

Feasibility of using Recycled Shipping Container Material in Building Construction, Design and Analysis using STAAD-Pro

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Abstract - Recently, a new concept has been developed over the world followed by many attempts in order to achieve sustainable and eco-friendly buildings. It depends on using shipping containers (SCs) blocks as structural components with a lot of advantages, such as energy efficiency, flexibility, sustainability and economy. Although architecture in India is subjected to continuous change and proposing solutions for many unresolved problems such as population inflation, low land area and slums, shipping containers have not been commonly used in India. As containers blocks are widely available in the India coastal zone; it has been selected to be our case study.

In this paper, an outline of the usage of SCs as flexible components for residential buildings has been presented. Besides, some residential design solutions have been suggested for the coastal zone in India. Then, a comparative assessment for their predicted environmental performance has been done. Finally, the most suitable design form with the highest energy performance based on SCs in the coastal zone in India has been concluded.

1. INTRODUCTION

Shipping containers are used for cargo, goods transportation and for next transportation either buy new container or reuse old container (better to get new), so generally new containers are used. Old one becomes waste (no reuse), so we can use it as building material.

Shipping containers can withstand shipment, storage. They are steel or corrugated boxes. Container homes are building erected with these containers.

Usual length are 6 or 12 meters, 2.6 meters high and 2.6 meters wide and also varies sizes are available.

Shipping containers can carry the maximum gross weight of 30480 kg /67200 lbs for general purpose containers and up to 45,000 kg (99,207 lbs) for flatracks.

1.1 History

In 1956, Malcom Mclean presented the first container to international trade knowing as the cargo shipping container. The achieved success allowed him to enter marine transportation business. Ships in average can carry about

200000 individual pieces of SCs and take about a week to load and unload.

Countries' trade globally uses shipping containers for a worldwide transportation network which produces lots of empty containers at the destination ports. While returning them to the home country may not be economical, leaving them in their new home could take lot of space. So, there are tons of empty containers out there waiting to be reused or recycled. Due to recent development of technological innovation, reuse of shipping containers for home building usage might deserve further investigation between its other usages.

Promising cases of transforming containers to youth center, classroom, emergency shelter, office, house and hotel are emerging around the world each year. This would be a kind of offset in a way, which could result in greener and healthier coastlines without creating another issue in landfill. However, the matter is how to transform those containers sustainably for homebuilding purposes in a way that makes our society greener and healthier.

Throughout history, Concepts of shipping container architecture which uses wasted shipping container blocks as building components.

1.2 Advantages of shipping container home

- Cheap: - Shipping container houses are significantly very resource efficient and can be made to look like regular house.
- Strong: - Shipping containers/cargos are much stronger than traditional wood light frame construction, this is simply because shipping containers are made from steel.
- Green: - As opposed to traditional brick and cement, shipping containers alloy cost and availability concerns and boast an eco-friendly edge.
- Independent: - We know that different material is used to construct traditional houses but in the case of shipping container houses, container is used to construct comfortable houses.
- Durable: - life span of shipping container is 10 - 12 years. A used container can easily surpass another 10+ years of use.

- Fast construction: - Total construction process from start to end about 30% faster than a conventional build.

2. PROBLEM STATEMENT

This is new innovation in building construction. In India, shipping container is used mostly for storage purpose and in construction industry it is used for temporary office. The literature shows that returning of empty containers is costly. So using them in construction as a building material could be a better option. So, we proposed to construct home from shipping containers in coastal area of India.

3. REPORT ON PRESENT INVESTIGATION

3.1.1 Data collection: - From various literature review, data required for design of home from shipping container i.e. weight of container, size of shipping container, materials used for shipping container, properties of material used for shipping container, common load point, young's modulus, shear modulus, thermal coefficient, density etc. is collected which is mentioned below.

3.1.2 Payload: - The payload or net weight is the weight of the cargo or contents that a container can hold.

3.1.3 Container gross weight: - The container gross weight is the weight of the container plus the maximum payload it can hold.

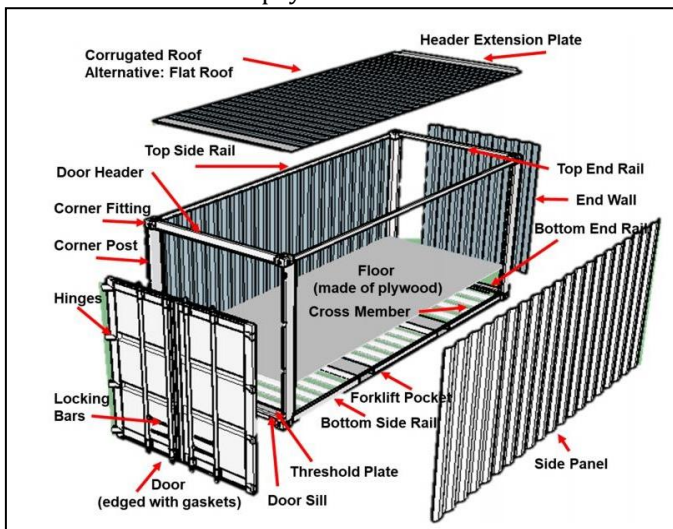


Fig-1: Schematic diagram of a 20 ft standard shipping container.

