

Industrial Revolution

Every home that is built is a representation of compromises made between different and often competing goals: comfort, convenience, durability, energy consumption, maintenance, construction costs, appearance, strength, community acceptance, and resale value. Consumers and developers tend to make tradeoffs among these goals with incomplete information which increases risks and slows the process of innovation in the housing industry. The slowing of innovation, in turn, negatively affects productivity, quality, performance, and value. This department piece features a few promising improvements to the U.S. housing stock, illustrating how advancements in housing technologies can play a vital role in transforming the industry in important ways. If you have an idea for a future department feature, please send your diagram or photograph, along with a few well-chosen words, to michael.d.blanford@hud.gov.

Upcycling Shipping Containers for Houses

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Abstract

The status quo for single-family home construction has been wood frame construction, commonly called “stick framing” because of the dominant use of 2” x 4” dimensional lumber. Wood frame construction has served the home building community well; however, alternative building approaches are beginning to catch on. One alternative—shipping containers—has captured the imagination of architects and homeowners.

Introduction

At the inaugural Innovative Housing Showcase (Showcase), shipping containers were front and center. The Showcase, which was co-hosted by the U.S. Department of Housing and Urban Development (HUD) and the National Association of Home Builders, was held June 1–5, 2019, on the National Mall in Washington, DC. The Showcase enabled tours and first-hand experience of a multitude of innovative, affordable housing solutions for the public. Among the exhibitors were three companies that featured shipping containers: indieDwell, a Boise, ID-based company that builds single-family and multifamily homes for underserved communities (show-unit shown in the following image); Piedmont Green, a Greenville, SC-based company that produces single-family and multifamily homes and new shipping containers for sale to other builders; and MinMax Spaces, which manufactures modular structures but used a shipping container as an exhibit space.



Indiedwell unit-construction on the National Mall for the Innovative Housing Showcase. Photo Credit: Dana Bres

The Status Quo

The typical American home is built onsite at the location of the new home. The construction crew frames the walls using dimensional lumber (typically 2” x 4” or 2” x 6”), which is a time-consuming building process that can leave the home’s structure exposed to weather elements for an extended time.

Some disadvantages of the status quo for wood frame construction in homes:

- Low energy efficiency as measured by the R-value, the common measure of insulation effectiveness

- Time—it can take weeks for a home to be placed under a roof
- Skilled framing crew required for installation or construction
- Additional strengthening is necessary for homes built in high wind and seismic areas
- Uses a significant amount of timber resources

History of Shipping Containers

Although the U.S. military used small shipping containers to supply troops during World War II, the first standard shipping container that consumers are familiar with today was not realized until the 1950s. Malcolm McLean, a trucking company owner, is noted as the inventor of the intermodal shipping container (Mayo and Nohria, 2005). McLean submitted a patent for his shipping innovation in 1954 and was awarded a patent in 1958 (McLean, 1954). The first voyage of a ship retrofitted to carry shipping containers was from Newark, NJ to Houston, TX, in 1956 (Levinson, 2006).

Shipping Containers as Homes

Although ad hoc use of shipping containers for temporary housing likely began soon after the advent of shipping containers, their use as housing was formalized in 1987 when Phillip Clark submitted a patent for a “Method for converting one or more steel shipping containers into a habitable building at a building site and the product thereof” (Clark, 1987).

What to Know About Using Shipping Containers to Build a House

Containers are unique structural units. They are engineered to carry large loads using the least material, wherein each part of a container’s structure relies on its other parts for strength. For example, a container’s side panels—together with the bottom side rail, top side rail, and corner posts—act as a truss, a structural element. Modifying a shipping container changes its structural behavior; therefore, each change must be engineered. Many engineers are not generally familiar with containers’ structural properties, so finding the right engineer can be difficult. Homeowners who want to make economical use of containers should do some preliminary planning and keep their designs simple. Here are a few guidelines:

- Use the containers in their original form and limit the amount of side panel removed
- Steer clear of cantilevered¹ designs. These designs are all over the internet, but they are either imaginative unbuilt designs, heavily reinforced constructions, or constructions built in countries with less restrictive building codes and enforcement. Building codes in the United States, especially in wind or seismic zones, require careful design to ensure safety.

¹ A cantilever design is when one shipping container is placed on top of another perpendicularly so that some of the top shipping container is not supported underneath.

- Minimize cladding² to maximize value. You may be interested in building with shipping containers because you like the way they look. If so, you are in luck—a container will require little maintenance over the years with the right industrial paint. If you add additional cladding, you are adding expense and maintenance.
- Make sure you can get financing and insurance before you jump in. Conventional mortgage lenders do not have a box to check for this type of construction. This same problem exists for insurers. You will have to look to “surplus lines” for a custom policy. It may not cost more, but it will require more work to get financing and insurance.

Benefits

Shipping containers seem like great choices for homes because of their strength and durability. The same characteristics that make shipping containers ideal for making multiple trips around the globe also support their use as a home building component. Possible benefits of shipping containers over wood framing include:

- Improved environmental performance by a reduction in the use of dimensional lumber and the minimization of waste. The interior frame-out of your container home is not structural³, therefore, you can increase the space between studs. Smart planning will reduce material usage.
- Improved durability by increasing high-wind resistance. Container side panels are made of steel 1.6mm or more in thickness. This steel strength exceeds that of most exterior cladding products. Because containers are constructed using continuous welds, the overall continuity of their strength exceeds traditional buildings, which are made of individual pieces fastened together.
- Reduced carbon footprint by using used shipping containers. Upcycling used shipping containers lowers your global warming impact (along with other environmental impacts) over wood frame and concrete masonry construction.

Drawbacks

As noted above, the primary benefit of shipping containers is that they can be reused. However, reuse also introduces some possible drawbacks as noted below:

- Used shipping containers may have contained hazardous materials. Because containers are painted steel with treated wood or bamboo floors, however, the chance that they can hold onto any hazardous materials after the original floor is removed and a good scrubbing is conducted is low.
- Used shipping containers may have structural or cosmetic defects. Generally, structural damage is repairable, but unwanted dings and dents are hard to remove. Always inspect the

² Cladding is covering used to protect the exterior walls of a house. Typical claddings are made out of vinyl, fiber cement, and brick.

³ Interior frame-out refers to the construction of interior walls, including those walls that abut the exterior walls of a shipping container. These walls allow for the installation of wiring, insulation, and drywall.

used units you plan to buy—with an engineer if you are worried—to make sure the shipping containers are up to your expectations and do not have unreparable damage.

- Metal exterior offers poor thermal performance. Thermal bridging³ can be avoided with proper architectural detailing, however.
- Convincing your local code official that this is a good idea could be a challenge. Most building codes do not prohibit the use of containers, but that does not mean that using them will be easy. Most jurisdictions will require that you provide plans sealed by a licensed architect or engineer before granting a permit. Think of this not as a problem but as an opportunity to engage with a professional who has some experience using shipping containers.

Manufacturers

Although homeowners can build their own shipping container home either by themselves or with an experienced homebuilder or architect, container homes will soon be increasingly available through manufacturers. The manufacturers recognize the strength and efficiency of the ready-made container and can put manufacturing systems in place to produce high-quality, energy-efficient container homes at affordable prices. Many manufacturers can use mass-customization practices to create location- and client-specific versions to satisfy the growing need for affordable housing solutions.

Further Reading

ICC G5-2019, Guideline for the Safe Use of ISO Intermodal Shipping Containers Repurposed as Building and Building Components, International Code Council, 2019.

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