Form and Function:
Shipping Container Architecture in a Changing Landscape

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Advanced Project Course 2019-2020 Winter

March 11, 2020

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Abstract

With growing populations and changing economics, Southern California is currently facing a housing crisis. Environmental concerns, limited resources, and local legislation add to the complexities of this issue. Architects and designers are using shipping containers, in various commercial, public, and residential applications, to resolve some of these challenges in various parts of the world. Many professionals within the industry are touting container construction as a cost-effective, safe, and efficient alternative to architecture constructed using traditional building materials.

The purpose of this stand-alone research paper is to examine data related to shipping container architecture to further understand its practicality, advantages, and limitations when used in a residential application. Critical data will be obtained through library and online research, interviews with working professionals, case study reviews, and the use of industry related publications.

The goal is to help design professionals and civic officials understand the basic facts of shipping container architecture while providing additional detailed analysis to determine if this design concept can be considered a viable option to help resolve components of the housing crisis experienced in Southern California.

Keywords: shipping container architecture, architect, residential

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Although California has historically been an expensive place to live, Southern California has been facing a housing crisis that has gained national attention over the past twelve years. Population growth, a changing economic environment, climate and natural resource concerns, as well as archaic legislation have all added to the complex housing-related issues that Californians face every day (Buhayar & Cannon, 2019). Though multiple cities and counties within the state have sponsored research in how to help address these issues, California still faces these challenges. Professionals within the design industry have constructed innovative methods using shipping containers to help address some of these issues. Many professionals within the industry believe this design concept offers cost-effective, safe, and efficient solutions to these widespread issues. Through various design applications throughout the world, designers are helping change the perception of shipping container architecture. Even with its challenges, shipping container architecture can potentially have a positive impact on neighborhoods, the environment, and the quality of life of its residents. This study helps examine the innovative concepts of shipping container architecture to scrutinize its viability in addressing housing-related issues.

Housing Issues

According to Buhayar and Cannon (2019), the median price for a house in California now averages just over $600,000, which is more than twice the national level. Out of the country's seven most expensive housing markets, five belong to California, with three of them being located in the southern part of the state. These markets are responsible for more than 50% of San Diego households being cost burdened (more than 30% are considered severely cost

burdened) where they are designating nearly half of their monthly income to housing (JCHS, Harvard University, 2020).

Local legislation also has influence over housing related issues. In an effort to preserve land and protect the environment, the "Not in my backyard" or NIMBY clause was enacted. This protects communities by limiting the amount of new development. This limits the amount of inventory to meet the demands of urban growth thus affecting affordability. As residents move further out of the city in hopes of cheaper alternatives, they are faced with new challenges in the form of wildfires. Due to climate change, wildfires have become more frequent resulting in personal devastation and billions of dollars in associated expenses. This increased risk limits development in new areas thus keeping the current inventory in high demand and prices high.

A price to income ratio (PIR) is typically the standard formula for gauging affordability of housing within a specified region that represents the ratio of a median house price to a person or family's annual income. In short, it is the amount of a household's income that is devoted to housing expense (Sani, 2015). Historically, the standard rule for PIR, used by the real estate industry, was that the cost of a house should equal approximately 2.6 years worth of household income (Florida, 2018). As of 2017, San Diego's PIR was over 8%, well above the historical national average (JCHS, Harvard University, 2018). Skewed PIRs, minimal "low-rent" options and inventory, as well as increased land value pricing have all contributed to why large companies like Facebook have subsidized housing for teachers who could not afford their rent, or the fact that policemen in various California cities resorted to sleeping in their cars. These situations are some of the reasons why California makes up nearly 25% of the country's homeless (Buhayar & Cannon, 2019).

Shipping Container Facts

Although shipping containers were originally intended to standardize the transport of goods from one place to another, engineers and architects started to see their potential for other unintended uses. Soon after, shipping containers were being integrated into architectural plans for residential, commercial, and military applications. This new approach to architecture has been adopted by many architects and designers who feel that this alternative to traditional design can not only address some of the current housing-related issues challenging the west coast of the United States but can do it with an aesthetic that is attractive and manageable to the builder, governing officials, the community and ultimately the client.

The standardized shipping container is a fairly recent invention. Malcolm McLean, the owner of one of the largest trucking companies in the United States in the 1950s, was frustrated by the lack of standardization within the shipping industry. McLean patented the first shipping container in 1956 which allowed him to experiment with his concept. After multiple attempts, he finalized a design that is now known as the International Organization for Standardization (ISO) shipping container. Due to its uniform design, durability, strength, and storage capacity, it is the standardized container used in various methods of transport throughout the world (ISBUA, 2016).

