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Analysis of Cost Effectiveness in Precast GFRG Over Conventional Method

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Abstract *-Ancient Roman builders made use of concrete and soon poured the material into moulds to build their complex network of aqueducts, culverts, and tunnels. Modern uses for pre-cast technology include a variety of architectural and structural applications featuring parts of an entire building system. The Possibility of building a house in just two weeks may seem like a joke to many. And those who intend to laugh it off should know that it is true and practicable.GFRGs are the pre-fabricated load bearing panels used for the construction of walls at a rapid rate. These panels can be sliced and resized to suit your needs and they simply need to be fitted on the foundation using a crane. Everything from walls to ceilings can be built in this manner. This paper is an attempt to prove that GFRG construction is cost and time effective than that of conventional method*
Keywords: Glass Fibre Reinforced Gypsom,Cost analysis

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I. INTRODUCTION

In the modern world, precast panelled buildings were pioneered in Liverpool, England, in 1905. A process was invented by city engineer John Alexander Brodie, whose inventive genius also had him inventing the football goal net. The tram stables at Walton in Liverpool followed in 1906. The idea was not taken up extensively in Britain. However, it was adopted all over the world, particularly in Eastern Europe and Scandinavia.

In the US, precast concrete has evolved as two sub-industries, each represented by a major association. The Precast Concrete Products industry focuses on utility, underground, and other non-prestressed products, and is represented primarily by the National Precast Concrete Association (NPCA). The Precast Concrete Structures industry focuses on prestressed concrete elements and on other precast concrete elements used in above-ground structures such as buildings, parking structures, and bridges. This industry is represented primarily by of the Precast/Prestressed Concrete Institute (PCI). Glass Fibre Reinforced gypsum GFRG. We are talking about walls built using GFRG panels, otherwise known as Glass Fibre Reinforced Gypsum Panels, manufactured by a Cochin based organization, FACT. These panels which are made using substances like gypsum and glass fibre is manufactured at their factory located at Ambalamukal. They are technologically backed up by the Australian Company, Rapid Building Systems.

GFRGs are the pre-fabricated load bearing panels used for the construction of walls at a rapid rate. These panels can be sliced and resized to suit your needs and they simply need to be fitted on the foundation using a crane. Everything from walls to ceilings can be built in this manner

1.1 What is precasting

Precast concrete is a construction product produced by casting concrete in a reusable mold or "form" which is then cured in a controlled environment, transported to the construction site and lifted into place. In contrast, standard concrete is poured into site-specific forms and cured on site. Precast stone is distinguished from precast concrete by using a fine aggregate in the mixture, so the final product approaches the appearance of naturally occurring rock or stone.

By producing precast concrete in a controlled environment (typically referred to as a precast plant), the precast concrete is afforded the opportunity to properly cure and be closely monitored by plant employees. Utilizing a Precast Concrete system offers many potential advantages over site casting of concrete. The production process for Precast Concrete is performed on ground level, which helps with safety throughout a project. There is a greater control of the quality of materials and workmanship in a precast plant rather than on a construction site. Financially, the forms used in a precast plant may be reused hundreds to thousands of times before they have to be replaced, which allow cost of formwork per unit to be lower than for site-cast production.

Many states across the United States require a precast plant to be certified by either the Architectural Precast Association (APA), National Precast Concrete Association (NPCA) or Precast Prestressed Concrete

Institute (PCI) for a precast producer to supply their product to a construction site sponsored by State and Federal DOTs.

There are many different types of precast concrete forming systems for architectural applications, differing in size, function, and cost. Precast architectural panels are also used to clad all or part of a building facade free-standing walls used for landscaping, soundproofing, and security walls, and some can be Prestressed concrete structural elements. Storm water drainage, water and sewage pipes, and tunnels make use of precast concrete units. To complete the look of the four precast wall panel types sandwich, plastered sandwich, inner layer, and cladding panels ,there are many different possibilities for the surface. The cement can be white or grey, and the color and size of the aggregate make a difference. Different colors, pigments, and paints can be added. The shape and surface of the precast concrete molds have an effect on the look: the mold can be made of timber, steel, plastic, rubber, or fiber glass, each material giving a unique finish

1.2 Why Precasting

If concrete were to be invented today, it would be hailed as a miracle. It is the most commonly used building material in the world, and because of that we take it for granted. Too often this means that we overlook the nearly limitless possibilities offered by precast concrete components. Precast is a multipurpose material. There are five good simple rules to follow to ensure the best possible initial price for precast concrete is achieved.

