

Reuse of Shipping Containers

Creative use of shipping containers, also known as Intermodal Steel Building Units (ISBU), is not a new concept (Fall, 2008). Shipping containers have been reused and transformed into art pieces, mobile hospitals, saunas, homes, condominiums, hotels, offices, shopping centers, and even “nomadic” structures. One of the largest structures thus far was a 120 bed London Travelodge made from 86 containers (Guevarra, 2008). Several resources are available to the engineer to understand the standards, materials, and performance criteria shipping containers are manufactured to. The real challenge with designs incorporating shipping containers is the determination of structural capacities and stiffness characteristics after the shipping containers have been modified and arranged. The modularity, strength, and geometrical variety of shipping container sizes poses simultaneous challenges for the architect and engineers.

In some circumstances the use of modularity reduced construction time and cost. Such was the case for the US Army Corp of Engineers 249th Engineer Company Operations Building at Fort Bragg North Carolina. Costing at \$150/sqft, the 4322 sqft two story office building used 12 Hi-Cubes (9.5ft high x 8 ft wide x 40 ft long), the project was completed in 101 days and under budget (Guevarra 2008). The “Shipping Container Housing Guide” website indicates that a container homes costs 20% to 50 % less than a traditionally designed home.

ISBUs are available in standard external dimensions. Typical containers are 8’-0” wide, with heights of 8’-6” or 9’-6”. Container can be found in 20 ft, 40 ft, 45 ft, 48 ft, and 53 ft in length. Most are made of structural steel coated with zinc. Certain containers are manufactured out of aluminum.

It is estimated that one million new units are made available each year, while 700,000 are retired (Guevarra 2008). Much of these containers are stranded in other countries, including the United States, because of an unbalanced import to export ratio (ISBU Assoc. 2008) There are two main routes by which a project team can obtain shipping containers. The first involves the purchase of a container that no longer meets the quality control requirements of the shipping industry, mainly due to damages such as penetrations. The second route is to purchase brand new or slightly used containers. In the former, the structural integrity of the system needs to be evaluated to a greater extent than the later. Freight containers can be damaged and are exposed to numerous environmental conditions during conveyance by road, rail, and/or sea. Toxicity, fungus growth, and bacterial residue should be evaluated and/or removed, or reduced to acceptable levels, prior to construction. At the time of purchase, one must also recognize the transfer of liability from the shipping container manufacturer to the engineer and architect of record.

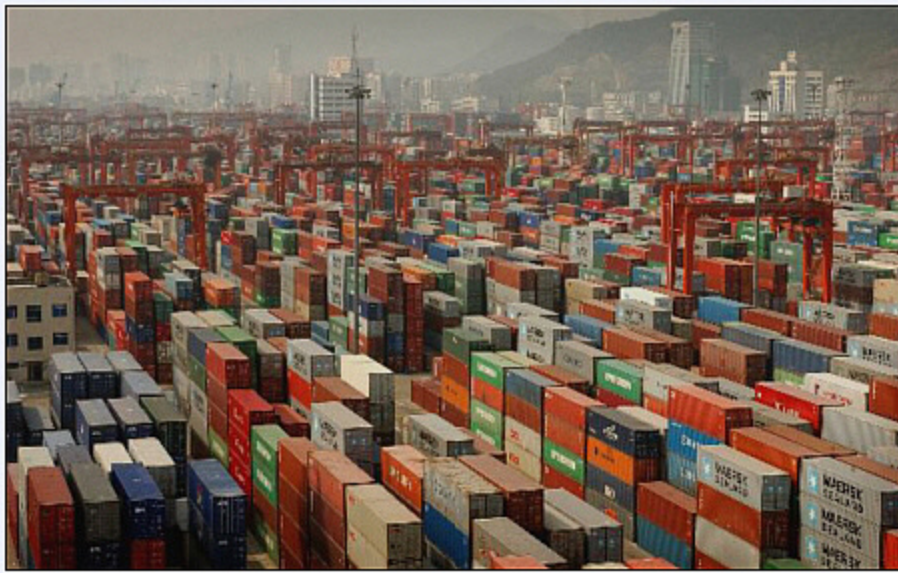


Figure 1 - Shipping Containers (ISBU Assoc. 2008)

