Project Title: The Pop-up Superstructure

Introduction

For my graduation project my aim is to design a demountable structural system that takes into account sustainability and easy of assembly methods, allowing it to be used and re-used for different applications within the realm of temporary architecture.

Despite the fact that pop-up and temporary architecture is slowly evolving, there is much room for improvement. While the focus is in the function it serves, it very commonly lacks in the aesthetic aspect and the quality of the space, being perceived by many as cheap, fast and disposable. Similarly, in the technical aspect, it lacks the diversity of material applications and building construction techniques that permanent buildings can have.

My fascination with temporary architecture and demountable systems came from my experience working for international sporting events, where temporary architecture was used in a very commercial and limited way, thus, lacking in the architectural quality of the space and the diversity of materials used.
The relationship between research and design

In order to accomplish the goal of my project I was faced with many challenges from both the conceptual and the technical sides.

Conceptually, I needed to investigate why create temporary architecture, its history, state-of-the-art and potential for development and place-making. To investigate these aspects I wrote a history thesis as well as a position paper on the subject of temporary architecture. In the history thesis, I researched how temporary architecture can be efficient in addressing a certain function with a temporary need (example world fairs and sporting events), therefore avoiding expenditures in gigantic buildings that have no future use, thus creating the known “white-elephant” effect as it can happen, for example, after major international sporting events. In the position paper, I investigated the pop-up effect of temporary architecture and how it can serve as a means to place-making, while enhancing a location that would be otherwise forgotten. Also, it was noted that the pop-up phenomena in architecture can be used to address the ever changing needs of our fast paced societies, and their aspiration for flexibility and portability.

Technically, I needed to investigate how to design a demountable system that would be at the same time more sustainable than existing structures as well as lightweight and easy to assemble. So, in my technical research I focused on 3 main criteria to help address these questions: materials, sizes of members and connections.

While looking at the material aspect of my research, a whole world opened up. Through the help of a material science software called CES Edupack I was able to select and compare materials that were either widely used in temporary architecture such as steel and aluminum, as well as alternative materials that are not yet largely used such as laminated wood and laminated bamboo. Through the creation of an extensive database, I was able to create a material selection tool based on three different criteria: material performance, material health and cost. The methodology created suggests that there is no one material that is absolutely better than the other, but rather that the selection of the right material will depend from case to case and based on different priorities for the design at hand.

My research also emphasized the importance of material selection, since building demolition accounts for approximately 30% of the total waste produced in Europe and the U.S. Bringing this knowledge for my project, my goal was then to find a strategy to re-use materials not from downcycling or upcycling. Instead of focusing on what happens with the material at the end of its lifecycle, design was used to achieve the 4th principle of the Circular Economy (as outlined by Ellen MacArthur Foundation) which consists of re-using materials that have kept its quality. This, however, is the most difficult circle to achieve given that it is hard to predict materials future uses and it needs to be implemented in designs that can be disassembled. With that in mind, the focus of my project was not only on the material selection but also on the design of a disassemblable system planned to achieve modularity yet versatility that would allow the same pieces to be re-used in different ways in the future.

Also during my research I looked into different methods of connections and what sizes would account for the creation of a modular system that could be easily handled on site and transported to and from site.

For my project, I used my research as a method from which I could effectively select a material knowing where it stands in comparison with other materials in terms of performance, sustainability (material health) and cost. Then, I used the research on transport sizes and permissible weights that a construction worker can carry to start creating the modules of my demountable system.

However, the connections part was very generic during my research just showing some different methods according to the choice of material I made: laminated wood. So, I had to investigate this aspect further along with the design that I had envisioned.
The relationship between the theme of the graduation lab and the subject chosen by the student

Having had such a strong technical fascination that preceded my coming to TU Delft, the Architectural Engineering chair was the right fit for me to develop and investigate it further, since I believe that the program is a great combination of architecture, engineering, building sciences and sustainable design.

From the very beginning my project was placed under the “make” division of the studio, where students are supposed to learn by doing.

In order to explore the potential modularity and flexibility of my proposed system, I had initially chosen 5 different sites around the IBA Parkstad area where I could use temporary architecture to either bring people together or to enhance a certain landscape or remote location that spoke to the history of the region. Throughout the process, I decided to eliminate one of the sites and just keep 4 of them for further development.

For my P2, I had the basic members of the system developed as well as sketches that would show the proposed interventions on each site.

But before I could think of implementing my system into these 4 sites, I first needed to create a toolbox. Therefore, for my P3 I chose to focus on the main site located in Heerlen to become an exhibition centre for the IBA Parkstad opening year, as well made efforts to developing a preliminary toolbox.
03 - The relationship between the methodical line of approach of the graduation lab and the method chosen by the student

Under the subject of “make” of the architectural engineering studio, I was faced with a huge challenge just before my P3: I hurt my back during a fall and could only move with difficulty, walk and sit limited amounts of time and carry no weight. So, achieving the goal of making prototypes seemed quite impossible.

