ARCHITECTURAL SPACES FROM SHIPPING CONTAINER

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ABSTRACT

Shipping containers are used as a new construction technology as it is affordable and feasible. A used 40-foot shipping container which provides over 300 square foot of living space cost about Rs 1,60,000 and when we stack few of these containers we will have a larger living space, and different types of container spaces can be built in a matter of weeks. These shipping containers are made up of steel and are having a lifespan of 30 years which make them so durable to use for construction and other purposes. Shipping containers are ecofriendly as there is no use of concrete construction techniques which is harmful for environment and it require less time to complete as compared to concrete construction which saves both the labour work (human resources) and time. The used shipping containers are sold in the form of scrap metals which makes them affordable. Shipping containers are easy to work on as we can easily trim it, cut it and weld it. "As there are finite resources in our planet, we need to find new sustainable construction techniques for the betterment of our environment."

KEYWORDS: Architectural Spaces, Shipping Container, Container Architecture

Shipping container architecture is defined as a type of architecture that is characterized by the re-use of steel shipping containers as a structural element and Architectural envelope that can host a specific function or a human activity. It is also referred to as cargotecture, a mixture of cargo with architecture. The use of containers as a building material has grown in popularity in the past several years due to their inherent strength, wide availability, and relatively low expenses. It was also noticed recently that many people built homes with containers because they are seen as more eco-friendly than traditional building materials such as brick and reinforced concrete structure, taking also in consideration the short time required to erect a building in this way, with future possibilities of moving these buildings to other locations or adding extra spaces or volumes.

AIM

To study and understand about architectural spaces from shipping container (container architecture).

OBJECTIVES

- To study and understand about Container Architecture.
- To study and understand about the necessity of Container Architecture.
- To study and understand about the spaces in Container Architecture.

SCOPE AND LIMITATION

- To study and understand about Container Architecture. (Definition of Container Architecture and Its importance)
- To study and understand about the necessity of Container Architecture. (Requirement of Container Architecture)
- To study and understand about impact of Container Architecture in sustainability. (Impact of Container Architecture & Sustainability in Container Architecture)
- To study and understand about the spaces in Container Architecture. (Architectural spaces in Container Architecture)

METHODOLOGY

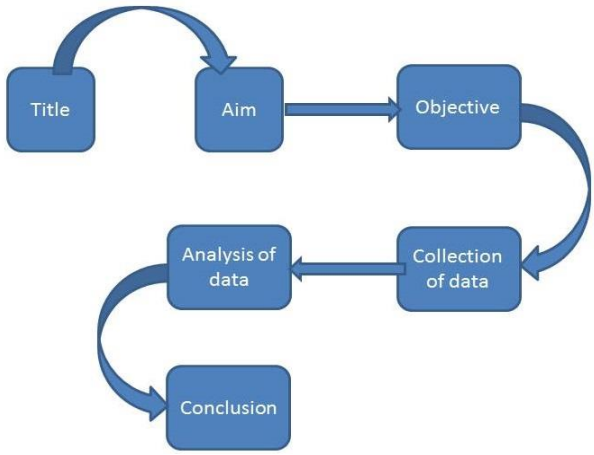

Figure 1: Methodology Chart

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TYPES OF SHIPPING CONTAINER

Shipping container come in three standardised sizes and that is 40 ft, 20ft & 10ft. The type of container depends on the type of products to be shipped or the special services needed from them, container units may vary in dimension, structure, materials, construction etc. Various types of shipping containers are being used now a days to meet requirements of all kinds of cargo shipping. Some of them are:

Dry Storage Container

Dry Shipping Container are most commonly used shipping containers; they come in various dimensions standardized by International Organization for Standardization (ISO). They are used for shipping of dry materials and come in size of 20ft, 40 ft and 10ft.

Figure 2: Dry storage container

Table 1 Data for Dry Cargo Container

DRY CARGO CONTAINERS

SIZE	DOOR OPENINGS* MM FEET/INCHES		INTERNAL DIMENSIONS* MM FEET/INCHES			VOLUME* M³ CUBIC FEET
Feet/inches	Width	Height	Length	Width	Height	Capacity
20 standard 20' X 8' X 8'6"	2.340 7' 8"	2.274 7' 6"	5.896 19' 4"	2.350 7' 8"	2.393 7' 10"	33 1,170
40 standard 40' X 8' X 8'6"	2.340 7' 8"	2.274 7' 6"	12.032 39' 6"	2.350 7' 8"	2.392 7' 10"	67 2,390
40 High 40' X 8' X 9'6"	2.640 7' 8"	2.577 8' 6"	12.032 39' 6"	2.350 7' 8"	2.697 8' 10"	76 2,700
45 High 45' X 8' X 9'6"	2.340 7' 8"	2.584 8' 5"	13.556 44' 6"	2.347 7' 8"	2.696 8' 10"	86 3,055

* General description – dimensions vary by specific units.

