as an extension of the Overhoeks-boulevard and
a connection between the centre of Amsterdam and
Amsterdam-North at the spot of Buiksloterham

Jan-Kees de Vries — Architectural Engineering graduation


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Studio
Theme: Architectural Engineering, lab 6
Teachers: Thijs Asselbergs (prof.), Jan Engels (architecture) and Wim Kamerling (engineering)
(p1: Ype Cuperus, Kees Regtop and Arjan van Timmeren)

Argumentation of choice of the studio
integration of design and engineering,
combination of research in a certain topic and designing on a specific location and program

Theme
adaptability and floating

Title
‘the IJ water experience’

adaptable floating cultural boulevard

as an extension of the Overhoeks-boulevard and a connection between the centre of Amsterdam and Amsterdam-North at the spot of Buikslooterveld
INTRODUCTION

It is the adjustment of the image. First a broad view of the situation of Amsterdam, its history and context. Let us say scale 1:20000. With its conclusion and findings we set a starting point to design and to do research with. It was the situation close before the 2nd poll: the urban plan, its outcomes and its basis for the architectural implementation.

From scale 1:2000 tot 1:200. A big step which has taken most of the time, but for sure the most important step in the process of this project. It was given answers to research questions, given the spatial design development


From urban situation, urban plan to architectural program and architectural implementation of a part.

Too long introductions are boring. So, keep on reading, and enjoy the pictures!

Jan-Kees de Vries
1.1 PRODUCT – statement

1.1 Problem introduction
The city district Amsterdam-North is rapidly changing. New plans, designed at old industrial areas, where one could work and live, both together, must inject a new spirit into the northern district. There is also the idea of the municipality to give the area a cultural purpose, called ‘the new creative industry’. The NDSM-site is already partly filled with these creative industry. Overhoeks, the area around the old Shell terrain, will be an upper class living area. Buiksloterham, the other area in between, will be in future a combination of building types for working and living. Let us say a hybride area.
The north bank of the IJ, what is the water which separated the North from the centre (and the other districts) of Amsterdam, is a major toplocation. In comparison with the shadowed south bank, where buildings standing very close to each other, the north bank is an oasis of space and sun. Beside this it is having the view on the beautiful buildings at the other side.
It is the wish of the city planners to make the north bank as a sun lighted green shore, what is also the main public route for pedestrians and cyclists to go from east to west, and especially from the centre to the new areas of Overhoeks, Buiksloterham and the NDSM-site.
But...
- In the common situation the green boulevard of Overhoeks suddenly stops at the front of the Shell headquarters.
- There is still no direct connection for pedestrians and cyclists between north and south (the centre)
- One could only reach the North by ferry.
This all brings me to the next problem statement.

1.2 Problem statement
How is it possible to realise a building which contribute to the cultural ambitions of the city, as an extending floating boulevard, which could change its position to make a connection between the north and south IJ bank.

1.3 Design assignment
Designing of a floating cultural boulevard which could change from position and becomes a connection, or bridge from north to south.
1.2 PRODUCT – goals

1.4 Field of research and design
Build on water
Build with adaptability

1.5 Goals
Designing a typical ‘Amsterdam building’
Development, flowering of the IJ area
Designing with adaptability.
Designing on the transition from water and land
How to make a building with cultural functions which is able to change from position.
Multiple use of space with a hybrid program: landscape/public space and insite cultural functions.

1.6 Engineering questions:
Learning more about floating buildings,
how it works,
how to reach acceptable stable situations, especially in relation to the possible adaptability of the design.
how to calculate stability, combination of floating body and upper-works
What kind of flexibility/adaptability of functions.
Does the building exist of one or more volumes?
How does parts moving?
How are parts connect to each other?
How can we guarantee stability?
What is the main- and a substructure?
What about infrastructure like electricity, gas, drainage?
How to design waterproof?
Possible systems: dock-principle, along rails, by cables, by motors, bridge-principle
1.2 PRODUCT – goals

1.7 Program:
Cultural boulevard
inner space: ateliers, podia, rendable spaces,
outer space: podia for concerts, park as strolling space
binnenruimte: een hoofdas (straat) met daaraan ateliers(units), verhuurbare culturele ruimten, en groot hoofdpodium

1.8 Qualities of the surroundings:
sunny shore of the IJ
placing in or along the water
sight on (activities) IJ
experience of (natural) elements
sound which ‘flows’ on the water
oasis of space (landscape) within city
possibility to get lots of people together during an event

1.9 Materialization:
The old harbour areas in the next environment gives lots of interesting examples of how different materials and forms are used. It is desirable to refer in the new building to the used materials (and the way how they are assembled) in the surroundings. Look also for the inspiration further in this report.
1.3 PRODUCT – relevance

The relevance about building on water is an answer of the question ‘Why do we make floating buildings?’
The icons right tells the story in pictures.
Climate changing is an important drive of building on water. Especially in a flat land of Holland could it be a benefit when sealevel is rising or weather conditions are more extreme than it ever was. Floating buildings don't have the problems of ‘normal’ buildings when the water is rising. Vertical flexibility is the advantage in this case.
Besides this, The Netherlands is already for centuries a water-coutry. To keep our country on the different aspects related to the theme of water on a high level of expertise, we have to go on working on new ideas. In our field of work, Architecture, we can add new ideas as designers. With this graduation and after that, I hope to contribute to the understanding of floating architecture, constructions and its potentials, difficulties and concerns
The possible flexibility on water is also a relevant addition compared with buildings on land. It is not only the vertical flexibility, also the easy possible flexibility to change the position in the horizontal plane. Related to a day or season cycle, or in this case a changing function/situation. The experience close to the water, or for example on water level, is a next added value.
In the way of construct these buildings, there is the ability to build several parts somewhere else and bring the components together on site, by shipping these parts on water to the wanted location. Then one make use of an other aspect of flexibility. So, the very good possibilities of prefabrication is an important advantage, too. Additional advantage is the economical benefit with this way of building.
De creatieve IJ-oever

In de omgeving van Amsterdam is veel behoefte aan kwalitatieve woon- en werkrusme. Verouderde industrieterreinen en het robuuste havengebied vormen hier een aan- trekkelijk aanknopingspunt voor grootstedelijke vernieuwing. Ten noorden van het IJ ligt deelgebied Buiksloterham, waar wordt ingezet op het winnen van waardevolle ruimte die grotendeels wordt ingevuld door de creatieve industrie.

Grootscheepse transformatie

Dewens is om een gemengd woon-werkgebied te creëren met een hoge ruimtelijke kwaliteit, aanwezig voor diverse ondernemingen. Dit versterkt de bedrijvigheid en de concurrentiepositie van de Randstad en draagt bij aan een goed functionerend woon-werkmilieu. Om een verouderd bedrijventerrein te transformeren tot deze ideale uitvalbasis moet het hele gebied onder de loep worden genomen. Startpunt is het wegnemen van de milieuhinderlijke betoncentrale middenin het plangebied. Verplaatsing van het bedrijf levert ruimte op en komt de milieukwaliteit van het gebied ten goede. Om woningbouw mogelijk te maken wordt de bodem gesaneerd. Bij de ontwikkeling van woonruimte en bedrijvigheid is ook een betere ontsluiting nodig, binnen het gebied zelf en naar de aangrenzende gebieden Overhoeks en NDSM (de voormalige scheepswerf, nu een creatieve broedplaats) en naar het centrum van Amsterdam. De creatieve industrie is de doelgroep voor de ontwikkeling. De ervaring leert dat de kwaliteit van de ruimtelijke inrichting van groot belang is voor de doelgroep om prettig te kunnen wonen en werken. Daarom worden ook groenvoorzieningen en recreatiegelegenheden ingevoegd in de ontwikkeling. Denk aan uitlopende kades langs het IJ, een jachthaven, aanleg van groen en behoud van industriële monumenten.

