

Containers Architecture

Reusing Shipping Containers in making creative Architectural Spaces

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Abstract:

Reusing and recycling of materials is considered as an important value in sustainable design and architecture that prolonged among many historical ages, from reuse of stone, wood, marble columns, etc... the previous decades witnessed the use of many materials in creating spaces that can host various functions, not only for economic or financial reasons but also for environmental reasons, in addition to the expenses of getting rid of these materials or reprocessing them by any mean. From re-use of paper, till reusing steel shipping containers, various attempts have been made to explore the possibilities, opportunities and examples of creating many functions, projects, or even large buildings been constructed in this way, the wide increase of these applications lead to the emerging of a type of architecture called afterwards containers Architecture. This paper is an attempt to explore this containers architecture, by studying different opportunities of reusing these steel boxes, that are usually supposed to be left unused or expensively reprocessed in a complicated manufacturing process that not only costs money but also consuming energy. This type of Architecture aims to create some architectural spaces that hosts different functions & human activities, not only on the scale of an individual building but also on a larger scale that can help in creating a quick or sometimes temporary solution for a building or a group of buildings that are structurally stable & safe, environment friendly, with very high capabilities of achieving aesthetic values that can be utilized by people. 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.

Index Terms:

Containers Architecture - cargotecture - Shipping Containers, Recycling, architectural spaces, reuse of materials.



1. INTRODUCTION

Shipping container architecture could be defined as that type of architecture that is generally 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 sometimes 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 expense(s). 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.

What is a shipping container?

A shipping container is a steel box-usually cuboid-with a suitable strength to withstand shipment, storage, and handling. Shipping containers range from large reusable steel boxes used for intermodal shipments to the ubiquitous corrugated boxes. In the context of international shipping trade, "container" or "shipping container" is virtually synonymous with "(standard) intermodal freight container" (a container designed to be moved from one mode of transport to another without unloading and reloading)¹



Figure 1: Shipping Container



Figure 2: Shipping Container Dimensions.

While shipping containers are constructed to be used again and again, many eventually fall into disuse and end up sitting around the ports in China, northern Europe, and the United States. It is reported that an estimated 17 to 20 million of these ISO containers are peppered across the globe at any given time, with as many as 1 million of them simply sitting around taking up space

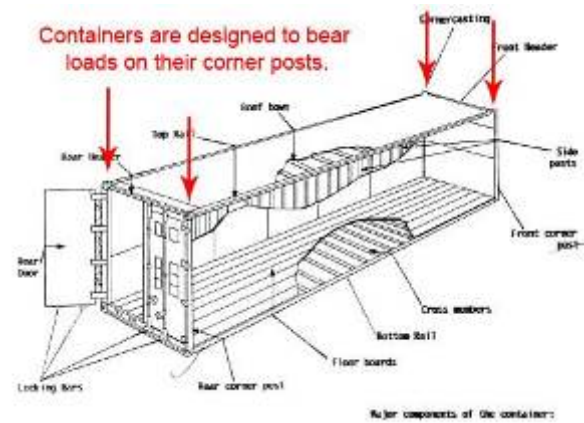


Figure 3: Bearing Loads on Corner Posts.

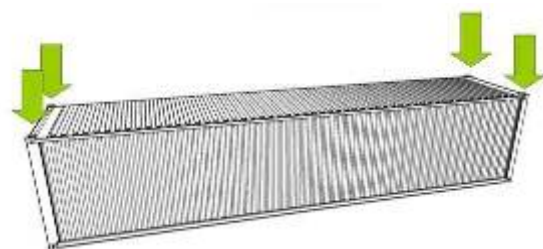


Figure 4: points of loading in a traditional Shipping Container.

2. FACTS

The following table shows the standard dimensions, volumes and weights of the shipping containers.

Specifications	10' Container	20' Container	40' Container
Inside Cubic Capacity	15.4 m ³	33.2 m ³	67 m ³
Max Gross Weight	non payload	30,480 kg	30,480 kg
Tare Weight	1,500 kg	2,360 kg	3,980 kg

Dimensions	Length	Width	Height
10' External	3.10 m (10')	2.44 m (8')	2.59 m (8'6")
10' Internal	2.98 m	2.35 m	2.38 m
20' External	6.05 m (20')	2.44 m (8')	2.59 m (8'6")
20' Internal	5.90 m	2.35 m	2.38 m
40' External	12.19 m (40')	2.44 m (8')	2.59 m (8'6")
40' Internal	12.01 m	2.35 m	2.38 m
Door Size		2.34 m	2.28 m

Figure 5: Various Shipping Container Dimensions.

