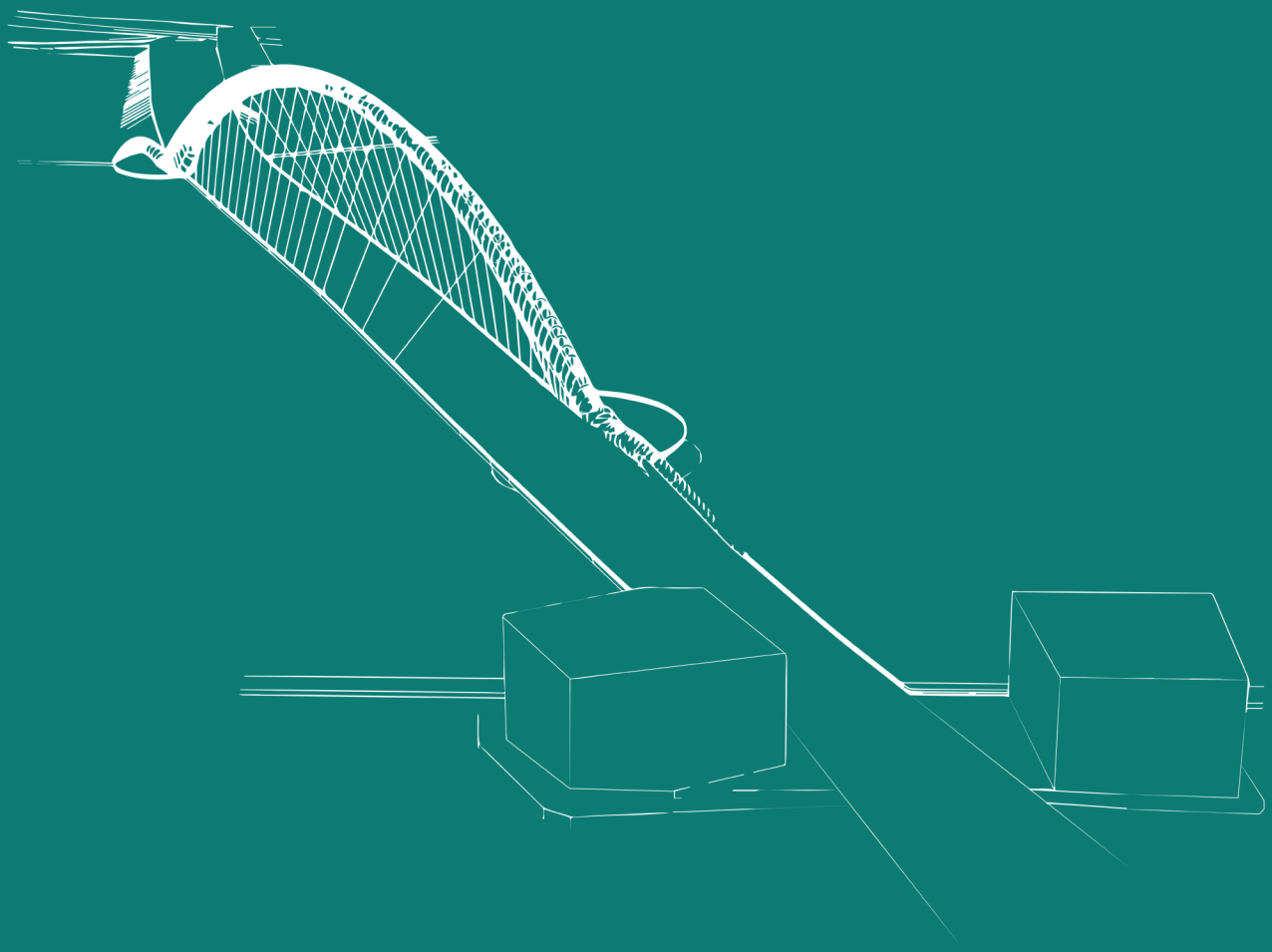
BRIDGING ROTTERDAM

A BRIDGE IS MORE



FLOOR VAN DIJK

Graduation report

February 3rd, 2017

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Rotterdam, bridge, local impact, harbour, infrastructure, networks, urban programme

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“Nieuwe stadsbrug is doodsteek voor de haven”

New city bridge is death to the harbour
(A. Bakker, 2016)

“Komst derde stadsbrug zorgt voor onrust in Schiemond”

Third city bridge is causing commotion in Schiemond
(Rubio & Kooyman, 2016)

“Dan komt ‘ie vlak langs mijn huis en daar heb ik geen zin in!”

I don’t feel anything for a new bridge which is close to my own house
(OPEN Rotterdam, 2015)

“Rotterdam wilt niet een, maar twee nieuwe bruggen over de Maas”

Rotterdam does not want only one bridge, they want two new bridges over the Maas
(Bas, 2016)

I grew up in a town in the shadow of the second biggest city of the Netherlands: Rotterdam. Because of this reason, me and my family were always oriented on Rotterdam. We often went to this city for shopping, train transfers, visits and later to visit cultural, architectural and urban projects. The development and dynamics of this city have always inspired me, not only the physical environment, the people in the city as well. During my study in architecture and urbanism, I have developed an interest in the movement of people through cities. The combination of the interest in movements, the city scale and the small scale living environment, resulted in the subject of this graduation project: a new city bridge for Rotterdam. The context of the project is the planning of this new bridge by the municipality. The results of a year of studying are combined in this graduation report for the studio of Urbanism, faculty of Architecture on the Technical University Delft.

Before you turn the page, I would like to thank my mentor team for their patience, time and feedback during the sessions we had in the past year. Their expertise and guidance during the process have been very inspiring and stimulating to bring the project to this level. Although I have not met Luisa Calabrese very often, the sessions we had were very effective and energising to the project, the design and to me. Machiel van Dorst was really helpful to structure the story and to rethink argumentation. Pieter Graaff pushed me on a realistic project. He and the Veldacademie made it possible to find some inspiration for the project in New York, this has been a very special experience. Besides this excursion and research in New York, they offered a comfortable place to work and they helped to contact the right persons for the interviews.

Besides my mentor team, I would like to thank my friends and family for their positive energy, distraction, relaxation, and for all inspiring bridge-projects, related news articles and all enthusiasm I have received from them during this past year.

Last but not least, a special thanks for all other graduation students. We have made the studio our home the last months and it will be hard to move out. I will always remember the fun we had with yoga and fish in the past months. It would not have been the same without you guys!

January 2017,
Floor van Dijk

TABLE OF CONTENT

“Waar water scheidt,

is onherroepelijk een vraagstuk der oeververbinding.”

Where water divides, there will always be a question for shore connections
(Bakker & Klooster, 2004, p. 120)

SUMMARY

Ever since the opening of the iconic Erasmusbrug, 20 years ago, the municipality of Rotterdam is thinking about a new shore connection over the Maas. As many other cities, Rotterdam has developed along a river. Rivers have been attractive for cities because of accessibility and opportunities for trade and agriculture. The relation between rivers and cities were always dynamic, it went from attraction for people to the backyard when people started to dump their waste in it. Climate change and the quality for recreation have turned cities. Rivers are becoming a more qualitative location in the city.

Although cities are working on their relation with rivers, it can not be denied that rivers are forming barriers through cities. The Maas is dividing Rotterdam into two districts: south and north. To reconnect both districts and to strengthen the infrastructural network, the municipality of Rotterdam has planned two new bridges as addition to the existing ones. The municipality is focussing on the resilience of the city network and the sprawl of cars over the city to guarantee future livability in the city. By offering a design from a different and new perspective, it is shown that ***a bridge is more*** and can be used as a method to reach other goals which are set by the municipality. To facilitate a growing population, city structures have to respond to these dynamics. A growing population is pressuring the waterways, infrastructure and services and housing facilities. To stay an attractive city, the municipality needs to build more residential buildings and wants to improve the quality of the shores along the Maas. This should be connected to the construction of a new bridge and its landings (and possible spin-off developments).

A bridge is defined as a connective object, made out of a human desire to cross a barrier. The quality of the design of bridges is that both the barrier and the new crossing can flow unhindered as with a separated junction *(ongelijkvloerse kruising)*. Over time, bridges have had many different appearances. From a tree to wooden structures and complex truss bridges. In line with historical appearances, a new typology for bridges is defined. Based on the combination of the traditional focusses on city, mobility and form, a new typology combines all aspects of architectural form, urban programme, construction and connectivity into an integral composition. ***A bridge is more*** than just a connective element and the combination of above mentioned aspects will create a new bridge as a location in the city.

Recently constructed bridges in Rotterdam are shifting from historical appearances and are focussing towards this new typology. In the past years, some pedestrian and cyclist connections are created to connect the city to recreational areas. This recreational purpose of these bridges is an introduction to the new typology as composition. This will show the added values of a bridge for a city as Rotterdam.

To complete the city structure and to stimulate the use of bikes in the city, four new bridges will be constructed over the Maas. On the long term, two bridges for pedestrians and cyclists are designed. On the short term, two new bridges will be constructed on the east and west location as was also assigned by the municipality. The locations of the bridges are decided on the multimodal accessibility of economic development areas and the missing links in the bike network. By making the bridge accessible for cyclists, the use of bikes is stimulated and this can compete for car use in the city. This is important to guarantee the quality of life in Rotterdam in the context of a growing population.

The four bridges are completing the rhythm of shore connections over the river Maas. By reducing the distance between the shore connections, it will become easier to cross the river. This stimulates developments in both city districts and improves the multimodal accessibility of many economic development areas.

PROBLEM FIELD

Rivers in cities

The context of this research is the assignment for a new city bridge for Rotterdam. In a mobility vision for the future, the municipality has presented two locations for new future bridges (Gemeente Rotterdam, 2016-b). As a connecting element over water, a bridge has an impact on the relation between the city, its inhabitants and the river. This is a dynamic relation. As many historical settlements did, Rotterdam started to develop along a river. The combination of accessibility and routes, water resource, and weather conditions made rivers an attractive location for urbanisation. Over 50% of the global population lives within 3 kilometres distance from water bodies (Benevolo & Culverwell, 1980, pp. 16-18; Studier & Sevick, 1992). The good conditions for agricultural production created conditions for population growth. The combination of different attractive aspects made the city an attractive place for people to live in (Benevolo & Culverwell, 1980, p. 17; Meyer, Westrik, & Hoekstra, 2014, p. 9). The river in the cities was seen as a source of life. More and more people were attracted to the cities on rivers. This resulted in the growth of settlements along rivers to cities (Benevolo & Culverwell, 1980, pp. 16-18).

The industrialisation of cities, population growth and the illegal dumping, turned the river from a source of life into a source of diseases. The polluted water and the introduction of the railways and highways, made cities turning their backs towards their origin (Heijse, 2008, pp. 5-6; Meyer et al., 2014, pp. 9-11). The introduction of a sewage system and the implementation of the Woningwet in 1901 improved living conditions and increased the quality of the rivers (Heijse, 2008).

The rivers are no longer the backyards of the city. Contradicting, it is now seen as a source of recreation and relaxation for urban citizens. Urban rivers are a qualitative context for walks and different functions have developed along the waterways. However, the river is still a threat to the urban life. Climate change and extreme weather conditions are resulting in a rising sea level. For this reason, water is a threat to the urban population.

Rivers as barrier

Another threat caused by the development near rivers is the division the water makes through a city. Two shores on both sides of the river are always resulting in the desire to cross water. Rotterdam is separated by the Maas. This separation of the city resulted in a development from ferries to permanent bridges and tunnels (M. M. Bakker & Klooster, 2004, p. 120).

In history, bridges became locations of densification in settlements. The ability to cross rivers brought opportunities for trade and communication. Modern bridges have had less impact on the location and population of cities, but the opening of many iconic bridges have been very important for cities (Biau, 2015; DeJean, 2014; *From Easy Crossing to Prosperity: The Role of Bridges in Urban Evolution*, 2014). A modern and iconic bridge can offer many opportunities for public spaces, social networks, economic developments and uses in cities (Burke, 2015; Project for public spaces, 2015; Taapken, 2014).

The location for bridges is an implementation for the long term and is not easily adapted. The durability is proved by the restoration and replacement of bridges when the original bridge is no longer functional. Objects within the structures have shorter life spans and are easier to be adapted to new requirements. The structure is the base of the city, and unlikely to change. Flexibility and well-thought interventions are the base of a sufficient network. An example in Rotterdam is the Hoogstraat. The street is over 600 years old, but still in the same location in the city of Rotterdam (Stadsarchief Rotterdam, n.d.).

The discussion in Rotterdam

The separation of the southern and northern district of the city of Rotterdam by the river Maas is stimulating a discussion about new shore connections. To reconnect both districts and to strengthen the infrastructural network, the municipality has planned two new bridges in addition to the existing ones.
The perspective of the municipality is based on mobility, accessibility, networks and connectivity within the scale of the city. However, an infrastructural connection can stimulate other developments and is related to employment, dwelling, health and a good living environment for the city (Gemeente Rotterdam, 2014, p. 12; 2016, pp. 7-10; Van Andel, Van Gameren, & Van Tol, 2015).

PROBLEM STATEMENT

From the first settlements along waters, urbanised areas along rivers have been attractive for people. Today, Rotterdam is still dealing with a growing population. This results in growing mobility demands and pressure on the existing infrastructural, climatologic and social networks. Without interventions, the city will get overcrowded and vulnerable for future events. The interrelated aspects of the structure of the city, need to meet the demands of a growing and changing population.

In order to facilitate the growth and the desire to cross the water, the municipality has planned two new shore connections over the Maas. It is not longer the question if the city will ever build a new connection, it is the question when, and where exactly and how will it look like?

A new shore connection for Rotterdam can never solve all the problems the city is dealing with. At this moment the municipality is looking at the new bridge on a city scale and is calculating the capacities of the existing shore connections in the network. It is important to predict the most efficient options and locations for the shore connection for the most durable intervention. However, only taking into account the city scale and its flows is a missed opportunity. Using the bridge as a development with opportunities for further development, a focus on a more local scale, and using urban programs, can create new insights in the rhythm of Rotterdam and the Maas. In this way, the bridge can help to reach other goals as set by the municipality. The bridge can create highly attractive locations at the landings on the shore and can even please the local citizens.

RESEARCH GUIDE

The goal of this research is to design a bridge which is representative for a new perspective on bridge design and to show that a bridge is more to a city than a connective element. The project is an exploration of the added values of a bridge on different scale levels.

The municipality is planning on this new bridge. The goals set in policies will be the context for this project. A new perspective will influence the outcome. Goals, as set by the municipality are a guide for the design but will not be a restricting factor.

In order to reach this goal and to design a bridge which is more than an infrastructural object, first priority is to explore the phenomenon of bridges. The goal of this chapter is to define the appearance of a new bridge, based on historical appearances. This is done by answering the question: ***"What do we define as a bridge, what does it look like and how did it evolve over time?"***. The definition of a bridge is based on existing literature. A historical overview of bridges is made to determine the appearances of bridges over time. By comparing specifications different typologies are distinguished. A combination of inspiration by experts, the historical typologies and the assignment for a new design in a new perspective, will lead to a new typology.

But a bridge is more than a phenomenon or typology. A bridge is location specific. The context is Rotterdam, which already has some shore connections over the river. To understand the context of the design, the following question is answered: ***"What has been the relation between the development of the city of Rotterdam and its bridges, and the explored typologies of bridges from history?"***. A historical overview of former projects in Rotterdam is made in order to answer this question. The existing shore connections are compared to the historical typologies. This leads to a specific assignment for a new bridge in Rotterdam.

For the design, the goals as set by the municipality are a guide for the process. To explore and understand these goals, the policies of the municipality are analysed. This will answer the question: ***"What are the ambitions of the municipality for the future for related developments and a new shore connection?"***. The existing policies are compared to the new assignment. This will form design goals for a new bridge from a new perspective. The design will be related to the ambitions of the municipality.

The design of a new bridge, within a new typology, requires an urban programme on the bridge. ***"What programme can a bridge facilitate?"*** In order to answer this question, existing bridges are analysed on the location of, and the type of programme.

A new perspective on the design, asks for a revision on the assigned locations by the municipality. The decisions by the municipality are not of restricting limits for this research. They have come up with two locations for new bridges, based on the infrastructural city scale. Exploring multiple scale levels will lead to a vision for Rotterdam and new shore connections, as an answer to the question: ***"Based on different scale levels, what is the best location for a new city bridge for Rotterdam?"***

The municipality is the governmental organisation, looking at the project on the scale level of the city. Interviews have been held to explore the local impact and the interests of multiple stakeholders, in order to answer the question ***"What are the interests of different stakeholders?".*** During these interviews, ideas for the design are tested.

Report structure

These questions are structuring the report into three chapters: The bridge as phenomenon, Bridges in Rotterdam and A new city bridge. The first question is researched in the first chapter, which is about the phenomenon of a bridge. In Bridges in Rotterdam, the second and third question are elaborated. The final chapter is about the assignment for a new bridge and answers the fourth, fifth and sixth question. This final chapter results in a design. The design is based on design principles, which are related to the outcomes of the different questions. The design assignment is to create an option, which has the best outcome for all principles and criteria. However, most of the time it is impossible to meet all requirements. Alternative concepts is a way to explore the different options and to make a founded decision for the solution which best fulfils all criteria.

The objective for the design is an exploration of the added values of a bridge, combined in a location specific design made from a new perspective. It is about the awareness that a bridge is more than only a connection in the infrastructural networks. The impact on the local scale should be utilised to add value and quality to the available public space and the quality of life for inhabitants of the neighbourhoods.

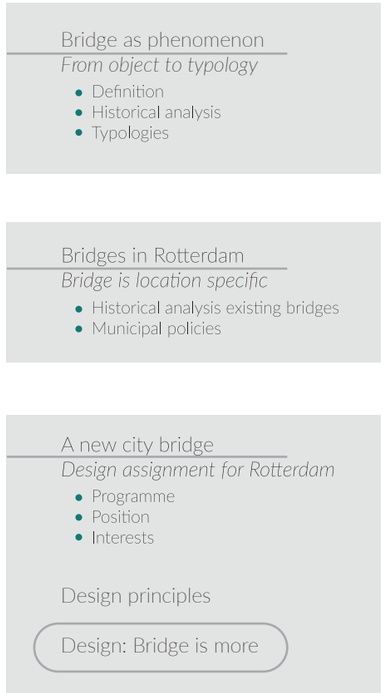


Fig. 1. Report structure

A bridge is more ...

RELEVANCE

The ambitions of the municipality are representative for the relevance of this project. Multiple stakeholders are researching the possible outcomes and effects of a design in their interests. The relevance of this research is divided between the academic relevance and the social relevance. The academic relevance is about the influence this research can have. The social relevance is about the separation of the population by the water.

Fig. 2. View on the Maas

ACADEMIC RELEVANCE

It sounds ideal, a world in which we can create and build exactly the projects we need to fulfil todays demands. However, different interests, the durability of structures in the city, and the complexity of relations make this only a dream. For this reason, municipalities are in charge of the planning and design of large scale and infrastructural projects. The division between the users and the planners often result in miscommunication and misinterpretation. The complexity of a city, where all systems are related, it is hard to predict the exact outcome and impact of many projects. This results in impact on the inhabitants. In this project, the added value of a bridge is presented to change the perspective on a connective object in an infrastructural assignment. This new perspective on the bridge as part of the city, can change the methods and approach for future design.

SOCIAL RELEVANCE

The northern and the southern district of Rotterdam are two completely different areas, divided by the river Maas. This results in the demand for a physical connection for social relations.

You might argue that the southern district of Rotterdam have had a false start. In the 17th century, the isolated southern bank of the Maas functioned as a residence for both plague patients and criminals. With the opening of the Nieuwe Waterweg in 1872, the harbour started to grow and more and more people from southern provinces of the Netherlands migrated to settle near the harbour employment possibilities. From this moment, a connection between the banks of the river was becoming more important. A bridge would form an obstacle for harbour operations and they started to operate ferries. The ferry has never been able to truly connect both river banks. In 1877, the first permanent shore connection opened. This made it possible to make the first real city expansion on the south shore.

The automation of the harbour took a lot of jobs. Labour migrants from the southern provinces moved out. Because of the lack of a good connection to the city centre on the north, the area was left to its fate. New migrants settled in the southern districts. Non-western migrants made it their own place. The dynamics of the southern neighbourhoods are confirmed by the new migrants from Poland. The southern district of the city has always been a dynamic society, with major differences from the original northern district (Strehl, 2008; Tempelman, 2011).

Still today, there are big socio-economical differences between the two city districts on both sides of the river. The municipality wants to bridge the gap created by the lack of connection over the river, bring the societies closer to each other and create equal opportunities. A special program is developed in collaboration with the national government to stimulate the position of the southern district.

Among other goals, the Erasmusbrug tries to bring the banks closer to each other. The connectivity between the two banks has improved. The opening of the multiple shore connections has made it easier to move between the two districts. A better connectivity should sprawl the opportunities more even over the city and so create opportunities for the southern district. A new bridge can contribute to the connectivity of the two banks, and create opportunities for yet unconnected districts. However, the focus of the bridge is based on infrastructural networks. Besides the position in the infrastructural network, the bridge is shaping opportunities for developments and can be an added value in the public environment.

“Mensen van Rotterdam Noord kennen Zuid niet”

People from Rotterdam North don’t know Rotterdam South
(RTV Rijnmond, 2015)

“Zuid is het echte Rotterdam”

South is the real Rotterdam
(Daamen, 2015)

BRIDGE AS PHENOMENON

A BRIDGE IS MORE THAN AN OBJECT

BRIDGE AS PHENOMENON

Because of the daily use of the objects, bridges are naturally included in our daily lifes. You can ask anybody and they will know what you mean with a bridge, but they think of different visual appearances. Every city, town or route has bridges, smaller or bigger, higher and more iconic or inconspicuous. ***But what do we define as a bridge, what does it look like and how did it evolve over time?***

DEFINITION

A bridge is one of the human made structures which is shaping our surrounding landscapes. Many structures have appeared over time and are influencing the shape of our landscapes. Today, we take these structures for granted. It seems that structures have always been there to make our lives a lot more convenient (Werkman, 2011, p. 7). The first bridge was not as iconic and prestigious as the ones we know today. Contradicting to these imposing bridges, the first bridge was not constructed consciously. The first bridge happened on coincidence by natural forces. From the moment a tree fell over a stream, people realized that they were able to cross rivers (Dupré & Gehry, 1998, p. 6; Werkman, 2011, p. 7). Imaginable, people crossed many streams by putting trees over it. However, the ability to cross water grew to the desire to cross wide rivers. Where the desire grew, trees were limited in length and stability. Trees did not longer meet the requirements of length and strength of the bridges. New constructions and treats were used to construct bridges over rivers. Because of material characteristics, non of the historic wooden structures have been preserved (Werkman, 2011, pp. 7-8).

Although natural forces are capable to create bridges themselves, bridges by definition are constructed out of a human desire to cross a barrier (Roig, 1996, pp. 8-12). The lack of contact and connection between two sides of any barrier are conditions for the start of the construction of a bridge. Rivers, canyons and infrastructures are examples of crossable barriers, but any thinkable barrier is bridgeable. To bridge as a verb is even used to bridge figurative barriers and problems. Throughout history, many cities have developed along rivers. Because of strategic locations for accessibility, trade and as water resource for agriculture, rivers have been the origin of many historical settlements (Benevolo & Culverwell, 1980, pp. 16-18; Breen & Olsthoorn, 1999, p. 13; Dupré & Gehry, 1998, p. 6). The junction of multiple routes, economical activities and increased demands for mobility were conditions shaping the human demand to cross rivers. Many permanent shore connections have been created out of the growth and developments of the settlements along the rivers (Breen & Olsthoorn, 1999, p. 9). The quality of a bridge is that two directions are uninterrupted, comparable with a crossing on different floors. A bridge is the object which allows the road to continue on both sides of the barrier, without interrupting the flows of the barrier (Breen & Olsthoorn, 1999, p. 9; Roig, 1996, pp. 8-12). Because of the function in networks, bridges are seen as functional constructions without their own aesthetics (Werkman, 2011, p. 7). These functional aspects were determining the appearances of bridges. Different periods in history are connected to different appearances. Bridges have been a representation of science in terms of construction, materials, mobility and technological knowledge. Bridges are not only the human strive for connection and

developments. Bridges are representations of the state of knowledge at the period of time they are constructed in (Breen & Olsthoorn, 1999, pp. 13, 25; Dupré & Gehry, 1998, p. 6).

HISTORY

The first period in history is defined by the legacy of the ability to cross barriers. As quick as the first bridge had appeared, as fast did the desire grew to cross wider rivers. The mindset changed from the ability to cross rivers to a modification of trees for the necessity to cross rivers for communication and trade in the Hellenistic period (3000BC). The increased routes over water, settlements and activities demanded more permanent shore connections. With easily obtainable local materials new built-up constructions were created. Most of these bridges were constructed from wood, bamboo and other local materials (Breen & Olsthoorn, 1999, pp. 13, 19; Roig, 1996, pp. 12-14). The local materials are all perished and no physical examples are existing of these first historical bridges (Werkman, 2011, p. 7).

Roman Empire

The oldest preserved bridges are originating from the Roman time (750BC-500) (Werkman, 2011, p. 7). The Romans developed a construction with arches made out of stone. The use of stone, made these bridges well preserved. Some of the Roman bridges are still in use. By combining multiple arches, it became possible to construct wider and higher bridges. The innovation of the construction combined with the technique of cement layers determined the appearance of Roman bridges. (Breen & Olsthoorn, 1999, p. 19; Dupré & Gehry, 1998, p. 6).

Bridges were of major importance for the Roman Empire. The construction of a vast road network started to connect separated parts of the empire. Bridges were essential for crossing rivers and connect the paved networks. The Romans did not only use bridges to connected to their Empire, bridges were also used to expand the territory of the Empire. Bridges were crucial for accessibility of the new terrain, the connection of the Empire and communication within the Empire (Roig, 1996, p. 14). In the Roman time, bridges were a crucial and functional element for the development of the city. The legacy moved from the ability to cross rivers, to the desire to cross rivers, to the bridge as a crucial connection within the city or empire.

Late Middle Ages

After the fall of the Roman Empire, many knowledge had been lost. No bridges were built from stone and cement disappeared. In the late medieval period, the legacy of the decline of the middle ages was changed to a new fruitful period. People got inspired by the classical Greeks and Romans, which resulted in the Renaissance (1400-1700). During this period the ancient times were the guiding theme of developments, construction and design.

Inspired by the Roman arch bridges, the phenomenon of the living bridge was introduced (Breen & Olsthoorn, 1999, p. 31; Dupré & Gehry, 1998, pp. 6-7; Murray, Stevens, & Cadman, 1997, pp. 16-17). Several bridges with housing, retail and theatres on top were built. These covered and built bridges were part of the city. In 1200, the first 'living bridges' were built because of a lack of space within the walled cities. Inside these walls, there was no space left for further developments and construction.

Bridges offered the opportunity to use extra grounds within the pressured borders of the medieval cities. Other reasons for the construction of living bridges have been for defensive reasons, self-financing constructions, and because of sanitary advances (Murray et al., 1997, p. 16). Because of the many activities on the bridge, the benefits were overruled by the development of mobility. Activities on the bridge became hinder for faster transportation modes (Neelen, 1998). This made an end to the tradition of building on bridges.

The functions and activities on living bridges made the bridge part of the city. The living bridges were included in the public space network of the city. They were not only functioning as connective objects. The legacy moved to the bridge was part of the city.

Industrial Revolution

Stone and wood have been the main construction materials for a long time. With the start of the industrial revolution in 1750, steel and iron were explored as new building materials. To avoid any risk, new materials were used in known construction principles based on the former arches and known wood joints (Breen & Olsthoorn, 1999, p. 19). But the new materials stimulated the inspiration and creativity of engineers. The strive for lighter and longer bridges, the use of new materials, in combination with mobility developments, were the foundation of new appearances of bridges (Dupré & Gehry, 1998, pp. 0, 7; Roig, 1996, pp. 14-18). The understanding of materials resulted in endless options and practices, and so in the variety of the shape of bridges (Werkman, 2011, p. 8).

The introduction of the steam-engine and the construction of railways resulted in a scale change for transportation and mobility. Possible travel distances increased and it resulted in a demand for more, and more heavy bridges to carry heavy trains. The possibilities by constructions made the number of bridges explode. The landscapes were affected by the construction and shapes of these new iron bridges for railway traffic (Werkman, 2011, p. 8). In this period, bridges became an object of representation of mobility and construction.

Second World War

Under the regime of Hitler, the first car available for the people was introduced. With the implementation of cars, the travel speed increased and the mobility demands changed. New road systems were built. Because of the speed of the cars and the size of the roads, there was hardly any relation between the fast traffic, the wide roads with many lanes and the landscape (Roig, 1996, p. 24).

A newly used building material was concrete. Combined with the use of steel and iron, it brought new opportunities for shaping the connective roads and bridges. The trend of making the construction as light and thin as possible was continued (Breen & Olsthoorn, 1999, p. 35).

Another phase in the history of bridges is the demolishing of them during the war. The demolishing of bridges had a large impact on cities (Breen & Olsthoorn, 1999, p. 13). Bridges and mobility were of large interest for cities. With the falling of many bridges, cities were hugely disadvantaged.

Engineering period

More and more constructive principles were explored. Theoretical understanding of forces on materials made it possible to calculate the influences. Many times in the past, new opportunities for the construction of bridges have appeared. The ability to calculate the construction stimulated the design of new constructive appearances (Breen & Olsthoorn, 1999, p. 25). Suspension bridges, cable-stayed bridges and combinations of these principles, determined the appearances of bridges (Dupré & Gehry, 1998, p. 7). Engineers were determining the shapes by calculating on forces and materials. Bridges from this engineering period were triumphs on the technical front. In this engineering period, it is about the functionality of the civil and technical pieces of art (Breen & Olsthoorn, 1999, p. 25; Dupré & Gehry, 1998, p. 0).

When architecture comes in

After the ability to calculate forces and construct bridges in the most efficient way, computer programs made it possible to design and calculate more complex forms. The quality of the appearance of a bridge was determined by the quantity of the materials used, it had to be long and light. The fewer materials and the lighter the construction seemed to be, the more aesthetic quality the bridge had (Roig, 1996, p. 10). Besides engineers, architects got involved in the process. However, many of the designs were determined by financial budgets, a little and thin construction, and sustainability. This resulted in designs which were neutral and not location specific (Dupré & Gehry, 1998, p. 10).

From 1980, bridges got a new impulse for appearances. More dynamic and dramatic shapes became implemented and appreciated. This resulted in an increasing influence of the architect and a shift of focus from engineering and construction to architectural possibilities and shapes (Breen & Olsthoorn, 1999, p. 39).

TYPOLOGIES

From the historical evolvement of bridges, different typologies can be deducted. These typologies are representing the appearance of bridges over time, which was influenced by knowledge about constructions, materials and mobility. Developments resulted in a change of legacy and changing characteristics of the appearance of bridges. The typologies are based on the historical evolvements.

I. The ability to cross rivers

Bridges in this typology are formed by nature on coincidence or made by humans, to explore the other side of the river. Local materials are used for the construction of these bridges. The focus in this typology is on the efficiency of connecting two sides of a river.

II. The bridge as crucial element

Bridges in this typology are made during the Roman Time or are based on the knowledge about construction in this period of time. The construction is made from stone, combined with cement. The bridges exist of one or multiple arches, to let the barrier beneath flow unhindered. The bridge focusses on its role in the city.

III. The bridge as part of the city

Bridges in this typology are based on the shapes of the Roman Time. Most bridges are built from stone and are formed by one or more constructive arches. The lack of space resulted in buildings on top of the bridge. In this way, the bridges became part of the city.

IV. The bridge as representation of mobility and construction

By developments in knowledge, materials and mobility new shapes of bridges existed. The appearance is determined by the used materials, construction and the modes using the bridge. Different construction principles fit within this typology: truss bridge, suspension bridge and the cable-stayed bridge and combinations of principles.

V. The bridge as form

New materials, the development of techniques, and the involvement of architects are creating more striking shapes for bridges. The appearances are derived from construction principles, but are more dynamic and dramatic.