Private kavels

Een deel van de bestaande werklocaties blijft behouden, een deel wordt vernieuwd en een deel wordt gereactiveerd voor woonruimte. Private kavels mogen naar eigen inzicht worden ontwikkeld, wat veel mogelijkheden biedt voor geïnteresseerden. De ligging van Buiksloterham tussen Overhoeks en NDSM maakt het gebied als geheel een aanwezigheid van groot belang, gezien de vele ontwikkelingen in de naastgelegen gebieden. Naast het wegnemen van de milieuhinder in Buiksloterham behoren de aanleg van groene oever en een verbeterde bovengrondse infrastructuur tot de Rijksinvesteringen in dit deelgebied.

| Het tweede mediacluster van Nederland |

Prettige leefomgeving

Festivals/Events around the IJ:

Whole area:

Sail Amsterdam  (once every 5 years) (August-September)  (sailing, shipping, water)  (1.5-2 million people)
Floating Olympics  (2028)  (sports)  (millions)

North:

Over het IJ Festival  (NDSM-yard)  (July)  (theatre, live-bands, lounge, eat)  (30,000 people)
Sundeck Festival  (NDSM-yard)  (July)  (soul, funk, jazz-festival)

Centre Amsterdam:

Queensday  (April 28-29th)  (300,000 people)
Amstelconcert  (Liberation Day  (May 5th))  (concert)
Holland Festival  (June)  (international podium art)  (70,000 people)
International Roots Festival  (June)  (world music, african)  (60,000 people)
International Theatre School Festival  (podium, theatre)  (10,000 people)
Grachtenfestival and
Prinsengrachtconcert  (August)  (classical music/art)
De Parade  (August)  (travelling theatre)
Uitmarkt  (August)  (cultural diversity)  (500,000 people)
Nederlands Theater Festival  (September)  (theatre)
several small festivals
2. URBAN SITUATION – history

The continue changing relation between land and water, between port and city is a typical characteristic of European port-cities. Water is both the tradeway, transport infrastructure and takes the role of protection zone against foreign domination. It is very interesting when we look at the situation of Rotterdam and Amsterdam. Those cities are very comparable; Rotterdam as a city along the end of the river Rotte, Amsterdam at the ‘mouth’ of the Amstel. And both cities are situated along a big river: Maas and IJ. Amsterdam and Rotterdam are ‘dam’-cities, build around the dams of the Rotte and the Amstel. Concluding: the geographical conditions of Amsterdam and Rotterdam are comparable.

At his website, sir Engelfriet (http://www.engelfriet.net) gives a reason for the enormous growth of Rotterdam as city: it is the geographical bending of the river Maas. Amsterdam have also a curve of its IJ. Nevertheless both cities are developed fundamentally different on relations between port and city and its oriëntation.

Amsterdam, is called by Meyer in his dissertation: the city with the ‘smooth’ informal waterfront. From the 17th century the city was growing away from the water. In the periods before, the city had already another orientation compared with Rotterdam.

The city was developing itself with the Damrak along the Amstel as the aorta. With the build of the cityhall and the ‘Beurs of Berlage’ this situation was being stronger. The double row of palisades, as defending against the waves of the IJ and against enemies, symbolize the first barrier of the city with the IJ in the 15th century.

Also the fact that big ships at the level of Texel already racked their loads to smaller ships, which on their way the loads racked to the small barges and vessels, contribute to a situation of a ‘smooth’ waterfront.

In the 18th and 19th century the Prins Hendrikkade had some grandeur, but nowadays it seems to have no any visible relation with the IJ. The build of the Central Station, one of the biggest mistakes of the cityboard in history, was the definitive closing of the city to the IJ.

The city seems totally closed, but mainly the new living areas, on the formal port-islands, start a new connection between city and water, between city and IJ.

Rotterdam was and is a city with a hard and more formal waterfront, originate in the 17th century. For a long time, Rotterdam exist of buildings within the so called city triangle. Like Amsterdam, Rotterdam has also a waterdefending system and palisades, but this city was growing further over this structures, in the water direction, so that a so called landcity and wa-
2. URBAN SITUATION – history

tercity where developed. This was the beginning of the interlocking of city and port.
The orientation was clearly focused on the river. The deep maaswater gives the possibility for big deep drafting ships to fit
the quay, close to the building city.
Where the river, the water for lots of cities is the aorta, or where cities orientating themselves to the water, was this totally
different for Amsterdam. For a long time already was this city turned away from the water.
There was other, safer water, where the citylife takes place.

Nowadays we are reaching a new situation. We see a revaluation of the IJ. Old port-areas are retuned in new living areas,
both on the southside as on the oevers of Amsterdam-North. The orientation of the city is not only to the Amstel any-
more.
But still there is a strong separation between the centre, Amsterdam beneath the IJ, by far the biggest part of the city, and
Amsterdam above IJ. However it is possible to go from south to north by lots of ponden, die veel varen, of met een auto
via the tunnel.
Een zichtbare verbinding is er niet. Voor voetgangers, fietsers De ervaring
Het wordt tijd om een brug te slaan tussen noord en zuid, letterlijk. Pas dan zal Noord volwaardig verbonden zijn met de
rest van Amsterdam, en wordt de kans groter dat het gebied van Buiksloterham, Overhoeks en het NDSM-terrein de am-
biteieuze doelen, zoals de stad ze voor ogen heeft, kan gaan bereiken.
Maar nog steeds grote scheiding tussen noord en centrum.

Heden ten dage is er een herontdekking, een her-erkenning van de kwaliteit van het water.
Most important question in this is: how could we change, or possibly better, improve the spatial orientation of Amsterdam.
2. URBAN SITUATION – history

Also from the north side old harbour areas are changing in area with dwelling

Next step: a real, visual connection between north and south?

Development of the green shore at the northern bank of the IJ

Cornerstones:

1. Amstel as a central axis
2. Coming of railway; Central Station definitive closed the city
3. Industry, port activities on the IJ banks
4. Released old harbour areas builted again with dwelling and new industries
2. URBAN SITUATION – history

Municipality of Buiksloot
Province: Noord Holland
Ended: 1921, Amsterdam
Additions: 26 juni 1816
“Een schild van keel, beladen met een zwaan van zilver, houdende in zijn regterpoot de een-drachtspijlen van goud.”

2. URBAN SITUATION – fascination

Bridge over the IJ

When Amsterdam in the 19th century began to expand, plans were made for a better connection with Noord-Holland above the IJ. A stream of plans came up for bridges and even tunnels. Between 1851 and 1886 a contractor from Amsterdam, Jan Galman designed 36 different possible bridges over the IJ. (https://#/stadsarchief.amsterdam.nl/archieven/archiefbank/overzicht/10059.nl.html idc_hEObp)

In his days, most drisively dubbed as ‘the Dutch Ferdinand Lesseps’, the designer of the Suez Canal. Nowadays, posthumously he is lauded as the only designer who tries to connect both sides of the IJ to a real urban unity. (volkskrant 10-10-1996; http://www.volkskrant.nl/vk/nl/2844/Achive/article/detail/439121/1996/10/10/Een-gewaagde-sprong-over-het-IJ-uit-het-rijk-der-illusien.dhtml)

It seems to me somewhat strange, that the city of Amsterdam, for lots of decades, rejected any plans of connections of both IJ banks. The same with the designs of Jan Galman. “It must be recognized,” said a city engineer, “plans of Galman may claim a careful, tidy and comprehensive treatment, great and fresh ideas, but unfortunate however that they, so it seems to me at least, are exaggerated to the realm of illusions.”

The city was afraid that siltation at piles the already existed silting of the port would worsen. Beside this, Amsterdam kept the situation of unhindered passage of large ships and found a connection to the then little-developed part of North-Holland, insignificant. So, Galman’s plans disappeared, yet in his century, in the archives. The city focused, with the North Sea Canal, on an open way to sea, and did not look to North. Amsterdam grew, expanded, filled up canals in the center, and built a new port in the East of the city, what asked more and more of a free passage of ships.
bridges designed by Jan Galman at the end of the 19th century.

left: his second bridge (1857)

ingarht: his eightest bridge (1879), more like a park-bridge
down: the first design of a bridge by Jan Galman (1852)
The first two bridges starts early at the quay, in a kind of drive to the water. The quality of these buildings, there view is incredible.

