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Shipping containers for a sustainable habitat perspective

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Abstract – Shipping containers have many names: cargo containers, sea cans, metal boxes, freight containers. Originally they were constructed, as the name reveals, "to contain" and store items and mainly to transport goods. Freight containers are built to strict international quality standards, to survive harsh treatment and a violent life in the marine environment [1]. The main technical details regarding containers were specified in an ISO (International Organization for Standardization) standard in January 1968 [2]. The history of the shipping container starts like any other invention with a simple thought. It takes Malcom McLean, father of the shipping container, over 20 years to realize his revolutionary idea for the shipping industry and create a closed transport chain of universal freight container for ships, trucks and trains [3]. It wouldn't be an exaggeration to say that shipping containers have laid the foundation for globalization and changed the world. Over 95% of the worldwide trade affairs are winded up in containers. Today, international freight transportation is no longer conceivable without containerization. There are approx. 28 million containers circulating the globe. In the last couple of years up to 3 billion TEU (Twenty-foot Equivalent Unit) shipping containers were produced annually, mainly in Asia [4]. Most of the freight containers are made out of COR-TEN-Steel, which ensures strong carrying and loading capacity and supports withstanding deformations or corrosion. Once they have served their purpose, shipping containers are being recycled as scrap. Another possibility is to be used in the architecture as spatial modules. A container's life is ca.12 years and every year up to 1.5 billion TEU are considered disused. The continued availability of shipping containers as a building block is thus assured. Therefore, the construction business with containers has a great potential regarding sustainability. In the last 15 years shipping container construction has become popular for not only living spaces and homes, but for offices, studios, schools – the variety of uses is huge. Containers offer suitable solutions for a wide range of uses. The increasing interest in these "icons of globalization" can be explained with the fact, that they are relatively inexpensive, structurally sound and in abundant supply [6]. Using old freight containers could be seen as an environmental protection strategy and also as a redesign of technical artefacts. Building with shipping containers is a new more affordable method of construction and design. Due to metamorphose in functionality and meaning of containers – from a cargo box into a habitable space – we realize how big the technical range of diversity is. Technique reaches and changes the "Social" through design. The imprecise term *design*, which has become a vogue term nowadays, is the interface between technique, body, mind and communication [5]. Designed objects are always also symbolic objects for different milieus; design has an effect on awareness raising, thus on environmental awareness. An ongoing project at RWTH Aachen University gives attention exactly to those disused shipping containers, their eventuality and boundary as environmental protection strategies in the living area, as well as to the well-known cleavage between environmental awareness and environmental behaviour. The project focuses on the living situation in Germany and its potential for such new and innovative living concepts.

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There are different perspectives on the shipping container: in addition to the business perspective and possible investment opportunities, there is the perspective of development aid and a fast help in a distant world end, expansion and improvement in different industries depending on the shipping container. Every one of these

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perspectives comes down to the globalization and world economy. The freight container made shipping cheap and by doing so changed the shape of the world economy. The container is at the core of a highly automated system for moving goods from anywhere, to anywhere, with a minimum of cost and complication on the way ([7], p. 2).

In this paper another perspective is taken into consideration: these relatively simply objects – a steel box held together with welds and rivets, with wooden floor and two enormous doors at one end – have great impact not only on economical and political levels, but also on society and its decisions in everyday life. In particular, the usage of old shipping containers as habitable spaces is concerned. Using old freight containers can be seen as an environmental protection strategy and also as a redesign of technical artefacts. Building with shipping containers is a new more affordable method of construction and design. Due to metamorphose in functionality and meaning of containers – from a cargo box into a habitable space – we realize how big the technical range of diversity is. Technique reaches and changes the "Social" through design. The imprecise term *design*, which has become a vogue term nowadays, is the interface between technique, body, mind and communication [6]. Designed objects are always also symbolic objects for different milieus; design has an effect on awareness raising, thus on environmental awareness.

In the next chapter a short history of the freight container will be introduced, followed by an overview of the "transformation" from container to architecture and the different utilisation of cargo containers as liveable spaces. Great importance is attached to the environmental protection and redesign of technical artefacts which will be discussed further on in this paper.

