Reflection P4

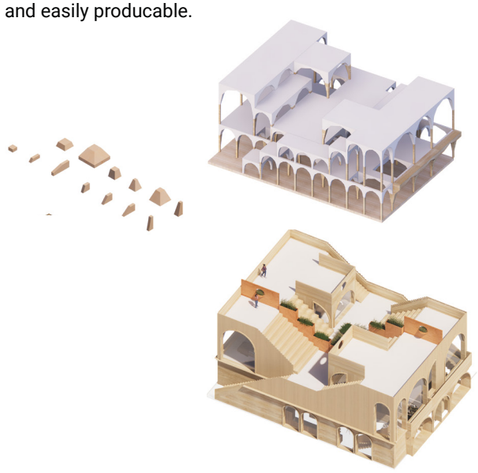
Tutors:
Design: Roel van de Pas
Research: Pirouz Nourian
Building technology: Hubert van der Meel

Student:
Leticija Aleksandra Petrova | 5306345

Delft university of Technology. | Explore lab 2021-2022

HOW AND WHY THE APPROACH DID OR DID NOT WORK, AND TO WHAT EXTENT?

The chosen approach worked for this Research & Development project because in order to devise a modular and discrete building system a method of how to even design such a system and what this system should be/should not be and how it works needs to be specified and explored, which fits well with the framework of any Research and development project. Furthermore, since spatial problems are multifaceted problems they also require several approaches to be used at the same time. In this case a more mathematical and geometrical approach was used for the combinatorial design and the logic in which the pieces are configured, but at the same time design studies were undergone to get valid spaces that are appropriate for the function and have certain qualities to them. The chosen method worked because the final system was found through prototypes, different studies of other systems (Gablok, Lego etc) as well as vault and arch studies both structurally as well as spatially. This all allowed to define the main guidelines if a new building system is being created, it allowed to adjust the logic towards the design and ergonomics as well as the other way around. Finally, the system led to a final method and a final set of building blocks that resulted into a design of a family home, within the validation section the research also describes how the goals of the system were met it was scalable, accessible and easily producable.

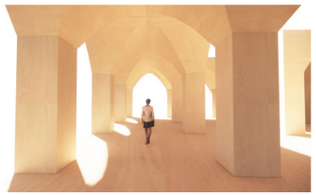


REFLECTION UPON THE FEEDBACK THAT WAS GIVEN BY MY MENTORS.

The feedback given by the mentors was most of the time complementary to each other yet sometimes also challenging in the sense that new solutions needed to be found to tackle several aspects such as the logic of the system, the architectural and spatial design but also the technical aspects of such a system. There was a constant “dialogue” between all these aspects. For example, the size of the system needed to work for the context - Netherlands, where thick structures can lose the highly valued m2. Or the shape of the arch had to work structurally but also be practical in the use of the space, in the spatial design of different rooms, and finally it had to work in the way the limited set of the pieces are designed and assembled.

HOW THE FEEDBACK WAS TRANSLATED IN MY WORK.

The feedback has been translated, firstly, in changing the size of the system to be more appropriate for the function and the context - Netherlands. The system is much thinner now, this resulted also in adjustments of how structurally it works and what spaces it creates.



Secondly, the constant control of the different scales in this project was achieved by including all scales at all times in mind and reflecting on how decisions at a 1:100 scale affect the 1:5 details etc.

The design feedback was taken into account by really exploring the system and pushing myself to find exciting massing options for my building and seeing to what extent the system can support my wishes.

This also meant that additional pieces or ideas appeared for the system itself. The technical aspects affected completely the shape of the arch and therefore a prototype was made and led to the final pieces. Finally, the system, the design and technical aspects really led each other to a complementary assembly process and materiality. To truly portray the mass-customization and the craftsmanship that can both be present at the same time.

HOW I HAVE LEARNED FROM MY OWN WORK.

