A Review Study on Comparison of G+10 Structure with Several Materials Masonry, Concrete and Glass Fiber Reinforced Gypsum Panel (GFRG)

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ABSTRACT
Glass fiber reinforced gypsum plasterboard (GFRG) is an environmentally friendly product. They are made of modified plaster and reinforced with fiberglass strips. Its main use is in the construction of walls, but it can also be used in combination with reinforced concrete on floors and roofs. The panels have voids that can be filled with concrete or reinforced with steel bars to increase strength and ductility. These panels can be used as an alternative building material to replace bricks and concrete blocks. IIT Madras has conducted several research studies and developed a structural design manual for designing buildings constructed by GFRG. Phosphor gypsum is a by-product of the fertilizer industry. In addition to its use as a fertilizer, building material, and soil stabilizer, approximately 85% of phosphor gypsum is disposed of near phosphate plants, which require large disposal sites. Phosphorus from gypsum can be effectively removed by creating glass fiber reinforced gypsum plasterboard (GFRG), also known as fast wall. They may or may not be used as support structures. In this research work we design three different models of G+10 in 5th zone of earthquake as on IS code. The lateral load such as earthquake is to be classified as live horizontal forces acting on the structure depending on the structure's geographic location, height, shape and structural material. In this study, a multi-story Glass fiber reinforced panel and Brick-infill and concrete block infill wall building has been shown **and performed by using software ETABS constructed on a plan ground having G+10 stories.**

Keywords: GFRG Panels, Concrete Blocks, Clay Bricks, Lateral Loading, Light weight Construction and Masonry etc.

I. INTRODUCTION

For use in creating buildings that GFRG will construct, IIT Madras has created a building design. A by-product of the fertilizer business is phosphor gypsum. About 85% of phospho gypsum is disposed of at nearby phosphate facilities, which need large disposal sites in addition to using it as fertilizer, building material, and soil stabilizer. By producing glass fiber reinforced gypsum plasterboard (GFRG), also known as quick wall, phosphorus from gypsum may be successfully eliminated. They might or might not be utilized as support.

II. LITERATURE REVIEW

Mehtab, Tauheed and Ritu Agrawal (2023) [1] in this study, the technical viability and quality of prefabricated glass fiber reinforced gypsum plasterboard (GFRG) as a building material were examined. According to research, GFRG panels were a useful alternative to conventional bricks with additional intangible advantages. Gypsum board reinforced with fiberglass was a great building material if the construction details required to account for contraction and expansion were known. GFRG panels offered a more contemporary method of creating wall systems than conventional masonry methods. The technical viability and characteristics of GFRG panels as architectural wall materials were specifically covered in this study. These panels outperform burned clay bricks in many respects. Gypsum raw materials, primarily natural, mineral, phosphogypsum, or chemical gypsum, were used to make GFRG panels, which had a lower energy consumption than conventional building materials like brick or concrete and a higher purity level. The high efficiency of the carpet surface and quick installation timeframes of the GFRG system proved to be very beneficial in all aspects of construction, especially in terms of time and cost.

More Shiv prasad R., et al. (2022) [2] This paper compares the utilization of GFRG panels with conventional construction methods in the Indian construction sector using Autodesk Revit Architecture to produce 3D models and

Primavera to plan the project. Make proposals using Microsoft Office Excel, produce thorough drawings using Autodesk Autocad, install solar energy systems, and construct vertical gardens to enhance interior air quality. These panels can improve air and water quality, safeguard natural resources, decrease water waste, and protect biodiversity and ecosystems. Economic advantages include lower operational costs, higher population productivity, and the emergence of a market for green goods and services. Therefore, more preparation is needed when using this technology to significant projects where landscaping is involved.

