

GREEN, AFORDABLE & RAPID HOUSING USING GYPWALL

- Latest Trend in building Technology

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The Development and growth of our communities, has adversely affected the quality of environment and has become a major threat to a sustainable society. Rapid industrialisation poses environmental issues, in terms of air, water pollution and land degradation .For a sustainable socio-economic system, sustainable environment is a prerequisite. The major challenge here is: how to ensure development in a sustainable manner by achieving a trade off between environment and development.

In India around 11 million tonnes of by-product gypsum are annually. The average consumption of by product gypsum is only half the quantity produced. Hence the pile up of phosphogypsum may end up as a threat to the environment.

Utilisation of Phosphogypsum as building material will clean the environment and transform the society by way of green ,affordable and rapid housing . Glass Fibre Reinforced Gypsum (GFRG) building technology reduces carbon foot print , save natural resources and completely green . This technology has many advantages like Light weight, Crack free, Termite/fire Resistant, Time saving and flexible in all aspects of home plan designs.

In an attempt to bring new construction system for mass housing, Building Material and Technology Promotion Council (BMTPC ,Under the ministry of Urban Development ,Govt: of India) has identified and evaluated GFRG technology as a building system which can help in providing safe, strong and quality housing in quick time.

In India housing using GFRG wall panel has crossed 20lakh Sft and it is helping to build a better society with affordable and rapid housing .

Key words:

GFRG : Glass Fibre Reinforced Gypsum

BMTPC: Building Material & Technology promotion council of India

IIT : Indian Institute of Technology

A.1 INTRODUCTION

The building sector accounts for about 40% of Co2 emissions. As per the estimate by the ministry of Urban development, the total housing shortage in Urban India alone is 20 million. These figures give an approximate affect on the carbon footprint by the construction industry alone. During the process of building dwelling houses, the

scarce raw materials available in the environment get depleted. So it is essential to find building materials which are green and adopt a green building methodology to protect the environment.

GFRG wall panels are completely green and help to save the rare natural resources. Technology was adapted with suitable modifications and improvements to manufacture GFRG wall panels from PhosphoGypsum. Building Material Technology promotion council (BMTPC) of India (under the ministry of Urban Development and poverty alleviation, Gov: Of India) has certified the product and extensive research is conducted at Indian Institute Of Technology (IIT), Madras.

A.2 GYPSUM

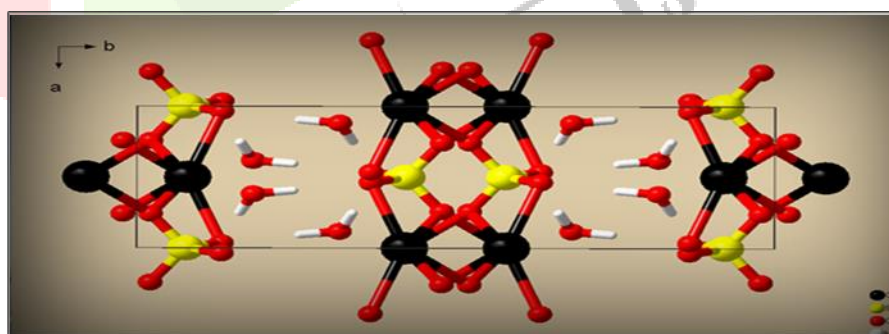
Gypsum consists of layers of calcium atoms and sulphate groups separated by sheets of water molecules. The effect of heating the mineral and setting the decomposition product by adding water has been known for thousands of years.

PhosphoGypsum is a by-product in the manufacture of phosphoric acid from rock phosphate by extraction with sulphuric acid. For every ton of phosphoric acid made, from the reaction of phosphate rock with sulphuric acid, about 5 tons of phosphogypsum are generated. The amount of phosphogypsum being generated each year is directly proportional to the industrial production of P_2O_5 . It is proved that phosphogypsum can be used in the manufacture of building products and in India there is a huge shortage of dwelling houses.