This was the first project where I truly trusted the process, trusted myself and most importantly the team of tutors to honestly and deeply explore. All the decisions I made by myself or with the tutors came out of the research and never from a previously decided upon choice.
I learned that only through truly integrating all 3 aspects - the architectural design, the outcomes of the research and the building technology it can lead to a building system that is an added value to the modular building system world. I learned how fruitful exploration can be if different studies from different aspects are reflected upon and start intertwining with each other or informing each other.

I learned that asking the correct questions for the most part can be more important than finding the correct answer, because the answer is just one part of the whole picture and the question tries to encapsulate the whole problem. I learned how to be involved in the architectural process from the sketch design right before the execution of the building, because of the connection between my research and design, the design had to very precisely work with the created system which resulted from an early start thinking about the production of the blocks, and finally the building.

HOW THE FINAL PART OF THE GRADUATION PERIOD WILL BE FILLED IN.

The final weeks will be filled in by several things:
- Integrating the research, the architecture and the building technology through different scales, through schemes and through prototypes
- Creating research models with side by side architectural ones to show the logic but also materiality.
- To filter the most important aspects of my project an to “clean up” the storyline
- To showcase the full cycle of my project - from a building block to a building structure to adaptation of the building to the building block again.
- To design the presentation through different means: prototypes, booklets, posters and digital presentation.

THE RELATIONSHIP BETWEEN RESEARCH AND DESIGN.

My design and my research could not be more interconnected, the research tries to find a scalable, compression only building system that consists of only a few timber pieces which can finally result in the structure of a building. This system then directly affects the architectural possibilities, the spatial qualities, the assembly process and the future of the building and its adaptation. It was a back and forth process of the designing the building system and going through many design studies in order to discover what works, what needs to be changed and vice versa.

The design informed the research as much as the other way around.

THE RELATIONSHIP BETWEEN MY GRADUATION (PROJECT) TOPIC AND MY MASTER TRACK.

My graduation topic, my Master track (A) and my Master programme (MSc AUBS) are highly interconnected and related. The graduation project tries to rethink the DNA of architecture to find affordable housing solutions. It rethinks the structure of a building, the assembly of it and the customization of the final design. The building block is in between a brick and a whole room. It is a continuation of the ideas of modularity and prefabrication; it is the next step - discrete architecture. Creating a building system directly relates to other design aspects such as sequence of spaces, variety of solutions and customization to clients needs. Even though it is a multi-disciplinary project intertwining Architecture, Maths, a bit of Computer science, in its core it tries to solve an architectural problem and asks questions which arise in every single architecture project, the difference is that it tries to encapsulate many answers in 1 system.

RESEARCH METHOD & SCIENTIFIC RELEVANCE OF THE WORK.

Scientific relevance

Research in digital design has moved beyond engaging the field not only through sophisticated forms but also through the politics and economics of fabrication. (Sanchez, 2021) Current discourse moves beyond modularity and prefabrication and demonstrates a higher degree of variability, versatility through only a limited set of building parts. In addition, it goes a step further using these building parts and exploring the possible patterns that can be created and provide variety and differentiation at a lower cost compared to custom made elements. The combination of a predefined set of elements and thinking in patterns is redefining the way how architectural production chains work, however, there is still a gap between these ideas and physical housing solutions.

Most work has been done either on different indoor or urban furniture (Retsin, 2019) or pavilion designs (Retsin, 2017), only with a few attempts to create a closed space. (Retsin, 2021)
There have been a few examples from building structures such as the Belgian “Gablok” (Gablok.be, 2022) for wall systems, but many of the examples can be found within game design such as the Lego (Lego.com, 2022) blocks. “Gablok” has achieved an architectural “Lego” piece that lays walls as easily as a Lego structure. The strength of the Lego logic is how simple it is to stack the blocks to create a structure and the grid on what all the elements are based on. The grid is rigid enough for everything to fit and create valid structures, yet it is small and open enough to not predetermine the result. The limitation of Lego is the fact that the structures are made to be viewed from the outside similarly as most sculptures. However, in architecture that would only represent the facade, a small part of the whole building. The most important part is the interior
space that is created which people can use for living, working etc. Therefore, the missing elements additionally to the walls are ones that create floors, roofs & ceilings in order to create an interior space. The Gablok system shows potential with the wall creation and the lego logic, therefore, there is room for shaping new elements to create complete architectural spaces.
This project, firstly, aims to use the ideas of reconfigurable discrete architecture, combinatorial design and compression-only structures to apply them to a limited set of stackable timber elements to reach a large design space and variety within the configurations that the elements offer. Secondly, the goal is to move beyond furniture and pavilions and to provide complete housing structures. To create floor, ceiling, and roof elements in addition to the “Gablok” wall system. Thirdly, to create a set of elements that work as smoothly as Lego blocks within the context of housing the size and shape of the elements need to be related to several aspects: ergonomics, people’s movement, the size of the spaces that are used and the standard elements used in such spaces, as well as the material and production of such elements to tackle the decrease in productivity. Finally, it also needs to provide variety within the solutions offered for clients to have the possibility to customize their homes.