ISO shipping containers have standardized specifications that typically come either in 20 ft (6.096 m) or 40 ft (12.192 m) lengths and are 8 ft 6 in (2.591 m) high. Both sizes come in a standardized width of 8 ft (2.438 m) which is why they are easily stackable. Their cubic footage is either approximately 1,700 ft^3 (33 m^3) or 2,400 ft^3 (67 m^3) respectively. Standard container dimensions are presented in Table 1 (Moore, Yildirim, & Baur, 2015, p. 2). Their construction consists of steel, aluminum, reinforced polymer, and wood. They have corrugated steel walls,

joists, and tops (optional) that are welded to steel rails and end-frames. Hinged doors with rubber seals and marine-grade wood flooring are used to ensure water resistance. Once completed, a typical container weighs approximately 8,400 pounds. According to Western Container Sales' website located at https://westerncontainersales.com/shipping- container-prices/los-angeles/, a shipping container wholesaler located in Los Angeles, California, typical costs for a new, one-trip, ISO dry goods shipping container averages between $2,600 and $5,000 depending on the size. Used containers have an average price range between $1,200 to $2,900.

Design Achievements

These specifications are only a few of the reasons that make shipping containers so appealing to advocates of this style of architecture. One of the major contributing factors to its appeal is the cost effectiveness of the product. Typically lower in cost when compared to new, used shipping containers can significantly reduce the overall costs of a residential housing project. Even with ancillary costs associated with design plans, delivery, permits, site preparation, infill, and customization, shipping container dwellings typically run almost half the price per square foot of conventionally built structures. A typical schema for a basic single story container based apartment can cost as low as $15,000. While this does not include transportation, site preparation, or furnishing, a significant savings is still gained in comparison to traditional construction (Berbesz & Szefer, 2018, pp. 2-3).

The ISO standardization that makes containers so functional in the transportation industry is what makes shipping container architecture so cost effective in the housing market. Standardization allows architects and designers the benefit of prefabrication. This advantage reduces the time needed to over customize architectural and mechanical plans, resulting in a reduction of design time, on-site construction, and additional costs. Additionally, certain building

materials can be prefabricated and drop shipped directly to the building site for immediate installation. According to SG Blocks, a leader within the container environment industry, this type of technology helps to shorten construction time by up to 40% and reduce costs up to 70% (Berbesz & Szefer, 2018, pp. 3-4). Economically, there is an undeniable advantage of using shipping container architecture to reduce building costs and construction time.

Globally, we consume raw materials, for the purpose of building materials, that has an acute impact on the environment. Millions of acres of forest are harvested, materials needed for building are produced in factories and transported in vessels that generate pollution. The U.S. Green Building Council states that building construction accounts for "39% of U.S. primary energy use; 70% of U.S resource consumption; use 12.2% of all potable water, or 15 trillion gallons per year; and consume 40% of raw materials globally (3 billion tons annually)" (USGBC, Senate Statement, 2007). Depending on the site, container construction typically requires less cement. There are some sites that do not require the use of cement at all. This supports a more environmentally friendly approach to building since the cement industry is notorious for being one of the biggest producers of carbon emissions.

According to Drewry Maritime Research, harbors around the world stored over 30 million containers since 2012 (Moore, Yildirim, & Baur, 2015, p. 3). Financially, transporting containers without cargo, back to its original port is not cost-effective, so repurposing and upcycling containers is not only fiscally effective, but offers the opportunity to build with materials that would have gone unused and become global waste.

Due to increased risk of wildfires, climate change as a whole, has reduced the zones in which developers are allowed to build. This issue is compounded by strict legislative conditions that reduce the availability of land, making building opportunities scarce, thus driving up prices.

Depending on the application, the modularity of container construction makes it possible to accommodate a higher volume of dwellings while reducing its land footprint.

The process to convert a container into a living space does require the use of resources. Sand blasting as well as the abatement of certain waterproofing chemicals and insecticides, are needed prior to installation. Additionally, openings for windows and doors must be constructed. Newer containers are being constructed using bamboo flooring which is a more sustainable product than hardwood. On average, a shipping container uses approximately 500 kWh of energy during its recycling process to become habitable. The disposal of an empty container typically requires almost 8,000 kWh of energy (Berbesz & Szefer, 2018, pp. 2-3). When comparing the difference in carbon emissions between building a two-story single family house using traditional architecture techniques (approximately equal to 88 tons) to building a two-story shipping container architecture using two 40' containers (approximately equal to 20 tons), it is easy to see which style leaves a smaller footprint (Falcon Structures, n.d.).

