

# INTRODUCTION

A stage is a place in a space from which information is transferred to the audience. The typical stage is designed in such a way that it facilitates the information flow with audial and visual support.

The stage is mostly used for presentations and discussions. The use of a stage can be summarized with the following events: presentation, discussion and (coffee) break. In these events the information flow changes gradually from a unilateral flow of information to a multifaceted information flow.

The typical stage is well designed to fulfill the presentation event, by providing visual and audial support to the speaker. The audience has no audial or visual support making it more challenging to communicate during for example a discussion.

The typical auditorium has a clear division between stage and audience, only providing a unilateral information flow. By giving the audience access to audial and visual support we can make the presentation more interactive. During breaks it should be possible to create your one stage to discuss a topic. In this way stage becomes a place for co-creation of information.

We've gone through a series of study and investigation, ending up with the three focus:

1/ Interactive components 2/ Ergonomic informed Design 3/ Deployment & Reconfiguration

## 1. INTERACTIVE COMPONENTS

To give the audience visual and audial support we designed sitting objects with sensors and actuators. They can detect light and sound. Depending on the light conditions or sound conditions of the space the chair can generate different light colors and light intensity. This all depending on the scripts.

The biggest problem during a presentation is that it is mostly a passive activity for the audience. Studies show that after 20 minutes most of the people lose attention. Colors have an influence on our concentration level. Blue and green have a calming effect on the brain and red and yellow activate the brain. Gradually changing the colors of the chairs during the presentation can help keep the attention at a constant level. The chairs will be blue at the beginning of the presentation to calm the audience. After 10 minutes the color will change gradually to red to activate the audience.

During a discussion some people want to participate and express their opinion or ask a question. Most of the people never participate. To have a better representation of the general opinion of the audience it's better to get everyone's opinion. When there is a vote for a topic or vote for opinion the color of the sitting objects can be changed individually. For example opinion A has a red, opinion B a blue and opinion C a green color. By changing the color of the chair to one of these colors you can express your opinion. The presenter can see in one go which opinion is the most popular. The color can be changed by blocking the light near the light sensor during a fixed amount of time.

Normally the (coffee) break is very chaotic, and people barely get in touch with each other. To stimulate informal discussions and meetings the furniture in the auditorium should not be fixed, and should be light enough to move. Grouping could be stimulated by enhancing visually where the sound comes from. The sitting objects are made of EPS to make them light. During the (coffee) break the sitting objects change

colors depending on the sound they detect. In this way its easy to see were the speakers are, thereby situated enhancing the forming of groups.

## **2. ERGONOMIC INFORMED DESIGN**

### **MACRO SCALE**

The stage

Our fragment renders a continual, flowing shape which evolves between different functions and spatial configurations. I.e. the lectern develops in a bench, then a floor and concludes to an elevated sitting area-auditorium.

The synthetic shaping procedure of the platform was affected by 3 main parameters: functionality, movement, and ergonomics. Additionally, the design was significantly influenced by working within a context of dialog with the different group fragments. The necessary volumetric spatial requirements for human movement and comfort of the platform where studied through multiple section developments of different ergonomic postures and a minimum space usage script (cave).

The overall construction is consisted by a concrete cantilever infrastructure which serves as a structural support for a number of different modular (interactive) components which, when assembled together, conform the main stage area.

These components will be able to interact with the lecturer by an embedded lighting and audio equipment (sensors, arduino and actuators), that augments the self-sufficient dynamic behavior and resilience of the stage. In this manner the stage attempts to enhance the ability of the structure to adjust in different use scenarios and transform from a compact platform, to various sitting configurations which can host discussions and other group activities in any given plot.

## **3. DEPLOYMENT & RECONFIGURATION**

### **MESO**

#### **STRUCTURAL OPTIMISATION**

During Workshop 1, we started with exploring the fabrication principle in a smaller scale that we believe the result would inspire the fabrication in larger scale.

The initial idea is to rebuilding the mass from a branching structure, then relate the thickness of the branches with the orientation and functions. In order to optimize the structural performance while minimizing the material use, we use Millipede(grasshopper plugin) to analysis the structural performance, and adjust our script according to the result. We planned to fabricate the structure layer by layer, however the resulting inter-crossing structure were very messy, the joinery between different layers are not designed and controlled. As a result, we found it not logical to model the joinery manually for fabrication.

With the previous findings in mind, we developed the cellular concept - Generate the branches by 3 layers of three-dimensional Voronoi cells, with the size and thickness are various according to the structural performance. After that, we also tried to divide the whole geometry in larger cells, and sub-divide them into smaller cells. That the number and density and distribution of subdivision are informed by the structural analysis.

When we look back to the over fabrication, we encountered several structural challenge including the cantilevering part of the design, counterbalancing and the required strength to accommodate the desire function on the stage. We then decided to fabricate the stage in two layers - The structural concrete shell, and the functional EPS layer.