- Make the precast elements as big as possible with transport and site crane limitations usually the controlling influences.
- Use standard moulds/forms or processes wherever possible.
- Have sufficient lead time to manufacture the precast in the most efficient way.
- Produce good consultant's drawings that encourage a quick and once only shop drawing process.
- Use element connections that are easily assembled on site.

1.3 Uses of precast

a) *Faster construction:* Precast elements can be delivered just in time for fast erection, reducing unnecessary handling and equipment use. With minimal propping and bracing, and with precast flooring providing an immediate working platform, precast concrete allows other trades to begin work more quickly, speeding the construction time and saving costs. Fast construction on site also means fewer disturbances for surrounding properties.

b) *Uses less concrete, cement and steel:* Being factory manufactured (with more advanced mix designs and better vibration), precast concrete requires less concrete, cement and reinforcing steel. Less concrete is also used in precast flooring systems such as hollowcore, bubbledeck and Ultrafloor than insitu alternatives. Long spanning precast flooring means reduced material use for any supporting structure.

c) *OHS benefits:* Safety can be improved on site with less trades, equipment, workers and material reducing site congestion. Construction sites are also cleaner and tidier. Precast floors provide a safe immediate working platform for the construction team.

d) *Minimises waste:* Exact precast elements are delivered to site, generating less air pollution, noise and debris on site than other building options. Recycled aggregate, recycled steel, grey water, storm water runoff and waste materials which would otherwise be used in landfill (such as slag and fly ash) are very often incorporated into the precast mix design. Any waste produced in the precast manufacturing process is easily captured and most is recycled.

e) *Locally supplied:* Precast elements are usually locally manufactured and supplied to sites meaning reduced haulage and fuel costs. Materials used by precast manufacturers are also usually supplied locally. This further reduces haulage and fuel costs. Local highly skilled erection crews erect precast concrete elements safely on site.

f) Cost savings of the building: Every day we hear, read or see how building designers are thinking more about sustainability - the capacity to endure - as the primary design input when a building is first considered. Precast concrete's inherent properties make it a natural choice for achieving sustainability with today's modern buildings.

g) *Energy efficient buildings:* The high thermal mass of precast concrete enables it to absorb, store and later radiate heat. Using precast concrete in passive solar designs allows natural heating in winter and cooling in summer, thereby reducing the need to rely on artificial heating and cooling. Systems such as insulated sandwich panels provide an exceptional solution for energy efficient buildings.

h) *Improved internal building amenity:* Use of precast concrete can even out internal diurnal building temperatures and some precast systems (such as TermoDeck can improve indoor air quality, providing fresh air inside the home.

i) *Good acoustic performance:* The high thermal mass of precast concrete assists with sound insulation to reduce noise and absorb noise impact.

j) *Fire resistant buildings:* Precast concrete is non-combustible, does not melt and therefore does not require additional fire-proofing applications. Precast concrete does not emit toxic fumes under fire and can limit smoke spreading in buildings.

k) *Environmentally considerate buildings:* Precast concrete is an inert substance which does not emit or give off gases or compounds. This is a huge relief to allergy sufferers. Precast does not attract mould or mildew. Precast concrete absorbs CO2. Being termite proof means the unlikelihood of requiring chemical spray to reduce termites and vermin which is safer for the environment.

l) *Recyclable precast buildings:* Precast concrete elements from redundant buildings are easily recovered for reuse, or crushed and used as aggregate for road bases or construction fill, providing economic and environmental savings. Alternatively, whole precast building structures can remain and simply be refitted.

II. LITERATURE REVIEW

Precast concrete construction methods have now became feasible alternatives in such applications as buildings and bridges. The primary benefit of precast construction is the speed of construction. Precast elements can be cast in controlled conditions at a precasting yard far in advance of when they will we needed, stock piled, and transported to the construction site. The structure can then simply be assembled like a puzzle using the precast elements. Allowing time for the concrete to cure before construction progress, which is a critical operation in terms of operational time and long term performance. The use of precast elements eliminates the operational step and optimises the curing time

Because the term precast is a generalised concept, most of the research works are going on precast technology in the world. Hence availability of specialist interest on this topic is the present technology in the world. Literature review has been done with help of articles live projects , text books as well as journal papers.