Three International Standards Organization (ISO) Standards related to General Purpose Freight Containers the engineer should consult are ISO 668, ISO/TR 15070, and ISO 1496-1. ISO 668 classifies Series 1 freight container external, minimum internal, and door dimensions. ISO/TR 15070 provides the rationale behind the required structural test specified in ISO 1496-1, and is useful in understanding freight container design loads. ISO 1496-1 provides basic specifications and testing requirements for ISO series 1 freight containers. This standard covers general purpose enclosed containers and certain closed, vented, ventilated, or open top containers suitable for international exchange and conveyance. ISO 1496-1 can provide insight into the structural performance of freight containers. Two tests performed are as follows: 1) 3392 kN load applied at four corners simultaneously, 2) 1696 kN load on the roof skin applied at the two end corners simultaneously.

The ISO standards, though, can only provide performance specifications for unaltered freight containers. The engineer must use engineering judgment when stacking containers beyond typical shipping practice, and/or possibly modifying the vertical and lateral load resistance of these structures.

Structural information and uses related to shipping containers can also be obtained from large container shipping firms such as Moller-Maersk, Mediterranean Shipping Company, CMA-CGM, and manufacturers such as BSL Containers. The “Shipping Container Housing Guide” (www.shipping-container-housing.com) and the ISBU & Container Home Association (www.isbu-info.org) websites provide useful information and links.

Although, the foundation requirements for freight containers are not explicitly stated in a building code, one should specify a foundation system when appropriate. If the shipping container is temporary and mobile, a foundation system may not be required. For permanent freight container structures, whether anchored or unanchored, an appropriate foundation or subgrade preparation should be installed. Whether the containers are anchored down to the foundation is an engineer’s specification. Depending on the geometry, it would be advised to anchor the structure to prevent tipping or toppling due to lateral loads. Under certain circumstances, the engineer could choose to allow the container “building” to rock and/or slide. In one case a container built home,

located directly over the Hayward fault, was designed to slide over a diamond polished slab on grade system (a poor man's friction pendulum) (Bruce King XXX). Past earthquake and hurricane reconnaissance reports should be consulted on the performance of stacked shipping containers, you may be delightfully surprised (XXXXX).

Continuity within stacked container systems should also be evaluated. Typically containers are bolted at corners with large machine bolts. New machine bolts should be used for these connections, to avoid utilizing used bolts that may show signs of fatigue, corrosion and wear. ISO 3874 may be consulted for information related to the handling and securing of freight containers.

The behavior, performance, and classification of freight containers as a main lateral load resting system appear to be unknown. Intuitively, an argument could be made that freight containers could be classified as steel plate shear wall systems. Variables such as the corrugation pattern of the walls and decking, the thickness of the container walls, the vertical load carrying characteristics of the walls, the end frame system, and the construction of the container, may very well work against such a cursory characterization. Additional research into the shipping industry's technical reports to understand the behavior and load transfer between stacked structures under loading into elastic and inelastic regions may provide insight. The engineer of record should diligently evaluate and strengthen/stiffen containers as required. Further research and/or testing should be pursued in order to understand the seismic performance of such systems.

From a life-cycle perspective, SG Blocks LLC, a provider of code engineered cargo shipping containers, claims that it takes approximately 800 kWh to convert a shipping container. Compare this to 8000 kWh of energy to melt a four ton shipping container and 1800 kWh to recycle a ton of steel from 100 percent scrap (Guevarra 2008).

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<http://abcnews.go.com/Technology/SmartHome/Story?id=6201752&page=1>
<http://weburbanist.com/2008/05/26/cargo-container-homes-and-offices/>
<http://www.trendir.com/green/repurposed-shipping-containers-1.html>
<http://www.sgblocks.com/>
<http://firmitas.org/>
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http://www.isbu-info.org/why_isbu.html
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<http://www.greenerbuildings.com/news/2008/09/18/recycled-shipping-container-construction>