Container Post Disaster Shelters – C-PoDS

A Generative Approach to Temporary Post-Disaster Sheltering

Sinan Mert Şener[1], Belinda Torus[2]
[1]İstanbul Technical University, [2]Bahçeşehir University
[1]smertsener@gmail.com, [2]belindatorus@gmail.com

Abstract: *Generative tools are used to generate rapid products and they support mass customization. These properties are mostly needed in the case of an emergency when rapidity in design and application means much more than anything else. Shipping containers are used in different projects as well as sheltering and housing projects. It is a standard module which can be used as a basic module in the sheltering projects. Small modifications are sufficient, which helps it being a rapid application. In this paper a generative tool named Container PoDS which using shipping containers as basic module for post-disaster sheltering is introduced.*

Keywords: *Generative design; post-disaster shelter; container.*

Introduction

The design industry is supported by generative computational tools especially for mass-customization and rapid production. Particularly in the case of a disaster, the need for shelter will be great and designing such accommodation projects computationally could be one of the optimum solutions to build shelters.

This paper introduces a tool to generate temporary housing alternatives for post disater shelters. The tool is developed in MAXScript and named as Container PoDS because it generates post - earthquake sheltering alternatives using containers as basic module.

Earthquakes and post-earthquake sheltering

Earthquakes can cause lethal and economic damage which can also be increased by following activities like aftershocks, landslides, fires, tsunamis and floods. (Coburn and Spence, 2002) A respond to an earthquake may save many lives which require a well-organized emergency management, an associated operation which involves many agencies, government, organizations and individuals. There are many phases and dimensions in emergency management, one of which is post-earthquake sheltering.

One of the recent and destructive earthquakes struck the Anatolian peninsula is the 1999 Marmara earthquakes with 285.000 collapsed residents. Thousands lost their lives and thousands more were left in a status of temporary "homelessness". In many cases, tents were the applied solution for emergency shelter demands. Temporary shelters could be erected after two months at the earliest. Different local and foreign temporary shelter systems have been used by earthquake victims for at least one year, before the construction of permanent housings were finalized (Sener, 2003).

According to the JICA report there are several estimations for different scenarios. And according to Model C (the most optimistic scenario among others), the need for temporary dwellings is possibly expected to be 70,000 in an earthquake magnitude of 7.1 on the Richter scale in the region.

There are many projections and researches -like the JICA report (2002)- but the exact numbers are unknown since the effects of the disaster are unpredictable. One of the main problems about designing a post-disaster shelter is the aforementioned uncertainty in numbers.

Properties of a shelter

Especially in a post-disaster context, shelter must be viewed as a series of actions fulfilling certain needs, rather than simply as objects such as tents or buildings [1]. Shelters are mainly planned to provide at least the minimum requirements for the survivors. Those reasons can be physical, psychological or both. In either situation it is important to handle sheltering without omitting the survivors' psychology.

The needs and targets for a shelter can be summarized as follows:

- Rapidity –To build tents or first temporary shelters quickly
- Efficiency – To achieve land efficiency and cost efficiency
- Implementation – The reusability of the building blocks as well as departure from site with as little effect as possible
- Material - To provide protection from environmental conditions with appropriate equipment
- Security – To achieve both physical and psychological security
- Cultural aspect - To respect and design according to the survivors' cultural and traditional values
- Psychological condition – To support the psychological condition of the survivor effected by the disaster

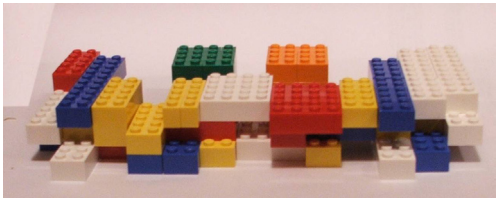


Figure 1
Model of a building block made up of LEGOs

Containers

Tents and other prefabricated building structures are mostly used because of their instant implementation in any environment. Shipping containers can be considered as a type of prefabricated structure. They can be in different sizes but the mostly used ones are in 2.40m x 12.00m x 2.60m and in 2.40m x 6.00m x 2.60m which make them modular building elements like "LEGO" blocks (Figure 1).