Sailaja A, 2015, Quality is the assurance of adherence to the customer specifications and it is a measure of excellence or a state of being free from defects, deficiencies and significant variation from standards. Customer specification of the product can be met by strictly adhering to the quality control measures in the production process and can be ensured in a cost effective manner only if the quality of each and every process in the organization is well defined and ensured without any lapses. Every activity in the supply chain line to be critically verified to identify the quality deviations incurring additional expense or loss to the organization. This is in line with the continual improvement principle of TQM philosophy . The cost of quality management system acts as the most significant tool in measuring, monitoring, controlling and decision making activities in a firm which aims on business excellence.

T.Subramani and K.Chinnadurai, 2015, Although the long-introduced Industrialized Building System (IBS) has promised to solve and improve the current construction method and scenario in our country, but the IBS method has not gained enough popularity. One of the reasons is due to lack of research works done to quantifying the benefit of IBS especially in construction time saving. In lieu with such scenario, this study conducted to quantify evidence of time saving in IBS application. Primavera P6 is amazing software, which is used not just by planners, but also managers, engineers, schedulers, and anyone else involved in planning, management, reporting of a project. Primavera P6 has benefited every industry from aerospace to manufacturing, electronics to IT, Telecom to Civil, any more. Primavera is an amazing project management software tool which is not just used by project managers. Designed to make managing large or complex projects a piece of cake, Primavera is the ideal tool for anyone who is involved in planning, monitoring and reporting on the progress of any big task, development or venture. The project management software tool of choice in industries such as construction, engineering, aerospace, transport and security, as well as in many other industry sectors. Primavera allows for top level planning as well as being ideal for managing the intricate details. This enables project managers, planners, planning controllers and other associated professionals to have instant access to all the project information they require at the touch of a button. Also from this study shown not all IBS components can improved to the overall construction duration, however by adopting IBS components can improve and expedite the construction of 18 stories residential building from the point of departure of the project throughout of the whole of project‘s with a total 405 days or 42% the time saving**.**

Heng Li, 2015, The construction industry is a crucial component of the Hong Kong economy, and the safety and efficiency of workers are two of its main concerns. The current approach to training workers relies primarily on instilling practice and experience in conventional teacher–apprentice settings on and off site. Both have their limitations however, on-site training is very inefficient and interferes with progress on site, while off-site training provides little opportunity to develop the practical skills and awareness needed through hands-on experience. Amore effective way is to train workers in safety awareness and efficient working by current novel information technologies. This paper describes a new and innovative prototype system — the Proactive Construction Management System (PCMS) — to train precast installation workers to be highly productive while

being fully aware of the hazards involved. PCMS uses Chirp-Spread-Spectrum-based (CSS) real-time location technology and Unity3D-based data visualisation technology to track construction resources (people, equipment, materials, etc.) and provide real-time feedback and post-event visualisation analysis in a training environment. A trial of a precast facade installation on a real site demonstrates the benefits gained by PCMS in comparison with equivalent training using conventional methods. It is concluded that, although the study is based on specific industrial conditions found in Hong Kong construction projects, PCMS may well attract wider interest and use in future.

Hary Agus Rahardjo, Priyasambada, and Dwi Dinariana, 2015 ,The increase of population in major cities led to the rise in housing need. In line with the growth of the city, the available land in urban areas increasingly limited and expensive. Construction of flats is one solution to meet the housing needs. In practice, many conventional construction methods require lumber for formwork and scaffolding. Excessive consumption of wood has shown to reduce forest cover and damage the environment, which is negatively affecting human life. This paper examines the precast method as an alternative system that can be used. Object of research is done on the construction of flats in the city of Batam, Bantul and Bandung. Result of the discussion suggests that the prefabricated system can save the use of wood, reduce the cost of construction, maintain the environment and also contribute to the green building.

P.P.Mane, J.R.Patil 2015 ,The best quality, time and cost are the important aspects of successful construction project which fulfills the main goal of construction industry. The quality management has to provide the environment within which related tools, techniques and procedures can be deployed effectively leading to operational success for a construction project. The role of quality management for a construction company is not an isolated activity, but intertwined with all the operational and managerial processes of the construction project. The quality management system (QMS) in construction industry refers to quality planning, quality assurance and quality control. The paper includes the outcome of the research methodology decided by authors based on interview of project participants and analysis of scrutinized interview data.