A.3 PROPERTIES OF GYPSUM

Gypsum has a monoclinic crystal structure with a hardness of 1.6-2.2 on the Mohr scale and it is a natural insulator due to its low thermal conductivity. It is a good fire retarder because of its non-combustible property and stop the chances of spreading fire which ensure life safety. The hydration of hemihydrates can be achieved by increasing nucleation by seeding action. During hydration of hemihydrates calcium sulphate, Gypsum crystallisation takes place and develops strength.

Gypsum is one of the first known binders of mankind. The oldest evidence of its presence is dated to 9000 BC even though the construction using plaster became publically known from the eighteen century only. The rate of movement of calcium and sulphate ions in the lattice can be modified when the Gypsum plaster is finely ground.



The particle size distribution of the Gypsum plaster helps in lower porosity and aid smoother finish. The porosity increases with water content as it was generated due to the evaporation of water from calcium sulphate dihydrate. The property of faster setting will aid Gypsum as a good building material by reducing the production life cycle.

The plaster properties may vary depending on the source and type of Gypsum.

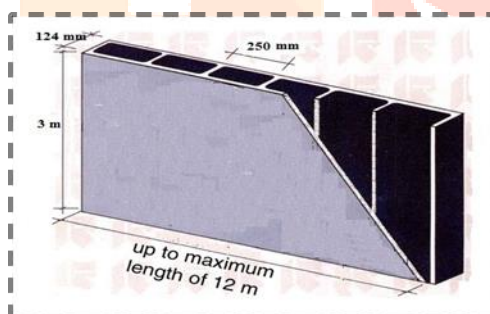
| PARTICLE SIZE DISTRIBUTION | | | |
|----------------------------|------|---|--|
| Sl No: | size | Plaster from PhosphoGypsum (% by weight) | Ground Plaster from PhosphoGypsum (% by weight) |

| | | | |
|---|-----------------|-------|-------|
| 1 | 2mm | 2.18 | 0.654 |
| 2 | 300micron | 4.05 | 0.581 |
| 3 | 212micron | 0.69 | 0.153 |
| 4 | 150micron | 1.35 | 0.571 |
| 5 | 106micron | 42.93 | 2.320 |
| 6 | 90micron | 25.94 | 2.880 |
| 7 | 75micron | 11.44 | 5.571 |
| 8 | Below 63 micron | 11.42 | 87.27 |

A.4 GLASS FIBRE REINFORCED GYPSUM WALL PANEL (GFRG)

When Gypsum is heated under normal atmospheric conditions between 40 & 200C, it loses some of its combined water and recrystallises to a rombohedral shaped crystal to form Beta Gypsum plaster .This Beta Gypsum plaster is used for manufacturing load bearing Glass Fibre reinforced Gypsum (GFRG) wall panels . The wall panels are cellular in form and produced on a flat bed table to a size of 12mx3mx124mm.

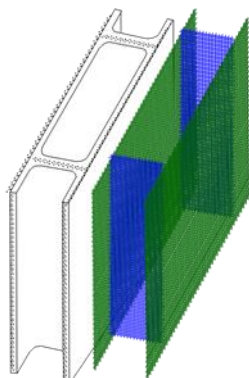
Gypwall is light weight when compared with brick or concrete .GFRG panel walling system serves as both internal and external wall and eliminates the need for bricks and reduces the consumption of cement ,steel ,sand and water .



Presently this material is widely accepted and constructions are going on throughout India

A.5 REINFORCEMENT WITH GLASS FIBRE

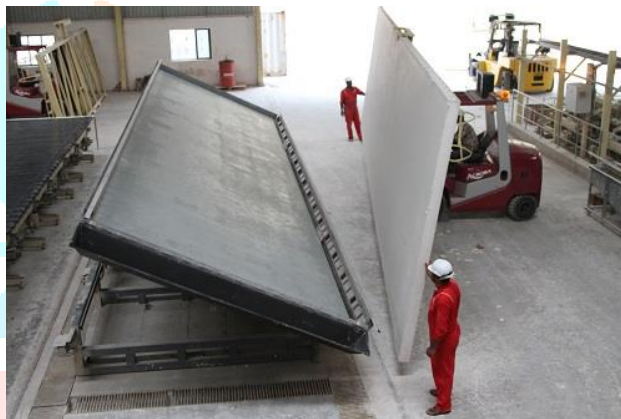
Gypsum plaster is strong in compression but weak in tensile properties. Glass fibres are used to reinforce the Gypsum plaster matrix and produce a strong composite material having improved tensile and impact properties.