Climate change is being felt in all parts of the globe and Southern California is no different. Strong winds and long periods of drought means that most of California is at high risk and subject to wildfires. This part of the country is also prone to earthquakes. Shipping containers have proven to be affordable housing solutions in this type of climate. When used in their original capacity, shipping containers are designed, and charged, with bearing heavy loads and transporting valuable cargo in extreme weather conditions (Radwan, 2015, pp. 1562-1564). Their steel framing makes them resistant to fires, and when properly anchored and installed, they are seismically sound and can withstand hurricane strong winds (Dugal et al., 2016). In response to shipping container architecture's popularity and acceptance, regulatory agencies, engineers,

designers, and other leaders within the industry are starting to work together to create guidelines and permits that will ensure its continued and enhanced safety.

Design Challenges

In spite of its numerous advantages, shipping container architecture has its share of challenges and opponents. While most architects and industry professionals agree that container architecture can be the right solution in the correct situation, some feel that the challenges simply outweigh the advantages under most conditions. “Carbon footprint” awareness and the growing acceptance of sustainable construction are responses to the unpredictability and volatility of climate change within the environment. Part of the sustainable appeal in shipping container architecture is the fact that used containers can be repurposed, thus reducing the amount of unused materials throughout the globe.

Since shipping containers are not intended for human habitation, chemicals such as chromate, phosphorous, arsenic and chromium, normally used as insecticides, must be removed prior to construction. Lead-based paints are often used when building containers and therefore must be removed during the sand blasting process. Containers are designed to have a lifespan of approximately 10 years. Used containers typically have dents and scratches which occurred during usage and transport. In order to maintain their lifespan, the dents and scratches must be refurbished to mitigate rust and further degradation. Refurbished containers that are painted regularly can extend the container lifespan by more than 20 years (Dugal et al., 2016).

Once a container has gone through a complete abatement process, it is ready for installation. This brings on a new set of challenges. Because of their steel construction, they quickly absorb heat and cold, thus making it difficult to regulate interior temperatures. While this issue can be mitigated, insulation (this can also be a detriment to the environment depending on

the type used) requires space which reduces the interior dimensions. Containers come in a standardized width of eight feet. Once insulation is installed, the interior dimension is reduced to seven, making for a narrow living space. International Residential Code R304.1 states that habitable rooms (typically living and sleeping) need to have a minimum of 70 square feet ($6.5m^2$) which includes a minimum length and width of seven feet (International Residential Code, 2018). Utilities also pose challenges to container architecture. Traditional construction allows builders to conceal electrical, plumbing, and other mechanical utilities behind walls, ceilings, and floors. While most electrical wiring is small enough to fit behind finished walls within the container, polyvinyl chloride (PVC) piping and heating, ventilation, and air conditioning (HVAC) ducts are not as forgiving. Sites, like those in Southern California, where hot weather is a concern, traditional central air conditioning cannot usually be installed due to the lack of space for HVAC ductwork (Discover Containers, n.d.).

Shipping container architecture has a series of complex requirements that is often confusing to building officials. It is very common that rules differ depending on whether the entire installation takes place on-site or if some of the parts come prefabricated and are constructed off-site. Interpretation of building codes and legislation is also a challenge when dealing with officials. Those who are unfamiliar with this style of building are often confused and determine compliance based on their own interpretation. Ambiguous building codes, zoning laws, and state legislation can often lead to struggles and occasional design modifications (Discover Containers, n.d.).

Shipping container architecture has been recognized and deployed through the joint efforts of architects, builders, interior designers, and urban planners throughout the world. The modular nature of containers have proven to be a successful solution to various multi-unit

dwellings that could potentially be used as a foundation in helping address certain housing-related issues in southern California.

Case studies of these applications can provide qualitative exploration to better understand, and compare, the theories and logic behind the solutions. Two case studies have been included to review how this particular architectural design concept has been used in different parts of the globe to address acute housing challenges. Examination of these concepts may not be conclusive but will provide details that can be used for additional research.

Case Studies

Case Study #1 - Maboneng Precinct

LOT-EK Studio, an architectural design firm with locations in the United States and Italy, is a firm dedicated to bringing innovative structures to the world while maintaining sustainability through the recycling and upcycling processes. Propertuity Ltd, a development company based in Johannesburg, South Africa, commissioned LOT-EK to design a multi-purpose building to include residential units with ground floor retail space. The structure was part of a project to support the Maboneng Precinct's urban regeneration.