Yu, Rui guang, et al. 2022) [3] the influence of various building materials on the properties of the sound field in a concert hall was investigated through experimental tryouts and numerical simulations. Utilizing an Omni-directional excitation source, a field test was conducted. A multipurpose concert venue had an acoustic analysis model that we developed. Tests were done on the sounded transmission index, initial decay time, reverberation time, and sounded pressure level (spl). At various areas on the first and second floors, we looked at the design of ceilings with and without sonic absorption, the sonic absorption of side walls, the impact of ceiling shape on acoustic characteristics, and the selection of architectural treatment for sonic qualities. According to the simulation results, the reference time at various receiving points varies slightly when the same processing strategy is used, and the sound transfer index rises as one gets farther away from the receiving end.Second-order performance in language exceeds first-order language performance. As you got further away from the receiving site, the sound pressure level dropped. The acoustics of a multifunctional music hall were not considerably impacted by the form of the ceiling. A shorter reference time had been obtained by employing sound-absorbing material on the ceiling than on the side walls. The multipurpose music hall's sound transmission performance had also improved at the same time. For ceilings made of sound-absorbing materials, the difference between the maximum and minimum sound pressure levels was less than it was for ceilings made of non-absorbing materials.

Pulupula, Sruti, and Sumedha Dua (2022) [4] this case study's expenses highlight the possibilities of modular construction for affordable homes. Due to the potential for material faults to manifest during the manufacturing process, the final manufacturing quality of every item has been the same. The fact that the units were made off-site and assembled on-site made construction faster than traditional building. When considering the viability of a certain place, storage and transportation may be important considerations. These systems, as demonstrated in this example, had larger initial investments but had lower life cycle costs than conventional systems. Considerations could include money allocation and affordability. During the building of formwork and other systems, waste could be reduced and raw materials could be utilized more effectively. The unique energy of each system must be carefully assessed in order to draw conclusions on sustainability-related issues.

Salvi Snehal Ashok, et al. (2021) [5] Due to the country's 24.7 million-unit housing shortfall, which primarily affects low-income people in metropolitan areas, demand for construction materials was rising in India. India must immediately adapt technology, employ quick procedures, and use other building materials, given the severe housing crisis, in order to complete construction projects on schedule. Additionally, construction must be sustainable and affordable. A solution for the quick and affordable creation of mass housing in India was offered by the home construction technique employing glass fiber reinforced gypsum board (GFRG) (cavity reinforced concrete) that was provided in this project. A load-bearing system of prefabricated wall panels made up the GFRG construction system, a quick construction technique. Additionally, an eco-friendly building material, GFRG, could be produced from either natural or synthetic gypsum. GFR panels could withstand earthquakes and had a great load-bearing capacity.An environmentally friendly choice that reduces the adverse impact of construction on the environment. Comparatively speaking to conventional construction techniques, construction was rather quick and straightforward. GFR panels were quite affordable for construction. By using this material, the building's structural weight was reduced. Fiberglass was not corroded by GFRG. This means that even after extensive use, there would not be any cracking or deformation. GFR panels were simple to install and did not require employees with a lot of technical training.

Jagtap Anuja, et al. (2021) [6] in all respects, it was better than conventional construction techniques. This building technique makes a significant contribution to sustainable living and benefits the environment. People with poor judgment because these structures could endure natural calamities like earthquakes, tornadoes, and fires, the deployment of quick walls could save lives. More significantly, this new technology may be able to protect those who are "homeless." Total project expenses were estimated using thorough estimates for GFRG and conventional construction. In comparison to traditional construction, GFRG panels could be used for huge numbers of pipes and could cover 15% of the cost of the construction technique for a four-story house because the expected cost was low for a single-story building and large for a high-rise residential building.

Bukhari Hamna, et al. (2021) [7] this analysis includes an economically and environmentally sound solution for a current housing project. Compared to existing dwellings, proposal B was 28% more energy-efficient. This resulted in annual energy savings of 799 units and construction-related cost savings per dwelling of $857.82. Adopting this suggestion would make dwellings more thermally comfortable, assisting the middle and poor classes in lowering building operation expenses in addition to construction expenditures. The nation's entire resource management and energy use had been impacted by this. In comparison to the current home, option B was 28% more energy efficient. 799 units of energy were saved last year, and each unit saves $857.82 in building-related costs. The middle class and the poor would benefit from lowered building and operating costs if these suggestions were implemented since life has been more thermally comfortable. This would have an effect on how the nation managed its use of resources and energy.

