Introduction
In this reflection of my graduation process I will discuss the relevance of this project within the Sustainable design graduation studio of the master track of Building Technology at the Delft University of Technology. The methodology, the relationship between research and design, the social context, the planning and any difficulties that occurred in this process will be addressed.

The relationship between research and design
In the development of my bridge design, research and design went hand in hand. Starting off with research regarding the city of Rotterdam and its needs and demands, leading to design decisions, which on their turn lead to new research within these newly set design boundaries and so on.

Research by design
This type of research started off after the P2, after the main research into the design brief was conducted. With the general knowledge of bridge design and the different forms of bridge design, the aesthetical demands and a clear definition of the problems of the city of Rotterdam, a well-founded first design could be made accordingly. Next, the impact of this bridge design to its environment and the position within the urban context could be analysed.

Design by research
This way of designing might be the biggest part of my graduation. By wanting to optimise the bridge in shape and topology, research was a big part of the design process and even made part of the design. Especially research in the structural behaviour of the design played an important role in the forming and adjusting of the design. Although this can arguably also be called research by design, since the design was constantly altered and analysed to optimise the behaviour within the set design boundaries. As I mentioned before, design and research went hand in hand.

Sustainable design graduation studio
In the design of a bridge, the design and knowledge of the technology are crucial. The structure of a bridge, next to its mechanical behaviour, also determines its character and look. This is what makes a bridge design, in my eyes, the ultimate form of structural design within the field of building technology. Structural analysis was a big part of the design process and optimisation iteration.

Sustainability
Although the bridge does not generate energy or collect rainwater, sustainability is addressed in the design in the fields of efficiency and a social aspect.

By optimising shape and topology the material usage is minimised, so only the actually needed material within the design boundaries is used. By setting up a parametric model, the behaviour of the structure was constantly being analysed. This has resulted in an efficient design and reduced the amount of issues that could have occurred due to unfeasible design choices. Also, by having a flexible design, prepared for the future, the design is very durable.

From a social point of view, the project handles with a very real problem. The barrier formed by the Nieuwe Maas, splitting the city of Rotterdam into two, has caused the South of Rotterdam to be left behind to the thriving North. By creating a new connection, in my opinion, this issue could be solved.

Methodology
The research, conducted for this project, consists out of two main analysis parts and a final design study. The first part of the analysis focusses on the location itself and the actual need for the connection and its demands. This analysis forms the boundary conditions for the second part of the research, where bridging types and structures are analysed. Together, these two analyses result in strategic guidelines from the location and technical/structural guidelines and demands for the design study.
In the design study, a bridge type is selected and a first draft design is created. Here starts the research by design bit. Practical problems are solved, leading to an adjusted first design. The determinative variables within the design boundaries can be determined. The optimising, whilst constantly checking functionality boundaries, can begin. Starting off with the shape. After the shape is determined, the detailing and topology optimisation starts. This all leading to an optimised bridge design.

In the process it proved quite difficult to determine the correct variables. The balance between design and structural analysis being the most important decision to be made. Especially the design within the urban context proved to be hard to integrate within this method. It was important to keep cross checking any decisions made on structural behalf with the urban context and the actual use of the bridge as well.

Social context

A social context in this graduation studio can be split into two regions; case specific and the research in general.

Case specific

The demand for a new crossing over the Nieuwe Maas is an actual question the municipality has to deal with. It is of relevance to the development of Rotterdam south, the health of the city and mobility. By increasing the options of sustainable means of transport, like public transport or the bicycle, car usage can be decreased and air quality and general quality of life in the city can be improved. Especially the South of the city, where the population is poorer and a higher level of unemployment is found, could benefit greatly from a better connection to the North, where a lot of job opportunities lie. A new crossing with high quality public transport makes for the North and the South to be a whole again.

General

In my opinion it’s important to implement structural analysis in an early stage of the design process. Using this method is a good way to do so. By integrating, not only structural, but also for instance climate design in an early stage, a complete design can be achieved. Optimising structure and climate for instance can reduce material usage and cost, energy loss etc. Next to this, there are also the passive benefits of avoiding trivial problems to occur because the design was made without any regard to structure or climate (for instance).

Planning

Up to the P3, where (most of) the scripting was done, there was an analysis of the first design and the first adjustments to the design had been made, the planning seemed quite accurate. However, after this, the finalising of the shape of the bridge and the design of the landings proved more difficult and time consuming than planned beforehand. As a bridge design is quite a lot of work for one person in four and a half months, this meant the detailing of the design had to be a bit rushed. Luckily I had help in finalising the design by some expert consultants in structural design (Kees van Ijselmuijden) and movable bridge design (Jacques Montijn). This helped a lot for the feasibility of the design and gave a bit more time for the detailing.

Final remarks

Altogether, I’ve had a lot of fun developing this design and conducting the research leading to it. Implementing this modern methodology has been very educational and convinced me even more that this way of working with integrated knowledge from the earliest of stages of the design should be the future.

Finally, I would like to thank Joris Smits and Michela Turrin for their tutoring and guidance throughout this educational process.