1 Short history of the shipping container

The history of the shipping container begins in 1937 when the young freight forwarder and truck driver Malcom McLean was impatiently waiting for the longshoremen to unload his freight of cotton from the truck onto the ship, bale by bale, with a hook. He had a revolutionary idea to adopt a metal box containing the whole freight, which could be taken off the truck, put onto the ship or train and reversed. Malcom McLean was seeking a universal solution for his vision. It lasted over 20 years until his idea was realized, because no one was prepared to invest in his project and nobody took him seriously. He established a very successful logistic company with almost 2000 vehicles determined to save enough money and complete his dream. 1955 McLean was constrained to decide between sea and land transportation. He liquidized the truck logistic business and invested all his money in a small ship owning company laying down the headstone of the first container vessel worldwide. In 1956, McLean had enough money to make his dream of a universal freight container for ships, trucks and trains come true ([3], p. 8). Trucking entrepreneur Malcom McLean was one of the first to implement the idea of standardized containers and their development. The US Army also developed such boxes that could be transported by water and by land. These developments were then adopted worldwide in the 1960s in line with the ISO[1] standards [2]. The first ISO standard for cargo containers was ISO 668 in 1968. Main technical details regarding containers were specified in this ISO standard, e.g. lengths of 20 and 40 feet. Transportation and lifting equipment over the world is tailored to match these dimensions ([3], p. 9).

2 From Container to an Architecture

The definition of a container comes from the Latin word "continere", which means to hold together, to surround, to store. A container is a vessel that surrounds a usable volume of space and thus defines the spatial boundary between interior and exterior[2]. Shipping container on the other hand is a container with strength suitable to withstand shipment, storage and handling[3]. The

[1] ISO: International Organization for Standardization.

[2] Dictionary online: http://dictionary.reference.com/browse/container,14.04.2011.

[3] Business Dictionary online: http://www.businessdictionary.com/definition/shipping-container.html.

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Fig. 1. ContainerCityII, London (source: Urban Space Management).

structure of a container is a combination of a frame and fillings. Most of the freight containers are made out of weather-resistant COR-TEN-Steel, which ensures strong carrying and loading capacity and supports withstanding deformations or corrosion. Once they have served their purpose, shipping containers are being recycled as scrap for new high quality steel products. But there is another option: to be used in the architecture as spatial modules.

Freight containers are extremely stable, up to eightfold stackable, inexpensive and in abundant supply. In the last couple of years up to 3 billion TEU[4] shipping containers were produced annually, mainly in Asia. A container's life as a transport vessel is ca.12 years and every year up to 1.5 billion TEU are considered disused. The continued availability of shipping containers as a building block is thus assured. Comparing the costs of erecting a conventional building to a container one, the price to build with containers is unbeatable: A new 20-foot container costs approx. 2.800 € and a used one approx. 1.500 €[5] (the price of a freight container depends on the fluctuations in the price of steel scrap and the exchange rate for the dollar), meaning the supporting structure and weather-protective shell is available for a price of approx. 200 € per square meter or approx. 80 € per cubic meter. Therefore, the construction business with containers has a great potential.

Shipping containers were first used in their unconverted form, e.g. as tool sheds or storage spaces. The next step was to use freight containers, converting them accordingly, for other purposes, such as for living in. Cargo containers are commonly used in architecture for temporary construction purposes due to the easy convert in a short time, also favoured in event architecture because of their image. They evoke associations of a well-travelled idem, automatically linked with the raw atmosphere of a busy port ([3], p. 9). Associations and meanings are important in the architecture. It involves more than stacking up or putting containers in a row to refer to a building as an architectural structure. The mobile shipping containers have to have a fixed location. They would require rooms and spatial connections created by architectural means, resulting in indoor rooms, intermediate areas, and outdoor spaces. Only when containers are placed in a spatial context with spatial and architectural qualities, container boxes do become actually *container architecture*, e.g. see Figures 1–4 ([3], p. 10).

Like other building container contractures have to fulfil criteria regarding

[4] TEU = Twenty-foot Equivalent Unit.
[5] Prices determined in April 2011.

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Fig. 2. Redondo Beach House in California, DeMaria Design Associates Inc., (source: Container Atlas2010).