Focusing on the structural concrete shell, we combined the previous findings on the layering and cellular concepts, we would like to achieve a more controlled design rather than the computer generated voronoi cells, aiming for more regularity without losing the essence of non-standard, computer aid design process. We decided to rebuild the concrete shell with hexagonal cells, the structural branches within the cells follows the geometry and create a uniform overall impression. Which the mobility of the stage in mind, we also designed the shell to be fabricated by groups of cells.

The variation of thickness on the concrete shell, size of the cells, thickness of the branches, internal structures within the cells, and the grouping of cells are informed by the structural analysis with the help of Karamba 3-D(grasshopper plugin) and UHPC experts form HI-CON. We related the mentioned parameter with the principle stress, structure deformation and compression-tension analysis, through the back and forth process, optimize the design of the concrete cells.

## FABRICATION

An important design decision in the fabrication procedure, in order to facilitate the modularity and transportability of the structure, was the division, cell population and perforation of this doubled curved concrete slab. Therefor aiming in material reduction and robust forms the team experimented with new possibilities of the (high performance) concrete production in structural optimized environments. As a result stress calculation data, topology optimization and robotic arm tool paths were the main input parameters used in the scripting process.

In this generic spatial swarm the different components are fabricated from an EPS core coated with an epoxy resin and rubber. This elastic coating, which constitutes the finishing layer of the overall construction, is applied in the bottom surface of the modular components and the resting areas of the stage. Thus, this material undertakes a role of comfortable sitting while in the same time it facilitates the interlocking process with the concrete honeycomb structure through an extrusion of the negative porosity pattern on the hexagon shells.

### Concrete fabrication

Our part of the stage will be constructed from two main materials: EPS and concrete. The EPS will be used to create the components nested in the top layer. These need a coating to protect the EPS from

damage. Two different coatings have been tested, one on an epoxy base and the other on a polyurethane base. The components are fabricated by EPS coated with epoxy resin and rubber paint. This elastic coating, which constitutes the finishing layer of the overall construction, is applied in the bottom surface of the modular components and the resting areas of the stage. Thus, this material undertakes a role of comfortable sitting while allowing the components to interlocking the concrete structure through an extrusion of the negative porosity pattern on the hexagonal shell.

The epoxy base coating will also serve to prevent the concrete sticking to the EPS in the mold removal process. The first conclusions are that the polyurethane coating is easier applicable, because it is less fluid so it will flow as much, but it has more texture due to the way it is applied. It does smoothen out a less clean surface though. On the other hand epoxy leaves a very smooth surface, but is harder to apply evenly. Mixing it in the right ratio is hard, but very important. Another argument for the epoxy is that glass fiber can be added to gain even more durability.

The mold for the concrete exists of three parts: a main mold from EPS, wooden edges and the components to top it off. The main mold consists of branches of coated EPS. To test the minimum thickness for these branches, a working model has been made. This model has branches with a diameter from 40 to 20 mm. These sizes are based on advice from the concrete supplier on structural minimum and to prevent lumping together due to the fibers in the concrete. For now, the mixture doesn't seem to get all the way through into the thinnest parts, but adding more water to the mixture might make it more fluid and thus more able to fill the whole model.

## **MICRO**

### **TOOL-PATH**

After defining the hexagonal pattern, we can use the volume of an individual cell to mill a mold of EPS in which we pour concrete. The cells need to be light but structural and according to the ergonomics, the top surface needs to be more solid in order to walk or sit on it. So our first direction is a cell of concrete that, as you near the bottom surface, will be more porous. The approach of milling is that we mount the piece of EPS on a robotic arm and program the arm in such a way that the arm moves the EPS according to the position of the fixed drill. In this way we can mill from all the directions except the bottom. Luckily this will not limit the design because of the higher level of porosity at the bottom. For the final result we aim for a straightforward design of the cell that exists out a milling method. So generate the tool paths and not receiving them from an already designed end result.

The first step is mount the EPS on the robotic arm and use the hot wire cutter to cut away the part of it that is not within the boundary of the cell. Then we can use the tool paths to guide the robotic arm. The principle of the method is using the faces of the boundary in relationship to the cells center. Each evaluated point on the face, according to the distance to the center of the face, will inform the robot a depth it needs to drill. The closer to the center of the face the less deep it goes. So at the corners of the face the drill will reach the maximum length of the cells center. This principle will create a branching structure within the cell.

## **CONCLUSION**

After understanding these new approaches of manufacturing, we decide to continue working on the project a little longer. After the Msc2 presentation we will continue according the schedule below. We will

improve the scales of macro, meso and micro and after finalizing the design we start testing the process of milling and hot-wire cutting with the robotic arm. When everything is prepared and installed we can manufacture the molds around the end of August. After everything is milled we can start testing the process of pouring concrete into the EPS molds with HI-CON.