Mrs.P.A.Chavan and .Ms.P.S.Bhamre , 2015, Planning and scheduling have become an essential part of any project for the timely and economical completion of the project. A proper construction schedule can be used for different purposes. By using construction schedule to predict project completion, contractors can adjust crew size, shifts or equipment to speed or slow the progress. All the construction projects will vary from each other in size. All the projects have time constraint. Delay in completion of project will increase the overall cost of the project. Small projects can be managed efficiently manually; whereas large projects are not so large projects can be better handled by the use of computers. Many types of software are available with the help of which project management can be done easily. Large quantities of different kinds of resources are also required for execution and the risk is more in the case of projects. So planning and scheduling of activities for construction of big projects is essential. In this study, an effort is made in planning, scheduling and delay analysis updating of various activities, which is done by using MS Project and MS Excel software, manpower of each activity is determined and allocation is done using the software. Labor requirement for each activity is calculated from standards obtained from site. An updated schedule, which helps to finish the project well in time with optimum resources and update helps in delay analysis, is under the scope of this study.

Tomas U. Ganiron Jr and Mohammed Almarwae, 2014 ,In view of the issue related to the demand of housing, the Philippine Government must find some alternative ways to lessen the expenses without altering the quality of the housing projects, the study paved the way to evaluate a comparison between the prefabricated housing components in modular house and the traditionally made housing components (CHB) in terms of cost, efficiency, effectiveness, and the time to spend during construction. It also attempts to search for the development and production of low cost housing, the end-users feedback and other institutions that used these materials and its impact to the market. One of the interesting insights in the study is that prefabricated components has a significance difference in terms of construction cost as compare to the traditional methods due to the materials, and fast and short time duration of construction.

Krish R. Villaitramani, 2014, Urbanization is the rapid influx of people migrating to cities. The UN has predicted that by 2050, 64.1% and 85.9% of the developing and developed world respectively will be urbanized. With limited resources of labour, time and finance, slums around the world continue to grow in size in uninhabitable conditions for humans. Prefabrication of houses, an innovation that has potential to address environmental and sustainability concerns at a rapid pace, mechanizes the construction process, enabling mass manufacture of affordable houses. This paper discusses the case of Mumbai, the city of maximum slum population density in the world, where prefabrication can be a promising solution to housing scarcity.

P. P. Bhangale, Ajay K. Mahajan ,2013, Low cost housing construction technologies aim to cut down construction cost by using alternatives to conventional methods and Input. "It is effective budgeting and technique which help in reducing cost of construction through use locally available material along with improve skills and technology without sacrificing the strength, performance and life of structure. ''Low cost housing merely satisfies the most bottom and fundamental human needs for shelter and neglects other needs that people

aspire home including psychological, social, and aesthetic needs and ultimately, need for self-actualization. This paper examined the cost effectiveness of using low cost housing technologies in comparison with the traditional construction methods. It was found that about 26.11% and 22.68% of the construction cost, including material and labor cost, can be saved by using the low cost housing technologies in comparison with traditional construction methods for walling and roofing respectively.

Nashwan Mohammed Noman Saeed, 2012 ,The study empirically examines the extent to which Total Quality Management (TQM) and project performance are correlated and the effects of TQM on project performance. In this study, a TQM framework is developed according to a comprehensive literature review. This framework demonstrates the relationship between TQM and construction project performance through examining the effects of nine TQM constructs on three element levels of project performance. The proposed model and hypotheses were tested by using data collected from Yemen construction firms. The survey covered 40 companies chosen from construction sector (30%of sample size). 29 questionnaires were returned. The response rate was 72.5 %, normal for such research). The results of this aforementioned model support the proposed hypothesis (TQM has positive effects on teamwork satisfaction, quality of construction project implementation, client satisfaction, and construction project performance. Finally, this research culminates with TQM process for improving construction project performance, a discussion and the general conclusions are extracted in the light of the survey findings. The results finding are expected to provide useful information for future research directions especially as an indicator for the development of a suitable TQM framework for the construction firms.

N. Ravi Shankar1, 2011, The completion time and non renewable resources are traditionally considered for construction of project. When renewable resources, quality and some criteria considered for the project, the risk related to criteria has to be taken into account. Thus project planning problem can be defined as multicriteria decision problem under risk. In this paper, a project scheduling problem including time, cost, quality tradeoffs is analyzed. First, evaluations of projects with respect to the criteria are generated. Next, these evaluations are compared with respect to the criteria. Finally, the interactive technique is used for the selection of the most desirable resource allocation. A numerical example is presented to illustrate the applicability of the new technique in construction of projects.

Tan Chin-Keng, 2011, Study Of Quality Management In Construction Projects research explores preliminarily the practices of quality management, management commitment in quality management, and quality management implementation problems in construction projects in the context of Malaysian construction industry. The research applies semi-structured interview approach with twelve project management practitioners. The findings of the study indicate that the state of quality management in construction projects in Malaysia needs to be strengthened and there are problems in relation to quality management implementation that require attention and further research. The paper provides an insight on the state of quality management in construction projects in Malaysia.