Fig. 3. 12 container house, architect: Adam Kalkin, (source: Container Atlas2010).

structural stability. Important issues that must be taken into consideration are fire protection and thermal insulation. In case of a simple container building, the metal boxes have their own structural weather and climate shell. By putting up a larger structure it is advisable to add additional weather and insulation functions. Container buildings do not have a special status and would need a building approval as any other conventional house.

3 Usage of freight containers

In the last 15 years shipping container construction has become popular for not only living spaces and homes, but for offices, studios, schools – the variety of uses is huge. Containers offer suitable solutions for a wide range of uses. Shipping containers in the architecture are always associated with temporary buildings because of their advantages of flexibility, mobile nature, and quick and

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Fig. 4. Inside ContainerCityI, (source: Urban Space Management).

short term availability. They are also the answer for a use where a spatial solution has to be found for a limited period of time. This is also the reason why container buildings use to have a negative image: they were applied in circumstances of natural disasters and emergency solutions in affected areas. However, current examples of container architecture show that solutions that fulfil high architectural standards are indeed possible using containers. The usage strongly affects the type of solution implemented and the architectural design too. Many factors are hereby relevant – range of usage, budget and overall economical aspects, geographical position and climate, cultural influences, ecological aspects, etc. Projects can be classified into public, office and housing buildings, also commercial architecture, social or low budget architecture, event or art constructions.

4 Environmental protection strategy and redesign of technical artefacts

Building with shipping containers has significant advantages compared to conventional construction methods from an environmental point of view. Container buildings can be compared to Lego® bricks because they are inherently demountable. Due to its modularity system container buildings could be extended even after project closure, it is possible that modules are reused. "The steel can be reused as raw material, as it can be better recycled than concrete for example, which can only be reproduced for low-grade uses" ([3], p. 18); steel on the other hand is up to 100% recyclable and reusable for any purposes. The investor can even recoup a small portion of the investment costs by selling the recycled steel, where in case of a conventional building, builder/client is liable to pay costs for construction debris – e.g. depending on the particular design, a container can contain between 0.5 and 4.0 metric tons of recyclable steel for the current scrap purchase price ([3], p. 18).

The short construction process for container housing means larger savings in resources like raw materials, time and money. Therefore, there is an opportunity to make late adjustments to the original container housing plans if necessary. A steel scaffolding is not needed, less energy is necessary to dispose of waste from building materials – in fact, there is less construction debris on site in general. An application of alternative

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energies is also possible and seen as appropriate as soon as speaking of environmental protection strategies: panels of photovoltaic equipment or solar panels can be integrated into the shell of the roof, which helps supplying container buildings with energy and reducing problems with excessive temperatures inside the building, e.g. in the summer by providing shading ([3], p. 18).

5 The interface between design and society

Design reflects society in all its forms and facets. Through design are taken positions on mental states like anxiety, indifference and euphoria, also on problems, and desires of social groups. In the living area, building with shipping containers is a new more affordable method of construction and design. When the steel boxes are transformed into habitable spaces, the functionality and meaning of containers have been changed. This states a redesign of technical artefacts and also the great diversity range of technique. Technique reaches and changes the "Social" through design ([6], p. 148). The imprecise term *design*, which has become a vogue term nowadays ([6], p.141), is the interface between technique, body, mind and communication ([8], p. 155). Design addresses the perceptual capacity of man's consciousness and it brings together communication and awareness.

Design is functional and all designed objects should serve their purpose which was defined from the developer, e.g. a birthday card should communicate a certain message. In the development process definite functions are implemented in the objects; these items have to correspond to the user with all his needs, interests, subjective background or even conversion. In addition, the designer cannot predict if the object will be used in the exact purpose intended – after all, if the birthday card has only a picture of a bouquet and a bottle of champagne on it, it could be used for any celebration or occasion.

Designed objects are not only featured, they also take constitutive effect in their environment and are furthermore exposed to other embodiments. People change their everyday practices because of designed objects. At the same time these items require an individual appropriation and thereby they have been charged with a meaning ([6], p. 143). This is how design influences society and society influences design. Design gains multifarious knowledge from different nature and disciplines – e.g. social and natural sciences, engineering sciences, the assistance of technicians, market and finance strategists, engineers and even psychological expertise.

