Graduation Plan for AE students

Personal Information

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Studio

Name of studio	Architectural Engineering	
Teachers	Teacher 1	Annebregje Snijders
	Teacher 2	TBA
	Teacher 3	Marcel Bilow

Argumentations of choice of the studio:
Throughout the bachelor the main focus was on designing, I found that the technical part was somewhat missing while I find that part very interesting. Therefor I wanted to do a technical master and chose AE over BT because I wanted to implement my technical research in a design and I think AE is the best studio for this.

Title

Building with dunes; a year-round beach pavilion

Graduation Project

Problem Statement

The problem statement is divided into 2 parts:

- Dune disintegration caused by the sea
- Dune disintegration caused by sand blocking

The sea level is rising; according to the deltacommissie it can rise up to 2 meters in just 100 years, which means that without any action land and houses will flood. The most brittle defense systems of our coast are the dunes, dunes are under constant attack from the sea and they disintegrate fairly quickly, the three most common fail mechanisms with dunes are fore dune erosion, flood erosion and dehydration, which are all caused by nature.

In the interdepartmental study of Kust op Koers is pointed out that the grow of the coastal areas is stagnating and that as a perspective to come out of this down going spiral we have to increase the quality of the existing building boundary, by stimulating the own character of these coastal area´s and to stimulate innovation of the touristic sector. Rijkswaterstaat wants to improve the experience and economic value of the coastal area by creating year round pavilions on the beach. This ambition can create another problem for dunes to survive. By creating a long-term building in front of them we cause the building to block sand sedimentation from the beach to the dunes. As a result the dunes will not be able to grow in a natural way.

Objective
The objective is divided into two scales:
- Building scale
- Dune scale

The objectives for the building scale are to create a year round pavilion in front of the dunes, this pavilion should be save and as a result should be able to resist heavy storms and thus be waterproof. Although it is not my main focus point but sustainability should be integrated in the design. because i think nowadays every design should be made in a sustainable way

On the dune scale I want to reduce the damage that is done to them by natural forces and decrease the disintegration of them. However by building in front of the dunes I block the sand sedimentation, this has to be minimized in some way. I see it as a possibility to increase the economic value of the area by creating new surroundings in it. Of course these buildings should be made with respect to nature and their context; it should be an integrated project of building and nature.

Overall design question
How to create a year round pavilion on the beach?

This question can be divided into a couple of sub questions:
How can you make a building waterproof, storm resistant, submersible?
What materials can resist salt water, high humidity and sand?
How can you integrate the building with its context?
How to integrate sustainability with all these extra restrictions?

Technical Research Question
My technical research question is more focused on the dune scale and its surroundings:
In what ways can a beach pavilion contribute to the protection and maintenance of dunes and how can this be integrated in a design?

Methodologies
The methods I am using in my research are a literature study for all the facts and regulations around beaches and dunes, some reverence projects for different techniques I might want to implement and research by design to come up with different solutions / alternatives and to see how it will all comes together.

Planning

week	schoolweek	Planning
36	1.1	*Introduction; brainstorm graduation topic*
37	1.2	*Presentation pavilion*
38	1.3	*Presentation collage; research context*
39	1.4	*Writing graduation manual; research dikes; narrowing down the context*
40	1.5	*Studies on different water protection systems*
41	1.6	*Dune studies; sea water behavior*
42	1.7	*Sea water behavior; wind*
43	1.8	*Preperations P1*
44	1.9	P1
45	1.10	*Relection*
46	2.1	*Testing research*
47	2.2	*Form research*
48	2.3	*Research on integration of sustainability*
49	2.4	*Sustainability*
50	2.5	*finalising*
51	2.6	*Final research paper*
52		
1		
2	2.7	*P2 preperations*
3	2.8	P2
4	2.9	*sketch design*
5	2.10	*maquettes / rough floorplans*
6		
7	3.1	*3D modelling*
8	3.2	*Reflection on research / new research*
9	3.3	*Climate design; calculation; structural design*
10	3.4	*details*
11	3.5	*putting together*
12	3.6	*finalize preliminary design*
13	3.7	*P3 preparations*
14	3.8	*P3*
15	3.9	*Reflection on feedback*
16	3.10	*finalising*
17	4.1	*finalising*
18	4.2	*finalising*
19	4.3	*maquette*
20	4.4	*P4 preparations*
21	4.5	P4
22	4.6	*P4 reflection*
23	4.7	*Rendering*
24	4.8	*finishing*
25	4.9	*P5 preperations*
26	4.10	P5
27	4.11	*reflection*

Relevance
The relevance of this research is that it contributes to the knowledge of building in an outer dike area. It will give an idea on how different problems in this area can be solved. The interest of Rijkswaterstaat in building on the beach and their ambition of increasing the economic value are making it an interesting research. I hope to contribute by giving some insight on how to make a submersible and waterproof building, in combination with building from a nature's point of view; how can I contribute to the system instead of minimizing the damage?