Selecting modular shipping containers has some technological and architectural benefits aside from responding the basic needs. They are easy to find, rapid to deploy and they are reusable. They can be transported by trains, ships and helicopters and can be built almost anywhere. They are easy to transport, lift and mount. They are adaptable to different configurations as well as being compatible with each other. They are modular and they have flexible articulation that can be used for different number of people related with the volumes. Small modules can be used for one or two people and larger ones can accommodate up to four people and for the families that are more crowded than four people these modules can be used together. So it can be sought to digitally form shelters with these two sizes of containers (Figure 2).

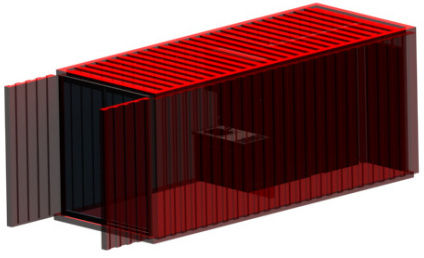
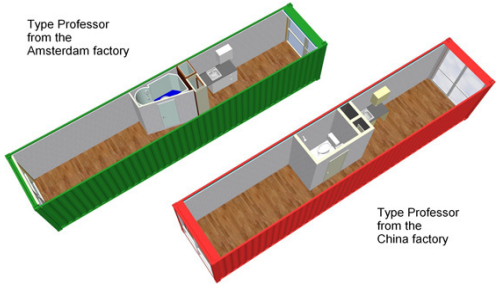


Figure 2
Container prototype

Figure 3
An example to NYC Sheltering Competition Project [2]

Figure 4
Dormitory in Amsterdam made by 1000 containers in 2005 [4]

Figure 5
One of the typical rooms in the dormitory in Amsterdam made by containers in 2005 [4]



Sheltering and container projects

There are many sheltering projects and competitions and most of them emphasize more or less the target aforementioned above. In the New York City competition the aim was to design post-disaster shelter after a hurricane [2, 3] (Figure 3). When it is about mass-production the aim focuses on density which supports higher buildings and mostly designing one or two prototypes and copying them several times. Containers are also used in housing projects as well as designed to be used in post-disaster projects. Mostly in container projects it is easier to pile-up regularly. It is also very rapidly to build the mass this way. But the massive and monotonous effect of the blocks needs an intervention in order to have a less solid block with light and air circulation. Mass customization and generative tools can also prevent these defects. They can be used after heat insulation and each unit has its own WC and shower as well as kitchen counter [2, 3]. There are other container projects made in different regions of the world, which are designed and built up in a very short period of time with small modifications [4] (Figure 4, 5).

Generative design

Some of the applications for urgent shelter settlements are lack of visual performance which also affects the survivors negatively. Their need for building ground can be higher because they cannot be multi-storied. The uncertainty in numbers supports a generative script for the optimized solution to build a rapid sheltering with containers which is called Container PoDS.

The program

There are some parameters and constraints in the formation of the script. The number of survivors or container needed and the size of the site and number of floors are the main parameters for the generation of the shelters. Although these containers can be piled up to form multi storey accommodations, it is limited to three in the script for safety reasons. The stairs, number of floors and shelters are all interrelated.

The script is basically generating the container blocks with the given parameters. The architecture

of the formation is dealing with the size, density, and the formation type. Therefore the interface of the script is divided into three major dialog boxes.

The first dialog box on the interface is the "General" dialog box (Figure 6). In this dialog box plan type can be specified and generation can be started. The execution with the given parameters can be in multi color or in single color. There are two types of plans. One of them is linearly formed, whereas the other one is centralized (Figure 7). In the linearly formed plan, one sequence of containers lines up with the stairs (if the block is multi-storied). In the centralized formation two sequences of containers line up facing one another with the stairs and other common-used spaces left in between.

