Reviews On Glass Fibre Reinforced Gypsum Panels

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Abstract - Nowadays there is a need for quick period construction for our society. By comparing the commercial concrete construction, the Rapid wall construction gives good result for our construction needs in the society. Glass Fibre Reinforced Gypsum (GFRG) is a new building material and it is also known as Rapidwall building panel. It is mainly used to overcome the lack of natural resources like River sand, water, gravel, etc., The product gypsum is abundantly available as an industrial by-product waste. GFRG panels are a composite material consisting of calcined gypsum plaster and glass fibre. The panel contains cavities that may be filled with concrete and reinforced with steel bars to impart additional strength and provide ductility and also it can be used for the construction of walls, floor and roof slabs. It has light weight, high compressive strength, shearing strength, flexural strength, stiffness and ductility. It has high level of resistance to fire, heat, water and corrosion. Concrete infill with vertical reinforcement rods enhances its vertical and lateral load capacities. The rapid wall buildings are also resistant to earthquakes, cyclones and fire. The paper carried out some of the literature study in the different samples of GFRG panels performance in experimental wise.

Keywords - GFRG, Rapidwall, Silica fume.

INTROUCTION

Glass Fibre Reinforced Gypsum (GFRG) Panel known as Rapidwall is a building panel made-up of calcined gypsum plaster, reinforced with glass fibers. The panel was originally developed by GFRG Building System Australia and used since 1990 in Australia for mass scale building construction. Now, these panels are being produced in India and the technology is being used in India. The panel, manufactured to a thickness of 124mm under carefully controlled conditions to a length of 12m and height of 3m, contains cavities that may be unfilled, partially filled or fully filled with reinforced concrete as per structural requirement. Experimental studies and research in Australia, China and India have shown that GFRG panels, suitably filled with plain reinforced concrete possesses substantial strength to act not only as load bearing elements but also as shear wall, capable of resisting lateral loads due to earthquake and wind. GFRG panel can also be used advantageously as in-fills (non-load bearing) in combination with RCC framed columns and beams (conventional framed construction of multi-storey building) without any restriction on number of storeyes. Micro beam sand RCC screed (acting as T-beam) can be used as floor/ roof slab.

The GFRG Panel is manufactured in semi-automatic plant using slurry of calcined gypsum plaster mixed with certain chemicals including water repellent emulsion and glass fiberovings, cut, spread and imbedded uniformly into the slurry with the help of screen roller. The panels are dried at a temperature of 275^{o}C before shifting to storage area or the cutting table. The wall panels can be cut as per dimensions & requirements of the building planned.

It is an integrated composite building system using factory made prefab load bearing cage panels & monolithic cast-in situ RC in filled for walling & floor/roof slab, suitable for low rise to medium rise (single to 10 storeys) building. The panels can be used with confidence as it has the potential for adequate strength, stiffness, ductility and energy dissipating capacity, if suitably designed. Because of higher ductility ratio, this can be used as an efficient structural system.

PREVIOUS STUDIES

COMPARING RAPID WALL PANEL CONSTRUCTION OVER CONVENTIONAL CONSTRUCTION WITH RESPECT TO COST AND TIME OF CONSTRUCTION

KadamSagar.P, DaradeMilind.M[2016] compared about rapid wall panel construction over conventional construction with respect to cost and time of construction. Rapid wall panels are used instead of bricks. Rapid wall panels have undergone testing by Indian authorities and are presently exported to India to satisfy the need for aCost effective, easy to construct and environment-friendly solution to their housing crisis. Rapid wall panels being low cost building materials, and easy to install, fit exactly the current void or demand for houses in India. Apart from being low cost and easy to install, rapid wall panels are also environment friendly, requires less number of labors (a very important factor in any construction project), versatile use, light weight, easy handling, water resistant and fire proof.

The objective of the paper is to make the economical comparison between construction of building using rapid wall panel and conventional method. Time analysis and effect on total construction duration is also mainly considered and have to understand the technology of Rapid Wall construction thoroughly.

Rapid wall panel is world's largest load bearing lightweight panels. This method of construction takes a giant leap towards sustainable living creating a positive effect on environment. It is more affordable housing to low income groups. Use of rapid wall protects the lives of people as these buildings will be resistant to natural disasters like earthquakes, cyclone, fire etc. After detailed study and analyze of building it is observe that rapid wall construction saves 67% in construction time and 27% in construction cost compare with conventional building.

