

Research Plan

Architectural Engineering Graduation

Studio

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Research title An evaluation method to assess user-friendly Design for Assembly and Disassembly of modular infill systems

Project title A CALL for circularity
Achieving Circular Architecture by Learning Locals

I. Introduction of the project's topic

When I started studying architecture, we learned about the notion to design buildings that were sustainable. Passive as well as active solutions to integrate into the project were possible. Nowadays, the shift has to be made towards a sustainable and circular built environment. However, as examples of projects pop up, comparing to sustainable approaches, this shift is still in its initial phase. Yet, more and more readings and videos about research or projects are being developed. These show how we can already make first big steps in this new field of building with for example CLT, the harvesting of secondary materials and designing according to the Open Building concept of J. Habraken (1961). This prove, that we can already make it happen and make it mostly happen by dealing with it in a creative way in all scales of and around the building, made me as an architect not only felt obliged to address the notion, but also excited and filled with new energy to design in a young and upcoming novel architecture.

Different approaches to achieve and accelerate this shift towards a circular built environment are taken and carried out in research or practice. However, these studies focus on how the building industry could increase the adaptation of circularity and act in a responsible manner towards the environment. A key participator in closing the loop of products and processes is overlooked: the end-user. The ones that cause the demand for certain buildings. Therefore the graduation project aims to reverse the approach and start at the end of a production process, taking a user-perspective.

A first step to make the end-user enthusiastic and willing to engage with an environmental topic like this, is to create awareness and to show the benefits of it. This can already be seen with sustainable inventions like solar panels, where people are being involved and informed about the working and benefits (Broers, Vasseur, Kemp, Abujidi and Vroon, 2019). The second step is to make the solutions part of the intrinsic motivation of people, meaning solutions people can apply themselves (Osbaldiston and Sheldon, 2003). Solutions that address the interaction between the end-user and circular products, however, are still in its infancy (Selvefors, Rexfelt, Renström, Strömberg, 2019). First studies that are done, address the relationship between the end-user and circular solutions by circular and flexible infill systems (Geldermans, 2020, The New Makers, 2020).

New thinking about how circular solutions could be adopted by end-users to increase the demand of a circular built environment and raise awareness among the notion of circularity should be further explored and developed on all building levels.

Overall design question

How can a mixed-use building based on the open building principle in the area of De Bossche Stadsdelta both be circular and promote circularity among starting and innovative end-users?

Problem Statement of the Thematic Research

Architects play an important role in spreading the notion of the shift towards a circular built environment, because of their central position in the building process (Jansen, 2019). However through studies, literature and media most of the time manufacturers and companies are addressed to increase knowledge around circular solutions and process integration. The, most of the time, not-part-of-the-building-process end-user is overlooked. Since this end-user causes the demand of the buildings that are built, awareness among this group is needed. With sustainable solutions on the contrary, user-integration to raise awareness, knowledge and show potential benefits, is far more common.

Geldermans et al. (2019) already started with the study of the synergistic potential between the circular design of flexible partitioning systems and user-benefits. However, no in-depth study was done on how end-users could engage with such systems by making them part of their intrinsic motivation (Osbaldeston, Sheldon, 2003). Therefore, further research has to be done concerning the requirements that will provide in the usability of circular modular infill systems by end-users. As a result, a tool for assessment could then help to test and improve existing systems or find the design principles to compose new systems in the design phase.

Research question

What are the preconditions for user-friendly design for assembly and disassembly of modular infill systems?

Sub questions

What criteria does a modular infill system have to fulfill to meet the requirements of design for assembly and disassembly? (DfA/DfD)

What criteria does a modular infill system require to be able to be assembled, disassembled and reassembled by its (unskilled) end-user?

What are the existing evaluation methods in the field of DfA/DfD and user-friendliness?

Can a first validation of the developed evaluation method be made by testing interior partitioning walls?