Flat Rack Container

Flat rack containers are shipping container with collapsible sides, these are like simple storage shipping containers where the sides can be folded so as to make a flat rack for shipping of wide variety of goods. These container are especially suitable for heavy load and cargo that needs loading from the top or sides.

Figure 3- Flat rack container

Table 2 Data for 20' Flat Rack Container

20´ flat rack container

Tare weight	Payload capacity	Cubic capacity	Internal length
2,360 kg	30,140 kg	32.7 m^3	5.94 m
5,203.8 lbs	66,458.7 lbs	1,154.3 cu ft	19.5 ft

Internal width	Internal height
2.35 m	2.35 m
7.7 ft	7.7 ft

Table 3 Data for 40'Flat Rack Container

40´ flat rack container

Tare weight	Payload capacity	Cubic capacity	Internal length
5,000 kg	40,000 kg	62.2 m^3	12.13 m
11,025 lbs	88,200 lbs	2,195.7 cu ft	39.8 ft

Internal width	Internal height
2.40 m	2.14 m
7.9 ft	7 ft

Open Top Container

Open top container are shipping container that come with a convertible top that can be completely removed to make an open top so that materials of any height can be shipped easily.

Figure 4: Open Top Container

Table 4 Data for 20' Open Top Container

20´open top container						
Tara weight			Payload capacity		Cubic capacity	
2,350 kg			28,130 kg		32.5 m^3	
5,181.8 lbs			62,026.7 lbs		1,147.3 cu ft	
Internal			Door opening		Roof opening	
Length	Width	Height	Width	Height	Width	Height
5.9 m	2.35 m	2.38 m	2.34 m	2.28 m	2.23 m	5.44 m
19.3 ft	7.7 ft	7.8 ft	7.7 ft	7.4 ft	7.3 ft	17.8 ft

Table 5 Data for 40' Open top Container

40´open top container						
Tara weight			Payload capacity		Cubic capacity	
3,850 kg			26,630 kg		66.4 m^3	
8,489.3 lbs			58,719.2 lbs		2,343.9 cu ft	
Internal			Door opening		Roof opening	
Length	Width	Height	Width	Height	Width	Height
12.03 m	2.35 m	2.38 m	2.34 m	2.29 m	2.21 m	11.57 m
39.5 ft	7.7 ft	7.8 ft	7.7 ft	7.5 ft	7.3 ft	38 ft

Tunnel Container

A tunnel-container is a standard shipping container but having double end doors on either end (double ender). From a standard shipping container, the back end of the container is cut off leaving it open, then a new set of double doors is welded in place creating a two-way access. A 'tunnel' can also be constructed from a high cube container, for clients needing the additional height.

Figure 5 Tunnel Container

Open Side Container

Open side storage units are provided with doors that can change into completely open sides providing a much wider room for loading of materials. This container is comprised of 14 gauge corrugated steel panels throughout and lockable double door in the end. The open side containers are only available in “new” or “one trip” condition it is only shipped once.

Figure 6 Open Top Container

Double Doors Container

They are kind of storage units that are provided with double doors, making a wider room for loading and unloading of materials. Construction materials include steel, iron in standardized sizes of 20ft and 40ft. The door of these container open in two sections allowing the entire interior end of the container to be accessed. In the used ISO shipping container world, the only option available is containers with cargo doors on one end.

Figure 7 Double Doors Container

SHIPPING CONTAINER AS A BUILDING MATERIAL

There are various reason for considering Shipping Container as a building material like its durability, low cost and efficiency. Some of them are as follows:

Expected Lifetime of A Shipping Container

Depending on the use of the container, shipping containers are designed and manufactured to cope with a long and arduous life moving goods around the world, accordingly they are very sturdy and secure. A used container will usually have been in international operation for in excess of 10 years and sometimes longer but depending on use, location and reasonable maintenance it is not unreasonable to expect a further 10 plus years of use. While new containers will have completed one journey from their country of manufacture and with reasonable use and maintenance can be expected to complete over 30 years as a storage container. (Levinson)

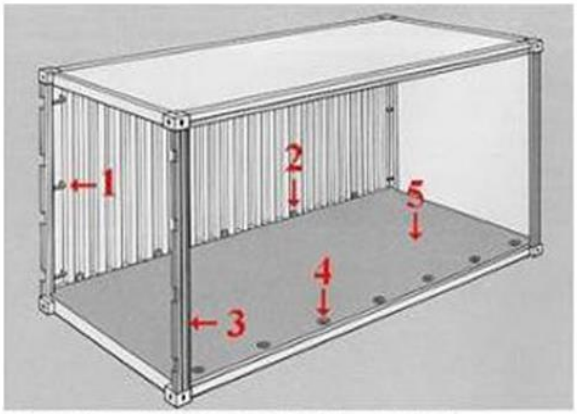
Using Shipping Containers in Creating Various Architectural Spaces

One of the main questions raised in Containers architecture is why a steel shipping container can be reused to create a liveable space. Knowing that geometrically any space could be defined by different planes, horizontal and vertical, with a spatial relationship that organizes this space, defines it, and represents the human function that this space was created to be performed in, with the scale and dimensions, another value is added, thus leading to a better performance in this function, or another function that could be added or performed. Container houses are becoming very popular now a days as it require very less amount of time and saves money.