Research method

This research project is a Research & Development project since it is within the realm of “Sciences of the Artificial”. (Simon, 1996) The methodological approach for the framework of this research is based on design science research which is a way of “structuring research methods as a methodology in the context of developing design or “spatial decision support systems” in the more general context of developing information or decision support systems”. (Nourian, 2016) (Peffers, Tuunanen, Rothenburger, Chatterjee, 2007) The more specific framework within the realm of design science research partially used in this research project is the “Go design” framework which is a modular generative design framework introduced by Shervin Azadi & Pirouz Nourian. (Azadi & Nourian, 2021) It is a framework for design processes in the built environment and it provides unification of participatory design and optimization to reach mass-customization and evidence-based design. This framework is articulated mathematically through 3 procedures: 1) space-planning, 2) configuring, and 3) shaping. (See figure 9) It frames typical design problems as multi-dimensional, multi-criteria, multi-actor, and multi-value decision-making problems (Azadi & Nourian, 2021) However, in this research only the 2nd (Configuring) and 3rd (Shaping) procedures of the Go Design framework are undergone, the 1st procedure (Planning) is seen as a given.

Process overview

0. The input of the process within the Configuring procedure is a given spatial configuration, therefore the Planning procedure is not a part of this research. The spatial configuration is meant to be a set of floor levels connected with a set of passageways - corridors, stairs, and ramps. (Figure 11)
1. The next step is to design/estimate an optimal/workable un-reinforced masonry shape for the given configuration, possibly separated according to the separate floor levels/rooms. (Voxel set) (Figure 11)
2. The final step is the approximation of the found shape by a set of predefined polyhedral building blocks that fit into a modular Lego-like 3D grid. (Figure 11)
The result of the procedures is a geometry for the desired housing project based on the created building blocks and inputted spatial configuration. (Figure 10) Additionally, all procedures together create a methodology, a meta level game, which are steps that can be taken, and another solution can be found to have a set number of blocks with which variety of valid solutions can be created.
The next subchapter explains the glossary and the used terminology as well as the exact steps taken within the configuring and shaping procedures which directly affect how the initial inputted spatial configuration will be approximated into a geometry for a building structure.

Configuring procedure

Step 1: Definition of a voxel grid

As mentioned in chapters 2 and 3 in this research paper, the configuring logic is built up on the logic of the Lego (Lego.com, 2022) grid with a real life example of the Belgian “Gablock” (Gablok.be, 2022) that proves how to create walls based on such a logic. This research focuses on how to develop this further and create floors, ceilings & roofs within such a system, because the Gablok system provides a solution for walls and the Lego game pieces only provide the exterior of the structure, but within the Built environment the interior spaces are equally as important. Since the Lego logic is chosen a 3-dimensional voxel grid is defined for the creation of the building blocks as well as for the universal logic of the system based on several constraints.

Step 2: Aggregation logic & interface between elements

Once the voxel grid has been made there are certain aggregation and interface rules and restrictions that have to be taken into account before shaping each element. These rules must provide that it is possible to extend each element upwards in the z direction (and some also in the x and y) and customize the scale of the building (ceiling height, room width etc) (Figure 13)

Step 3: Spatial unit validity constraints

For the configuration to be spatially valid several constraints must be met when configuring. The constraints concern topics such as daylight, access to and from spaces on the same and different levels and, finally, structure. In this research the daylight falls out of scope, however access and structure are tackled.