3. 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.

4. 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 livable 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. So looking at any steel shipping container, the main and basic conditions of a space exists, with some modifications it can host various human activities of functions, thus creating not only functioning spaces but also interesting spaces for people to live, use and enjoy.

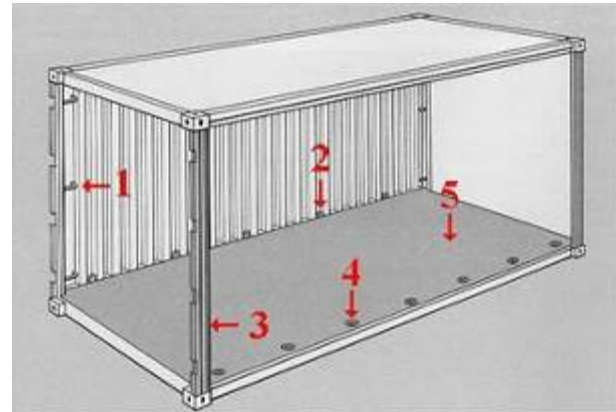
5. Why could a shipping container be used as a space unit that can create a building or a group of buildings.

6.1. The composition of the shipping container:

Any 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, its designed to resist forces as mentioned that exceeds the forces being developed in many architectural spaces like residences, offices, dorms, etc.

6.2. 2-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".



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

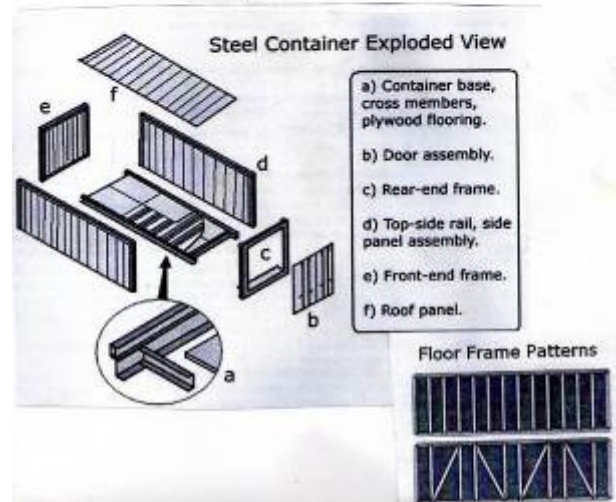
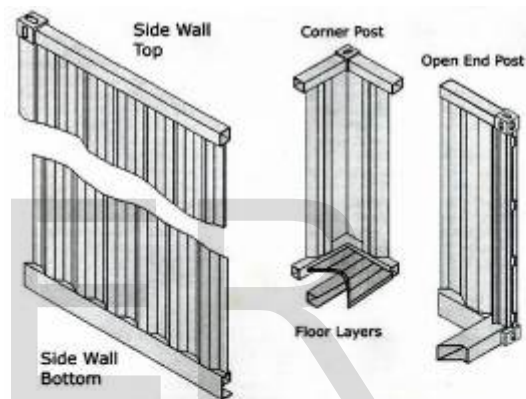


Figure 6: Steel Container Exploded View showing its structural composition.



Figure 7: Shipping Order of containers in regular horizontal and vertical lines.

6. The building functions that shipping containers can host.

As a result of its structural composition, a shipping container, in addition to its uniform, regular cuboid shape, besides its modular size(s), many functions inside a building or even complete buildings could be easily constructed by reusing these containers, several examples existed all over the world for functions or buildings that was constructed this way. In general shipping containers could be reused to construct these kinds of buildings/functions:

- Affordable housing.
- Press boxes.
- Emergency hurricane shelters for thoroughbred horses.
- Concession stands.
- Fire training facility.
- Military training facility.
- Emergency shelters.
- School buildings.
- Apartment and office buildings.
- Artists' studios.
- Stores.
- Moveable exhibition spaces on rails.
- Bank vaults.
- Medical clinics.
- Radar stations.
- Shopping malls.
- Sleeping rooms.

