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Shipping containers in a sustainable city

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Abstract – The challenges of sustainable urban development are tremendous. More than half of the earth's population lives in cities and there is an upward trend. On a global scale, the cities are the greatest greenhouse gas producers and the biggest consumers of water and energy. Urbanisation, climate change and demographic change are forcing metropolises to make their infrastructure more efficient, be environmentally friendlier, keep the high standard of living and if possible save costs. One of the keys is the selection of materials. Buildings are responsible for 40% of the energy consumption and approx. 21% of produced CO_2 worldwide. Scientists and researchers from all over the world are looking into new technologies, so that energy could be used efficiently and CO_2 emissions reduced, without having to pass on comfort or "lifestyle habits" [http://www.siemens.de/nachhaltige-stadtentwicklung/nachhaltige-stadtentwicklung.html?stc=deccc020187 (accessed 27.04.2012)]. Sustainability is a complex term, used in the last 2–3 decades. It involves more than just the environment and it concerns every one of mankind [cf. Schlussbericht der Enquete-Kommission Globalisierung der Weltwirtschaft – Herausfordeung-en und Antworten, Drucksache 14/9200, http://dipbt.bundestag.de/dip21/btd/14/092/1409200.pdf, p. 393]. This is why social and engineering scientists from RWTH Aachen University have joined in their efforts to figure out how used shipping containers, which are in abundant supply, can play their role in the future of sustainable construction. After they have been used several times, freight containers are considered disused and begin to accumulate in the surroundings of seaports and harbours. The energy to produce a container is significant and considered wasted if the steel box has completed only a few runs. The first association with containers can be a cold and uncomfortable cell, however, after a glance at the properly adapted shipping containers, converted into cosy, pretty and affordable habitable spaces, this preconception can soon be dismissed. Research has shown, in terms of environment and design, they are innovative and intelligent – building with cargo containers is cheaper, "greener", faster and more flexible than traditional methods. With the increase of life expectancy and population continuing to grow, demand for housing will rise as well. Demographic change and the demand will contribute to rising construction prices. Habitation is one of the essential basic needs of all people. If one takes into account population growth and the timely provision of housing for all people, existing construction methods have to be adapted and new ones developed. Space in the social sense is an expression of the society and not its reflexion [cf. M. Castells, The Rise of Network Society, Wiley-Blackwell, 2010, p. 440f]. Bearing in mind the diversity in Europe's population and the anxiety for environmental protection and sustainability, also the contrariness in environmental awareness and behavior, likewise eco-friendly and polluting habits in our everyday life, which are linked together in a various and unconsidered way, validates having different levels of environmental awareness depending on the different segments of society. We speak here of the "patchwork" – character of lifestyles and values, which is illustrated and explained easily with the Sinus-Milieu-Model [Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Umweltbewusstsein in Deutschland 2010, Ergebnisse einer repräsentativen Bevölkerungsumfrage, 2010, p. 13]. This paper discusses the existing Sinus-Milieus® [http://www.sinus-institut.de/en/ (accessed 27.04.2012)] and their features and show hereupon the growing demand in the society on flexible living concepts and habitat designs. The theory supports, that building with steel containers could be a real solution for the social and environmental problems. A continuously availability of shipping containers as a building block is expected and therefore the construction business with steel containers has a great potential in terms of sustainability towards a sustainable construction in a sustainable city.

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In many examples in the history of the world, cities had to face the challenge to deal with growing population, e.g. london, great britain in 19th century [6, p. 100]. in modern days this challenge is even bigger because standards, requests and demand are higher – everything is a "priority" and a "focus" due to a complexity of the matter. The reason for this is the desired sustainable development! urbanisation, climate change and demographic change are forcing metropolises to make their infrastructure more efficient, be environmentally friendlier, keep the high standard of living and if possible save costs. More than half of the earth's population lives in cities and there is an upward trend. On a global scale, the cities are the greatest greenhouse gas producers, the biggest consumers of water and energy. Nevertheless, according to the discussion in national geographic in january 2012, environmental balance of the cities is better because their houses need less energy to heat up, cool down or light up and in addition, city dwellers don't drive as many cars. Metropolises make it possible, half of the earth's population living on approx. 4% of urban land area and so there is more room left for nature [6, p. 100].