Literature

Athanassoulis, G.A. & Mamis, K.I. (2013) *Modeling and analysis of a cliff-mounted piezoelectric sea-wave energy absorption system*. Coupled systems mechanics 2(1)

Bergen (2009) *Jaarrond exploitatie van jaarrond strandpaviljoens gemeent Bergen.*

Delta commissie (2008) *Samen werken met water; Toelichting op door de deltacommissie gebruikte klimaatscenario's.* Deltacommissie: Den Haag

Deltares*. Interactive program Open Earth*. Retrieved 23-12-2013 From http://test.kustviewer.lizard.net/kml/

Ecomare (2012) *De erosie van de Nederlandse kust.* Retrieved 23-12-2013 From http://www.zeeinzicht.nl/vleet/index.php?id=4292&template=template-vleetned&language=0&item=De-erosie-van-de-Nederlandse-kust

ENW (2013) *Bedreigingen en faalmechanismen*. Retrieved 23-12-2013 From http://www.enwinfo.nl/asp/content.asp?DocumentID=4#anchor4

Haney, P. (2011) *Aerodynamic drag*. Retrieved 23-12-2013 From http://www.insideracingtechnology.com/tech102drag.htm

Hoedemaker, A.Th.M (2008) *Zandvoort strand en duin.* RBOI: Rotterdam

Jong, E. de (2010*) Een analyse van het windklimaat in Nederland. Universiteid van Amsterdam*: Amsterdam

Ministerie van verkeer en waterstaat (2000) *3e kustnota; Traditie, trends en toekomst.* Snoek - Ducaju & zoon: Gent

Prigg, M. *Is the 'hairy skyscraper' the future of cities? Radical eco-design covered in energy generating fibres revealed*. Retrieved 23-12-2013 From http://www.dailymail.co.uk/sciencetech/article-2328938/Is-hairy-skyscraper-future-cities--Radical-eco-design-covered-energy-generating-fibres-revealed.html

USGS (2004*) Coasts: sand and dunes.* Retrieved 23-12-2013 From http://geomaps.wr.usgs.gov/parks/coast/dunes/

Vosatka, E.D. (1970*) Observation on the swimming, righting and burrowing movements of young horseshoe crabs, limulus polyphemus.* Ohio journal of science 70(5)

Waterloopkundig laboratorium Delft (1982) *Rekenmodel voor de verwachting van duinafslag tijdens stormvloed.* Waterloopkundig laboratorium: Delft

Architectural Engineering
Technical researchpaper

Building with dunes,
A year-round beach pavilion

Student: Bouke Bosch
1352326

Tutors: Annebregje Snijders
Marcel Bilow

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1. Abstract

This report is about finding an answer on how we can build a year round pavilion in front of the dunes in order to increase the recreational value of the area. It deals with the problem of how to solve the sand sedimentation blocking that occurs when a building is placed in front of a dune and tries to implement ways on how to contribute to the protection of the dunes.

The coast of the Netherlands is under constant attack of the forces of nature; especially the dunes can take a lot of damage in times of storm. New improvements in the coastal defense system can decrease the amount of this degradation. By protecting the dunes against the sea in some way the dunes will degrade less quickly and the amount of sand supplementations on the beach can be decreased.

There are plenty of places at our coast where dune degradation is a problem, however not every spot on the beach is allowed for year round pavilions to stand. These pavilions are only allowed near a beach town or a recreation point and these spots are normally chosen because of the strong defense system they already have.

Another factor in this report is how nature and building can be integrated in a design. The beach is a very dynamic place where nothing stays the same, a building placed in this context should be able to adapt to its surroundings and circumstances. Sustainability is also a factor on how an adaptable building can be realized, by implementing the right techniques like piezoelectric energy generation the building can really blend into its dynamic location.

