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Container House using GFRG Panels

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Abstract: ***In India the demand for housing is ever increasing and hence there is an increase in demand for building materials. Providing affordable housing is a challenge for developing country like India. India have an shortage of millions houses. Now days, more than 17 million retired shipping containers are stacked on the port worldwide. Container building still facing the various challenges. To avoid this challenges GFRG panels use as a Walls and Roofs of container house. So, Container house using GFRG panels provide an adequate solutions to the various problems. Building materials which are energy efficient strong and durable at an affordable cost are in great demand GFRG panels are of much relevance in India where there is tremendous need for cost effective mass scale and rapid housing. They are not only eco-friendly, but also resistant to termites, heat, rot, corrosion, water and fire. Concrete infill with vertical reinforcement rods enhances its vertical and lateral load capabilities. Comparative studies of GFRG and conventional buildings have been carried out in the present investigation. Rapid wall panel provides speedier construction and leads to environmental protection. Subsequently, it is a perfect option building material to replace bricks or concrete blocks. GFRG wall is a green product which can erect a building fast in prefabricated method.***

This paper highlights the positive aspects of GFRG panels with respect to Time, cost of construction Strength, affordability, energy efficiency over the conventional construction materials and its suitability in the Indian Housing Scenario. This research aims in providing adequate shelter for all individuals that is one among the recent challenges long faced by the developing countries. Economical plan and development of structures, utilizing green material is an option in contrast to exhaustion of totals and increment in cost of concrete. Glass fiber reinforced gypsum panel (GFRG) is a green material, which is a rapid wall construction method and a cost effective construction process. With the end goal to enhance the productivity, and decrease of waste, the lean the development has been presented as another administration rule for better execution. In India, the usage of lean administration in the development industry is a noteworthy errand. Because of the absence of consideration and uneducated towards the lean administration guideline the proprietor, contractual worker, engineers and so on are as yet creating a stage to actualize this standard in their task. This venture primarily centers on to recognize the potential outcomes of execution of lean administration in the development industry. This paper shows the probabilities of compelling usage of lean administration guideline in the development industry, which can definitely diminish the use of time, increment the nature of work, and benefit rate by wiping out the wastage of materials. It finally, points in giving lodging to all classes of people, in this way enhancing the economy of India. Going through this study, it will explore & analyze some projects and case studies from many points of views, Geometrically, Architecturally, structurally, financially, and of course environmentally. The deployment of containers as building modules has grown in popularity over the past years due to their inherent strength, modular construction, and relatively low cost. Finally, conclusions are going to be drawn on the important worth of lean construction against the traditional practice with consideration for the future benefits within collaborative technological models.

Keywords: GFRG, Lean administration guidelines, deployment of containers

I. INTRODUCTION

A. Introduction Of Container House Using Gfrg Panels

Nowadays, more than 17 million retired shipping containers are stacked on the port worldwide. Huge expenses are required for their destruction transportation and their non- degradable materials occupy a large landfill space when they are not in use. Due to this reason, the concept of use of modular and prefabricated houses and components is becoming a prevailing trend. The modular architecture and the large accessible quantities with affordable cost are thus driving the rise in popularity of container homes. Shipping containers are stackable construction elements being able to reduce the construction time cost and waste. The exiting studies stated that the reduce of containers for buildings results into a significant decrease in embodied energy when compared with conventional building. After many years of development, container home architecture has become a versatile solution to application of container homes in post-disaster settlement, commercial usage, military operation, residential buildings, temporary homes, and low- cost housing. However, the overall performance of repurposed container building still causes challenge. Such challenges are for instance, insulation and overheating risk, cold, resistance to heavy rains, rust, corrosion risk around the roof and potential toxic substances during service time.

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On the other hand, the unquestionable urgency of climate change is entailing the increase of temperature/humidity/ levels and in heavy rains. Thus, the existing container building design strategies may no longer respond effectively to such problems. In this regard, this study aims to explore the use of container homes in a long- term usage as a building system towards the increase of temperature/humidity, heavy rains, etc. It involves usage of GFRG (Glass Fiber Reinforced Gypsum) panels as the walls and roof of container homes. Use of GFRG panels have cut down the construction cost, improved stability against temperature/humidity rise, heavy rainfall. Studies regarding these aspects are made in this paper.