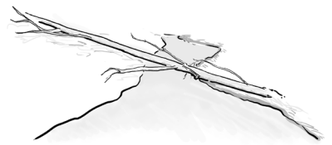


Fig. 3. I: A fallen tree over a stream, representing the use of local materials in the period of the ability to cross barriers

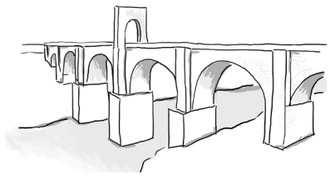


Fig. 4. II: A stone arch bridge as crucial element for a city

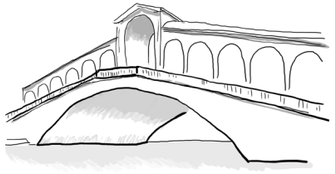


Fig. 5. III: A living bridge , or built bridge, as part of the city

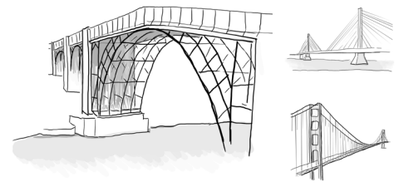


Fig. 6. IV: Bridges as representation of mobility and construction

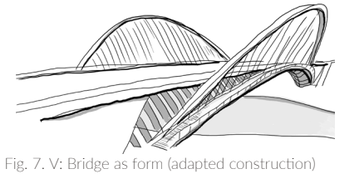


Fig. 7. V: Bridge as form (adapted construction) by Calatrava

MODERN INSPIRATION FROM DENMARK IN ROTTERDAM BY JAN GEHL

In order to release the Dutch translation of the book 'Cities for people', Jan Gehl gave a lecture on September 7th, 2016 in Rotterdam. During this lecture, he shared the legacy of new paradigms for the 21st century.

During the modernism, all that was old was dismissed. The street was a place for bad activities such as street fights and drug abuse. Public space, pedestrians and meeting among citizens were located on the back of all developments. The combination of the legacy of this period of time, combined with the car invasion, neglected the inhabitants of the isolated buildings and denied public life.

The car-invasion was thought to be solved by giving the car more room in the city. All available space was used to facilitate the increasing demands for cars, parking spots and roads. The thought about this process was that if cars were happy, people would be happy as well. Everything was done to make the car use as comfortable as possible. However, the increase in car infrastructure resulted in an increase in car use and crowds in the city. The car was the king and was taking over all public space. The pinnacle of this legacy was the scale and focus of urban design. A residential area was qualified as good for people when it looked good from the highway.

This trend was criticised by Jane Jacobs. In 1961 she published an innovative book for the urban developments: 'The Death and Life of Great American Cities'. In her work, she predicted the end of all great cities when planning would continue to base its perspective from motorised vehicles. This trend would end in cities without people on the streets, because of a lack of space, barriers, noise and air pollution and risks. This book introduced the beginning of a change in the paradigm of urban design.

In the new paradigms for the 21st century, the focus shifts from cars to people. The paradigms are evolving from the modernism and the car invasion to liveable, sustainable, and healthy cities in the 21st century. This new paradigm is focussing on the human desires and scale, in order to make the citizens happy with their environment. A lower priority for the car network is compensated with the new urban quality of life. The message is not to be against cars, it is about being pro-people and balance them in the city. A new paradigm is about getting the people, and so the culture and identity of a city, back out on the streets! (Gehl, 2016, pp. 1-32)

Gehl, J. (September 7, 2016). BNSP Lecture/Bookpresentation: Steden voor mensen.

Fig. 8. The only bridge that actually reduces traffic? (Gehl, n.d., p. 42)

MODERN INSPIRATION FROM NEW YORK BY NANCY NOWACEK

Nancy Nowacek is an artist from Brooklyn, New York City. Based on her interests and fascination for the location, she decided to start building a bridge. She had dreamed of a bridge connecting Redhook, her neighbourhood, with Governers Island. In the past, the island was accessible by a sandbank at low tide. It became an important military base and later the Coast Guards housed on the island. In 2005, Governers Island was reopened to the public. In 2010 the City of New York became responsible over the island and a decision was made to start the redevelopment into a public park. Today, the only way to get to the island is by crowded ferries. Nancy her apartment offered a view on the island. The land was available again and she had experienced the island as unique public space on the water. This raised the idea to design a bridge, connecting her neighbourhood to the island.

What really inspires about her project, is her position on the bridge and the river and their role in the city. In the context of a city getting more and more crowded by people and traffic, Nancy started to look at the river as a sidewalk of the city. This new sidewalk could function as an extension of the city, as a unique part of the network of public spaces. This rediscovered space of the river will be the context for Nancy her addition to the public space as a bridge.

New York and the river are not in good terms. In the past few years, New York has been impacted by several climatological disasters. The power and risks of floods, and the quality of the water, makes the citizens look at the water as an inconvenience to the city. Besides a connection to the island, Nancy wants to show the dynamics of the water and explore the opportunities and threats.

The overall goal of her project is to create a public space that stimulates interaction among people, in the context of the water. She already succeeded to bring people together in the cooperative design process. Here ambitions to create a floating bridge forced to involve many experts. A community is formed during the process with a common goal: to create a floating bridge. The ambition is to make a modular system. This system allows the bridge to return annually and be transported to other locations all over the world. The main lesson from this project is that a bridge should be seen as part of the city.

Nowacek, N. (May 25th, 2016). Interview for research to the we-society, executed with the Veldacademie: The inclusive society and The Floating Citizen Bridge.

Fig. 9. Prototype of a floating element for the bridge (Nowacek, 2015)

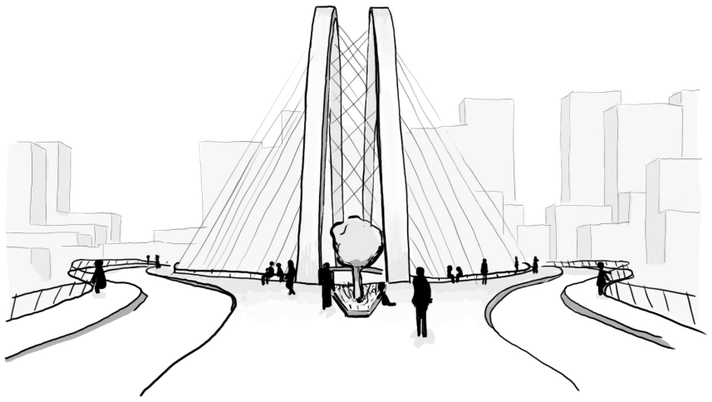


Fig. 10. New typology with the context of the city and the inhabitants on the public space of a bridge

CONCLUSION

We all know examples of bridges and can think of what this phenomenon means. We use them to cross rivers or roads during our daily trip to school, work or for other purposes. Bridges are objects to help us cross barriers, made out of a human desire to cross these barriers. By definition, the flow of the barrier should not be interrupted. The appearance of these connective objects is determined by the period of construction. They represent the state of knowledge about construction and materials in history. The historical periods can be divided in different typologies: the ability to cross rivers, the bridge as crucial element, the bridge as part of the city, the bridge as representation of mobility and construction and the bridge as form. A bridge is more than a connective object, it is a representation of time and is shaping our surrounding landscapes and cities.

The first typology is focussed on the ability of connection. The next typologies were focussed on the role in the city. The bridge as crucial element was part of the Roman Empire. During the Renaissance, bridges were included in the public spaces of the city. Knowledge has involved and the next typology made bridges as a representation of mobility and construction. After this tradition, the architect was introduced and form became more important. However, a new legacy is introduced with the movement towards the people of the city. The focus is on the quality of the living environment for the inhabitant of the context of a new development (Bakker & Klooster, 2004, p. 9). This input of the city and its inhabitants was completely abandoned during the legacy of mobility and construction.

A new typology: The bridge as composition

The past typologies focussed on different aspects. A new typology should be a combination of the city, the architectural form and the construction. A balance should be found between the urban programme and the role in the complex system of public spaces in a city. By changing the focus from cars to the city, this new balance can be found.

This new legacy is inspired by a talk by Jan Gehl and an interview with Nancy Nowacek. Jan Gehl introduced paradigms for the 21st century. The focus moved from the car invasion to a livable, sustainable and healthy city. In this new paradigm, it is about the inhabitant of the city and their demands. When the people are happy, the cars will be happy. Nancy Nowacek sees her bridge as addition to the public space of the crowded city. This is in line with the typology of a bridge as part of the city. This feels like a reintroduction of this typology.

A bridge is more than a phenomenon, it is the complex development of focus, mobility, form, programme, and construction. The design of a bridge includes multiple expertises.

BRIDGES IN ROTTERDAM

A BRIDGE IS MORE THAN A PHENOMENON

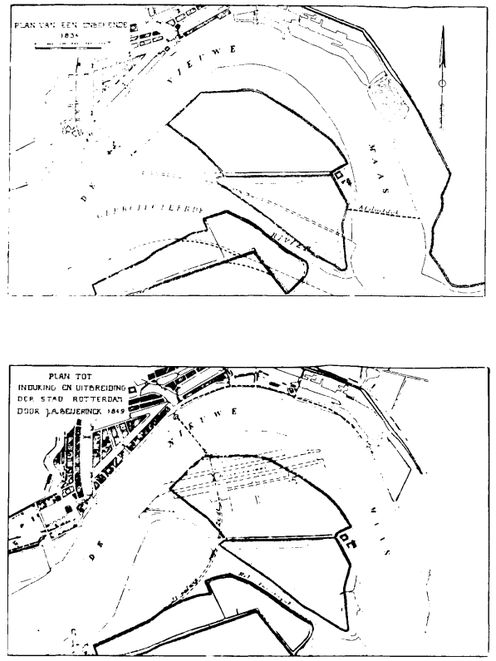


Fig. 11. Plan by an unknown person (1834) and the continuation by J. A. Beijerinck (1849) (Kraaij & Van der Mast, 1990, p. 34)

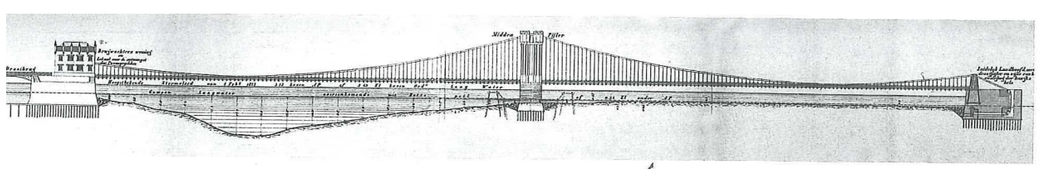


Fig. 12. Design by J. A. Beijerinck for a bridge over the Maas (1849) (Bakker & Klooster, 2004, p. 123)

BRIDGES IN ROTTERDAM

HISTORICAL DEVELOPMENTS

A bridge is more than a connecting phenomenon divided in typologies. The new typology is a bridge as part in the system of the city. The function of this bridge is location specific. In this research, a new city bridge for Rotterdam is explored. This new bridge will not be the first jump over the river. This jump was made in 1877, with the opening of the first permanent shore connection over the river Maas. In this chapter, the projects of connecting the shores in Rotterdam are explored to research the question: ***What has been the relation between the development of the city of Rotterdam and its bridges, and the explored typologies of bridges from history?*** A historical analysis can tell the strong relation of the river, shipping and the growth and welfare of Rotterdam. The locations in Rotterdam are made visible in Appendix VI. Locations in Rotterdam on page 163.

Early history

Many cities developed along rivers because of the benefits and opportunities of the water. Just like many others, Rotterdam has a history based along a river. The small river named the Rotte forms the origin of the city of Rotterdam. From 900 on the location was inhabited. From 1270 a settlement developed along a dam in the Rotte. The dam was protecting the hinterland from floods and disconnected the river Maas from the Rotte. Fishing was the first source of income and was replaced by trade. To facilitate in trading products, harbours were developed along the good connected river Maas (*Geschiedenis van Rotterdam*, n.d.). The ability to cross the river was determining the location of the settlements. The Maas was too wide to cross. This made the city grew next to a river, instead of over it. This is the base of a split city on two shores. However, the dam allowed the city to grow over the Rotte, which is less wide (Bakker & Klooster, 2004, p. 120; Lebesque & Koekebakker, 1998, pp. 5-9).

After the Eighty Years' War, the city was able to grow even further and develop more and more harbours. Because of the strategic position and political disadvantages in surrounding cities, Rotterdam was able to benefit from trade with the USA, Spain, England and France (*De geschiedenis van Rotterdam in vogelvlucht*, n.d.).

The 18th century was a period of decline. Construction was focussed on projects within the walls of the city. The combination of industries and residents made the inner city overcrowded. In the surrounding polders, the construction of country cottages started and industries were dislocated to polders (*De geschiedenis van Rotterdam in vogelvlucht*, n.d.).

Because of the importance of the harbour and movements over the water, talking about a shore connection was unacceptable until 1800. A permanent shore connection would have hindered the many sailing boats in the Maas. Some ferries were moving between the two shores. These were mainly used by citizens going to Katendrecht on the south shore for recreation. It took about half an hour to go to the other side, but harbour operations were unhindered (Bakker & Klooster, 2004, p. 123).

Although the river was intensively used and unreliable, the first plans for a jump over the river were made in 1834 by an unknown person. Because of the size of the project and the high investment, this plan was not accepted by the municipality. As an engineer, J.A.

Beijerinck got inspired and made a continuation of this first idea to cross the river. His argument for the project was the necessity of the development of the city on the south bank. The plan was never realised. Nobody was willing to invest in the construction of a bridge and the development of the south bank (Bakker & Klooster, 2004, p. 123).

From 1850 Rotterdam could grow again from developing trade on existing connections and new trade with Africa and the Ruhr area. The amount and size of ships did not longer match with the existing facilities, located on the shore of the inner city. The harbour extended and the capacity for trade grew. Employers from Zeeland and Noord-Brabant were attracted to Rotterdam and settled in. The movement and development of the harbour shaped opportunities for and supported developments on the south shore for residential areas. This development has stimulated the first jump over the Maas for city expansion on the south bank (*Geschiedenis van Rotterdam*, n.d.; Lebesque & Koekebakker, 1998, p. 10).

Maasbruggen

Former plans were cancelled by the harbour activities combined with the risk of investment. But the plans by an unknown person and J.A. Beijerinck, as visible in Fig. 11 and Fig. 12, were inspiring and four different plans were made to investigate the development of a residential area on the south bank. Two of these plans approached the southern bank as an expansion of the city. The two banks were about to form one city. The other plans were made by W.N. Rose (Fig. 13 and Fig. 14). He was town architect of Rotterdam. He saw the southern developments as separated satellites. The self-functioning cities were

Fig. 13. River variant by W.N. Rose (1864) (Kamphuis & Van der Hoeven, 1994, p. 168)

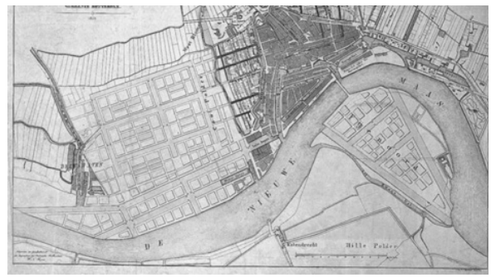


Fig. 14. Coolpolderplan by W.N. Rose (1858) (Kamphuis & Van der Hoeven, 1994, p. 167)

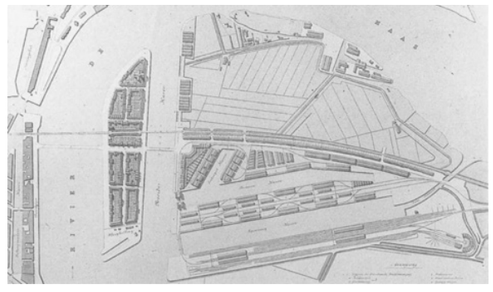


Fig. 15. Design Koningshaven and Noordereiland (Kamphuis & Van der Hoeven, 1994, p. 170)

connected to the northern bank by a bridge but were functioning as separated unities.

Developments in the harbour made it acceptable to talk about a permanent shore connection. Of other major influence, was the development of a national railway network. Rotterdam was a gap in the network between Amsterdam and Antwerp. A connection over the Maas was needed to close this gap.

The combination of developments in the harbour, the national railway network and mobility developments which demanded a better regulated network, accelerated the project of a permanent shore connection. The acceleration of the process resulted in a new, more pragmatic and easy plan for the residential area on the south bank. The separation of the Noordereiland from the south bank combined with the Koningshaven made it possible to organise shipping traffic, this design is visible in Fig. 15. Over this canal, a movable bridge was designed for bridges which were too tall for the permanent connection.

The first design for the bridge was a double decked bridge, combining the railway with other modes of travel; such as walking and horse-drawn carriage. This double decked bridge is projected in Fig. 16. The expected advances were the financial support by the national government. Besides the investments, this design would only be a single hindrance for harbour operation. However, after research to the soil, this bridge was unrealistic because of a soft peat soil. The two decks were separated into two bridges. In 1877 the first permanent shore connection was opened for trains. Afterwards, they constructed a bridge for other modes. This second bridge was aligned with the design of the railway bridge and opened a year after the opening of the first bridge.

(Bakker & Klooster, 2004, pp. 123-128; Kamphuis & Van der Hoeven, 1994; Lebesque & Koekebakker, 1998, pp. 10-11)

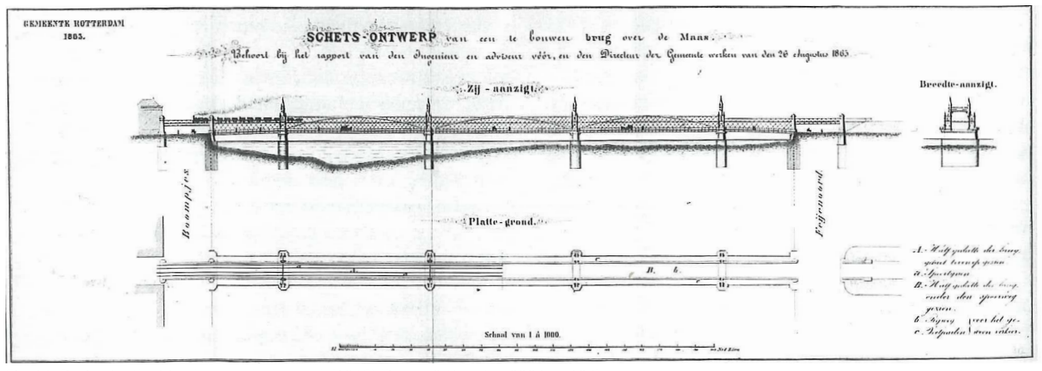


Fig. 16. Design for the Maasbrug as double deck (1865) (Bakker & Klooster, 2004, p. 124)

Since there was only one permanent option to cross the river, this connection was very vulnerable. The traffic crossing the river was completely depended on harbour operations. Once the bridge was opened to allow boats to cross, traffic stagnated in the city. Ships were growing in size and the bridge had to open multiple times a day. The opening could last for one hour and this made the complete city got over crowded. Combining the fast expansion of southern neighbourhoods, the expansion of the harbour, and the growth of car use, capacities of the bridge were exceeded. Ferries, specifically for car traffic, were not able to solve the congestion. A new bridge was designed to replace the existing Maasbruggen. This new bridge was twelve meters above the water level, which would allow most boats to cross without opening of the bridge. This was beneficial for the city network. However, the height resulted in long slopes which would have ruined the new developments on the shores of the river. This resulted in resistance to the project. Still, the capacities of the Maasbruggen were in need of action.

Many plans were made for the replacement of the bridge, a reconstruction of the network or an extra bridge. One of the most striking plans was made by B. van der Tak in 1919, Fig. 17. A machine of 60 meters high would bring people to the other shore by a cabin. The frequency of one cabin every 3,5 minute could never keep up with the mobility demands. Just like many other plans, this plan was never realised (Bakker & Klooster, 2004, pp. 128-130).

Maastunnel

The lack of connection resulted in unequal opportunities for development on both shores. A new shore connection was really needed to offer equal opportunities for development on both banks of the river. W.G. Witteveen made a plan for the future development of Rotterdam and suggested a structure with multiple new shore connections on city scale. He was part of different departments of the municipality of Rotterdam and he founded the department of city-development (Dienst Stadsontwikkeling). Because of financial limits, not all planned constructions could be constructed. His preference was a connection on the location west of the Noordereiland at the location of the current Erasmusbrug. Because of the city moving westwards and an uneven spread of traffic over the city, a connection more west of this location was chosen.

To minimise the impact on harbour operations, the city started to explore the possibilities for the construction of a tunnel on this location. This tunnel was about to be the first traffic tunnel in the Netherlands. Doubts were tested in projects abroad and this proved the feasibility of a tunnel.

Because of the financial budget, the municipality was in need of support by the national government. The construction of a shore connection on the decided location would fit in the national highway planning. For this reason, the municipality gained financial support from the national government.

At first, the national government doubted the decision for a tunnel on this location. They asked for a comparison study with a bridge. J. Emmen obtained its doctorate with a study to ferroconcrete and iron in bridge constructions. He made a design for a bridge on this location (Fig. 18). His bridge was compared to two designs for tunnels made by W.G. Witteveen. In this comparison study, it became clear that the bridge was not as cheap as expected. A very long access slope was needed because of the need for height for the harbour operations. The curves in the slopes were criticised. Also, the expected gas costs needed to climb the slope were questioned. In 1936, the final decision was made to built a tunnel.

Because of its function in the national network, the access routes to the bridge were lowered. This made the route less influenced by local traffic on busy crossings. This lowered access route is known as the Maastunnel-trace

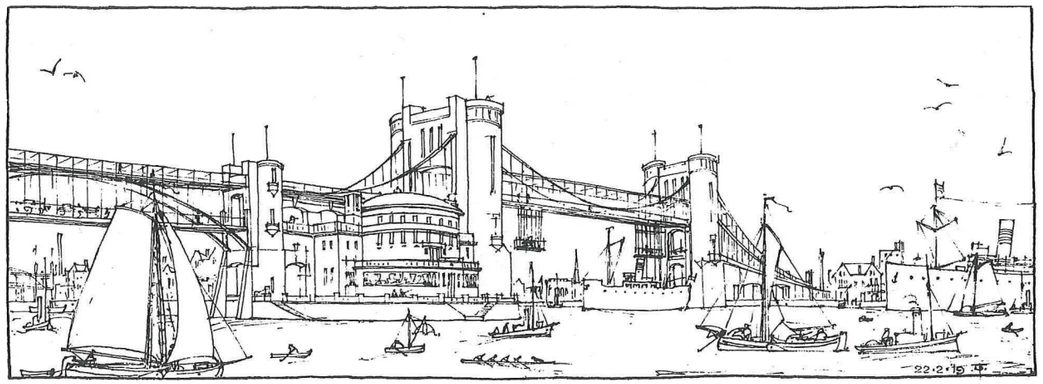


Fig. 17. Bridge with cabins by B. van der Tak (1919) (Bakker & Klooster, 2004, p. 130)

Fig. 18. Design bridge by J. Emmen, 1935 (SteenhuisMeurs, 2009, p. 26-27)

and is called 's Gravendijkwal. Besides the importance of the access route in the north, the southern developments were aligned with this new tunnel. The crossing of al these lines formed a new centre in the southern city district named Zuidplein. The tunnel opened in 1942, during Wold War II.

(Den Ouden, 1991; Lebesque & Koekebakker, 1998, p. 12; Mens, 2007, pp. 129-135; SteenhuisMeurs, 2009)

Twenty years after the opening of the national corridor of the Maastunnel, the long distance traffic was relocated to the national highway crossing the Maas. A new bridge was constructed; the Van Brienenoordbrug, in order to connect the national highways. In the same period of time, a metro line was constructed under the river Maas to reduce traffic in the Maastunnel. It became easier to get to the other shore, instead of waiting in line for the escalator in the tunnels, you could go by metro. This contributed to the connection between the two city districts on both shores (Lebesque & Koekebakker, 1998, p. 16). Never has this shore connection been accepted as a true city bridge. It was located at the edge of the city and used for regional scale traffic (Bakker & Klooster, 2004, p. 120).

Willemsbrug

Rotterdam was heavily affected during Wold War II. After the bombings, the complete inner city burned down. The task of the city was to clean the messes and rebuilt the society in the inner city. The first reconstruction programme was made by W.G. Witteveen. Four days after the bombings, May 18, 1940, he dropped all of his regular tasks to focus on a design for a new inner city for Rotterdam. He slept in the library during the design period to be able to spend as much time as possible on the plan. This was needed to avoid a German reconstruction of the city. Although his reconstruction programme was judged as basic, it was accepted by the municipality in 1941. Because of the continuation of World War II, the reconstruction existed of the construction of temporary and emergency housing. In July 1942 the decision was made to freeze all constructions. Empty plots in the city were temporarily used for crops to feed the inhabitants.

On April 1, 1944, W.G. Witteveen quit his job because of sickness and stress. He was overworked and exaggerated. Ideas and visions had changed during the war and the assistant of W.G. Witteveen, Cornelis van Traa, designed a new reconstruction programme. Based on the ideas of W.G. Witteveen, 'Het Basisplan', as is visible in Fig. 19, was presented as a flexible framework with a strict division of functions. Part of 'Het Basisplan' was the railway network and the location of Rotterdam Central Station and a traffic junction located at the 'Oude haven'. The complete plan was designed for cars, trams and busses and the Maasbruggen were an important connection between the north and south bank of the city. Van Traa designed a new bridge on the same location. The bridge was high above the water. This height demanded a long slope and this was solved in a doubled roundabout, covering an area of 500 x 500 meters. This roundabout is visible in Fig. 20. The closing of the old harbour and the demolishing of the monumental 'Witte Huis' caused frustration among the both the municipality and citizens. In 1955, a commission was founded to decide about the replacement of the Maasbruggen. The bridges were not able to deal with the traffic demands any longer. Cars were hindered by the narrow bridge, which was not designed for cars. The municipality decided to research the option for a tunnel on this location. A tunnel would not hinder harbour operations and this would bring opportunities. However, the national railway company was not willing to pay for a combined tunnel for both cars and trains. Their bridge was still in function. Besides, inhabitants did not want to lose the bridge as a physical element over the water. In 1972 the municipality decided for a bridge over a tunnel. The tunnel with six lanes would work against the goal of improving the traffic flow through the city centre and a huge aversion was created for more traffic through the centre.

Fig. 19. Basic reconstructionplan by Van Traa (*Plan Witteveen, het eerste wederopbouw plan*, n.d.)

Multiple bridges were designed by the Public works department of the municipality. In 1975 citizens could vote for their preferred bridge out of six designs. During the exposition 'Kom over de brug', 24% of the voters had chosen the option of a metal cable-stayed bridge with a single column with diffracted cable says. The final decision was made by the municipality and they chose the cheapest option over the one preferred by the public. They constructed a new ring road around the city centre. Their vision was influenced by both financial and infrastructural benefits. The replacement of the traffic bridge was constructed and opened in 1981. This bridge was mirrored into a design for a railway bridge (Fig. 21). In the end, a tunnel for trains was constructed. This could create new opportunities for the inner city, the train was now moved out of the city to an underground tunnel construction. The railway moved underground in 1996.

(Gemeente Rotterdam, n.d.-c; Lebesque & Koekebakker, 1998, pp. 18-20; *"Nieuwe Willemsbrug 1 juli in gebruik:*

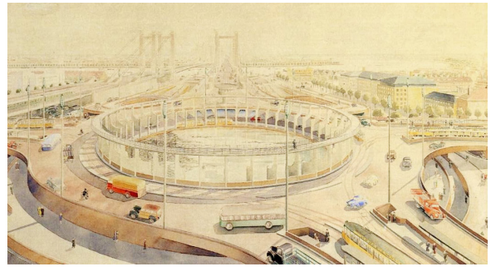


Fig. 20. Traffic intersection on the location of the Oude Haven, design by Van Traa (1946) (Groenendijk, 2016)

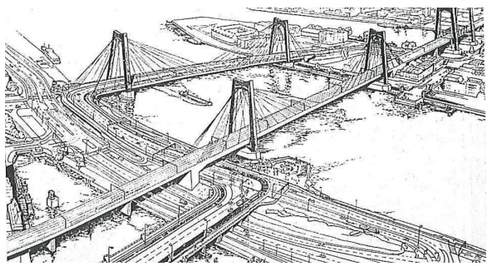


Fig. 21. Design for twin bridges for train and car traffic (Bakker & Klooster, 2004, p. 136)

Eerste daad prins Willem-Alexander", 1981; Plan Witteveen, het eerste wederopbouw plan, n.d.; "*Vervanging Rotterdamse Willemsbrug: Meeste stemmen voor brug met een draagkolom*," 1975)

New ideas were included in the design for reconstruction, this caused a division of functions over the city. The number of residential buildings were decreased by half and replaced with offices, retail and banks. Larger residential areas were built in the fringes of the city. The Willemsbrug was opened in 1981. In the years after, the reconstruction programme is finished with highrise. This highrise is supposed to give the city an international character (*De geschiedenis van Rotterdam in vogelvlucht*, n.d.).

Erasmusbrug

An important part of this image of Rotterdam is the iconic Erasmusbrug. We can not imagine the city without this bridge. This bridge was opened in 1996 and celebrates its 20th birthday during this research. The first plans for a shore connection on this location were made during the explorative process for the Maastunnel. From 1980, plans became more serious. Many plans failed on the major differences among both sides of the river. The harbour had become an attractive location for employees. Migrants came over for jobs and settled in the southern neighbourhoods. Among other things, this caused a socio-economical difference between the northern and southern neighbourhoods (*De geschiedenis van Rotterdam in vogelvlucht*, n.d.).

In 1985, Riek Bakker became director of the department Dienstenstructuur Ruimtelijke Ordening Stadsvernieuweing (department for city development) for the municipality of Rotterdam. She started a renewal plan for the city, from a different point of view as many predecessors. She had the ambiguity for long lines (Fig. 22) and she looked at city scale to problems. In request of Riek Bakker, Teun Koolhaas made a design for the masterplan of the Kop van Zuid, which was related to the design of a new bridge.

The fact is that the Erasmusbrug was never built to solve traffic problems in the city network. The recently opened Willemsbrug had enough capacity to keep up with the traffic demands. However, the construction of a bridge made the Kop van Zuid more accessible. This connection shaped opportunities for a mixed development with residents, offices and recreation. The bridge was also meant as an icon. An icon for the international image, but also for the representation of the connection between both shores of the Maas and a connected city.

As unthinkable Rotterdam is without the Erasmusbrug, as unthinkable was the urban development of this bridge. Riek Bakker had a real struggle with governmental support for the bridge. During an interview, she said: "nie-mand wou!". Nobody liked a bridge crossing the intensively used river. A new bridge would again negatively impact the harbour operations and developments.

It was tradition to let the department of public works make a design. Maarten Struijs from this department got the assignment to make a design. He designed two options (Fig. 23) from different perspectives. He struggled between a bridge as a piece of art, matching my typology of a bridge as form and a bridge as a physical connection. The second option fits the first typology of a bridge as the ability to cross a river. Riek Bakker was not impressed by both options. She thought these designs were camouflaged versions of the Willemsbrug. Both options did not meet her expectations of a bridge as an image with status. She asked the architect Ben van Berkel to make a design. Although this last design was the most expensive option, both the municipality and the citizens had a preference for this expensive and provocative design. Showing multiple options can change a discussion. The decision whether or not a bridge should be built changed to the question which of the designs had to be built on this location.

During the design process, it was never an option to built a tunnel. Riek Bakker her vision, required a bridge as an icon for the city, for renewal and development. A tunnel would never been able to reach the effect the bridge has.