2. Background

2.1 Problem statement

The problem statement is divided into 2 parts:

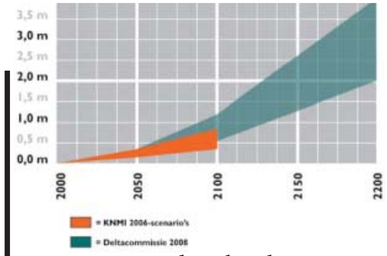
- Dune disintegration caused by the sea
- Dune disintegration caused by sand blocking

The sea level is rising; according to the deltacommissie it can rise up to 2 meters in just 100 years[1], which means that without any action land and houses will flood. The sea defense system will continuously be in need of improvement. Our coastal area has some weak links in the defense system as is shown in figure 2.3 All the red lines are weak spots in our coast. Most of these areas have been reconstructed and meet the safety regulations at the moment; although most of these improvements are just meeting these regulations for the next 50 years, after which new improvements are necessary. What does this mean for the dunes? Dunes are under constant attack from the sea and they disintegrate fairly quickly. The three most common fail mechanisms with dunes are fore dune erosion, flood erosion and dehydration; these problems will be elaborated later on.

Especially in times of storm the dunes are very brittle. At the coastal areas in the Netherlands there is an increasing amount of storms a year and the average speed of these storms is also increasing; at the moment there are on average 4 storms a year. We speak of a storm when there is a minimal wind speed of 20.8 m/s or wind force 9. The average wind speed at the coast is around 7.5 m/s.[2]

In the interdepartmental study of Kust op Koers is pointed out that the grow of the coastal areas is stagnating and that as a perspective to come out of this down going spiral we have to increase the quality of the existing building boundary, by stimulating the own character of these coastal area´s and to stimulate innovation of the touristic sector.[3] Rijkswaterstaat wants to improve the experience and economic value of the coastal area by creating year round pavilions on the beach. This ambition can create another problem for dunes to survive. By creating a long-term building in front of them we cause the building to block sand sedimentation from the beach to the dunes. As a result the dunes will not be able to grow in a natural way.

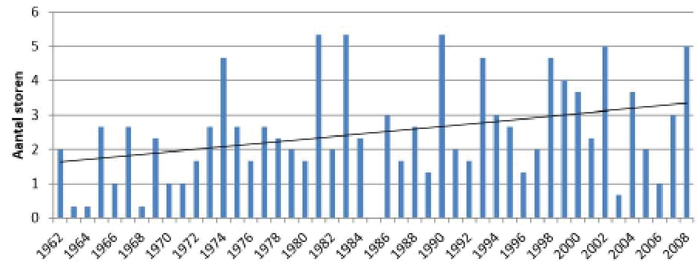
1 Delta commissie (2008) p115
2 de Jong (2010) p14-21
3 Hoedemaker (2008) p14