B. Lean principles in Product Development

Lean product development follows the same lean principal as in traditional lean applications:

1) With the target to obtain products/services faster and with fewer costs for the customer:
a) Value,
b) Value stream,
c) Flow
d) Pull and
e) Perfection.

2) Lean management Principles

The Five Principles of Lean

1) Define Value. To better understand the first principle of defining customer value, it is important to understand what value is.
2) Map the Value Stream. The second Lean principle is identifying and mapping the value stream.
3) Create Flow.
4) Establish Pull.
5) Pursue Perfection.

C. What is a Container Deployment?

Containers are a method of building, packaging and deploying software. A container includes all the code, runtime, libraries and everything else the containerized workload needs to run.

Fig1.1 Container House

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II. LITERATURE SURVEY

Steel shipping containers in all different sizes have been used to store and ship things in a early 1940's. They come in various sizes, colours, and thickness. Nowadays, they have become popular to be used in house construction. They are extremely well suited to handle exterior tears due to their rigid design and all steel elements. By doing so, we are recycling a large amount of steel waste by using them in constructing liveable houses. This form of construction is a perfect example of adaptive reuse of containers and transforming them into emerging housing permanent housing permanent housing etc constructing homes using this method is also called as cargotecture. These have low environmental impact, inexpensive can be constructed rapidly. Most containers are made to fulfil at least one decade lifespan with three decades being chief lifespan target. Shipping containers is composed of 6 plans i.e floor , top and four sides . sides are made of steel in regular corrugations that makes these sides strong enough to resist loads or pressure . In addition to this, steel post are there at corners or at intersection of these sides , below the floor and above the top. This type of house can be excellent cost-effective and temporary disaster relief houses. This type of construction can be built modular, which allows them to be taken apart and moved around and in this way container construction is one of the most versatile forms of construction for emergency situations.

Previously, the containers were used as it is as they were brought the steel corrugated sheets acting as the sides used to provide good strength but where we can provide in thermal insulation. The container houses used to become extremely hot during summers within which it was impossible to stay and inventors, they were used to become very good rapidly as climate cools resistance to this alternate heat and cool was not taken into consideration in previous ages also the roots of containers. When not that strong to take the load of a person story. Due to this reason, only single storey container house were constructed in previous year. Known alternate solution to strengthen roof watch provide preference. International Journal, your journal of scientific and engineering research issue 11, November 15 earlier, the shipping container homes were used as post disaster or emergency settlements and their homes were used to be prefabricated and movable they were not used as permanent houses. There are the best options to be used in case of disaster reference :- A.T , A.T and M.B (2018) assessing the air tightness of container houses in relation to its effect on energy efficiency S.E (2014) using shipping containers to provide the temporary housing in post disaster recovery. Considering all about the disadvantages problems in container houses and carrying out further study we are supposed to remove the problem of heat accumulation, cold, etc. By replacing the current gated steel sides with GFRG glass fibre reinforced gypsum panels, the hollow spaces in the body of.

GFRG panels can be filled with polyurethane, where is excellent heat insulating and water roofing material use of polyethylene as to safety against heat and temp nature silicone sealant is also one of the effective and low cost waterproofing material. Due to this, the containing home became safer. In summer and heavy rains became more stable to be used in areas like Kokand. Similarly due to the good strength, excellent dimensional stability and durability. GFRG panels can be used as roofing materials we are going to replace the steel roof sheet of original containers with GFRG panels.

III. CURRENT PRACTICES IN CONSTRUCTION OF CONTAINER HOUSES

1) *Shipping Container Standards:* Almost all containers used globally comply with two main shipping container standards developed By the International Organization for Standardization (ISO) and the International Convention for Safe Containers (CSC), respectively. These documents dictate shipping containers' specifications, structural strengths, serviceability, and applications. CSC standards and ISO container standards 668, 830, 6346, 1496-1, 1161, 2308, and 3874 encompass every specification for shipping containers including structural limits. However, there are no ISO standards which specify the framework conditions for the use of containers as building materials. After the end of their usage as cargo transport, containers used in construction are termed as ISBI—Intermodal Steel Building Units. Then, the Safe Use Compliance of Containers provides guidance of both codes and regulations going forward for the modified shipping container through four industry segments.
2) *Container Building Typology:* The container architecture is increasing accepted with a great variety of applications, from simple emergency temporary housing to multifunctional, complex layout of various building types. Generally, there are six common types, as below:

a) Post-disaster or emergency settlements such as the Ex Container Project, anywhere, Japan and Community Flowers, Chengdu, China. These containers meet the requirements for emergency response characterized by prefabricated, easy transportation, lower overall cost, and rapid construction process. They especially provide great possibility for the victims as a safe asylum and a temporary settlement point for a longer term.