1 Sustainability, sustainable development and the situation today

Sustainability is a complex term, used in the last decades. It involves more than just the environment and it concerns every one of mankind cf. [2, p. 393]. The most popular definition of sustainability and sustainable development is, "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [10]. The definition is general, "but captures the two fundamental issues, the problem of the environmental degradation that so commonly accompanies economic growth, and yet the need for such growth to alleviate poverty" [11, p. 2]. Since this definition in 1987 the meaning has evolved in three very important pillars, or overlapping circles, of environmental, social and economic demands. The idea of sustainable development is over 35 years old; since 1992 however, when the United Nations Conference on Environment and Development (UNCED) was held in Rio, "the volume and quality of environmental legislation (international, national and local) has expanded hugely, and international agreements (such as the Kyoto protocol) have not only raised the profile of environmental change but also begun to drive global policy change" [11, p. 2]. In 2005 the World Conservation Union (IUCN) presented the adopted Programme 2005-8. The interlocking circles model shown in Figure 1 was used to demonstrate that the three objectives need to be better integrated, with action to redress the balance between dimensions of sustainability.

In the last decades environmental and social issues were also communicated to the public. Citizens in almost all countries are aware of the problems and a big number feel that the environment is important for them as well as for the common good. In Germany for example, according to the last report on the status of environmental awareness in Germany (2010) which analyses the findings of current representative survey, the environmental consciousness of the Germans is very high [4]. The important thing indeed is, not to ignore "sustainable development" when it comes to practical decisions.

One of the keys is the selection of materials, which this paper stresses on. Buildings are responsible for 40% of the energy consumption and approx. 21% of produced CO_2 worldwide. It is important to find a solution, e.g. new technologies, so that energy could be used efficiently and CO_2 emissions reduced, without having to pass on comfort or "lifestyle habits" [1].

With the increase of life expectancy and the population continuing to grow, demand for housing will rise as well. Demographic change and the demand will contribute to rising construction prices. All people have the essential basic need of habitation and when population growth and the timely provision of housing for all people is considered, it is evident that existing construction methods have to be adapted and new ones developed.

A current project at RWTH Aachen University investigates how used shipping

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Fig. 1. The three pillars of sustainable development, from left to right, the theory, the reality and the change needed to better balance the model (source: 11, p. 2).

containers can play their role in the future of sustainable construction. After they have been used several times, freight containers are considered disused. The resources, e.g. energy and manpower, to produce a container are significant and considered wasted if the steel box has completed only a few runs. On the other hand the gained steel scrap is a source for secondary raw material. For the reason that the shipping containers are made out of COR-TEN-Steel, which is a corrosion resistant type of steel, the proposed temporal (ca. 40 years) conversion in habitable spaces does not influence the quality of the accumulated steel scrap for the future.

The first association with containers can be a cold and uncomfortable cell, however, after a glance at the properly adapted shipping containers, converted into cosy, pretty and affordable habitable spaces, this preconception can soon be dismissed.

2 New construction methods or forgotten old approaches: shipping containers as a building component

The idea of using shipping containers in construction is barely new. Already in the 1970s Nicholas Lacey writes his Ph.D. thesis on using shipping containers as accommodation facilities. Unfortunately it takes almost 20 years before actually implementing it. After that there are many examples of shipping container constructions, which are in fact used as habitable spaces: for living, working, storage etc. [7].

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. [8]. To adapt a container for its new "assignment" is quick and easy, especially due to the currently available high-performance cutting and joining technologies.