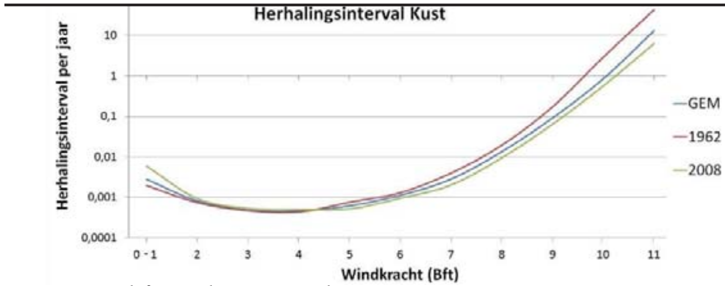
2.1 Estimated sealevel rise


2.2 Flooded house

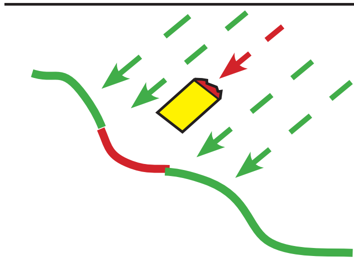
2.3 weak links dutch coast



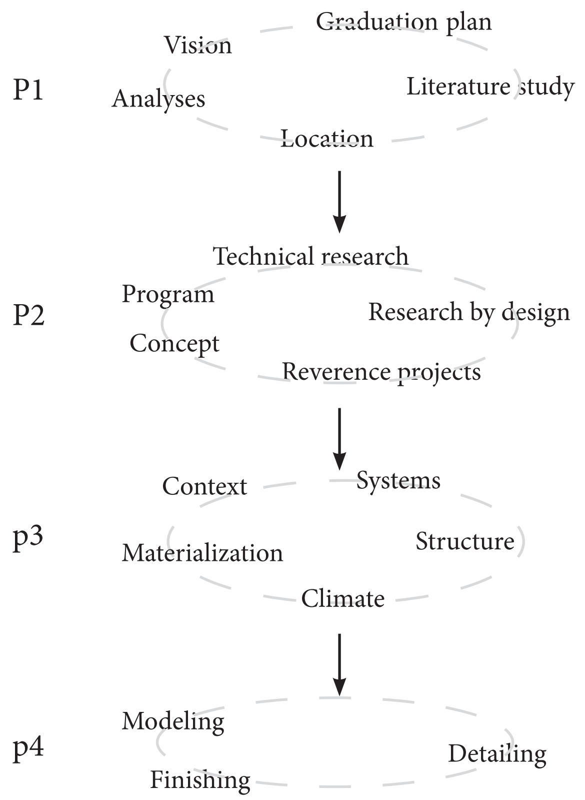
2.4 Amount of storms at the coast



2.5 Wind force division at the coast


2.6 Sand sedimentation blocking


2.6 Dune stopped growing



2.7 Work division

2.2 Objective

The objective is divided into two scales:

- Building scale
- Dune scale

The objectives for the building scale are to create a year round pavilion in front of the dunes, this pavilion should be save and as a result should be able to resist heavy storms and thus be waterproof. Although it is not my main focus point but sustainability should be integrated in the design. because i think nowadays every design should be made in a sustainable way

On the dune scale I want to reduce the damage that is done to them by natural forces and decrease the disintegration of them. However by building in front of the dunes I block the sand sedimentation, this has to be minimized in some way. I see it as a possibility to increase the economic value of the area by creating new surroundings in it. Of course these buildings should be made with respect to nature and their context; it should be an integrated project of building and nature.

2.3 Research questions

My technical research question is: In what ways can a beach pavilion contribute to the protection and maintenance of dunes and how can this be integrated in a design? This is more on a dune scale and focused on the surroundings. For my design research I am more interested in the building scale: How to create a year round pavilion on the beach? This question can be divided into a couple of sub questions: how can you make a building waterproof, storm resistant, submersible? what materials can resist salt water, high humidity and sand? How can you integrate the building with its context? How to integrate sustainability with all these extra restrictions?

2.4 Relevance

The relevance of this research is that it contributes to the knowledge of building in an outer dike area. It will give an idea on how different problems in this area can be solved. The interest of Rijkswaterstaat in building on the beach and their ambition of increasing the economic value are making it an interesting research. I hope to contribute by giving some insight on how to make a submersible and waterproof building, in combination with building from a nature's point of view; how can I contribute to the system instead of minimizing the damage?

3. Method

The methods I am using in my research are a literature study for all the facts and regulations around beaches and dunes, some reverence projects for different techniques I might want to implement and research by design to come up with different solutions / alternatives and to see how it will all comes together.