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b) Residential buildings such as the Caterpillar house in Los Trepanises, Lo Barnechea, Santiago De and The Container Guest House in San Antonio, USA. Being similar to the first type, the standard container offers excessive feasibility for large-scale residential purpose in a shorter time. Furthermore, the size of the ISO shipping container satisfies the basic requirements of space, structural safety, lighting, and ventilation. Depending on the design condition and investment, it varies from the low-income apartment to luxury vocational villa.

c) Leisure and education premises, such as APAP (Anyang Public Art Project) Open School, Anyang, Korea and the Nomadic museum, Tokyo, Japan. Owing to the advanced level of industrial assembly, it is possible to manufacture the majority of interior decorations in the factory and then assemble the remaining part on site. This will allow settling containers for leisure purposes to special places, such as archipelagos and nature reserve areas, by reducing the influence on the local environment. Another possibility would be as a potential solution of nurseries or primary schools, providing a high-quality learning environment at low prices for suburbs or for under-resourced occasion.

d) Office premises, such as Sugoroku Office, Gifu, Japan. Most of time, the development Of new construction requires huge temporary offices. This kind of construction property is applicable to containers. Both environmental protection measures and low construction cost enable high-quality offices.

e) Commercial premises, such as Marketing shopping place in Puma, Sepia. Container transformation into commercial buildings has been widely found in newspaper kiosks, commissaries, coffee shops, fast food kiosks, showrooms, and small shops.

f) Others, such as Container Observatory, Incheon Songdao New City, South Korea. Container buildings can serve as urban facilities, such as public toilets, telephone booths, or the expansion and construction components of buildings. Moreover, in places, such as National border deafens line, scientific research bases, where there is less population and it is difficult to live, container architectural form is the best choice due to its low construction time and cost.

3) *Container Building Construction Elements:* Container materials roughly consist of steel, aluminum, stainless steel, and fibre glass. Both walls and ceiling of a ship container consist of corrugated metal sheets 2 mm thick, in which each element is made of “cornet” steel. The only exception is the floor, made of plywood. As transportations units, containers are well processed in terms of rust, fire, and mildew resistance and once warned out, they could be used for at least another five to ten years. As an example, according to the data reported by Alejo Andrés and Palma Olivares, every time a 20-inch standard container is used, the carbon dioxide emissions can be cut by 12 tons over the life cycle with respect to concrete buildings. The majority of shipping containers are in standardized dimensions. Table 1 presents the basic container parameters, such as dimensions (width, length, and height), floor areas, and weight. The standardized dimension makes it an ideal building component for modular and prefabricated construction projects [5]. The most popular containers used as building components are 2.438 m in width and 6.096 m or 12.192 m in length. In many national regulations, there is a minimum height limitation of 2.4 m for residential buildings. Thereby, in this context, the residential building design only consider the high cube container with total height of 2.9 m to comply with the minimum clear ceiling height building requirement. Meanwhile, the containers’ internal dimensions differ from the external ones. In fact, internal walls have a plurality of corrugations, each one 25 mm depth. This narrows the container inner width by 50 mm due to both a concave and a convex corrugation. The backside, the other side without the door, is corrugated too. The doors have a thickness of 50 mm, which results in a total loss of 75 mm in length. The height of the inner dimension is less compared with the outer dimension. Depending on the floor type, this reduction, consisting of floor clearance and thickness, is approximately 177 mm. Since roof material is also corrugated, the internal height is Reduced by slightly more than 200 mm in total.