Despite the circumstances, I created my first model to explore and understand the potential of the proposed system. The model was made using thin lasercut pieces of MDF that were put together to mimic the lamination process of laminated wood (with adhesive on one side of the MDF that glued the multiple laminae). Most importantly, these pieces were connected by fitting one into another with no glue. The system I had envisioned in the beginning was to be made using just wood and no steel connections or bolts.

During my P3 presentation, I had the models showing in the picture and the design of one of the sites and a preliminary toolbox. At the occasion, the feedback I got from my tutors were mainly concerning the limitations of my system and its structural integrity. Their number one concern was related to the wooden connections and how weak they were. In order to achieve stronger wooden connections my system would get too bulky and therefore I would loose on the desired lightness. Secondly, they wanted to know how the stresses work in the connections so I could design them accordingly.

So, at P3 I was faced with questions that were related to structural engineering so I soon discovered I needed to go beyond the engineering knowledge we learn in architecture schools and dig deeper into the engineering side.

Pictures of first model

Attempt to create a demountable system using wood only.
Unfortunately, my health condition had deteriorated with time and I had to interrupt my studies to seek medical treatment. Therefore, I stopped at P3 and couldn’t continue to do P4 that semester.

After hospitalization and still during recovery and rehabilitation processes, I first studied engineering more deeply in order to establish which load cases to use for my calculations. I then started by doing hand calculations. However, the issue was complex due to the many geometrical shapes that was possible with the system and therefore, hand calculations could only take me so far. Then, I sought help from an engineering consultancy with whom I could discuss the structural challenges of my project. During the process I learned how to use an engineer software called FTool, which was simple enough and where I could draw all the frames I had created in an index format, so that I could check the limits of my design.

After establishing the limits of my design in terms of maximum allowable deformations, I was able to compute the maximum stresses in certain types of connections and only then design them appropriately. This study soon revealed that wood connections were not possible and I would have to adapt to steel connections.

The next step was then to design these connections to the very minimal detail so I could try and prototype them. With help of the family, I was able to create wood prototypes in scales 1:2 and 1:5 showing the critical connections of my design.

While experimenting with wood and trying to create a demountable system, the next big challenge to address was the bolt. A regular bolt or pin when entered tight into the wooden hole would get stuck in it. Therefore, the system could not be potentially demountable and re-used again. Any efforts to trying to get a regular pin or bolt out did damage the wood. So, I researched expandable bolt systems and tried first to adapt anchor bolts (which expand on one end only). But it failed, since once it got expanded at one end it got stuck in the wood anyway. So, I researched expandable bolts that would expand and retract allowing for ease of disassembly. However, none was to be found for the application in architecture. So, I designed the bolt based on the study of a few precedents in other industries. Later, I found a company who was willing to trying to produce it.

After all this time studying on my own and experimenting with things, while also going through a very intensive rehabilitation process, I was then able to come back to Holland. So, now I am focused on further developing the 4 architectural interventions I had envisioned from the very beginning of my graduation year using the system I have created. This exercise will require me to zoom out and change from designing on the scale of a bolt to designing on an urban scale.

After P4, my focus will be on showing the implementation of this system on small physical models of each site (if possible).

Pictures of prototypes

Prototype 1:2 and 1:5 disassembled to be brought to TU Delft
**04 - The relationship between the project and the wider social context**

I do believe that a system that allows for the creation of temporary architecture with an enhanced spatial quality and more consideration for sustainability can benefit society in many ways, whether it be as a response of a natural disaster, a showcase of technological innovation, a response to an environmentally sensitive site or simply built for an event that has a short lifespan.

Even if the system I have created were to be implemented solely on a single niche market, such as events, the range of possibilities and architectural spaces it can create would still render the project successful. In fact, just the idea of having a system that can be used and re-used in different project scales would be interesting. When looking at the niche market of events, for example, there are numerous possibilities for implementation in various cultural and leisure programs, such as: exhibitions, fairs, festivals, recreational venues, markets, or simply spaces to connect with one another or with nature.

It is a fact that the development of the proposed system would need further elaboration depending on its target market and would demand a team of professionals of different sectors to make it possible and viable. But I hope at least that my project can stimulate the development of ways to construct that will demand less extraction of materials, less depletion of natural resources and less production of waste. If only buildings can be easily dismantled and re-used, then the built environment will benefit from not having to deal with costly derelict buildings. Instead, these buildings will be able to serve their temporary function effectively living minimum or no trace behind once they are dismantled. Furthermore, they will have the possibility of being re-used in a new setting and adapted to future needs.