4. Results

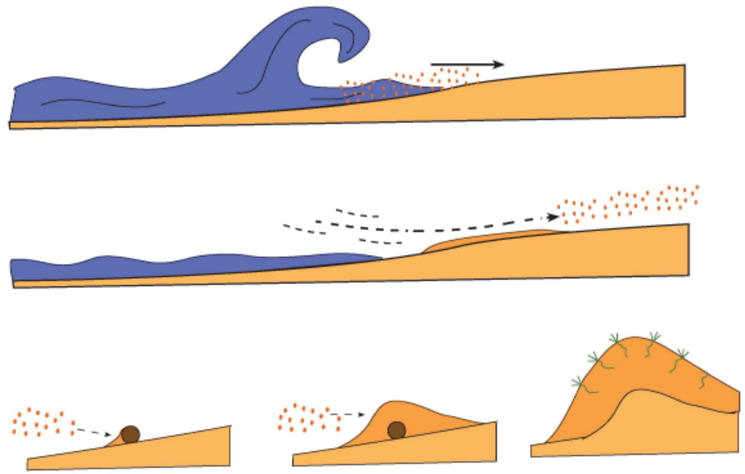
4.1 Dunes

4.1.1 Dune formation

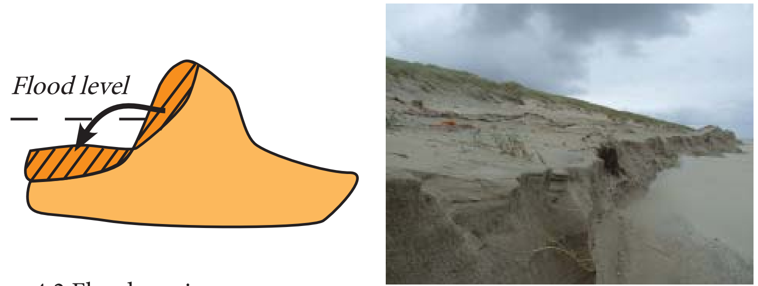
Dunes are big piles of sand created by the wind and sea. It starts with a wave breaking on the shoreline, the impact of this wave causes the sand on the beach to get loose. When the tide is falling and the sun dries out the sand it becomes very light loose sand. The wind on the beach is blowing most of the time in a land inwards direction; this causes the sand to be blown inland. On the beach there are multiple obstacles where sand could stay behind, at some point one of these obstacles will hold so much sand that it will create a lump of sand which will consequently hold more sand; this will continue until there is a large pile of sand. The nutrient poor fresh water in the ground makes it able for sand reed to grow. These plants give stability to the dunes and cause the sand to stick together as well as catch more sand to repair the dune or to grow it even further. [1]

4.1.2 Fail mechanisms

Dunes disintegrate fairly quickly, the three biggest problems are Flood erosion, dehydration and fore dune erosion. Storm or flood erosion is the biggest problem for dunes, although this problem mainly happens in times of storm, it can cause some severe problems. What happens is: when a wave gets all the way to the dunes and it breaks on one of them it could take away big chunks of sand causing the dune to deform. The seaward force of the sea takes away the sand and drops it somewhere on the beach or takes it even further back. The dune formation system will bring some of the sand back to the dune, but it takes time to become as big as it was. The results are thus height loss, weight loss and possible dehydration.[2]

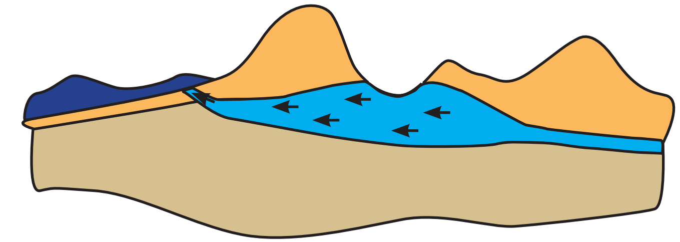


4.1 Dune formation in steps



4.2 Flood erosion

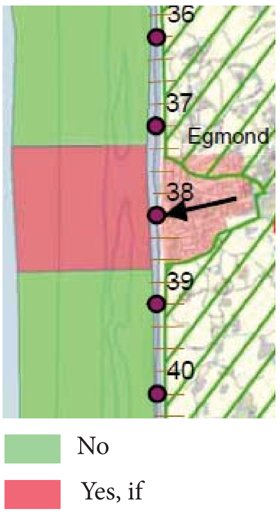
1 USGS (2004) www.usgs.gov
2 ENW (2013 http://www.enwinfo.nl



4.3 Dehydration

4.4 Foredune erosion

4.4 Eolic sedimentation



4.5 Possible locations Egmond

4.6 Flood erosion Egmond

Dehydration is the second fail mechanism. Right below the dunes there is a big buffer of fresh groundwater situated; this is nutrient poor water and makes it able for dune vegetation to grow, this gives stability and strengthens the dunes. However when a wave breaks on the shoreline it can damage the sand barrier to the fresh ground water. Since fresh water floats on salt water this will cause the fresh water to be sucked out of the ground and float on top of the salt water where it will disappear. As a result dune vegetation will not be able to live on the dunes and will decrease the stability of the dunes. They tried to solve this problem by putting eutrophic river water in the ground however dune vegetation need nutrient poor vegetation and weed takes over.[1]

The last fail mechanism addressed in this paper is fore dune erosion. This causes sand on the beach to disappear and shortens or lowers the beach. There are two different sorts: eolic erosion and marine erosion. Eolic erosion means that sand is blown away from the coastal area by wind; it is simply blown over the dunes or in the sea. Marine erosion is erosion caused by the sea and tidal change. This can create small cliffs like you see on the picture.