The 75,000 square feet space consisted of studio apartments that ranged between 300 to 600 square feet, and was constructed entirely of 140 unpainted shipping containers. The structure was built using a "V" formation plan to allow for a triangular courtyard which included a pool and deck (LOT-EK, n.d.). Since the metalwork was completed onsite, the team was able to become more efficient and recycled most of the residual materials for reinforcement and other public art forms such as garden sculptures (Eicker, 2018). LOT-EK Principals Ada Tolla, Giuseppe Lignano, and project architect, Sara Valente, along with many other industry professionals were able to complete this project in 2017 which was intended to support the

rejuvenation of the downtown area while actively engaging the community that had seen the urban center fall into decay and crime post-apartheid. Even though the area has successfully regentrified, rental costs within the development are still below market prices and average around 4,000 Rand ($300 US) (Zilliacus, 2019).

(Southwood, n.d.)

Case Study #2 - Keetwonen Student Housing Project

High costs associated with construction and building operations, makes affordable student housing almost nonexistent. In 2004, approximately 6,000 students found themselves on a waiting list to find affordable housing while attending the University of Amsterdam. In an effort to respond to the University's housing issues, Dutch developer, Quinten De Gooijer, founder of Tempohousing, devised a solution using shipping containers as student housing. The Keetwonen Student Housing Project, which proposed the use of shipping container architecture,

was the only proposal “deemed feasible, defined as one in which rents could support building costs,” by the city of Amsterdam, the University, and various housing agencies.

Keetwonen consists of residential and supporting retail spaces made up of 1,000 containers. The development includes laundry facilities, a convenience market, a restaurant, and a bicycle repair shop. Due to their modular nature, builders were able to implement between 20 and 25 units per day. The project site has a footprint of approximately 4.5 acres with a height of up to 5 stacked containers. Courtyards, connecting stairways and bridges, along with bicycle storage and walkways provide public areas that give a sense of community to the 12 structures that make up the development. First floor units have attached garden areas while balconies are standard for apartments above ground level. Sustainability was a requirement so cross ventilation, eco-friendly insulation, and specially designed roofs to collect rainwater were incorporated into the construction.

At the time of completion, each unit had a total cost of approximately $28,000. While this price did not include taxes, it did include amenities such as the balconies and stairways as well as the mechanical infill. Container prices can sometimes be dependent on the volume of units purchased. As a result, the project benefited from an economy of scale. This cost benefit was passed along to the student tenants by providing them with affordable rent. Monthly rent averaged approximately $600. The Keetwonen project has proven that container architecture can provide affordable, safe, and private (each student has their own unit) housing that is considered “cool” (Uittenbroek & Macht, 2009).

(Tempohousing, n.d.)

The Maboneng Precinct and Keetwonen projects have shown that shipping container architecture has the ability to challenge the conceptions conventional urban planning, architectural design, and building materials. Tenants who might normally be excluded from obtaining cost-effective housing, are now afforded the opportunity of quality housing. Due to their economies of scale, larger projects such as Maboneng and Keetwonen provide the fortuity of financial return for private investors through lower costs associated with building materials. Their modular nature creates a more efficient construction process which can result in reduced labor costs. The scale, efficiency, and success of these projects can potentially lead to increased capital that can be used to fund future projects.

One of the significant conclusions that can be established from these two case studies is that public policy should be challenged. Governing agencies around the world are tasked with finding solutions to their particular housing-related issues. Affordable housing, disaster

mitigation, budget and economy stability, and environmental impacts are a few of the top issues and challenges being discussed by public lawmakers (Lays, 2019). The Maboneng Precinct and Keetwonen projects have shown that shipping container architecture can help address these challenges and have a positive impact. Beyond their cost-effectiveness, both projects injected growth into their communities through the integration of residential and commercial spaces. Their efficient construction resulted in cost savings and reduced building time. By repurposing containers, these projects support recycling and reduced energy consumption initiatives. Though challenged with the burden of reviewing current building codes and zoning laws, policymakers have the opportunity to realize the overall savings in resources, community revitalization, and positive environmental impact that shipping container architecture can bring to a local area. Updated legislation and continued research can help determine if using this type of architecture can be a long term solution to some of the current issues that lawmakers are debating.

Industry Perspectives

Qualitative research interviews with design industry professionals were conducted. Interviewees were asked a series of "semi-structured" questions related to their perception of shipping container architecture from varying perspectives. The purpose of these interviews was to obtain details from real-life experience as it relates to the theories, client interactions, applications, and effectiveness of this particular design concept.

RAD LAB is a San Diego based architecture firm that was founded by three graduates of the local New School of Architecture and Design. RAD LAB's first completed venture is now a very well known community space called Quartyard. Although originally started as a school project, Quartyard is an urban outdoor space constructed from upcycled shipping containers. Located in San Diego, it serves as a "green" public space dedicated to community engagement.

The success of this project helped position RAD LAB as specialists in container architecture and experts within the local design industry.