The second dialog box is the "Survivors" dialog box, in which the numbers of survivors or shelters can be input. Either the number of survivors or the number of shelters can be specified as program variable (initial condition). The numbers of depots and the density of site layout can be specified. Because the number of shelters and the number of survivors are related, if one of them is changed; the script will distribute the other(s).

The third dialog box is the "Block Properties" dialog box. In this dialog box, following variables are input: one dimension of the site (shown as x-size on the menu, since the other y-size is determined by container length), the number of floors and the number of stairs. If it is decide to be single storey, naturally there will be no stairs. In other cases the number of stairs is related to the x-size given.

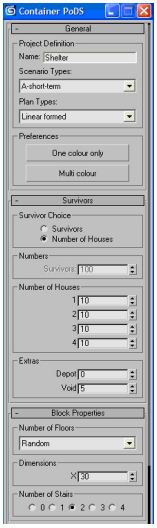


Figure 6
C-PoDS interface

The controls and execution

The execution can be started by pressing the "one color only" or "multi-color" button. With the default values or with the values that has been specified as explained above, the execution starts (Figure 8).

In the first phase the calculations are made. Also the adequacy of the site dimensions is checked for the desired number of shelters in this phase. If it is, the execution starts; if not, the error message "The given parameters are not enough for the formation" is displayed.

At first desired number of stairs with the defined number of floors is developed. The stairs are located in accordance with their number and x-size. Then the halls are developed for each floor. When stairs and halls are formed, then it is time to form the shelters

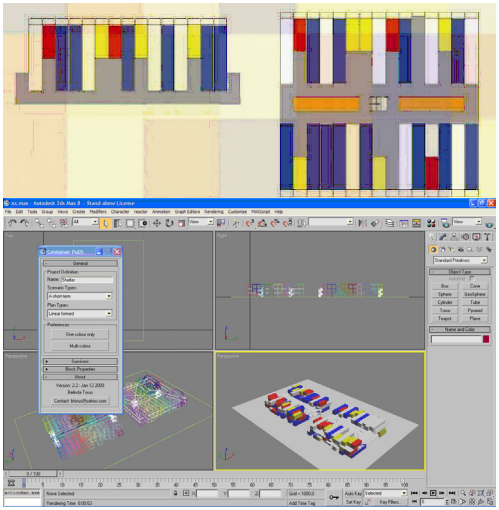


Figure 7
Linear and centralized formation

Figure 8
Script in 3dsMax environment

and locate them. Shelters are formed according to the specified numbers given and they pile up randomly (Figure 9).

The units are designed to come together randomly but they are limited to stack up to three levels at most and a maximum of fifty containers can come together to form a building block.

Number of depots and void can also be selected while forming the blocks which made it possible to create these sponge-like blocks with desired number of void for required number of people.

There are two main scenarios for these shelters. They are mainly blocks both with movements of the mass and solid-void effect (Figure 10). The scenarios are based on these relations of the containers with the hall. The containers can be placed on one side or both sides of the hall. All the containers are designed to have natural light. Other scenarios or configuration rules sure can be added with similar or different specifications without omitting the main perspective.

Conclusion

Generating a sheltering project with a module with defined numbers seems to be a good solution for designing post-disaster shelters rapidly. The advantages of this kind of approach can be counted as below

- The visual performance. It is higher than standard sheltering projects (both container projects and tent cities) because of the randomness of the containers coming together. Compared to