Designed objects are always also symbolic objects for different milieus[6] ([6], p. 153) which are characterised through artefacts and items from our (everyday) life. Designed objects are thus prime carrier of meaning for self-ordinance in the society; and the different milieus are built not least by owning featured items. Consequential design has also an effect on raising awareness, thus on environmental awareness.

6 Awareness about environmental protection

An ongoing project at RWTH Aachen University gives attention to the disused shipping containers, their eventuality and boundary as environmental protection strategies in the living area, as well as to the well-known cleavage between environmental awareness and environmental behaviour. The project focuses on the living situation in Germany and its potential for such new and innovative living concepts. The assumption that building with containers is an environmental protection strategy and it depends on the environmental awareness and the sustainable consumption of the citizens is suggested. According to a report on the status of environmental awareness in Germany in 2010 which analyses the findings of current representative survey, the environmental consciousness of the Germans is very high [9]. The population in Germany is aware of the hazards which environmental pollution and climate change constitute for mankind; most of them "agree with the principles of sustainable development (e.g. resource protec-

[6] Term explained further in chapter 5. Awareness about environmental protection.

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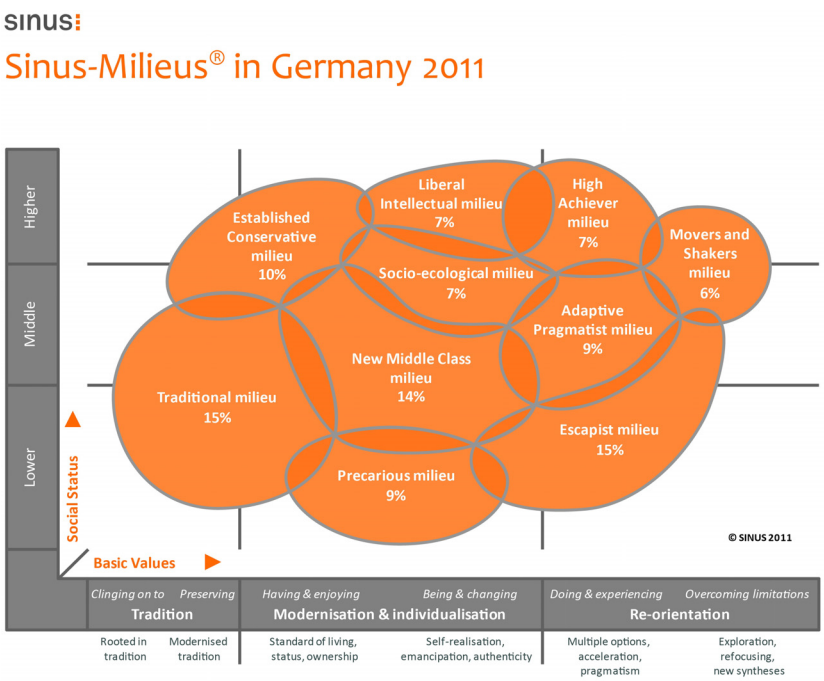


Fig. 5. Sinus-Milieus® in Germany 2011 (source: Sinus-Institut, Heidelberg 2011).

tion), fair trade, and intergenerational equity, and many people voice readiness to behave in an environmentally friendly way in everyday life" ([10], p. 4). There are different levels of environmental awareness in Germany depending on the different segments of society, particularly with regard to social milieus. Lifestyles and values affect opinions on environment and climate protection and often these differentiate better than socio-demographic characteristics like age, sex, educational background, and income. "The milieu perspective therefore significant contributes to the understanding of patterns of attitude". To improve environmental communication, "group-specific barriers and resistance to environmentally friendly behaviour patterns as well as approaches for promoting environmentally compatible attitudes and behaviours" are worked out through two agencies in 2008: "Sinus Sociovision GmbH" and "ECOLOS-Institut für sozial-ökologische Forschung and Bildung gGmbH" ([10], p. 4).

