From Designing Buildings from Systems to Designing Systems for Buildings

Heike Matcha¹
¹Aachen School of Architecture
¹Matcha@fh-aachen.de

We study the novel possibilities computer aided design and production open up for the design of building systems. Such systems today can, via individualized mass production, consist of a larger number and more complex parts than previously and therefore be assembled into more complex wholes. This opens up the possibility of designing specialized systems specifically for single buildings. The common order of starting with a building system and designing a building using this system can be reversed to designing a building first and then developing a system specifically for that building. We present and discuss research that incorporates students design projects into research work and fosters links between research and teaching.

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Systems not only allow us to think in an orderly fashion, following a certain plan, but to be able think at all.
Georg Christoph Lichtenberg, 1776

Introduction and Background: Monotony vs. Variety in Systematization

Every building has to be assembled from parts that can be handled and transported. And bearing the advent of large-scale on-site 3D printing or comparable building technologies, the assembly of buildings from individual components (i.e. bricks, panels, beams, girders) will remain an integral part of architectural production. More generally speaking, building designs have to be subdivided into components that can be produced, transported and assembled. The more those components are related to one another, the better, because production, transport, handling and assembling is simplified by regularities and made more difficult by irregularities or differences between the parts or components. So in a way, all building is systematic building and always has been - starting from simple stone huts where the individual stones are selected for similarity to straw huts where the strands of straw are as equal as possible, via the pyramids assembled from similar stones. The question is not whether a building is systematic, but how much. In modern architecture, much design started from industrialized production methods, idealizing Henry Ford's automobile conveyor belts. Such Fordist mass production, though, resulted in extremely regular, even monotone structures, because only parts equal to one another could be produced. Systematizing production and therefore design meant minimizing variety, thereby maximizing monotony and anonymity. This, we propose, was and is an important reason for the public dis-
missal of much of modern architecture. As the advent of computer aided construction and production today allows for the cost-neutral mass production of variety, building systems can be seen in a new light: systems can be much more complex, and therefore monotony and anonymity avoided in favour of diversity. We see the mass production of diversity in architecture as a desirably goal because it can bring architecture closer to the diversity found in the natural environments (and to some extent, medieval townscapes) humans have evolved to feel comfortable in. (Matcha 2015, Matcha and Barczik 2009, Matcha 2010, Matcha and Karzel 2013.)

**Buildings from Systems or Systems for Buildings?**

The possible conception and production of complex building systems allows to reverse the relationship between direction and design that has been prevalent in modern architecture (and still is in much of current architectural production): the systems are developed first, aiming for greatest versatility, and architects design their buildings using those systems. The most famous example of such a building probably is the Mero Construction System. This procedure has monotony inscribed in its core: through the availability of only one or merely a few types of components. Today though, this 'classical' way can be re-
versed. A system may be derived from a building design. This would have been non-sensical under the paradigm of fordist mass production where the economic goal was to reduce the number of parts as much as possible. When variance can be mass produced, the parts can be different, and the systems more complex and therefore individualized to a specific design project. Furthermore, instead of one system having to be able to generate different types of buildings (e.g. housing, schools, administrations), a system may now be devised for ones specific building only. Even if every part is different, and only used once, for just one building, the production would still be cost-neutral in comparison to the ‘classical’ systems of identical parts due to the benefits of customized mass production as long as the parts are related like relatives in a family. Instead of designing buildings from systems, we can now design systems for buildings.

Research project Overview
We study these novel systematization possibilities through a series of hypothetical student design projects. Building designs of varying complexity are developed and then studied for possible segmentation into parts. In order to be able to be produced, the parts need to be related to one another, like members of a family. Such relationships can be devised via parametric variation. Students are therefore familiarized with parametric design concepts, tools and technologies. The back-and-forth between systems and buildings is studied in both directions. Different complexities and sizes of parts are studied together with different means of connecting them. Assembly and modular building systems from the 1960s and 1970s, when many projects attempted to stretch the possibilities of mass production to the limits, are studied together with possibilities to extend them for more variability.

A closer look at the research project and the incorporation of student projects
The course consists of two parts, the first of which has three lines of study running in parallel: First: becoming acquainted with parametric CAD tools. We give an overview and choose to work with Rhino and Grasshopper as they are widely used and easily contain the functionality we require. Second: Analyzing existing buildings for which building systems have been used. The students understand how the systems work, how they have been used and which shortcomings they have - mostly, with 'classical', non-customized systems, the architects striving to escape monotony, thereby working against an aspect that lies in the systems' principle. Third: Playfully creating a simple design from a readily available simple, even primitive, building system: matches (Figures 1 and 2). The students experience the possibilities and restrictions of a tightly constraining building system literally at first hand. For us, it is very important that the students work in several media in parallel. Using their hands to immediately create something physical facilitates a much richer understanding than

Figure 2
Designing with Systems: Experimental student studies for lamp designs, Aachen School of Architecture.

Figure 3
Experimental pavilion design, Physical and Digital Models, Student Project by Markus Schöps and Ramon Pardo Vaquez. Aachen School of Architecture.
purely mediated work. Especially the spatial possibilities are - as a matter of course, perhaps - much easier to explore in a three-dimensional medium (physical models) than in a multi-dimensional medium (CAD) that is, however, forced through a two-dimensional means of representation (computer screens).

The second part of the course consists of the design of a simple pavilion (Figures 3-5). It should be situated near our architecture faculty's buildings, contain a summer café and multifunctional gathering space for students and visitors and serve as a physical display for the ongoings with the faculty. This design should consist of individual components that are varied, and these variations should be systematized. The students are to start with a geometrical shape that fulfills the desired functions and then develop a system for the components. In order to be able to focus on working on and with the systems, we restrict the building's functionality to that of an enclosure, a shell, without the need for internally separated individual rooms. In the design of the pavilions the students employ their newly learned skills in parametric and advanced geometrical modelling and work back and forth between building design and systems design. Eventually, the designs are build in medium-scale physical models, and CAM methods used.

**Outlook**

In the future, we aim to extend the work in two spectra: Firstly the size and performance of the individual building components. So far, they are merely able to be assembled into two-dimensional enclosures of one specific size and use. We want the systems to create more than one shape, more than one size of enclosure that can contain more than one type of function. Secondly, we want to study the possibilities of systems where the components already contain functional space. Larger-scale CAM methods like printers or robots for example weaving a material allow for this. Our overall goal is to free the producers of architecture from the mental constraints of fordist mass production and the restrictions of pre-existing building systems without increasing the actual cost of building. Apart from versatility with current design tools, conceptual understanding and a reversal of the direction of thought are necessary.

**REFERENCES**