(Bakker & Klooster, 2004, p. 139; Beyond Plan B, 2014; Brandsma & Horsten, 1996; De Lange, 1995; Galema & Tijhuis, 2006; Horsten, 1995; Sulsters, 1993; Van Berkel & Bos, 1997)

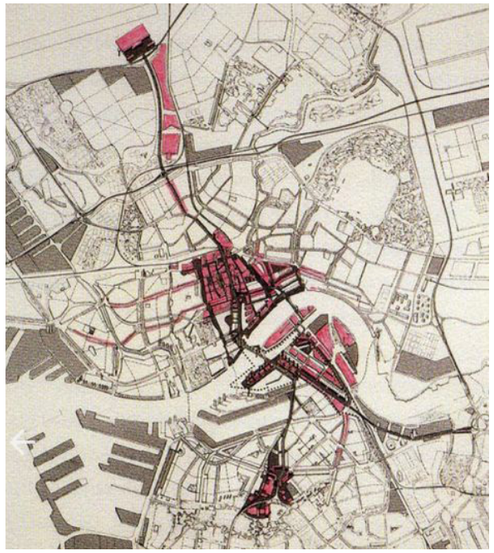


Fig. 22. City axes through the city by Riek Bakker (1987) (Galema & Vollaard, 2007, p. 104)

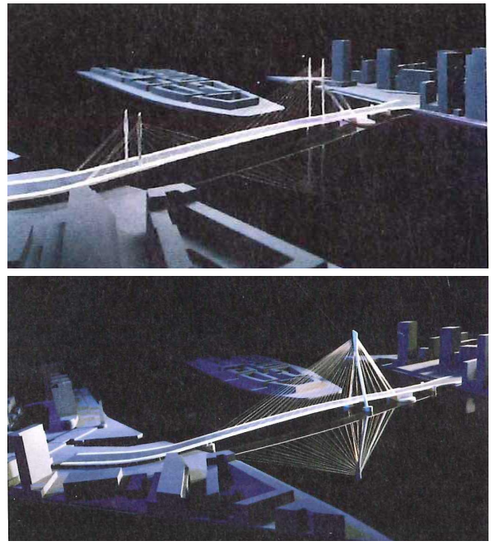
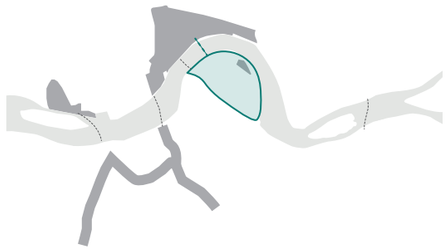
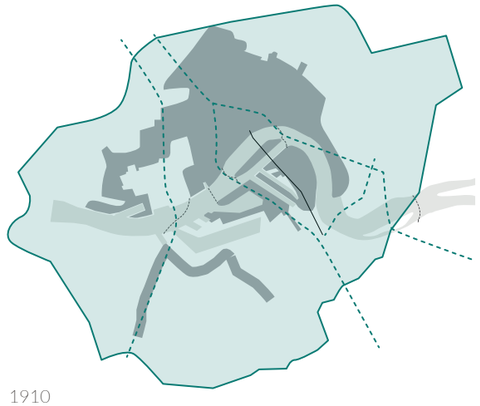


Fig. 23. Alternatives for De Erasmusbrug by Maarten Struijs: above: vierstokkenbrug as physical connection , under: esthetical option (Galema & Tijhuis, 2006, p. 50)



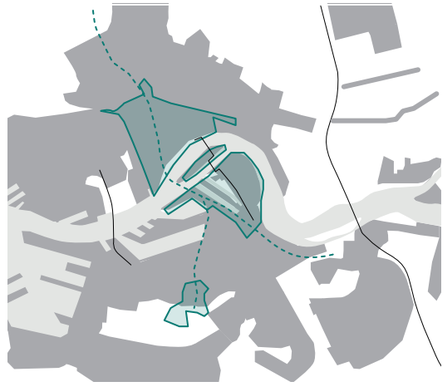
1860

Plans for Maasbruggen



1910

Plans for Maastunnel



1950

Plans for Van Brienenoordbrug

1965

Plans for replacement Willemsbrug

1988

Plans for Erasmusbrug

2015

Plans for a new city bridge

Fig. 24. Historical analysis of the development of Rotterdam with axes and shore connections

Physical development

In Fig. 24, the relation between the plans and the physical development of the city is made visible. A shore connection was always planned in combination with a plan for the city or for a specific part of the city. The plan is visible in the first image. In the second image, the realised developments are visible, combined with the next plans for shore connections with the corresponding city plans.

In all developments, there is a relation between the location of the bridge, the ferries, and the existing developments. From the map of 1860, all ferries are realised in permanent shore connections on about the same location. Comparing the ferries in 1860, with the permanent connections in 2015, it is visible that the connections are connecting about the same areas as the ferries were. The only ferry missing in the permanent connections is the one between the Erasmusbrug and the Maastunnel. From a historical perspective, this should be a rational option for a new shore connection.

River Maas
Ferry
Urbanised area
Plan area
Planned shore connection
Realised connection, based on previous map
Bombing outline

2 km 5 km N

Arguments to built bridges

Rotterdam is a city, where the story of shore connections was always related to both the city and the harbour. For a long time, the harbours controlled the development of the city. Until the first changes and movement of the harbour westwards, a permanent shore connection was unthinkable. The harbour was such a big meaning to the city, that is was able to control the river and the related developments of the city. The first jump over the river in 1877 was needed for city expansion to house employees for the harbour. From this moment on, multiple shore connections have been built. Even more shore connections for Rotterdam have been designed but never been built.

All shore connections were related to plans on city of district scale. The Maasbruggen are developed in combination with the expansion plan. The Maastunnel was built as a link in the national highway planning. Combined with the reconstruction plans after the second World War, the Willemsbrug was designed. The Erasmusbrug was designed in combination with a city axis and the development of the former harbour piers at the south bank. The scale of these plans is comparable, the aim of the plans differs.

The influence of the national government is striking from this historical analysis. Without the investment of the national government, the Maastunnel would never have been built. The construction of the Willemsbrug was also influenced by multiple large scale parties. The national railway company played a major role in the decision making. Financial limits in a plan can be solved to prove the national impact and benefits of it.

Appearances and typologies

The appearances of bridges in Rotterdam are reflected to the typologies derived from the historical evolvement of bridges.

The appearance of both of the Maasbruggen fit the legacy of The bridge as representation of mobility and construction. During the opening of the bridges, they were stated as genius plans of engineers (Bakker & Klooster, 2004, p. 128). The argumentation of the projects was about mobility. Boats, trains, and other land-traffic determined the appearance of these constructions. Second reason to fit these bridge in this typology is the used material. These materials were explored during the industrial revolution. The suspension bridge was rejected to built a bridge fitting the existing knowledge of this period of time. The form of the construction is depending on the possibilities of the materials and knowledge of that period of time.

After some discussion, a tunnel was constructed as second shore connection. This tunnel was constructed to complete the national highway plan. Access to the tunnel was constructed in an efficient way through the city. Mobility and accessibility were important factors to determine the structures of the tunnel. During the explorative process, there was made a design for a bridge. From this design, the legacy of this period can be derived. The appearance of the design is a large and very high suspension bridge. The background of J. Emmen as an engineer, combined with the showcase of cars on the slopes and the form connected to the construction, this bridge fits in the typology of The bridge as representation of mobility and construction. This is in line with the decision and functionality of the constructed tunnel.

The reconstruction of the first permanent shore connection of Rotterdam was a crucial development for the city. Because of mobility development, the bridge was congested and this caused traffic overflows in the rest of the inner city. Combined with the reconstruction programme to rebuilt the inner city, the Willemsbrug was planned. This crucial role in the network of the inner city, combined with its role in the reconstruction makes this bridge a crucial element in the city. It does not have the same look with arches from stone, but the reasoning fits this typology. Although its role in the structure and character of the city, the appearance of the bridge is purely based on the mobility demands, combined with knowledge about the construction. The bridge is one of the many cable-stayed bridges made during the 1980's. The decision for the cheapest option confirms the legacy of a bridge as representation of mobility and construction.

The most recent shore connection is the Erasmusbrug. This shore connection is a representation of the typology of A bridge as form. It is an architectural exploration or adaptation of the cable-stayed construction principle. The construction principle is tested and adjusted in order to create a more dynamic, specific and iconic shape. At first, the suggested form by the architect Ben van Berkel was not even able to deal with the forces on the bridge. This new shape is specifically designed for this location between the two city districts. Comparing the shape of the Willemsbrug with the Erasmusbrug, the architectural influence on the shape is clearly visible. The Willemsbrug is just a representation of the construction principle, against the Erasmusbrug which is a clear variation on this principle.

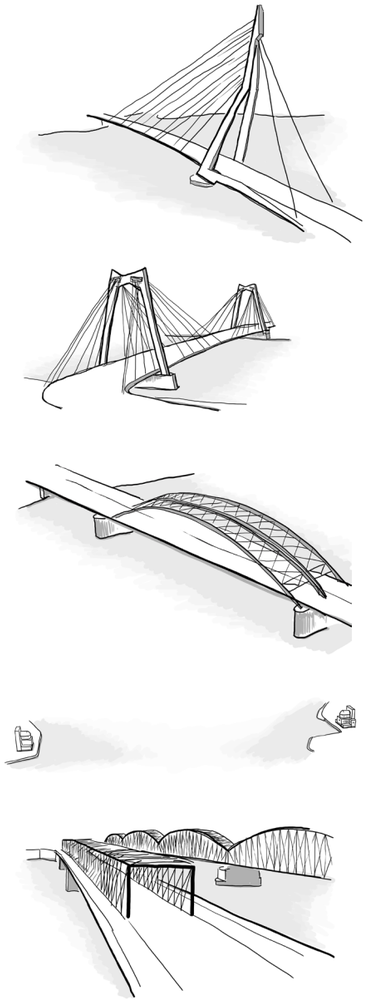


Fig. 25. Top to bottom: Erasmusbrug, Willemsbrug, Van Brienenoordbrug, Maastunnel and Maasbruggen

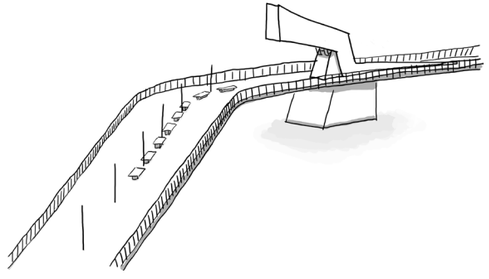


Fig. 26. Rijnhavenbrug (2012)

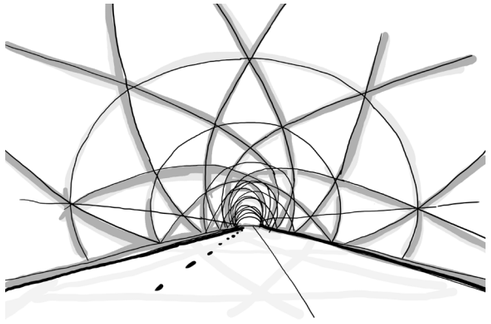


Fig. 27. The green connection (2014)

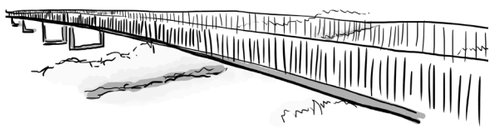


Fig. 28. Bike bridge (2015)

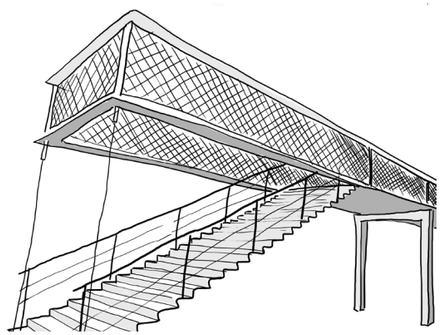


Fig. 29. Bridge from Charlois to Waalhaven (2016)

CONCLUSION

The development of Rotterdam and the construction of permanent shore connections are inseparable. Without the construction of the Maasbruggen, Rotterdam is unlikely to have developed a new district on the southern shore of the river. The division of the river has developed to an assignment of connection and separation of the two city districts. Over time, shore connections have had a strong relation with the context of city planning of specific locations, which were directly connected to the shore connection.

The bridges of Rotterdam are dividable over the typologies of bridges. The Maasbruggen are representations of mobility and construction, the design of the Maastunnel and the Willemsbrug fit this typology as well. Besides, the Willemsbrug was a crucial element in the city for traffic overflows. The Erasmusbrug is an example of a bridge, designed with the influence of an architect.

In these shore connections, the missing typologies are the bridge as part of the city and the newly introduced typology as a composition of form, construction and programme. One of the reasons of the missing typologies is the large scale and size of shore connections in this research. However, when zooming in to smaller scale bridges, these typologies are still not present in Rotterdam.

Possible reason for the absence of some typologies could be the replacement of old bridges by bascule bridges in 1843 by W.N. Rose. 50 years later, some of these new bridges did not longer meet the requirements for land and water mobility. These were replaced by the director of city development of the municipality G.J. de Jongh. According to expectations, the replaced bridges could fit in the typology as the bridge as crucial element for the city with a stone arch construction (Top010, n.d.). As far as known, Rotterdam never had a bridge with buildings on it as part of the city.

The most recent developments of bridges in Rotterdam are approaching the new typology. The latest bridges are connecting recreational spaces in the city or are of influence on the development and accessibility of certain areas. The Rijnhavenbrug (Fig. 26) is a bridge over a harbour mouth, connecting the development area of Kop van Zuid with Katendrecht. The bridge has lights and banks on it as urban programme. Because of the connection to the city via this bridge, Katendrecht got new opportunities to develop. The Green connection (Fig. 27) is a bike bridge crossing the highway for a connection between the city and the recreation outside of the ring. A new bike bridge between Rotterdam and Schiedam (Fig. 28) results in a better accessibility between the cities for bike traffic. The latest bridge built in Rotterdam is a pedestrian connection between Charlois and the harbour (Fig. 29).

The recreational purpose of these bridges can be seen as an introduction towards the new typology of bridges in Rotterdam. However, the size and the programme is not fitting the typology. A new city bridge should be an innovative combination of form, programme, mobility and construction in the new typology of bridges. The new bridge should be a composition to show the added values of a bridge.

POLICIES

A new city bridge is part of the agenda of the municipality. From newspaper articles, it became clear that they are planning a new shore connection, which forms the context for this research. This new shore connection is included in the visions and policies of the municipality for the coming future. ***What are the ambitions of the municipality for the future for related developments and a new shore connection?***

Rotterdam is, like other cities, in a trend of a growing population. For many years, cities on waterfronts, have been attractive to people. Over half of the global population is living in cities and this number is expected to grow all (Department of Economic Social Affairs: Population Division, 2014, pp. 7-12). A growing population means a dynamic and changing city. To stay attractive for people and for businesses, a city needs to deal and keep up with the dynamics. A growing population is demanding for good housing facilities, attractive public spaces, and environments with facilities and a good liveability (Meyer, Westrik, & Hoekstra, 2014, pp. 9-10). The growing population in Rotterdam and in other cities is pressuring the riverways, the quality of life and the existing infrastructural networks in the city. The dynamics of an ever developing city are part of the character of Rotterdam (Vlasblom, 2016).

About twenty years ago, inhabitants of Rotterdam started to actively raise awareness for 'big city problems'. For example, poverty, segregation, degeneration of the inner city, vulnerability and pollution are part of the problems cities have to deal with. The inhabitants started to believe in the 24 hours' economy for a more vibrant and safer city ("*In Rotterdam zijn de problemen net een beetje erger*," 1996). Ten years later, the municipality published their vision for the city in 2030. The goals of this vision are related to the big city problems and share the same general vision as the public had. Both the municipality and the inhabitants want to keep the city as attractive as it is and become more attractive. According to the municipality of Rotterdam, an attractive city is a city with a strong economy with many employment opportunities and a city to live in with a balanced composition of the society (Gemeente Rotterdam, 2007).

To keep up with population growth, Rotterdam has to build 56 thousand dwellings before 2030. To protect the rural land and to attract specific target groups, the municipality wants to construct these dwellings within the existing boundaries of the city (Gemeente Rotterdam, 2007, pp. 60-62). Building within the boundaries of the city means extra pressure on the existing networks and the facilities in the city. This threats the attractiveness of the city.

Inner city and mobility

To keep up with the demand for a growing population and an attractive city to live in, the municipality has stated qualitative goals for the inner city of Rotterdam. The qualitative goals are a hospitable and vibrant inner city with a good image, an inner city with possibilities to live in, a connected and liveable city, and an active, busy and operative inner city (Bureau Binnenstad, 2008). To reach these goals, the construction of good housing facilities in a good living environment is important. They will pay attention to public space, employment, facilities, mobility and infrastructure, health, and heritage.

The goals as set by the municipality are interrelated. For example, employment, housing, and infrastructure are strongly complementing each other (Van Andel, Van Gameren, & Van Tol, 2015). Infrastructure, accessibility and mobility can create opportunities and qualities for a healthy living environment within the city and both for economic developments. In this way, infrastructure can also been seen as a method to reach related goals within the desired future for the inner city of Rotterdam (Gemeente Rotterdam, 2014, pp. 7-10; 2016, p. 12). Infrastructure is not a goal on its own but shapes conditions and opportunities for other goals.

The mobility assignment is to create a resilient, reliable and robust network to ensure the quality of life in the inner city. Especially with the prospects of a growing population, the infrastructural networks are pressured. Combined with the quality of life, little car traffic in the inner city is demanded. Fewer cars in the city will improve the quality of life and reduce pressure on networks. In order to reach these goals, car traffic has to be spread more even over the city. The growing demand for mobility, combined with the pressure by a growing population will result in stress on the existing shore connections. The developments will result in the demand for a new shore connection or a more efficient use of the existing ones (Stadsontwikkeling, 2016, pp. 4-5). Most pressured are the Erasmusbrug and the Van Brienenoordbrug, but the Maastunnel aswell (Gemeente Rotterdam, 2014, p. 10). Without a more efficient use and without the construction of a new shore connection, the urban densification assignment, the economic development and a healthy and attractive living environment are unlikely to be realised before 2040 (Stadsontwikkeling, 2016, p. 9). The development of a new shore connection is crucial for the future of the city. It will combine the development of a robust network, with an improvement of the quality of life, and economic development. Other mobility challenges as defined by the municipality are the congestion by bikes, new demands for bike parking, air quality, spatial quality, the balance of modes and the concepts for the structures of networks (Gemeente Rotterdam, 2016-b, pp. 5-11). All aspects will benefit from a new shore connection.

For a long time, the Maas has been a social and physical barrier for the city. The two shores of the city grew apart and have major differences. A new shore connection can improve the relation between the two city districts. To strengthen the relation between the two shores, the distance between shore connections should be reduced and the shores should be better connected (Gemeente Rotterdam, 2016-b, p. 22).

Locations

A better balance in the use of modalities, the reduction of the distance between the shore connections and the location of economic developments, have assigned two possible locations (a western and an eastern bridge) for a new shore connection crossing the Maas. The two locations with its related developments are presented in the historical analysis of the city of Rotterdam in Fig. 24 on page 40.

The western option was developed in combination with the optional candidature for the World Expo 2025. Although this candidature is cancelled, this process caused an acceleration for the exploration of the possibilities for this option (Stadsontwikkeling, 2016, p. 5). This option will contribute to the developments in the southern district of the city. It can reduce the car traffic in the Maastunnel with 50%, this will result in better quality of life around the access routes and the connection of the Erasmus Medical Center and connected development locations. The new western shore connection will shape opportunities for the public transportation between both city districts (Gemeente Rotterdam, 2016-b, pp. 32-38; Stadsontwikkeling, 2016, pp. 10-11). A second shore connection is planned on the east, in the middle of the Van Brienenoordbrug and the Willemsbrug. This connection will complete a corridor to the university campus. This economical axis can stimulate developments and is a strengthening for the living environment. The diversity along this axes is more connected, and residents from the south district will have more access to education and employment. This eastern bridge shapes opportunities for the development of the area around the soccer stadium. Besides a movement of car traffic from the inner city, this bridge is expected to reduce car traffic on the national highway and the Van Brienenoordbrug as well (Gemeente Rotterdam, 2016-b, p. 39). The relevance for the national networks can result in financial support for the bridge, as happened by previous shore connections.

On the long term, the realisation of both shore connections, combined with the transformation of the existing ones for a more efficient use, will offer a resilient network for a vital and livable development of the area along the Maas with its influence on the complete city. A better sprawl of car traffic will result in economic developments through the city centre and this balances the use of modes of transportation. This will create room for development, residential areas with a high quality of life and many accessible facilities (Gemeente Rotterdam, 2016-b, p. 42).

Shores and connections

Rotterdam is a city with a unique position in relation to the river and the harbour. A new shore connection will bring the city closer to the water. From the reconstruction plans after World War II, the city has developed with its back to the river and a focus on the city. Today, the waterfront is in development, some places are better connected and accessible, and have a qualitative design. However, this attractive waterfront is fragmented through the city. Many neighbourhoods have a poor relation and bad accessibility to the water, although they are nearby. The complete waterfront is not yet benefitting from the opportunities it has. The development of the waterfront is a showcase of the unique strength of the city as a city in transition along the river and harbour (Bureau Binnenstad, 2008, pp. 56-58). For the design of a new bridge, this means that it is not only about connecting the two shores, but also about the quality of the waterline in relation to the bridge.

Conclusion

A new city bridge is planned to facilitate the growing population of Rotterdam. A growing population is demanding for more mobility services and housing. To meet these demands, the municipality wants to enhance the quality of life by reducing cars in the inner city. In order to meet these goals, the municipality has assigned two locations for future shore connections. Both options are dealing with the same challenges, but are offering different opportunities for development in Rotterdam.

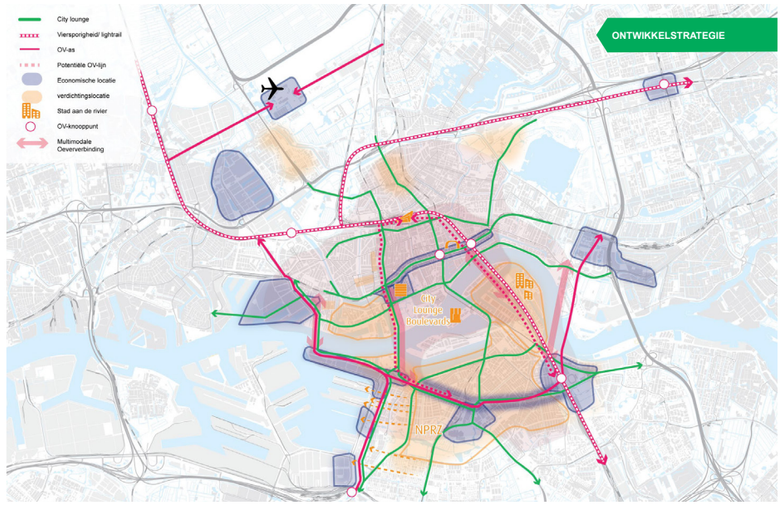


Fig. 30. Locations of the shore connections by the municipality of Rotterdam (Gemeente Rotterdam, 2016, p. 40)

CONCLUSION

The arguments used in history for the decision to build a bridge were all based on city or district plans. The city expansion plan, the reconstruction plan, the national highway planning which was even on a larger scale. The argument behind the Erasmusbrug was the need for an icon for the city. Although the base and focus of the city plans were different, the scale can be seen as similar. All arguments for shore connections were based on the city scale plans, but they were very location specific. It was not only about a new bridge for the city. Developments were related to the landings of the shore connections.

The decision to build a new bridge is based on the goal of the reduction of car traffic in the inner city and the population growth. The new bridge aims to make the network more resilient for future demands, to connect the two city districts and to enhance the attractiveness of the city. The locations for new bridges are chosen based on different arguments. Both arguments are based on the same scale and are similar to the scale of previous shore connections. A new city bridge for Rotterdam is connecting two socio-economical separated parts of the city. The bridge is needed to deal with future traffic demands and pressure on the car network, to keep the quality of life on a high level. Spin-off developments are expected to stimulate the economical and functional (re) development of the harbour (even though the World Expo got cancelled) and the stadium-area.

The previous shore connections are related to the typologies of the developments of bridges in history. A new typology is determined and combines form, construction, connectivity and programme in an innovative composition. Latest developments are in line with this new typology. The recreational developments aligned with these bridges are the first steps towards this typology. A bridge should be more than a phenomenon and be related to developments in the surrounding and the qualitative design of the shoreline. A new bridge for Rotterdam should be a location, an addition to the public space network. This opportunity of added value for a bridge is not yet included in the current approach.

A bridge is more than a phenomenon, it is related to city developments and networks in the city. A story about city bridges in Rotterdam is a story about the harbour and the city and its borders and transition zones (Lebesque & Koekebakker, 1998, p. 5).

A new bridge should be a composition of form, construction, connectivity and urban programme. The quality of the shores should be included in the design and included in the masterplan is a development plan for the areas in the influence zone of the landing of the bridge.

A NEW CITY BRIDGE

A BRIDGE IS MORE

Fig. 31. Inspirational urban programmes for on bridges

PROGRAMME

The new bridge will be a representation of a composition. Part of this composition is the urban programme, which should be included in the design. In the new typology, an urban programme should be included in the design of a bridge. In the historical typology of the bridge as part of the city, many programs have been accommodated on bridges. Even bridges from other typologies can facilitate some programmes. ***What programmes can a bridge facilitate?***

A bridge is more than just a connective object, facilitating daily traffic going from one shore to the other. By analysing the programmes on different existing bridges, an overview of possible programmes is made and is shown in Fig. 31. These programmes are the inspiration for the design of programme on a new bridge for Rotterdam.

Fig. 32. Positions of programme on bridges in relation to traffic

The programme on the bridge can conflict with the connecting function of it. The division between the programme and the traffic on the bridge, resulted in four typologies as shown below in Fig. 32. Programme and traffic can be separated and happen next to or above each other. It is also possible that specific spots at the bridge are assigned for any programme to happen locally. The last possibility is that the complete bridge facilitates an urban programme. The bridge can be temporarily closed off to regular traffic, or no traffic at all is able to pass the bridge.

The position and typology of the programme are related to the type of programme. Per separation different kinds of programmes appear. The local programmes are restaurants, shelters, possibilities for relaxation and meeting, and a viewpoint. Abreasted functions are buildings, fast connections and nature. Stacked functions can be a viewpoint, nature under the bridge, fast connections and possibilities to stay for a longer period of time on the bridge. In a solid section, the bridge can be used for many activities, such as annual events, but also for sustainable energy, shops, traditions, music performances, creating recreational networks, nature and competitions. For some programmes, it is necessary to close the bridge for traffic.

In the new typology of a composition, a bridge is an integrated combination of traffic, form, programme and construction. A bridge is more than a connecting element over the river Maas. A bridge is an integrated location in the public networks of Rotterdam. The urban programme for this new bridge is inspired on this analysis of urban programme on existing bridges.

Fig. 33. City structures in a regional comparison

POSITION

A bridge is more than a phenomenon in the general context of a city. The river Maas is 925 kilometres long, of which about 15 kilometres are within the highway ring of Rotterdam. The city has 202 kilometres of shore length in total, because of harbour mouths and piers (Havenbedrijf Rotterdam, 2015). This gives an unlimited amount of possible locations for a new city bridge. The municipality has determined two locations for the bridge, as presented in the former analysis of the municipal policies on page 47. A different perspective on this bridge requires a review of these locations. ***Based on different scale levels, what is the best location for a new city bridge for Rotterdam?*** The goal is to assign a position which fits the new perspective on bridges.

International comparison

The opportunities by rivers resulted in the development of many cities along waterways. The Maas is dividing the north and south of Rotterdam, but created opportunities for trade and harbour and economic developments. The importance of the harbour activities on the Maas resulted in a city with few shore connections compared to other water-oriented cities (Taapken, 2014). The number of shore connections is made visible in Fig. 33 and Fig. 34. Most of the cities have a significant number of shore connections, compared to the number of connections in Rotterdam. In Fig. 33, a comparison of different cities along waterways is made. The structure of the city, its centre and infrastructure are drawn. Some cities have their centres on both sides of the river, as is the ambition by the municipality of Rotterdam. The cities with their centre on two sides of the river are Cologne, London, Paris, Lyon, Frankfurt, and Dresden. With the centre of Zuidplein in the south district of the city, Rotterdam can be seen as a polycentric city. Other polycentric cities on rivers are Hamburg, Cologne, Frankfurt and Dresden.
Besides the location of the centre, the length of the river is determining the number and rhythm of shore connections. In Fig. 34 on page 58, river length and the number of shore connections is compared. In the barcode study, the length of the river is represented by the length of the bars. The length of the river of London is comparable to the length of the Maas within the city ring. Next to the length of a river, support for shore connections is important for the decision to build them. More support for a shore connection is achieved with more inhabitants and a higher density. More people using a network requires a more delicate city infrastructure. Frankfurt is similar in density and the number of inhabitants. For this reason, Frankfurt is a comparable city to Rotterdam.

Rotterdam had never developed as many shore connections as most other cities. This is caused by the width of the river and the influence of the harbour. Hamburg is a city in which the location of the harbour related to the city centre can be compared to Rotterdam. However, Hamburg has a city on only one side of the river over a smaller canal. This canal is crossed by eight bridges to connect the east and west of the city. The movement of the harbour of Rotterdam to the west, combined with the ambition to create the city centre on both sides of the river, makes a comparison of Rotterdam with Hamburg unnecessary. The width of the river Maas is closest to the Rhein in Cologne and the East River in New York. The rhythm of shore connections per length of the river in these cities is similar to Rotterdam. To make a jump over the river, and create a stronger relation between both districts the city needs more shore connections.

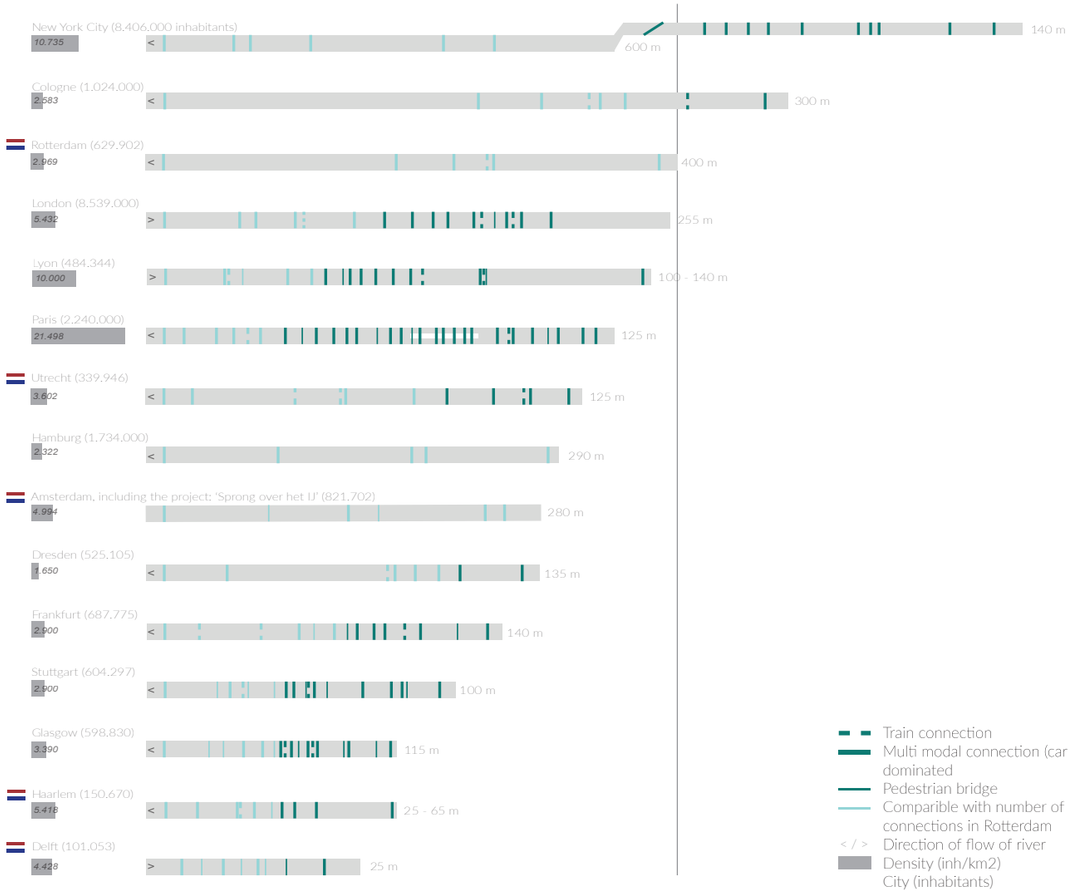


Fig. 34. International barcode comparison

Regional scale

The national government has been important for the decision making process for the Maastunnel and the Willemsbrug. They were responsible for the financing of these connections. Without their financial support, Rotterdam would not have as many bridges as they have today. For other bridges, the city plan has been important. For the new city bridge, the national government is of major influence for financial support. The necessity for the city is not acknowledged by the national government. However, the city is not able to finance the planned bridges themselves. Relieve pressure from national highways, could be an argument for the government to invest in the project (Rubio, 2016).

Goals for connectivity and mobility are set by the government of South-Holland. Their goals are an efficient network, the improvement of the balance between mobility and the quality of the direct surroundings, and to balance public transportation with the public demand. In the plans for both public transportation and cars, there are no projects for a new shore connection of the city network through Rotterdam. However, to improve the regional connection they are planning a new tunnel on the west of the city. Projects on this scale are about the connectivity between cities (Provincie Zuid-Holland, 2014).

The regional network does not benefit from a new shore connection. For this reason, the connection can be focussed on the city and more local networks.