(Smit, L. - *De sprong over het IJ* - Uitgeverij Toth, Bussum (1996))
2. URBAN SITUATION – context

left: old and designed situation, the transformation from industry to mixed use

right down: design of a building at the Grasweg for the design-competition Open Fort 400

top right: difference between green shore and city-shore has been made clearly in this render.
Green shore along the Northern banks

On the 29th of November on the office of Citythoughts Architects at the Grasweg, in the middle of the development area in Amsterdam North, a discussion was held about the possibilities of the northern shore of the IJ. As munition for the debate four plans were highlighted by involved designers. There was also a discussion about the possibilities of a continuous route along the IJ.

The series of presentations were ended by Harkolien Meinsma who explained the idea of a connected promenade along the IJ, which she designed together with Marina Roosebeek on behalf of ‘De Groenen’ of the North district.

The plan was to build along the whole Northern IJ bank a public route for cyclists and pedestrians, what connects different areas of the North district and Waterland, the area in the surroundings, with the centre of Amsterdam. This promenade should construct independently from any developments of other locations on the IJ, and should enhance the chances of developing of the area.

In this research the looked at the whole north bank, from site to site, and also how one could take jumps over the various canals and harbor basins. By showing divers reference images, one could see how the shore of the IJ might be designed on different locations.

(http://www.citythoughts.org/arc_activities/upgm/northernijshore/northern_ij_shore.htm)

For me, one interesting thing was not in vision: a possible bridge from North to the centre. Because then, the pedestrians and cyclists have a real fixed connection to the centre, or vice versa. For me, the called public route is then really finished.
3. DESIGN VARIANTS

The left pictures shows the possibilities how public space and building (parts) are positioned to each other.

1 building(s) above the public space
2 building(s) and public space on the same level
3 public space over the buildings (as the roof)
3. DESIGN VARIANTS

slipway

rotation

floating pontoons
3. DESIGN VARIANTS
3. DESIGN VARIANTS
3. DESIGN VARIANTS
4. DESIGN

connection: bike, walk
visitors, program
enjoying elements
connecting boats

- SLOW
- FAST

- working people
- circuit: event
4. DESIGN
4. DESIGN
4. DESIGN

Van Nellefabriek,
Rotterdam
Leendert van der Vlugt & Mart Stam
(1927-1929)

passengers bridge
cruise liners and airplanes
4. DESIGN

Royal Theatre,
Lundgaard & Tranberg
4. DESIGN

Almere Theatre, SANAA
4. DESIGN

ETFE (Ethyl Tetra Fluor Ethylenene)

WHY?
1% weight of glass
big strain possible (4 times strain of its own length)
free forms (not folding)
good insulation ratings
possible ventilation in space between layers
good transparence
recyclability of 100%

WHAT?

INSULATION RATINGS: \( U \) (W/m²K) \( R \) (%)

1 layer foil 5,6  0,17
2 layers foil (1 air room) 2,94  0,34
3 layers foil (2 air rooms) 1,96  0,51
4 layers foil (3 air rooms) 1,54  0,72
regular double glass 3,8 0,26
HR++ glass 1,2 0,83

ZTA
1 layer foil 0,85
2 layers foil 0,72
3 layers foil 0,61 (0,85³)

LTA
1 layer foil 0,92
2 layers foil 0,85
3 layers foil 0,78 (0,92³)
4. DESIGN
4. DESIGN
4. DESIGN
4. DESIGN
5.1 RESEARCH – conditions

As the start of the research part of this graduation project, before the P2 (halfway assessment) we set our goals and asked questions to research with. The research part is never separate of the design part, like is written in the process-story, so a lot of outcomes are obtained by a hand in hand situation of both parts of the project. First we describe the problem statements again, to have the goals clear, followed by some engineering questions. Among others, this gives us a basis for the description of the conditions the design has to have finally. Spatial conditions supplements these description.

**Problem statement (from urban view)**
How is it possible to realise a building which contributes to the cultural ambitions of the city, as an extending floating boulevard, which could change its position to make a connection between the north and south IJ bank.

**Design assignment**
Designing of a floating cultural boulevard which could change from position and becomes a connection, or bridge from north to south.
In the 2nd semester (MSc-4), I focused on a part of this big floating boulevard: the theatre.

**Engineering questions:**
Learning more about floating buildings,
how it works,
how to reach acceptable stable situations, especially in relation to the possible adaptability of the design.
how to calculate stability, combination of floating body and upper-works
What kind of flexibility/adaptability of functions.
Does the building exist of one or more volumes?
How does parts moving?
How are parts connect to each other?
How can we guarantee stability?
What is the main- and a substructure?
What about infrastructure like electricity, gas, drainage?
5.1 RESEARCH – conditions

How to design waterproof?
Last two questions are more questions for another research, but of course always give us conditions to take into account.

Possible systems to use: dock-principle, along rails, by cables, by motors, bridge-principle. This was set as a starting point after the P2.

Displacements
On water displacements will occur by 3 possible loads:
- Changings of variable loads, like the movement of people.
- The continue changing load of the wind (think about storm-situations)
- Waves of water and swell.

More information
Speed water IJ: 0,1m/s
Maximum draft: 4,5m
Maximum rotation: 1°

Literature list
Kamerling, M.W. - Het ontwerpen van pontons voor drijvende gebouwen - (faculty of Architecture, TU Delft) 2005
Vries, J.H.C. de - Moveo Stabilis sum - (faculty of Architecture, TU Delft) 2011 (research and design report P1)
Winkelen, M. van - how high can you float - (faculty of Architecture, TU Delft) 2007 (graduation report)
Cement:
CES-software database

These are the forces which have any effect on the buildings construction. As an extra variable load, and therefore a difficulty, is that the building has to deal with the movements of water. Both loads from waves, as the continuous changing swell.
5.2 RESEARCH – design possibilities

What is the relation between building and water?
What are the shapes of the floats?
Is there one big float, pontoon?
How much floating bodies are desirable?
Is it one big building, or does it exist of several parts?
How are they connected to each other?

Right: the development of the floating parts in cross sections.
Left: possible places of floats in overview.

HORIZONTAL SECTIONS

CROSS SECTIONS

covered outer space

 Incredible catamaran
5.2 RESEARCH – design possibilities

LONGITUDINAL SECTIONS

Left:
- How are several parts connected to each other?
- What type of connections?
- Is the building one big pontoon, one big building?

Right: alternative designs
- Right-top: cross-section truss (we see it later on); how does it act?
- Right-middle: hinge situation with limit of rotations, subfloats acting separate
- Right-down: same as before, hinge situation with bigger turning-circle

IMPOSSIBLE;
- unstable, will collapse

IMPOSSIBLE;
- not really connected

IMPOSSIBLE;
- too much torsion (because of two hinges on one body

POSSIBLE;
- but big overhangs

POSSIBLE;
- but strong hinges needed because of transferring huge forces

POSSIBLE;
- most easy / logical way
The Queen Emmabridge (also called 'swinging old lady or 'pontjesbrug')
is een recognizable pontoonbridge in het centre of Willemstad (Curacao). De bridge has a length of 168 meter and is nowadays the only floating wooden turning bridge in the world. The bridge exist of 16 pontoons.