EXPERIMENTAL STUDY ON GLASS FIBER REINFORCED GYPSUM (GFRG) PANELS FILLED WITH ALTERNATE CONCRETE MIX USING SHREDDED THERMOCOL AND PHOSPHOGYPSUM

NithyaNandan A, Renjith R [2016] experimentally investigated about Glass Fiber Reinforced Gypsum Panels filled with alternate Concrete mix using Shredded Thermocol and Phosphogypsum. Glass fiber reinforced gypsum (GFRG) panel is a green product .They are made with modified gypsum plaster and reinforced with cut glass fibers. The panels contain cavities that maybe filled with concrete and rein-forced with steel bars to impart additional strength and provide ductility. Phosphogypsum is a byproduct of fertilizer industries. Thermocol is a type of polystyrene used for packaging.

The effective disposal of phosphogypsum is done by the manufacture of Glass Fiber Reinforced Gypsum (GFRG) panel, also known as Rapid wall. These can be used as load bearing as well as non load bearing structures. Phosphogypsum and shredded thermocol are used as partial replacement of cement and fine aggregates respectively and formulating an alternate light weight mix equivalent in strength to that of M20 grade concrete.

The test was done for all the alternate concrete mixes for determining 7 and 28 day compressive strength. From the results obtained it is observed that the strength decreases with the addition of shredded thermocol. Replacement up to 15% shows strength greater than that of panels filled with M20 grade concrete. The density of the GFRG panels was found to be decreasing with the addition of shredded thermocol.

The optimum combination of phosphogypsum and shredded thermocol which can be used as an alternative to M20 mix which can be filled in GFRG panels was found to be 10% and 15% respectively. The reduction in density of GFRG test specimens filled with alternate mix was about 4.08% when compared to that filled with M20 grade concrete.

LOW COST HOUSING BY USING GFRG PANELS

Sk. Subhan Alisha et al. [2016] found gypsum is a durable material, and it is already heavily in use as partition walls. Experts predict that a building made of GFRG panels can have a life span of 60 years. A GFRG building does not require beams and columns and the material has been approved as green building material by the United Nations Framework Convention on Climate Change (UNFCCC). The panel cavities can be partially or fully filled with reinforced concrete to provide additional strength.

The foundation cost comes to about 10 to 15% of the total building. It is suggested to adopt as arch foundation in ordinary soil for effecting reduction in construction cost up to 40%. The traditional R.C.C. lintels which are costly can be replaced by brick arches for small spans and save construction cost up to 30 to 40% over the traditional method of construction. By adopting rationally designed construction practices like filler slab and precast elements the construction cost of roofing can be reduced by about 20 to 25%. It is observed the construction procedure and techniques are being used for GFRG panels construction, complete cost and estimation of building, relevant procedures used for panel manufacturing, analysis and duration of the every element of building. Here we studied about how to reduce cost by estimating the quantity of materials for different building components, and thereby evaluating the total cost of the project.

STUDY OF GFRG PANEL AND ITS STRENGTHENING

Eldhose M Manjummekudiyil et al. [2015] studied about GFRG Panel strengthening using different concrete mixes filled in the cavities. They used three different concrete mixtures in the panels for testing. The concrete are Nominal mix M25, Flyash concrete and Recycled Aggregate concrete. The main objective of using fly ash in most of the cement concrete applications is to get durable concrete at reduced cost. The addition of fly ash as an additional ingredients at concrete mixing stage as part replacement of OPC and fine aggregates is more flexible method. It allows for maximum utilization of the quality fly ash as an important component (cementatious and as fine aggregates) of concrete. Hence, here 30% of cement is replaced by flyash.

From the results obtained from various tests conducted on GFRG panel, it is clear that the compressive strength gets increased with the inclusion of filler materials. Nominal- M25 mix gave maximum strength when used in panels. Recycled aggregate concrete filler also gave satisfactory strength in compression, and in turn it leads to an economic method of construction. Flyash being a bi-product of fertilizer industry can be effectively used along with the filler material in GFRG Panel.

RAPID AFFORDABLE MASS HOUSING USING GLASS FIBRE REINFORCED GYPSUM (GFRG) PANELS

DevdasMenon [2014] discussed about a demo building constructed in IIT Madras. The building is constructed using GFRG Panels which is made out of gypsum, largely available in form of Phosphogypsum, a waste by product of fertilizer industry and Glass fibre as reinforcing agent which enhances the strength of the panels. The building panels are suitable for affordable mass housing, with the advantages of cost-effectiveness and rapid construction. GFRG panels contain cellular cavities between the outer flanges and the inner ribs, which can conveniently be filled with concrete and reinforced with steel bars, if required, to achieve the desired capacity as load bearing walls. Buildings built using this technology without any columns and beams can go all the way up to 8 to 10 storeys in low to moderate seismic zones, and to lesser height in high seismic zones. The empty cavities in the panels can be used for concealing electrical wiring and other plumbing works. In a typical building, all components, including walls, slabs, staircases, and even parapet walls can be constructed using GFRG.