Sand is added to the beach by either wind or sea forces. Eolic sedimentation is the basis of dune formation however on unwanted spots it can create problems, in front of a building for example or on the beach where it might form a new dune while it should be blown to the actual dune behind it. It is the base for dune formation and by building in front of the dune this formation is blocked for the part of the dune that is directly behind the building. Another form of sedimentation is marine sedimentation; this is sedimentation which is mainly formed by the overall water direction. As a result structures like groins cause the sand to pile up on one side and cause erosion on the other side; this gives the beach an uneven form.

4.2 Location

The design is about giving a general solution for the given problems with building in front of dunes; it should not be pinpointed to a location, however in order to come to a good integrated design in its surroundings a location is needed. The best location of the pavilion would be a coastal area where dunes are frequently hit by waves, where sand sedimentation is important but where at the same time recreation is desirable. The government has mapped out areas where year round pavilions are allowed. This is regulated in the 3e kustnota where it states: year round pavilions are only allowed in an area directly related with either a coastal town in or directly behind the embankment or a recreation point in or behind the embankment.[2]

1 Ecomare (2012) www.zeeinzicht.nl
2 Ministerie van verkeer en waterstaat (2000) p68

The first interesting location was Zandvoort because recreation is the main element of this area and year round pavilions are really encouraged here. However since it has a broad beach and organized boulevard dune degradation is minimal in this area. A better location would be a more remote place like Egmond. This shorter beach has had its problems in the past; waves have beaten off chunks of sand from the dunes multiple times already and there is a strong inland movement of the shoreline in front of Egmond. Despite these problems a year round pavilions are wanted in front of these dunes. The grain size of sand is a very important factor for dune degradation, in general the bigger the grain sizes the less erosion of the dunes because small grain sizes result in sand that is easily movable by wind or water.[1] Sand can have a grain size between 180 and 320 µm, the grain size in front of Egmond is around 250 µm.[2]

The dunes need sand sedimentation in order to survive, this makes building a year round pavilion in front of them a challenge. By putting a building in front of a dune, you create an obstacle for the sand, it cannot pass the building easily and the part of the dune that is situated directly behind the building does not get as much sand as the other parts of the dune, this causes the blocked part of the dune to shrink. Noord-Holland has put up some criteria of which they want an outer dike pavilion to meet. These are:[3]

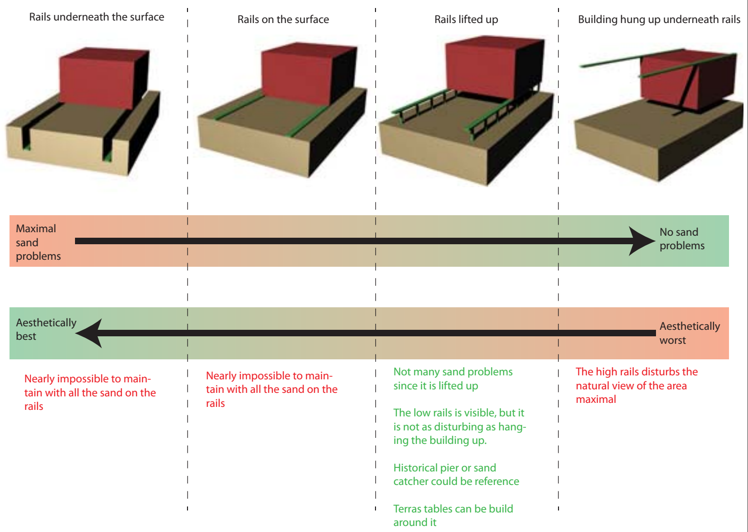
- Maximal 50m wide
- Maximal 500m2 and maximal 1 outbuilding of 75m2
- Maximal 1 building layer
- Maximal 5,5 meters high
- Maximal for a period of 5 years
- Minimal distance between pavilions is 150m
- Demountable
- Amni directional
- Suits the dynamic surrounding