Koyande Animesh Sharad, et al. (2021) [8] In this study, normal RC and GR structures that had been subjected to seismic stress were compared in terms of performance, construction cost, and planning analysis. In seismic analysis, GFRG structures outperform RCCC buildings. This was due to a 20% lower base shear force caused by the GFRG unit's lighter weight than the RC's. A cost comparison of GFRG and RCC structures reveals that there may have been direct and indirect savings of up to 20–30% when GFRG structures were used. Additionally, it could be said that when using time series analysis, the GFRG design was superior to the RC design. This was due to the formwork curing process, which took 7 to 14 days, speeding up and saving time and space during the installation of GFRG panels. For economically underdeveloped locations, GFRG housing solutions made an excellent alternative to RCCC building when taking into account safety, prices, environmental benefits, construction time, etc.

Chandra V. Sarat and N. Lingeshwaran. (2020) [9] A major component of human civilization's development activity was viewed as revolutionary work. Load-bearing walls were first constructed by civil engineers. Unique ecological materials were anticipated and have been utilized in the structural beams of the masonry to strengthen the beauty and tenacity of the structure without losing its strength, stability, performance, structural presence, or ecological features. The working limit method and the limit state method were then enhanced, and frame structures were added. Recently developed load-bearing partitions with hollow brick walls, on the other hand, may support heavier loads while saving money relative to equivalent load-bearing frame constructions. The findings of the study demonstrate that the bending strength of the walls of the frame construction was greater than that of hollow brick walls. By contrasting conventional frame constructions with hollow brick walls, we discovered that hollow brick walls were significantly more practical and affordable than frame structures in terms of strength. Because frame buildings cost more per unit than hollow brick walls. This improved the safety and competitiveness of the construction while also increasing the structural efficiency of the infill plan.

Cherian Philip, et al. (2020) [10] in this paper, the energy efficiency of a two-story home constructed using load-bearing bricks and GFRG (glass fiber reinforced gypsum) was compared. Gfrg technology employs less reinforced concrete than conventional construction techniques and load-bearing walls and floors built of gypsum waste. According to the study, GFRG buildings had an embodied energy in building materials that was 16% lower than that of conventional stone buildings, whereas the embodied energy in transportation capacity was twice as high. According to the study, the main benefits of constructing GFRG structures were a reduction in structural weight and construction cost of around one-fourth, a reduction in construction time of about three-quarters, and a reduction in labor requirements of about half. It must be completed. In addition, there was a significant 25%, 36%, and 44% decrease in the consumption of cement, steel bars, and sand.

Dharmasastha K., et al. (2020) [11] Significant energy savings and CO_2 emission reductions were possible by switching to energy-efficient air conditioning systems and adopting environmentally friendly building materials. A new energy-efficient cooling technology called thermally activated building systems (tabs) provides greater thermal comfort than conventional air conditioning systems. With tabs, cooling water ran through pipes installed in a variety of roof, floor, and wall configurations to cool the structure while also preventing heat intrusion. An adhesion solution would involve combining tabs with green building products like glass fiber reinforced gypsum (GFRG). In this study, a hybrid system that combines tabs with a GFRG roof was investigated. Thermal images of the internal and external roof surfaces, attenuation coefficients, and various watered temperature changes were used in an experimental analysis of the thermal behavior of thermally activated glass fiber reinforced gypsum (TAGFRG) roofs. Greater cooling loads could be supported by the TAGFRG roof reinforcement area than by the air cavity area. The daily temperature variation on the internal surface of the roof in the air gaped and reinforced regions was decreased by 5.1 and 6.7°C, respectively, with TAGFRG roof cooling.

Movahedni, Mehrdad and S. Mohammad Mirhosseini, (2019) [12] in this paper, finite element simulations was used to examine the behavior of steel frames with plasterboard infills. The reference model was a standard steel frame with tested infill walls. By calibrating the finite element simulation results with corresponding experimental samples, the accuracy of the numerical model was confirmed. The influence of plasterboard thickness, fiber reinforcement in the infill walls, and local reinforcement in the vicinity of the infill walls was then tested using parametric analyses on four models. Each of these elements contributes to a significant boost in the model's strength and ductility. It was clear that increasing the infill walls with fibers would result in a 3.2% and 6.3% increase in the model's strength and ductility, respectively. The strength and stiffness were increased by 6.7% and 3.3%, respectively, when the filling wall's thickness was doubled; however, this alteration significantly reduced the infill frame's ductility. The improvement in strength and ductility was minimal due to the limited strengthening of the infill walls' marginal area, but the stiffness of the model increased by 30% as a result.

