DRAFT REFLECTION

MASTER OF SCIENCE ARCHITECTURE, URBANISM & BUILDING SCIENCES

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STUDIO

Studio: Building Technology

Mentors: ir. A. Borgart (Structural Design) and Dr. P. Norian (Computational Design)

GRADUATION PROJECT

Title: TENSEGRITY STRUCTURES FOR LARGE SPAN ROOFS (for Feyenoord Stadium)

Location: Feyenoord, Rotterdam, the Netherlands.

REFLECTION

On the theme graduation lab and the chosen method, topic, outputs of the thesis

The theme of Building Technology graduation lab is to bridge the gap between architecture and engineering. It directs architecture with technological methodologies. Following this purpose, the investigation of the thesis in tensegrity structures is exactly the area in-between architectural design, structural engineering, and computational design.

This thesis contributes to constructing the library of tensegrity structures with a design method for application in large-scale construction. This is a new method of making double-surface tensegrity structures. In fact, there are some studies on double tensegrity structures, but in these systems, there are struts touching the others. The method propose by this thesis makes sure that one can build a pure tensegrity structure with almost any given geometry, struts are completely floating in the network of cables, the connections between compression members are prevented. It helps to resolve the obstacles posed by the complexity of such the systems by the innovative use of computational tools. In addition, a way of improving the rigidity and usability of tensegrity in mega-structure is explored, which paves a way to realize the construction and fabrication of the buildings using this structural system.

The thesis provides a plenty of possibilities to develop further in terms of structural composition, computational programming, topological mathematics, and possibly the combination of them.

The thesis constructs a new way of structural approach towards structural skin to potentially make the systems more transparent and integrated within urban contexts, architectural quality, technical installations, and services. The design helps to make the building honest in its own way of structural performance.

On wider social context

A new way of tensegrity application can reflect the technological innovation of our time in a complex type of building covering a huge open space, a stadium. A stadium is a major component in social interaction in the culture around the world. It is currently the place where people are able to come together to celebrate sport, enjoy a concert, or congregate for self-expression, or some other similar social events. Society would obviously benefit from the impact of using tensegrity systems for the redevelopment of a current urban context.

Throughout the history of stadium construction, the stadium roof is always representing the technological innovation in structural engineering of that time, which is an inspiration to push architecture going forwards. The structural span of a stadium roof is always enormously large, and normally coming along with a big central opening which makes it even more challenging. Being able to use new composition of tensegrity structures for a stadium roof is absolutely an innovation. Feyenoord stadium, as well as the city of Rotterdam, has its own tradition of applying high-end technology and innovation in architecture. To continue this avant-garde tradition, the singularity of a tensegrity roof will be the right answer.

On relationship between design and research

There is a strong coherence from design method, structural principles, constructing digital models, physical models, and structural models towards the construction in real scale.

Research and design have been always going along. They have a dialectical relationship. One has always been moving back and forth to achieve positive results in the end of the process. Since nothing comes from the blue, one cannot design without research. They are not two separate areas. Research provides inputs to design process, and in turn, design helps to redirect the research procedures, programs. One cannot create an invention from scratch, but by transforming the existing materials, one can acquire a new thing.

One could choose either 'Research by Design' or 'Design by Research' or the combination of them as the way of conducting the thesis. 'Research by Design' seems to fit me well since I feel it is very enjoyable while I was trying out a number of design options, comparing them, and sometimes a new design appears in-between these options. The physical modeling, critical thinking, and the combination of computational tools are crucial in both design or research process of tensegrity study.

Evaluating the design process

The process was not linear from one step to another as expected in the research framework, but it is always going back and forth, revaluating, redirecting, redoing, resetting, and recalculating. I went from very generic model to specific one, then to very complex one. But with the complex one which is computationally expensive, it is almost impossible to calculate in the beginning, even with the computer, the calculation time is just too long, for days. For this reason, I had to simplify the complex model to the simplest version of the type to be able to perform simulations in the computer. For computational form-finding, physical models are crucially important. One has to play around with these form-finding techniques in several software programs many times to achieve the right method. When the behavior of physical models and form-finding models are similar, the right form-finding method is selected. To do the form-finding, the model needs to be designed beforehand, in terms of topology and geometry. The form-finding did give some interesting alternatives. In the end, it is mostly about giving the right pre-stress forces to the tensegrity structures, and it needs to be locally customized.

I actually successfully created a new design method for new types of tensegrity structures which are able to stand by itself in reality. I have gone through all the steps planned in P2 and achieved positive results. Although the full-scale structural model of Feyenoord stadium still has some difficulties to analysis, it can be handled afterward. Also, I have not managed to have a fully parametric structural model, which is a limitation that prevents from having more alternatives. But in a way, doing certain parts manually helps me build up the understanding of tensegrity structures very well. I could consider that the lack of programming part actually helps me to spend more time on constructing the new design method for double-surface tensegrity structures. I realized that slowing down the process is essentially valuable for both research and design.