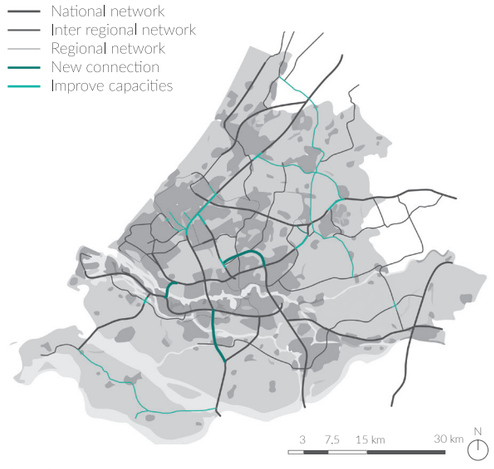


Fig. 35. Province of South-Holland with plans for the car network

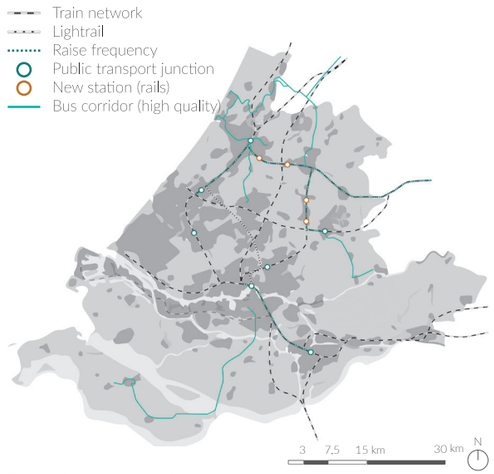


Fig. 36. Province of South-Holland with plans for the public transportation network

North-south route: primairy
North-south route: secundairy
East-west route: primairy
East-west route: secundairy

2 km 5 km N

Fig. 37. Missing links in bike network of Rotterdam

Accessibility in car network:

Centrum network
Highway
Connected to center network

Accessibility in bike network:

1 2 3 directions

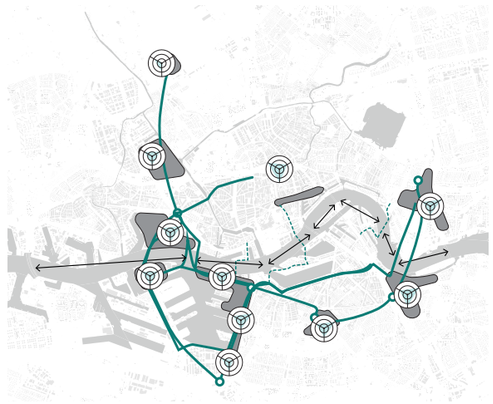
Accessibility in public transportation network:

Bus
Tram
Metro
Train

Economic development area
Accessibility
New route
Bike traffic: new connection
Rhythm of shore connections

2 km 5 km N

Fig. 38. Improvement of the accessibility of economic development areas



City scale

The assignment for a growing population in the existing city will result in densification. More people means more demand for mobility and pressure on the current networks. To enhance the quality of life the municipality aims to reduce car traffic in the inner city by building a new bridge. But, the car should not be seen as most important form of mobility in the decision making for infrastructural networks (Gemeente Rotterdam, 2016-b). The use of cars is related to the built environment. The relation between car traffic and the built environment can be explained by 3d's: density, diversity and design. By the design of the physical environment, specific modes of transport can be stimulated (Cervero & Kockelman, 1997). The demand for fewer cars should not let to more roads. In the past, the construction of car traffic facilities, let to even more traffic and more crowds. New car networks, will result in more cars in the city (Gehl, 2016, pp. 9-11) More information about this subject can be found in Appendix III. Mobility in the city on page 143. To stimulate the use of bikes, an analysis is made on the missing links in the bike network. These missing links can determine the location of a new bridge to complete the bike network. The investments in the bike network will result in more bike use and competition with the efficiency of the car.

The second analysis is the multimodal connectivity of economical development areas. These areas are assigned by the municipality as multimodal hubs of economical development. The multimodal accessibility is tested and improved by suggested connections. The separate networks with the improvements per mode are attached in Appendix IV. Mobility analysis on page 152.

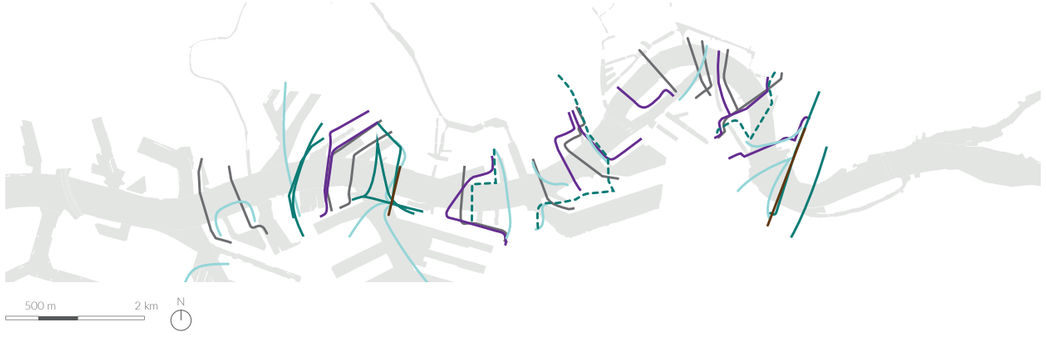


Fig. 39. Possible locations from all analyses in rhythms over the Maas

VISION FOR ROTTERDAM

A new perspective on the design has led to the analysis of locations for a new shore connection. The combination of the previous analyses on different scale levels resulted in suggested locations as presented in a map in Fig. 39. From this map, a rhythm for the river Maas is derived. This rhythm is translated in barcodes, as used in the international comparison. The barcode of the city scale is leading, and determines the rhythm for shore connections over the Maas. The new rhythm of shore connections and its modalities are presented in Fig. 40 on page 64.

By adding new shore connections, a more balanced rhythm over the length of the river is made. For the long term, four new permanent bridges are added. Two new connections are desired on a short term, on the same locations as the municipality suggested. The high priority connections are fast and multimodal connections. The later added slow connections are for pedestrians and cyclists and will strengthen the position of the bike in the city. On the short term, the water-bus and water-taxi can fulfil the connection on these locations. Firstly, the multimodal fast connections are constructed. They are positioned similar to the suggested locations by the municipality. This means that these positions fit with different perspectives on the design of bridges. To stimulate the use of bikes, cars have less priority. Good alternatives to cross the river by car are available nearby. On a more local scale, developments can benefit from the ability to cross the bridge by car so cars should be able to use the bridges. The focus on these fast connections is on public transportation and cyclists. The strategic position in the network and the multimodality result in a higher priority for construction. These fast connections are connecting two city district, by several modes. Besides, it is reducing car use in the inner city by offering alternative routes for cars and stimulating the use of other modes. On a long term, slow connections complete the bike network and stimulate the use of bikes. The axes in this vision, are related to the access routes and connectivity of existing and future shore connections. These axes are connecting the most important users and districts to the bridge. Developments are expected to happen along the new axes. In the vision, the distance between the axes is reduced and more even, which makes it more easy to connect axes from east to west and so improve connectivity of the complete city.

The positions of the shore connections are based on the analyses of different scales and perspectives. To position the bridge, the local scale should be included to point the exact location of the landing of the bridge and reduce the negative impact. The vision map is about the connected districts, as are connected by the created axes.

Four bridges are included in the vision. From the multimodal connections, only one bridge is elaborated further in this research. This decision is made, based on the context of the landings of the bridges. The eastern option is landing in a natural area in the north, and connected to the stadium zone in the south. The expected (re)developments for this stadium are related to the design of a bridge and the developments in the natural zone. Because of the lower density in this natural zone, the programme has more options for a proper fit in the urban context. The western option is a connection between a residential city district and the harbour. The movement of the harbour to the west and the pressure of a growing population is creating frictions on this location.

The possibilities for a bridge as added value are explored for this western option for a fast shore connection.

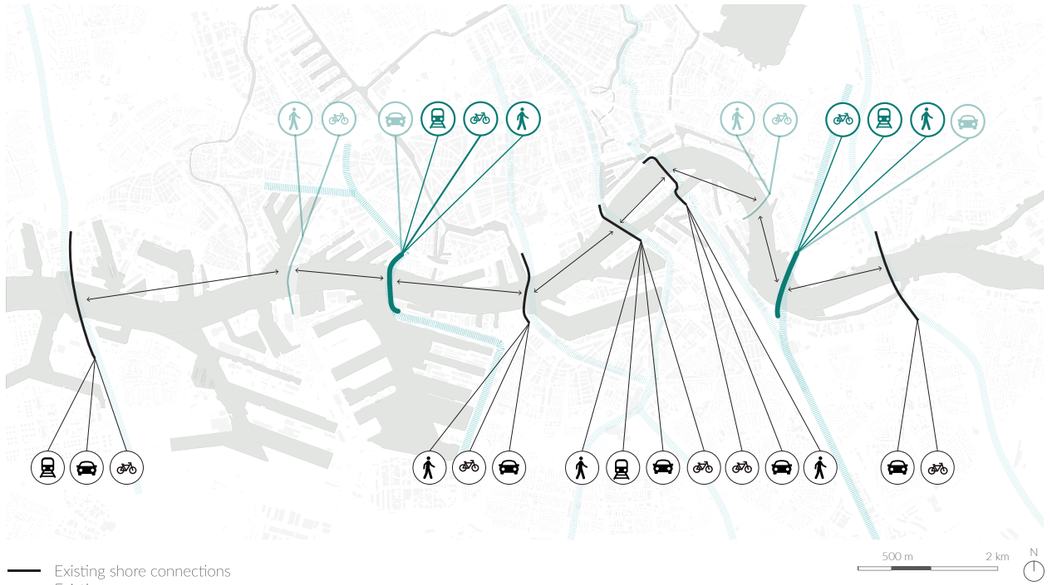


Fig. 40. The new rhythm for shore connections over the Maas

North shore:
Harbour in transition
Schiemond
The Delft and the multiplein
Lloyd pier and Mullerkade
Het Park

South shore:
Harbour in transition
Head of Charlois

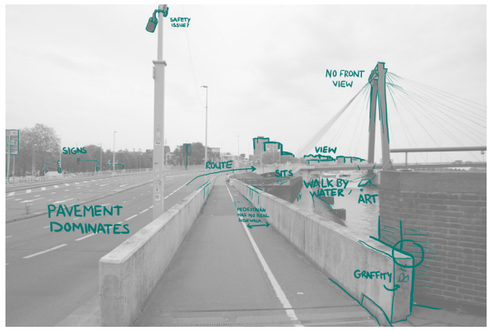
POSITIONING OF THE BRIDGE

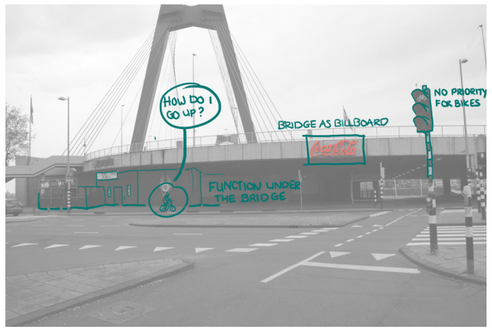
At this moment, the support of the inhabitants for the construction of a new bridge is lacking. They resist against the developments, as there is no clarity to the prospects of their neighbourhoods. By a proper positioning, the bridge can add value on a local scale and this can create local support for the construction of a new bridge. For the exact positioning, the shores are analysed and classified. From these different shores, multiple connections and relations are possible.

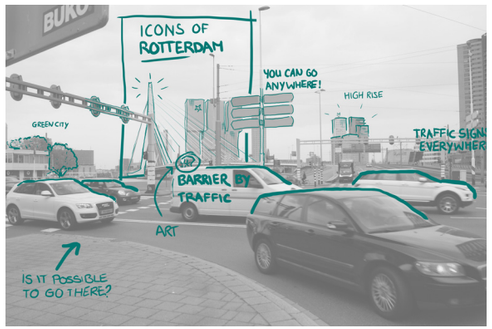
Connecting the southern pier to the harbour in transition is a connection between to areas in development. This can negatively influence the search for identity and growth of new areas, functions and developments. Because of the expected developments in these city harbours, there is an opportunity to relate this to the landing of the bridge. Schiemond is a residential area, where inhabitants are protesting against a new bridge. The area offers no options for a landing without a major impact on the structure. The third possible landing on the north shore is a multifunctional square, which is most of the time an empty piece of land. Developments offer opportunities to improve the quality of the public space. The connection of this location can strengthen the relation between the hinter-city districts. By a connection to the south pier from this location, the pier is divided in different areas and can develop in different qualities. On the Lloydpier and Mullerkade, already many developments are happening. The landing of a bridge should have been included in earlier plans. By a connection from the most eastern location, the bridge is accessible without driving the complete pier. However, this location is already connected by the Maastunnel.

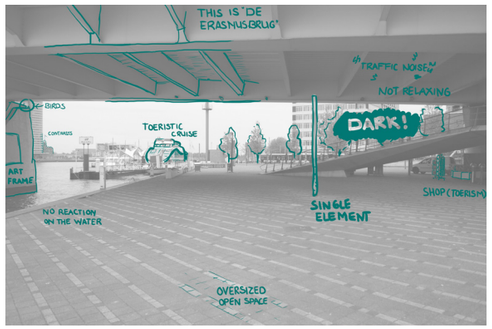
The location of De Delft and the multifunctional square offers most opportunities to create a landing without demolishing houses. The functions on this location can be replaced with new offices of higher quality. A big quality of this position is the division of the southern pier. By this location in the middle, a very accessible location appears. Because the bridge has its access route crossing the first part, two different areas are created. The different areas have different possibilities for future development with a variety of qualities.

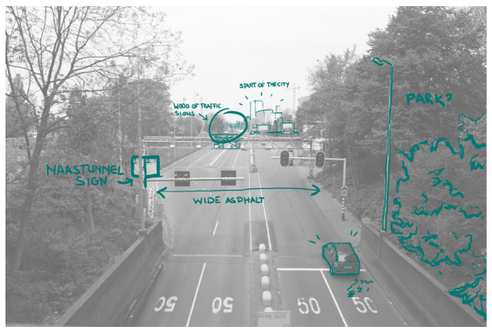
Fig. 41. Types of shores and possible locations of landing of the bridge (Apple maps, 2016)











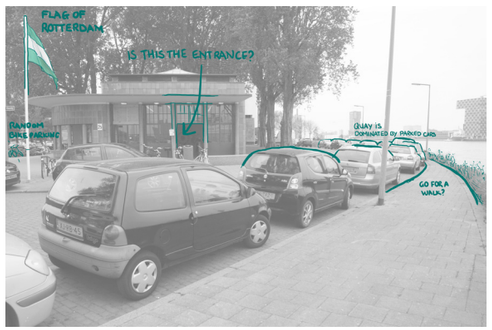
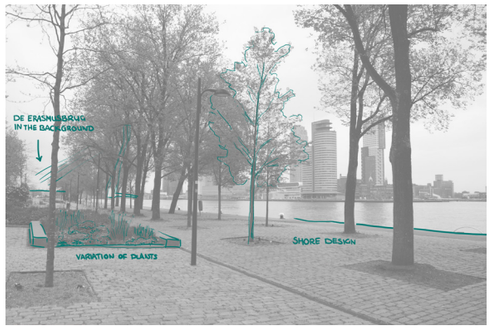


Fig. 42. Selection of connected locations. Top to bottom: Willemsbrug, Erasmusbrug, Maastunnel



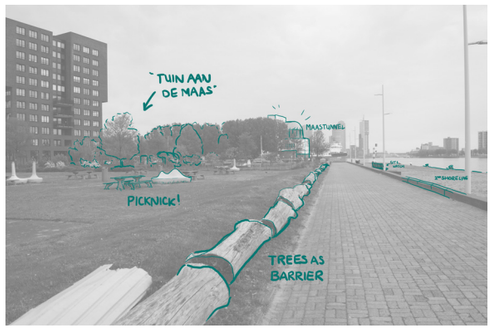


Fig. 43. Selection of unconnected locations along the Maas. Top to bottom: Westerkade, Mullerpier, De Esch (eastern bridge location)

Local scale

The exact position of the bridge is determined. A lot will change by the construction of the landing of the bridge. Change often result in resistance, but change can also add value to a location. The local scale of existing shore connections in Rotterdam is analysed with photos and a site visit. The goal of this analysis is to find a pattern in the design of landings and to improve this in the design.

From the photo analysis, it is clear that connections are combined with large fields of asphalt and with a forest of traffic signs. Barriers are cutting of the relation between the city, the people and the river. Unconnected locations are of higher qualitative design. Multiple activities are taking place along the unconnected shores in a much greener environment with a view on the other side of the river. There is a big difference between the connected and unconnected locations.

A bridge is defined to be a crossing of a barrier out of human desire on different levels. Both flows, under and over the bridge, should be unhindered. Bridges have been developed with new barriers of large traffic flows and height differences. Quality is lost in these locations. The newly created barriers are threatening multiple relations in the city.

A new barrier should be avoided in the design of the new city bridge.

INTERESTS

Many stakeholders are involved in a project of a new bridge. Among other stakeholders, the municipality, the Port of Rotterdam, local entrepreneurs, designers and planners, and inhabitants are involved and affected by the opening of a new shore connection. They all have different interests and ambitions. To explore their interests and the conflicts, interviews have been held to answer the question: ***What are the interests of different stakeholders?*** Interviews have been held with the Port of Rotterdam (Kees Kleinhout and Arjan Hoefnagels), Inge Spaander as a writer for VersBeton and inhabitant of the southern district and Joep van Eijk as entrepreneur and founder of the local interest group. A summary of the insights from these interviews is presented here. The results of the interviews can be found in Appendix V. Interviews on page 155. The starting point for the interviews was the impact of a bridge, the focus on cyclists and the new barriers, connections and borders a new bridge is creating.

The port of Rotterdam

The Port of Rotterdam is focussing on harbour operations and the needed facilitations to operate the harbour and the needed developments. From this perspective, a new shore connection is a barrier for the navigable water and will hinder harbour operations. A new bridge will mean the movement of the border between the city and the harbour, which is now located at the first bridge from the sea: the Erasmusbrug. A new bridge on the west will make high intensively used shores inaccessible. This will result in capacity problems in the existing harbour and its activities. For this reason, the preferred option by the Port of Rotterdam is a tunnel or a bridge of over 70 metres high so the flow under the bridge is unhindered as is defined as a bridge in this research.

But the Port of Rotterdam sees the necessity of a new bridge for the needs of the city. Although this bridge will influence the possibilities for harbour operations, a new bridge will bridge opportunities for the accessibility and developments of the harbour. It will create a better connectivity by public transportation for the Waalhaven. In this way, jobs in the harbour are getting more accessible for the city as a whole. This stimulates opportunities for future businesses and developments. The access route between the harbour (Waalhaven) and the city (Charlois), Waalhaven Oostzijde, will get more used by traffic. The creation of a new barrier between these two districts should be avoided. The Waalhaven is offering many jobs for the inhabitants of the southern district, these jobs should be well accessible from the city, as well it should be connected to the north of the city with a new bridge.

Inge Spaander

She was informed by the city council member Pex Langenberg, that a new shore connection will be an(other) ugly traffic connection. She wonders if this is what the residents of the city are waiting for and if it can solve future traffic problems. She shares my opinion that a bridge can be more than just this connective element in the car network. From her perspective, a bridge on this location can reduce travel time and increase the experience of moving through the city by bike or by public transportation.

As connected development of the bridge, she imagines a 'makers-space', which connects the characteristics of surrounding neighbourhoods: knowledge and local initiatives. The mixture of art, culture and knowledge can create a spinoff in social developments.

Another suggestion she made during the interview is to create an alternative option for crossing the river, such as cable cars or lifts, rollercoasters and air balloons. Combined with this suggestion, a collaboration with Hennie Most can be possible. He is developing a leisure park in the southern district along the Maas. By connecting the bridge and the leisure park, a qualitative and attractive access route to the park can be created. This embeds the bridge in its context and stimulates the inhabitants of the city to visit the leisure park.

Local entrepreneurs

The first impression of the interests of local entrepreneurs is their bond to the location and the unwillingness to think of the movement of their business. They agree to a new shore connection, as long as it is not affecting their business and properties. A local entrepreneur prefers a tunnel, because of the expected impact on its business and the accessibility. All arguments were about land activities. Navigable waters seemed not to bother their business.

But every story has two sides. The developments of a new shore connection and the conditions of a changing city can also be seen as an opportunity for entrepreneurs. A better accessibility can result in the growth of their business. A good entrepreneur its ambition is to grow and to develop the business. Also employees benefit from a better connection between their house in the city and their work.

A bridge can possibly result in the redevelopment of the complete harbour area. Some businesses will be forced to move to other locations in the city. Most of the businesses on the pier are not related to the water and can function well on a location on distance from the water. These forced moves should be guided and supported by the municipality. It can also be possible to move to another location on the pier to stay in their own environment.

The movement of businesses is a natural process. The growth of the business as result of the ambition of entrepreneurs, often result in the outgrow of properties. Even without the construction of a new bridge, businesses are forced to move one day or another. Because of this reason, entrepreneurs should see the move of their business as opportunity for further development of their situation.

Kleinhout, K. & Hoefnagels, A. (November 7th, 2016). Interview: Port of Rotterdam.

Van Campenhout, B. (November,1st, 2016) Short talk: local entrepreneur.

Van Eijk, J. (November, 18th, 2016). Interview: Entrepreneur and founder of the interest group.

Spaander, I. (October 28th, 2016). Interview: Writer for VersBeton and inhabitant of the southern district.

Fig. 44. Connected neighbourhoods with historical buildings around 1900 (Smits, 2003; Stichting Historisch Oud-Charlois, n.d.)

CONNECTING NEIGHBOURHOODS

A new bridge will connect the middle of the Sluisjesdijk-pier to De Delft/Multiplein, as discussed before. The new axis formed by the development of this new bridge will connect the neighbourhoods of Delfshaven and Schiemond in the north and Oud-Charlois in the south. This is visible in Fig. 44. The touched neighbourhoods and the possible developments are related to the characteristics of these locations.

Delfshaven

This neighbourhood was developed as a harbour for Delft along the Schie. In 1389, this canal was dug to connect Delft to the Maas. The two were separated by a sluice. Around this sluice, the harbour grew (*Geschiedenis historisch Delfshaven Rotterdam*, 2015).

As is visible in the historical analysis Fig. 46 on page 73, the city of Rotterdam started to grow westwards to Delfshaven. In 1886, this resulted in the annexation of Delfshaven to Rotterdam (Gemeente Rotterdam, n.d.-b).

The most striking monumental buildings of the area, are the (leftovers of) windmills. The one in the middle of the peninsula is still in good shape, others have lost their sails. The mill in the middle of Delfshaven is a landmark defining the historical centre. The mill was built in 1727 for a distillation cattle. Around this time, the area had eight operating mills and 31 distilleries. The mill in the middle was operating till 1922. After a fire during World War II, only the trunk of the mill was left. In 1980 the decision was made to rebuilt the mill, for the image of the neighbourhood: the historical centre of Delfshaven was not the same without the windmill in the middle (Molendatabase, 2015).

Other characteristics of this neighbourhood are the many romantic restaurants and the cosy cafés in the historical buildings along the old harbour. It is a perfect neighbourhood for a walk along the water (Gemeente Rotterdam, n.d.-b).

Schiemond

In the first maps of the historical analysis, the area of the neighbourhood of Schiemond is part of the river Maas. From the 19th century, a sandbank started to develop at the mouth of the harbour of Delft. This sandbank was named Ruygeplaat. The sandbank was developed as a harbour. From 1980, the area was transformed into a residential area. The neighbourhood offers a view over the water with its specific comb structured parcelling and wide an open boulevard. The neighbourhood is

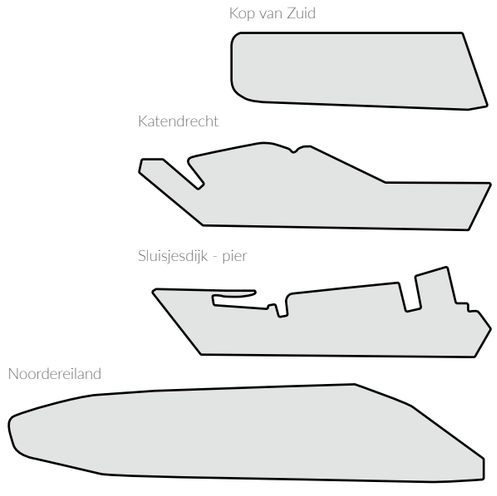


Fig. 45. Size comparison with areas which are currently in transition from harbour to city

known for its socio-economical problems. This led to a renovation project in 2013 to restructure the public space and improve the image. The neighbourhood is improving. Inhabitants of the neighbourhood are very positive about the neighbourhood with education, living and work combined (*Geschiedenis historisch Delfshaven Rotterdam*, 2015; Rotterdam Woont, n.d.).

Oud-Charlois

In 1462, Charlois was founded as an agricultural village with a church in the middle. This church is the historical character and centre of the area. In 1895 the village was annexed by Rotterdam to stimulate harbour activities and developments in the southern district of the city. Around the church and village, a neighbourhood started to develop. Many working-class housings were built for all working migrants who came to this area.

The neighbourhood has a very green character and many active inhabitants: about 150 artists, creative entrepreneurs and many active interest groups by inhabitants. All these active inhabitants result in improvements and care for other locals (Gemeente Rotterdam, n.d.-a; Stichting Historisch Charlois, n.d.).

Connecting the neighbourhoods

Both areas are different, Delfshaven is focussed on the urban life with restaurants and cafes. The municipality invests in good quality housing. Charlois is a creative environment with a strong and investing community. The connection of these neighbourhoods will result in the stimulation of developments and investments of both the municipality and the communities.

The historical centres are separated from the river Maas. Dikes and harbour developments are forming barriers between the city and the river. With a new city bridge, these barriers can be bridged. A new relation between the river and the historical centres can bring more quality of the public space (Stadsontwikkeling, 2016, p. 37).

To connect both historical centres with the river, and make an axis between them, this bridge will be focussed on a local axis. This local axis means that the bridge is more attractive for local traffic, especially bikes. The quality of the bridge should bring more for local inhabitants.

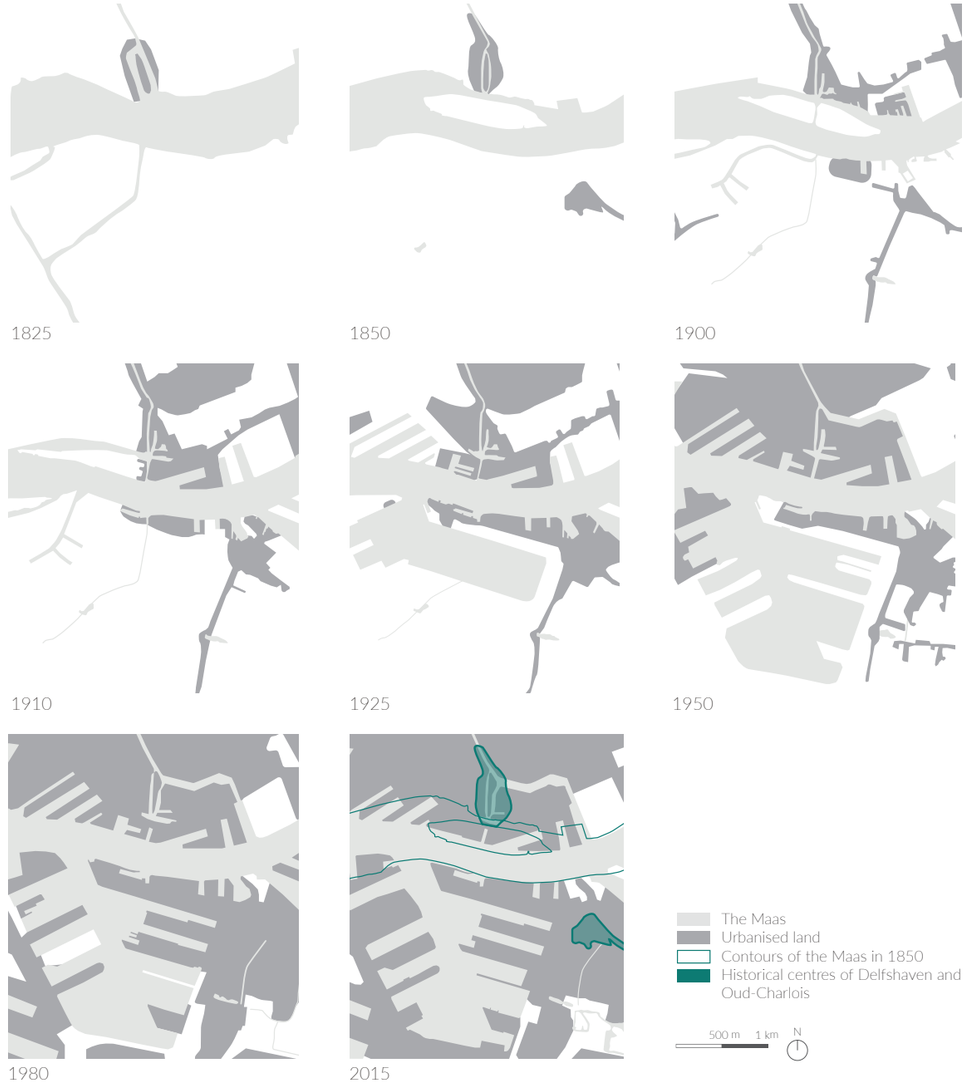


Fig. 46. Historical analysis from the location of the new bridge

DESIGN PRINCIPLES

Typology of the bridge:
- Bridge the barrier of the river Maas
- No other barrier appears with the construction of this bridge (river to city, east to west)
- Integrated compositon of form, construction, programme and connection

Technical principles:
- Harbour operations should be possible
- Bike-oriented design (slope, no detours)
- Flexible over time for modalities, because of the durability of the network (durability)

Form:
- Complete the rhythm of Rotterdam and its bridges
- Not more icon than the Erasmusbrug, this means not higher or bigger, keep it clean but relate to the image of the harbour city

Local neighbourhoods:
- Connect historical centres of Delfshaven and Oud-Charlois to each other
- Relation between historical centre and the Maas over barriers of dikes and roads
- North and South are equal
- Developments related to the bridge
- Quality of the design of the shore

A bridge is more than the phenomenon of an infrastructural challenge for a dynamic city. To design a bridge from a new perspective, research is done to the location and the characteristics of the bridge. The conclusions are summarised in the design principles. These principles are starting points for the design, which in the end will be tested to these criteria. A bridge which is fulfilling these design principles is a design which has added value for the direct surroundings of the bridge.

The typology is the bridge is based on the definition of the phenomenon and the historical research to the appearance of bridges from the first part of this research. A bridge in the new typology should be part of the city and combine the architectural form, construction and programme with daily traffic. The bridge is a composition of all historical aspects.

The technical principles are based on the mobility demands of the city. The harbour is the base of the city and has been important in the decision making for previous shore connection projects. The height of the bridge is based on the needed height for properly navigable water (at least 9,1 m). The primary land-traffic modality for this design is the cyclist. For them, the bridge should be highly accessible and no detours should be made.

Local principles are based on the historical position of the neighbourhoods. A new bridge can form new relations between the northern and the southern areas and between the historical centres and the river.

All design principles combined, will result in a bridge which is more than just an infrastructural connection for cars over the river Maas.

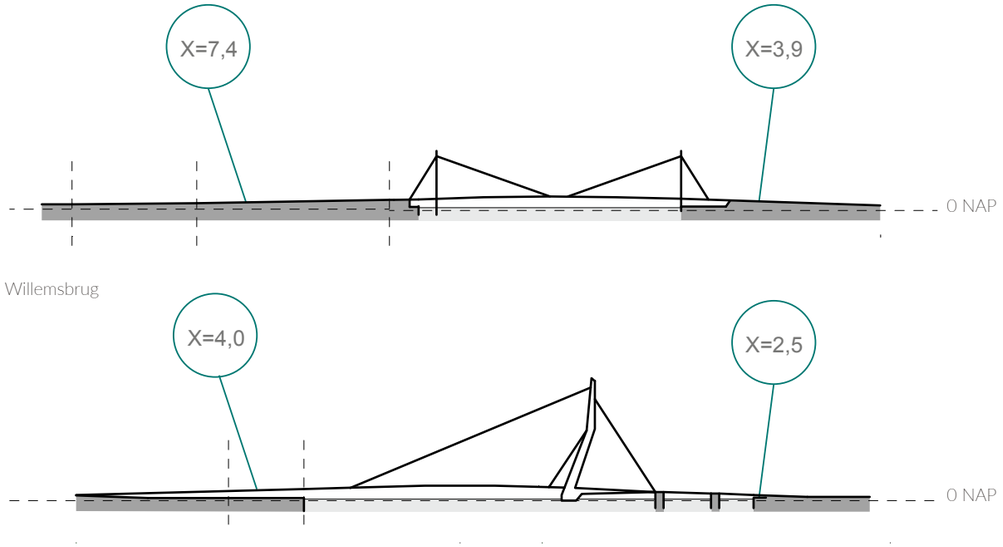


Fig. 47. Section with X-factors of existing bridges in Rotterdam

SLOPE AND HEIGHT

The new city bridge is designed from the perspective of a cyclist, in order to stimulate the use of bikes over cars as was discussed in the positioning of the bridge on page 61. The attractiveness of the bridge for cyclists is among other things, determined by the access route and slopes. Detours and very steep slopes are not desired and will be negatively judged by its users. Compared to cars, it requires a lot of effort to climb the bridge. To stimulate the use of bikes, the demands for cyclists are included in the design.