As part of my research, I interviewed Philip Auchettl, Chief Executive Officer and Co-Founder of RAD LAB and member of The American Institute of Architects. When asked to briefly sum us his thoughts on shipping container architecture, Auchettl stated that, “84% of RAD LAB’s projects involve, or have involved, shipping container architecture.” (P. Auchettl, personal interview, February 18, 2020). Due to the flexibility, sustainability, and affordability of containers, they are a pragmatic solution for projects involving single family and multi-unit dwellings, as well as commercial spaces.

During the interview, Auchettl addressed the advantages and challenges that must be considered when utilizing containers as architecture. He echoed other industry professionals who support this type of building design when he stated that container architecture is typically “cheaper” than conventional construction methods, even when taking the upcycling costs into consideration (Auchettl, 2020). Containers are also a more sustainable option, which is a major concern in Southern California. Using containers for unintended purposes reduces the number of unused containers that would otherwise just become “useless surplus.” This is significant as San Diego and Los Angeles both have international ports.

Auchettl added that container architecture is more efficient because of how and when the mechanical utility systems and building finishes can be installed. Conventional construction methods require a great deal of utility “pre-work” that needs to follow a particular routine while at the site. This can delay progress of the project. However, “Utility connections can be done all at once instead of [depending on] the normal ‘pre-work’ processes.” This does not mean that this method of construction is without its challenges. According to Auchettl, the biggest challenge he

and proponents of this design method face is “the lack of experience in contractors and building crews” (Auchettl, 2020). Due to its unique techniques, highly experienced builders are scarce, even in an area that is embracing this type of construction. But this does not take away from the overall benefits.

When asked what the most significant advantage is when using container architecture in local projects, Auchettlresponded with “time.” He added that the concept of container architecture is typically well-received by most municipalities within the state of California. As a result, the processing of permits and “plans” is a much quicker process than that of conventional construction. Shipping container architecture can receive permits within two weeks while conventional method projects can take up to six months. This has a major impact on how solutions are developed when considering new construction.

RAD LAB’s mission statement, located at https://www.radlabsd.com/mission, incorporates a purpose to “Inspire individuals, foster community, and impact the future.” When asked how RAD LAB can fulfill this mission and influence the local community, Auchettl referenced a current project in Logan Heights which has historically been an underserved neighborhood. Auchettl and the rest of the project team believe that this new project acknowledges the need for affordability and opportunity. He closed the interview by sharing that, “Shipping container architecture is driving projects that allow for affordable housing, retail, office, and community spaces. Ownership fosters a sense of community. Plus it has a cool factor”(Auchettl, 2020).

Architects are not the only design professionals involved in shipping container architecture. As partners within the design industry and on projects, interior designers also play a role in this type of architecture. When addressing housing-related issues, inhabitable space must

be considered. John Scott, Owner and President of Keevan Sadock Design, National Council for Interior Design Qualification certified, and former President of the Illinois Chapter of the American Society of Interior Designers, was also interviewed as part of the research for this paper. As an interior designer who is responsible for ensuring safety, comfort, aesthetic, and functionality to design clients, John is a proponent of shipping container architecture. While he has seen "very successful applications," he has concerns related to function and comfort because he feels that most people would be challenged by the long narrow space (J. Scott, personal interview, February 16, 2020). The finished interior space on a typical container housing structure is seven feet due to insulation and drywall installation. This issue is important due to International Residential Codes (IRC) that regulate minimum regulations for residential structures which was discussed earlier. This requirement was updated in 2015 in response to housing-related issues in areas around the globe. Per the IRC,

> Proponents of minimalist living have advocated smaller dwellings to reduce environmental impact and provide for lower living costs through reduced mortgage and maintenance expenses. These dwellings are intended to allow for a minimalist lifestyle that doesn't demand large volumes of living space (International Code Council, 2015, pp. 46-47).

However, Scott adds that stacking, connecting, or cantilevering multiple containers together to create a larger space can minimize this (Scott, 2020).

In a separate interview, Kolleen Elmer from Keevan Sadock Design expressed her thoughts about using shipping containers as residential structures. When asked about the challenges interior designers face when working with this type of space, Elmer addressed the potential of residual hazardous materials. "Abatement of these materials can be costly, followed

by the decision as what to do with those materials, as waste, exists as well" (K. Elmer, personal interview, February 11, 2020).Elmer's second concern centered on the shipment of the container itself since there are not a lot of companies that are familiar or specialize in the movement of shipping containers outside of their immediate area. Moving a container could be of great cost when shipping them to a desired location. Despite these concerns, Elmer expressed support for using container architecture because of cost savings in other areas like labor and materials, as well as a significant reduction in time for the entire project. She added the "footprint" of a shipping container is typically smaller than traditional structures, so there are opportunities to utilize them in smaller spaces that would not historically be approved for residential construction.