The Composition of Shipping Container

The Shipping container is composed of 6 planes, floor, top, and four sides, made of steel, in regular corrugations that help in making these sides strong enough to tolerate loads, or pressures that may occur during the transportation process, in addition to steel posts and enforcements whether in the corners, or intersections of these planes (sides), or below the floor, or above the top. Accordingly, as a structure, it's designed to resist forces as mentioned that exceeds the forces being developed in many architectural spaces like residences, offices, dorms, etc. (Levinson)

Figure 8 - Interior of Container house



Cargo securing components in the container.
(Hapag-Lloyd AG, Hamburg)

1 - Lashing bars (corner posts)
2 - Lashing bars (side rail)
3 - Corner posts
4 - Lashing rings
5 - Wooden floor

Figure 9 Composition of Shipping Container

Storage Order

Shipping Containers are designed to be stacked under very prescriptive loading conditions. It's impossible to see containers stacked onboard ships or even in shipping yards other than the way they were designed and intended to be stacked – i.e. in horizontal and vertical alignment and the reason for this, that they are simply not designed to carry the types of loads created by "criss-cross stacking". (Levinson)

Figure 10 Vertical & Horizontal Placement of Shipping Container

Social and Economic Factors for Containerized Buildings

Jure Kotnik describes the cultural development of the container building as 'bottom-up'; containers were first used as shacks and shelters in low economy countries before they became popular with architects. Containers have been successfully deployed in areas prone to extreme environmental conditions and used as emergency shelters and medical centers such for post-hurricane housing.

Container buildings are cheaper than most modular building systems, which in Europe can be anything from 5 to 20% more costly than traditional on-site construction. Modular buildings bring other commercial benefits to a project such as program savings, more predictable quality, and reduced snagging, but other factors may come into play in the choice of modular units, such as issues of access, and local availability of skilled labor. (Bergmann, 2010)

Figure 11 Low Cost Housing Unit of California

BUILDING INFORMATION MODELING AND PARAMETRIC DESIGNS

A further development of the customized container product has been the development of a standard building configuration for hotels and other residential buildings, based on a 'complete building' platform with customizable architecture with clear advantages for a parametric approach to building modeling and production.

Figure 12 Use of Shipping Containers for making parametric design

CONS OF SHIPPING CONTAINER

The main disadvantages of shipping container are Temperature and Humidity. Taking in account the three commonly used shipping routes that is Japan – Netherlands, Japan – Memphis and Japan Portland. (Broeze, 2002)