Chan T K 2011, In their efforts to bring about improvements in build quality and increasing construction productivity, many developing countries have suggested policies to increase mechanisation or prefabrication in their respective industries. This paper presents a strategy to optimise construction output by examining the relevant political, social and economic circumstances, and related constraints for the adoption of precast concrete technology. Case studies of precast concrete building costs in Melbourne, Australia and in Perak, Malaysia clearly illustrate the technological trade-off between capital and labour in the production function. The results indicate that the higher labour costs in Australia leads to a more economical precast solution whereas the low wages of migrant construction labour in Malaysia precludes the use of the more capital intensive precast technology. Current fiscal incentives for the adoption of industrialised building systems in Malaysia are clearly deficient. The impact of labour policy, employment of migrant labour, training, and technology is discussed to identify appropriate policies, reforms and incentives that could increase the adoption of prefabricated components into buildings and perhaps strengthen the construction industry in the long run.

P.A. Bowen,2011,The clients of the construction industry are primarily concerned with quality, time and cost and yet the majority of construction projects are procured on the basis of only two of these parameters, namely time and cost (Bennett and Grice, 1990). This is understandable since the majority of project management control systems highlight time and cost, and overlook the relative importance of quality (Hughes and Williams, 1991). It is argued by Herbsman and Ellis (1991) that the major failings in traditional approaches to project delivery have been in extensive delays in the planned schedules, cost overruns, serious problems in quality, and an increase in the number of claims and litigation associated with construction projects.

Ying Chen, 2010 , Prefabrication offers a substantial opportunity to improve projects' sustainable performance. However, decisions to employ prefabrication are still largely based on familiarity and personal preferences rather than rigorous data. Methodical assessments of an appropriate construction method for a concrete project have been found deficient. This paper presents an objective and transparent tool, the Construction Method Selection Model (CMSM), which is designed to aid building team members during early

project stages in evaluating the feasibility of prefabrication and exploring an optimal strategy to apply prefabrication in concrete buildings. The model is divided into two sequential levels: the strategic level and the tactical level, respectively. The Simple Multi-Attribute Rating Technique (SMART) is used in the first level for preliminary feasibility evaluation of prefabrication. The Multi-Attribute Utility Theory (MAUT), which considers uncertainty and risk attitude, is employed in the second level to assess to what degree of prefabrication is appropriate for the project at hand. A detailed case study through in-depth personal interviews with four decision makers is presented to illustrate the use of the model and to demonstrate the capability of the model. The results show that the proposed model is a useful and effective decision-making tool for prefabrication adoption and optimization in concrete buildings

Rinku Taur And Vidya Devi T 2009, Low Cost Housing paper aims to point out the various aspects of prefabricated building methodologies for low cost housing by highlighting the different prefabrication techniques, and the economical advantages achieved by its adoption. In a building the foundation, walls, doors and windows, floors and roofs are the most important components, which can be analyzed individually based on the needs thus, improving the speed of construction and reducing the construction cost. The major current methods of construction systems considered here are namely, structural block walls, mortar less block walls, prefabricated roofing components like precast RC planks, precast hollow concrete panels, precast concrete/Ferro cement panels are considered.

Lara Jaillon, C.S. Poon ,2009, Prefabricated building components have been adopted in Hong Kong for over two decades for high-rise buildings. In the public sector, prefabrication together with standard modular design was introduced in the Housing Authority's public housing projects in the mid-1980s. Over the years, precasting techniques have significantly evolved in public housing projects. In contrast, prefabrication has only recently been adopted in the private sector. The aim of this paper is to examine the evolution of precasting technology in high-rise residential developments in Hong Kong, and then explore the technological influences in both sectors. A database of 179 prefabricated residential buildings was developed and detailed case studies of five residential developments were conducted. The findings revealed that a greater extent of prefabrication use over the years, in terms of precasting percentage by volume and types of precast elements utilised. Major prefabrication innovations, in both sectors, influenced the technological advancement in prefabrication in Hong Kong.

D. Benros, J.P. Duarte, 2009 ,An Integrated System For Providing Mass Customized Housing, this paper describes an integrated system for enabling the mass customization of housing. The goal is to lower the costs through recourse to large scale, serial production while satisfying the unique requirements of each individual household to guarantee customer satisfaction. The integrated system includes a design system that encodes the rules for generating customized designs and a prefab building system that makes it possible to construct from such designs. Integration is achieved through a computer tool that enables the easy exploration and visualization of solutions, and automatically generates the information required for production.