Table 3.1. Basic parameters of the most popular containers

Size	Width (m)	Length (m)	Height (m)	Floor Area (m2)	Volume (m3)	Empty weight (kg)
20ft equivalent unit	2.438	6.096	2.591	14.86	33.1	2200
20ft high cube equivalent unit	2.438	6.096	2.9	14.86	43.09	2350
40ft equivalent unit	2.438	12.192	2.591	29.72	67.5	3800
40ft high equivalent unit	2.438	12.192	2.9	29.72	86.19	3900

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a) *Container Building Foundations:* The three most common foundations of container house are speared footing, mat foundation, and piles. Speared footing consists of reinforced concrete blocks or cylinders, which are located under the corner post of the container. In general, speared footings are especially suitable for small- to medium-sized buildings on strong or medium-strong ground. When the ground is too weak and unsafe, or the groundwater level is above the foundation, mat foundation can be used. Another option is the use of piles (long beams of concrete, metal, and wood) that run deep into the ground. Obviously, this method is more expensive and only used when the top layer of the ground is too weak to support the load of the building. Through the columns, the load can transfer to deeper load-bearing ground layers. For this reason, speared footings and mat foundations are more common under container houses.

b) *Container Building Structure:* The container structure is consisted of (a) bottom structure; (b) front end frame structure (c) backend frame structure; (d) side wall, and (f) box top structure, as illustrated in Figure 1.

c) *Container Building Connections:* When stacking on the foundations, all the containers need to be connected to each other or fixed to the foundation. Now, owing to a lack of standards, the connection method must be developed individually according to each project. Roughly, the connection has two ways: one is the permanent welding connection, while the other one is the temporary joint anchor bolt connection. For connection to the foundation, the container is usually welded to an additional steel base plate. The latter is characterized by reinforcing bars on the underside that are generally inserted into the wet concrete foundations. After hardening of the concrete, the steel base mat first and the container afterwards are anchored to the foundations. For connection with other containers, there are normally two methods. Temporary anchor bolt connections are generally composed of holes in the lower and upper corners, which can be locked together. In this way, twist and latch locks are the two main possibilities to fix the containers during the stacking. These connections can take the horizontal and vertical loads from the shipping operations. For housing constructions, this joint can be sufficient depending on their use. Particularly with unusual stacking constructions, it is suggested to design other adaptations for the joints.