Reflection on the relevance of the graduation project

The graduation project aims to continue the little research and design that is already done around the exploration of architectural circular solutions with direct benefits for the end-user and the possibility for the end-user to engage in the application of it within a building. The research and design thereby try to find a way to increase the awareness and notion towards a circular built environment among a broader audience than the building sector itself. As a result, the responsibility that is now mainly felt by architects, will be spread and the transition will be accelerated.

Secondly, the project focuses on the group of people with a necessary demand for buildings; home-seeking starters. However, for residential buildings in this financial segment, circular solutions are currently not feasible. The demand for these new residential buildings is accompanied by the ask for housing that suits the end-user (Boelhauwer, 2020). The cooperation between parties in the building sector (architects, housing cooperatives) and future residents to achieve both circularity and spaces that fit, can already be seen in smaller projects or projects for a higher segment (Patch 22, Amsterdam; Reconsider, Eindhoven). Since the project's focus is on the target group starters who are part of the generation Z, the generation of not dreaming but doing, the generation that wants to tackle environmental issues and wants to be in control of their own future, user-involvement in the design process has a great potential (Tielbeke, 2018; Straver, 2017; Vollebregt, 2019).

Relation of the Thematic Research with the Overall Design objective

In relationship with the overall design objective, the research touches upon a possible solution to promote circularity from a user-perspective within the social, stuff and space plan (adapted from Loughborough University (2012) and Brand (1994)). The two subjects of circularity and user-friendliness that form the basis of the research, can however be further explored on all building levels (figure I). This concerns the program, access and circulation, configuration of spaces, the balance between private and shared spaces, the load bearing structure, climate design, detailing, façade design, public space and so on.

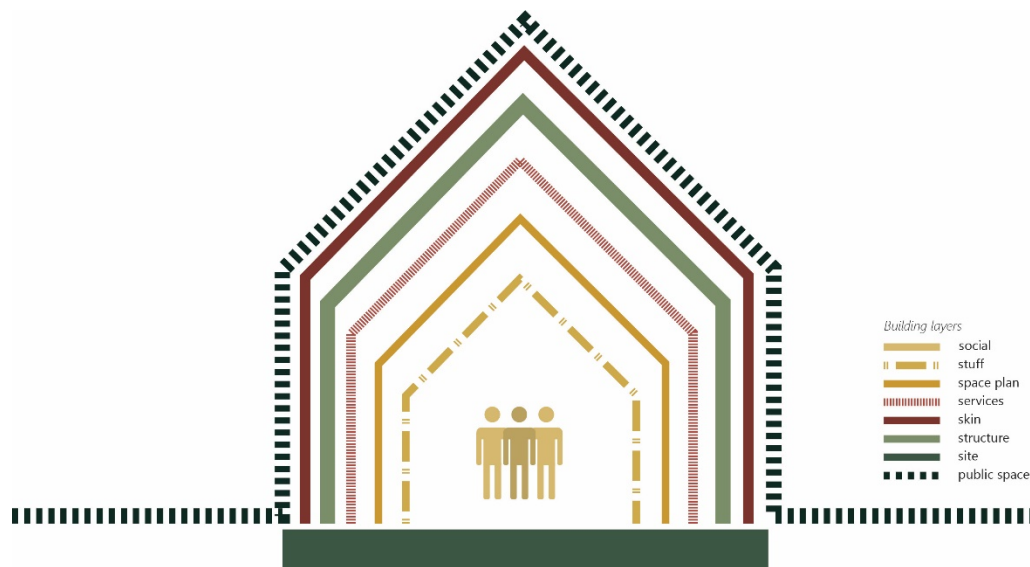


Figure I Building layers (adapted from Loughborough University, UK, 2012 and Brand, 1994).