The properties of glass fibre like linear weight of roving, filament diameter and tensile strength need to be strictly adhered. In order to achieve the strength glass fibres need to be uniformly dispersed in the matrix to form a composite material with high degree of stress distribution by fibres. This will also give improved resistance to micro cracking and crack progression.

A.6. MANUFACTURING PROCESS

For the production / manufacture of Gypwall building panels, main raw material is the calcined gypsum (hemihydrate) called gypsum plaster. The gypsum is calcined in a fluidised bed calciner for uniform product quality. Required quantity of water, water resistant emulsions and retarder are mixed with plaster to produce slurry of required viscosity. By mixing water into the calcined gypsum it re-converts and forms an efficient building material and which is reinforced by micro-strand glass rovings. The slurry is poured into casting tables to produce the panels. Micro-strand glass rovings are provided into the inner and outer flanges and inter connecting webs through an auto-computer controlled mechanical process supported by technicians and skilled factory workers.



Gypwall building panels are made through casting process in which the Gypwall ingredients set itself to form large building panel. A unique design of Core pullers and plugs are monitored through computer network to provide cavities. After casting the Gypwall panel, it is lifted up and dried using the latest state-of-the-art drying system.

A.7. ADVANTAGES OF GYPWALL

Prefab Gypwall is a Greener product made from Gypsum and it has many advantages like Light weight, Crack free, Termite/fire Resistant, Time saving and flexible in all aspects of home plan designs. In an attempt to bring new construction system for mass housing, BMTPC has identified and evaluated our technology as a building system which can help in providing safe, strong and quality housing in quick time. FRBL Wall Plaster reduces plastering/finishing time by 60%, improves durability and provides a level surface like putty finish with crack/shrinkage free wall/ceilings. GYPWALL comes under Green building concept and aid in faster construction. This is the best solution to provide affordable houses to the masses for the betterment of the society.

A.8 PROCESS MODELLING

Gypsum plaster when mixed with sufficient water it recrystallises to form gypsum. This property of the plaster is utilised in the manufacture of plaster boards and Gypwall (GFRG). The strength of Gypwall (GFRG) depends on the setting properties of gypsum plaster and the material used as reinforcement. When gypsum plaster sets it forms

an interlocking mass of gypsum crystals that exhibit high strength and hardness. The setting property of gypsum plaster depends on various factors.

Generally casting wall panels is carried out using natural Gypsum . In the world itself conversion of phosphor Gypsum to wall panels is not so common. The properties of PhosphoGypsum depend on the rock source and the process . In the case of Phospho gypsum the free water content is generally on the higher side . Hence experimental data pertaining to a particular source of PhosphoGypsum along with its mathematical modeling is essential for understanding plaster properties and transforming it to a building product..

| Slno : | Type of Gypsum | Combine d water (%) | Water to plaster ratio(%) | Retarding agent(%) | Slurry Temperature (c) | Knife set(m) | Initial Gilmore(m) | Final Gilmore(m) |
|--------|----------------|---------------------|---------------------------|--------------------|--------------------------|--------------|--------------------|------------------|
| 1 | Phospho Gypsum | 5.0 | 58 | 0.07 | 33 | 22 | 36 | 44 |
| 2 | Phospho Gypsum | 5.6 | 62 | 0.23 | 35 | 19 | 32 | 38 |
| 3 | Phospho Gypsum | 5.9 | 62.5 | 0.27 | 35 | 21 | 35 | 41 |

The particle size varies with source. Phosphogypsum has a tendency of forming lumps depending on the age of the stock pile. The Gypsum need to be firmly ground dried and screened for better fluidization properties. Uniform mobility of the gypsum particle shall be ensured through equipments.

Higher water content tend the particulate to get adhered to the surface which shall be avoided. The PhosphoGypsum feed bin shall be accommodated with a vibrating and a breaker mechanism to ensure uniform flow of particles . Conveying methods need to be designed wider to aid mobility and the quantity fed shall be regulated with adjustable openings.