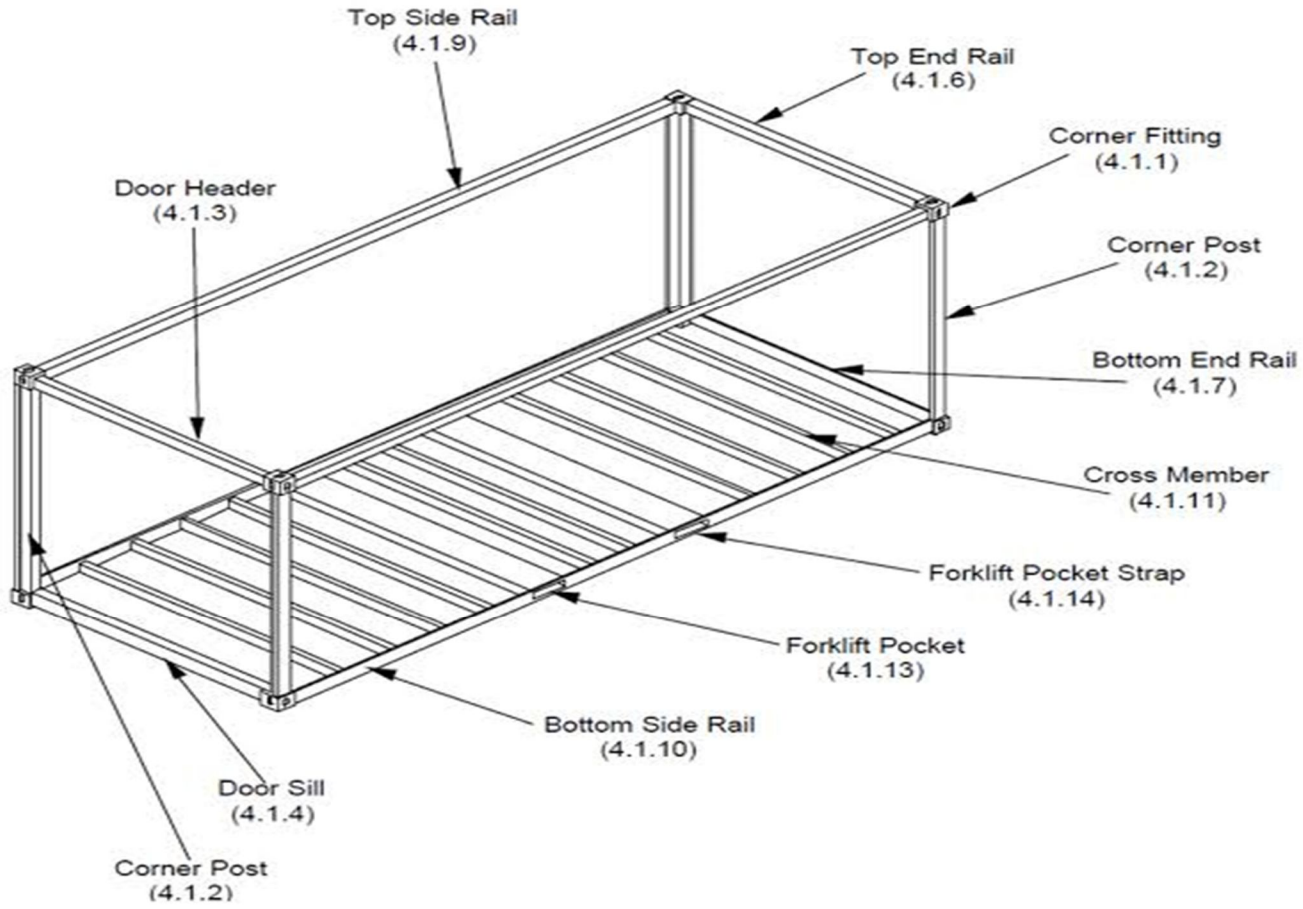

Fig 3.1. Schematic diagram of a 20 ft standard shipping container

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Fig 3.2 20ft Shipping Container

IV. PROPERTIES OF GFRG

A. GFRG Panels As a Potential Material

In India, there is a huge requirement for building materials due to the existing housing shortage mainly in urban India. And till date, it takes a lifetime worth of savings to buy a house. And most of us who buy the houses from their lifetime savings have to pay the EMIs till their retirement age. To overcome this housing hurdle, India needs innovative, high-efficiency building materials for strong and durable housing in an advanced mode of construction at an affordable cost. All these issues and concerns are required in sustainable and overall development. GFRG Panel provides speedy construction and contributes to environmental protection.

There have been a lot of efforts made earlier by the industry experts to find an alternative to existing construction material to make it more affordable. Glass Fiber Reinforced Gypsum (GFRG) is one such component in the construction field that could reduce the construction cost by 65% or more or it also helps to build portable houses.

The word GFRG signifies Glass Fiber Reinforced Gypsum which is also recognized as Rapid Walls. It is made up of high strength resistant glass fibers bonded with high-density gypsum cement. It was invented in 1990 by the GFRG Building System Australia. Now, this component of construction is broadly accepted by a few Asian nations such as India, Saudi Arabia, Oman, and China.

Glass Fiber Reinforced Gypsum (GFRG) Panel is a modern building component used for mass-scale construction of container houses in a very short span of time. This is a technological advancement in the construction container houses Industry. They are basically white in color and have a glazy surface. They are energy-efficient green building material with enormous potential for use as container house panels. It is suitable for the construction of both external and internal walls. It cannot be used as an flooring material to carrying a load in container houses.

GFRG panel possesses high flexural strength, shearing strength, compressive strength, and flexibility. It has a very high level of resistance to fire, water, heat, corrosion, rot, and termites. GFRG panel filled with high density foam to maintain a required temperature in container and it also helps in vertical load resisting capacity. GFRG made container houses are resistant to fire, earthquakes, and cyclones.

After the foundation is placed applying the advanced method, these GFRG panels are being set on a unique locking system is being used to grip the ribs of the panel to the container frame.