4.3 Program

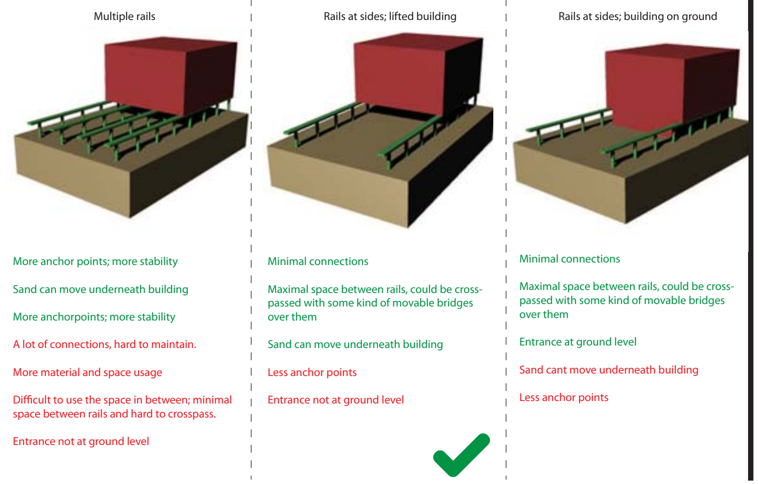
For year round pavilions on the beach there is a strict policy concerning the functions that it could poses. The only functions that are accepted for a year round pavilion is that of an entertainment character, these are functions like a restaurant; a small scale beach related shop; a small theater; wedding location or a seminars/ training building.

4.7 Inland movement of the coastline near Egmond

1 Waterloopkundig laboratorium Delft (1982) p17
2 Deltares; www.openearth.eu
3 Bergen (2009) p7-9



4.8 Different positioning for rails



4.9 Amount of rails and positioning building

The best would be to make the program of the pavilion flexible; it should adept to the market and be able to easily switch from one function to another by making removable walls for example.

4.4 Design

4.4.1 Rails

The sand stream from sea to dune should be minimal blocked by a building in front of it. In order to do this the building should block different parts of the dune at different times. By doing this a larger part of the dunes is blocked periodically instead of a small part permanent. This could be done by making a slow movable building that could for example move from one point to another point in a week and back. This moving should be done with a lot of guiding, it cannot move on its own without knowing the exact direction of the building at all times. This can be reached by guiding the building on rails letting it move back and forth. The vertical position of the rails can be done in four different ways: in the ground; on the surface; a bit lifted from the surface; and high in the sky hanging the building underneath it. The higher the rails the fewer problems with sand, but also the less it fits in the natural surroundings. The first two are nearly impossible to realize because of the sand that would get on the rails and the last one is just too prominent present and really pollutes the natural view of the area. The best choice is to lift the rails up a bit in order to avoid getting sand on the track, but minimize the view pollution.

There should be as less rails as possible underneath the building to minimize connections and to maximize the space between the rails giving this space more value and makes it easier to cross the rails by some sort of small stairs. The best would be to only have rails at the sides of the building, but there might be a third rail needed in the middle in order to realize the big span. The building will be situated on top of the rails rather than in between because by creating a space underneath the building sand can flow through and the building can pass little piles of sand easier.

4.4.2 Shape

The main priority of the shape of the building is in first place to maximize the sand flow from the sea to the dunes and secondly to break waves in times of storm. The best way to maximize the sand flow is by creating an aerodynamic shape. A lot of studies has been done about aero dynamic shapes and the best aerodynamic shape is the shape of a streamlined drop[1], this shape is for example also used for airplane wings.

1 Haney (2011) http://www.insideracingtechnology.com

If you look at buildings on the beach you see that wind blown on a vertical wall will give convection at the botom of this wall. By letting the building end in a vertical way it will create a constant wind force at the ground which will dig out a hole in front of the building (figure 4.14). To get the best airflow over the building you want to slowly guide the air up and let it slide over. For a good aero dynamic shape which will also give more downward force and more stability i looked into the shape of an horseshoe crab. When investigating this crab it becomes clear that its shape is formed in such a way that the water can easily slide over the crab while at the same time it creates a downward force on the crab to push them against the ground giving them more stability. The downward force of this shape is further proved by this crab when it starts to swim. When it swims it turns upside down so that the shape creates an upward force keeping the crab up.[1] Stability is very important for the building because it will have to withstand some huge powers in times of storm and with high wind velocities.

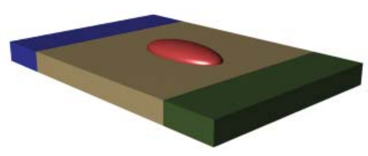
4.4.3 Wave breaking

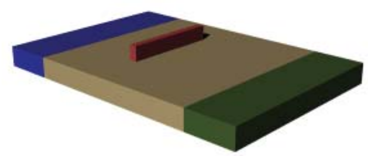
Storm erosion is the biggest fail mechanism for dunes; a building could contribute to the protection against this storm erosion by positioning a building in such a way that it breaks waves which would otherwise collapse on the dunes. The best shape for a building to break a wave is a rectangular building perpendicular on the waves, creating a maximum area that could stop the wave. However this shape is exactly the opposite of an aerodynamic shape. There are different ways of solving this problem: by turning the building in times of storm facing the long side of the building to the sea; by doing this you can have an aerodynamic normal moving building from right to left in times of no storm and you can have a very broad building breaking the waves in times of storm. This takes a lot of extra space because of the extra rails that should be there in order to make the turn when there is a storm. The other option is to somehow unfold the building or the skin keeping the main building in the same spot, but fold the skin open that could break the waves. This variant might be hard to realize because it is fairly weak since it is only fixated at the building creating a huge cantilever.