Elmer's final thoughts during the interview reflected on the potential that shipping containers have for being considered a sustainable building option. "I see these containers sitting stacked in the Midwest rail yards, particularly west and south of Chicago. They are there, and they are doing nothing. If there was a way to reel in costs of abatement and shipping, this could be a viable solution. It would be wonderful to see them used for a greater good" (Elmer, 2020). Further research is needed to determine the cost-effectiveness of utilizing shipping containers as architecture in areas of the United States that do not have point-of-entry ports.

Social Impacts

Regardless of their application, shipping container architecture has the ability to impact its surrounding community. Numerous projects around the globe, much like the Maboneng Precinct development in South Africa, have explored its impact on the rejuvenation of neighborhoods, how to address affordability issues, how to maximize space, and how to bring an appreciation for community within urban spaces.

Quartyard, the sustainable urban public structure, constructed of shipping container architecture, that was once a vacant lot in the East Village neighborhood of San Diego. Converting the space into a multi use outdoor space has successfully engaged the local community. Quartyard provides a dog run, beer garden, restaurants, and an area dedicated to events and art displays. As a result, it has played a role in helping the neighborhood transform itself into a thriving area of businesses, residential spaces, and entertainment venues. During his interview, Auchettl stated that with every shipping container project that RAD LAB has participated in, the introduction of this type of architecture has created "community curiosity and intrigue" (Auchettl, 2020).

According to the San Diego Housing Commission, over 20,000 families in San Diego are on a waiting list for financial aid to subsidize their rents, with a list that increases by approximately 500 names per month (Halverstadt, 2020). Architecture built out of shipping containers averages half the cost per square foot of a conventional structure (360mobileoffice, n.d.). This type of architecture could provide opportunities for developers, governing agencies, and many of the underserved members of the community whose names are included on this list. Permanent housing, community involvement, and inclusion could lead to some level of control that could be used to stabilize affordable housing efforts.

Gary Warth's article, "Shipping Container Homes May Be Set Up at Area Church", (Warth, 2019) speaks about a group called "Yes in God's Back Yard" (YIGBY) that is coordinating shipping container projects on church properties to assist individuals in securing affordable housing. YIGBY is a San Diego based group that advocates on behalf of San Diegans, in conjunction with other non-profit groups, to help assist in securing affordable housing for those unable to do it for themselves. Although often met with the "Not in my backyard" backlash

as well as zoning laws that prevent the development of low-income housing, the group is circumventing these challenges by partnering with churches who are willing to use their underutilized land as the sites for these needed projects.

Andy Ballester, a co-founder of GoFundMe.com, is a resident of San Diego County and an advocate of the YIGBY mission. He stated that the goal is to create projects involving 10-30 units in total. Through partnerships with local social agencies, these projects would focus on assisting low-income families, veterans, seniors, and homeless individuals throughout the county (Warth, 2019).

Each unit would cost between $140,000 and $167,000, far below other housing projects that have cost between $500,000 and $700,000 per unit. Each container would be converted into a one-bedroom studio unit that includes a bathroom and kitchen. Each participating social service agency would determine the rent, but the idea is to set the price of rent below market rate. The projects would allow residents an opportunity at permanent residency while providing rental income for the hosting church and participating agencies[1], thus allowing them to remain active within the neighborhood to provide various types of outreach to the community (Warth, 2019).

The shipping container project on Colden Avenue in South Los Angeles proves that this innovative concept can impact lives and neighborhoods. This particular project, sponsored by Flyaway Homes, a local non-profit housing organization, transformed 48 containers into 9 units housing a total of 32 tenants. Each 800 square foot unit provides a permanent and supportive solution to tenants that were formerly homeless (Klemack, 2018). Although typically met with neighborhood opposition, Kevin Hirai of FlyawayHomes, emphasized that the residents of the Colden Avenue neighborhood did not oppose the project. It took only one presentation to the

[1] According to Ballester, the participating organizations and churches would own the buildings on their respective sites after 20 years. Until that time, they would still earn income from tenant rent.

governing council to get approval. Multiple residents expressed that they viewed the shipping container project as an improvement to their neighborhood (Smith, 2018).

According to John Cadiz Klemack's report (2018), the Colden Avenue shipping container project provided John Kilgore, a single father and current resident, the opportunity to stop the constant "couch-surfing" and transition into permanent residency. As a result, he was able to provide shelter to his five children who now reside with Mr. Kilgore as a family. Hirai is aware that affordable housing is needed and that shipping container architecture can often be an efficient and cost-effective solution. In the report, he said that there is a need for this type of housing opportunity and that it is FlyawayHomes' mission to help pave a way to prove that affordable housing can be done differently (Klemack, 2018). According to Flyaway Homes' homepage on their website, they are building "Quality permanent supportive housing for one-third the cost and in one-third the time of traditional methods. We build by-right, using modular techniques to develop shared housing units, and use social impact equity or other private funding methods to do it" (flyawayhomes, n.d.).

