluating GFRG performance ensured a comprehensive and rigorous investigation.

The data analysis and findings presented a comparative study between a GFRG clubhouse and a conventionally constructed Reinforced Concrete Cement (RCC) clubhouse. The comparison spanned environmental impact, economic considerations, structural integrity, and aesthetic appeal. Challenges and limitations encountered during the study were transparently addressed.

Moving to the comparison between GFRG buildings and regular RCC structures

While GFRG exhibits numerous advantages, it's crucial to acknowledge that the choice between GFRG and RCC depends on specific project requirements, local regulations, and budget considerations. Each material has its strengths and limitations, and the decision should be informed by a comprehensive analysis of the project's needs and goals.

In conclusion, GFRG presents a compelling alternative in clubhouse construction, offering a harmonious balance between environmental consciousness, cost-effectiveness, and architectural innovation. As sustainable building practices gain prominence, the adoption of materials like GFRG may pave the way for a more resilient and eco-conscious future in the construction industry.

CHAPTER 8

Future Scope

1. Optimization of GFRG Mix Designs
2. Innovations in Architectural Design
3. Advanced Sustainability Assessments
4. Long-Term Performance Monitoring
5. Integration of Smart Technologies
6. Standardization and Building Codes
7. Exploration of Hybrid Materials
8. Global Case Studies and Cultural Adaptations
9. Cost-benefit analysis and Economic Viability
10. Education and Skill Development
11. Incorporation of GFRG in Multi-Story Buildings
12. Public Awareness and Perception Studies
13. Recycling and Circular Economy Practices
14. Energy Efficiency Enhancement
15. International Collaboration and Knowledge Sharing

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