In order to demonstrate this technology, a two storeyed GFRG demo building was built inside the IIT Madras campus. This building, constructed within a span of 30 days housing a total area of 1981 sq.ft., has 4 flats, two having a carpet area of 269 sq.ft meant for the EWS (economically weaker section), and the other two with 497sq.ft carpet area each meant for the LIG. The saving in cost was almost 35%, when compared to conventional construction.

COST MODEL FOR USING GLASS FIBRE REINFORCED GYPSUM SYSTEM (GFRG)

Mohamed Said MeselhyElsaeed (2016) Studiedabout the GFRG system & design cost model to analyse direct cost for the system during the design phase. The market price for this system is divided into two main aspects; cost & mark-up. The

mark-up aspect is divided into contingency, which is mainly related to risk analysis & it differs with respect to site, owner & project. The other aspect is profit margin, which depends on market status & feasibility study for project. Cost aspect is divided into two phases which are the direct cost & indirect cost. Mark up & indirect cost aspects can't be analysed in this research as they are project oriented aspects. The paper aims to analyse the direct cost aspect for GFRG system & design cost model during the design phase; to achieve optimization level for system. It divided in two parts; theoretical aspect will discuss the building design using Glass Fibre Reinforced Gypsum panels according to design manual, installation manual, and system requirements. Practical aspect concerning cost of Glass Fibre Reinforced Gypsum during operation process, In addition to that, data was gathered from different projects using GFRG system concerning construction cost & installation procedures on site. The direct cost of GFRG system for buildings, assuming that there is three hundred working days per year, eight working hours per day & one GFRG panel is operated in half an hour, and knowing the foot print and built up area for the building.

A REVIEW OF RESEARCH ON BUILDING SYSTEM USING GLASS FIBER REINFORCED GYPSUM WALL PANELS

AishwaryShukla, Mohd. Afaque Khan (2016) researched on wall panel building system. This paper reviews about developments in the field of building systems using glass fiber reinforced gypsum panels. GFRG panels, manufactured in standardized parts or sections ready for rapid assembling and erection as buildings, are ready-made gypsum panels with hollow cavities. This Rapid wall is utilized in residential as well as commercial constructed dwellings. When the hollow cavities of GFRG panels are filled with reinforced self-compacting concrete, the bond between the concrete and the GFRG panels yields another composite. As a result, the structural performance of Rapidwall and the related building systems are more sophisticated than that of other conventional building systems.It also comprises of the study of response of lengthwise or longitudinal reinforcement on periodic or cyclic shear behavior of GFRG panels and its durability.

GFRG panels have meaningful axial and shear strength when cavities of the panel are filled with reinforced concrete and therefore are relevant for construction of multi-story buildings. GFRG panel faces very much alike problem as that of concrete shear walls, i.e., concern regarding the adequate connection between the precast units.

The GFRG hollow cavities are filled with concrete but the bond as if in other conventional building systems is not alike in it. The bond between concrete and GFRG wall surface is neither strong nor reliable. But the beauty is that as long as we put them together and connect them and make them into a unit actually lack of bond is also advantageous because there will be loss of energy. The energy can be dissipated through fraying of surfaces and making the structure a little more flexible. All these things help in earthquake performance of this GFRG building system. Shear failure mode of GFRG walls was completely different from that of reinforced concrete shear walls. As in RC shear walls the shear failure modes were diagonal tension failure, diagonal compression failure, and shear sliding failure whereas in GFRG panels its different due to the separation of the concrete cores by the internal ribs of the GFRG panel. The typical shear failure mode observed was longitudinal shear in the gypsum plaster.

Based on the experimental results a design procedure for the building system has been proposed. The lengthwise reinforcement has no significant effect on shear response of concrete filled GFRG panels. Therefore, panels with starter bars as reinforcement could be used for which shear failure controls the design. Axial load has a similar effect on the shear strength of the walls. As a result, Starter bar is acceptable for GFRG wall building if failure is due to shear strength of the wall. However, this isonly valid for shear prevailing wall panels. They are not valid for the walls with flexural deformations, for which the continuity of reinforcement is substantial.