Figure 9
Linear samples of one color and multi color

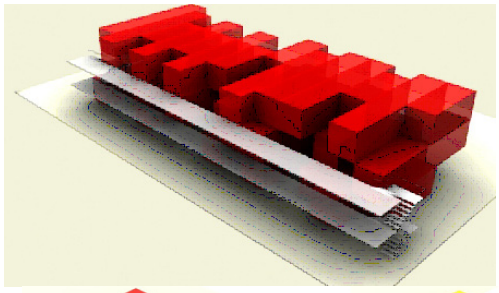
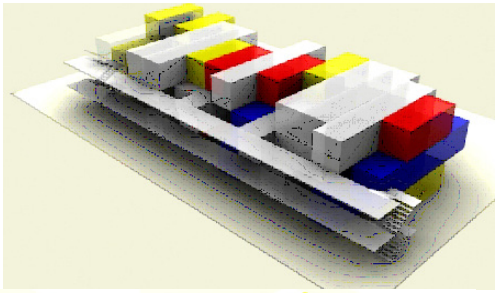
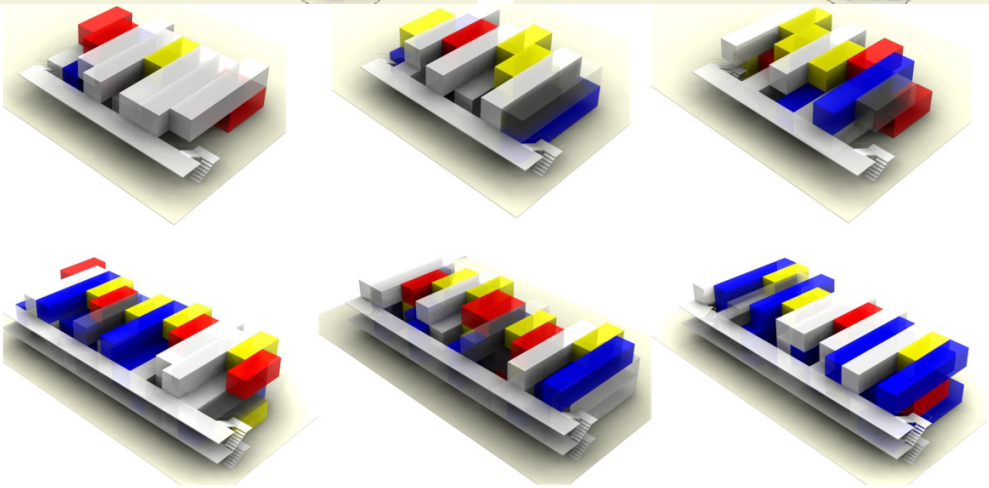


Figure 10
Generated two and three storied linear blocks





manual generation, computerized generation has the capacity to generate randomly, which prevents monotonous blocks. One other important specification is the movement on one side of the generation which supports the dynamic façade.

- Space performances: A modified container is adequate for the number of survivors which is designed for. All containers have their WCs and showers and at least one side is always open. The randomly generated blocks also allow semi-open spaces for the survivors. Different containers pile-up randomly which generate unique blocks each time preventing repetition and maybe in some cases supports the psychology of the survivor giving the feeling of belonging and uniqueness.
- Efficiency: The modularity of the shipping containers as well as the differentiations of the building blocks both support mass customization. Mostly temporary post-earthquake shelters are single-storied or simply tents are used which need a lot of land for temporary shelters. Even though traditional container projects can pile-up the containers more than three levels, in the script blocks are limited up to three levels. These randomly generated blocks support efficiency in land-use by piling-up and by limited levels security codes are also obtained.
- Flexibility: One of the most important specifications is the flexibility of the numbers that can be input in the program. The number of the containers or the survivors from the disaster cannot be foreseen before the disaster. Manually and beforehand design can be inadequate for different number of survivors and containers. The generation starts based on the values entered and the flexibility in the numbers makes the program more effective. Also void and depot can be selected in the script.
- Rapidity: The rapidity to design, transport and build these blocks is one most important feature especially in the case of an emergency. By the help of the script the blocks can be generated in no time and they can be detailed rapidly. The containers can be modified and transport in a very short period of time by several means of transportation and they can be deployed rapidly.
- Reusability: If there is no need for a container, a level of container or an entire block; they can be moved out. They can also be transported to another place and be re-used.
- Scenarios: The script can be developed by adding different type of plans or defining different relations of the containers. Different plan types of generating building blocks can be added to the script and alternate ways that these blocks come together can also be pursued in the further phases of the research. In the time of a need other spaces which aren't designed before can be added in the script as well as depot can be thought or designed with different functions.

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