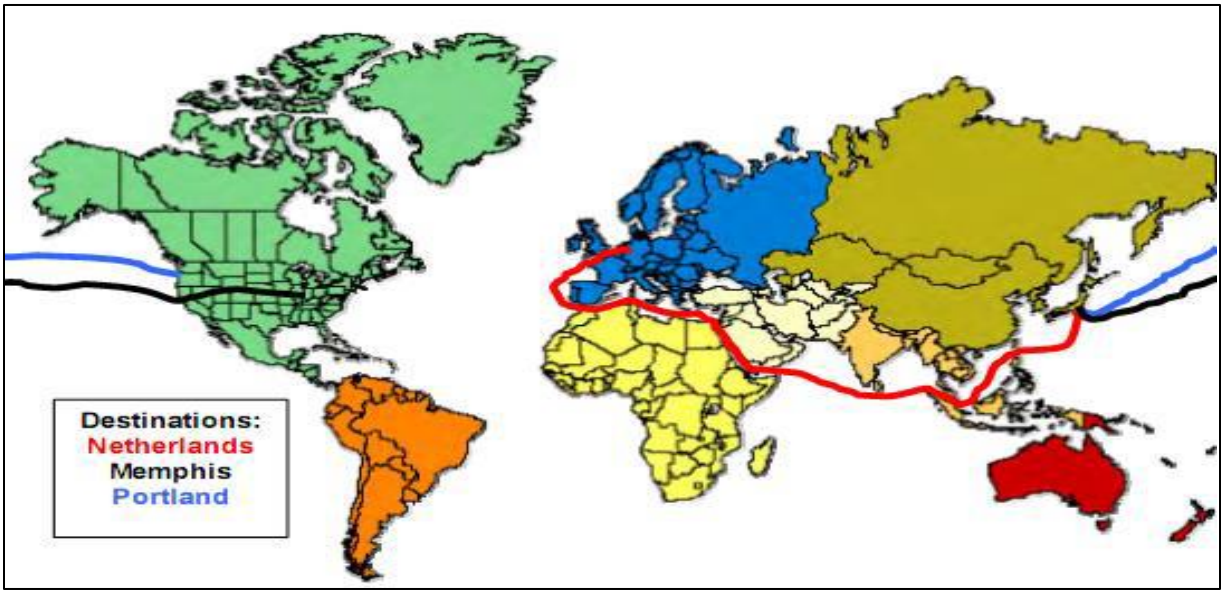


Figure 13 Shipping Routes

SHIPPING CONTAINER HOME BY WHITAKER STUDIO, CALIFORNIA

Blossoming from the rugged terrain of the California desert, Whitaker Studio's Joshua Tree Residence is taking shipping container architecture to the next level. The home is laid out in a starburst of containers, each oriented to maximize views, provide abundant natural light or to create privacy dependent on their location and use. (Arch Daily, N.D.)

Figure 14 Whitaker Studio

Situated on a 90-acre plot owned a Los Angeles-based film producer, the house is a reconfiguration of an earlier concept by Whitaker Studio for an office building in Germany that was never realized – a project recalled by a friend of the client's during a recent trip to the site.

Figure 15 Interior of Whitaker Studio and Site Plan

The concept of this house is a typical grass that grow in California desert, the site is located atop a rocky outcropping where a small gully had been created by

rushing storm water. The shipping container "exoskeleton" will be raised on concrete pilotis, allowing water to continue to pass underneath.

Inside, the 2,150-square-foot (200-square-meter) home will contain a kitchen, living room, dining area and three bedrooms, each filled with natural light from the angled container light monitors and furnished with pieces from designer/architect Ron Arad, Whitaker's former employer. Off the back, two containers extend to meet the natural topography, creating a shielded outdoor area with a wooden deck and hot tub.

Figure 16 Whitaker Studio concept model

CONCLUSION

Although having a very systematic and regular shape, shipping containers could be reused to create not only functional spaces, but also various configurations of architectural programs or functions, that vary from a very simple residential unit, to a small office building extending to a shopping mall, or a cultural center, that hosts bigger number of users. Many attempts have been done globally to create interesting architectural space that can be constructed in a relatively short interval of time, with a reasonable cost. Possibilities are extended also to compose livable urban spaces, 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. Containers architecture is not a rigid type of construction of buildings or spaces configuration, although it's based on the modularity of volumes, yet many examples showed a wide range of varieties in spaces externally and internally.

Shipping Containers Architecture Benefits could be briefed in the following points:

- Renovation of previously utilized containers that have fallen into disuse from ports located worldwide
- Containers are highly inexpensive compared to conventional building material, ranging from between $1,500 to $3,000 United States dollars per individual container and in India a 40' brand new shipping container cost around Rs 1,20,000 – 1,40,000 and old ones are sold in scrap metal value.
- Containers are considerably sturdier compared to wooden or brick structures, they also late for multiple decades with little decay.
- Containers are all standardized with identical designs, thus all containers can be stacked upon or placed side by side without requiring additional resources or planning.
- Renovation of containers take little time, there have been reports of a container being successfully renovated for personal living in little as 72 hours.
- Durable against extreme temperature and pests.
- Easily broken down for movement and reassembled with the same structure intact, requiring little expense for transit of house between locations.

REFERENCES

ASTM Shipping Container Standards and Related Techinical Material. (2007). 5th Edition.

Bergmann S.T., 2010. Container Atlas: A Practical Guide to Container Architecture.

Brody A.A., 1997. Encyclopedia Of Packing Technology. John Wiley & Sons.

Broeze F., 2002. The Globalisation of the Oceans :Containerisation from the 1950's to the Present. International Journal of Maritime History .

Container Houses. (n.d.). Retrieved from Shipping Container Housing: http://www.shipping-container-housing.com

Criss, M. (n.d.). Study.com. Retrieved from https://study.com: https://study.com/academy/lesson/what-is-sustainable-architecture-definition-examples.html

Gittins, 2013. How the invention of a box changed our world -Business. In The Sydney Morning Herald.

Kotnik, 2008. Container Architecture.

Levinson. (n.d.). How shipping container make the world smaller and the world economy bigger.

McKinley, 2004. Transport Packaging. Institute of Packaging Professionals.

Metaferia, M. (n.d.). Scholarly Commons. Retrieved from https://repository.upenn.edu: https://repository.upenn.edu/dissertations/AAI8816205/

Portable Fuel, 1999. In Oil Freight Container :Design CriteriaFor Specialized Shipping Container.

Radwan A.H., 2015. Reusing Shipping Containers. International Journal of Scientific & Engineering Research.