The most optimal slope for a bike is defined by the formula: *'length of the slope = X * the square of the height'*. X is a factor for slopes, with an optimal value of 10. With an X-factor with value 10, the slope will be assessed with a sufficient mark by all users. A higher value for the X-factor will result in a slope that is less steep, and in a better appreciation of the slope. A lower value for the X-factor results in a steeper slope which is less attractive to bike over (Ter Braak, 2009).

The height of this bridge is defined by the harbour operations on the Maas. The minimal clearance is 9,1 metres above the water level (Dienst Verkeer en Scheepvaart, 2009, p. 32). Once a year, the water gets to a level of +2,4 metres above NAP. With an X-factor of 10, the length of the access slope is about 900 meters long to reach the desired height. Because a bridge is a connection between two shores, this slope is about the same length down. The total length of the bridge will be about two kilometres, which is unrealistic to fit in the urban context of the new city bridge.

An X-factor of 10 is not feasible in a highly urbanised context. The X-factors for the existing shore connections are way lower compared to the optimal value as is visible in Fig. 47. This means that many people will assess them as too heavy and too steep. This makes the Willemsbrug and the Erasmusbrug not really attractive to go over on a bike. The new city bridge will be designed with an X-factor of 6. In this way, the slope can be fit in the urban context. Although it is not the most optimal X-factor, the new bridge will be more attractive for cyclists than the existing shore connections.

5 CONCEPTS

Already a concession is done for the X-factor of the slope. With an X-factor of 6, the slope of the bridge has a length of about 550 metres on two sides. It takes a lot of space, and many solutions are thinkable for the integration of these slopes. From the combination of the design principles, five different concepts can be made for a new city bridge on this location. The variations in these concepts are the height of the bridge, the X-factor and the landing of the slopes. These concepts will be assessed with the design principles.

Fig. 48. Section concept I. Bridge for bikers

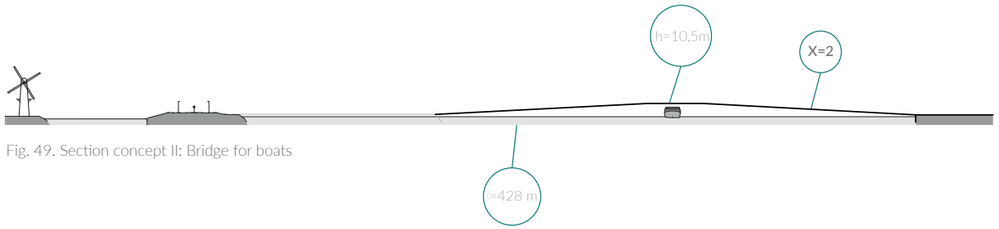


Fig. 49. Section concept II: Bridge for boats

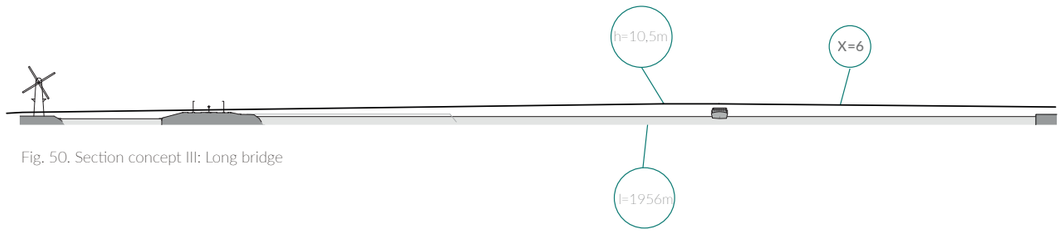


Fig. 50. Section concept III: Long bridge

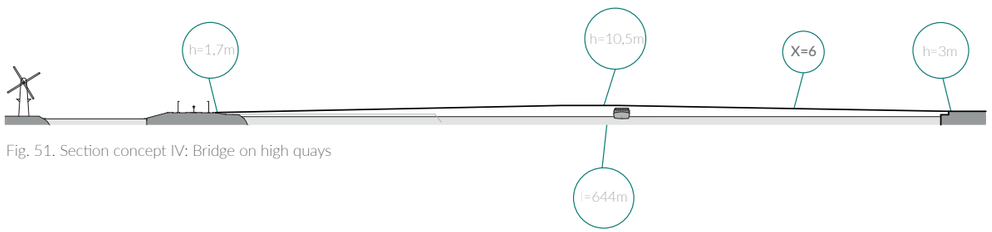


Fig. 51. Section concept IV: Bridge on high quays

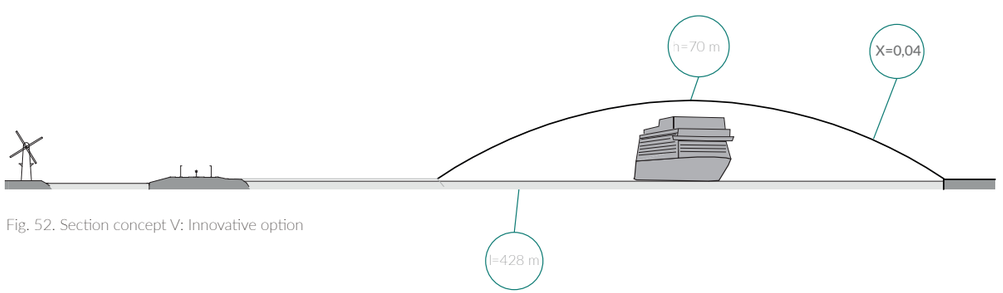


Fig. 52. Section concept V: Innovative option

I. Bridge for bikers

This bridge is specifically designed from the perspective of cyclists. No detours are made for a functional and effective crossing of the river. Also, the optimal slope for bikers in an urban environment is taken into account. With an X-factor of 6, this bridge is a positive experience for the target group. Because of the optimal urban slope, the bridge will not rise high enough above the water to let ships pass. This will result in a bridge which opens multiple times a day. This will interrupt the network for both harbour operations, cars and bikers. Because of the landing of the bridge, a good east-west connection can be created on the shores along the river.

II. Bridge for boats

This bridge starts at the existing shores and is high enough for harbour operations. The slope is dependent on the desired height for boats to cross without problems. This results in a slope which is unfavourable for cyclists.

The route on both shores can continue without any hindrance from slopes, it only has to deal with the access route to the bridge. A qualitative route along the river can be developed in this concept.

III. Long bridge

The desired height for harbour activities combined with the desired slope for bikes determines the shape and length of this bridge. The slope has a length of almost 2 kilometres and is reaching for in the connected neighbourhoods. This is a bottleneck for the design and created detours in different networks. Having the bridge crossing the dike, piers, roads and buildings will give conflicts in height and routes. This will result in a design assignment of the integration of the long slopes in the existing urban situation.

IV. Bridge on high quays

The northern shore has a dike at some distance from the water. This height of the dike can be used for the access route to the bridge. Starting from a higher point gives an advance for the slope and X-factor. Using plateaus and multiple slopes will increase the attractiveness of the route. Higher the quay on the south side will give opportunities for a boulevard along the water, combined with an uninterrupted bridge and route from east to west.

V. Innovative option

Building a bridge has many consequences for the movements in the city. A bridge on the assigned location will not be high enough for cruise ships to cross. A forced move of the cruise terminal to another location more west in the city is one of the movements in the city caused by the construction of a new bridge. The advances of an innovative, mechanical alternative for a bridge will shape conditions for cruises to cross the bridge. But cars and cyclists are not able to climb the slope. An innovative system is needed to help both modes to get up. This will take a lot of time, as was the case in the design shown in Fig. 17 on page 34. Although this bridge will allow many city networks to continue, it is more of an attraction than a proper connection between two city districts. This makes this option very vulnerable.

This innovative and alternative option is based on the suggestion by Inge Spaander to explore other options. This was discussed on page 68.

	I.	II.	III.	IV.	V.
Typology of a bridge:					
• Bridge the barrier of the river Maas	●●●	●●●	●●●	●●●	●●●
• No other barrier appears with the construction of this bridge (river to city, east to west)	●●●	●●●	●●○	●●○	●○○
• Integrated composition of form, construction, programme and connection	●●○	●●○	●○○	●○○	●●●
Technical principles:					
• Harbour operations should be possible	○○○	●●○	●●○	●●○	●●●
• Bike-oriented design (slope, no detours)	●●●	○○○	●●○	●●●	●○○
• Flexible over time for modalities, because of the durability of the network (durability)	●○○	●●●	●●○	●●○	●○○
Form:					
• Complete the rhythm of Rotterdam and its bridges	●○○	●●○	●○○	●●○	●●○
• Not more icon than the Erasmusbrug, this means not higher or bigger, keep it clean but relate to the image of the harbour city	●●○	●○○	●○○	●●○	○○○
Local neighbourhoods:					
• Connect historical centres of Delfshaven and Oud-Charlois to each other					
• Relation between historical centre and the Maas over barriers of dikes and roads					
• North and South are equal					
• Developments related to the bridge					
• Quality of the design of the shore					

Fig. 53. Concept assessment

ASSESSMENT OF CONCEPTS

In Fig. 53 the previous concepts are assessed on the design principles. By scoring the principles, the best concept is chosen over the other ones. The local neighbourhood-principles are left open blanc. These aspects are not influenced by the slope and height of the bridge and form separate design assignments for each of the concepts. For all concepts, these principles should be included in the design of the bridge in its urban context. These principles are not influencing the decision making.

The most favourable concept is the one with the higher quays (concept IV). The design will be based on this concept and developed further into a complete design of a bridge, landing.

Challenge for this concept is the composition of form, construction, programme and traffic. By starting to develop all aspects from the start, the bridge will become an integrated object.

Important for the integration in the city is the connection from east to west over the shoreline. A public route can bring quality for the relation between the city and the river.

Fig. 54. Birds eye view on the bridge and its landings >

THE DESIGN

THE BRIDGE
Construction

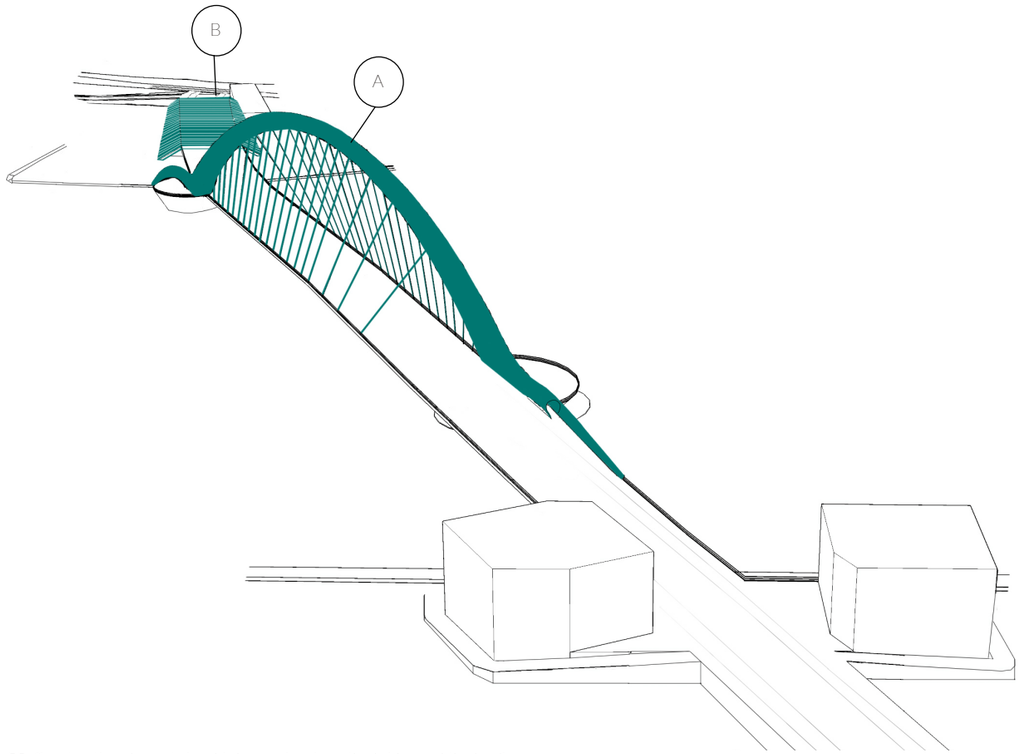


Fig. 55. Constructive elements in a birds eye view from the bridge and the landing

Because of the dimensions of the bridge, the design is based on a constructive principle. In this way, the construction is present in the design process from the start. The architectural form of the bridge will be an adapted version of a construction principle and the dimensioning of the bridge can be based on this.

A. Arch bridge

Out of many principles, a combination of an arch and suspension bridge is chosen. Cables are attached to an arch form over the bridge and connected to the paved deck. With this construction, it is possible to have a small number of supports in the water. This takes into account the desired harbour operations.

An arch bridge is chosen over other principles, in order to complete the rhythm of shore connections over the river Maas. Besides the completion of the rhythm of Rotterdam, a combination of these bridges is perfectly suited for urban programme. This constructive principle is shaping many opportunities for locating a variation of programme on different locations on and along the bridge. This is further elaborated on page 88. The combination of construction and urban programme fits with the legacy of the new typology of a composition.

The construction, adaptation and dimensioning of the arch are presented in Fig. 57, Fig. 58, Fig. 59 and Fig. 60.

B. Beam construction

The second constructive principle is used on the landing on the north shore. The beams are a reflection of the form of the dike, to which this element is connected. The beams are also inspired from the harbour and its cranes. The industrial forms are returning in the architectural design of the location under the bridge, which can be used for different urban programmes, as presented on page 88. The beams are forming the lift on the quay, as was assigned by the concept for the design in Assessment of concepts on page 81.

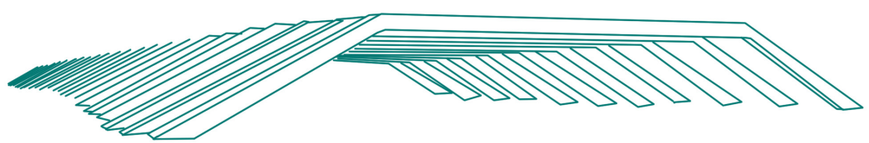


Fig. 56. Beam construction (B)

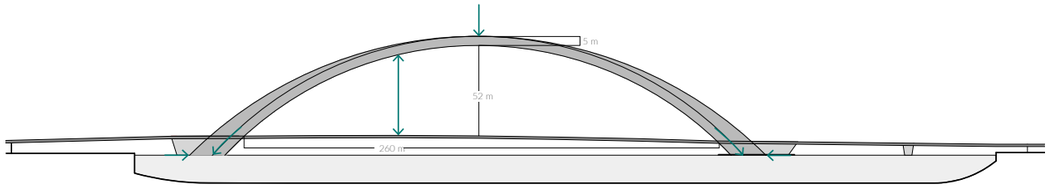


Fig. 57. View on the bridge: dimensions of the arch

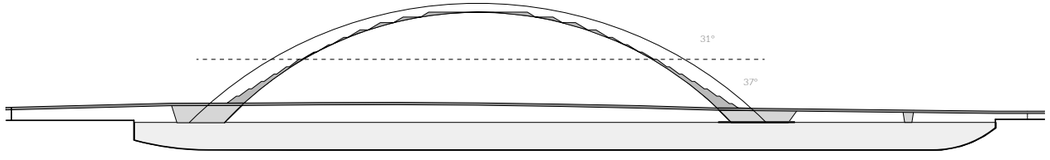


Fig. 58. View on the bridge: public stairs

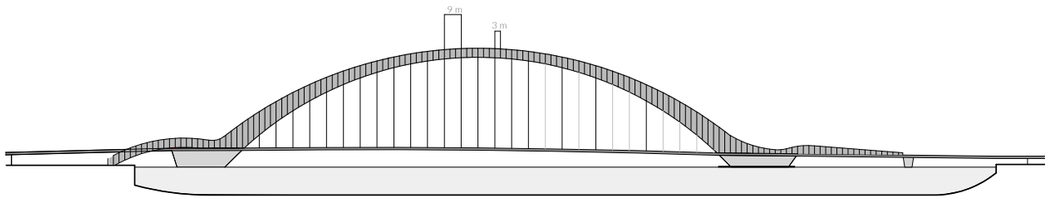


Fig. 59. View on the bridge. cables

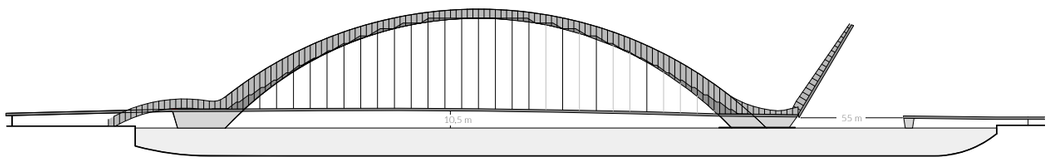


Fig. 60. View on the bridge. bascule bridge for boats

Dimensions of the arch

Since the starting point of the design is the constructive principle, the form of the bridge is determined by the desired form of the construction. The span length is set on 260 metres, as was determined by the width of the river and the necessity of a bascule bridge. This bascule bridge is a moveable part where large boats can cross.

The span length determines the height of the arch by the formula: *' height of the arch = span length / 5'*. From this equation, the ideal height of 52 metres is derived. This height is needed to transfer forces in an optimal way. When the arch is not high enough, it will work as a beam. In this way, there is no benefit from the light construction which is possible in this constructive principle. An arch will use only 25% of the materials used for a beam construction on the same span length (Nijsse, 2012, p. 31).

Foundation on both sides of the arch is needed to balance the forces and prevent the bridge from collapsing. These foundations are used for programme. This is visible in number D on page 88.

Public stairs

The arch is used as part of the programme, as is visible in number C on page 88. To be able to reach the top of the arch, public stairs are constructed. The angle of these stairs is determining the form of the arch: stairs can not be to steep to be accessible and the arch should be high enough to not bump our heads. The maximal slope of a public stair is 31°. To complete the stair within the arch, the stairs at the bottom have a slope of 37°. This slope is at the border of private and semi-public and is well accessible (Motmans, 2016).

Cables

To hang the paved deck on the arch cables are attached in between them. These cables are attached to rings, which are forming the mass of the arch. The arch stands diagonally on the deck. Cables are attached per half and continue in a less dense proportion. The mass and form of the arch continues with its form on both sides into a smooth shape.

Bascule bridge for boats

The south part of the bridge can be opened to allow larger boats to cross the bridge and sail into the city. The bascule bridge is 55 metres wide. This is about 4,5 metres more than the Erasmusbrug. When the bridge opens, the mass of the arch continue in a smooth way up.

Urban programme

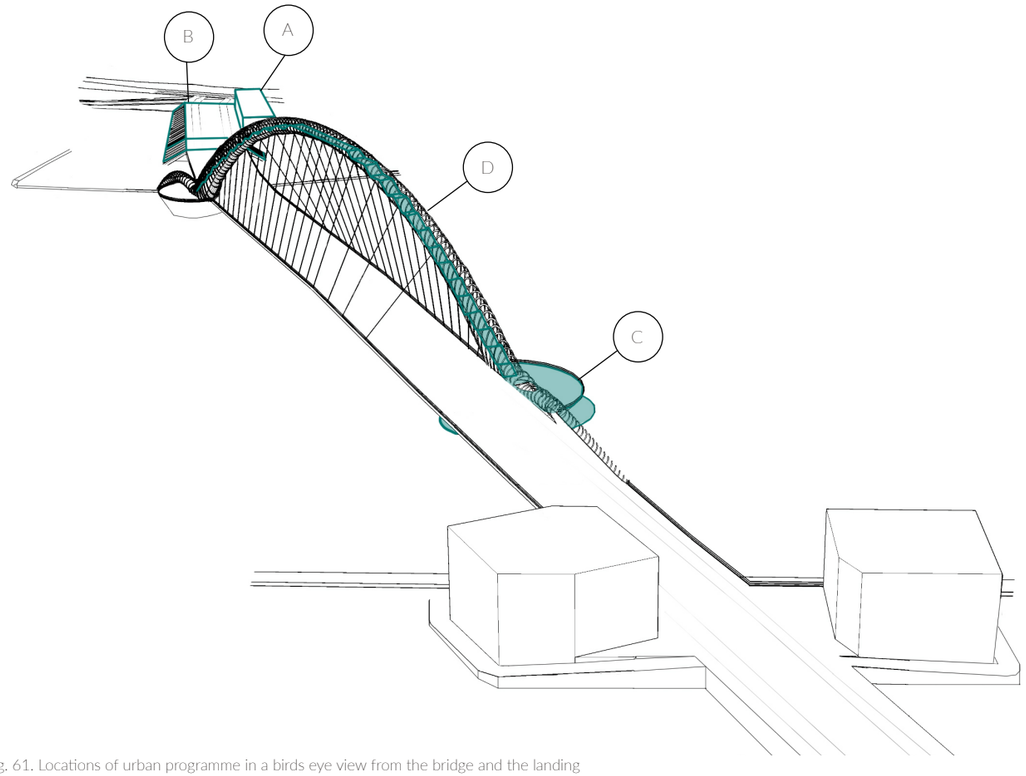


Fig. 61. Locations of urban programme in a birds eye view from the bridge and the landing

The constructive principle as assigned has multiple options for the positioning of the urban programme to complete the composition. The programme can be located on the arch, in the arch, under the arch and along the arch or bridge.

To locate a variation of programme on the bridge, a combination of principles is used. Different programmes are assigned to different positions on the bridge. This fits the principle of local programmes on the bridge, as was determined in Programme on page 55. This means that there are different locations with different kinds of programme along the length of the bridge. Per location, a specific kind of programme fits best. These matches are explained on the following pages.

Fig. 62. Progamme principle from the research to programme on bridges

Fig. 63. Street along the bridge

A. Street

Based on the different examples of so-called 'Living bridges', this programme is made. A building on the side of the landing of the bridge forms a street with a view towards the historical mill of Delfshaven.

The local character of the bridge, allows people to live in this highly accessible building. On the lower level of the building, there is room for some shops and restaurants to open their doors connected to the access route to the bridge.

Besides programme, this building is also a 'bridge' for the height difference of the land level and the level of the bridge. With access on both levels, this building is connecting the bridge to its direct surrounding on a different level.

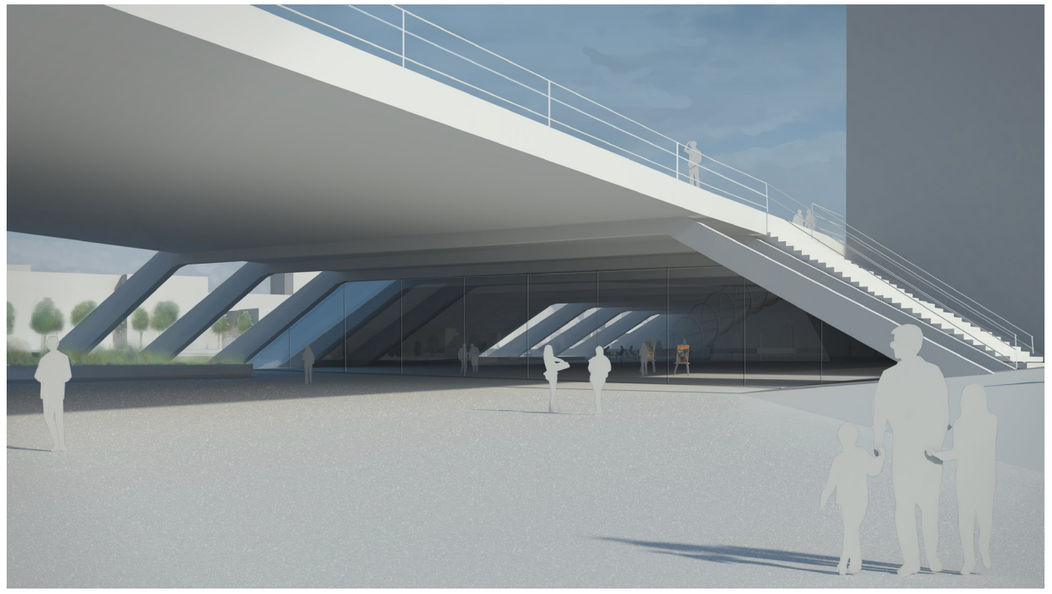


Fig. 64. Activities under the bridge

B. Under the bridge

The southern neighbourhood (Oud-Charlois) has a tradition of creativity, artists and community. To bring these qualities to the northern districts, a flexible studio is designed under the bridge between the constructive beams. This studio can be used for several temporary functions. Artists can use the space as atelier or exposition space or musicians can rehearse their set of their performance later in this studio. The combination of good accessibility from both shores and the flexible programme, can result in an area with programme for both shores of the river.

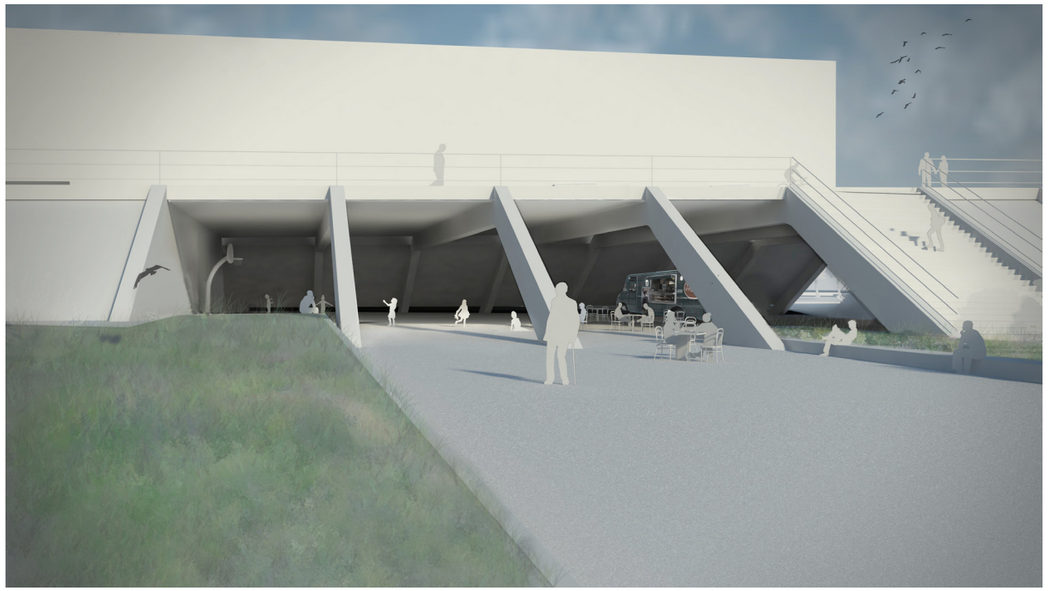


Fig. 66. Activities under the bridge. View from the Urban Garden

B. Under the bridge

Besides a studio, the area under the bridge can be used for other functions as well. The area can be used for sports, which is an additional function to the conclusion of the programme-research. In this area, also a pop-up restaurant can appear with a relation to the urban garden (Masterplan). The area which is to low to sport in, can be used for parking for the development area on the east side of the bridge.

Fig. 65. Indoor sport in Brooklyn Bridge Park, New York (Michael van Valkenburgh Associated INC., n.d.)

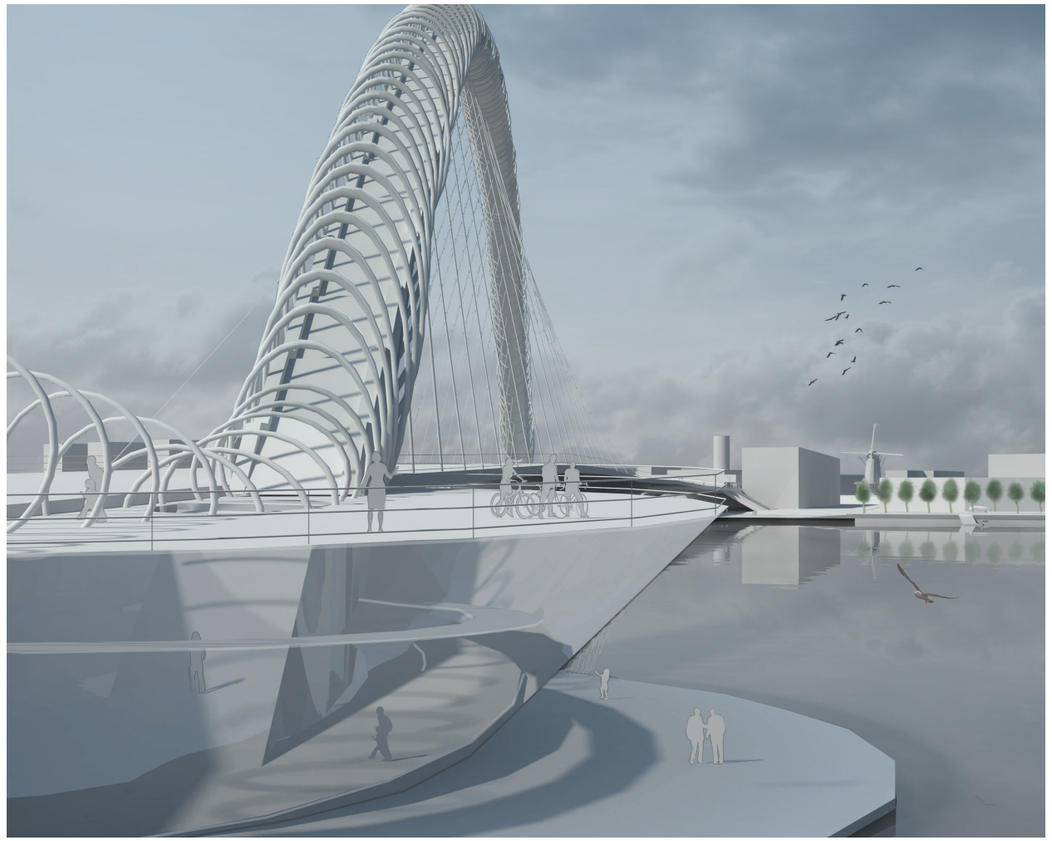


Fig. 67. Impression of the island and deck

C. Deck

An island is formed on the crossing of multiple routes. It is the location where the construction meets the connecting element of the bridge and meeting is facilitated on this widening of the section of the bridge.

Down the support of the bridge, there is a lower island, related to the water. The support of the bridge is a transparent cone-formed element with a surrounding slope moving down to the water. From a terrace on the water, a unique view is created over the water.

The island is inspired on the historical sandbank, which was formed by the harbour of Delfshaven in the Maas. It was named Ruygplaat. Other islands in the Maas are the Noordereiland and the island under the Van Brienenoordbrug.

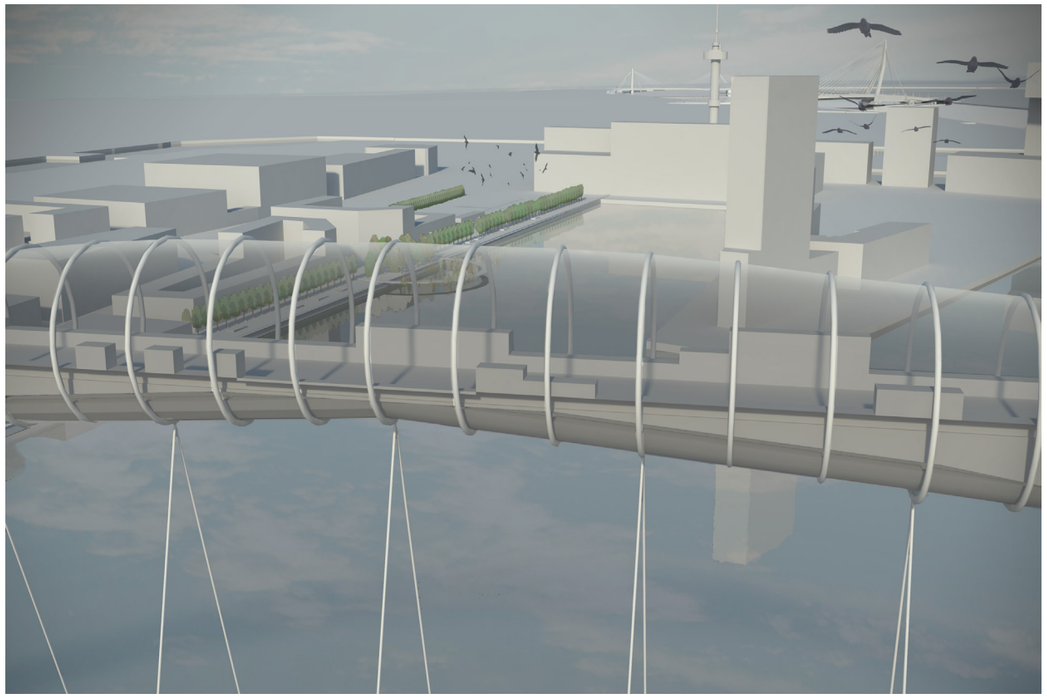


Fig. 68. Impression of the top of viewpoint

D. View

The arch forms a combination of the construction and a unique urban programme. Via a stair in the transparent arch, visitors are invited to climb the bridge. The climb is about 52 metres and offers access to a view point on the edge of the harbour and the city. The highest part of the bridge is a tube of about 50 metres, inspired on the Oceanium in the zoo of Rotterdam: Blijdorp. Masses on the sides of the tube forming benches and tables where people can rest and enjoy the view over the Maas.