Gouri Krishna S. R., et al. (2019) [13] the paper looked at the energy and interior thermal comfort sustainability of buildings with GFRG panels. According to the results of this study, the case study building at IIT Madras had a lower energy content than typical structures. Given that the building industry uses 40% of the global energy supply, this statistic is noteworthy. Furthermore, by lowering the interior temperature by 2°C, the building's need for air conditioning and energy usage during operation were decreased. The GFRG pilot building's low internal energy of 5.24Gj/m2 shows that GFRG saves internal energy by over 50% when compared to conventional building technologies. Therefore, GFRG stands as an effective alternative to conventional building materials and systems. Additionally, even on the hottest days, GFRG buildings provided higher internal thermal comfort. This saves electricity and lowers the amount of energy required to cool the building. This demonstrates how GFRG panels used in construction could improve the sector's sustainability.

Singhal Siddhant and Bilal Siddiqui (2019) [14] this paper defines how prefabrication technology could cut down on both the price and duration of construction projects. The advancements in the field of prefabricated building systems using GFRG construction technology, also known as rapid wall construction technology, in India were summarized and discussed in this article. Fiberglass-reinforced structural gypsum plasterboard was manufactured in standard cuts and had a cavity, making it a profile ready for quick building construction. In both residential and business locations, quick walls of this sort were used. Without the use of exterior columns or beams, GFRG walls could be employed as decorative and structural elements, such as walls and panels. Because it was environmentally benign and didn't call for intricate structural design specifications, it is currently frequently employed. For the purpose of cost comparison, there are two types of building methods. Cheap construction employing prefabricated technologies (for example, GFRG wall panel systems) and conventional construction methods (for example, structural SMRF and load-bearing systems) were considered commodity materials. The builder in the area bears the expense of these building supplies. The primary objective of this contribution was to compare cost estimates for prefabricated (GFRG) and traditional building systems. From the costed analysis presented above, we draw the conclusion that the GFRG building option was very cost-effective and that the time savings provided by this construction technique were essential given the rising demand for housing. By lowering your carbon footprint, these panels not only last longer than conventional materials but also contribute to environmental protection. At the moment, the use of panels in architecture is developing gradually. However, this process of house construction was unknown to the majority of people and engineers. It would raise readers' awareness of issues such as resource allocation, time management, and the construction and pricing of GFRG panel systems.

Chauhan Bhumi R and Gargi Rajpara, (2019) [15] Author concentrate on using GFRG (glass fiber reinforced gypsum) wall panels to construct affordable houses in his workplace. It was known that the population grows every census year based on preliminary research on overall population growth and the rate of population growth in slum regions, as well as observations of the actual condition in slum areas. Every year, slum settlement populations get denser as a result of urbanization. Families in slum areas had a high demand for improved housing. For the construction of massive-scale homes for the general public, traditional building materials like concrete, brick, and steel were highly demanded and expensive. In order to reduce overall expenses and mitigate the environmental impact of concrete, you should look for composite materials. Gypsum composite waste and fiberglass are combined to develop GFRG (Glass Fiber Reinforced Gypsum) panels, a plasterboard substitute. Compared to conventional building materials like concrete, brick, and steel, fiberglass and gypsum are substantially less expensive. As a result, GFRG panels are a good choice for cladding because they are affordable.

III. RESEARCH GAP

- Comparative analysis of brick walls, GFRG panel and concrete blocks are not combined done yet.
- Most of researcher uses push over analysis with GFRG panels and brick walls.
- On sloping ground with set-back area used for study skip plan area for study.
- Most of papers not provided details of GFRG panel manufacturing.
- Approx. all the researches use these panels for reduce cost but not for reduce effect of earthquake loading.
- Few of them use concrete block and GFRG panels for comparison.