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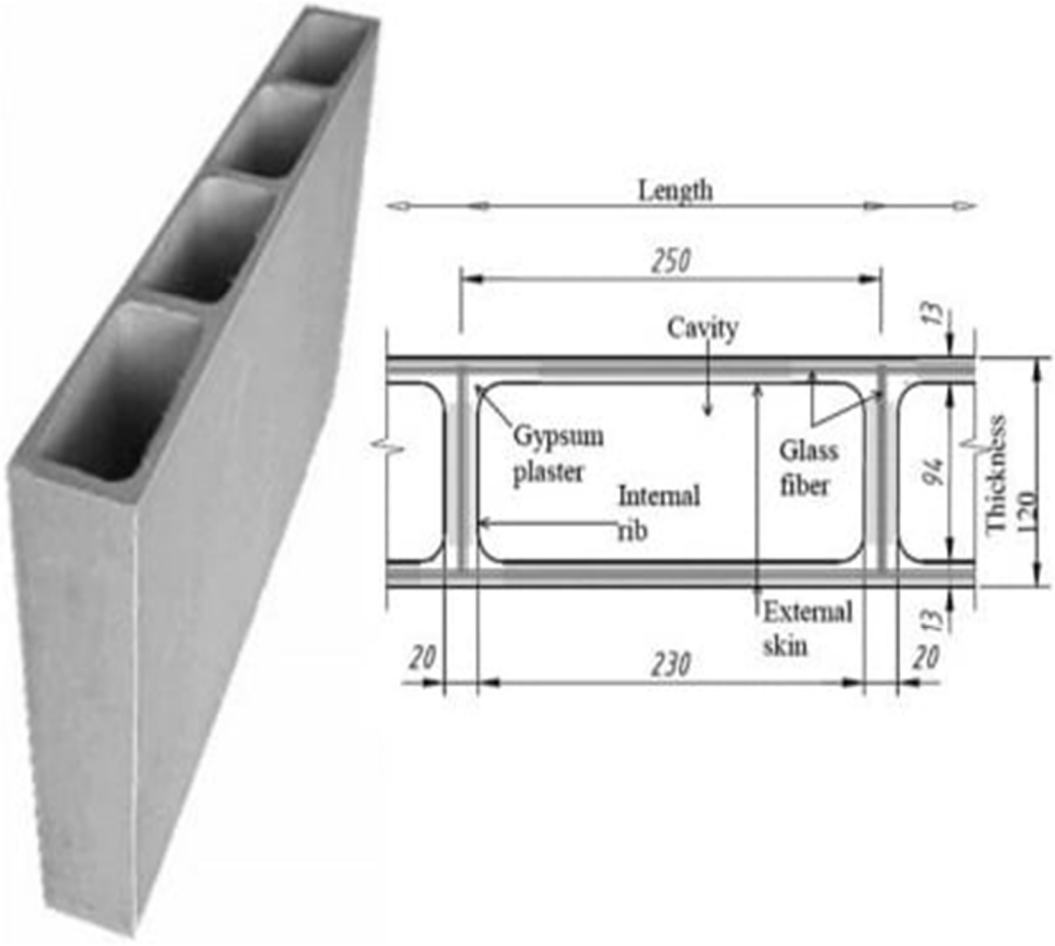

Fig 4.1 Details of GFRG Panels

B. Mechanical Properties of GFRG Panels

Table 4.1 Mechanical Properties

Mechanical Properties	Dimension
Unit Weight	1440 kg
Compressive Strength	73.2 kg/cm2
Flexural Strength	21.25 kg/cm2
Tensile Strength	35 KN/m
Ductility	4
Thermal Resistance R	0.36 K/W
Thermal conductivity	0.617
Sound Transmission	40
Axial Load capacity	16 tons/m
Unit Shear Strength	50.90 kN/m
Fire Resistance	700-1000*C (up to 140 min)
“U” Value	2.85 W/M2K
Elastic Modulus	3000-6000 Mpa
Water Absorption	<5%

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V. LIMITATIONS OF CONTAINER HOUSE

A. Limitations to Current Practices

Limitations of container house:-

1) Steel construction is not as environmental friendly.
2) Most factory built container homes are built from (one-use) container that only had a single trip. These containers are be in good shape. Without trust or dents so they are nice for building, but the container which is out of service that cannot be used for construction, we can only use the frame of that container and walls can be replaced with other material.
3) A shipping container is very strong at the corners, but the roof is not just not that strong, 4. The corrugated steel walls are essential to the strength of the structure
4) Container are made of steel and spend most of their near, and on the ocean saltwater, and metal is a recipe for corrosion and rust.