Table-1: Loading scenario on shipping container.

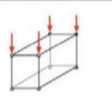
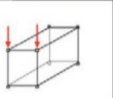
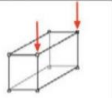
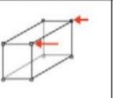
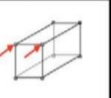
Loading Scenario 1	Loading Scenario 2	Loading Scenario 3	Loading Scenario 4	Loading Scenario 5
				
Compressive Point Loading (4 corner fittings)	Compressive Point Loading (2 corner fittings short side)	Compressive Point Loading (2 corner fittings long side)	Transverse Point Loading (Inward)	Longitudinal Point Loading (Inward)

Table-2: Size, capacity and payload of various shipping container.

TYPES	Length (internal)	Width (internal)	Height (internal)	Capacity	Max. Payload
Dry Cargo Container	20 ft	5.90 m	2.34 m	33.1 m ³	28770 kg
	40 ft	12.04 m	2.34 m	67.6 m ³	28800 kg
High Cube Container	20 ft	5.90 m	2.71 m	37.4 m ³	28130 kg
	40 ft	12.04 m	2.71 m	76.4 m ³	28620 kg

Table-3: Properties of corten steel.

Sr. no.	Properties of corten steel	value
1.	Young's modulus	190 * 10 ⁶ KN/m ²
2.	Poisson's ratio	0.29
3.	density	77.50 KN/m ³
4.	Thermal coefficient	12 * 10 ⁻⁶ /°C
5.	Critical damping	0.03
6.	Shear modulus	73 * 10 ⁶ KN/m ²
7.	Yield stress	275 * 10 ³ KN/m ²
8.	Tensile strength	430 * 10 ³ KN/m ²
9.	Yield strength ratio	1.5
10.	Tensile strength ratio	1.2

3.2 AutoCAD Plan of Shipping container

The following figure shows plan of shipping container home as well as schedule of door and window which we have proposed for our project. we have used 40 fts two container and 20 fts two shipping container.

Fig-2 : AutoCAD Plan of Shipping container.

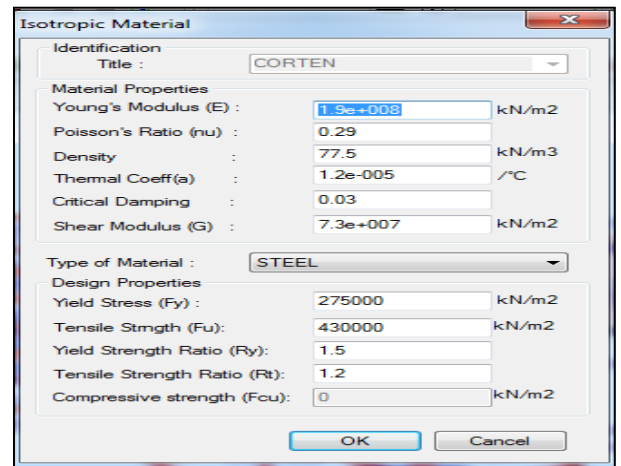
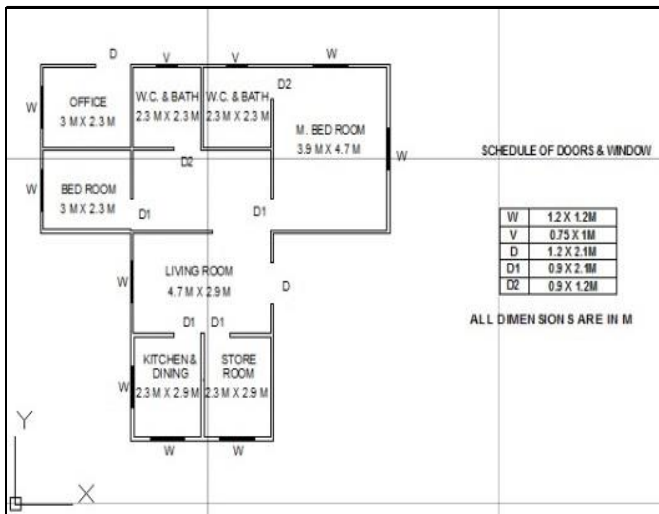


Fig-4 : Property.

In corner post, ISMC 300H (face to face) and other than corner post, ISMC 250H (face to face) is provided which make the structure safe to transmit the load.