A. Afshar, A. Kaveh and O.R. Shoghli, 2007, Construction planners often face the challenge of optimum resource utilization to compromise between different and usually conflicting aspects of projects. Time, cost and quality of project delivery are among the crucial aspects of each project. Emergence of new contracts that place an increasing pressure on maximizing the quality of projects while minimizing its time and cost, requires the development of models considering quality in addition to time and cost which has modelled extensively. In this paper, a new metaheuristic multi-colony ant algorithm is developed for the optimization of three objectives time-cost quality as a trade-off problem. An example is analyzed to illustrate the capabilities of the present method in generating optimal/near optimal solutions. The model is also applied to two objective time-cost trade-off problem, and the results are compared to those of the existing approaches.

Vivian W.Y. Tam 2007, There is an urgent issue on huge quantities of wastage generation in construction. There should not be lack of environmental support from construction stakeholders. The current implementation of prefabrication seems unable to provide satisfactory results to the construction industry. This paper provides a feasibility analysis in adopting prefabrication in construction activities. Advantages, hindrances and future development on prefabrication's applications are provided based on a questionnaire survey. The suitability in adopting prefabrication of various project types is also examined. Furthermore, a financial analysis is also investigated by a local case study. It found that wastage generation can reduce up to 100% after adopting prefabrication, in which up to 84.7% can be saved on wastage reduction.

Arvydas Juodis, 2007, Construction cost estimating, control and analysis are the main tools in construction project management. Construction cost estimating influences the final project effectiveness. Construction cost estimating goals, methods and accuracy differ according to the stage of construction project. Contractors should know what the dynamics and value of construction cost is in every stage of a construction project. The object of this re-search was the implementation of a project of a chain of petrol stations of the same contractor in Lithuania. According to the analysis of statistical characteristics of a chain of petrol stations construction bid price, cost, duration and profit, the contractor can estimate parameters and make decisions for

future similar projects. The performed research and obtained results revealed that construction bid price of petrol stations in Lithuania depends on the occupied area and land plot. The offered subordination of the mathematical expression can be used practically estimating the construction bid price of petrol stations and adopting a decision regarding contractor's participation in the tenders

III. WHAT IS GFRG

Glass Fibre Reinforced gypsum GFRC**,** The Possibility of building a house in just two weeks may seem like a joke to many. And those who intend to laugh it off should know that it is true and practicable. We are talking about walls built using GFRG panels, otherwise known as Glass Fibre Reinforced Gypsum Panels, manufactured by a Cochin based organization, FACT. These panels which are made using substances like gypsum and glass fibre is manufactured at their factory located at Ambalamukal. They are technologically backed up by the Australian Company, Rapid Building Systems.

GFRGs are the pre-fabricated load bearing panels used for the construction of walls at a rapid rate. These panels can be sliced and resized to suit your needs and they simply need to be fitted on the foundation using a crane. Everything from walls to ceilings can be built in this manner

3.1Qualities of GFRG

The panels are manufactured in sizes of 12 * 13 metres, weigh 1.6 metric tonnes and are 5 inches thick. (Concrete panels of the same sizes would probably weigh 10 metric tonnes and would be 9 inches thick.) The less thick walls give the rooms a wider carpet area. These materials are eco-friendly and hence are resistant to moisture, corrosion other damages and also reduces the heat inside the house. They can bear as much weight as bricks or similar materials can. Since the panels come in white colour and with a smooth texture on the surface, they do not require plastering or painting. Nevertheless, you can paint them if you wish to.

India has a severe housing shortage problem, which is well known. In particular, there is a need to address the shelter needs of the lower income groups and their aspirations. The challenge is to make these aspirations a reality, by providing for an affordable solution. Ideally, the solution should be scalable to reach the masses and should be quickly built, and at the same time addresses issues of sustainability and quality. Clearly, we need a 'game changer' in the housing industry.