- Recording studios.
- Abstract art exhibitions.
- Transportable factories.
- Experimental labs.
- Combatant temporary containment (ventilated).
- Bathrooms.
- Showers.
- Workshops.
- Intermodal sealed storage on ships, trucks, and trains.
- House foundations on unstable seismic zones.
- Elevator/stairwell shafts.
- Hotels.
- Construction trailers.
- Mine site accommodations.
- Aviation maintenance facilities.
- Food Trucks.

Talking more specifically on real life projects, Shipping containers have been used all over the world in creating various projects, and in various countries, with very different scales and functions, the following are case studies been explored and analyzed for what globally known as container architecture, starting from a very simple residence till large scale developments.

6.1. Small Size Residence² small Shipping Container Cabin

- This small Shipping Container Cabin was created in 2008.
- It is composed of two 20 ft. shipping containers stacked on top of each other in a crisscross configuration, this seems to bear out that crisscross stacking can be done as another solution or alternative of formulating a non-traditional box shape.
- Adding some modifications and reinforcement required carrying the loads, specifically the additional I-beam and supports.
- Reinforcement is required not only in the lower container but in the upper container as well, the walls of a standardized container are not designed to support the placing of a container off the corner points, that means the upper container is balanced.
- it's not just a case of getting a crane to drop the two containers down on top of each other as it is aesthetically pleasing to the human eye by applying a specific color theme.
- Modifications have been made to connect the 2 containers vertically thus creating a staircase that connects the 2 levels.
- This crisscross stacking created a shaded area on both sides of the lower container besides two terraces on both sides of the upper container.
- Possibility of adding a third container on top of the second one, in case of needing an extra space.

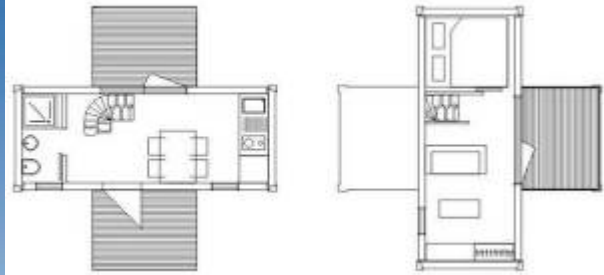


Figure 9: floor plans showing the internal and external spaces been created using the 2 containers on top of each other.



Figure 8: crisscross configuration of 2 containers on top of each other.

6.2. Shipping Container Guest House ³

- Texas architect Jim Poteet has designed this garden guest house in San Antonio. The small house is made of an empty steel shipping container and also serves as a playhouse, a garden retreat and a working studio. The container is 8 by 40 feet and features floor-to-ceiling glass doors and windows. Besides, there are heating and air-conditioning systems installed. The roof is filled with different plants. There are a small sink, a shower, and a toilet inside of the house.
- This guest house is made out from a recycled shipping container. Because of the container's nature not a wide range of possibilities is available to decorate it, the container was painted blue and two sections were cut and windows and big sliding doors were mounted.
- There is a small patio in front and above it a bit of a roof so the rain doesn't smash directly into the door. The interior feature wood panels on walls for the sensation of warmth and comfort.
- Bold combinations of colors and materials make from this structure a fine place to hang out looking permanently to the surrounding landscape. This unique residence idea and design belongs to Poteet Architects and you should know that this is not their only project involving shipping containers.



Figure 12: the integration of the guest house with the surrounding environment.



Figure 10: Making some modifications in the vertical planes to create doors and windows.



Figure 13: the guest house could be also a temporary residence.



Figure 11: using wood for the internal planes to change the industrial look of the container.



Figure 14: the guest house green roof .

6.3. Mid-Size Residences ⁴

Applying the same way, not only to a single or double shipping containers, many containers could be utilized to create a larger scale, with different configurations to host families of bigger size, with a bigger number of spaces, whether internally or externally.

The DeWitt and Kasravi Sea Container Home

- The home was designed by Modulus using four high cube shipping containers.
- The containers were pre-fabricated off-site then delivered to California before they were re-assembled.
- The very top floor has nine skylights fitted into the roof which provides huge amounts of natural light.



Figure 15: staking the containers in a way that can create an external space.



Figure 16: floor plan showing the internal and external spaces.