COMPARATIVE STUDY ON ESTIMATION OF WALL PANEL SYSTEM WITH CONVENTIONAL BUILDING WORKS IN CONSTRUCTION INDUSTRY

K.Kalaipriya, R.Jayanthi (2015) focused on comparison of conventional construction with wall panel system. Building construction is the process of adding structure to real property or construction of buildings. The vast majority of building construction jobs is small renovations, such as addition of a room, or renovation of a bathroom. Glass fiber reinforced gypsum, abbreviated as GFRG (better known as Rapid wall in the industry) is the name given to a new building panel product, made of gypsum plaster, reinforced with glass fibers. Main application is in the construction of walls, it can also be used in floor and roof slabs in combination with reinforced concrete. The present report introduces five construction systems that have been tested on the structural laboratory. And this mean time the financial problems are also the main reason for these different construction systems. So we have to invent low cost construction for avoid the financial problems.

The main part of the project is estimating the building work for a residential house based on the Quotation collected from five different zones for each work. The collection of quotation includes Cost for each Material like Cement, Sand, Aggregate, etc and each activity like Excavation, Centering work, Flooring, Plastering etc. The estimation work is carried out for both wall panel system and conventional building system. The estimation of the building quantities can be carried out by either long wall- short wall method or by centre line method.

The wall along the length of room is considered to be long wall while the wall perpendicular to long wall is said to be short wall is called long wall- short wall method. To get the length of long wall or short wall, calculate first the centre line lengths of individual walls. Then the length of long wall, (out to out) may be calculated after adding half breadth at each end to its centre line length. Thus the length of short wall measured into in and may be found by deducting half breadth from its centre line length at each end. The length of long wall usually decreases from earth work to brick work in super structure while the short wall increases. These lengths are multiplied by breadth and depth to get quantities.

Walls of similar cross sections is knowncentre line method. The total centre line length is multiplied by breadth and depth of respective item to get the total quantity at a time. When cross walls or partitions or verandah walls join with main wall,

the centre line length gets reduced by half of breadth for each junction. Such junction or joints are studied carefully while calculating total centre line length. The estimates prepared by this method are most accurate and quick.

The estimation result provided from the paper is only for a single zone based on the quotation collected. From this they concluded that conventional buildings are more costlier when compare to panel system. The panels has good life span as same as concrete structures. Nowadays the use of panels for construction evolves gradually. But still most of the people are not aware about this type of construction practices for residential buildings.

DEVELOPMENT OF BUILDING SYSTEMS USING GLASS FIBRE REINFORCED GYPSUM (GFRG) PANELS

A Meher Prasad (2013) focused on new building panel product, made of gypsum plaster reinforced with glass fibres. It is also known as Rapid wall in the industry. GFRG is of particular relevance to India, where there is a tremendous need for cost-effective mass-scale affordable housing, and where gypsum is abundantly available as an industrial by-product waste. The product is not only eco-friendly or green, but also resistant to water and fire. The panel contains cavities that may be filled with concrete and reinforced with steel bars to impart additional strength and provide ductility. Experimental studies and research have shown that GFRG panels, suitably filled with reinforced concrete, possess substantial strength to act not only as load-bearing elements, but also as shear walls, capable of resisting lateral loads due to earthquake and wind. It is possible to design such buildings up to ten storeys in low seismic zones (and to lesser height in high seismic zones). However, such construction needs to be properly designed by a qualified structural engineer. The design capacities are based on limit states design procedures, considering the ultimate limit state for strength design. It should also satisfy serviceability requirements. The GFRG wall panels behave as structural walls (shear walls). Hence, it is necessary to understand the performance of GFRG wall panels in terms of strength, stiffness, ductility and energy dissipating capacity. The performance parameters are captured in terms of elastic shear stiffness andductility of a GFRG wall assembly when subjected to quasi-static cyclic (reversed)lateral load. The 'ductility factor' (under monotonic lateral loading) value for GFRGwall panels is found to vary between 7 and 10, whereas the 'ductility ratio' (undercyclic lateral loading) is found to vary between 4.6 and 10. The wall panels filled with reinforced concrete(RC) possess considerable ductility and energy dissipating capacities.

Panels that have higher reinforcement exhibit shear-dominant behavior, while those having lesser reinforcement exhibits flexure-dominant behavior. The GFRG wall panels showed continued increase in energy dissipation despite substantial reduction in the lateral load capacity in the post-peak region, indicating gradual failure. The panels can also be used with confidence as it has the potential for adequate strength, stiffness, ductility and energy dissipating capacity, if suitably designed. Because of higher ductility ratio, this can be used as an efficient structural system.