IV. FINDINGS

The technical sustainability and quality of manufactured glass fiber reinforcing gypsum plasterboard (GFRG) as a building material are examined in this study. According to research, GFRG panels offer more intangible advantages than regular bricks and are a viable substitute. [1]

The paper compares the use of GFRG panels with conventional construction methods in the Indian construction sector. It does this by using Primavera for project planning and Autodesk Revit Architecture for 3D model creation. [2]

The source of omnidirectional encouragement was used at an experiment site. We developed a multipurpose auditorium sound analysis model. We investigated the sound pressure level (SPL), sound transmission index, reverberation time, and beginning analysis time. Compared to ceilings made of uninsulated materials, the variation between the lowest and maximum sound pressure levels is less for ceilings with acoustical individuals. [3]

These systems have lower overall expenses than common systems, as shown in this example, but they require a larger initial investment. Funding allocation and affordability are two possible considerations. [4]

An additional environmentally beneficial building material is GFRG, which is produced from either industrial or natural gypsum. [5]

It is better than conventional building techniques in every way. This building technique benefits the environment and is a significant step toward sustainable living. Describe it in low terms. Because rapid walls are made to survive natural calamities like earthquakes, tornadoes, and fires, their deployment has the potential to save lives. [6]

In order to enable low-income people to live comfortably, this research aims to present an energy-efficient housing project with thorough cost control based on technologies that offer both thermal comfort and economic efficiency. [7]

The performance of conventional RCC and GFRG designs under seismic loads, building expenses, and schedule analysis are compared in this study. [8]

Load-bearing parts with brick wall cavities have been made possible by modern inventions. These partitions may carry higher loads while costing less than equivalent load-bearing frame constructions. [9]

The electrical energy connected to the carrying capacity in this study was twice that of typical stone buildings, whereas the energy related to GRRG building supplies was 16% lower. According to the study's findings, the biggest advantages of creating GFRG structures were a roughly 25% reduction in structure weight and construction costs, a 75% reduction in construction time, and a 50% reduction in annual labor transportation expenses of the building construction. [10]

Everyday variations in temperature, pictures of the inside and exterior roof surfaces, humidity effects, and various temperature changes of the roof were used in a temperature gradient of highly active glass fiber reinforcement gimbal (TAGFRG) roof failure. if the air cavity length is exceeded by the temperature demands. [11]

It was found that the model's strength and ductility increased by 3.2 and 6.3, correspondingly, when fibers were added to the infill walls. The infill walls' thickness doubles, increasing the material's strength and stiffness by 6.7 and 3.3 times, respectively. But the infill frame's ductility is much diminished by this alteration. The model's stiffness is increased by 30% due to local reinforcement at the borders of the infill walls, but there is very little gain in strength and ductility. [12]

Actually, 40% of global energy consumption is attributed to the construction industry. Furthermore, by lowering the interior temperature by 2°C, less energy was used for operating the building's air conditioning system and less energy was needed overall. [13]

The paper explains how prefabrication technology may decrease building schedules and save expenses. The advancements in the field of precast structure systems using GFRG construction approach also referred to as rapid wall construction technology in India are reviewed and summarized in this paper. [14]

Furthermore, Prime intends to concentrate on constructing affordable housing utilizing GFRG (glass fiber reinforced gypsum) wall panels. Developed and implemented in Australia in 1990, Rapid Wall is entirely glass fiber-reinforced gypsum plaster (GFRG), a glass fiber-reinforced architectural plaster used in massive building projects. [15]

V. OUTCOME

An excellent building material is fiberglass-reinforced gypsum, as long as the design specifications are understood to accommodate expansion and contraction. When constructing wall systems, the use of GFRG panels presents a more contemporary method than conventional masonry processes. [1]

Lower operating expenses, boost population productivity, and provide a market for goods and services that require payment. As a result, people's quality of life is enhanced, their comfort and health are improved, and less local infrastructure is required. This strategy might be suitable in situations where quick progress is required, like in SAP or social housing. [2]

With increasing length, certain structural elements have a greater influence. Compared to the first layer, the second layer reduces sound quality more effectively. For Odeon's acoustic simulation analysis, the ideal position of soundproofing materials is chosen. In multipurpose concert halls, sound-absorbing materials placed in the ceiling have a stronger effect on sound pressure levels and speech intelligibility because they have a greater reverberation duration than materials placed on side walls. Installing materials that absorb sound on the ceiling during concert hall design can enhance the auditory experience. [3]

