

PAPER • OPEN ACCESS

Using Container Structures in Architecture and Urban Design

To cite this article: Karol Grbowski and Daniel Kadunek 2017 *IOP Conf. Ser.: Mater. Sci. Eng.* **245** 042087

View the [article online](#) for updates and enhancements.

Related content

- [Urban landscape architecture design under the view of sustainable development](#)
WeiLin Chen
- [Overview of Modular Design Strategy of the Shipping Container Architecture in Cold Regions](#)
Zexin Sun, Hongyuan Mei and Ruixian Ni
- [Urban Landscape Architecture in the Reshaping of the Contemporary Cityscape](#)
Maria Ananiadou-Tzimopoulou and Anastasia Bourlidou

Using Container Structures in Architecture and Urban Design

Karol Grębowski¹, Daniel Kaldunek²

¹ Faculty of Architecture and Faculty of Civil and Environmental Engineering,
Technical University of Gdańsk, ul. Narutowicza 11/12, 80-233 Gdańsk, Poland

² Faculty of Architecture, Technical University of Gdańsk, ul. Narutowicza 11/12,
80-233 Gdańsk, Poland

karol.grebowski@pg.gda.pl

Abstract. The paper presents the use of shipping containers in architecture and urban design. Even today, houses and apartments are still too expensive. Since 1923 architects have been improving the living conditions of citizens by building very simple, repeatable forms. With prefabrication technology it became possible to build quicker, causing house prices to decrease. Apartments in block of flats became affordable to more and more people. Modernism had great impact on the quality of living spaces, despite the detrimental effect of large panel technology on social life. It gave people their own bathrooms, and gifted them with simple solutions we now consider indispensable. The ambition to build cheaply but effectively is still here. The future of housing lies in prefabricated apartment modules. A well optimized creation process is the key, but taking into consideration the mistakes made by past generations should be the second most important factor. Studies show that large panel buildings were too monumental and solid for a housing structure, and offered no public spaces between them. Lack of urban design transformed a great idea into blocks that are considered to be ugly and unfriendly. Diversity is something that large panel structures were missing. While most block of flats were being constructed out of the same module (Model 770), differentiated architecture was difficult to achieve. Nowadays, increasing numbers of shipping containers are being used for housing purposes. These constructions show that it is possible to create astonishing housing with modules. Shipping containers were not designed to be a building material, but in contrast to large panel modules, there are many more possibilities of their transformation. In this paper the authors propose a set of rules that, if followed, would result in cheaper apartments, while keeping in consideration both tremendous architecture and friendly urban design. What is more, the proposed solution is designed to adapt to personalized requirements. In this paper the authors include information about design guidelines for structures made from shipping containers.

1. Introduction

Buying a place to live is one of the biggest expenses one is likely to occur in a lifetime. For many years, people have been trying to minimize the cost of house-building. When multi-family residential became too expensive, large panel technology was the solution. Nowadays, a private bathroom in each household is far from unusual. It was large panel technology that pioneered this solution. Thanks to low prices of such apartments, many were able to afford this housing option. One after another large-panel structures rose, their height often exceeding comfortable limits. There are many advantages and disadvantages of large panel housing, but key factors here are a low price and a relatively short building time. This is the reason behind the success of this solution in Easter Europe.



Today, the number of buildings made out of shipping container is rising. Although not as tough and long lasting as conventional structures, they are much easier to build with. [1] In Europe there is 200 million tons of concrete waste annually. Due to the difficulty in recycling concrete, its only hope lies in reusing it as an aggregate in future concrete batch. In contrast, steel is 100% recyclable, indefinitely. This means that, once made, a steel beam could serve its purpose and then be recycled into another steel beam of the same original form. This highlights another problem arising from large panel structures.

The future of housing lies in prefabrication and fully recyclable building materials. Human kind must develop a way to continue building constantly far into the future, unhindered by the weather or any other obstacles.

2. History of large panel technology and its impact on current housing

At the beginning of the 20th century, architects and engineers were looking for improved construction methods. Building with larger objects compared to bricks resulted in a faster building time, meaning costs could be minimized. Because using prefabricated elements requires more forward-planning, architects could have focused on maximising the comfort and appeal of such apartments. Early building projects showed that in order to make large-panel technology profitable it is necessary to build a large number of buildings. As a result, urban master-plans began to appear in the minds of architects. They saw white, shining ships sailing through the seas of greenery. Another advantage was that the design of each apartment was required to be carefully considered. A small mistake in one single room would be multiplied by the number of apartments. Architects were able to develop great ideas, which are widely used in today's designs. Big wide windows, a private bathroom in each apartment, functional kitchens; these are brilliant ideas introduced by the modernists. Soon, large-panel settlements were built and people moved in with great enthusiasm. These buildings offered apartments well suited to every individual's needs. It was the biggest revolution of residential areas to date.