II. Research framework

2.1 Key terms, concepts, theories, methodology

The research of the graduation project is based on a qualitative approach. Literature in the field of circularity and user-friendliness among modular infill systems is studied. The research extends itself in the design when applying the theories on a larger scale, involving the learning potential of architecture on all building levels. These levels can then be related to the Open Building principle found by J. Habraken in 1961, where structure and the infill is separated to provide in flexible buildings that could meet the

preferences of all different residents. Nowadays it is seen as a design approach that addresses the need for a circular built environment.

The knowledge gained from literature in different areas serve as a theoretical framework to reflect on and evaluate reference products in the research and case studies during the design. This results in the start for a design trajectory focused on experimenting with, prototyping and testing of new and existing design principles in sketches, physical and digital models. Since the research and the design is carried out on the one hand from a material/product point of view and on the other hand through out a user-perspective, both the epistemes of praxeology and material culture are integrated.

In the first part of the research, the key concepts of circularity, concerning design for assembly & disassembly (DfA/DfD), and user-friendliness are explored and explained on the basis of previous studies relating to building products. Because user-friendliness is something that is experienced differently for each person, previous carried out research is studied and considered from various points of view.

After this, literature study is used to define a framework of criteria for modular infill systems to meet both the requirements of DfA/DfD and user-friendliness. Methods to assess the extent of DfA/DfD and user-friendliness are found, compared and reflect on to see how these could be used or combined to compose a suited tool for measurement were both aspects are integrated. The resulted framework of criteria and tool for assessment will then function as a basis to test reference systems and as concrete guidelines in circular design.

In the end, the research as well as the design is searching for solutions to enable learning about circularity through architecture. The integration of smart systems and space configurations will then MAKE flexibility and user influence possible.

2.2 Methods

Whereas the research focused on theoretical sources by means of literature and ended with a practical exercise by applying and testing the results on reference products, the design project will carry on with practical studies. These practical studies concern sketching, prototyping and modeling of modular infill systems by means of the found guidelines. Physical scale models will then allow for tests among (unskilled) end-users. Also, the design of modular infill systems for housing is extended in the question of what kind of spaces are preferred by the target group of the design project. To find out, a sketch exercise will be held among the studio's students (future starters) to see what their preferences are for a future floorplan.

To translate the theories not only in the stuff and floor plan layer (figure 1), but in all building layers, the two main topics of circularity and user-friendliness are studied further on in reference projects, systems and products. Followed by sketching and model exercises, physical and digital, to see how these concepts will take shape in the building that is designed on the specific site of De Bossche Stadsdelta.

Finally, the overall aim of the project is to discover the learning potential of architecture. Student research within this topic was found and will be read, results and used theories will be evaluated and implemented in the design.

III. Preliminary conclusions, choices and design strategies

The research resulted in an method to evaluate existing modular infill systems for user-friendly design for assembly and disassembly. Next to this, it provided concrete guidelines for the design of new modular infill systems. The criteria that form the basis of the evaluation method and the guidelines were found in literature and during testing with partitioning walls. These relate to either the object domain, the technical related aspects of the building products or the user domain, the process related aspects of the assembly

and disassembly process. As all criteria 32 can be used to evaluate existing modular infill systems, for the design of new systems 15 key criteria are filtered to use as concrete guidelines. These 15 key criteria provide in guidelines that can directly be applied to the design (figure II) and will be used in the upcoming design phases. The remaining criteria are relevant when the system would go into production.

The guidelines and evaluation method developed in the research specifies itself on user-friendly design for assembly and disassembly of modular infill systems and focus thereby on the social, stuff and space plan layer of a building. However, the theories behind it can apply to a broader field, touching upon all different building layers (figure I). During the design project, these relationships are pursued to explore, develop and integrate in the next stages of the design.

