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COST, SCHEDULE AND SUSTAINABILITY COMPARISON BETWEEN A TRADITIONAL AND GFRG BASED BUILDING

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Abstract - *Glass fiber reinforced gypsum (GFRG) walls are prefabricated large gypsum panels with hollow cores. The underlying focus of this paper is to analyse the two different methods of construction technique the above mentioned GFRG panel based construction method and the traditional method of construction (using concrete). An observable difference in the method of GFRG construction practiced in Kerala and that in Tamil Nadu (1st building IIT Chennai) was clearly visible .By taking this knowledge into consideration estimates and work packages are calculated for both GFRG and traditional method of construction of a building. A comparison of the various building parameters such as cost, time and carbon emissions show interesting results which can be useful.*

Key Words: GFRG Panels, cost estimation, schedule, embodied carbon emissions.

1. INTRODUCTION

GFRG panels has its origins in Australia where it was introduced in the year 1990, this form of construction was introduced in India by IIT Madras in 2015 when its guest house was constructed using this building material. In India these panels are manufactured under the name Rapidwall panels. These panels are 12 meters long, 3 meters high and 124mm thick. Each panel has 48 cavities of sizes 230mm x 94mm.[1]

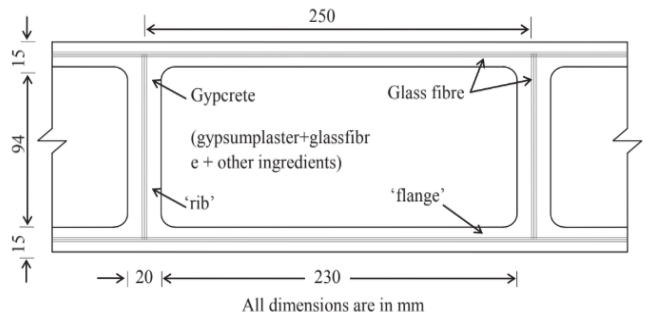

Fig-1: Dimensions of cavities in GFRG panels

The properties of GFRG panel are given below[2]:-

Property	Value
Unit Weight	44g/m^2
Uniaxial compressive strength	7500N/mm^2
Modulus of elasticity	160kN/m
Ultimate shear strength	21.6KN/m

Table 1:- Properties of GFRG Panels

2. OBJECTIVE

1. To explore GFRG based construction and equivalent traditional building construction in the field and from the literature and choose parameters to study for comparison.
2. Prepare WBS/estimate and construction procedures to tabulate cost, schedule and sustainability parameters during the stages of construction for both type of buildings.

3. SCOPE

1. Only single storied buildings of approximately 2000 sq ft are considered for evaluation.
2. Features of buildings commonly found in Kerala are considered for evaluation.
3. Estimation of cost and schedule is done on the basis of construction procedures commonly used by engineers in Kerala.

4. CASE STUDIES

4.1 Case study 1

Location:- Chalakudy
The foundation of this building was constructed similar to a conventional building with random rubble masonry. The panels were placed over a plinth beam constructed over this foundation with starter bars for reinforcements for GFRG panels. All cavities in the panels were filled with M-20 concrete.

The roof was also made of GFRG panels and had embedded beams with triangular reinforcements. The beams in the roof were placed after cutting one in every three cavities. After placing of reinforcements a 50mm thick layer of screed was placed on the roof with a weld mesh embedded inside it.
The construction of the building was completed in 8 months despite delays due to transportation and rainfall.
The cost of the first finish of the project was 1100 Rs. Per square feet.

Fig 2:- Building at Chalakudy, Kerala

4.2 Case Study 2:-

Location: - Mulanthuruthy, Kerala
The construction of the building is similar to that of the building in Chalakudy as its foundation is similar to that of a conventional random rubble foundation with a plinth beam casted on top of it. But however in this building the sunshades and staircase were also made with GFRG panels.

The panels too were erected similar to that of the former case study with all cavities filled with concrete and one out of three cavities in the roof having embedded beams in it.
A coat of WDT 30 was applied on the walls for waterproofing.
The construction of the building was completed within 6 months and cost of construction was 1750 Rs. Per square feet.