Material of corten steel is to be made from property of corten steel table. The following figure shows making of corten steel material.

3.3 Design of shipping container home in STAAD PRO:

3.3.1 Geometry: -We have done geometry of shipping container home according to requirement of loading and according to manufacturing of shipping container.

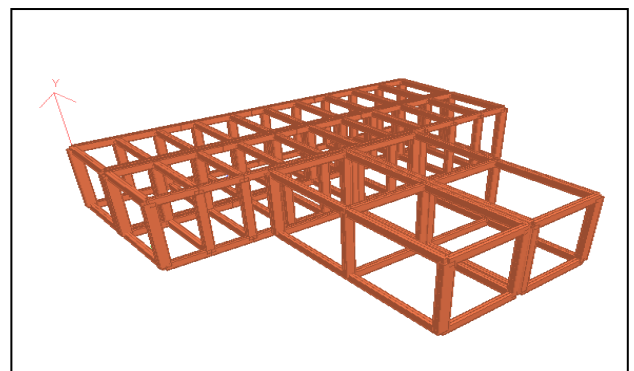


Fig-5 : Making of material of corten steel.

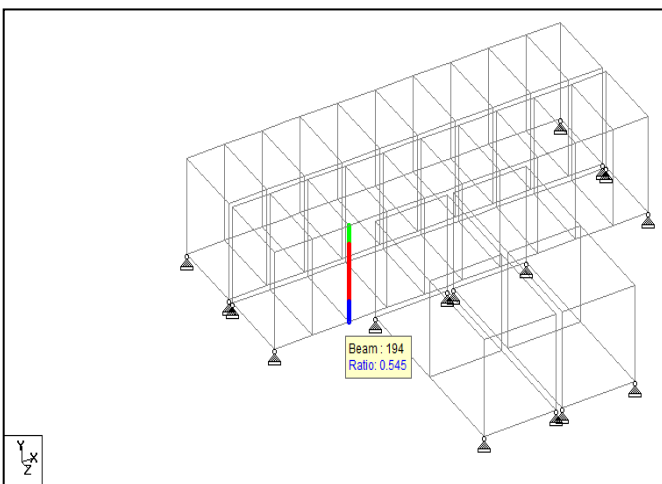


Fig-3 : Geometry of shipping container.

3.3.2 Property:

The following figure shows property of corner post, beam and cross member of shipping container.

3.3.3 Supporting & loading: -

The following figure shows types of dead load, live load and combination of loads which applied on shipping container.

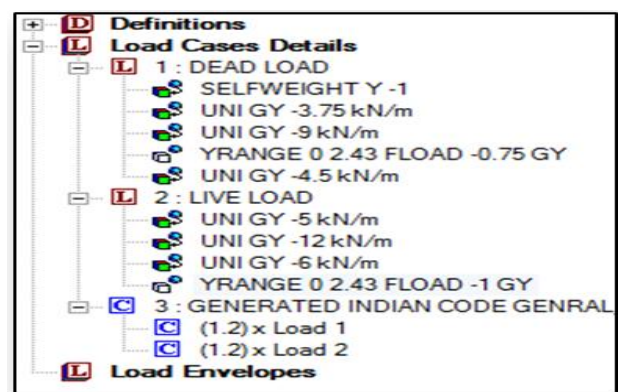


Fig-6 : Loading.

3.3.4 Analysis

Analysis is to be done in STAAD Pro to check that geometry, property, support and loading is done properly. If error is zero, then structure is proper.

The following fig Show the different views of STAAD Pro after application of load.

Fig-7 : Plan View

Fig-6 : Left side View

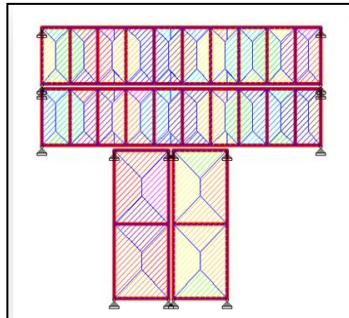
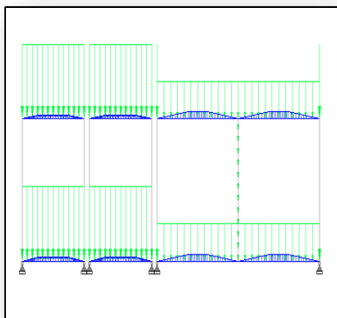
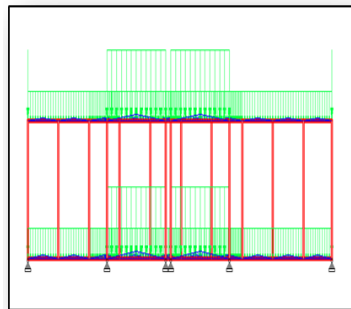
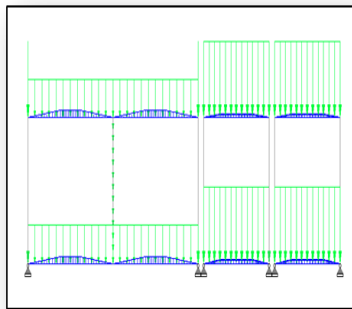


Fig-8 : Right Side View

Fig-9 : Front View



3.3.5 Design: -

Designing is done to check element i.e. beam, corner post, cross member is safe in carrying load. We have designed beam, column of shipping container by taking command and define parameter.