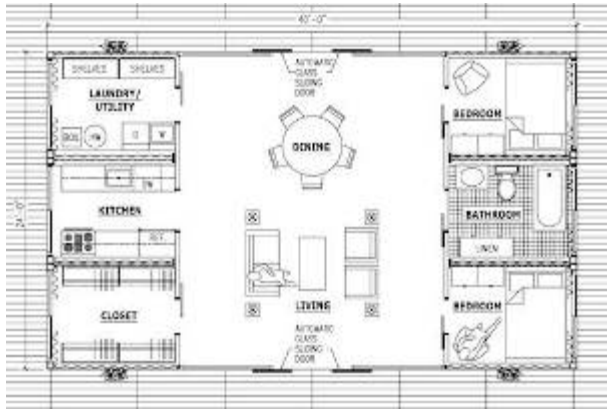


Figure 17: various configurations of staking the containers can lead to various models of residential units.



Figure 18: various configurations of staking the containers can lead to various models of residential units.

6.4. Keetwonen in Amsterdam, The Netherlands ⁵

Keetwonen is the name of the biggest container city in the world, living in a converted shipping container was a new concept in the Netherlands when launched by Tempo housing, but the city of Amsterdam took the step to contract Tempo housing to go and realize it. It turned out to be a big success among students in Amsterdam and it is now the second most popular student dormitory offered by the student housing corporation "De Key" (www.dekey.nl) in Amsterdam. The initial fears of some people that the container homes would be too small, too noisy, too cold or too hot,

all turned out to be unfounded: they turned out to be spacious, quiet and well insulated and certainly offer value for money, compared to other student homes in the city.

They also come complete with amenities often missing in other student dormitories: own bathroom and kitchen, balcony, separate sleeping and study room, large windows that provide daylight and a view and even an automatic ventilation system. The whole project was designed with an eye on how students like to live: a place for yourself, not having to share the shower and the toilet with strangers, but at the same time lots of possibilities to participate in the social life of the dormitory, including the many parties that come with being a student. The blocks have a closed off internal area for safe bicycle parking.



Figure 19: Keetwonen is the biggest container city in the world.



Figure 20: Keetwonen is the biggest container city in the world

Tempo housing's Keetwonen project was created in 2005. Residents may technically be studying in containers, but by no means are the individual rooms bare boned; each room has a bathroom, kitchen, balcony, and even high-speed Internet. The temporary project was originally meant to move on this year, but residents will be happy to know that relocation will not take place until 2016. And upon relocation, yes, the home can go with you.



Figure 21: floor plan for a typical room.



Figure 22: using a distinctive color helped in creating an eye-catching mass of rooms.



Figure 23: the designer worked on creating dynamic external spaces.

6.5. Cite A Docks

- Architect: Cattani Architects
- Location: La Havre, France
- Date: 2010
- Cité A Docks is a creative student housing project, located in Le Havre, France.
- 100 new student dorm rooms were created by transforming old shipping containers into a four-story building.

- Each apartment has 24 square meters and includes a bathroom and a kitchen, which is just about everything a student could need.
- when seeing the exterior of this building, as it looks too “metallic” and industrial while the overall gray certainly doesn’t go with the exuberance and energy of students.
- the architects had to say about this: “The metal structure allows a better identification of the different rooms, and enhances them through the external extensions that become terraces and balconies.
- The sequences of the transverse corridors giving access to the apartments on the façade creates a succession of full and empty spaces that gives the structure a more visual transparency.
- The new town is the result of the transformation of old containers in modular housing units equipped with every comfort. Mounted on a metal grid, the containers have given shape to a four-story building that houses 100 apartments of 24 square meters each.
- The architect Cattani said the thoughts that accompanied her work. “How do I prevent students, prospective tenants, they feel put in the box? Compelling needs have arisen. Necessary to conceive of a lightweight, transparent, and certainly not solid. Hence the idea of independent living, to avoid the stacking effect.”
- The solution was found in a metal frame that acts as a structural support to the old container, while allowing to stagger the units, and create new space for walkways, patios and balconies.
- The metal structure – Cattani says – allows a better identification of the different rooms, and enhances them through the external extensions that become terraces and balconies. The sequences of the transverse corridors giving access to the apartments on the façade create a succession of full and empty spaces that gives the structure a more visual transparency.
- The building designed by the metal structure is spread over four floors, which are distributed on the 100 studios. The first level was raised from the ground. In this way, the units here guests can enjoy the same privacy afforded to units on the upper floors.
- All the apartments overlook a garden inside and are equipped on both ends of the glass walls that allow natural lighting of spaces.
- To ensure maximum heat and sound insulation, the walls of the container adjacent to the outside and those that divide the different units have been coated with fire walls in reinforced concrete 40cm wide, and come within layers of rubber to dampen vibrations.
- The external facade is designed by the combination of the old “boxes” that has kept the undulat-

ing, repainted in metallic gray. Inside, the designers chose white walls and wooden furniture. Each studio has a bathroom and a kitchen.