(pictures.traveladventures.org)

Leftdown: American temporary bridge on the river Inn (1945)
(http://nl.wikipedia.org/wiki/Pontonbrug)

Rightdown: A design vision called N A P Amsterdam by Rietveld Landscape.
“a temporary flexible floating park in the IJ, Amsterdam”
“creates a new public domain in the heart of the old city”
“The grid generates flexibility because it can easily be expanded and decreased in size by changing the number of connected barges”
Leftdown:
Yumemai Bridge (2001), Osaka, Japan
This is a floating bridge
Middle: Mooring system of the bridge
Middle-left: pontoon

Right-top, Rightdown:
Floating bridge for the Malediven,
designed by RoyalHaskoning
5.3 RESEARCH - Bernoulli

\[ P_1 + \frac{1}{2} \rho v_1^2 + \rho g A_1 = P_2 + \frac{1}{2} \rho v_2^2 + \rho g A_2 = \text{constant} \]

potential energy / unit volume = \( \rho g A \) (density \( \times \) gravity \( \times \) area)

kinetic energy / unit volume = \( \frac{1}{2} \rho v^2 \) (half \( \times \) density \( \times \) speed\(^2\))

Bernoulli’s principle states that for an inviscid flow, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid’s potential energy.

This law tells us that there is always an equilibrium between different data points measured in flows of fluids or gases.

Close before the reduction of a ‘flow section’ (or height), the pressure will increase, and when the water finally reaches the ‘narrowing’, the pressure reduces to normal level or lower, because there is no blockade or narrowing anymore. Only the pressure from behind will give the water an extra flow, so speed.

\[ A_1 = 120 \times 5 = 600m^2 \]

one big pontoon situation: \( 120 \times 2 = 240m^2 \)

(less draft because bigger area, about 3m)

earlier design: \( A_2 = (12.5 + 17.5 + 17.5 + 12.5) \times 5 + (120 - (12.5 + 17.5 + 17.5 + 12.5)) \times 1 = 360m^2 \)

(after calculations of loads and draft, the area of the floats had to increase so that this \( A_2 \) had been smaller in reality)

final design: \( A_2 = (5.75 + 16.5 + 21.5 + 16.5 + 5.75) \times 5 + (120 - (5.75 + 16.5 + 21.5 + 16.5 + 5.75)) \times 1 = 384m^2 \)
5.3 RESEARCH — Bernoulli

\[ A_1 = 120 \cdot 5 = 600 \text{m}^2 \]
\[ A_{2 \text{ pontoon}} = 480 \text{m}^2; \frac{240}{600} = 40\% \]
\[ A_{2 \text{ final design}} = 384 \text{m}^2; \frac{384}{600} = 64\% \]

\[ P_1 + \frac{1}{2} \rho v_1^2 + \rho g A_1 = P_2 + \frac{1}{2} \rho v_2^2 + \rho g A_2 = \text{constant} \]
\[ (\text{and suppose } v_2 = 1 \text{m/s}) \]

\[ P_1 + \frac{1}{2} \rho v_2^2 + 600 = P_2 + \frac{1}{2} \rho \cdot 1^2 + 384 = \text{constant} \rightarrow P_2 = 0.68 \cdot P_1 \]

The deeper the water, the smaller the difference comparatively

- **Situation A**
  1. act as an inlet
  2. very turbulent water
  3. dangerous swirls
  4. much horizontal waterpressure
  5. with storm extra pressure from wind
  6. difficult to hold the pontoons on its position, because of the amount of waterpressure

- **Situation B**
  1. form floats regulate flow of water (aerodynamic form)
  2. less horizontal waterpressure because of form
  3. less obstacle(s) for water to flow further on
  4. less material needed
  5. also windflows will flow better along the masses, so give less pressure on building

From the knowledge we have about water, -flows and -transport, translated into for example the Bernoulli’s principle, we know that such a blockade in situation A, with that strong reduced permeability of water lead without doubt to problems. First it causes an enormous pressure on the float, because the pontoon as a whole works as a sort of valve, like we see at inlets, civil works in polders. Besides this more problems will take place, summarized in the table above.
5.3 RESEARCH – Bernoulli

FORM FOLLOWS FUNCTION

The form of the floats is not only dependent on the story of last pages: the flow of the IJ water. Also the ability to move the building ask us to find a good way to deal with. The movements are from boulevard situation to the situation of a connection/bridge over the water, but also for movements to a random location somewhere else. Like the port of Rotterdam, and its municipality has their own ship to have their formal and informal meetings on, the ‘Nieuwe Maas’, this floating building could also use as a ‘party-ship’. Or during the possible Floating Olympics of 2028 it could be used for several purposes.

For these limited movements and limited shipping distances with a low speed, but they are there, is it wise to design these floats well. After talkings with a Maritime Engineer we came to the conclusion that optimization to costs and practical form is more important than use they optimum frictional resistance. However, for low speeds, the frictional resistance is dominant for the propulsion, in contrast to high speeds. Then the wave resistant is dominant, what means to design a slim form. Now we can deal with a length-width ratio of 1:5 (like working boats, pontoons mostly have). High speed boats like fregats have a ratio about 1:8. Lowest speed boats around 1:3. The whole building will change from position by tugboats.

Right picture shows us the best form to get the lowest friction value.

The drop (‘druppel’) gives the best shape.
CORE
Loadbearing area (main two floats): \(3188 \, m^2\)
\((30 \times 50 + 2 \times 45 \times 18.75)\)
Surface two core-floats: \(2 \times 1000 = 2000 \, m^2\)

WING
WING 1 = WING 2: \(922.5 \, m^2\)
\((22.5 \times 35 + 3.75 \times 36)\)

The ratio between the load of the core and the load of the wing, will be the same ratio as the \(m^3\) of displaced water between core and wing.

\[
\frac{922.5}{3188} = 0.289
\]
Loadbearing surface of a WING is equal to 0.289 times the loadbearing surface of the CORE, so the surface of a subfloat is \(0.289 \times 2000 = 600 \, m^2\)
This 600\(m^2\) is correct when the draft of all floats are the same.

Right picture asked us the question why the subfloats are not positioned at the end of the wing.
Because of the bending of the truss it is better to place the subfloat somewhat back, so that the length and its possible deformation will reduce. The overhang will contribute to this reduction.
Also for design reasons it is more desirable to lay the subfloat back from the end of the wing.
5.4 RESEARCH – structural design
5.4 RESEARCH – structural design
5.4 RESEARCH – structural design
All loads together. All these loads were continuous changing during designing. Big fluctuations are possible with the weight of the pontoon, which is also needed to get the right draft and stability.

More detailed load-determinations are in the Appendix.

Rule of thumb deadload construction:
10kN/m²

<table>
<thead>
<tr>
<th>loads core</th>
<th>information</th>
<th>loads</th>
<th>total loads</th>
<th>comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEAD LOADS</td>
<td>(kN/m²)</td>
<td>(kN)</td>
<td>(kN)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>roof</td>
<td>staalplaatbeton</td>
<td>2,5</td>
<td>8343,75</td>
</tr>
<tr>
<td></td>
<td>floor</td>
<td>staalplaatbeton</td>
<td>2,5</td>
<td>8343,75</td>
</tr>
<tr>
<td></td>
<td>facade</td>
<td>composites</td>
<td>0,1</td>
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</tr>
<tr>
<td></td>
<td>inner walls</td>
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<td>0,15</td>
<td>500,63</td>
</tr>
<tr>
<td></td>
<td>Loadbearing structure</td>
<td></td>
<td>0,6</td>
<td>352,25</td>
</tr>
<tr>
<td></td>
<td>soffit</td>
<td></td>
<td>0,6</td>
<td>548,25</td>
</tr>
<tr>
<td></td>
<td>TOTAL without floats</td>
<td></td>
<td></td>
<td>27668,08</td>
</tr>
<tr>
<td></td>
<td>Floats</td>
<td></td>
<td></td>
<td>5526,13</td>
</tr>
<tr>
<td></td>
<td>TOTAL dead loads</td>
<td></td>
<td></td>
<td>80048,21</td>
</tr>
</tbody>
</table>

| VARIABLE LOADS | (kN/m²) | (kN) | (kN) |
| | roof | staalplaatbeton | 0,56 | 1868,09 | 0,05 |
| | floor | green | 0,5 | 1337,5 | 0,05 |
| | facade | composites | 0,15 | 141,25 | 0,01 |
| | inner walls | | 0,6 | 352,25 | 0,01 |
| | Loadbearing structure | | 0,6 | 548,25 | 0,07 |
| | soffit | | 0,6 | 143,09 | 0,02 |
| | TOTAL without floats | | | 2354,13 | 0,34 |
| | Floats | | | 481,48 | 0,07 |
| | TOTAL variable loads | | | 3541,61 | 1 |

