DIGITAL MANUFACTURED REINFORCEMENT BAR IN CONCRETE STRUCTURE

PERSONAL INFORMATION
- Name: Mohammad Ali Bijani
- Student number: 1393391
- Telephone: 0650875248
- E-mail address: Ali.Bijani@gmail.com

STUDIO
- Studio: Structural Design, Building Technology
- Mentors: Ir. Arie Bergsma
- Ir. Joris Smits
- Ir. Paul de Ruiter

TITLE OF THE GRADUATION
Digital manufactured reinforcement bar in concrete structure
# Contents

2 Graduation plan .................................................................................................................. 3

2.1 Problem Statement ......................................................................................................... 3

2.2 Objective ......................................................................................................................... 4

2.3 Research Question ......................................................................................................... 4

   Main research questions .................................................................................................... 4

   Sub research questions ....................................................................................................... 4

2.4 Approach and methodology .......................................................................................... 5

2.5 Time plan ......................................................................................................................... 8

2.6 Reflection ......................................................................................................................... 9

   2.6.1 Industrial relevance ................................................................................................. 9

   2.6.2 Personal relevance ................................................................................................ 9
2.1 Problem Statement

The freedom of imagination was always one of the architect’s dreams. In eyes of them, a building is not always a pure functional object. Like sculpture, a building could also be perceived as an art piece. Designers try to achieve aesthetic qualities by various ways. Designing fluid form structures is one of the ways to achieve that dream. However, dreams are not always achievable. The architect initial idea should go through different phases and each phase has its own obstacles. With the help of computer programs, architects have great freedom to design what they have in their mind. But when it comes to manufacturing, the current technologies does not offer the same level of freedom. The digitally designed project need to get constructed by traditional ways.

Concrete is one of the most common materials in building industry and its initial fluid phase makes it suitable for freeform objects. However since concrete was invented, its fundamental construction principles has not changed a lot. Concrete can be formed into any shape but it needs different equipment’s. Formwork is essential equipment in concrete construction and it will dictate the final shape of the object. Creation of these items in complex project requires lots of effort and additionally these items can only be used once. In standard concrete structures, around 50% of budget is invested on these items(Robert, 2007)

It is also a known fact that in big loadbearing structures, basic concrete is not sufficient. Concrete have a weakness on handling tensile forces and therefore it needs reinforcement. In simple building with straight walls, this is not a problem and it can be solved by placing several reinforcement bars. However, when building has non–lineal forms, reinforcement bars are also affected. Sometimes complexity of these types of items can force designers to changes their materialization.
2.2 Objective

Freeform concrete structures are one of the challenges in building industry. This is mainly because the conventional methods are developed for simple and lineal objects. However, these structures are getting constructed by modifying and adjusting those techniques. The main purpose of the research is to develop a technique that is suitable for these types of objects.

The other objective of this research is to shift manufacturing techniques to more digitalized manner. Currently most stages in design phase are done digitally. Programs such as 3Dmodelling, BIM and parametric design revolutionized the design process and mad life so much easier for architects. However, manufacturing techniques are still following the traditional routes.

List of objectives
- Develop a technology suitable for freeform concrete structure
- Adapting digital manufacturing techniques in construction process
- Fill the research gap in digitally fabricated reinforcement bars

2.3 Research Question

Main Research Questions
- How can digital fabrication be used to create a customizable reinforcement element in freeform concrete?

Sub Research Questions

Evaluative
- Can reinforcement structure eliminate the need for conventional concrete formwork?
- Can the developed reinforcement technique makes construction of complex projects more efficient?

Informative
- What are the requirements for reinforcement structure?
• What are the existing reinforcement techniques?
• What are the conventional methods for creating freeform concrete and

2.4 APPROACH AND METHODOLOGY

This graduation will be in a six stages (see Figure 1).

1. Preliminary study
2. Literature review
3. Case study
4. Design and concept development
5. Test and evaluation
6. Finalizing

In preliminary stage, a brief research was done on digital manufacturing and concrete background information. With the help of gained information, the focus point and objectives of this research was set. It has also helped to create a framework to research on literature and case studies.

In the Literature review, all the necessary information for developing a new reinforcement technique should be collected. This is done by theoretic studies and research. The first section will cover the following points:

• Properties of concrete
• Requirements and regulations for reinforcement structure
• Alternative material for reinforcements
• Production process for rebar and formworks

In the second literature section, we will look at information regarding to digital fabrication:

• Available technique
• Pros and cons and its limitations
• Possible printable materials with high tensile strength

The knowledge that is gained in the second stage is very important. However, it is important to know how these techniques are used to handle the problems in our research question. For these purposes a list of case studies need to be find:
• Digital manufactured project suitable for reinforcement structure.
• Freeform concrete building

With the help of these case studies we can get a better insight on solutions and latest developments in the building industry.

With the combination of literature and case study information, we should be ready to start with the designing process. In design development stage different ideas should be developed. These thought then will be evaluated and tested. These steps will give us the feedback for further developing the new ideas and it also help us to create boundaries for the final design.

After design development stage, a final concept should be chosen. Based on available techniques, an initial model will be created. This model can be further used for testing and analyzing purposes. For verification and testing of purposes, FEM analyses software will investigate the developed ideas. These steps can be repeated several times the collected feedback collected will be used to create our final design.
FIGURE 1 METHODOLOGY
2.6 REFLECTION

2.6.1 INDUSTRIAL RELEVANCE

Freedom in form is always what architect desires and after development of digital designing software’s, designers gained the capability to create even more complex geometries. As we know, not all the design can be constructed. This is mainly due to limitation on current manufacturing techniques or financials issues.

Freeform and double curved forms are a trending design choice in architecture world. However, construction of these objects is considered as one of the most challenging tasks. Most of existing techniques are developed for lineal structures and they are not the most suitable and efficient ways for handling these types of geometries. This restriction in constructing techniques will eventually prevent new design possibilities in architecture.

During the preliminary literature study, it was observed that the most of the ongoing researches are focused on formwork techniques or additive concrete production. However, in reinforcement structure field, it is hard to find that many research papers and there is a big research lack on that topic. Therefore investigating the new possibilities for reinforcement structure will have a great potential to make a change in construction industry.

2.6.2 PERSONAL RELEVANCE

Digital fabrication was always a topic that I was fascinated by. I also have a great interest on developing building construction process and knowing how things are done in detailed level. Regardless of the eventual outcome of this paper, the related literature study and designing the process for construction techniques will expand my knowledge in this field and give me a better perspective.