VI. ADVANTAGES AND DISADVANTAGES OF GFRG PANELS

A. Advantages of GFRG Panels

1) GFRG is lightweight and strong-Glass Fibre Reinforced Gypsum is a building material that is quite strong. GFRG is also light, weighing in at just two to three pounds per square foot. Also Easy for the installation of sturdy elements without extra support.
2) Excellent Dimensional Stability and Durability-GFRG board is used to construct strong, high quality walls and ceilings for excellent dimensional stability and durability. Surfaces created using GFRG board are easily decorated and refinished.
3) No Crack and No Distortion after Long Life Use-GFRG has no corrosive action on glass fibre. They do not typically require extensive maintenance and regular repairs, and are not susceptible to mould which ensures the stability and durability of the product and appears no Crack and no distortion after long life use.
4) Less Manufacturing Time-Mould-release time and drying time of GFRG products is less when compared to other which can largely decrease the manufacture period.
5) Easy for Installation-GFRG are flexible different styles based on designing, architects. Also it can be spliced in large piece which can be integrated into different style without errors.

B. Disadvantages of GFRG Panels

1) During the construction process more space is require for the crane to move.
2) As the design of the GFRG panels is complicated, it can make the construction process less economical.
3) To install the GFRG panels, highly qualified and experienced labour is required.
4) There are specific tools are required cutting GFRG panels.
5) These panels cannot be used for the walls that have higher or circular curvature.

VII. SCOPE OF WORK

A. Scope of Work

The research scope of this paper focuses on the conceptual design issues of the up cycled container buildings. In a longer term, it involves more design issues at the following stages. In order to well up cycled a shipping container into a living building, summarizes the holistic climate-adaptive container building design questions from aspects of design features, production/process, and challenges in implementation. Different roles, from designers, owners, stakeholders, and constructor, are recommended to seriously review these design questions on their way towards a sustainable container building module. So that the up cycled container architecture can comprehensively benefit from passive design measures, low cost operation and management, and versatile functions under the future climate scenarios. In addition, temperature-dependent material properties in different climates should be considered when simulating the energy performance. Further LCA case studies of the three container buildings will be conducted in the specific climates, due to dissimilar inventory data, system boundary, and assumptions in different climates.

1) *Features of Container Building Temporary Building*

a) Short term usage, movable
b) Non-construction Prefabricated Module
c) Quick construction speed
d) Controllable in both quality and price Repeated Utilization

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e) Reuse of cargo container
f) Recycled construction unit
g) Movable building block Customized Appearance
h) Support bespoke design
i) Decoration from self-structure characteristics

2) Production and Process Concept Design
a) Use or repurpose existing containers
b) Complying with the relevant/binding codes
c) Use recycled or carbon sequestered material
d) Specify higher grade options to resources usage
e) Design for durability under future climate change
f) Understand site and passive resources Schematic Design and Design Development
g) Massing comparison
h) Mechanical and plumbing system integration
i) Envelop reinforcement
j) Establish operational and embodied carbon performance targets Construction and Operation
k) Logistics information with all the assembly parts
l) Assembling and installation
m) Follow-up operation and maintenance

3) Challenges in implementation Construct Component Design
a) Prefabrication of components
b) General elements and customized elements
c) Integration and separation of construct components Construction In-Site
d) Prefabrication in manufacturer
e) Feasible dimensions for transportation and installation
f) Unified external construction to avoid thermal bridges leakages
g) Maintenance during remaining service time Commercialization
h) Marketing positioning
i) Cost and environmental impacts control
j) Standardization and Customization
k) Derivatives and updates of product
l) Follow-up operation and maintenance.

VIII. CONCLUSION

A. GFRG Panels provides a new method of building construction in fast track, fully utilising the benefits of prefabricated, light weight large panels with modular cavities and time tested, conventional cast-in-situ constructional use of concrete and steel reinforcement.
B. By this process, man power, cost and time of construction is reduced.
C. These of scarce natural resources like river sand, water and agricultural land is significantly reduced.
D. Rapid wall panels have reduced embodied energy and require less energy for thermoregulation of interiors. Rapid wall buildings thereby reduce burdening of the environment and help to reduce global warming.
E. Rapid wall use also protects the lives and properties of people as these buildings will be resistant to natural disasters like earthquakes, cyclone, fire etc. This will also contribute to achieve the goal of much needed social inclusive development due to its various benefits and advantages with affordability for low income segments also.
F. Fast delivery of mass dwelling/ housing is very critical for reducing huge urban housing shortage in India. Rapid wall panels will help to achieve the above multiple goals.