<table>
<thead>
<tr>
<th>loads wing</th>
<th>information</th>
<th>loads</th>
<th>total loads</th>
<th>comparison</th>
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</thead>
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<td>(kN)</td>
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<tr>
<td></td>
<td>roof</td>
<td>staalplaatbeton</td>
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<tr>
<td></td>
<td>floor</td>
<td>green</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>facade</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>inner walls</td>
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<td></td>
<td>Loadbearing structure</td>
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<tr>
<td></td>
<td>soffit</td>
<td></td>
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<td>TOTAL without floats</td>
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<td></td>
<td>9153,38</td>
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<td>Floats</td>
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<tr>
<td></td>
<td>TOTAL dead loads</td>
<td></td>
<td></td>
<td>9634,86</td>
</tr>
</tbody>
</table>

| VARIABLE LOADS | (kN/m²) | (kN) | (kN) |
| | roof | staalplaatbeton | | | |
| | floor | green | | | |
| | facade | | | | |
| | inner walls | | | | |
| | Loadbearing structure | | | | |
| | soffit | | | | |
| | TOTAL without floats | | | 2354,13 | 0,34 |
| | Floats | | | 481,48 | 0,07 |
| | TOTAL variable loads | | | 3541,61 | 1 |

5.5 RESEARCH – design analysis
5.5 RESEARCH – design analysis

The development of the counter force. The subfloat will give a counterreaction, equal to the load of (a part of) the wing. At a certain moment (picture 5 and 6) change the situation from compression to tension for the bottom beams. The moment

Without any subfloat, the critical places are draw in left-down picture. The connections from wing to core are normative because of the biggest occurring stress.
Left the situation without centre floats. Right that one without subfloats. The most perfect situation would be that one, when last graph happens. The moments and stresses are at the tops of the curves the lowest of all possible situations.
LONGITUDINAL ROTATION BY PEOPLE

What will be a maximum rotation caused by people. This situation is created when at the end of the building a lot of people stands together, and when the rest of the building is free of anyone. Maybe this is possible when at a moment a big group entering the building, for example during a big event.

I take an area of 30m times 20m, which is 600m². Let’s say that one person needs 1m². So at the end of a wing 600 persons standing close to each other.

When one person is about 75kg; 600 person are together $600 \times 75 = 45000kg = 450kN = F_v$

First hypothesis: 450kN compared with 9000kN deadload of the building will not give that big rotation, at least smaller than the maximum of 1°

Moment = Force times arm, like the lever principle.

The final rotation we find, is dependent on the chosen $e$ value. This means what distance of arm we choose. What is the moment-centre-point, and what place reacts the counter reaction.

The above pictures shows us the questionable $e$-value, and the mass-centre points ($a$).

Rotation:

$$\alpha = \frac{M_{tot}}{C} = \frac{M_{rep}}{F \cdot mc} = \frac{(n/n-1)\cdot M}{F \cdot mc}$$

$$M_{rep} = F \cdot e$$

$$M_{tot} = \frac{(n/n-1)\cdot M}{F \cdot mc}$$

$$C = F \cdot mc$$

$$mc = \frac{b^2}{12d + \frac{1}{2}d}$$

$$n = mc/a$$

$$a = \frac{(F-a)}{\Sigma F} = \frac{(15710+15+27868+15+52680+2.1)/(15710+27868+52680)}{7.94}$$

The value of $a$ is 7.94

$b = 120m$

$d = 4m$

$e = 50m (!)$

$F = \text{total dead load building} = 90000kN$

$F_v = 450kN$

$mc = \frac{(120^2)(12-4) + 15}{2} = 302$

$n = 302 / 7.94 = 38.0$

$M_{rep} = 450 \cdot 50 = 22500 kNm$

$M_{tot} = (38.0/37.0) \cdot 22500 = 23130 kNm$

$C = 90000\cdot302 = 27180000kNm$

$$\alpha = \frac{M_{tot}}{C} = \frac{23130}{27180000} = 8.5 \cdot 10^{-4} \text{ rad}$$

$x = 17.5m$

$11m$

$5.5m$

$\text{level 0}$

A rotation of 0.05 is far beyond the allowable rotation. But this is not the real situation. The $e$-value in above calculation is chosen a half of the length, because this is the turning axis.

Another calculation, faster, is that one of the operation of the subfloat.

The questionable $e$-value, now reduced because of the subfloat

This calculation has a view at the increased force, and the counter-reaction of the subfloat, which is required.

Area of a subfloat: 600m²

Water has a density of about 1000kg/m³

So, with an incidental load, in this case people, of 450kN=45000kg, an extra counter-reaction is needed of 450kN 45000/1000 = 45m³ displacement of water gives this counter reaction 45m³ devided over 600m² (45/600) gives an displacement downwards of 0.075m, so 7,5cm.

The rotation of the building that belongs to this displacement is $\tan (\alpha) = 0.075/60 (=1/2 times total length) = 0.072°$

We see her almost the same rotation, but bigger because we did not take the effect of the right centrefloat into account.
LONGITUDINAL ROTATION BY WIND
ULTIMATE LIMIT STATE
windload + deadload+ instantaneous load, safety class 3 (many people)
Afloats = 2000m²
y = 10
d = measured of core part = F / A • y
d = (1.2 • 46000 + 1.2 • 50000 + 1.5 • 8000) / (3200 • 10) = 4.0m
freeboard centre floats: 6 - 4 = 2m
a = (F / A) / y = (1.2•46000+1.2•50000+1.5•8000)/3200=10.9

Fbuilding = 46000kN ; Ffloat = 50000kN ; Finstantaneous = 8000kN
a = 10.9
d = 4.0
M = 1.5 • 200kN • 14m = 4200kNm
mc = (b²/12d + ½d) = 120²/12•5.6 + 1/2•5.6 ≈ 435.7kNm
n = mc/a = 435.7/10.9 ≈ 39.7
C = F•mc = 90000•435.7 = 27180000kNm
Mrep = F•e = 4200kNm
Mtot = (n/n-1)•Mrep = (39.7/38.7)•4200 = 4357kNm
α = Mtot / C = 4357 / 27180000 = 1.6 • 10^-4 rad
x°/180•π = rad   --->
1.6 • 10^-4 rad ≈ 0.009°

ULTIMATE LIMIT STATE
deadload + instantaneous load + extreme load on floors, safety class 3 (many people)
Fbuilding = 46000kN ; Ffloat = 50000kN ; Finstantaneous = 8000kN ; Fextreme = 34000kN
d = (1.2 • 46000 + 1.2 • 50000 + 1.5 • 8000 + 1.5 • 34000) / (3200 • 10) = 5.6m
freeboard centre floats: 6 - 5.6 = 0.4m
a = (F / A) / y = (1.2•46000+1.2•50000+2.1•1.5•8000+2.1•1.5•34000+12)/46000+50000+8000+34000 = 11.4
mc = (b²/12d + ½d) = 120²/12•5.6 + 1/2•5.6 = 217
n = mc/a = 217/11.4 = 19

5.6 RESEARCH – design calc.

VARIABLE LOADS

<table>
<thead>
<tr>
<th>information</th>
<th>length</th>
<th>width</th>
<th>depth</th>
<th>measurements</th>
<th>loads</th>
<th>specific load</th>
<th>total loads</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(m)</td>
<td>(m)</td>
<td>(m)</td>
<td>(1 x h) (m²)</td>
<td>(kN/m²)</td>
<td>(kN/m²)</td>
<td>(kN/m²)</td>
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<td>Extreme variable loads on floors</td>
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<td>3337.5</td>
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<td>(event buildings)</td>
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<td>Extreme variable loads on roof by snow</td>
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<td>1800</td>
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<tr>
<td>(event buildings)</td>
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<tr>
<td>Instantaneous variable loads on floors</td>
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<td></td>
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<tr>
<td>(event buildings)</td>
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<tr>
<td>TOTAL instantaneous loads</td>
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WIND LOADS