Shaping
The procedure of shaping takes the configuration (voxel set) of the configuring procedure and approximates a geometrical representation of the tile set using predefined building blocks. (See figure 14) This section explains the actual steps of designing the building blocks that are predefined and used to translate the voxel tile set from the configuring procedure into final geometry of a building.

Step 1: Structural logic & Scalability
Since the Shaping procedure defines the final shape, material & production of the building blocks it needs to have a structural logic of how the elements work together. The goal for the predefined set of the building blocks is to:
- create a stable compression only structure (test through prototyping and through defining the arch/vault shapes)
- have a dry connection,
- be scalable
- be easily producable

Step 2: Manufacturing costs and limitations:
For example, the shaping procedure faces the constraint of the manufacturing process, more specifically the costs and the limitations of this process. The limitations include the material and its production, meaning the shape of the module must be related to the size of, for example, standard wooden sheets as well as the possible shapes that can be reached with such a material. (see figure 14)

Step 3: Element creation approach
There needs to be an approach of creating the elements in such a way that they directly relate to the type of structure that has been chosen, meaning, the elements must always create a compression-only structure once assembled together.

Step 4: The final shape of the desired spaces
Shaping also specifies more specifically what each type of building block offers within the context of creating a house, how a room will function & look like. These are the final adjustments of the elements.

RELATIONSHIP BETWEEN THE GRADUATION PROJECT AND THE WIDER SOCIAL, PROFESSIONAL AND SCIENTIFIC FRAMEWORK & TRANSFERABILITY OF THE PROJECT RESULTS.

Societal relevance
Due to a very slow and expensive process of construction the act of building is accessible only to a few actors, therefore the housing supply is limited and leads to a housing shortage. Firstly, housing solutions are necessary, for example, in the Netherlands to take control of the situation, “845,000 homes need to be built by 2030” (Lalor, R. (2021)). Secondly, a home is one of the biggest investments in most people’s lives where a considerable amount of time is spent, therefore a sense of identity and variety within the housing supply is necessary for user’s to be able to customize their spaces. By redefining the spatial configuration problem through mathematics and using combinatorial design enough repetition and low costs can be reached yet also variation within the housing units can be offered. Through intertwining design, fabrication & automation a more accessible and open-ended built environment can be created.

Transferability of the project results
The result of the research part in itself is a method. It is a method which guides you through making a modular, discrete building system. It is free enough that the shape of your building blocks can be completely customized, but through its configuring logic it makes sure that it creates valid and scalable results.

ETHICAL ISSUES AND DILEMMAS ENCOUNTERED IN (I) DOING THE RESEARCH, (II, IF APPLICABLE) ELABORATING THE DESIGN AND (III) POTENTIAL APPLICATIONS OF THE RESULTS IN PRACTICE.

Firstly, creating a building system always means that certain aspects need to be set such as the grid and the size, the function, the extendability, the target group etc. Which effectively leads to assuming certain dimensions that are based on ergonomics and comfort, which will always be related to an “average” and of course it never fits every person perfectly. However, it is the price you pay if only with a few pieces you want to reach a large space of design solutions.
Secondly, the system was intended to strive to be affordable yet the design process and the exploration and showcasing of the building system went into a direction where luxurious solutions were also added to the overview in order to push the limits of the system. Which then moved the focus to truly strive to make the system affordable, more into a direction of exploring the possibilities and validating if the system can solve different architectural needs.
Thirdly, the carbon footprint of the chosen materials and production process as well as the assembly of the building needed to be taken into account, because the goal was to reach an affordable solution yet also environmentally conscious one.
Fourthly, of course there is not just one perfect building system, but some systems can make the act of building more accessible to people, fit different functions, scales, contexts. Therefore, the application of this system is not intended to reduce the diversity of architecture, but more so to be a means to create a modular structure that can be reused in the future, adjusted and adapted.

Delft university of Technology, | 2021-2022