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IX. ACKNOWLEDGEMENT

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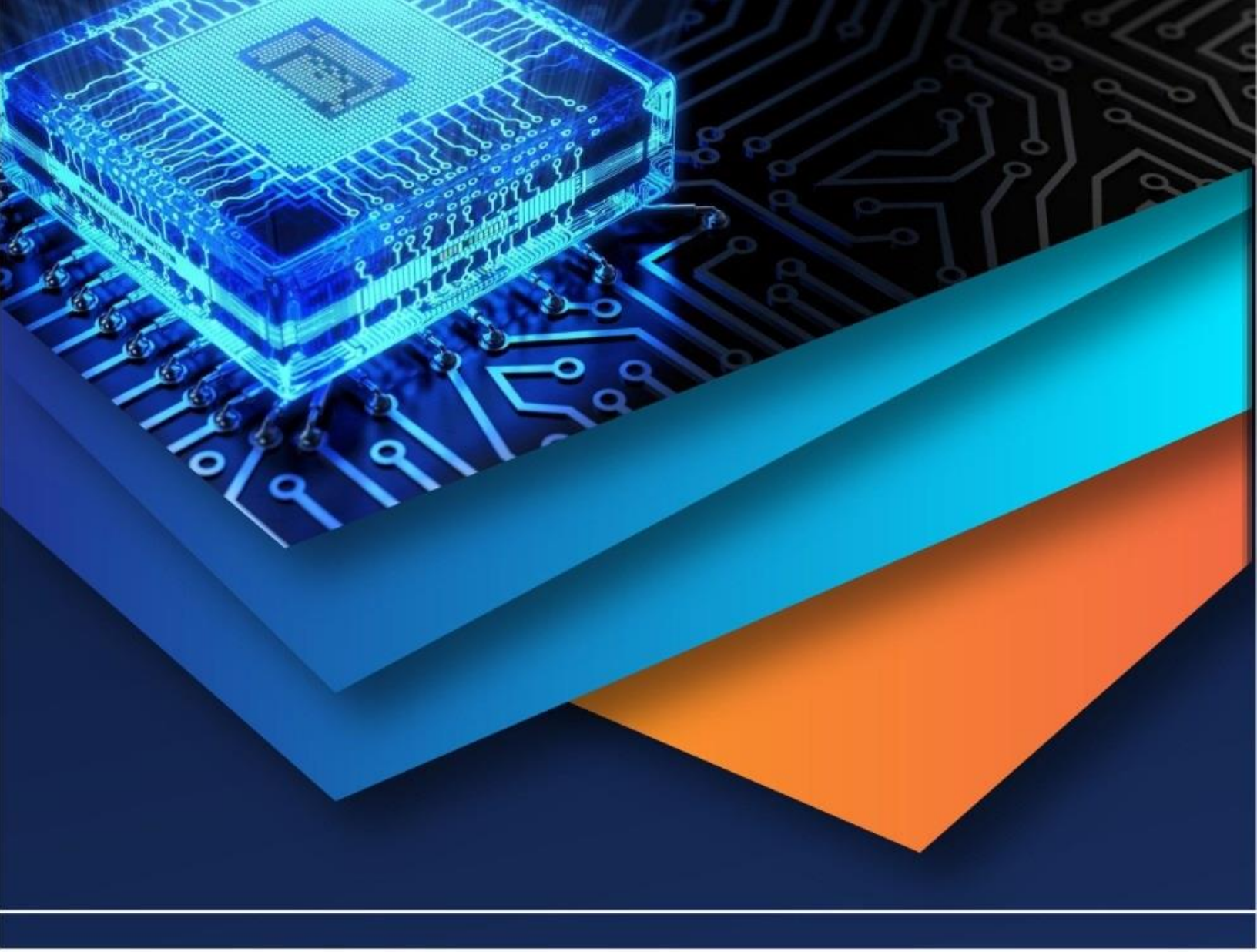

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