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<th>Cpe / Cdim</th>
<th>Ceq</th>
<th>measurements</th>
<th>loads</th>
<th>specific load</th>
<th>total loads</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1 x h) (m²)</td>
<td>(kN/m²)</td>
<td></td>
<td>(kN/m³)</td>
<td>(kN)</td>
<td>(kN/m²)</td>
<td>(kN/m²)</td>
</tr>
<tr>
<td>Fw pressure</td>
<td>= pressure + Psuction + Pf friction facade + Pf friction roof</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fw suction</td>
<td>= pw x Cpe x Cdim x Cex x Afrontfacades</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pf friction facade</td>
<td>= pw x Cpe x Cdim x Cex x Afrontfacades</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pf friction roof</td>
<td>= pw x Cpe x Cdim x Cex x Azidefacades</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

pw extreme thrust (kN)
Cpe / Cdim wind shape factor
Cdim factor dimensions building
Cex pressure equalization coefficient

Wind facade short side
<table>
<thead>
<tr>
<th>information</th>
<th>pw</th>
<th>Cpe / Cdim</th>
<th>Ceq</th>
<th>measurements</th>
<th>loads</th>
<th>specific load</th>
<th>total loads</th>
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</thead>
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<tr>
<td></td>
<td>(1 x h) (m²)</td>
<td>(kN/m²)</td>
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<td>(kN/m³)</td>
<td>(kN)</td>
<td>(kN/m²)</td>
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<td>1</td>
<td>200</td>
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<tr>
<td>Fw suction</td>
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<td>0.4</td>
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<td>1</td>
<td>200</td>
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<tr>
<td>Pf friction facade</td>
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<td>0.01</td>
<td>1</td>
<td>1</td>
<td>200</td>
<td>1.4</td>
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<tr>
<td>Pf friction roof</td>
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<td>0.01</td>
<td>1</td>
<td>1</td>
<td>1500</td>
<td>12.5</td>
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<tr>
<td>Total windload</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>
5.6 RESEARCH – design calculations

‘CROSS’ ROTATION

This situation during an event, when a lot of people standing at one long side. So, now we take the cross section and look at the possible rotation by people over the small side.

\[
surface: 15\cdot30 + 2\cdot10\cdot22 + 2\cdot5\cdot23 = 1120m^2 = 1120 \text{ people of 75kg}. \\
1120\cdot75 = 84000kg = 840kN
\]

\[
\begin{align*}
a &= 7.94 \\
b &= 80m \\
d &= 4m \\
e &= 20m
\end{align*}
\]

\[
F = \text{total dead load building} = 90000kN \\
F' = 840kN
\]

\[
mc = \frac{(80^2)(12-4) + \frac{1}{2}\cdot4) = 135 \\
n = 135 / 7.94 = 17.0 \\
M_{re} = 840 \cdot 20 = 16800 kNm \\
M_{tot} = (17.0/16.0) \cdot 16800 = 17850 kNm \\
C = 90000-135 = 1215000kNm
\]

\[
\begin{align*}
\alpha &= \frac{M_{tot}}{C} = 17850 / 12150000 = 0.0015 \text{ rad} \\
x'/180\cdot\pi &= \text{ rad} \quad \Longrightarrow \quad 0.0015 \text{ rad} = 0.08^\circ \\
\delta &= \frac{1}{2}b\cdot\tan\alpha = \frac{1}{2}\cdot80\cdot\tan(0.08) = 0.06m = 6cm
\end{align*}
\]

CONCLUSIONS

- In all directions the building is stable enough on water.
- The rotations caused by people or wind, does not reach by far the maximum of 1°
- Changing situations by extreme variable loads will not cause an insurmountable problem. The freeboard is big enough. The buildings draft is 1.6 more, which is quite a lot, but only happens in situations of extreme loads, during events for example. And there exist still a freeboard after this draft.

Next page: references

Left-top:
Detail of Klimmendaal institute, 
Arnhem 
Koen van Velsen.

Middle-top:
Detail Unilever-building ‘De Brug’, 
Rotterdam, 
JHK Architecten

Right:
Differences in steel-profiles, material properties, and detailing:
background: ‘De Brug’, Unilever building
foreground: ‘De Hef’, bridge, Rotterdam

Left-down:
Steelframe of overhang construction
‘Scheepvaart en Transport College’, 
Rotterdam, 
Neutelings Riedijk
Attention to the amount of profiles they use.
To get a good view on acting stresses and deformations, I have simulate one truss-element in Matrix Frame.
This major truss-element is one of the haviest of all trusses of this design, which leads to the result that the obtained information is normative for all other trusses.

To compare the results of the Matrix Frame model, I first made some handwritten calculations.

About the model.
With this simulation we can show the obtained deformations and stresses. The information I get is useful to get the right, or acceptable steel profiles. We can also see that it is possible to make building on water like this design, grounded on more then one float. Caused by rotations of the building, the counterloads on the floats, from the water, are continuous fluctuating.
This is dependent on the depth of the floats into the water. The amount of water which is moved away caused by the depth of the float is exactly the weight, and with this the force, which gives the counter force that is needed to get the building 'grounded'. This

3 types of modeling:
1 counter reactions
2 elastic foundation
3 pole-foundation

3 amounts of counter reactions subfloat:
1 0kN
2 2200kN (2m depth)
3 4400kN (4m depth)
5.7 RESEARCH – calculation model

All models are made with the same given forces and profiles, like we see in the pictures. These profiles are chosen by trial and error of the model, and are finally set in:

HD400x314, for the main structure
HE400B, for the diagonals.

MODEL 1
modelled with counter forces as foundation

MODEL 2
alternative calculation model
modelled with given elastic support on bottom beams.
The Cz-value of this subgrade reaction is 10 kN/m³, like water.

MODEL 3
alternative calculation model
the poles simulate the water, by giving it a spring value. It acts like a spring

$$\Delta = \frac{(F \cdot l)}{(E \cdot A)}$$
$$E=210; \ A = \text{small}; \ l=10\text{m}; \ I=\frac{1}{2}bh^3 = \text{small}$$

Previous page:
loadbearing area of a truss-element (red shape)
trusses (red lines)
5.7 RESEARCH – calculation model

Calculations by hand

Maximum stress: dependent on steel-quality = 235 N/mm²

From the found dead and variable loads of the building, and the rule of thumb, we set the load to calculate with on 10kN/m².

Two situations are calculating here. The one with the full counterload and the one without any counterload. The range which the output of those two situations gives, is the range of profiles we can choose.

**Situation 1: full counterload from subfloat**

\[ q = 10kN/m² \]
\[ l = 30m \]

2 layers: \( 10kN/m² \times 10m \text{ width} \times 2 = 200kN/m = q \)

\[ 1/8ql^2 = 1/8 \times 200 \times 30^2 = 22500kN/m \]

\[ M = F \times a \text{ (arm)} \rightarrow F = 22500/10 = 2250kN \]

\[ \sigma = N/A \rightarrow 2250 \times 10^3/235 = 9574mm² = 96cm² \]

The profile which provides this is for example **HE240B** (A=10599mm²;G=84,8kg/m)

**Situation 2: no counterload from subfloat. The whole wing is an overhang situation here.**

\[ q = 10kN/m² \]
\[ l = 40m \]

2 layers: \( 10kN/m² \times 10m \text{ width} \times 2 = 200kN/m = q \)

\[ 1/2ql^2 = 1/2 \times 200 \times 40^2 = 160000kN/m \]

\[ M = F \times a \text{ (arm)} \rightarrow F = 160000/10 = 16000kN \]

\[ \sigma = N/A \rightarrow 16000 \times 10^3/235 = 68085mm² = 681cm² \]

The profile which provides this is for example **2x HE1000B** (A=40005mm²;G=320kg/m)
5.7 RESEARCH – calculation model

Conclusions:
A situation with a full overhang is undesirable, because than we had to choose a steel construction which is 8x more heavier than without a possible overhang. Between these two extreme values/situations, the building behaves the building, so to choose a right steel profile, the dimensions are somewhere in between.