Examples of living spaces built up from shipping containers are shown below. We can observe the diversity in appearance and functionality of the container buildings: student homes in Amsterdam, Figures 2 and 3, studios and ateliers in London's ContainerCity II, Figures 4–6, as well as architect Adam Kalkin's modern 12 container house, see Figures 7 and 8, and the more traditional looking Alex Klein's ISBU homes, Figures 9 and 10. These buildings are very different on their outside, but they have one thing in common – they are all constructed from shipping containers.

Building with shipping containers has significant advantages compared to conventional construction methods from an environmental point of view. The short construction process for container housing means larger savings in resources like raw materials, time and money. A steel scaffolding is not needed, less energy is necessary to dispose

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Fig. 2. Keetwonen aero view (buildings in red), Student housing in Amsterdam.



Fig. 3. Close-up of Keetwonen (source: http://www.tempohousing.com/).

of waste from building materials – in fact, there is less construction debris on site in general.

"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" [7, p. 18]; steel on the other hand is up to 100% recyclable and reusable for any purposes.

There is also an opportunity to make late adjustments to the original container housing plans if necessary. An application of alternative energies is also possible and seen as appropriate as soon as speaking of environmental protection: 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 [9].

3 Sinus-Milieus® and their features

Bearing in mind the diversity in Europe's population and the anxiety for environmental protection and sustainability, also the contrariness in environmental awareness and behavior, likewise eco-friendly and polluting habits in our everyday life, which are linked together in a various and unconsidered way, validates having different levels of environmental awareness depending on the different segments of society. We speak here of the "patchwork" – character of lifestyles and values, which is illustrated and explained easily with the Sinus-Milieu-Model [4, p.13].

The Sinus-Milieu-Model is a result of a 30-year research in the social sciences. Sinus Sociovision has developed Sinus-Milieu-Models for eighteen countries worldwide already (fifteen in Europe plus USA, Canada, China) [12]. Investigations here are restricted to Germany, where currently ten different milieus exist. The Sinus-Milieus® Tool, shown also in Figure 11, helps to understand socio-cultural change, the structure of society, and the psychology of citizens and consumers [5]. 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 [8, 9].

The Sinus-Milieus® in Germany (see Fig. 11) are defined from Sinus-Institute with the following characteristics [5]:

- **Established Conservative milieu:** Responsibility and success ethic; aspirations of exclusivity and leadership versus tendency towards withdrawal and seclusion.
- **Liberal Intellectual milieu:** Desire for self-determination; an array of intellectual interests.
- **High Achiever milieu:** With a global economic mind-set and a claim to

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Figs. 4, 5 and 6. Container City II in London, several views (source: Urban Space Management).





Figs. 7 and 8. 12 container house, view from outside and inside (source: Container Atlas 2010).

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Figs. 9 and 10. Alex Klein ISBU homes (source: http://containerhomebooks.com/?p=5).