Affordable housing options have proven that it has the capacity to influence the way that communities interact and live. Container architecture transforms landscapes that may have remained undeveloped into useful thriving spaces. Its ability to integrate "form and function"can change the way a neighborhood looks and serves its residents. Additional research should be conducted to determine how affordable, sustainable housing options influence socioeconomic factors such as income, education, and health.

Discussion

The main object of this research paper is to support the theory that this particular architectural design concept can be considered a feasible response in addressing housing-related

issues, particularly in Southern California. The various industry related case studies, publications, and professional interviews included in this research have supported this theory while providing insight to its potential to generate public interest and rejuvenate communities.

Larger projects like Maboneng and Keetwonen proved that this approach can make a significant difference in the resolution of addressing acute housing affordability issues regardless of region. Both projects were successful in achieving their goals of providing comfortable, safe, attractive living spaces while passing substantial savings onto their tenants in the form of below market rent. Their economies of scale presented opportunities for additional savings on building materials, resulting in lower construction costs. Commercial space was integrated into both projects allowing for rejuvenation of the surrounding community as well as financial growth opportunities.

Even when applied in slightly smaller scales, shipping container architecture can provide effective and lucrative solutions outside of the project's initial intent. The Colden Avenue apartment project in Los Angeles was a housing experiment that fulfilled a social need while extending financial benefits to private investors that expect to see a five percent annual return on their investment (Smith, 2018).

As the success of these types of innovative projects become more frequent and publicized, they will start to have a larger impact on how local and state governments can address their growing housing challenges. Combined efforts of private funding and economical alternatives to conventional housing construction will reduce the burden on budgets, tax-payers and citizens unable to secure affordable housing. Even when upcycling and transportation costs are factored into a cost versus benefit formula, the containers' inherent modular design allows

for construction efficiency, flexibility, and practicality that brings value to a project when compared to conventional building methods.

Since their inception in the mid 20th century, ISO shipping containers have proven to be extremely durable under harsh conditions (ISBUA, 2016). This is particularly beneficial to Southern California when building residential structures, as the area is prone to extreme environmental conditions. Ocean salt water, earthquakes, high winds, and wildfires make land development very challenging. The durability of shipping containers is ideal when trying to mitigate these hazards and identify long term solutions - when installed and maintained properly, shipping containers can last far beyond 20 years (ISBUA, 2016). When constructed, shipping containers are designed to withstand the elements associated with global shipping, which means they are waterproof, air-tight, aseismic, and wind resistant. During the upcycle process, containers must go through an insecticide abatement process to remove harmful chemicals. Even after the abatement process has been completed, shipping containers are still termite resistant due to their steel structure. This puts them at an advantage in certain parts of the country as conventional residential architecture typically uses wood for its framing, leaving it susceptible to termite infestation. Mitigation of these threats to structures and the public can have potential long term advantages in relieving some of the financial strains associated with maintaining resources affiliated with these risks. Allied Market Research, has conducted research that helps support the theory that shipping container architecture is a feasible solution, for multiple reasons, in response to various housing-related issues around the world. The firm forecasts that by the year 2025, the global shipping container home market will grow at a compound annual growth rate (CAGR) of 6.5% (Allied Market Research, 2019).

Considering the benefits associated with this architectural element, guidelines that directly address shipping container architecture is still largely unavailable. This type of approach does not fit into a simple framework that can be easily solved. Local conservative policies have been some of the main challenges in getting building codes and zoning laws updated to meet the needs of the market. Although shipping container building permits can be obtained much faster than conventional building permits (Auchettl, 2020), some neighborhoods, particularly those where single family homes are the majority, perceive shipping container structures as "subsidized" housing and enact the "NIMBY" vote. In turn, this may influence the political structure to remain silent for fear of constituent resentment. The result is a stagnated policy structure that impedes the advancement of affordable, innovative, sustainable solutions to a growing housing crisis. Further research would need to be conducted to see if certain housing-related issues are beyond the scope of creating fast affordable housing options using architectural elements like shipping container structures, due to self-inflicted obstacles.