**Maximum deformation:** $0.004 \cdot l_{\text{rep}}$

$\begin{align*}
l_{\text{rep}} &= 7.5\text{m} \\
0.004 \cdot 7.5\text{m} &= 0.03\text{m} = 30\text{mm}
\end{align*}$

**‘Normal’ situation:**
\begin{align*}
&\frac{5}{384} \cdot \left( q \cdot l^4 / EI \right) \\
&q = 200 \text{kN/m} \\
l &= 7500\text{mm} \\
&E = 210 \text{GPa} = 210000 \text{N/mm}^2 \\
&I = (\text{choose HE500M}) = 1/12 bh^3 = 161929e10^4 \text{mm}^4 \\
&5/384 \cdot ((200 \cdot 7500^4) / (210000 \cdot 161929e10^4)) = 24.2\text{mm}
\end{align*}$

In the Matrix Frame model we use HD400x314. However, this profile is not find in tables that easy, so I change this for this calculation in a HE500M. HD400x314 is heavier than HE500M and is with this fact acceptable.

**Overhang situation:**
\begin{align*}
&\frac{1}{8} \cdot \left( q \cdot l^4 / EI \right) \\
&q = 200 \text{kN/m} \\
l &= 7500\text{mm} \\
&E = 210 \text{GPa} = 210000 \text{N/mm}^2 \\
&I = (\text{choose HE500M}) = 1/12 bh^3 = 161929e10^4 \text{mm}^4 \\
&1/8 \cdot ((200 \cdot 7500^4) / (210000 \cdot 161929e10^4)) = 232.6\text{mm}
\end{align*}$

By far not realizable. A far more heavier profile is needed here. Also when I choose HE1000M, the deformation is too big (52.2mm), however this is not a real situation, because the overhang is part of a truss system. In this case a big part of the load is led away by the diagonals of the truss. So, let us see what the Matrix Frame model gives us.
5.7 RESEARCH – calculation model

MODEL 1
5.7 RESEARCH – calculation model

First model on previous page shows the result without any counterload from the subfloat. Second model gives a a counterload of 2x 1100kN, and third one of 2x 2200kN

Conclusions:
First model changes at the end of the truss from position 0.13m downwards. In the second model we see that the counterload is probably bigger than the load of the buildingpart that discharges its forces via the subfloat. When the counterreactions of the subfloat are too heavy, like the third model shows us too, the stress of the elements will becomes more large and reducing of the counterload is needed. With trial and error-method I find a wanted situation down on this page. The counterload of the subfloat is 2 times 800kN now, which gives the smallest deformations and stresses in the truss. With the very small rotatings of the building by variable loads, like we saw in earlier calculations, the counterload will not change that much over time. I think that the largest variability in counterload will comes from the swell of the water.

Two things are possible to change the depth or the area of the subfloats, so that the counterforce will reduce. Whether add some weigth to the subfloat to bring the deadload and counterload in equilibrium. Or change the area or the draft of the subfloat and reduce with this action the counterload. When the area of the subfloat stays the same, the associated draft of the subfloat, in best situation like the calculation model down on this page shows us, will be: 
$$d = \frac{2 \cdot 800}{110 \cdot 10} = 1.5\text{m}$$
5.7 RESEARCH – calculation model

MODEL 2

Alternative calculations

Model 2 has to explore more. The output does not really corresponds with other models.

Model 3, with the elastic foundation gives also larger outcomes, however they are just a little larger.
5.8 RESEARCH — evaluation

General conclusions about the structural part of the project.

The results gives us a good example how such a project is realizable. The time I spend on working on the Matrix Frame model was large, but finally I got the right input and results. I had made a sketchdesign in an early stage, what gives you the opportunity to make calculations early, and getting a feeling of the dimensions. To get the right feeling about dimensions, distances between the trusses for example, it was also good to use the example I found in the Unilever building, ‘De Brug’, in Rotterdam.

Recommendations:
The size or scale of the project is huge. This was a challenge therefore. Next time it is wise to keep a project small, as small as possible. Be bold in possibilities to reduce amounts, area’s or spaces. Use in an early stage rules of thumb like 10kN/m² for calculating loads, and simplified always the design situation.
## APPENDIX - loads core

### Wind loads

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### Summary

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### Additional notes

- **Fw friction roof** = $\frac{pw \cdot Cf \cdot Cdim \cdot Cex}{Ceq}$
- **Fw suction** = $\frac{pw \cdot Cf \cdot Cdim \cdot Cex}{Ceq}$
- **Fw pressure** = $\frac{pw \cdot Cf \cdot Cdim \cdot Cex}{Ceq}$

### Notes

- For t.: For pressure + For suction + For friction facade + For friction roof
- For t.: For pressure + For suction + For friction facade + For friction roof
- For t.: For pressure + For suction + For friction facade + For friction roof

### Load distribution

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### Notes

- **pw** = wind pressure
- **Ceq** = equivalent load factor
- **Cdim** = dimension factor
- **Cex** = exposure factor
- **Cf** = wind shape factor
- **Fw friction roof** = $\frac{pw \cdot Cf \cdot Cdim \cdot Cex}{Ceq}$
- **Fw suction** = $\frac{pw \cdot Cf \cdot Cdim \cdot Cex}{Ceq}$
- **Fw pressure** = $\frac{pw \cdot Cf \cdot Cdim \cdot Cex}{Ceq}$

### Load calculations

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### APPENDIX - loads wing

#### 1. Wind loads

#### 1.1. Total wind load

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#### 1.2. Instantaneous wind loads

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#### 1.3. Extreme wind loads

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#### 1.4. Dead loads

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#### 1.5. Total loads

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Inspiration: Uros islands, Titicacameer

These islands exist of floating rush and are therefore called ‘islas flotantes’. Nowadays, of the 3000 offspring, a few hundred of them still live on the islands. The island are artificially made, and continuous maintenance is needed to keep the island liveable, otherwise the island will sink. Typically also are the rush boats.
Inspiration: Floating cabins, Khao Sok national park, Thailand
Khao Sok national park, Thailand

In a national park in Thailand, on a lake, one can find these cabin houses, or what I read somewhere else: raft houses. This means that we are talking about floating houses, and floating bodies. Raft could also be explained as wooden floats, like we see on the pictures. It’s all and only of different wooden materials: wood, trees, bamboo, cane and rush. Strong wood as the floating body, lightweight cane and rush as the upper part. They are all together connected to a wooden scaffolding. Just amazing!
Inspiration: floating park

Floating Spa, Amsterdam
- still ongoing
- Plan for a wellness spa in the form of an island in the lake IJmeer (Amsterdam) fully covered by vegetation, 2,000 m²
- Designed by Anne Holtrop, commissioned by Studio Noach

(www.studionoach.nl)
(http://www.anneholtrop.nl/home.html)

- free forms possible
- multiple use of space (above and below roof)
- green roofs
- beautiful inner spaces
- openings possible to wanted direction
A design vision called NAP Amsterdam. "a temporary flexible floating park in the IJ, Amsterdam" creates a new public domain in the heart of the old city. The grid generates flexibility because it can easily be expanded and decreased in size by changing the number of connected barges. (http://www.rietveldlandscape.com/en/projects/185)

Inspiration: Rietveld Landscape
Inspiration: Renzo Piano

NEMO, Amsterdam
designed by Renzo Piano (1992-1997)
(http://www.rpbw.com/)
- its materialization
- its reference to the past
- its reference to a ship/harbour
- its platform and sight view
Inspiration: Floating Dwelling