Today, old large-panel structures are considered unfriendly. The success of the large-panel solution was mainly due to high density construction, which was at same time its utmost flaw. With around one thousand residents in a single building, it was impossible to form any social bond among them. In some cases, the population of such buildings was larger than that of many small rural towns. Massive apartment blocks offered public space only between consecutive buildings – an unattractive space to residents which was scarcely utilised. Designers of large-panel settlements lost regard for the human scale in the development of urban design, and that made a brilliant idea unattractive. In Western Europe many large-panel structures were either demolished or reduced in height to adapt to the human scale. Beside urban design, large-panel structures have some further disadvantages. Their construction involved joining prefabricated elements together, a job for experienced, qualified workers. In many cases there were minor defects. Garbage chutes inside each segment and asbestos panels on the facade were key factors contributing to the decrease in hygiene and safety. On the other hand, in Easter Europe many large-panel structures are still standing. In Romania [2] 60% of residential housing is large-panel structure, and thanks to affordability of this solution, 96% of inhabitants own the apartment they live in. In Poland 12 million people still live in large-panel structures. In the nearest future there will be a demand for similar solutions, and modernist's heritage needs to be taken into consideration in the development of an imminent housing revolution.

3. Houses out of shipping containers

Home building is neither a cheap nor easy process. Residents of multifamily buildings have in mind that sooner or later they are going to buy or build their own house. Such temporary solutions are considered too expensive and resultantly, many home-owner's dreams do not become reality. It is a common fact that renting a flat is, in most cases, a waste of money because buying into real estate is an investment. Current trends show that shipping containers have an impact on today's architectural design. Furthermore, people are increasingly aware of limited resources on earth. Reusing shipping



containers contributes to smaller concrete waste which helps to slow down the rising problem. Compared to traditional housing, these structures have significantly less longevity and architects have to struggle with completely different challenges. There are many ideas on how to use containers in architecture. Containers are 2.438m wide and other dimensions vary with type. The most common is the 40' HC (high cube) type that is 12 meters long, and 2.7 meter high inside. Within a structure of two 40' HC containers there is 55.2 m² of space to adapt. This is in general more than a typical apartment has to offer, in the same price range. After preparation in the workshop, the containers can be transported to the building site and then placed on the prepared bedplate or pillars for better insulation. Construction of a shipping container house takes only few hours in order to be ready for finishing works. Besides the initial structure, all other technical aspects of the building remain the same. Building with modules gives the ability to compose astonishing forms, which typical, low-cost architecture lacks. Shipping containers are also easy to transport because of their unified size. Some architects use them to design pavilions that can be moved from one place to another, even worldwide if required. Such structures do not need to be fixed to the ground, allowing them to be installed in extraordinary places.

4. Shipping container modifications

Shipping containers are sufficiently sturdy to withstand the negative impact of weather during transport. They are also able to carry loads of up to 30 tons. This combination provides sufficient properties as base block for modular structure.



Figure 1. Small restaurant made out of 40' HC shipping container

However, with every hole this structure loses its attributes a little. What is more, each modification must be carried out by highly skilled workers because of the internal stresses of the steel panels. Entire panels can only be removed if minor reinforcements are made. This type of work cannot be done on the building site, but only in a large enough workshop. Currently, building with shipping containers comprises strict prefabrication, and involves a large amount of forward-planning and designing time. On the one hand, this is a great deal of work for one simple house, but on the other it can prove to be very efficient when designing settlements, with the right optimization of manufacturing.