Figure 24: the designer worked on creating dynamic external spaces.

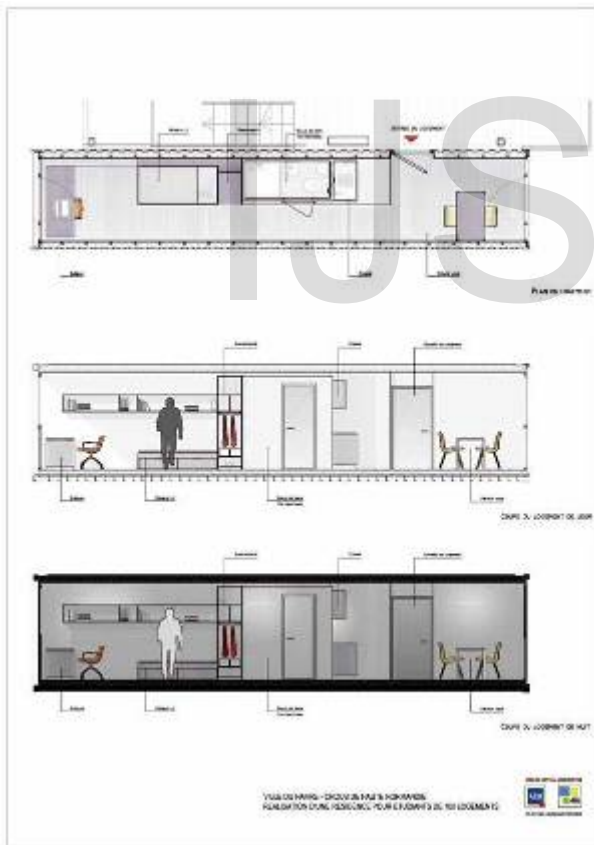


Figure 25: plans and sections through the room – shipping container.



Figure 26: containers staking in various directions created a distinctive urban configuration.



Figure 27: a steel skeleton was constructed to host the containers.

6.6. Cultural centers.

Platoon Kunsthalle, berlin, Germany.

- An example of shipping container architecture.
- Platoon Kunsthalle serves as an exciting and inspiring new exhibit hall and art center in Germany, berlin
- Built from standard shipping containers by Graft Lab Architects.
- the Kunsthalle, provides a modern space where new ideas thrive and creativity is let loose.
- The building houses art studio space, exhibit areas, a restaurant and bar, as well as lots of open space to gather
- Platoon Kunsthalle is designed as an experimental space for artists and creatives, and for the members of the Platoon Network.
- Opened on 2012



Figure 30: stability of structure.



Figure 28: internal view showing the spans that can be created.



Figure 31: creating a transparent elevation by removing the doors and replacing them with glass panels.



Figure 29: vertical stacking of containers lead to a reasonable height that is suitable for art works display.



Figure 32: main elevation with sculpture displays.

6.7. Crou in Le Havre, France ⁶



Figure 33: The pyramid-like arrangement of shipping containers.

- Olgga Architects made a livable, pyramid-like structure out of these 100 recycled shipping containers.
- Each container makes up one room, and appears to be much more spacious than jail-cell-sized accommodations back in college
- A housing complex for students have been designed by the French architectural firm Olgga Architects.
- The designed hostel will be built on 100 recycled shipping containers.
- And they named it "CROU". This is called green technology. What a thought!!! It's really amazing.



Figure 34: Front View.

- Shipping container structures are seen gaining a lot of popularity in current times. Not only are they beautiful and stylish, but also portable, affordable, durable and eco-friendly. This time I introduce you to a student housing complex built from recycled shipping containers.



Figure 35: 'Crou' student housing made from 100 recycled shipping containers

- Olgga architects, a French firm shaped 100 shipping containers into a sturdy, economical and sustainable student housing in Le Havre, France. Each of these containers will function as an individual room for a student while max-

imizing space limitations. Dubbed the 'Crou', the 2,851m² structure intends to make use of recycled containers, stacked in a somewhat pyramidal arrangement. From what it appears in the images, one side of the container will function as the entrance, and will have connecting stairs and platforms to reach the entrance. There is an environmental benefit associated with it which is it puts surplus containers to use instead of letting them slowly rust in a landfill.