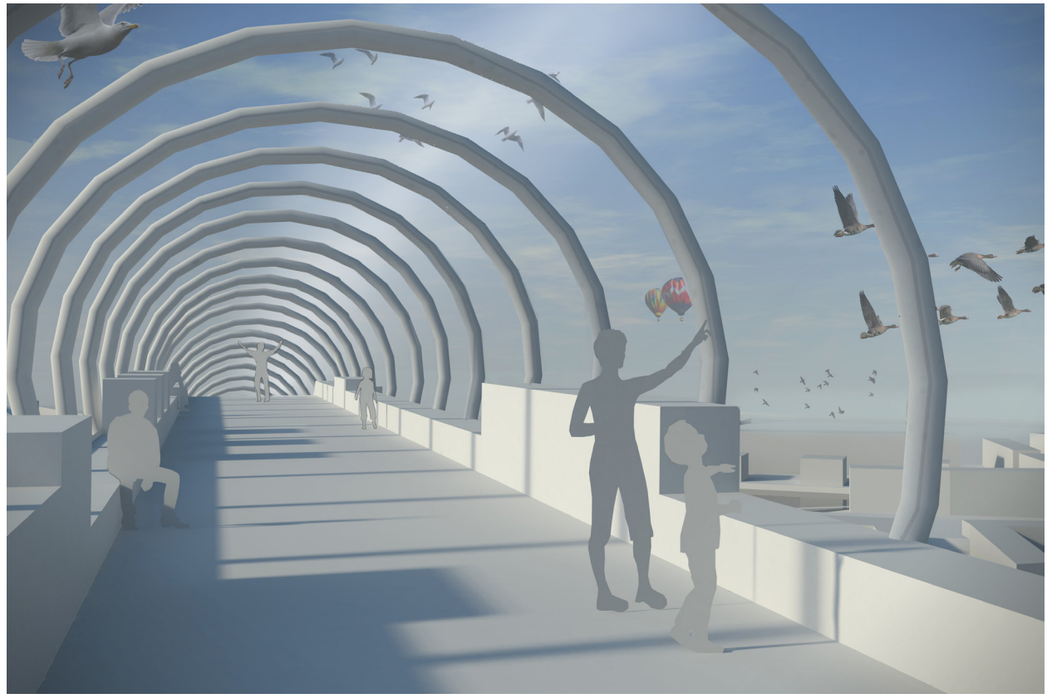


Fig. 69. View

Fig. 70. Oceanium in Blijdorp, Rotterdam (Van der Wel, n.d.)

Connectivity

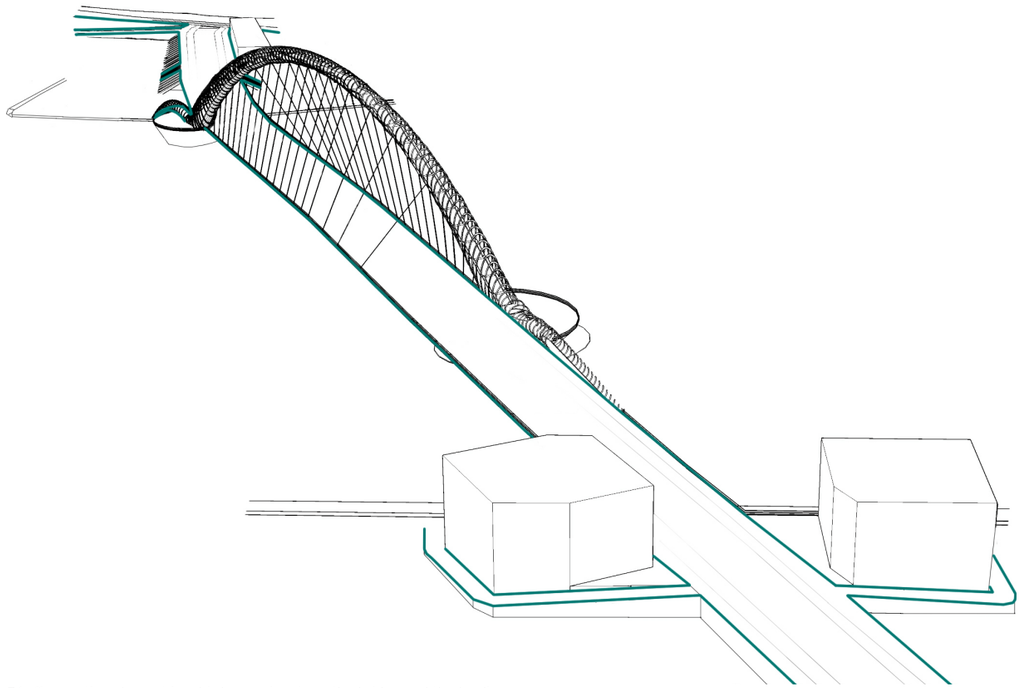


Fig. 71. Connective element in a birds eye view from the bridge and the landing

Different modalities do have different requirements for the connective element of the bridge. In Fig. 72, different modalities on the bridge are presented.

For slow traffic: pedestrians and cyclists, multiple access routes are available. From each direction, they can easily access the bridge to cross the river. On the north shore, multiple stairs are added to climb the dike structure made out of beams. There is also a connection to the city network on the Westzeedijk and a connection to the neighbourhoods of Delfshaven and Schiemond. On the south shore, slopes are created to connect the lower east - west route along the water to the bridge. The slopes are surrounding two buildings. These buildings will be the highest buildings on the pier and are marking the landing of the bridge. Another access route is combined with the access route for trams and cars and is moving towards Oud-Charlois.

The tram over the bridge is connected to the existing network over the dike in the north side of the bridge. There is a direct connection between the dike and the bridge for trams. The cars need to exit the dike road at a local exit for the neighbourhood of Schiemond. Via a road on the edge of this neighbourhood, the cars can access the bridge.

The different modes are combined on one connective element between the two shores. Because there is a combined section for all modalities, the layout of the section can be adapted for future mobility demands.

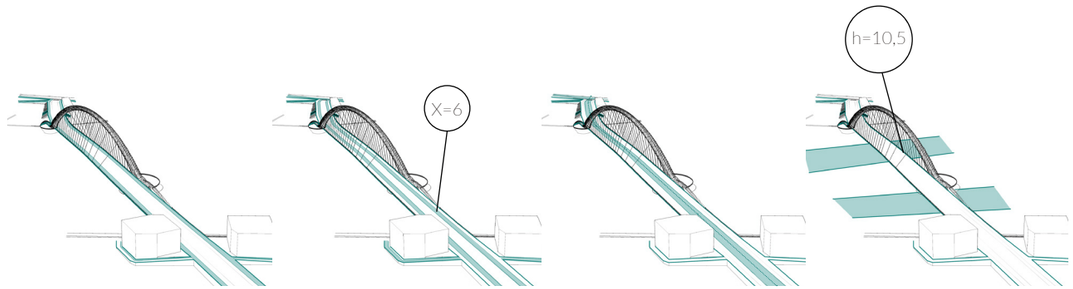


Fig. 72. Connectivity on bridge per mode, from left to right: Pedestrians, cyclists, cars & trams, boats

Composition

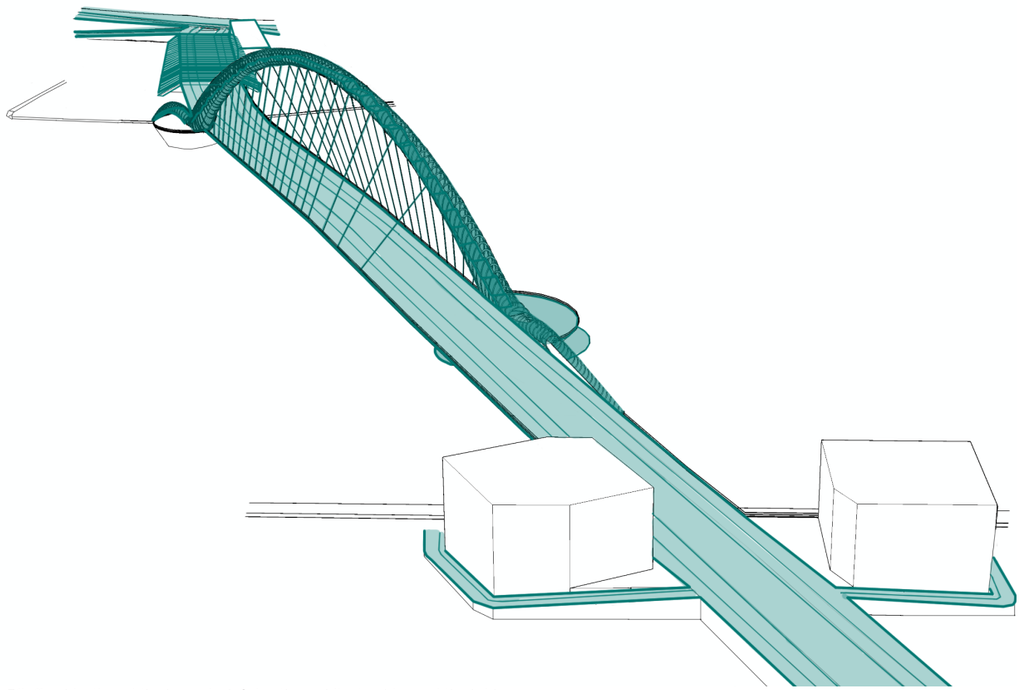


Fig. 73. Combination of the layers is defining the architectural form of the bridge

The new typology of the appearance of bridges was defined as the combination of the city and the urban programme, the architectural form, the construction and a connective element. These aspects form an integrated composition in the urban context of Rotterdam.

The new city bridge is a composition of a constructive principle, which is adapted to a specific architectural form, different urban programmes and a connective element. Fig. 73 is a combination of the themes of mobility (connection), construction and programme. When overlaying these themes, the bridge is completely coloured. All aspects are covered in the explanation of the themes and the bridge forms a composition of all these elements. This makes the bridge an example of a bridge in the new typology.

But, a bridge is more than a phenomenon or object. It is related to its context and results in developments.

In the following part, the bridge is seen as element in a bigger part of the city. First the masterplan of area is explored. Second, this masterplan is projected in the spin-off developments of the related surroundings. These spin-off developments will happen over time and are explained by the phasing. Finally, the project is seen in the bigger scale of the city.

This zoom out is a further elaboration of the meaning of *a bridge is more...*

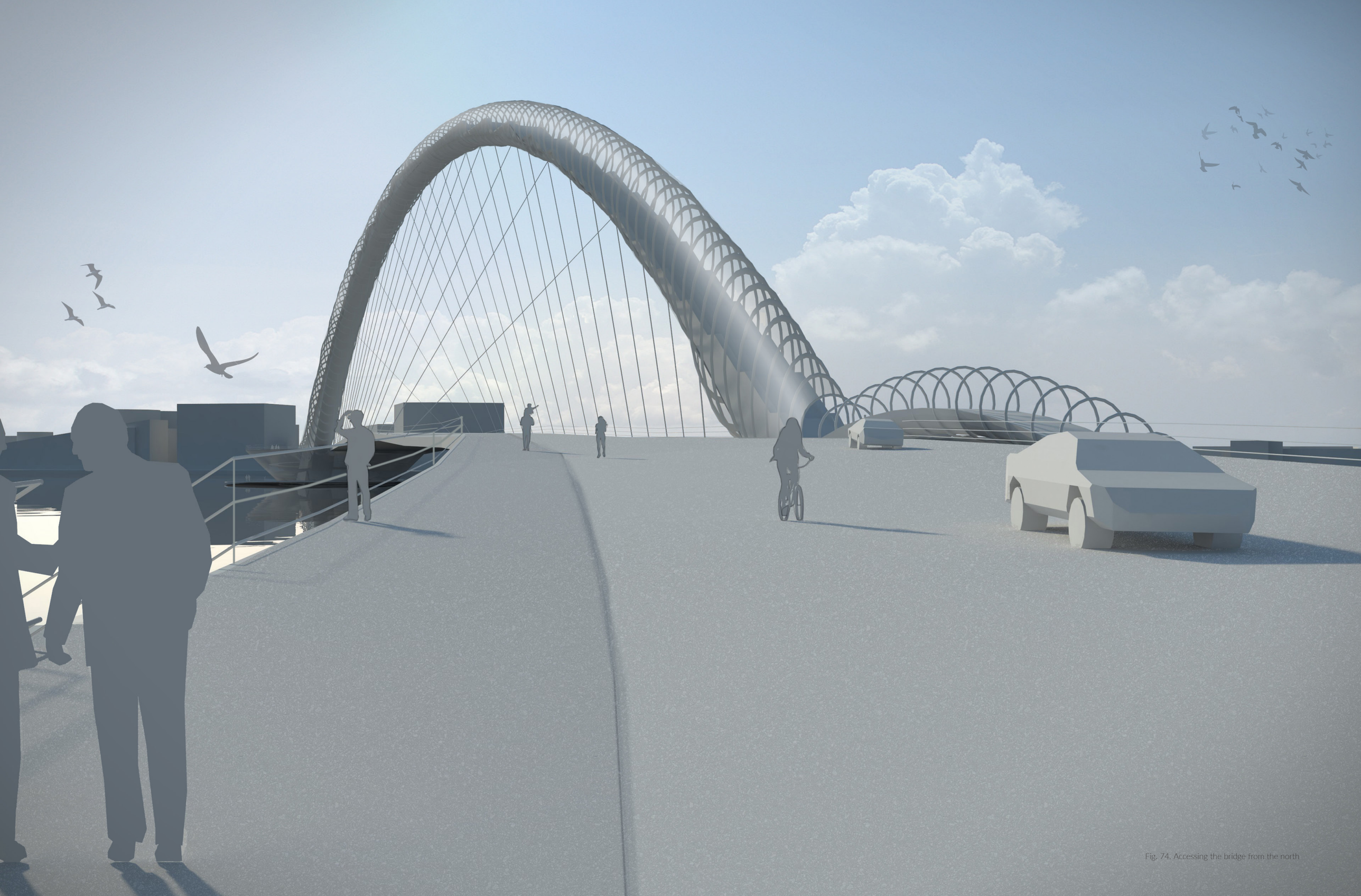


Fig. 74. Accessing the bridge from the north

MASTERPLAN

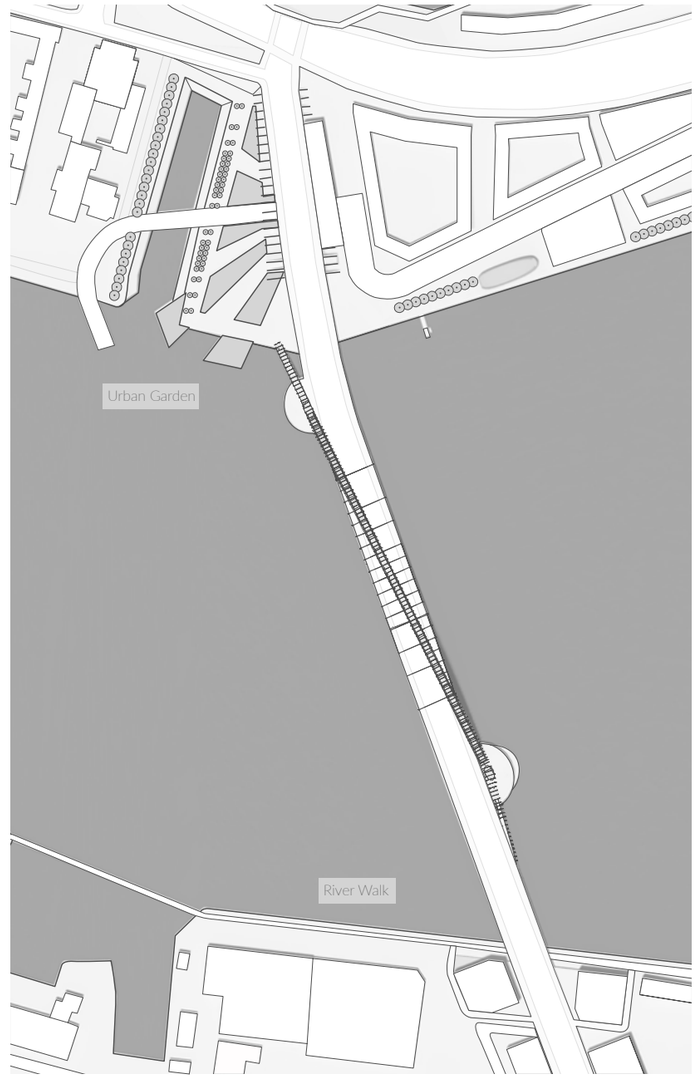


Fig. 75. Masterplan: the bridge and its landings

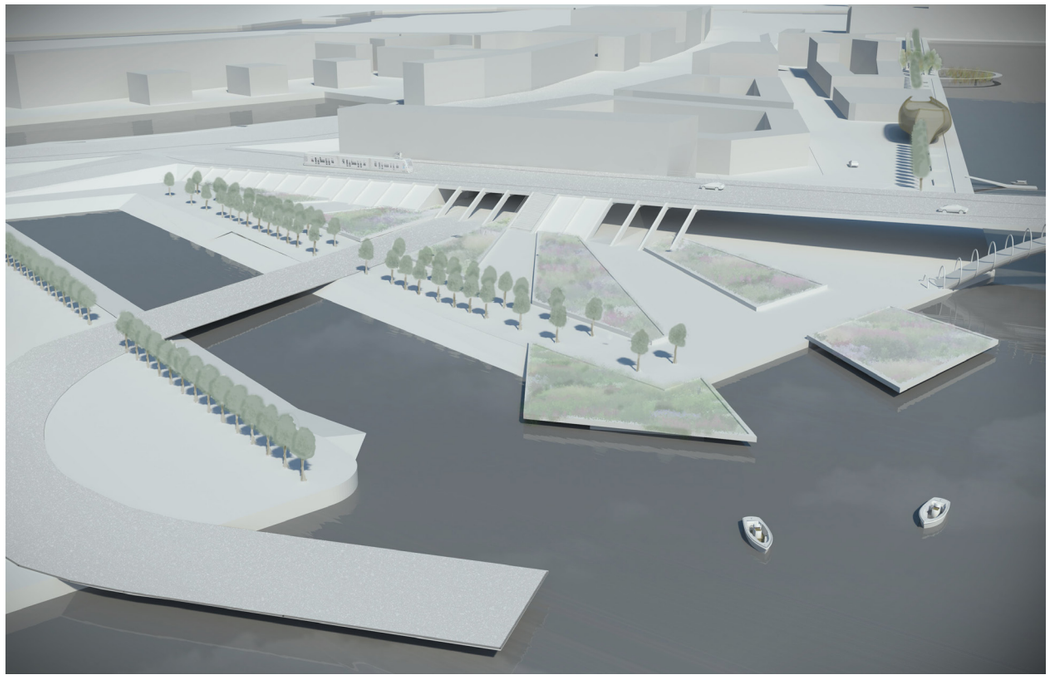


Fig. 77. View on the Urban Garden at the north shore

Urban Garden

The area between the landing of the bridge, the programme under the bridge and the old harbour mouth, is transformed into an urban park. The Westerkade and the Leuvenhoofd are designed by Piet Oudolf. This atmosphere is a returning element along the Maas and this new public space along the water and related to tbe bridge will continue this design. By stabbing the elements through the beams of the dike, the urban garden is connected to the programme under the bridge. The design, programme related to the bridge and elements will invite people to ***stay*** for a longer period of time in this area.

Fig. 76. Leuvehoofd Park by Piet Oudolf (JesperB_nl, 2014)

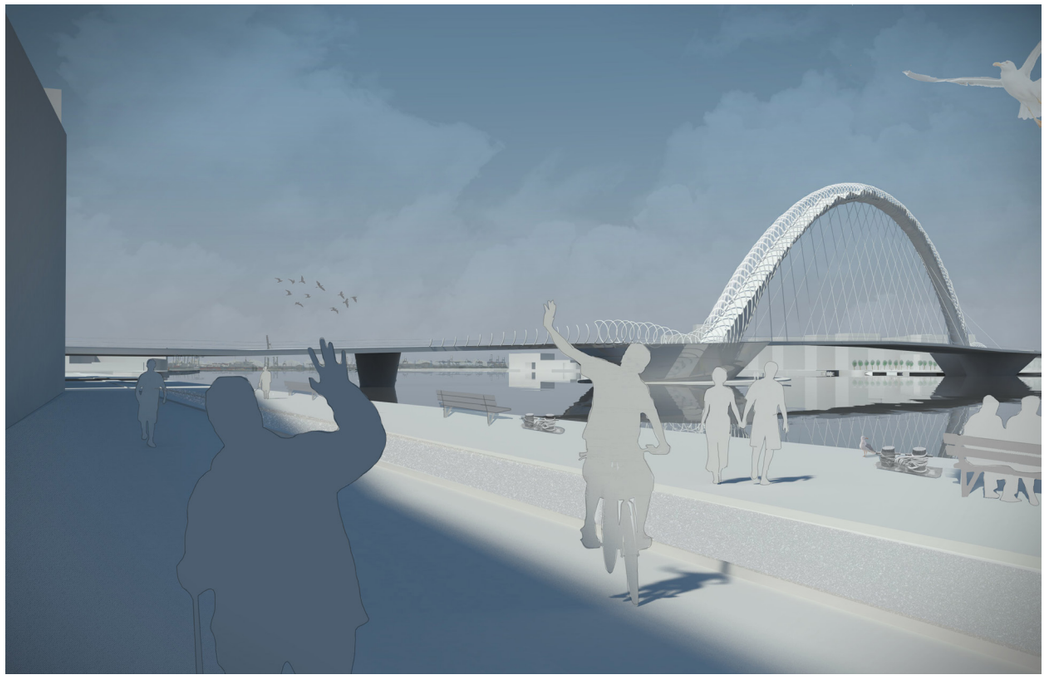


Fig. 78. Impression of the River Walk on the south shore

River Walk

The connection on the south part of the bridge has an east west connection going under the bridge. The landing of the bridge is marked by two high buildings, which have slopes around it to go from the deck to the connective route. This route is designed as an area to go and not to stay for a longer time. In the second phase of the spin off developments on the pier, this river walk is connected to the network of the city.

The river walk differs from the urban garden. Except for some elements where people can rest, the path is designed as a route to ***go***, and for a longer stay. The walk will be in the shadow of the developments, since it is located at the north side of the pier. This makes the area less attractive to stay for a longer period of time. Because of this, it is more attractive for walks and bike tours.

SPIN-OFF DEVELOPMENTS
On the south shore

The pier of Sluisesdijk is directly influenced by the landing of a new shore connection. The current functions on this pier are based on harbour and maritime related industries, services and garages. With the landing of a new shore connection, this pier gets highly accessible by multiple modes and a movement of the city westwards is facilitated. The dynamic city is pressuring on the functions in this transition area. The area is functioning as a transition between the harbour and the city. With the opening of a bridge and an improved accessibility, the city will develop towards this pier.

This redevelopment from harbour to a city environment will happen in different phases. In the first phase, the accessibility is improved. Along the access-route, some businesses will develop. The second phase exists of the construction of a public accessible shore along the Maas. The third phase is enclosed by the developments of the first phase and the pushing city on the east. The last phase is the completion of the redevelopment of the former transition pier. The end of the pier has both qualities of being highly accessible, but not being part of the access route or the city network. Because of this reason, only destination traffic will enter this last area.

Different phases will develop areas with different characteristics and qualities. The characteristics are explained per phase in the upcoming part of this report.

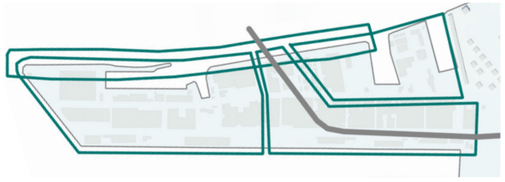


Fig. 79. Structure of phasing on Sluisjesdijk-pier

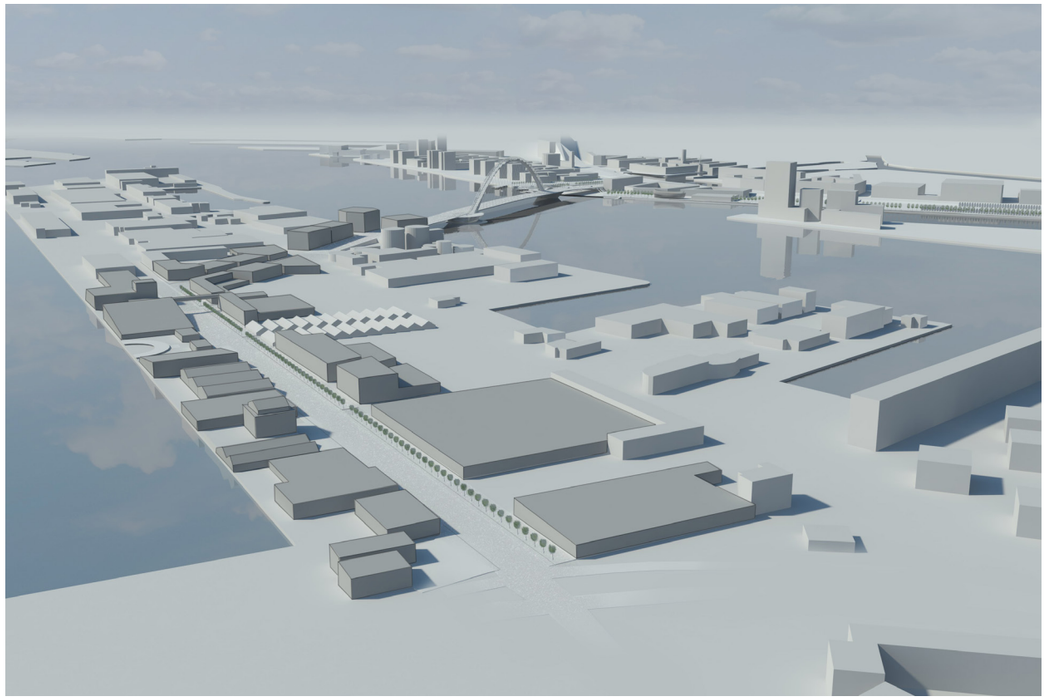


Fig. 80. The developments of phase 1 on the pier

Phase 1: Harbour quarter

Het haven-kwartier

During the first phase, the harbour quarter will be developed. These developments are defining the access route to the bridge and will form an axis of employment.

The developments are inspired by the interview with Inge Spaander. She suggested a 'makers-space' as a connection between the education and knowledge at the RDM campus, the local initiatives of Oud-Charlois and Delfshaven. The axis includes a mix of functions in this makers-space. For example, both offices and garages can be included in this area. New businesses can move to the area, but there will be room enough for businesses from the pier who want to relocate to this harbour quarter at the Sluisjesdijk. The area is not suited for residential developments, because of the hindrance of the harbour on the west and industries which are still located at the pier.

For the development of this area, it is important to not only focus on the access route to the bridge. It is important to create some secondary and perpendicular routes. These routes are connected to the development in the third phase and to the water of the Waalhaven. These routes are connecting the river, the city and the harbour with each other.

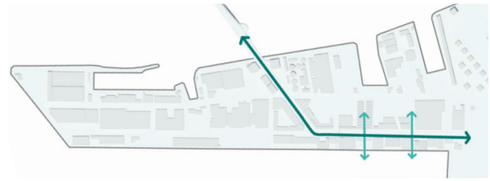


Fig. 81. Structure phase 1

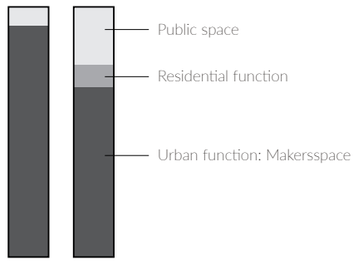


Fig. 82. Programme of phase 1 (right) to the existing situation (left)

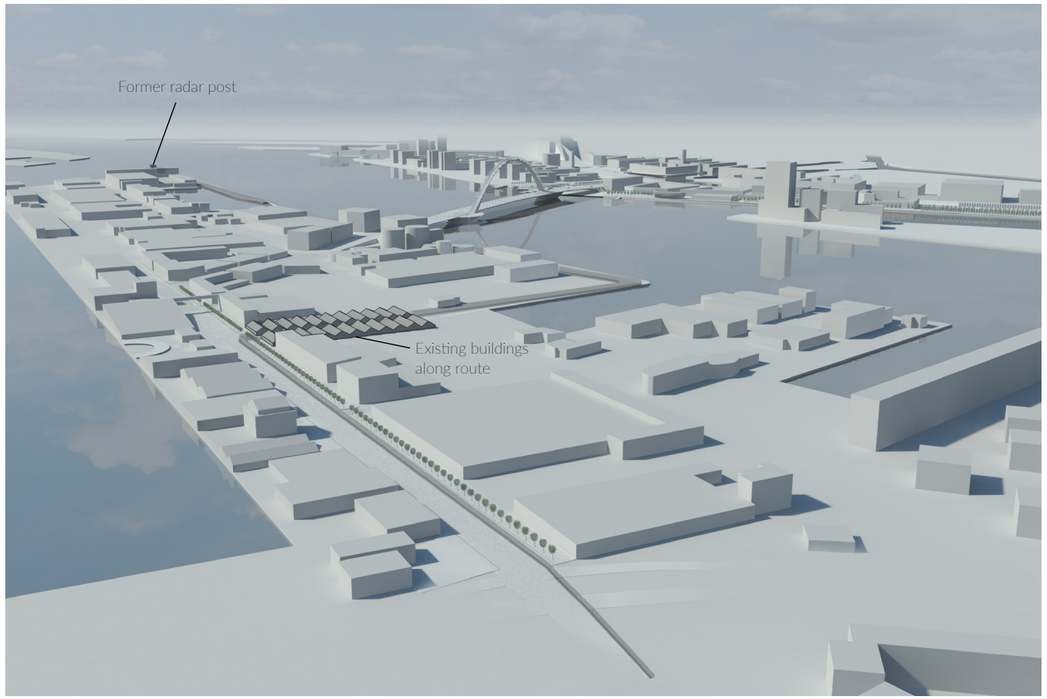


Fig. 83. The route of phase 2 over the pier

Phase 2: River quarter

Het rivier-kwartier

During the second phase, a public route is constructed along the shore of the Maas. This route is leading to the former radar post of the harbour, on the edge of the pier. This former radar post used to be the house of Riek Bakker. She has been very important for the construction of the Erasmusbrug. By connecting the new bridge with a public route to this building, a unique endpoint is created. The radar post can function as a viewpoint to the developments in the harbour and on the river, as a reference to its historical function. The radar post is also a symbol for the development of bridges and its shore connections in Rotterdam. The route is connected to the River walk (page 105) and to Oud-Charlois (page 121).

There are no related new buildings to this route. The route is connected to the access route of the bridge via a small street in between of existing buildings of the harbour. These buildings can be transformed in relation to both the first, and the third phase. These buildings can host functions related to the makers-space or to a residential area. The route through this street, ends in a public space on the waterfront on the south side of the pier.