3.2 ADVANTAGES OF GFRG OVER CONVENTIONAL BUILDINGS

- High speed of construction: GFRG demo building with four flats in two storeys
- (total 1981 sq.ft.) built within a month!
- Less built up area for the same carpet area: wall panels are only 124mm thick.
- Less embodied energy and carbon footprint: significant reduction in use of cement, sand, steel and water; recycling of industrial waste gypsum.
- Lower cost of structure: savings in materials; no plastering.
- Lower building weight (panels weigh only 43 kg/m2), contributing to savings in foundation and reduction in design for earthquake forces, particularly in multi-storeyed construction.
- Buildings up to 8-10 storeys can be designed using this load bearing system, without the need for beams and columns.
- Excellent finishes of prefabricated GFRG panels used for all the walls, floors

Excellent finishes of prefabricated GFRG panels used for all the walls, floors and staircases, with minimal embedded concrete: no need for additional plastering

IV. COST EFFECTIVENESS

4.1 Site 1 at Irinjalakkuda conventional method

A residential building of area 2236 sq.ft was selected and total detailed estimation has been done for conventional method. The abstract for the 1st site has been given below

Table -1 Abstract of Estimation Site 1

SL No:	Particulars	Quantity	Unit	Rate	Amount
1	Site clearance and levelling			LS	5000.00
2	PCC 1:4:8 using 40 mm metal for foundation concrete	$12m^3$	$1\ m^3$	3600.00	43200.00
3	Earthwork excavation in ordinary soil for foundation	$32m^3$	$10m^3$	950.00	30400.00
4	RR masonry in CM 1:8 for foundation and basement	$50m^3$	$1m^3$	4000.00	200000.00
5	RCC 1:4:8 using 40 mm metal for foundation concrete	$6m^3$	$1m^3$	4500.00	27000.00

6	Brick masonry in CM 1:6 using first class country burned bricks				
	51m^3	1m^3	4500.00	229500.00	
	41m^3		5000.00	205000.00	
7	Supplying and fixing teak wood doors with fully panelled shutters				
	17m^2		9000.00	153000.00	
	13m^2	1m^2	9000.00	117000.00	
8	Supplying and fixing teak wood windows and ventilators with fully glazed shutters				
	19m^2	1m^2	9000.00	171000.00	
	16m^2		9000.00	144000.00	
9	RCC 1:2:4 using 20 mm metal for beam. Lintel, sunshade roof slab etc				
	15m^3		12500.00	187500.00	
	13m^3	1m^3	12500.00	162500.00	
10	Steel requirements				
	1200kg	1kg	55.00	66000.00	
	1040 kg		60.00	62400.00	
11	Ceiling plastering in cement mortar 1:3				
	100m^2	10m^2	750.00	75000.00	
	66m^2		850.00	56100.00	
12	Inside and outside wall plastering in cement mortar 1:3				
	522m^2	10m^2	625.00	326300.00	
	449m^2		650.00	292000.00	
13	Flooring with granite				
	100m^2		2500.00	250000.00	
	66m^2	1m^2	2550.00	168300.00	
14	Granite for kitchen dusk	7m^2	1m^2	2500.00	17500.00
15	Painting walls with approved quality colour paint				
	622 m^2	10m^2	600.00	373200.00	
	515m^2		650.00	334800.00	
16	Painting doors and windows with synthetic enamel painting				
	36m^2		450.00	16200.00	
	29m^2	10m^2	475.00	4300.00	
17	Glazed white or coloured tiles for toilet				
	22m^2		1200.00	26400.00	
	22m^2	1m^2	1200.00	26400.00	
18	Wall rob for bed room and kitchen cabinet with teak wood			2200.00	46500.00
19	Providing hand rail for sit out balcony and staircase with teak wood			3500.00	70000.00
20	Providing water supply and sanitary works (8% of the				310900.00

	total)				
21	Providing electrification work (7% of the total)				272050.00
22	Other unforeseen items				15000.00
					4484450.00
		TOTAL			**4500000.00**

4.2 Site 2 at Perurkkada conventional method

A residential building of area 1321.33 sq.ft was selected and total detailed estimation has been done for conventional method. The abstract for the 2nd site has been given below.