The aim to create architecture that stimulates learning about circularity will sharpen and focus the design on the development of a concept that facilitates this process. This will include for example making various spaces that facilitates the different stages of learning, but also incites to think about what should be exposed when speaking about installations and constructions, what definition has aesthetics from this point of view? As a result, the second key aspect of circularity concerning 'material-use' becomes an important aspect in the upcoming design stages. New biobased materials that can be found in the area and new processes to cope with secondary materials will be explored and see how this will blend in the existing architecture or result in a new form of architecture. De Bossche Stadsdelta appointed as a testing ground for new forms of temporary living and working fits perfectly with the goals of the design project.

The preliminary design consists than of the exploration of these fields mentioned above in reference projects and theories, first ideas, sketches and drawings on all scales, and, most of all, a lot of questions and thoughts about how to develop these further in the Q2 (figure III).

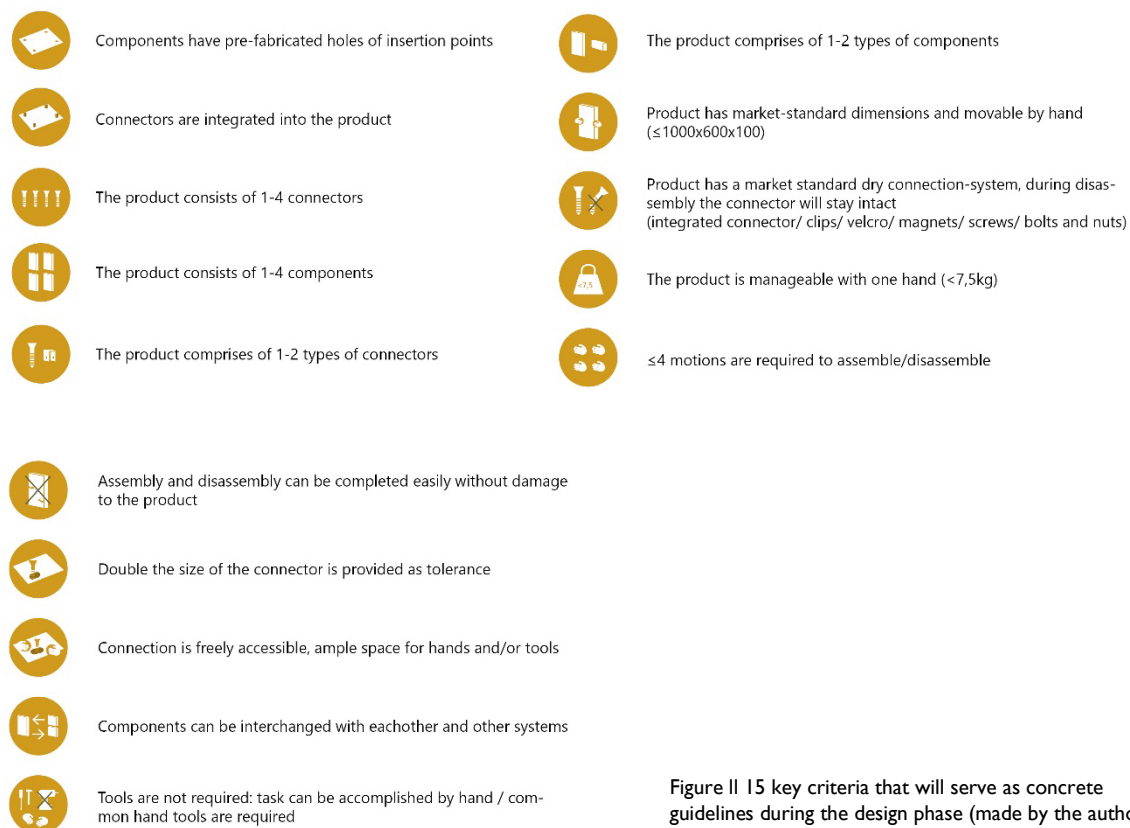


Figure II 15 key criteria that will serve as concrete guidelines during the design phase (made by the author).