Fig 3:- Building at Mulanthuruthy, Kerala

4.3 Case Study 3:-

Location:- Chelad
The foundation was similar to that of a conventional building but however the depth of the foundation was 1.5 meters on average due to the nature of the soil in that region.
The GFRG panels of the entire building was erected in a day with a lifting crane and lifting jaws and a work force of 7 people. This was done to reduce the cost incurred on hiring the crane.
Unlike the former examples the roof of this building was not made of GFRG panels, instead it was made of concrete like a traditional building two columns were erected before casting of the roofs.
Total plinth area of the house is 2500 square feet and the total cost of construction is estimated to be about Rs. 50 lakh

Fig 4:- Building at Chelad, Kerala

4.4 Case Study 4:-

Location:- Aluva, Kerala

Just like the other examples on the list the foundation of this house is also done using random rubble masonry and a plinth beam with starter bars was casted on it.

Erection of GFRG panels was completed in a day and with a workforce of 7 people, and the roof was made of concrete just like the building at chelad mentioned above.

Unlike the other examples given above this building is a two storeyed house and efforts were made by the designing team to make the house more aesthetically pleasing.

Fig 5:- CAD drawing of the Building in Aluva, Kerala

4.5 Case study 5:-

Location:- Taramani guest house, IIT Madras, Chennai, Tamil Nadu

This was the first GFRG building constructed in India. It is a two storeyed house with walls, roofs and staircases made of GFRG panels.

The total built up area of the house was 1981 sq ft. and the total cost of construction was 23 lakh Rs. and time of the construction of the sub structure was 30 days.

Fig 6: Taramani guest house at IIT Madras

5. COST ESTIMATION OF SIMILAR GFRG AND TRADITIONAL BUILDING

For cost estimation the plan of building at chelad was considered but however the roof of the building was assumed to be made of GFRG unlike the roof actual structure which was made of concrete and steel, the sunshades and the slabs above sitout were assumed to be made of concrete just like the actual structure.

Based on this information a similar plan of a house was made except that the walls of the structure was made of brick and roof was made of concrete (i.e. Traditional Building). The plan of the similar building was made assuming both the buildings had the same center line, hence the carpet area of both houses are different. In this case the carpet area of the GFRG building is 221.75m^2 whereas the carpet area of the considered traditional building is 200.16m^2.

The foundations of both plans were assumed to be the same that is (footing of 1:4:8 concrete, RR Masonry of 60cmx60cm and basement of 45cmx60cm). Similarly the cost and time for activities such as plumbing, electrical works, casting of columns, beams, sunshades and lintels were assumed to be almost same in both cases. Hence major difference in terms of cost and time of construction of GFRG and Traditional Building lies in roofing, erection of panels and Staircases.

For GFRG Building one out of three panels were assumed to be filled with concrete with minimum reinforcements and other panels were filled with quarry dust mixed with 5% of cement. Also the cost and time of plumbing and electrical activities were directly entered without analysis on the basis of the information provided by the engineer.

Cost estimation of traditional was done using DAR Vol. 1 and DAR Vol. 2 Whereas cost estimation of GFRG Building was done Using DAR Vol1, DAR Vol. 2[5] and "Schedule of Items and Rate analysis for GFRG Construction" by BMTPC, New Delhi.[6]