Table -2 Abstract of Estimation Site 2

SL No:	Particulars	Quantity	Unit	Rate	Amount
1	Site clearance		Ls	10000.00	
2	Earthwork excavation for foundation and basement. The rate includes all costs of materials and labour charges etc complete	35.34	m^3	850.00	30050.00
3	PCC for foundation. The rate includes all cost of materials and labour charges etc complete	5.54	m^3	3600.00	19960.00
4	Random rubble masonry for foundation. The rate includes all cost of materials and labour charges etc. Complete	66.52	m^3	4000.00	266100.00
5	Earth filling in basement. The rate includes all cost of materials and labour charges etc. Complete	23.78	m^3	1000.00	23800.00
6	Brick masonry in cement mortar 1:8 for using with first class country burned bricks including all cost and labour charges etc complete				
	Gf	27.24	m^3	4000.00	136200.00
	Ff	33.12	m^3	4500.00	182200.00
7	Providing doors windows and ventilators. in jack wood. The rate includes all cost of materials and labour charges etc. Complete				
	Doors	17.43	m^2	8000.00	140000.00
	Pvc doors	3 nos		6000.00	18000.00
	Windows and ventilators	25.89	m^2	9000.00	233100.00
8	Providing RCC lintel in cm 1:11/2:3 . The rate includes all cost of materials and labour charges etc. Complete				
	Gf	1.91	m^3	11000.00	21050.00
	Ff	1.91	m^3	11500.00	22000.00
9	Providing RCC roof slab in cm 1:11/2:3 . The rate includes all cost of materials and labour charges etc. Complete				
	Gf	7.43	m^3	12000.00	892000.00
	Ff	7.43	m^3	12500.00	93000.00
10	Providing RCC sunshade in cm 1:11/2:3 . The rate includes all cost of materials and labour charges etc. Complete				
	Gf	4.08	m^3	11500.00	47000.00
	Ff	2.26	m^3	12000.00	27200.00
11	Plastering all inside portions of newly constructed wall,				

	the rate includes all cost of material and labour charges etc complete				
	Gf	232.92	m^2	600.00	140000.00
	Ff	276.32	m^2	650.00	221100.00
12	Plastering all outside portions of newly constructed wall, the rate includes all cost of material and labour charges etc complete				
	Gf	114.08	m^2	600.00	91300.00
	Ff	98.33	m^2	650.00	88500.00
13	Plastering ceiling with 1:4. The rate includes all cost of materials and labour charges etc. Complete	105.70	m^2	750.00	79300.00
14	White washing all area . The rate includes all cost materials and labour charges etc complete	729.02	m^2	200.00	145850.00
15	Quantity of steel RCC work. The rate includes all cost materials and labour charges etc complete	2502.00	kg	60.00	200200.00
16	Flooring with verified tiles on all rooms and stair case. The rate includes all cost of materials and labour charges etc. Complete	102.25	m^2	1200.00	122700.00
17	Painting with emulsion on all inside plastered surfaces after applying two coat putty finish . The rate includes all cost of materials and labour charges etc. Complete	562.17	m^2	600.00	337500.00
18	Painting with apex on all outside plastered surfaces after applying two coat putty finish. The rate includes all cost of materials and labour charges etc. Complete	212.41	m^2	450.00	95600.00
19	Providing stainless steel handrail. The rate includes all cost of materials and labour charges etc. Complete	20.00	m	3500.00	70000.00
20	Providing shelves at bedroom, living room. The rate includes all cost of materials and labour charges etc. Complete	21.08	m^2	2200.00	46400.00
21	For plumbing works. The rate includes all cost of materials and labour charges etc. Complete				85000.00
22	For electrification works. The rate includes all cost of materials and labour charges etc. Complete				100000.00
23	For miscellaneous items				15000.00
		TOTAL	2996227.00		
					3000000.00

4.3 Site 1 at Irinjalakkuda GFRG method

As the detailed estimation was done earlier the components that can be replaced with GFRG has been taken and re estimation has been done.

Table -3Abstract of Estimation Site 1

Description	M^2	Rate For GFRG (Rs)
For wall	402.65	654306.25
For roof slab, kitchen slab, pillar, sunshade etc	553.52	881481.25
steel (35% less than that of conventional method)	784	50960
concrete for filling roof slab and lintel	495.72	49500
concrete for filling wall panels	402.65	18411.43
	TOTAL	1654658.93

4.4 Site 2 at Perurkkada GFRG method

As the detailed estimation was done earlier the components that can be replaced with GFRG has been taken and re estimation has been done.

Table -4 Abstract of Estimation Site 2

Description	M^2	Rate for GFRG (rs)
For wall	319.95	519918.75
For roof	165.25	268531.25
Steel (35% less than that of conventional method)	875.7	56920.50
Steel (35% less than that of conventional method)	154.56	33000.00
Concrete for filling roof slab	319.95	27154.29
Concrete for filling wall panels	Total	905524.79

The above tables clearly shows total quantity, unit rate and the total cost of the project using GFRG panels. By comparing both the values and rates we can clearly say that using GFRG is cost effective

V. CONCLUSION

Precasting makes the construction work lighter and good results are obtained at the end of the project. Total cost of the project is reduced as the no of labours is less and also the amount of construction materials has also been reduced. The cost has been reduced by 28.27% for site 2 and 30.60% for site 1. The system provides an efficient design cost effectiveness and a strong durable appearance that will maintain its image throughout a long survive life

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