STUDIES ON THE BEHAVIOR OF GLASS FIBER REINFORCEDGYPSUM WALL PANELS

MagantiJanardhana et al. (2004) studied about behavior of Glass Fiber Reinforced Gypsum wall panels. In a high seismic intensity zone, resistance of buildings to earthquakes is often ensured by adopting structural systems where seismic actions are assigned to structural walls (shear walls), designed for horizontal forces and gravity loads while columns and beams are designed only for gravity loads. Structural walls provide a nearly optimum means of achieving the important objectives, viz., strength, stiffness and ductility. Buildings braced by structural walls are invariably stiffer than framed structures, reducing the possibility of excessive deformations under small earthquakes. The necessary strength to avoid structural damage under moderate earthquakes can be achieved by properly detailed longitudinal and transverse reinforcement. There are two types of shear failure modes in a building constructed with GFRG walls. The first mode is the shear failure of the panel itself, and the second is shear sliding at the interface of a wall and the floor slab. The continuity of longitudinal reinforcement at the horizontal joint may affect the shear strength of both the failure modes.

Axial load carrying capacity of unfilled GFRG wall panels, of various widths when subjected to eccentric loads, is estimated using numerical analysis. The lateral load carrying capacity of panels is also estimated. A simplified procedure has been suggested for assessing in-plane flexural strength of concrete filled wall panels. For a given force demand, reinforcement required for a concrete filled GFRG wall panels can be obtained using interaction diagram that has been developed. Using simple approach, the capacity of unfilled panels under shear load is estimated. It is also established by comparing the results of finite element buckling analysis with the available experimental results, that failure of the GFRG wall panel does not occur due to buckling, on account of in-plane axial and shear loads, as the critical loads are much higher than the actual capacities.

SUMMARY AND CONCLUSION

This paper has introduced GFRG panels and its structural performance. All the experimental and theoretical values set in motion by the authors since 2016 have been bestowed from the structural elements and overall building point of view. The accurate calculations of the tests were not possible due to the relative movement between the concrete cores and GFRG wall surface. Based on the experimental results a design procedure for the building system has been proposed. Thus, rapid wall construction is more economical. Rapid wall Panel provides a new method of building construction in fast track. Using rapid wall construction we can reduce man power, cost and time of construction. The use of natural resources which are now day not easily available like river sand, water and agricultural land is reduced. It reduces adverse effects on environment. The building constructed using RW panel comes under Green building categories as after constructing it energy requirement for heat insulation, sound insulation, humidity and Temperature inside is less than conventional building. It is very effective technology to beat the current rising cost of construction. And the most important, this new technology is having potential to provide shelter to the "Homeless Indians".

REFERENCES

[1] AishwaryShukla, Mohd. Afaque Khan, Abhishek Kumar (2016) "A Review of Research on Building System Using Glass Fiber Reinforced Gypsum Wall Panels" International Research Journal of Engineering and Technology (IRJET).
[2] DevdasMenon, A Meher Prasad (2013) "Development of Building Systems using Glass Fibre Reinforced Gypsum (GFRG) Panels" The masterbuilder.
[3] DevdasMenon (2014) "Rapid Affordable Mass Housing using Glass Fibre Reinforced Gypsum (GFRG) Panels"International Journal of Scientific & Engineering Research.
[4] Eldhose M Manjummekudiyil, Basil P Alias, Biji K Eldhose, SarathRajan, ThasneemHussain (2015) " Study of GFRG panel and its Strengthening" International Journal of Civil and Structural Engineering Research.
[5] KadamSagar.P, DaradeMilind.M (2016) "Comparing Rapid Wall Panel Construction over Conventional Construction with Respect to Cost and Time of Construction" International Journal on Recent and Innovation Trends in Computing and Communication.
[6] K.Kalaipriya, R.Jayanthi (2015) "Comparative Study On Estimation Of Wall Panel System With Conventional Building Works In Construction Industry"International Journal of Science and Engineering Research (IJ0SER).
[7] MagantiJanardhana, A. Meher Prasad and DevdasMenon (2004) "Studies on the Behavior of Glass Fiber Reinforced Gypsum Wall Panels" Indian Institute of Technology Madras.
[8] Mohamed Said MeselhyElsaeed (2016) "Cost Model for using Glass Fibre Reinforced Gypsum System (GFRG)"International Journal of Development and Economic Sustainability.
[9] NithyaNandan A, Renjith R (2016) "Experimental Study on Glass Fiber Reinforced Gypsum (GFRG) Panels Filled with Alternate Concrete Mix Using Shredded Thermocol and Phosphogypsum" International Journal of Scientific & Engineering Research.
[10] Sk. Subhan Alisha, Sajja. Neeraja, Sk. Akber, G. SaiManoj (2016) "Low Cost Housing by Using GFRG Panels"International Journal of Scientific Research in Science, Engineering and Technology.