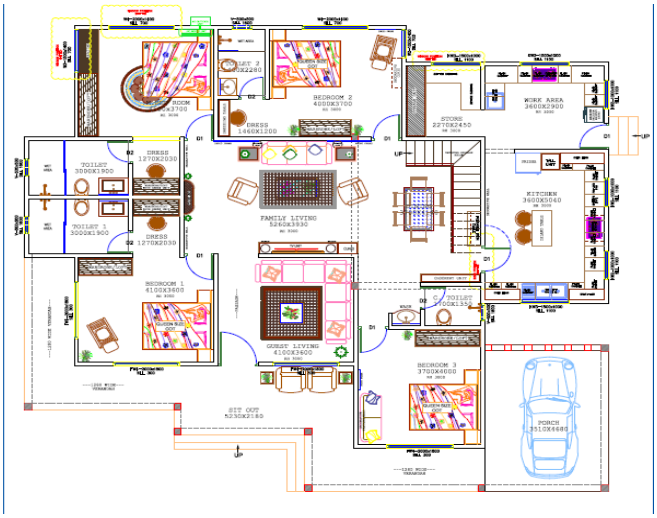

Fig 7:- Plan of the GFRG Building at Chelad

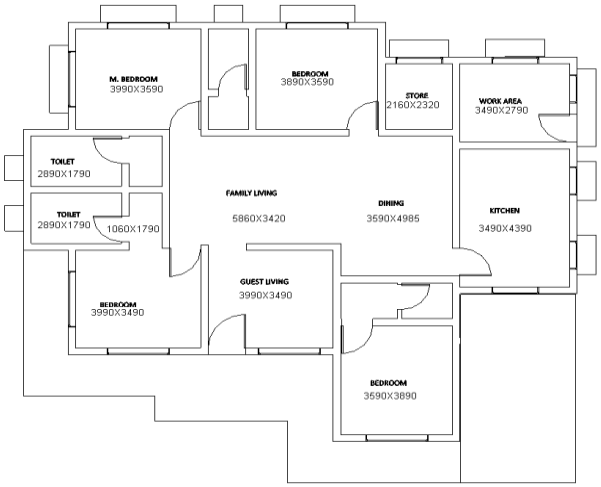

Fig 8:- Plan of assumed traditional building

Cost estimation of a traditional building:-

WORK	COST(Rs.)
EARTH WORK	15,417.79
CONCRETE WORK	6,50,943.94
FORM WORK	2,38,291.83
STEEL WORK	2,62,193.17
RR MASONRY	1,95,591.39
DOORS AND WINDOWS	1,98,397.57
FLOORING	2,45,236.99
FINISHING	2,62,696.20
WALL FINISHING	86,307.12
PLUMBING	5,73,500.00
ELECTRICAL WORKS	4,50,000.00
BRICK & STONE WORK	5,03,826.83
TOTAL	36,82,402.83

Table 2: Cost estimation of a traditional building

Cost estimation of a GFRG building:-

WORK	COST(Rs.)
EARTH WORK	15,417.79
CONCRETE WORK	6,42,529.47
FORM WORK	1,51,666.07
STEEL WORK	3,21,152.95
RR MASONRY	1,95,591.39
DOORS AND WINDOWS	1,98,397.57
FLOORING	2,71,081.65
FINISHING	1,74,472.41
WALL FINISHING	86,307.12
GFRG PANEL WORKS	11,43,914.37
WATER PROOFING	53,134.33
PLUMBING	5,73,500.00
ELECTRICAL WORKS	4,50,000.00
TOTAL	42,77,165.12

Table 3: Cost estimation of a GFRG building

When comparing the plinth area, the cost per sq ft, of GFRG building is around 1533 Rs per sq ft. whereas the cost for the traditional building is 1311 Rs. per sq ft. But since the carpet area of both houses are different with the carpet area of GFRG buildings being slightly greater than the other, the difference in cost per sq ft. of carpet area of both buildings becomes less intense. The cost per sq ft. of carpet area of GFRG building is 1792 Rs per sq ft. whereas that of the traditional building is 1709 Rs. per sq ft.

The cost estimation of both buildings was done by Candy software.

6. ESTIMATION OF TIME FOR A SIMILAR TRADITIONAL AND GFRG BUILDING

The schedule of two similar buildings were prepared to calculate the overall time required for completion of the both projects. The total time of completion was calculated assuming 6 workers work on the project at a time.