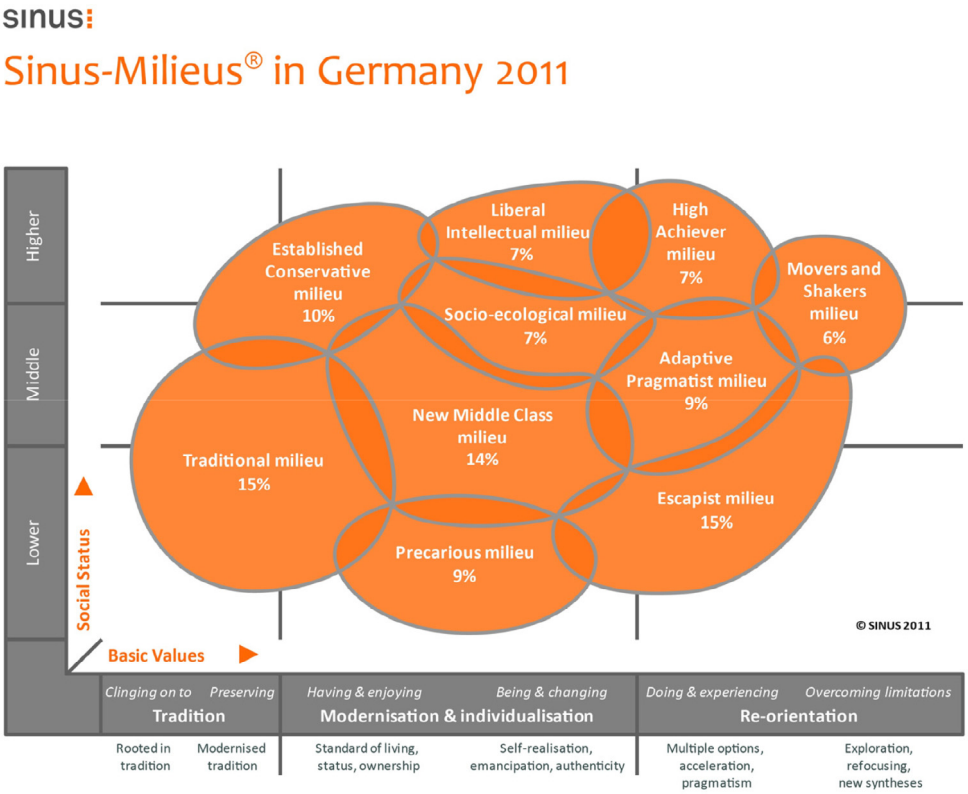


Fig. 11. Sinus-Milieus® in Germany 2011 (source: Sinus-Institut, Heidelberg 2011).

avant-garde style; high level of IT and multi-media expertise.

– **Movers and Shakers milieu:** Hyper-individualistic, mentally and geographically mobile, digitally networked, and always on the lookout for new challenges and change.
– **Socio-ecological milieu:** Pronounced ecological and social conscience; globalisation sceptics, standard bearers of political correctness and diversity.
– **Adaptive Pragmatist milieu:** Success oriented and prepared to compromise, hedonistic and conventional, flexible and security oriented.

New Middle Class milieu: Striving to become established at a professional and social level, seeking to lead a secure and harmonious existence.

– **Traditional milieu:** Rooted in the old world of the petty bourgeoisie or that of the traditional blue-collar culture.

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– **Precarious milieu:** Keeping up with the consumer standards of the broad middle classes in an attempt to compensate for social disadvantages; scant prospects of social advancement, a fundamentally delegative/reactive attitude to life, and withdrawal into own social environment.
– **Escapist milieu:** Living in the here and now, shunning convention and the behavioural expectations of an achievement-oriented society.

The creative idea of reinterpretation of containers on one hand supports the general social trend to manage objects flexible and open (in particular for the Movers and Shakers Milieu and the Adaptive Pragmatist Milieu). On the other hand a container building could resemble a conventional house/home and the general association of how a house or an apartment should appear (see Figs. 9 and 10). This demonstrates that container architecture could have a wider audience. Current research at the RWTH Aachen University will provide in the near future information which milieus in Germany are attracted to such concept of life – living in a building made out of shipping containers. Obviously the appearance is not an issue from an architectural point of view, but the values of the people living in the building. Another interesting aspect is, to what extent persons already living in container buildings identify themselves with these homes and how they have exchanged their mobility value with a value of local fixing due to the redesign of technical artefacts. Only representatives of certain Sinus-Milieus® would be appealed and choose to inhabit such buildings due to their standards, ideals and values.