During calcinations of phosphogypsum , proper controlling of temperature profiles inside the equipment is very important to get a uniform plaster . The combined water range of the calcined plaster is very important for nuclei formation and to develop binding properties. The study on plaster properties will help to fix the water content for various seasons . E glass fibers are used to reinforce gypsum plaster matrix to improve tensile and impact properties .Glass fibers need to be uniformly dispersed in the matrix to form a homogeneous mixture which ensures a high degree of stress distribution by the fibers and give improved resistance to micro cracking and crack propagation .

The continuous research work on the available PhosphoGypsum will only help to fix the setting time without any loss of workability and strength .It is very important to set the right water /plaster ratio for ensuring proper bonding of plaster and fiber .

A.9 STRENGTH OF GYPSUM WALL PANEL

Gypsum is widely used as a binding material as it quickly sets and hardens. The Egyptians were the first to use the gypsum as the building material. The set plaster strength depends on the size, amount of water used, impurities present, degree of interlocking and bonding of gypsum crystals. Mixing time, temperature, speed & efficiency are very important factors in achieving maximum strength. Other requirements include good impregnation and coating of the fibres with slurry, uniform dispersion of fibres and reasonable compaction to achieve a dense material.

| Slno: | Mechanical Property | Nominal value | unit |
|-------|---------------------------------------|---------------|-------------------|
| 1 | Unit Weight | 49 | Kg/m ² |
| 2 | Compressive strength | 160 | Kn/m |
| 3 | Moment capacity ,Rib parallel to span | 2.1 | kNm/m |

Particle size distribution affects the water demand there by influencing the nature of recrystallising gypsum matrix. The factors effecting the disintegration of gypsum include the type, calcinations method, impurities present, aging and mixing.

The water repellency can be increased by adding additives or by means of membrane coatings.

A.10 GFRG METHODOLOGY

Glass fibre reinforced Gypsum (GFRG) wall panel is energy efficient, load bearing and have high compressive and flexural strength. It has very high level of fire resistance, Thermal resistance, Termite proof and earthquake resistance. Instead of Brick by Brick construction, Gypsum panel enables wall by wall construction leading to considerable savings in Bricks, steel, cement, river sand and construction time. The modular cavities in combination with concrete form a composite material by which the strength increases many folds. The Buildings designed with wall panels can resist natural disasters like earth quakes and cyclones.



The wall panels which are of size 12mx3mx124mm weigh around 1.8 tons only. Meanwhile the standard brick wall of 23cm thick weighs around 19 tons. The construction methodology helps to reduce the construction time by 50 % and cost by 20%.

A.11 AFFORDABLE HOUSING

In India construction using GFRG wall panels has crossed 20lakh Sft. GFRG construction methodology is faster than conventional methods and can adopt any type of plans and designs. Traditional Building products is around for a very long time but there are serious concerns about the impacts of these products on the environment. Hence it is time to think above the traditional building products so that the people and the whole world are benefitted.



GFRG building technology is completely green and help to save the rare natural resources and reduces carbon footprint. This concept uses load bearing design technology and it is gaining acceptance in India which can provide affordable houses in a reasonable time frame.

A.12 CONCLUSION

It is essential to find building materials which are green and adopt a green building methodology to protect the environment.

Green building materials and fast construction methods are the only solution to provide affordable mass housing in India by protecting the environment. BMTPC has identified GFRG technology as one of the potential technologies for providing safe, strong and quality housing in quick time.

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SAJO FRANCIS is **BTech (Hons)** in CHEMICAL ENGINEERING from Govt: Engineering College ,Trichur,INDIA . Has MBA (*Marketing*) and took **MTech** from Cochin University of Science & Technology (CUSAT) . Has 27 years experience in Fertiliser, Refinery and petrochemical plants. Had the opportunity for Optimisation / modernisation of the panel process and conduct various studies /modelling on Gypsum plaster properties for 9 years. Presented technical papers in International/ National conferences and various study reports were published in technical journals. A member of Indian Institute Of Chemical engineers (IICHE)and former vice chairman of Kochi Chapter.