Building layers of learning

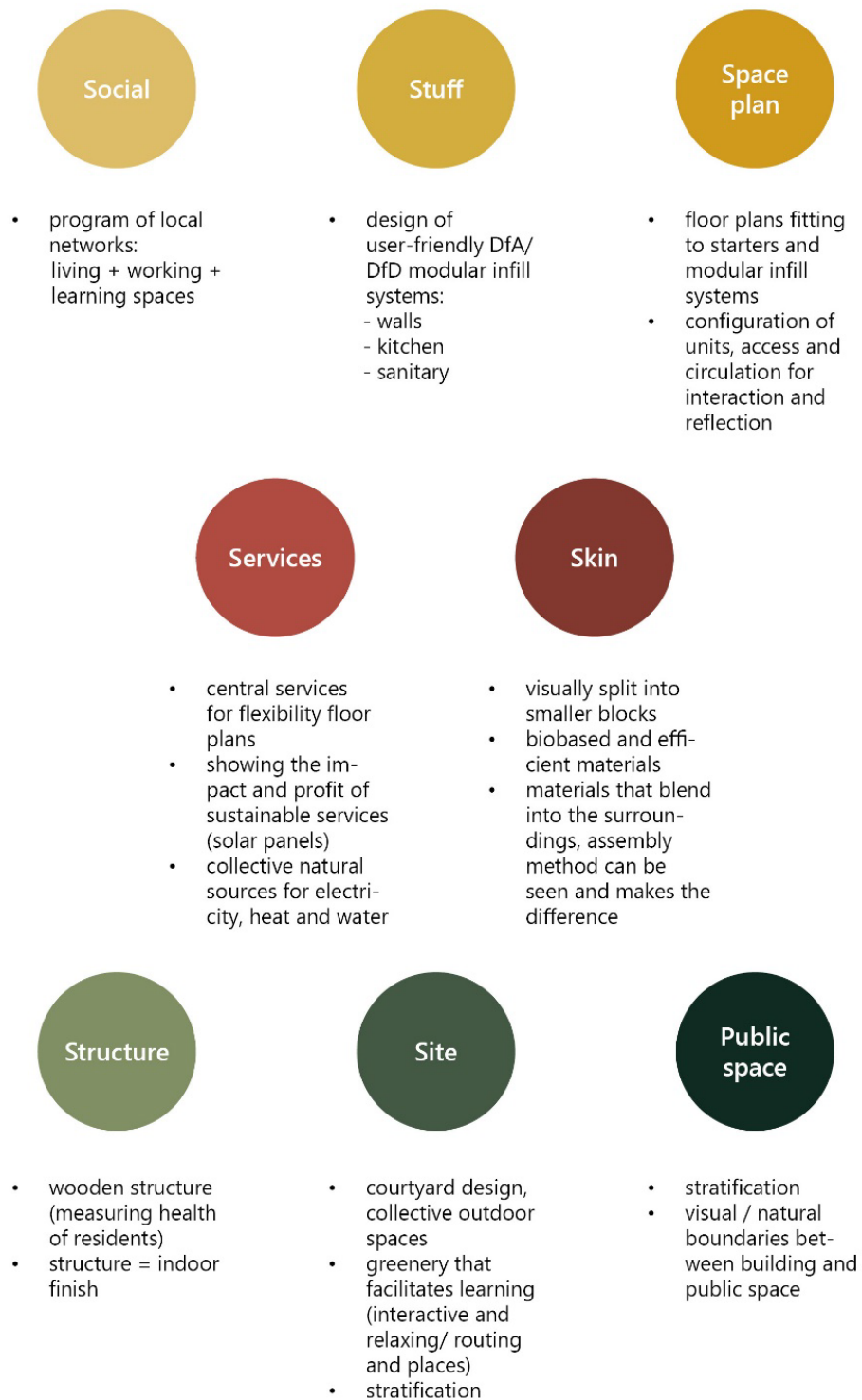


Figure III Topics to study to facilitate learning and touched upon in products of the P2 (made by the author).

Research plan diagram