Conclusion

Since the first shipping container home was built in 2006 by Peter DeMaria, in Southern California, this new style of architecture has caused innovative thinking to stretch the boundaries of function and form (Pagnotta, 2011). What started out as a simple design concept has turned into a global movement to bring sustainable, affordable, and efficient housing into the mainstream. Industry professionals have worked together to find effective methods to overcome the challenges that are inherent with this style of design and construction. Though not originally intended for architecture, architects, developers, and interior designers have jointly exploited these objects into habitable and functional structures. The Maboneng Precinct and Keetwonen

projects both prove that shipping container architecture, when used as a multi-unit dwelling, can address immediate housing-related issues. Its modular style supports easy installation with minimal disruption to the surrounding environment, while keeping building costs to a minimum. In short, shipping container architecture is able to bring value, function, community, and style to something otherwise considered waste.

As housing issues and the homelessness problems become more acute in California, Governor Gavin Newsom has responded with an aggressive request to lawmakers that will provide $1.4 billion in funding to subsidize rents, build shelters, and provide solutions for those struggling with securing affordable long-term housing (Allyn, 2020). If the state is willing to pass this type of legislation, some of that money could be reallocated and invested in constructing residential container communities.

Although further research is needed on the long term influences that container architecture may have on its residents and the environment, shipping container architecture's low cost model, durability, longevity, modular construction efficiency, and low maintenance make this innovative building concept a feasible solution in addressing some of the immediate housing-related issues in Southern California and other parts of the United States. Other countries around the world have adopted shipping container architecture as a mechanism to address similar housing-related issues. Local and state governments across the U.S. should take advantage of this information and challenge themselves to embrace this innovative concept and disrupt the status quo.

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Table 1

ISO Shipping Container Dimensions

		20' Container		40' Container		40' High-Cube Container	
		Imperial	Metric	Imperial	Metric	Imperial	Metric
External Dimensions	length	20' 0"	6.096 m	40' 0"	12.192 m	40' 0"	12.192 m
	width	8' 0"	2.438 m	8' 0"	2.438 m	8' 0"	2.438 m
	height	8' 6"	2.591 m	8' 6"	2.591 m	9' 6"	2.896 m
Interior Dimensions	length	18' 8 13/16"	5.710 m	39' 5 45/64"	12.032 m	39' 4"	12.000 m
	width	7' 8 19/32"	2.352 m	7' 8 19/32"	2.352 m	7' 7"	2.311 m
	height	7' 9 57/64"	2.385 m	7' 9 57/64"	2.385 m	8' 9"	2.650 m
Door Aperture	width	7' 8 1/8"	2.343 m	7' 8 1/8"	2.343 m	7' 6"	2.280 m
	height	7' 5 3/4"	2.280 m	7' 5 3/4"	2.280 m	8' 5"	2.560 m
Internal Volume		1,169 ft^3	33.1 m^3	2,385 ft^3	67.5 m^3	2,660 ft^3	75.3 m^3
Max. Gross Weight		66,139 lb	30,400 kg	66,139 lb	30,400 kg	68,008 lb	30,848 kg

Glossary

Abatement: The process of removing or reducing hazardous materials

Cantilever: A structure that projects from another, supported only at one end

Carbon Footprint: The amount of greenhouse gases (carbon dioxide) that is transmitted into the atmosphere due to a specific activity

Compound Annual Growth Rate (CAGR): Measurement used to determine revenue growth between given years.

Economy of Scale: A proportionate reduction in production costs as a result from purchasing materials in large quantities.

HVAC: Acronym for heating, ventilation, and air conditioning duct systems typically installed in buildings.

Infill: Non-loadbearing panels that are used in construction to create usable surfaces in floors and walls.

International Residential Code (IRC): International building standards for residential construction.

Inventory: Refers to total unsold or available housing units in a specific area.

ISO (Shipping Container): Acronym for International Organization for Standardization which most products around the world use as their defining standard of manufacturing.

Land Value: The price of a plot of land.

Mechanical Utilities: Construction terminology that encompasses mechanical, electrical, and plumbing systems and standards that make buildings habitable for human occupancy.

Prefabricated: The practice of assembling various structural components onsite at the manufacturer. Finished products can be quickly assembled at the construction site.

Price to Income Ratio (PIR): The standard ratio between the median price of a house to a median annual income within a specific area. This formula is typically used to gauge the affordability of housing within a geographic area.

Polyvinyl Chloride (PVC): Polyvinyl chloride is the standard material that plumbing pipework is made from. It is commonly used in construction to refer to plumbing systems that are installed in buildings.

Qualitative: Associated with data and research methods. This type of method focuses on non-numerical data that tries to provide answers to why and how things occur. This approach typically involves case studies, observation, artifacts, and interviews.

Schema: The representation of an idea through a design model.

Sustainability: Design theory or philosophy to create structures that reduce negative impact to the environment as well as its occupants.

Upcycling: Process where items that may no longer be of use are refashioned and recycled into products of improved material and environment quality.

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