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Rapid wall as an alternative building material with low carbon footprint

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ABSTRACT

The implementation of prefabricated building methodologies and adoption of alternate building materials is increasing followed in modern construction industry owing to numerous reasons. Foremost purpose being may be due to cost effectiveness and environmental sustainability. Glass Fibre Reinforced Gypsum (GFRG) Panel known as Rapid walls one such load bearing prefabricated walling system of low cost that finds application in different types of buildings. It is cent percent recyclable and being resistant to water, heat, rot and termite. Today, it is the least energy embodied building product around the globe and is eligible for Carbon Credits. The panels originally developed in Australia in 1990 and in India by IIT Madras. At present country like India has a stock pile of 31 million tonnes of Phospho Gypsum with which 5 million 30 m^2 of Rapid wall homes could be developed.

KEY WORDS: Rapid wall, GFRG panels, Alternate building materials, Carbon Credits, Environmental sustainability.

1. INTROUDCTION

The building construction industry in India is undergoing changes with every passing days in terms of demand, supply, and technology as also environmental sustainability. The demand for construction of houses at a faster pace and lesser cost is currently most sought after. The houses thus built should also sustain the impacts of natural disasters like earthquake, cyclone, high tides, fire etc. which is becoming more common than ever before. The planning, designing and development of such houses often makes it expensive and unaffordable for the common masses. There is also the threat of climate change being triggered by the growth of greenhouse gases in the atmosphere which a global concern. The important construction materials used for the construction of various structures till date are cement, steel, sand, stone, concrete, RCC, bricks, timber, plastics, polymers etc. The conventional method of construction with these materials produce large quantity of CO_2 (about 40%) as an outcome of embodied energy consumption for cooling and heating of indoor environment and hence increases the global warming. Therefore, a staunch necessity for an efficient and substitute building material which could be available at affordable cost to build safer houses and buildings without producing terrible effect on the environment. The buildings should be able to sustain natural disasters like tsunami and protect humans and there assets. In contrast, the growth in agricultural and industrial activities has led to the disposal of huge quantities of wastes and bye products like flyash from power generation by burning pulverized coal, blast furnace slag from steel and iron industry, non-ferrous metal smelters, slate and marble waste, alumina red mud, etc. Lime sludge, phosphogypsum, mine tailings and red mud are the next category of waste after blast furnace slag and flyash, available in substantial quantities. Disposal of phosphogypsum creates an enormous techno-economic problem and huge area required for its dumping. Hence by using Gypsum as a building material, challenges in dumping of waste can be solved in ecologically-friendly manner. Presently, there is an efficient, ecologically-friendly alternative building material available at cheap cost which has many advantages and benefits. Rapid wall technology was developed in Australia in 1990's. The technology includes developing large size load bearing panels which can be utilized for roofing and walling purposes. Glass Fibre Reinforced Gypsum (GFRG) known as Rapid wall panel is an energy efficient building material with enormous potential for use as load bearing and non-load bearing wall panels in buildings. It has modular cavities fit for both internal and external walls. This could also be used as intermediary floor slab/roof slab in conjunction with RCC as a composite material. The concrete infill with vertical reinforcement rods will increase its vertical and lateral load be raring competencies. Rapid wall technology, from its introduction has been used for buildings varies from single storey to multi-storey buildings. The light weighted Rapid wall has high compressive strength, ductility, shearing strength, flexural strength. It has extremely large resistance to fire, water, heat, rot and corrosion as well as earthquakes and cyclones.

2. MATERIAL AND MEHODS

Rapid wall panels are made from Gypsum, Glass Rowing and special chemicals using Australian technology. The panels are 12m long, 2.85m high and 0.124m thick. Tensile strength of single filament glass roving is 3100-3800 Mpa, which is much higher than that of steel used for concrete reinforcement having maximumof500 Mpa. The glass roving elastic modulus is 76-78 Gpa. This provide very high load bearing capability to the panel making into a composite building material.

Figure.1. Rapid wall Panels reinforced with glass roving

There are 48 modular cavities of size 230mmx94mmx3m present for each panel. The weight of each panel is 40 kg/m^2 or 1440 kg. And its density is 1.14g/cm^3 being only 10-12% weight of the brick/concrete masonry. A model Rapid wall panel is presented in Fig.1.The physical and material properties of panels are as shown in Table.1.

Table.1. Physical and material properties of Rapid wall Panel

Weight- light weight	40 Kg/ sqm
Axial load capacity	160 kN/m {16 tons/ m}
Compressive strength	73.2 Kg/cm^2
Unit Shear strength	50.90 kN/m
Flexural strength	21.25 kg/cm^2
Tensile Strength	35 KN/ m
Ductility	4
Fire resistance	4 hr rating withstood 700-1000° C
Thermal Resistance R	0.36 K/W
"U "Value	2.85W/M2K
Thermal conductivity	0.617
Elastic Modulus	3000-6000Mpa
Sound transmission{STC}	40
Water absorption	< 5%

The strength capabilities of Rapid wall for both vertical and laterally can be increased many times by infill of concrete after placing reinforcement rods vertically. According to the structural requirement, cavities of wall panel could be filled in different combinations.

Some Case Studies: Rapid wall is being used magnificently for the construction of different types of buildings including buildings up to 10 storeys high. A few projects mentioned below are successfully executed in India.