Fig. 84. Existing buildings along connection between the public walk along the water and the access route of the bridge (Google Maps, 2014)

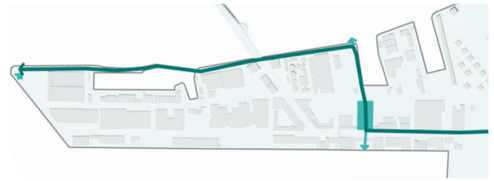


Fig. 85. Structure phase 2

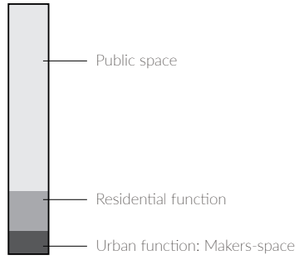


Fig. 86. Programme

Fig. 87. Former radar post and former resident of Riek Bakker (Van Damme, 2008)

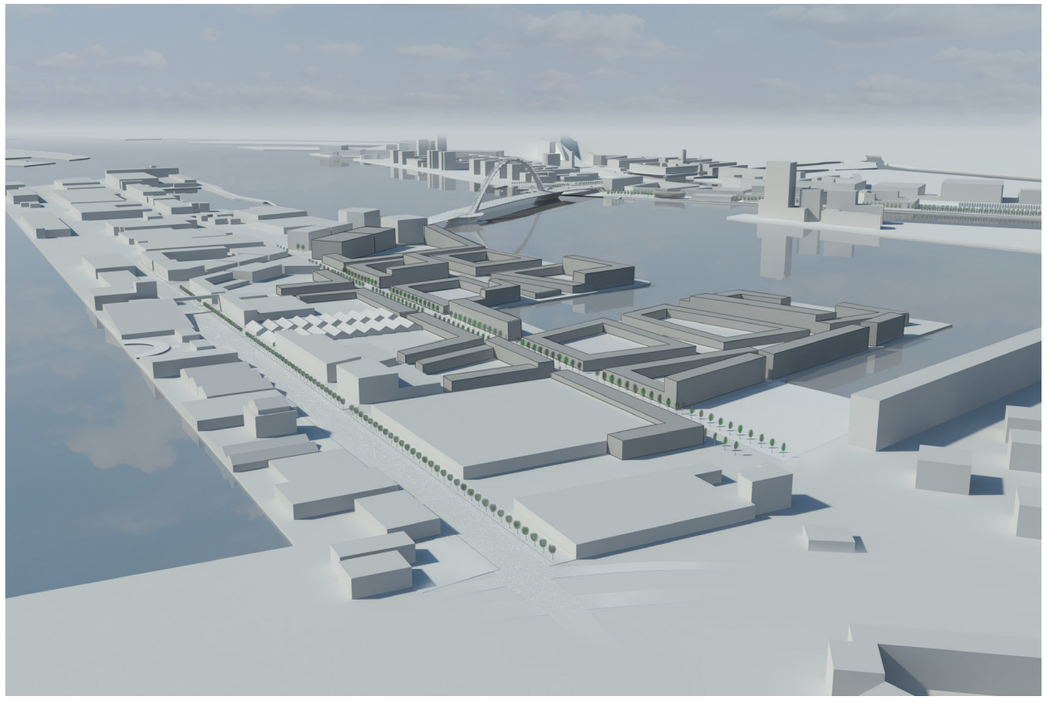


Fig. 88. The city growing over the harbour in phase 3

Phase 3: City quarter

Het stads-kwartier

The development of the bridge created an improved accessibility for the complete pier. The growth of the population has been pressuring the harbour. By the completion of the bridge, expected movements of the harbour and the development of techniques makes it possible to transform the enclosed area into a residential area. The structure is based on Delfshaven and Oud-Charlois. Closed building blocks are forming communities with their own space per block. The different sizes of the blocks will give different qualities to these inner areas and so attract a divers population.

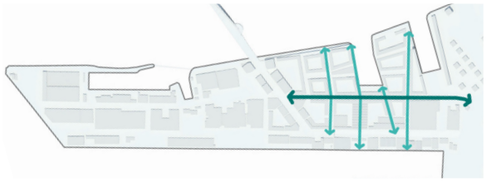


Fig. 89. Structure phase 3

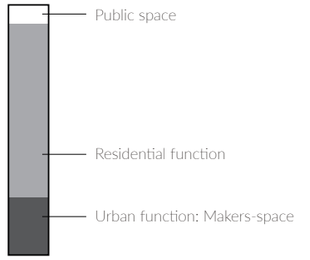


Fig. 90. Programme

Fig. 91. Birds eye view of Delfshaven (Apple maps, 2016)

Phase 4: Pier quarter

Het pier-kwartier

The more time passed, the more insecure the conditions for future developments are. For this fourth phase, different scenarios are possible.

Scenario 1: Village

The development of a harbour village is taking the most advantage of the quality of the location. It is benefitting from the accessibility, but also of the dead end as is created by the positioning of the bridge. Rotterdam has a tradition of villages, surrounded by the harbour. To build a village on the end of the pier, the area will be connected with the developments of the third phase. The harbour village is less dense and a strong community. Rotterdam has multiple harbour villages, which are presented in Fig. 92. From this image, it is clear that the Sluisjesdijk-village is about the same scale as existing villages.

Scenario 2: Mixed developments

To construct a harbour village, the harbour has to change. At this moment, the end of the pier is influenced by noise and safety issues caused by the harbour. When the harbour is not changing or moving, living at this location will not be possible. In this scenario, the end of the pier is developed into a continuation of the harbour-quarter as makers-space with a mix of functions. This development can be compared to the Kop van Zuid, which is a former harbour area. The area is redeveloped by the influence of the landing of the Erasmusbrug. The size of both piers is about the same. A comparison of size is presented Fig. 45 on page 71.

Scenario 3: Cruise terminal

Another scenario includes the movement of the cruise terminal. Cruise ships are not able to cross the bridge and this result in a forced relocation of the terminal. Among other options, it is possible to locate the terminal at the end of the pier. This will stimulate traffic over the bridge and investments in the public space. The quality of being a dead end is lost in this scenario, but urban development is stimulated. The movement of the cruise terminal is also described in the CIty scale on page 123.

Scenario 4: Zero developments

Doing nothing will possibly result in investments by investors and entrepreneurs themselves. The investments will improve the quality of the public space, but will not benefit from the changes on the pier by the landing of a new shore connection.

The decision for the development will be made based on the developments of both the harbour and the city. The activities in the east part of the Waalhaven are dominant for the possibility to built a residential area on this location. The noise produced by the activities on this location is higher than allowed for this type of function. According to the developments in this part, a residential development on this location is decided. It also depends on the demand to live in this kind of locations.

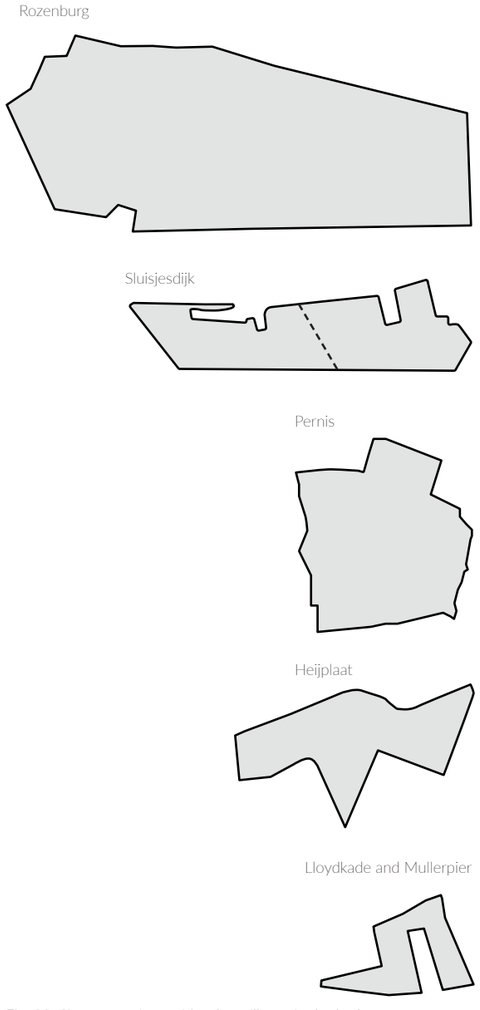


Fig. 92. Size comparison with other villages in the harbour area

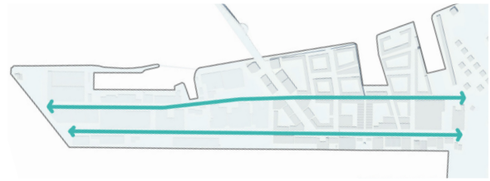


Fig. 93. Position phase 4 with possible relation with phase 3 or phase 1, according to different scenarios

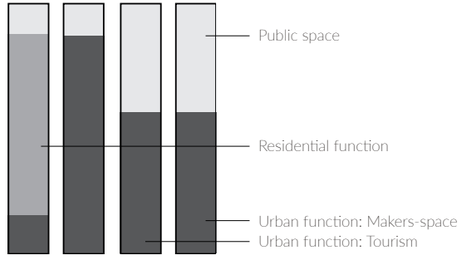


Fig. 94. Programme scenario's. From left to right: scenario 1, 2, 3, 4

Fig. 95. Rozenburg, harbour-village

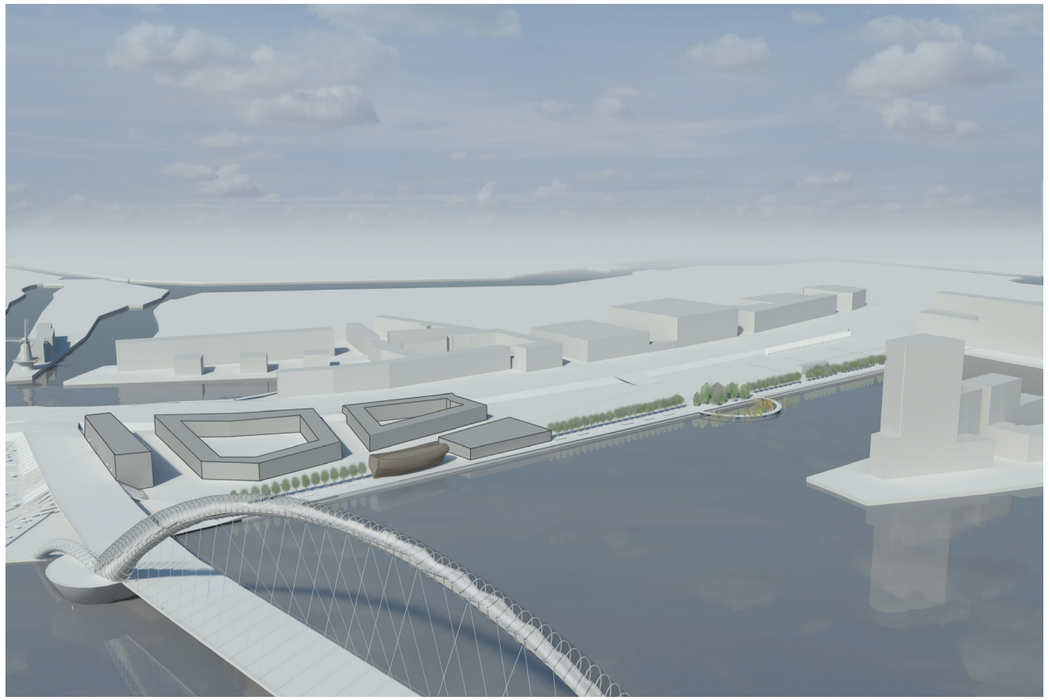


Fig. 96. Phase 1 of the north shore

Phase 1

Also, the north shore will develop, according to the impact of the new city bridge. Along the water, a public route is created to emphasise on the east - west connection. On the centre of this route, a public space is created. This public space is in line with the access route to the dike, and to the neighbourhood on the other side of the dike. By creating this axis from the existing city to the water, a cut off neighbourhood gets a new connection to the water and a relation with the new bridge.

The bridge is positioned near to the location of De Delft. This is a non-profit foundation, which is building a replica of a ship from the 18th century. In the current situation, this ship is placed behind some docks and other industrial buildings. The ship is cut off from the city. The building related to the construction of the ship is located to the side of the ship, to create an open view from the older neighbourhood, over the dike towards the ship and the water. In this way, the ship is an important fringe in the development and connection of the new neighbourhood and a reflection of the former harbour function. In this way, the edge of harbour and city is softened and the relation is emphasised.

The programme of this development is related to the programme in the connected neighbourhood. It forms a continuation of the city towards the Maas.

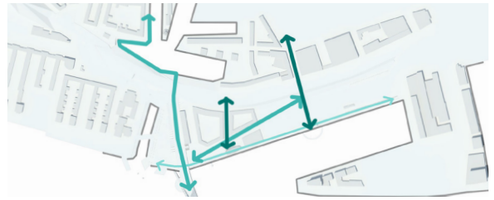


Fig. 97. Structure phase 1

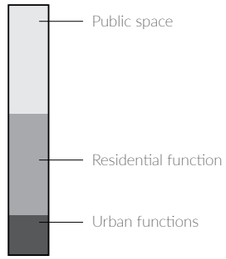


Fig. 98. Programme

Fig. 99. Impression of the replica 'De Delft' (Stichting De Delft, n.d.)

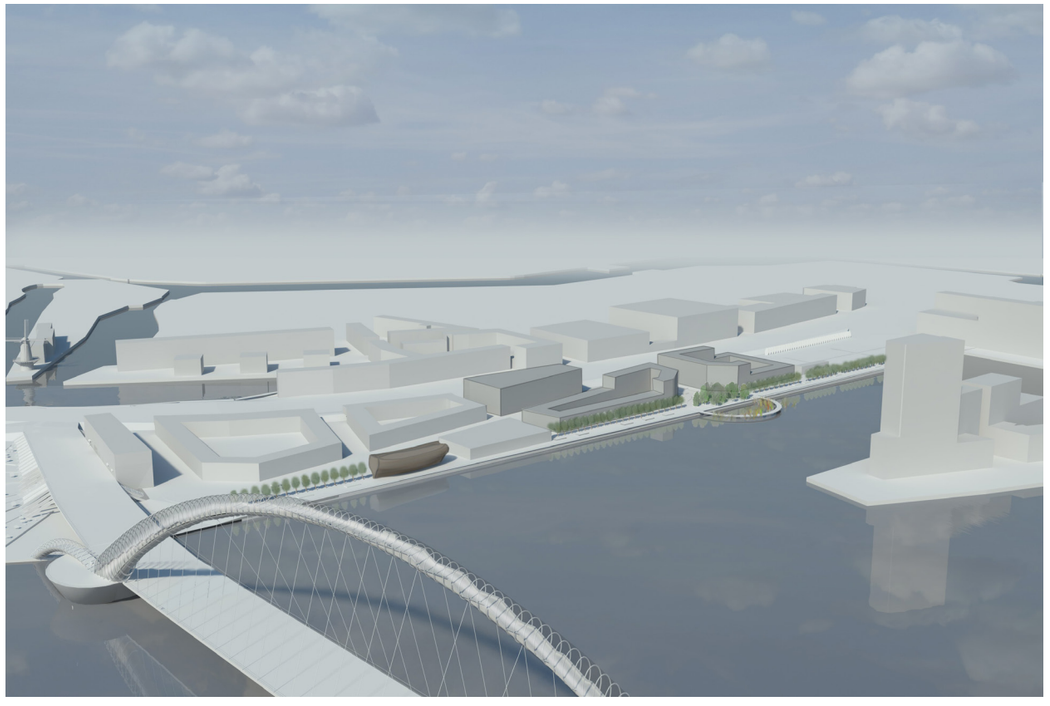


Fig. 100. Phase 2 of the north shore on the former multiplein

Phase 2

Next to the construction site of the wooden ship, is a multi functional square. This square is used for temprary events, driving lessons for motors and an annual fair. The function of this square is not related to the exact location in the city and the water. A relocation of this area brings opportunities for water related developments. The outdoor public sport fields will connect the development and the public route along the water to the indoor sport area under the bridge.

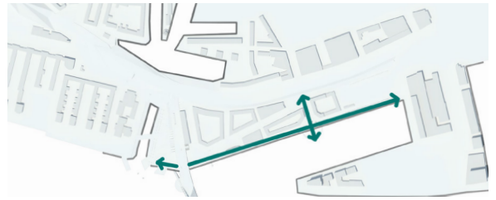


Fig. 101. Structure phase 2

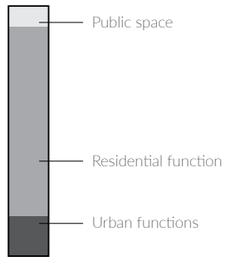


Fig. 102. Programme

Fig. 103. Overview of connections and relations created by the new city bridge

DISTRICT

One of the goals of the design was to reconnect the historical inner cities to the river. With the use of connections over barriers, these relations are made.
The route of the historical centres starts in Delfshaven, goes via the bridge, to the church towards the new leisure park by Hennie Most, as was introduced by Inge Spaander during the interview. By connecting the bridge to the leisure park, new opportunities occur. The local axis can be designed in relation to the park. The park gets well connected to both the north part of the city as the southern districts.

The route can continue towards Katendrecht and towards the Kop van Zuid and so to the city centre of Rotterdam. The route and connections explain the angle in the bridge. It is less efficient to cross the river at an angle. It means more length of a bridge. However, the connection towards the historical centres of Delfshaven and Oud-Charlois are forcing a natural angle in the crossing of the Maas.

The construction of the bridge stimulates development in the direct surrounding, but can also connect other parts of the city to each other, to the harbour and to the river.

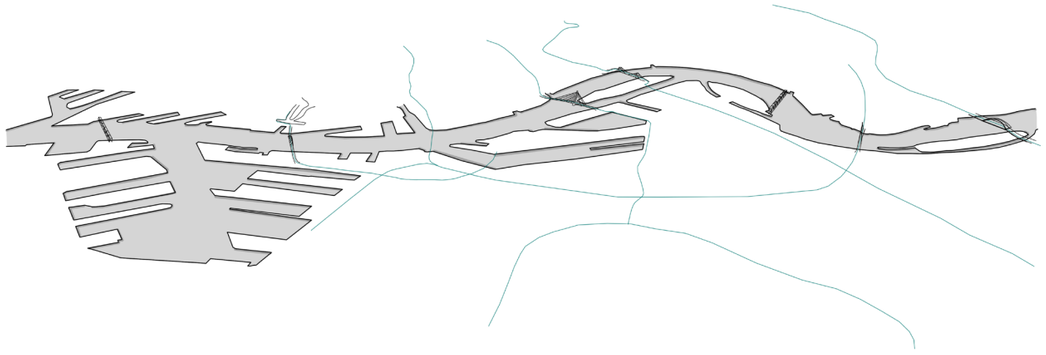


Fig. 104. Rhythm of shore connections and axes in Rotterdam South

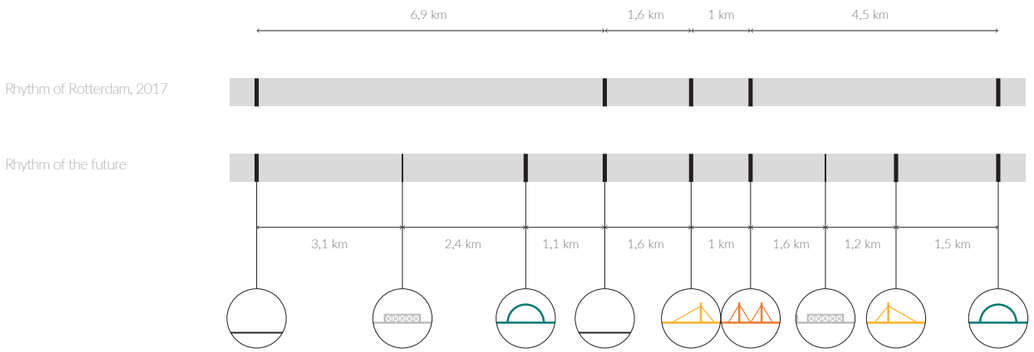


Fig. 105. Rhythm in barcode

CITY SCALE
The Rhythm of the city

The already existing shore connections, combined with the addition of new shores, create a rhythm of shore connections over the river Maas.

The decision for the constructive principle is based on this rhythm. By the decision for an arch construction, the new rhythm of Rotterdam is: arch, single pylon (Erasmusbrug), double pylon (Willemsbrug), single pylon (decision for a new fast shore connection) and an arch (Van Brienenoordbrug). The slow connections will be based on the fact that the constructive requirements for this mode, can be much lighter and thinner. A minimalistic design will let these bridges form a new element in the rhythm of bridges over the river Maas.

Cruise Terminal

The construction of a new bridge will influence the accessibility of the current cruise terminal at the Kop van Zuid by cruise ship. To allow ships to cross, the bridge has a required height of 70 metres and a width of 70 metres. These limits are threatening both the design of the bridge and both the financial feasibility. The relocation of the cruise terminal will bring opportunities for the design of the new bridge. Besides, it will also stimulate the urban development on a new location.

In the past two years, the visits by cruise ships to Rotterdam has increased by 118%. In 2017, 83 ships are expected to visit the city. The current terminal has no capacity to serve two ships at the same time. With over one ship a week visiting Rotterdam, this is the required capacity in the near future. A new terminal will be designed to keep up with expected future growth. Besides the growth, pollution is another reason to move the terminal. The emission of CO2 in 2017 by cruise ships, will be as high as the pollution of 14 times all privately owned cars within the municipality. The current terminal is located on the edge of an environmental zone in which old and polluting cars are banned (ANP, 2016; RTV Rijnmond, 2016).

Even without the construction of a new bridge, the growth of cruise ship tourism and the pollution in the inner city will eventually result in the relocation of the terminal. Multiple locations are suited for the developments related to a new cruise terminal. At this moment, the municipality is researching the relocation to the Merwevierhavens, part of the city-harbour developments. Another option is the relocation of the terminal to the Pier-quarter, as is presented in the fourth phase of the south pier.

Fig. 106. Improvement in public transportation network by two new fast traffic shore connections

Fig. 107. Improvement in car network by two new fast traffic shore connections

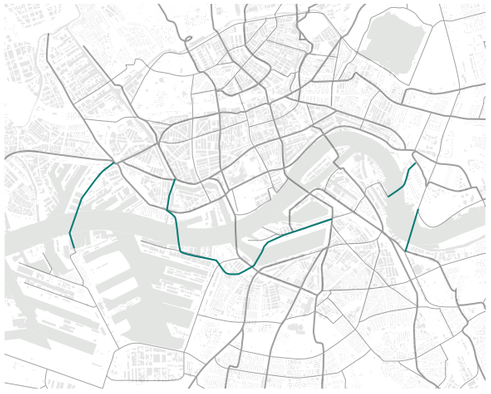


Fig. 108. Improvement in bike network by four new shore connections, both fast and slow network on short and long term

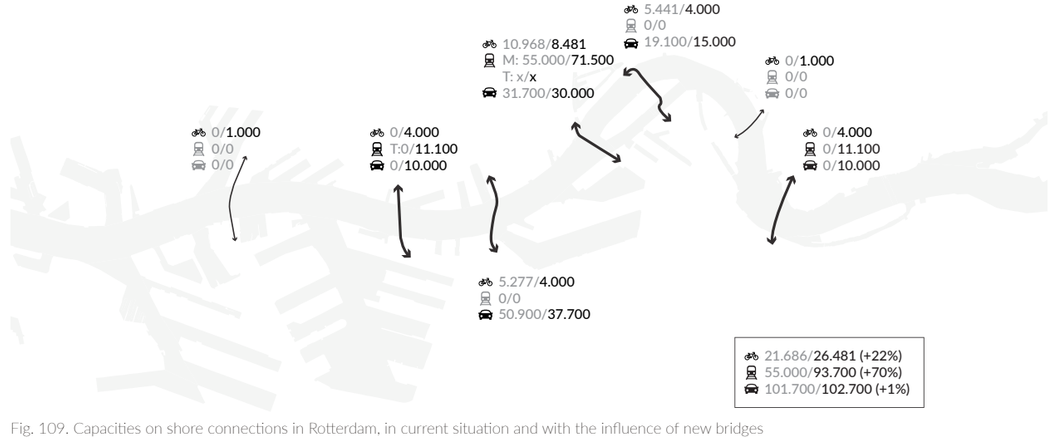


Fig. 109. Capacities on shore connections in Rotterdam, in current situation and with the influence of new bridges

Use of city-networks

Per day, 178.386 people are using shore connections to go to the other side of the river Maas. Caused by a population growth, but also by the development of the southern district, this number is expected to grow. To facilitate and stimulate the crossing of the river, new bridges are created in the vision in Fig. 40 on page 64.

Based on the prospects on alternatives as made by the municipality and the current numbers, the intensity of use is estimated (Fig. 109). This results in a growth of 17% more crossings to 208.881 crossings of the river per day (Gemeente Rotterdam, 2016-a, pp. 8-9; Stadsontwikkeling, 2016, pp. 19-21).

In Fig. 106, Fig. 107 and Fig. 108 the improvements in the networks on city scale are visible. These improvements are connecting the missing links in the bike network and are improving the connection and accessibility of multimodal economic development areas as presented in Fig. 38 on page 60.

Fig. 110. Sunset view

CONCLUSIONS

The goal of this research was to design a bridge from a different perspective and to show the qualities of the added value of a bridge. ***'A bridge is more'***, is a statement formed during the research and is used throughout the project to underpin my ambitions. Creating a design for a new bridge, which can fit into the existing context of the urban environment and can contribute to the living environment on a local scale. A bridge is more than just a connection in the infrastructural network, these opportunities should be taken in order to add value to the local network. The design was made according to some design principles, which were derived from the research.

Research questions

"What do we define as a bridge, what does it look like and how did it evolve over time?"
A bridge is an element, which allows people to cross barriers. From a historical research, different typologies are derived. This has lead to the suggestion of a new typology for the design of bridges. This new typology is an innovative and integrated composition of urban programme, architectural form, connection and construction. It is a combination of historical focusses on the city, mobility and architectural form. This typology is the base for the design.

"What has been the relation between the development of the city of Rotterdam and its bridges, and the explored typologies of bridges from history?"
The existing shore connections in Rotterdam are made in relation to a city (district) development plan. Always there has been a relation between the development of the city and the construction of a new connection over te river.

Over time, Rotterdam has developed bridges in different typologies, fitting the historical typologies. Slowly, there is a move to a more integral design with recreation and the city, as defined as new typology. Latest built bridges are forming recreational connections for pedestrians and cyclists, but are of a different scale than a new bridge over the Maas and yet there is no bridge that fits the new typology in the skyline of Rotterdam.

To show the added value of a bridge, and to show that a bridge is more for a city of Rotterdam than just an addition to the car network, the new bridge should be a composition of urban programme, architectural form, construction and the connection over the river Maas.

"What are the ambitions of the municipality for the future for related developments and a new shore connection?"
The municipality wants to build a bridge, in order to enhance the attractivity of the city. A growing population is pressuring the quality of life and city structures. To make sure that the city will stay attractive in the future, cars should be banned from the inner city and spread more even over the city. In order to reach this goal, the municipality wants to create two new shore connections. From this perspective, new bridges fit in the typology of a bridge as representation of mobility (and construction). At this moment, there are lots of doubts to the approach of the process and the future impact of the bridge.

"What programme can a bridge facilitate?"
An exploration of different bridges has resulted in suggested programmes for the new bridge. This programme is part of the typology and should be facilitated by the form and construction of the design. Different options for the positioning of the programme are suggested: abreasted, stacked, local or a solid function over the bridge. In the design phase, suites locations are assigned for different programmes.

"Based on different scale levels, what is the best location for a new city bridge for Rotterdam?"
From the perspective of cyclists, the positioning of new bridges is influenced. This differs from the perspective of the municipality. Several analyses, among others the analysis of the bike network, have led to a vision for Rotterdam with four new shore connections. On the short term, two bridges should be built on the suggested locations by the municipality to strengthen the public transportation and bike networks. In this way, they are more able to compete with the use of cars. On the long term, two slow connections are created to connect all missing links from the bike network. For the exploration of the new typology with a design, the location at the west of the city is chosen. This location is challenging because of the densed and pressured urban context on the edge of the harbour and the city.

"What are the interests of different stakeholders?"
To explore the interests of stakeholders, interviews are taken. These have resulted in some insights for the design:
- Entrepreneurs should not be afraid of moving and possible growth by better accessibility
- A possible connection with the attraction park by Hennie Most can be created to
- The bridge is forming a border between the harbour and the city, a new bridge will mean a movement of this border
- The meaning of the position of the Waalhaven and its functions for a transition zone between harbour activities in the east and employment for the city

The design related to principles

The typology of the design fits the set principles. It is crossing the barrier of river Maas and is even connecting neighbourhoods over barriers in the morphology of the city to the water. The routes along the shores are a result of the focus on the east-west connection. From a local analysis, it became clear that many bridges are forming new barriers at their landing. By focussing on this principle, this new barrier is prevented. Last, the bridge is a proper composition of form, construction and programme. The bridge is high enough and not too steep to fulfil the technical requirements. The section of the bridge allows a change of a changing mobility demand. The form of the bridge fits within the rhythm of the city (it is even completing this rhythm). The iconic value of this bridge can not be assessed. The iconic value of the bridge will be based on the activities and related programme more than on its form.

A new typology for the design of bridges

The suggested design of this arch bridge for the connection between Delfshaven and Oud-Charlois is a combination of different aspects and is strengthening the bike and public transportation network. The related spin-off developments show the added value of the bridge.

A bridge is more....

REFLECTION

Graduation lab: Design of the urban fabric and Veldacademie

Within the graduation lab 'Design of the Urban Fabric' both the physical urban environment and the psychological, socio-cultural, ecological, managerial and economic structures are researched from a design perspective. Both the tangible and the intangible structures are part of the context for the projects, which have an impact on different scale levels. The relations between these structures and the scale levels are one of the focus points for the research of this graduation lab. From the position of this project for the municipality, I would like to show how these decisions on city scale are having an influence on the local scale of the quays and neighbourhoods. In the policies by the municipality, most decisions are based on conclusions conducted from research and analysis on the city scale and based on infrastructural arguments. But especially on the scale of the quays and the neighbouring areas, a new shore connection will have a major local impact. The goal of this project is to show this impact and show a design for combining the necessity of a shore connection on city scale with the impact on a local scale level. Besides the influence on different scale levels, the project is an investigation of the added value of a bridge. Not only is a bridge influencing the infrastructural networks of a city. On the local scale, the bridge is a spatial intervention, with impacts on the cultural activities of inhabitants of the surrounding neighbourhoods. The impact a bridge has is also on to local social structures of the city district. It can affect the population. Basically, the statement 'A bridge is more' is a reference to the impact on both the tangible and intangible structures of the project.

One of the themes of the graduation lab is the research to urban growth and transformation. The reason for the municipality to construct a new city bridge is the growing population in combination with the attractivity of the city. To enhance attractivity, mobility demands should be fulfilled and cars should be spread over the city. A changing city and a changing and growing population are causing a transformation of the city, which results, among other things, in a new bridge over the river. Per definition, a bridge is made out of the human desire to cross the water (barrier). This new bridge is a representation of the urban growth and transformation of a dynamic city.

To explore the position and interests of the stakeholders (the intangible structure), a collaboration with the Veldacademie is started. With interview The condition for a collaboration with this academy is a relevant project within the context of Rotterdam. The relevance of the project is proved by the number of news items and articles on the bridge, in the past year.

Research and design

Research in the graduation project is the foundation to refer to during the design phase. Decisions for the design are based on conclusions from the research. To be able to develop a grounded design, the research methods should fit the desired outcome and should cover the complete context for the project. The project of a new shore connection in Rotterdam is located within a context of political discussions in a period of financial resistance. The topic of the new city bridge is one of the daily discussions of the municipality of Rotterdam. Many other stakeholders are interested in the outcomes of the discussion.

The municipality has done much research about the impacts on the infrastructural network and possible outcomes for a new city bridge. Their conclusions and visions are presented in many policies. But, as was written in the newspaper (Rubio & Kooyman, 2016), inhabitants are having fear for the possible landing of the bridge in their neighbourhood. To show the possible added values of a bridge, a added research is done. To test the design possibilities, this research of the project is translated into a design. This is done by setting ambitions from the research. These ambitions can be used as criteria or principles for the design. The final design is an example of a bridge as added value for the inhabitants.

Methods

The collaboration with the Veldacademie has resulted in interviews with stakeholders. During these interviews, their interests are explored to use as input and assessment for the design. Other methods used which are linked to the graduation studio are historical analysis to explore the characteristics of the city, the bridges and the location. Also the fieldwork with its photos and observations has been very important for the outcome of the local scale ambitions for the design.

During the design, I have used different tools such as sketching, mapping and 3d models (conceptual form model and Sketchup model for the 3d design). Per tool, the focus differs. This results in a combination of different perspectives in the final design.

Wider context

The supposed final products are possibly impacting the wider social context. The design of the bridge is part of a new typology in the history of the development of bridges. In the past, bridges were seen as part of the city and as an extension of a city over the river. Because of mobility and technological (material) developments, this starting point and definition of a bridge is lost. By designing a bridge with the combination of urban programme, constructive form, architectural form and connections in networks, I hope to show the possibility to change the known typology of a bridge in the current context. This new typology is tested in the context of Rotterdam and can be implemented in other projects for new shore connections. One of the examples of comparable projects is the desire for a bridge over the IJ in Amsterdam, to possible replace the ferries between the north and south district.

Fig. 111. Facebook post (A bridge over the IJ is a natural development, but it should not be too steep). Article about the challenges of a new shore connection in Amsterdam (Facebook, 2017)

APPENDICES

I. LITERATURE

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II. LIST OF FIGURES

All images in this research report are made by the author, unless included in this list. Icons used in this report are downloaded from www.flaticon.com.