Each unit will have the same end-product quality because there is very little possibility of material flaws developing during the process. The fact that the units are built on-site after being manufactured off-site speeds up construction compared to traditional methods. A specific area's viability may be compared with consideration given to storage and transportation. [4]

Because of its complex nature, construction may call for the services of highly skilled designers and laborers. This is due to the fact that a single error made during construction could harm the entire building. The cost of materials and labor will increase. The construction of a building takes longer than with traditional methods. Compared to conventional buildings, GFRG panel construction can be completed up to 50% faster. Since the majority of the work will be done within the facility, the weather won't be an issue for the duration of the project. [5]

Estimates of the project's overall expenses are provided by detailed estimates for both traditional construction and GFRG. Because the cost difference is substantial for multi-story buildings and minor for single-story buildings, GFRG panels can also be employed on lines with large surfaces. Rapid wall construction technology can save 60–70% of construction time and 15% of construction costs for a four-story structure when compared to traditional construction methods, according to a project planning study done by MS Projects. This method is unknown to many individuals. For this reason, we have made and will continue to make a commitment to teaching the public about accessible, eco-friendly, and creative structures that can support you in realizing the objectives of your project. [6]

An affordable and energy-efficient solution for current housing projects is presented in this study. Offer B outperforms 10 incumbent operators in terms of efficiency by 28%. This results in annual energy savings of 799 units and $857.82 for each newly constructed home. [7] In seismic analysis, GFRG structures outperform RCC buildings. This is because GFRG has a 20% lower fundamental shear strength than RCC because of its lower unit weight. When GFRG and RCC structures are compared to RCC buildings, direct and indirect savings of up to 20–30% are attainable, according to cost analysis. In schemes in the economic production phase, GFRG budget solutions are a good substitute for RCC construction when taking into account designs, costs, ecological advantages of construction, etc. [8]

Framing walls have a higher bending strength than hollow brick walls. When we compared hollow brick walls to conventional frame buildings, we discovered that hollow brick walls are significantly more affordable and useful in terms of strength. Compared to frame buildings, hollow brick walls are less expensive per unit. This raises the infill building's structural efficiency while enhancing construction safety and affordability. [9]

The main advantage of this research is that the particular energy results described here may also be applied to other GFRG buildings with spans not exceeding 5 meters that were predominantly built for supermarket workday housing. If a certain room requires a lot of light, beams supporting the columns can be used to achieve this instead of cheap housing. In this instance, the energy is thought to be superior to the research findings. This study's focus is restricted to GFRG structures featuring RC-filled load-bearing panels and GFRG load-bearing walls. [10]

The highest temperature on the outside of the air cavity zone (AZ) is 1.2 times higher than in the enhanced zone (RZ) when the zone is noncooled (NC) and there is a lot of solar radiation. This also results in a blockage of solar heat penetration into the cavity's air. Due to convective heat transfer with visible cold air, the outside roof temperature is lower than the interior surface temperature between midnight and early morning. The minimum temperature outside the surface of NC is 2.2 °C less than the minimum temperature inside the surface. [11]

The design's strength and ductility increased by 3.2 and 6.3, respectively, when fibers were added to the fill walls. A 30% increase in model stiffness but a negligible improvement in strength and ductility are caused by the strengthening of limited areas at the edge of the infill walls. The infill walls were strengthened in response to damage seen in earlier versions, when stress concentrations caused massive cracks at the infill walls' edges. [12]

The GFRG pilot building's internal energy is just 5.24 GJ/m^2, indicating that, when compared to traditional building technologies, GFRG reduces internal energy by over 50%. This saves electricity and lowers the energy required to cool the building. This demonstrates how the construction sector may become more sustainable with the use of GFRG panels. [13] By lowering your carbon footprint, these panels not only outperform conventional materials but also contribute to environmental protection. Panel architecture is now making slow but steady progress. Nonetheless, this kind of home-building technique is unknown to the majority of individuals, including engineers. [14]

Glass fiber is used in place of masonry walls in GFRG (Glass Fiber Reinforced Gypsum) panels, which are made using gypsum as the raw composite waste material. Glass fiber and gypsum are far less expensive than traditional building materials like steel, cement, and bricks. Therefore, employing GFRG panels as an affordable housing material is a good idea. [15]

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