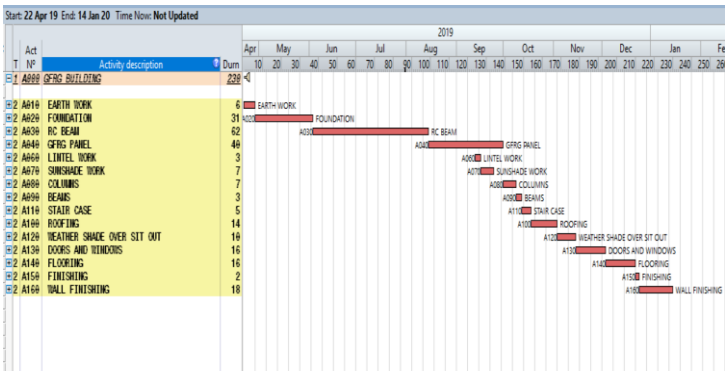

Fig 9:-Schedule of a traditional building prepared using Candy software

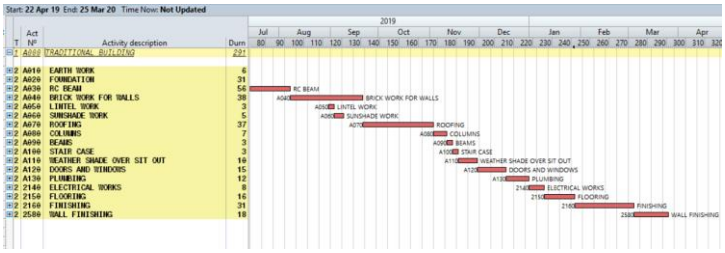

Fig 10:- Schedule of a GFRG building prepared using Candy software

From the schedule prepared we can infer that a GFRG Building was completed in 230 days whereas a traditional building was completed in 291 days. Hence a GFRG Building was completed in 80 % of the time required for completion of a Traditional building.

Hence we can infer that GFRG Structures are constructed faster than a typical traditional building due to reduction in formwork, erection of brick work, casting of roof and staircase etc.

7. COMPARISION OF SUSTAINABILITY OF GFRG AND TRADITIONAL BUILDING

To measure sustainability we measure the embodied carbon emission due to the construction of the structure. This is done by multiplying the quantities with the embodied carbon emission coefficient. For this project the embodied carbon emission coefficient is obtained from the Inventory of carbon and energy or ICE[4].

The carbon emission coefficient is multiplied with the quantities of various resources specified during cost estimation using Candy software. Embodied carbon emission in terms of KgCO2/Kg for GFRG and Traditional Building is given below:-

WORK	KgCO2
CONCRETE WORK	26,973.00
FORM WORK	41
STEEL WORK	7,740.00
RR MASONRY	4,098.00
DOORS AND WINDOWS	423
FLOORING	3,702.00
FINISHING	8,989.00
WALL FINISHING	3,702.00
BRICK & STONE WORK	33,698.00
TOTAL	89,366.00

Table 4:-Embodied carbon emissions of a traditional building

WORK	KgCO2
CONCRETE WORK	27,540.82
FORM WORK	37.99
STEEL WORK	7,644.40
RR MASONRY	4,098.26
DOORS AND WINDOWS	420.53
FLOORING	4,091.88
FINISHING	5,456.11
WALL FINISHING	405.07
GFRG PANEL WORKS	914.05
WATER PROOFING	202.5
TOTAL	50,811.61

Table 5:-Embodied carbon emissions of a GFRG building

The total embodied carbon emission for a traditional building was 89366Kg of CO2 whereas that for a GFRG building was 50812 Kg of CO2

From this we can infer that Embodied carbon emissions for GFRG structures are much lesser (about 45% lesser) than that of a similar traditional building. This is because GFRG panels are made from waste products and does not contain large amounts of embodied carbon unlike materials used for the construction of conventional buildings like bricks.

8. CONCLUSIONS

From the analysis of the case studies conducted by the team it was found that the cost of construction of GFRG structures was 42.8 lacs whereas in case of traditional building it was 36.8 lacs hence based on present mode of construction in Kerala a GFRG Structure is slightly more costlier than a similar traditional structure.

Based on the schedule of rates we can infer that a construction of GFRG structure is quicker than a Traditional structure as there is a difference of about 60 days in construction of both similar structures.

Based on Sustainability we can infer that GFRG Structures contain about 45% lesser embodied carbon emission when compared to similar Traditional Building.

Hence we can infer that GFRG Structures have an edge over Traditional structures in terms of the time of construction and sustainability but however using the construction processes preferred in Kerala the cost of GFRG structures increases above a similar Traditional Building.

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