4 The social theory of space and the theory of the space of flows by Castells

In his theories about space and space of flows, sociologist Manuel Castells presents his view on space in the social sense. According to his interpretations, space is the expression of society. He takes the challenge to analyse a new logic characterizing forms and processes in the society. "The task is not an easy one because the apparently simple acknowledgment of a meaningful relationship between society and space hides a fundamental complexity. This is because space is not a reflection of society, it is its expression. In other words: space is not a photocopy of society, it is society" [3, p. 441]. Social processes influence space by acting on a built environment inherited from previous socio-spatial structures. Castells explains step by step how he comes up to his theories - first of all he defines what space is: "space is a material product, in relationship to other material products – including people – who engage in [historically] determined social relationship that provide space with a form, a function, and a social meaning". "From the point of view of social theory, *space is the material support of time-sharing social practices*[1]" and he adds that any material support bears always a symbolic meaning [3, p. 441].

There is no doubt for Manuel Castells that our society is constructed around flows: flows of capital, flows of information, flows of technology, flows of organisational interaction, flows of images, sounds and symbols. "Flows are not just one element of the social organisation: they are the expression of processes dominating our economic, political, and symbolic life" [3, p. 442]. By *flows* Castells understands purposeful, repetitive, programmable sequences of exchange and interaction between physically disjointed positions held by social actors in the economic, political, and symbolic structures of society. [cf., ibid.] Castells makes the remark that the symbolic connection of architecture belongs to space of flows and that architecture is a formal frontier of the space of flows. If his theory is "truly the dominant special form of the network society, architecture and design are likely to be redefined in there form, function, process, and value in the coming years" [3, p. 448]. He gives examples that architecture in its history has been the "failed act" of society to express itself – to express its deeper tendencies that could not be openly declared but yet were strong enough to be cast in stone, in concrete, in steel, in glass, so they can be assim-

[1] Cursive in the original text.

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ilated from the humans, living, working etc. in such forms.

And still, people live in places, so Manuel Castells differentiate the space of flows from space of places. He gives the following definition: "A place is a locale whose form, function, and meaning are self-contained within the boundaries of physical contiguity". Places are not always communities, but they could contribute to the community-building. There are good places and there are bad places depending on the value judgment what a good life is. "Not all places are socially interactive and spatially rich. It is precisely because their physical/symbolic qualities make them different that they are places" cf. [3, p. 455–457].

Manuel Castells argues, that time and space cannot be understood independently of social action – "The space of flows is the material organization of time-sharing social practices that work through flows".

The society of today interacts dynamically with space and time. Transformations occur because of these interactions. Places will continue to be important in people's everyday life, because we associate them with memories, feelings etc. On the other hand, the role of place will decrease due to the rise of information technology and globalisation.

After all we would need balance, more than we need space!

5 Summary and conclusions

Sustainable building refers to a structure and it uses a process that is environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition[2]. All these criteria are fulfilled when we look closer at the container architecture. The presentation in this paper of building with disused shipping containers is hardly new. The idea exists since the 1970s, current examples of container architecture show that solutions fulfilling high architectural standards are indeed possible using containers. It is cheaper, "greener", faster, more flexible than traditional methods and yet unflavoured.

With the expected growth in population (e.g. due to migration in Western Europe, due to birth rate in other parts of the world) and the increase in life expectancy in general, demand for housing will rise as well. Demographic change and the demand will contribute to rising construction prices. Habitation is one of the essential basic needs of all people. If one takes into account population growth and the timely provision of housing for all people, then existing construction methods have to be adapted and new ones developed. Building with old steel shipping containers is suggested, because it gives a positive answer to the idea of sustainability and reusing materials as much as possible.

Education, integration and immigration are important for national and cultural development and also subject of the urban management. These issues however cannot be solved only by architecture. The research at RWTH Aachen University on existing Sinus-Milieus® in Germany and their features are a convenient tool of investigation on the aspect building with shipping containers. The different groups of people in the society verify the growing demand on flexible living concepts and habitat designs. Building with steel containers could be a real solution for social and environmental problems. The continuous availability of shipping containers as a building block is expected and therefore the construction business with steel containers has a great potential in terms of sustainability towards a sustainable construction in a sustainable city.

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