Again analysis is done, This analysis is done to check applied property is capable of carrying applied load or not.

The following figure shows no member is fail in carrying load. Thus, we have designed the shipping container home in STAAD Pro and found that is safe to use for human beings.

3.3.6 Design of welding: -

Fig-10 : Weld joint

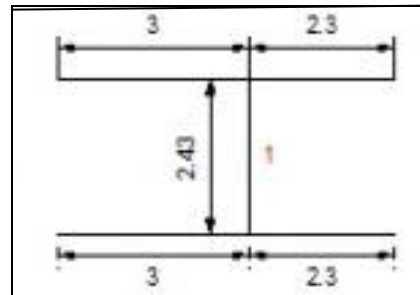


Table-3: Design of weld.

t	14mm
$A_p \bar{y}_p$	$228.629 \cdot 10^6 \text{mm}^3$
I_{zz}	$323.655 \cdot 10^9 \text{mm}^4$
V	242.89 KN
$T_v =$	6.128N/mm^2
Strength of weld	198.46N/mm^2

We show here one sample of weld similarly done for the all wall location. Thus, we have done design of weld which is done to place partition wall in shipping container.

4 Methods for Thermal Comfort Assessment

It can be found that the envelope design is one of the most effective strategies to increase interior insulation. Specifically, Vacuum Insulation Panels (VIP) have been used providing higher thermal resistance and inner space saving with respect to conventional insulation materials.

Moreover, the additional use of wood strip and wooden frame can take full advantage of the limited space on the container wall bases, adequate protection of vacuum insulation panels, and work as the fixed framework for interior wall panels' installation. Fig is shown for roof n side wall.

In order to meet the generic container building design through the three different location each external part of the envelope with the minimum U-values has been proposed and estimated according to ISO 10456, ISO 6946.

Fig-11 : Partition Wall.

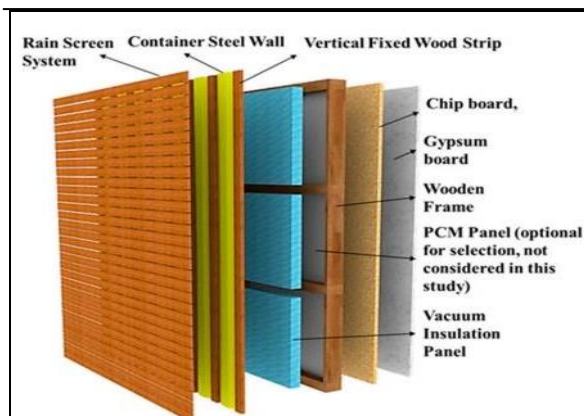
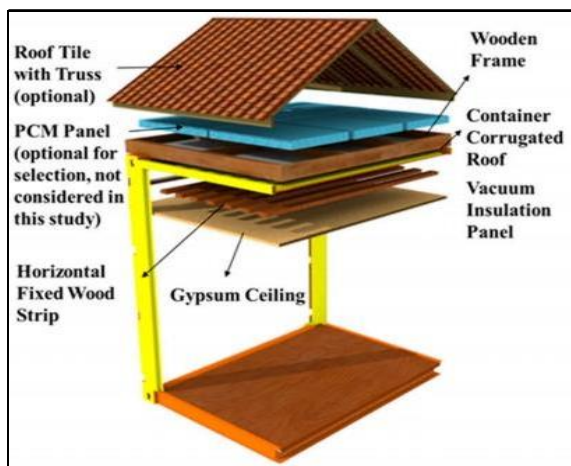


Fig-12 : Roof.



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5. RESULT : -

From this design of shipping container, we can conclude that it is safe for use as all members are safe i.e. no member is failed in design.

6. CONCLUSIONS: -

- The proposed conceptual design responds to new challenges with the feature of a future built environment.(low energy use, low carbon footprint and construction practices under different climatic scenarios.)
- That can be easily constructed and relevantly in a low budget within a short time, in addition to the flexibility and possibility of been reconstructed in other locations or sites.
- This study shows that the calculation of structural projects with this construction system by using the resources currently available for the structural engineer (structural codes).