The Federal Ministry for Environment, Nature Conservation and Nuclear Safety and the Federal Environment Agency have been commissioning empirical research about environmental awareness and environmental behaviour in Germany since the beginning of the 1990s. These surveys are conducted on a biennial basis and each study always involves new, current subject areas. In 2010 the study dealt with three major subjects: Technological and cultural innovations (e.g. Car-sharing), Climate change and Sustainable consumption (e.g. Tourism) ([9], p. 12). The Sinus-Milieus® Tool, shown also in Figure 5, helps to understand socio-cultural change, the structure of society, and the psychology of citizens and consumers. At least three equal important essentials determine people's everyday life: social situation, values and lifestyle. Those are linked by causation, stabilisation and reproduction's connections. These three dimensions constitute social milieus, which are basically groups of people who are similar in their view and way of life. The Sinus-Milieu-model is a result of a 30-year research in the social sciences. Currently, there are ten different milieus in Germany, see Figure 5. Environmental awareness is to a certain extent one of the fundamental particle to characterise a milieu.

Some of the results from the last survey "Environmental Awareness and Environmental Behaviour in Germany in 2010"

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are summarized in the following important findings: (1) despite the financial crisis, protection of the environment is a priority in Germany, 20% of the Germans state it as the most important issue in the country; (2) almost two third of the population in Germany demands an increased involvement on the part of the Federal Government; (3) interviewees ranked environmental protection as an important political task, which will solve important and current social challenges and problems like unemployment, securing competitive capability, serve up more social justice; (4) two fourth of the interviewed persons see big potential in industry, state and oneself to contribute more to environmental and climate protection; (5) 87% of the respondents attest their community good environmental quality, but 80% of them give bad grades for the global state of environment; (6) technological innovations and also cultural modernizations are welcomed from the respondents. 85% of them think forceful switch to renewable energy is necessary ([9], p. 10ff).

The implied mobility in container buildings can be in particular appealing for the social milieus, which see mobility as a fundamental value in their lifestyle. The cooperation between the two Departments at RWTH Aachen, Department of Ferrous Metallurgy and Department of Sociology of Technology and Organization, enables discussions and views on the same topic from different perspectives. Both disciplines bring their own "research toolboxes" to reveal how container buildings can develop environmental protection strategies in the living sector, how habitants reflect upon the history of containers, which is easy to perceive even in their home and house design. Which milieus are attracted to such concept of life is yet to be found out. A research will be done, to show to what extend persons already living in container buildings and identify themselves with these homes, have exchanged their mobility value with a value of local fixing due the redesign of technical artefacts.

7 Summary and conclusions

In the beginning of the last century the shipping container was constructed and since 1968 worldwide standardised. There is no doubt that containers will be also in the future a significant chapter in the big book of international freight transportation. Shipping containers will be always there because the international logistic is no longer imaginable without containerization. Therefore, disused shipping containers will be always in abundant supply and can be used as a building block. Short planning and implementation periods, the cheaper to conventional buildings erection and their system-based advantages such as prefabrication, mobility, modularity and global availability are only favourable for a possible great success in the construction business. Container buildings have a great variety of utilisation, especially regarding sustainability. Building with cargo containers has significant advantages compared to conventional construction methods from an environmental point of view. It is a new inexpensive method of construction and design. The freight container sector should not be dismissed now or in the future as a main resource for recyclable building material for habitable spaces. So far developments have influenced and will continue to influence the use of containers in construction and reverse, considering the developments in optimizing containers, e.g. introducing the high cube container which is one foot (ca.30 cm) higher, the isolated 45-foot-long containers or the widening of containers (maximum 2.5 m allowed in Germany) achieving the maximum allowed by German road traffic regulations.

Freight container' buildings are from an economical point of view also a big competition to conventional buildings. They could be built up at an advantageous price and they are also raw material accumulators and investments. The range of uses of container buildings is huge and it opens up the possibility of creative, sophisticated and lively way of working with modular space. Of course, architectural input and expertise are required and the potential and the limitations are also influenced by engineering constraints. However, construction based on containers is now "in" and considered as design, the image of these shipping container constructions has changed to a progressive and intelligent one. Container architecture

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delivers adaptable building solutions and therefore considered as prospective and relevant for the future.

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