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Fig. 41: Apple Maps. (2016). [Map modified by author]

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III. MOBILITY IN THE CITY

An essay about the relation of mobility and the built environment in the Netherlands

Mobility and accessibility are core issues for the urban quality of a city. Because of the urban population growth and intensification of our cities, the infrastructural networks are being pressured. Originally, the compact city concept is created to make more efficient use of resources and a densified city is considered to be most sustainable (Banister, 2008, p. 1; Neuman, 2005). More than 40 years after the first introduction of the compact city, it is still a well discussed vision densification is on the agenda of many planning departments of governments. In this research paper the relation between mobility and the compact city is explored. It aims to clarify the impact of mobility on the development of cities and low density urbanization. Counter wise, the effect of the built environment on mobility and specifically car use is explored on the basis of the 3D's by Cervero and Kockelman (1997): Density, Diversity and Design. The two sided relation is questioned with the current traffic programs of big cities in relation to traffic innovation. The paper results with the remark that traffic innovation should not be taken only as advantage and improvement. Disadvantages should be explored to prevent the cities from being dominated by the new innovations, as is happened with the introduction of the car.

Keywords: Compact city, land use, traffic demands, car use, traffic innovations

Introduction

For a long time, we were depended on walking, cycling, boats and horses for mobility. Mobility is fundamental for society. It has been one of the standards for economical and social well-being and was an important factor for the shaping of settlements (Metz, 2013, p. 255). The introduction of motorized vehicles after the growth of the private cars have had a huge impact on possibilities for mobility and moving through cities and even countries. Traveling by car brought possibilities to travel larger distance with less effort and in a shorter period of time. Because of the many possibilities were brought by the introduction of cars, the use of cars grew. In 2014 there were about 8 million cars in the Netherlands (CBS, 2014). On average, we spend 1 hour a day traveling (Metz, 2013, p. 256). For a long time, only the advantages of car use have been seen. Cars started to occupy public space within the cities for parking, but also roads are occupying more and more space (Wagenaar, 2013). However, from the sixties growing awareness about the disadvantages of car use pushed back cars out the public space. Still they were essential for accessibility and mobility (Meyer, 2014). Besides the disadvantages of the impact on the quality of public space, the awareness of the environment rises. Climate change and the depletion of sources are caused by the use of cars. Next to social problems and physical barriers the air pollution and serious health risks are reasons to try to reduce car use (Melia, Parkhurst, & Barton, 2011, p. 3).

The reduction of car use can be hard as travel demands stay equal. Finding a way to reduce travel demands

or create a shift in travel demands can be helpful in the reduction of the use of private cars. In this review paper the relation is explored for a relation between the built environment and travel demands and the use of cars. In what way are they related and how can the built environment influence on the use of cars? In the first part of the paper the development of land use is discussed. Car use have caused sprawl and the urbanization of open lands. In the Netherlands there were developed policies to prevent the country from being completely urbanized. In the second section the contradictory relation is discussed. The influence of land use on mobility and travel demands can explain how the built environment can be used to reduce car use and improve the environment. This section is divided in three parts: the relation of car use with density, diversity and the design of the built environment. Thereafter, there will be a question raised about the influence of the built environment on the people choosing to move there, are the people with their lifestyles and demands or is the land use crucial for the travel behavior and the use of cars. In the final section there is a short overview of traffic visions in the larger cities in the Netherlands and how this is related to the built environment. This paper is concluded with a summary and a new question for future research.

The effect of mobility on land use

The first settlements were shaped because people were not that mobile and they started to cluster housing and other facilities for eating and socializing. With the clustering they reduced the need for travel. This made live more efficient (Metz, 2013, p. 255). From the first settlements, mobility has been a determinant for the shape of the built environment. The growth of private car use had a major impact on possibilities for development and was an important factor for the land use and sprawl towns and cities nowadays (Bontje, 2001; De Vos & Witlox, 2013, p. 117). The transportation innovations of cars were important determinants for the increase in accessibility and mobility, this resulted in larger possible travel distances. The average distance travelled per person a day increased rapidly from 1,5 kilometers to over 17,5 kilometers in 1950. In the 1970s, after the construction of many highways, the average travelled kilometers increased even further to 35 kilometers a day (Gordon & Richardson, 1997, p. 100). In about 30 years the distance travelled by car has almost doubled (De Vos, 2015, p. 171). The proximity to facilities and jobs had become less important (Hart & Parkhurst, 2011, p. 7). The possibility to travel further for daily activities and needs, made it possible for citizens to leave the crowded cities and the land use could become more wide spread (De Vos & Witlox, 2013, p. 118; Susilo & Maat, 2007, p. 490). This is clearly visible in the sprawl of urbanization in Flanders, Belgium. Also Gordon and Richardson (1997, p. 100) expected future cities to become less and less compact by being able to travel further.

The possibility of sprawl was also threatening the Dutch country sides and nature in the country. The 'Green Heart', the green centre of the densely populated Randstad in the western part of the country, was threatened by urbanization (Dieleman, Dijst, & Spit, 1999, pp. 4-5). Planning policies from the Dutch government in the 1960s tried to guide the urbanization to the north and south of the country. The second possibility was to appoint specific 'growth centres', locations outside of the existing cities with a possibility to urbanize (Bontje, 2001; Dieleman et al., 1999, pp. 5-6). In this way the government guided the urbanization and protected the country side, opposite from urbanization in Flanders. The development of growth centres started a new discussion about urban compactness versus decentralization in the 1980s (Dieleman et al., 1999, p. 3; Gordon & Richardson, 1997). The growth centres were imbalanced, less jobs were created and people living in the new residential areas had to commute to the city for their jobs which caused major congestion around city centres. Because of population losses and shrinking services support combined with a growing environmental awareness, larger cities were the first introducing 'compact city' as a strategic planning goal. Rising awareness about the environment has had its influence on these policies. People became more aware of the impact of car use on air pollution, noise pollution and the use of scare resources. Also they became more aware about the impact of air and noise pollution on public health and livability (Banister, 2008, p. 5; Hart & Parkhurst, 2011, p. 7; Melia et al., 2011, p. 10). This mindset changes, let to the demand of cities to have more people within the city itself. In 1998 the compact city strategy was adopted in national policies. New locations for residential development were appointed in direct connection to the existing cities: also known as VINEX locations. Economical business locations were developed near railway stations for good accessibility, although some still appeared in direct relation to highway access. The goal of the compact city policies was to dissimulate the car use and promote other modes (Bontje, 2001, pp. 1-2; Dieleman et al., 1999, p. 6). The result of the compact expansion projects in the fringe of cities is that mobility and accessibility is still demanded.

Nowadays, many cities want to house more people within the existing boundaries of the city. A shift towards a more local scale for the compact city. Before, it has always been a more national scale development. The new direction in densification is to intensify the number of people within the city. Previous policies were about housing people on the fringes of the existing cities, to prevent all unbuilt land from becoming urbanized. With this planning goal local governments want to improve livability and accessibility for the existing urban structures and make them more vibrant. Second, the want to preserve natural areas (Dieleman et al., 1999, p. 2; Nabielek, Boschman, Harbers, Piek, & Vlonk, 2012). An advantage of building within the existing urban fabric is the possibility to use the existing infrastructural network.

Another effect of car use and mobility in cities is the design of public space and streets. The open spaces in cities became more and more occupied by cars and historical parts of inner cities were demolished to provide more space for the car network and mobility (Wagenaar, 2013).

The effect of land use on mobility

Opposed to the reaction of land use on the development of car use, land use has its effects on mobility and accessibility. The effects of land use on mobility is explained with the 3D's of Cervero and Kockelman (1997): Density, Diversity and Design.

I. Density

Density is defined as the number of units in a given area (Boyko & Cooper, 2011, p. 27). In an urban environment it can be measured in units of population, housing or jobs (ECMT, 2007, p. 122). An increased density for these three units will cause a shift in the mobility and accessibility of a place, but also in citizen's travel behavior.

With the densification of the existing structures, the infrastructural network is more pressured on a local scale level by higher traffic volumes and this will result in more congestion (Cox, 2003; Melia et al., 2011, p. 5; Nabielek et al., 2012). But also more practical problems may occur. For example, parking facilities will demand more surface for more vehicles pressuring the quality and quantity of public space (Nabielek et al., 2012, p. 28).

But on the other hand, higher densities tend to discourage private car use and ownership (De Vos & Witlox, 2013, p. 118). First, with an efficient use of land when density is high, travel distances will become less. Destinations are expected to be closer to the starting point of the trip, which decreases travel distances in a densified city (ECMT, 2007, p. 119; Limtanakool, Dijst, & Schwanen, 2006, p. 329; Schwanen, Dijst, & Dieleman, 2004, p. 10). Shorter distances may stimulate other, non motorized, travel modes such as walking and cycling. Local environment will benefit from the use of non motorized travel modes by facing less air pollution (Banister, 2008, p. 13; ECMT, 2007, p. 123). Secondly, a higher density makes a public transport network more feasible and efficient for longer and medium length trips (Boyko & Cooper, 2011, p. 25; Gordon & Richardson, 1997, p. 4). More people create a larger support for public transportation. The network can be optimized and reduce the average distance and access time to a public transport station and become more and more attractive as alternative for the private car (Limtanakool et al., 2006, p. 329). A higher density will result in a different mode share. In a high density area about 50 % of the trips to work are made by private car compared to over 70 % in non-urbanized areas. The use of public transport is around 15 % for high urbanized areas and less than 5% for the non-urbanized areas (Susilo & Maat, 2007, pp. 3-6). For trips less that 3 kilometers, walking or cycling is the preferred mode (Susilo & Maat, 2007, p. 11). For the Randstad the levels of walking, cycling and the use of public transport will fall related to the decreasing densification level of the area (Schwanen et al., 2004, p. 5).

II. Diversity

Diversity and density can be seen as related variables for a city. A higher density mainly means a higher diversity in land use and functions (ECMT, 2007, p. 119; Schwanen et al., 2004, p. 5). For this reason, the level of diversity will have about the same influence on mobility as density has. Besides the effects of proximity and density, diversity has the effect of less travel demand (Cervero & Kockelman, 1997, pp. 19-21). A higher diversity means less distance to reach certain facilities. The travel demand is reduced and other modes besides private cars will get more attractive.

III. Design

The design of the network has influence on the use of travel modes as well. For example, streets can be closed off for cars. The road-system shows gaps and it is not possible to reach certain destinations by car. Prohibiting cars is not completely necessary, streets can be designed in a way that it stimulates the use of certain travel modes (Banister, 2008, pp. 2, 7; De Vos & Witlox, 2013, p. 119). A street without sidewalks is unlikely to be used by pedestrians. A street with a wide sidewalk will increase pedestrian accessibility and stimulate people to walk more. For cycling, it is important to have safe parking facilities close to destinations. Thinking about the specific demands for preferred modes; shade, sitting elements, parking facilities, safe routes, retail, views, nature, and so on, will contribute to the essential mode share shift (Cervero & Kockelman, 1997, p. 3).

Involving citizens in the policy making process will help reach a successful result. Their travel behavior influence the success of policies, and will have its effect on the local environment and resource use (Banister, 2008, p. 4). Policies need to be made, to ensure mobility and accessibility qualities for a city (Melia et al., 2011, p. 8). We can not longer follow the demands of the network and improving the supply. The network is becoming the determining factor and has to steer the demand (De Vos & Witlox, 2013, p. 117). This demands for a change in modal split, and can be achieved by taking in mind the influence of land use on mobility.

The effects of land use

Both mobility and land use have a direct relation with social aspects. The characteristics of a location will attract specific people and will create diversity over different areas. A location close to the highway access, will attract people prefer travelling by car. Opposed, a location close to a railway station will attract people who tend to use train over car for traveling (Nabielek et al., 2012, p. 28). The city centre is more attractive for people who like to walk and cycle. This phenomenon is called 'self-selection'. People will move to locations which fit their mobility preferences best (Melia et al., 2011, p. 11). It can be questioned if the land use influences the citizens for their travel behavior, or if the travel behavior was used to pick the best location for their preferences (J. Cao, 2014; X. Cao, Mokhtarian, & Handy, 2009). But the built environment is proven to have influence on people who have chosen a location for other reasons than mobility opportunities, for example people that could not afford living in the preferred neighbourhood (X. Cao et al., 2009, pp. 36-37). People who are living in a neighborhoods mismatching the travel demands will face difficulties when travelling with their preferred mode such as limited parking for cars in the city centre. It is a matter of attitude and lifestyle to change to a more facilitated travel mode. Per mode it differs which aspect has more influence on mode choice: the built environment or the preferences and attitude, especially the use of public transport, cycling and walking are issues of attitude and lifestyle. Car use is influenced by the built environment and can be less attractive by the design of streets, as was described earlier (De Vos, Derudder, Van Acker, & Witlox, 2012, pp. 6,8). But also, streets with heavy traffic are having impact on social contacts. People living along important

routes which are intensively used, have 1/3 of the social contacts in their street compared to quite streets (Hart & Parkhurst, 2011, pp. 3-6). This has impact on social safety and livability of the area.

Cities in the Netherlands

Large municipalities have specific traffic programs to present their vision for mobility in their city. In these traffic programs they present their goals and how they expect to realize the desired future in terms of mobility. Rotterdam, Amsterdam and The Hague have a notion of the necessity of good accessibility. Especially good conditions for economical development are depended from good accessibility, but different locations and companies are demanding for different forms of mobility. Also for good quality of life and being an attractive city to life in the accessibility is a measure (Dijk & Buursink, 2013, p. 15; Gemeente Den Haag, 2011, pp. 19, 46; Gemeente Rotterdam, 2016-b, p. 13).

The three cities have about the same goals for the future living and mobility conditions. Rotterdam want to become more green and more attractive (Gemeente Rotterdam, 2016-b, pp. 5,9). Amsterdam wants to enhance the quality of a good accessible inner city and let it stay economical healthy (Dijk & Buursink, 2013, p. 28). The Hague is looking for a more sustainable and healthy city (Gemeente Den Haag, 2011, p. 19). Without bothering the overall mobility, the cities are planning to lower car traffic in their inner cities, spread it more even over the city and its ring roads, and stimulate the use of other transportation modes as public transport, walking and cycling (Dijk & Buursink, 2013, pp. 6, 24, 28, 37; Gemeente Den Haag, 2011, p. 20; Gemeente Rotterdam, 2016-b, pp. 7, 9, 21).

Rotterdam uses methods which can be closely related to the built environment. They are planning to redesign important car routes to discourage the use of cars. By intensification and increasing diversity they can reach the goal of the reduction of short car trips in the inner city and they want to make the cycling network more attractive by facilitating priority on intersections and design an attractive and safe network (Gemeente Rotterdam-b, 2016, p. 7). Also the other cities will be able to reach their goals with the design of the built environment and the land use. In this way the built environment can be used to improve livability and to better environmental conditions by reducing the use of (private) cars. These solutions can simply include actions to reduce travel demand by intensification along public transportation networks (Banister, 2008, p. 3; Melia et al., 2011, p. 15). Another option is to change the hierarchy and make the bicycle and pedestrian network a fine grid, to make the city good accessible for those modes of transportation and prioritize them over cars (Banister, 2008, p. 7). With the awareness of the relation of the built environment on car use, the municipalities can expand their methods to reach their goals.

Future innovation

All of the traffic programs are focusing on existing problems and technical possibilities. The only innovation included in the programs is the trend of car sharing were multiple people make use of the same car(s). Many other innovations are expected and possible to be implemented in the transportation sector in the coming years or decades. For example, they are testing the Hyperloop One which should be functional in 2020. It is expected that this form of transportation will reach a speed of 1000 km/h and will be suitable for long distance transportation (Van der Kolk, 2016). Although this is an example of long distance transportation, it can be expected that innovations for short distance transportation will occur as well. Those innovations will be more efficient in use in inner cities were transportation is pressuring the built environment most. An example of short distance transportation is the Hoverboard for one-person transportation. another example is the self-driving car which can park on other locations and so public space is being released from parking facilities.

Conclusion

In the previous part of the paper it is explained that the innovation of cars has had its impact on the built environment and the possibility for sprawled urbanization. The possibility to travel over larger distances brought possibilities to live in areas and commute to different locations everyday. Policies prevented the Dutch open land from being completely urbanized and cities expanded in the direct edge of the city or densified within the existing boundaries. Today, the intensification of the number of houses within the boundaries is part of the assignment for future development. By the intensification of the existing network, the infrastructural network is pressured and together with the awareness of environmental impact, the necessity of the reduction of car use is felt.

Current policies of cities are presenting goals about the reduction of cars in inner cities and showing the methods to reach the goals. The design, density and diversity of the cities do have an important relation with the amount of traveled trips and kilometers per car. With having this relation in mind, they can expand their methods and reach their goals more easy.

What is not part of the current literature and traffic programs is the innovations within the field of mobility. With the relation of the built environment and car use in mind, it is expected that innovative forms of mobility will have its impact on cities and cities will have their impact on new forms of mobility. The least we can learn from the development of cities in relation to car mobility, is there are never only advantages. For a long time, the only aspect seen was the ability to travel over larger distances. It took some time to realize that the use of car also brought negative effects along: noise pollution, air pollution, and the domination of public space. Planners can better be careful with total commitment to a certain type of transportation and let new technologies not dominate our land use and the design of the built environment.

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IV. MOBILITY ANALYSIS

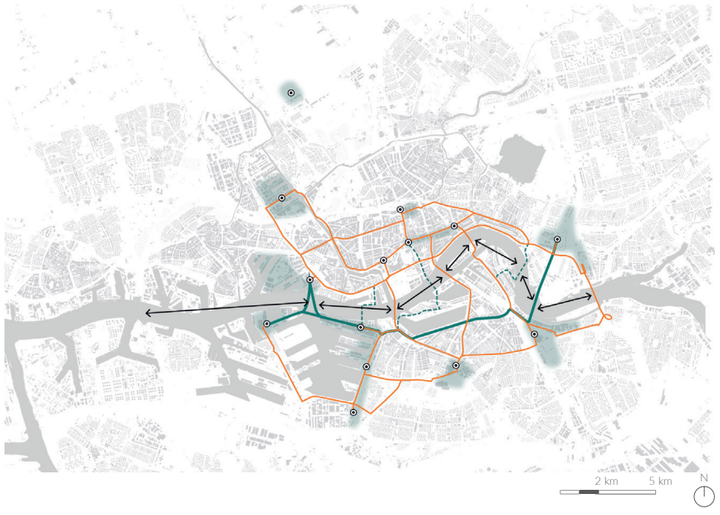

Fig. 112. Bike network in economical development area with improved connections

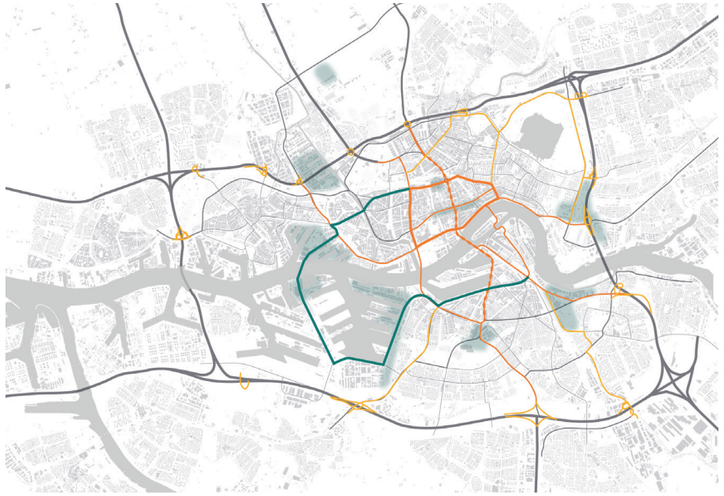

Fig. 113. Car network in economical development area with improved connection

Fig. 114. Frequent public transportation network in economical development area with improved connections

V. INTERVIEWS

INGE SPAANDER - VERSBETON

Without any background or experience in either architecture or urban planning, Inge Spaander wrote an article about the location and the design principles for a new city bridge in Rotterdam. As inhabitant of the southern part of Rotterdam and interested and curiousity for developments in the city, she is involved in the complex stakeholder group of this process. Her article was published on Vers Beton with the following title 'Oost versus West: Waar de stadsbrugdiscussie echt over moet gaan'. Vers Beton is an online platform or magazine for hard-thinkers from the city of Rotterdam. In the article Inge argues that a bridge can offer development opportunities for the surrounding neighbourhoods. Besides the location, she emphasises here position on car use in the city and on this new bridge. Because of apparent similarities in our position, I organized a meeting with Inge on October 28, 2016 in a coffee bar in the southern part of Rotterdam where we discussed options for developments around the new city bridge according to my conceptual design.

In a discussion meeting with Pex Langenberg (city counsel member) she was informed that the municipality is planning an(other) ugly traffic connection on the design location. According to Inge the possible candidature for the World Expo 2025 was a funny reason to plan a bridge with this kind of local impact. She wonders if this is what residents of the city of Rotterdam are waiting for.

We shared the position that a bridge on this location should be more than a purely car connection within the existing network. Although she does not own a car, she can imagine the impact of the bridge in the ease to cross the river by car and in the decision to use a car for this purpose. She uses her bike and the public transport to cross the river northwards from here house in the southern part of the city. She has experience with people avoiding the Maastunnel as much as possible. Because of the escalators, lines for the elevators and the tunnel they prefer a longer travel time and distance. A new bridge focussed on bikes can have a major influence on the travel time and distance, a detour by going over the Erasmusbrug is completely out off the track. Besides a good link in the bike-network, the bridge can contribute to the public transportation network. At this moment bus line 44 is running between Zuidplein and Rotterdam Central Station. In line with the planned renovations in the Maastunnel this bus will be ended. A new bus connection over this new bridge can compete the use of cars for crossing the river. To further discourage car use, she suggested to look in possibilities for a Park and Ride system from Sluisjesdijk.

In line with the environmental zone for cars in the inner city of Rotterdam, she also thinks about cruise ships. The polluting ships can form a statement for the developments in the city-harbours on the west of the design location. Having one of these boats in front of your office/house/neighbourhood/business is a sign of a highly developed urban area. Although the opinion of the statement a cruise ship can be, Inge does not have a clear opinion about the location of the ships. Possibly because of the lack of relation with the activities related to these ships.

Besides the modalities on the new shore connection, Inge has an opinion on the locations and kinds of

developments related to the new bridge. She feels like the locations now are kind of remote places in the end of the city. She wonders if a new bridge can connect these locations and what kind of impact it will have on the special atmosphere on Sluisjesdijk. The realm of the southern pier is completely different from other known developments in the harbour of the city. The pier can possibly be a link between the different scale levels of the harbour and its surrounding. The developments around the construction of the bridge can result in a link between the local initiatives in Oud-Charlois and the knowledge on the RDM campus. In this link a mix of art, culture and knowledge can develop in a makersspace. This makersspace should be easy accessible and form a combination of meeting people and sharing knowledge. To connect the different scales and locations, the suggested walk or park along the shores in the conceptual design can form a good connecting element.

Inge suggested a possible collaboration with Hennie Most. He is currently working on the development of an amusements park in the former waste incinerator. Combining the linear park and walk along the shore with the access routes to the amusements park can bring opportunities for the identity of it.

Important for the developments on the northbank is the phenomenon of gentrification. By developments in a neighbourhood the original inhabitants are pushed out by wealthier people, who will take over all dwellings and both jobs. Inge thinks that neighbourhoods suchs as Schiemond should be reserved. Some renovations are acceptable, as long as it is for the current inhabitants.

Our talk was closed with an inspirational talk about alternative ways to cross the river. Examples for this are a cable lift, a roller coaster and an air balloon.

JOEP VAN EIJK - INTEREST GROUP ENTREPRENEURS

Communication with the municipality and the Havenbedrijf Rotterdam is hard for individual entrepreneurs. Before, the businesses in the southern part of the Waalhaven were united in an interest group. Two years ago, a new interest group is found. In this new interest group both the southern part is united, combined with Sluisjesdijk and Heijplaat. Joep van Eijk was chairman of the former interest group and now involved in the set up of the new group. Among other things, the discussion about a new city bridge are forming context for the founding of the interest group. November 18th, I organized a meeting with Joep van Eijk to discuss the interests of local entrepreneurs in a new city bridge. Besides member of the interest groups, he is manager of Kroonint. A business in the south of the harbour.

As a chairman or as member of the board of the interest group it is not about individual interests. The main aim is to provide a tool for communication between the local stakeholders and the departments which have power over the projects. Interests may differ within the interest group. Some will be against a new bridge, and others will stimulate the new connection. The role of the interest group will not be of influence on the decision. The decision that a bridge is needed is already been taken by the municipality. One way or another, this bridge will be built. Although not all businesses may agree this decision, they should realize that this bridge is not only of influence on their lives at this moment. The bridge is of influence on a city as a whole and on the future city. The aim of the interest group is more to guide the process of the decision making and the construction and future developments. The focus is on the gradual and pliable process.

From the perspective of an entrepreneur, change and development caused by a new shore connection should be seen as an opportunity. Obviously, it is more easy to stay at the same place in the same building. This can cause large resistance to development plans. For this reason, it important to guide, think along, and cooperate in the moving process of businesses. Joep van Eijk sees opportunities in the entrepreneurs-spirit of the businesses. Growth, employment, and accessibility are in focus of the development of the entrepreneurs. Moving their business to another location, or benefit from developments around the new bridge will bring opportunities for the entrepreneurship in terms of financial growth, marketing, employment and accessibility. Even without the impact of a new city bridge, the businesses on this location are moving. Kroonint is an example for the natural moving processes in a company. Kroonint is a company which supplies in paints, tools and machines, and cleaning devises. This company moved their production- and storage-departments to Dordrecht. This movement was necessary, because of safety regulations and both limited available space. The issue of limited space is tangible in the surrounded companies as well. Because of growth and intern developments, the businesses are growing larger than their accommodations. Because of small sized plots, extension of the buildings is hard or impossible. Selling their properties to external parties seems a good option. But most have a long lease contract with the Havenbedrijf Rotterdam and do not own the ground under their buildings. Secondly, it is hard to find an interested party for the size of the plots on this location.

The development of a new city bridge, combined with better public transportation accessibility can attract new businesses to the area and stimulate a flow through. Mobility and businesses are changing and a better accessibility by public transportation for employees is a must for potential success and growth.

Besides the ambitions of an entrepreneur, the city is changing. This changes in the city will eventually force business to move. When it is not today or tomorrow by the construction of a new bridge. The force to move will come next year. Among other things, De Kop van Zuid as development area will fight its way along the shores and will push on industrial activities. Being resistant to development, can result in becoming the last man standing in the area. Would businesses benefit from being the only one left on a location?
Not only the city is changing in shape, also mobility and data is changing. The new bridge should facilitate in these changes. It would be good to not focus on cars only. Public transportation will become more and more important with an improved network.

The changing city with improved accessibility will bring this location many opportunities for future developments. Entrepreneurs should not be resistant towards these opportunities for the location. People are in general negative towards changes. A better accessibility will bring opportunities for employment, mobility and financial growth. With the developments combined with a new city bridge, this area will develop in an urban area with employees living close or well connected to their employers. When the development will result in the forced movement of companies, the interest group will represent the interests of the local entrepreneurs. In this way they will guide the process in a structured and positive way. The movement of the businesses will result in opportunities for the location to develop a public shore line, public safety, resiliency, and a new city district. A new bridge will improve travel time to this location and is necessary for a city as Rotterdam.

BRYAN VAN CAMPENHOUT - SLUISJESDIJK ENTREPRENEUR

Contradicting to the positive words of Joep van Eijk are the statements in a short conversation with the manager of Van Campenhout montage and construction company. During a talk with Bryan van Campenhout it became clear that they are sceptical against a new city bridge. Their main interest is the location of their store and offices. At this moment they are not interested in moving the company and they do not see benefits from a more crowded location which is better accessible. Bryan van Campenhout prefers a tunnel, not because of hinder on the water, but because of the expected impact on surrounded roads.

KEES KLEINHOUT & ARJAN HOEFNAGELS - PORT OF ROTTERDAM

Besides a connection between the two banks of the river, the new city bridge will reconnect the harbour to the city. One of the big stakeholders in the discussion about the location, the programme and the related development is the Havenbedrijf Rotterdam (Port of Rotterdam). I organized a meeting with two district managers of the following areas: Waalhaven, Eemhaven and Merwehaven. Kees Kleinhout is manager of both the southern and the eastern part of the Waalhaven. Arjan Hoefnagels is besides district manager of the remaining areas also coordinator for the project of the third city bridge. The bridge will land at the northern pier of the Waalhaven. He is involved in the process together with the municipality. Just like this graduation project, the location for the new city bridge was assigned to be halfway the most northern pier. The meeting took place on November 7th, 2016 at the World Port Center in Rotterdam. The outcome of this meeting is summarized in the following chapter.

The harbour layout

At first, it is important to understand the area we are dealing with from a harbour perspective. The area is a traditional and dated harbour structure with small plots. Because of small sized plots, the land is cut into pieces. Most of the land and plots are owned by the Havenbedrijf Rotterdam. Because of the ownership, the Havenbedrijf Rotterdam has major influence on the developments in the area. They are investing €10 million annually to improve the quality of the public space. Not all land is owned by the Havenbedrijf Rotterdam. Some of the plots are privately owned. Their interests differ from the Havenbedrijf Rotterdam. For example, after the opening of a new bridge they can sell their properties with high profits.

Because of the small sized plots, the harbour activities on the east side of the Waalhaven are of smaller scale compared to the companies more westwards. The companies at the eastern edge of the harbour are mainly maritime related services. Most of them are not directly related to water activities and are not location specific. However, they are related to harbour activities. A location connected to their businesses is more important than good accessibility. The settled businesses prefer a location in the harbour area. As well as the larger harbour activities, these smaller scale business are growing. Because of their scale and they are providing many jobs (12.000) to the inhabitants of Rotterdam. The businesses benefit from their location next to the residential areas. Especially the southern part of the city can take advantage of these jobs.

The function of the area makes it a buffer for the hardcore harbour activities on the west side of the basin. Maritime ships and containers are producing a lot of noise and vibrations. This makes it unsuited for the developments into a residential (related) district. The buffer zone should be replaced. With this, the whole harbour should be rearranged.

Accessibility

When travelling by car, the Waalhaven is well accessible from all directions. However, a good public transportation connection is lacking. A new bridge connected to this eastern part of the Waalhaven will bring opportunities

for the accessibility by public transport. It is important to reserve space in the section of the bridge for high quality public transportation. In this way, jobs are more accessible for other parts of the city as well and this could attract even more businesses. The disadvantage of a better accessibility is the expected overcrowding on Waalhaven O.Z. Because of the new bridge, more cars are expected to use this road. This will form a new barrier between the inhabitants of the city and the jobs in the harbour. Crossing the barrier of the river by a new bridge will create a new barrier between the harbour and the city.

The bridge is defining a border

The exact location of the berming of the new city bridge is of major influence on maritime shipping routes to the inner city. The location of the bridge will determine the end of navigable water for maritime shipping. This will be the end of the city and the beginning of the harbour (or the beginning of the city and the end of the harbour, depending on the perspective). By defining the end of the navigable waters, the bridge can be seen as the end of the city and the start of the harbour. The pressure of the city with its housing assignment will push the bridge and push the border more westwards. Moving the harbour related businesses more westwards is not possible. There is a lack of space for relocating these businesses. Especially the characteristics of small sized plots are representative for the businesses. The location of the bridge in the middle of the pier is more in favour of the harbour. In this way the navigable waters, and so harbours and berthing quays are less impacted.

Another problem appearing by closing the navigable water are the ships with temporary mooring. About 1500 ships annually are moored on the city side of the new bridge. By closing the navigable water, these ships are not able to moor on the shores without consequences. This means the bridge should be opened multiple times a day for these ships or should be high enough. The height of the bridge therefor has to be about 25 meters high. Taking into account the s, mooring at De Kop van Zuid, the bridge should be 70 meters high. Most ideally should be a tunnel, this will not solve the development issues and the barrier on a new corridor. A tunnel is the best option for the possibilities for shipping traffic.

Remarks

It is clear that the municipality and the harbour do have different interests in the location and development of the bridge with its connected programme. Although the Havenbedrijf Rotterdam is not in favour of moving the edge of the harbour with a new city bridge, they are will benefit from a fast decision. In the past few years, the eastern part of the Waalhaven is climbing back up. For a long time, they have experienced a downwards spiral in the public space. The insecurity about future developments is possible to result in paralysis in investments. This will put back the area in their movement downwards and will undo the effort of the investments.

To conclude, building a new city bridge on this location will result in the movement of the transition zone with small businesses. The bridge will define a new border between the harbour and the city. The development is slow. De Kop van Zuid took 20 years to develop. Today, we have the discussion about moving the border between the harbour and the city and this exact same discussion will happen again 20 years after the opening of the bridge.

Kleinhout, K. & Hoefnagels, A. (November, 7th, 2016). Interview: Port of Rotterdam.

Van Campenhout, B. (November, 1st, 2016) Short talk: local entrepreneur.

Van Eijk, J. (November, 18th, 2016). Interview: Entrepreneur and founder of the interest group.

Spaander, I. (October 28th, 2016). Interview: Writer for VersBeton and inhabitant of the southern district.

VI. LOCATIONS IN ROTTERDAM

VII. EXPLORATIVE SKETCHING