Figure.2. Rapid wall 2 storeyed Residential building at Manipal

A two storeyed building constructed for residential purpose in 2013 in Manipal (Fig.2). It has 5 bedrooms and parking provided in the ground floor. The wall panel erection was completed in 30 days. It is given an elegant look outside by the usage of dark, rough texture of exposed brick masonry.

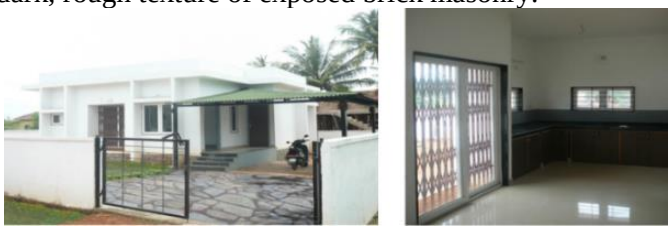

Figure.3. Rapid wall Residential building at Mumbai

This project for CF Mumbai Plan (Fig.3) was the earliest building to be constructed using GFRG Panels in India and so, received ample attention and recognition by the press, several organizations including the public. It paved the way to the several Rapid wall constructions in Karnataka in the years after.

Figure.4. Rapid wall Courtyard Home in Vellore

Courtyard home: A sustainable home amidst nature built for the director of Christian Medical College, Dr Prathap Tharyan, in Vellore (Fig.4). This beautiful courtyard home of 2300 ft^2 in area was constructed in record time of 90 days. The site in Vellore was surrounded by hills and the design marries traditional Indian vernacular architecture and modern design. The emphasis of the planning was on large and open living spaces which encourages a communal living.

3. RESULTS AND DISCUSSIONS

The numerous projects that are studied reveal the cost effectiveness and speedy construction with the usage of rapid wall. Further investigation on completed projects with rapid wall divulge the saving in percentage for different materials and items over that of conventional building construction is presented in Table.2.

Table.2. Comparison of Rapid wall vs conventional building

Materials/ items	Rapid wall Building	Conventional Building	Saving in %
Cement	16 tons	32.55 tons	50.8
Steel	1800 kg	2779 kg	35.2
River sand	20 cum	83.37 cum	76
Granite metal	38 cum	52.46 cum	27.56
Bricks	-	57200	
GFRG Panel	500sqm	-	
Water	50000 ltr	200000ltr	75
Built Area	143 sqm	154.45sqm	8
Labour	389 man days	1200 man days	67.59
Construction Time	21 days	120 days	82
Total Weight of superstructure	170 tons	490 tons	65
Construction Cost	Rs 13.25 lakhs	18.27 lakhs	27.47
Embodied energy in kWh	82921	215400	61.5

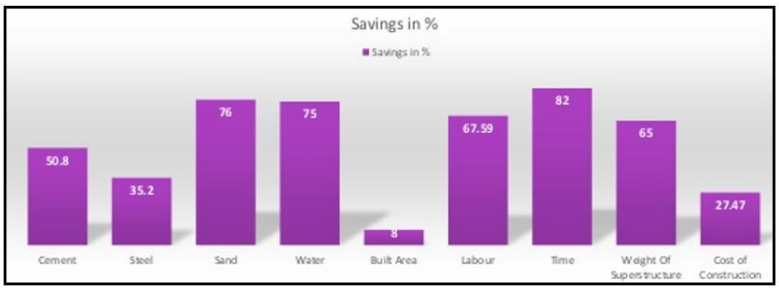

Figure.5. Histogram showing the comparative savings between rapid wall and conventional construction

The histogram given in Fig. 5 reveals a massive savings in materials, time, weight and cost due to Rapid wall adoption are as follows: cement (50.80%), steel (35.20%), sand (76%), water (75%), built area (8%), labour (67.59%), time (82%), weight of super structure (65%) and construction cost (27.47%).

The estimated population of 1,400 billion in India by 2026 and the estimated shortage of housing will be of 90 million. As per the records for every million bricks production needs 5.6 megawatts of energy and 310 tonnes of CO_2 is emitted and 0.8 hectares of agrarian land is destroyed in addition to depletion of huge reserves of sand, minerals and water. For 90 million people require an average of 22.50 million dwelling unit if 4 members occupying one unit. For an average dwelling unit 25 cum brick work required, total quantity of brickwork will be 562.50 million cum and the estimated number of bricks will be 281.25 billion. As per the above data, for producing 281.25 billion bricks it requires 1575 gega watts of energy, emits 87.189 trillion tonnes of CO_2 and effects 225 Thousand hectares of agriculture land

4. CONCLUSIONS

It is apparent from the above discussions that in the construction with use of Rapid wall, waste is used as a resource, making it very economical and environmentally sustainable. The construction is very fast which has

transformed brick by brick construction into wall by wall construction. Since it is Green alternative technology, the buildings are environment friendly and fire resistant. And very less labour force is required in the building construction process. The overall weight of structure is very less. More carpet area is available for the same built up area. There is no need of plastering, thus further reducing the cost in finishing.

However, Rapid wall construction experience reveals that at the project site certain points should be ensured before commencement of the project. These are-availability of Crane in the nearby area, power and water, terrain conditions and SBC (soil bearing capacity) of soil, all weather access to site, roads for delivery of trucks and crane. The attention should also be paid to ensure any obstructions to installation that might be present in the area, overhead power or communication, overburden and site buildings, underground and cables works, trees and overhanging branch etc. Aforesaid things being ensured, the construction with this alternative material of GFRG panel can prove to be economic and can gain further popularity among the general population in India.

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