Floating Dwelling designed by Marlies Rohmer (http://www.rohmer.nl/)

- amazing materialization
- many glass
- hsb (= lightweight)

A concrete bin, which has a half part under water level. (sous-l'eau)

synthetic slats cladding
Inspiration: West 8

3 wavedecks, Toronto - its motion - its materialisation - its harbour-feeling

(http://www.west8.nl/projects/all/rees_wavedeck/)
Inspiration: waterfront buildings

left:
unknown building along the water
- way to deal with a possible ongoing route
- multiple use of space
- its orientation

left:
morphotel, a design of a floating hotel.
- possible movement
- sort of bridge-building
- like ships next to each other

right:
design of a Munch Museum by Ghilardi Hellsten Arkitekter
Inspiration: Tadao Ando

above: design of munch museum
left and down: design of a Maritime Museum, Abu Dhabi

above: design of munch museum
right: Naoshima Hotel
Inspiration: Zaha Hadid

right:
design of a waterfront building called 'regium'
- its sculpture
- its fluent lines and motion
- its scale
(http://www.zaha-hadid.com/home)

left:
design of a central hall of the Olympic Games of London, 2012
- its front and openness
- its scale
left: design of a central hall of the Olympic Games of London, 2012
- its front and openness
- its scale

right: stage, stairs at Times Square, New York.
- attractor of people
- nice view on street
Inspiration: 3XN

'Muziekgebouw aan ’t IJ', Concert-building, designed by 3XN
- its open view to the IJ
- its transparancy
- its openness (inside)
- its materialisation

(http://www.3xn.dk/)
left:
- futuristic floating water park
- GRO Architects
- (http://www.groarc.com/)
- its modules
- building as a machine
- free orientation

down:
- floating arc

right:
- decor opera Andre Chenier in
- Constance Lake, Bregenz, Austria

above:
- water-airplane,
  both flying and floating, an
  interesting combination
left:
new boulevard at Benidorm, Spain
	right and next page:
green roofs
Inspiration: floating sport facilities

left top: floating soccer stadium
left down: at the same location changed in a concert stage
right top: Shimizu Port, Shizuoka
middle: Floating Tennispark at the river Thames
right down: Floating Golf Green, Coeur d’Alene Resort
Inspiration: floating stage

floating stage by kyungam architects

- its possibility open-close
- its futuristic appearance

(http://www.designboom.com/weblog/keyword/kyungam-architects.html)
An early example of a floating bridge can be found in our own country. In 1603, the Dutch city Arnhem gets a floating bridge (schipbrug). The city was now more accessible for the farmers from the other side of the river Rhine.

A floating bridge, or maybe a better term: shipbridge, exist of several small ships with on top a floor, where passengers could walk or ride from the one bank to the other side of the river. When a ship on the river would pass the bridge, a part of it could than navigate away so that there was created an opening for ships to continue their trade.

Schipbrug

Pontoonbridges
(images: http://nl.wikipedia.org/wiki/Bruggen_van_Arnhem)
Tijdelijk danwel vast.

Gebruikt door de genie (leger)
Inspiration: pontoons, bridges

Till the beginning of the 20th century, Arnhem has had a floating bridge.

[http://www.yagis.nl/Meijnerswijk/Foto's%20schipbrug..htm]

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Floating Runways for Seaplanes

- To enable take-off of seaplanes with heavy loads—especially the additional fuel which is required for transoceanic flights—a new apparatus has recently been invented to launch them on the water, but not from it. As shown, it comprises a track, supported above the water by pontoons; so that the seaplane is given the advantage, not only of its own power, but also of a mechanical pull. It can maneuver itself, in the water, up the track; and the latter, being pivoted, can turn to the wind at the moment prevailing. The seaplane thus obtains the advantages of land planes, without the added weight of amphibian construction.

It is not, of course, intended for deep-sea operation, like the proposed floating seadomes, but for the quiet water of harbors.

[Proposed seaplane launching tracks. (U. S. Patent No. 2,020,231)]

[Left: (blog.modernmechanix.com)]
Inspiration: pontoons, bridges

The Queen Emmabridge (also called ‘swinging old lady or ‘pontjesbrug’) is een recognizable pontoon-bridge in het centre of Willemstad (Curaçao). De bridge has a length of 168 meter and is nowadays the only floating wooden turning bridge in the world. The bridge exist of 16 pontoons.

Left top: (pictures.traveladventures.org)

Left down: (curacao.web-log.nl)

Right top: (4.bp.blogspot)

Right down: (photo Theo Landman)
Inspiration: pontoons, bridges

Left:
American temporary bridge on the river Inn (1945)
(http://nl.wikipedia.org/wiki/Pontonbrug)

Above:
A temporary bridge on the river Waal, Nijmegen. It was a bridge for pedestrians who were walking the Nijmeegse Vierdaagse (four days walking event)
(http://gisellavanhelteren.web-log.nl)
Inspiration: Yumemai bridge
Inspiration: overhang constructions
Inspiration: Unilever 'de brug'
**Inspiration: Unilever 'de brug'**

**DRAAGSYSTEEM**

Het gebouw bestaat vier bouwlagen van ongeveer 32 x 133 meter. De hoofddragconstructie bestaat uit 2 spanten in het midden en 2 spanten in de gevels (rood). Deze spanten bestaan uit 3 secties van circa 44 meter lengte, waarin 4 schuine liggers lopen. Er is gebruik gemaakt van HD profielen. Uitzondering zijn de gevelspanten van vierkante stalen profielen. De secties zijn compleet gelaste staalconstructies. De 4 hoofdspanten zijn verbonden door liggers met een lengte van 10,8 meter (blauw). Er ontstaat een rechthoek met 36 vierkanten, met zijdes van 10,8 meter, 3 in de breedte en 12 in de lengte. In het midden van deze liggers komt nog een ligger om de gewenste overspanning te realiseren van 5,4 voor de staalplaatvloeren (geel). Voorgaande geldt voor iedere bouwlaag. Het gehele gebouw is een stapeling van kubussen.

Gestart wordt met de 2 binnenspanten, van waaruit de overige spanten met boutverbindingen worden vastgezet, dus stijve verbindingen. Voor extra zijdelingse stijfheid zorgen de schuine liggers die per sectie dwars door de vloeren gaan. Deze kolommen constructie is voldoende dragen. Alle gevelelementen, vloeren, installatie en wanden staan of hangen aan deze constructie. Deze constructie behoefte geen verdere maatregelen om de sterkte, stijfheid en stabiliteit te vergroten. Is ook logisch omdat het gebouw op stutten in elkaar wordt gezet en daarna in zijn geheel verplaatst wordt. Tijdens dat transport moet de constructie al voldoende stabiel zijn.

deBrug bestaat uit een kantoorgebouw van vier verdiepingen met elk een oppervlak van ca.130 meter bij 30 meter. Het niveau van de onderste van deze vloeren ligt op 25 meter boven maaiveld en direct boven het bestaande fabriekscomplex van Unilever. Het totale vloeroppervlak bedraagt 15.700 m² BVO.

Het gebouw is uitgevoerd als een staalconstructie in combinatie met een staalplaatbetonvloer. Doordat het gebouw op slechts drie steunpunten staat zijn in de gevels grote stalen vakwerken nodig. Deze geven het gebouw het uiterlijk van een ouderwetse brugconstructie en vandaar dat het gebouw de naam "de Brug" heeft gekregen. Teneinde de afmetingen van de staalconstructie te minimaliseren is gekozen voor het gebruik van lichtbeton in plaats van grindbeton als druklaag op de staalplaatvloer. Voor de fundament is gebruik gemaakt van een trillingarm en grondverdrijvend paalsysteem."
Inspiration: Klimmendaal, Koen van Velzen
Inspiration: beauty of trusses
Inspiration: hydrofoil boat
Inspiration: mooring systems