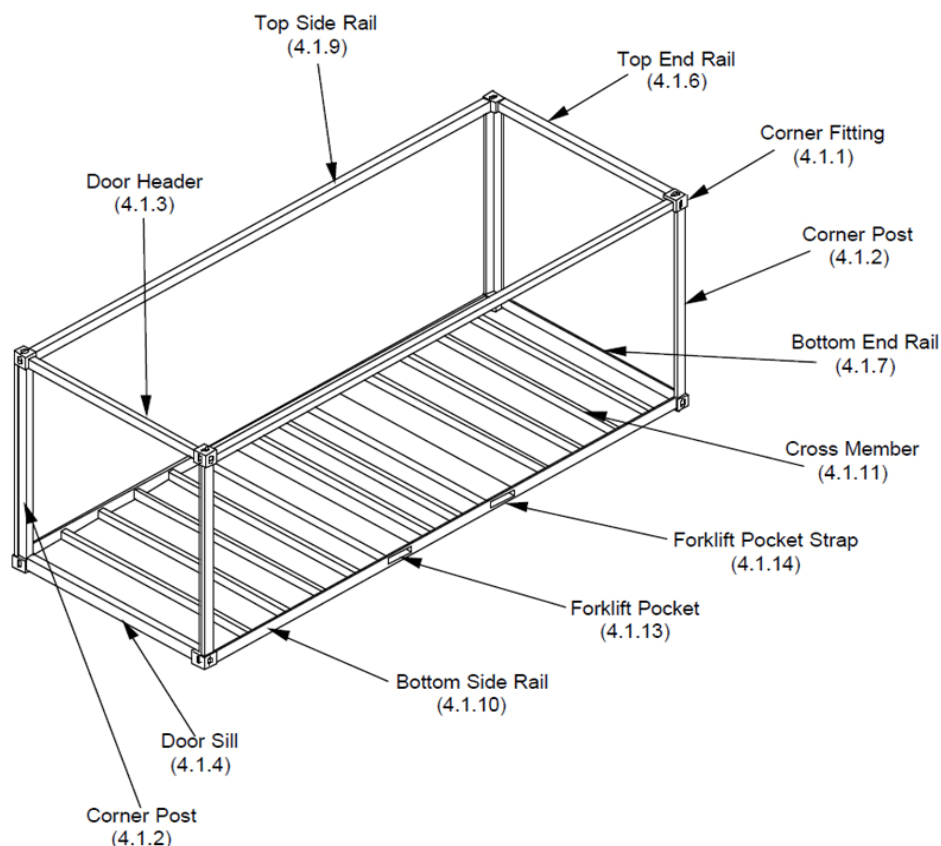


Figure 2. Shipping container structure [3]

There are endless possibilities of connecting different modules. An important aspect of container-home design is correct insulation. After all, wall panels are very thin and made out of a heat conductor. An additional 20 centimetres of Styrofoam will provide sufficient insulation of the future container-home. To ensure longevity, the steel structure needs to be treated with an anti-corrosion substance. Another crucial part is the connection of modules. It is a critical process in every modular building and should be treated individually. Some pavilions made out of shipping containers have hydraulic lifts that move the front wall panel up, so that this wall not only functions as a door but also provides shade in front of the container. This particular solution is excellent for small seasonal services like food stands or tourist information points.

5. New era of prefabricated buildings

Currently, apartment cost is not going to drop unless some new solutions are introduced. Whilst previous large-panel technology offered monotonous architecture, new ideas of modular prefabricated buildings are more tremendous. Habitat 67 is a composition of prefabricated, reinforced concrete apartment modules that were placed independently on each other. This was an excellent answer to problems large-panel technology did not foresee. Repetitive use of the same module is not mundane if it is constructed with thought. First step is thought-through urban design using identical modules. Creating new settlements with the same base blocks reduces diversity, therefore reducing the time required to build and design. This was the key factor of large-panel technology's huge success. Individual base-types of identically sized segments should first be designed. The next step involves creating various combinations of these modules so that new settlements will not be lifeless. Ensuring that human scale is taken into consideration is also important. New residential areas should consist of open and friendly social spaces.

6. Conclusions

Prefabrication is the future of architecture. Nowadays many prefabricated elements are being used, from ceiling boards to stairs. There is still place for more improvement, and the goal is to minimise building time by making the maximum possible use out of building sites. Another important element is the easily-recyclable nature of building material used or large, innovative settlements because of the inevitable aging of every structure. Since large-panel technology is connected to the cause of large problems, both in the past and in today's society, it will be difficult to convince people of the benefits of prefabricated modular structures. However, with the right urban design and distinctive architecture, it is possible to build astonishing settlements. Future apartments should meet the requirements of their residents and be affordable to more people. History of prefabrication shows that, with the right optimization, modular structures can prove to be the future of successful settlements.

References

- [1] S.W. Tabsh, A.S. Abdelfath, Influence of recycled concrete aggregates on strength properties of concrete, „Constructions and Building Materials”, 23/2009.
- [2] M. Popov, A. Dogariu, D. Grecea, V. Ungureanu, M. Georgescu, Steel Structure Apartment Extensions for Existing Large Prefabricated Panel Collective Dwellings, „Procedia Engineering”, vol. 161, pp. 1076-1083, 2016.
- [3] Fig.2:
<http://www.residentialshippingcontainerprimer.com/CONTAINER%20COMPONENTS%20AND%20TERMINOLOGY>
- [4] Z. Dzierżewicz, W. Starosolski, Precast large-panel building systems in Poland in 1970-1985. Wolters Kluwer Polska, Warsaw, 2010 (in Polish).
- [5] P. Knyziak, M. Witkowski, Estimation of the Technical State for Large-Panel Residential Buildings in Warsaw (in Polish) Inżynieria i Budownictwo, 12/2007, pp. 639-641
- [6] A. Mersal, Sustainable Urban Futures: Environmental Planning for Sustainable Urban Development, „Procedia Environmental Sciences”, vol. 34, pp. 49-61, 2016.
- [7] E. M. Generalova, V. P. Generalov, A. A. Kuznetsova, Modular Buildings in Modern Construction, „Procedia Engineering”, vol. 153, pp. 167-172, 2016.
- [8] M. C. Cortés, Industrialized architecture in a globalized world, Abstract collection book, 2016.