Figure 36: One of the room typologies.

The project is named Crou, and will be spread over an area of 30,700 square feet on the school campus. It is an interesting design, and appears to be a well-designed project. What would be interesting to see is how the architects deal with the problem of noise that would be inherent to this all metal structure. But there should be a way to take care of that in the 4.45-million-euro budget this has.



Figure 37: Another room typologies.

Puma City

- Puma City is an 11,000-square-foot store, crafted with 24 red shipping containers, located a mere stone's throw from Boston's Fenway Park.
- Puma City is a three level indoor-outdoor structure, constructed out of 24 steel shipping containers.
- The building acts as a store, lounge and mobile home base at different ports around the world.

- The structure is designed to be easily taken apart, shipped and reassembled anywhere in the world.



Figure 38: Puma City – external and internal views.

6.8. London Container City I, II:

Early in the Trinity Buoy Wharf project we devised an innovative way of building affordable new workspace. Container City is a fully flexible modular system of using redundant shipping containers to create stylish and high quality, yet affordable, accommodation for a range of uses.

The prototypes, "Container City 1" and "Container City 2" were built at Trinity Buoy Wharf in 2000 and 2002, and since then a growing number of projects has been prefabricated in the Wharf's workshops, commissioned by a variety of local authorities, educational and health establishments and private companies. In 2005 the Fawood Children's Centre in Stonebridge, North London, made of containers, was shortlisted for the coveted RIBA Sterling Prize.

USM's headquarters at the Wharf occupy part of the largest and most recent Container City structure, "The Riverside Building", made from 73 containers and providing 22 separate units on five floors, completed in September 2005.

This versatile modular system is an outstanding example of recycling in practice, cutting both building costs and construction times dramatically and, with its strong yet lightweight framework, keeping the need for environmentally damaging concrete foundations to a minimum.

One of the most famous container building in the world, Container City II is easily recognizable by its ziggurat shape and bright colors designed to reflect the creative nature of who occupy its 22 studios.

As the second phase of the original Container City project at Trinity Buoy Wharf, Container City II is both an extension and evolution of the first building.

Built adjacent to Container City I, with inter-connecting bridges, a new lift and full disabled access, Container City II was completed in 2002 providing a further five floors of workspace and a great focal point to this exciting arts quarter.

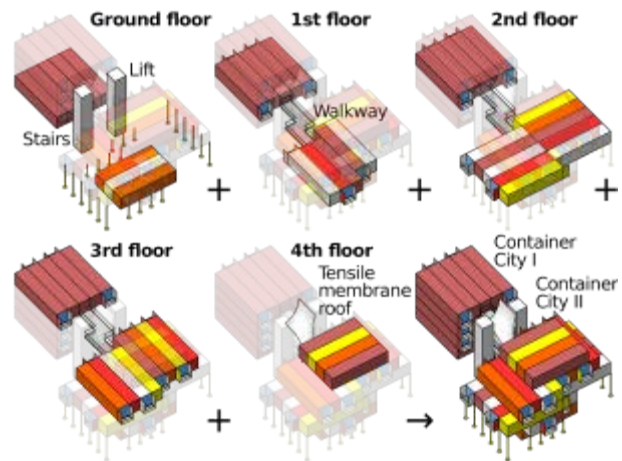


Figure 39: London shipping containers city.

7. CONCLUSIONS

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(s), 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:

- Eco-reusing thousands of unused containers scattered around global shores
- Economical, with empty shipping containers costing anywhere from \$1,000 to \$2,000 each.
- shipping containers are typically stronger than wooden frames, durable and made from galvanized steel,
- the modular design leads to an Easily designed plans with the ability to place containers side-by-side or up to 12 empty containers on top of each other
- Reinforced and ready for reuse, people have assembled pre-built homes in as few as three days
- Resistant to mold, fire and termites
- Can be converted into homes wherever is most convenient, and then easily transported and assembled at final destination
- Materials age well and require very little maintenance
- When building a house with shipping containers homes can be modified later on to include new modules

8. FURTHER RESEARCHES THAT CAN BE DONE BASED ON THIS RESEARCH

- Several researches can study the possibilities of using Containers Architecture in constructing low cost housing projects, whether in Egypt or in developing countries that need a quick solution to maintain a shelter for

- the homeless people.
- Studying the possibilities of high rise buildings using shipping containers.
- Wider emphasis on urban configurations using shipping containers.

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