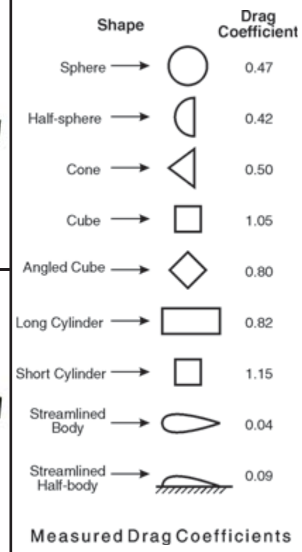
4.4.4 Wind vs Water

Two of the main characteristics of the beach are the water and the never ending wind. Since the wind is never ending it would be nice to somehow integrate it in the design. As a result of an aerodynamic shape there will be a lot of wind gliding at the sides of the building making energy generation at the skin of the building the best spot. Piezoelectric pads are a very nice technology for generating wind energy on a 'flat' surface.

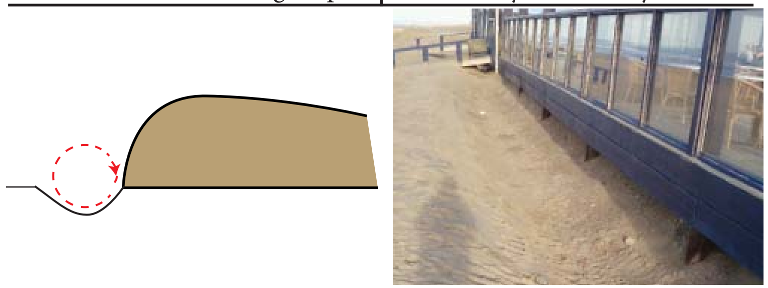
1 Vosatka (1970) p278

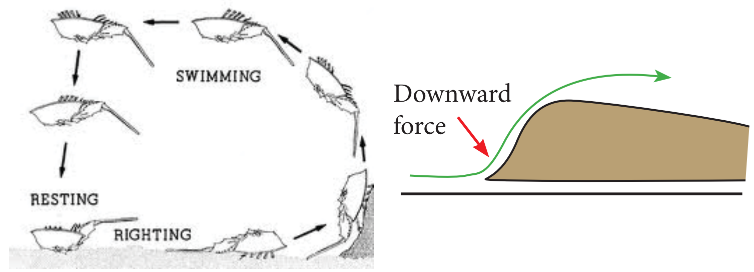

4.10 Best aerodynamic shape


4.11 Best wavebreaking shape

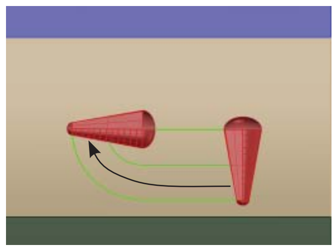


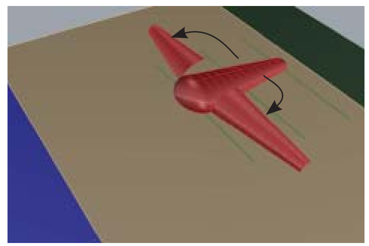
4.12 Aerodynamic study

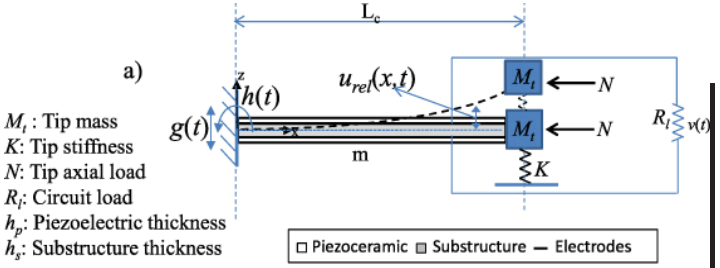

4.13 Hole creating effect by covection at the bottom of the facade



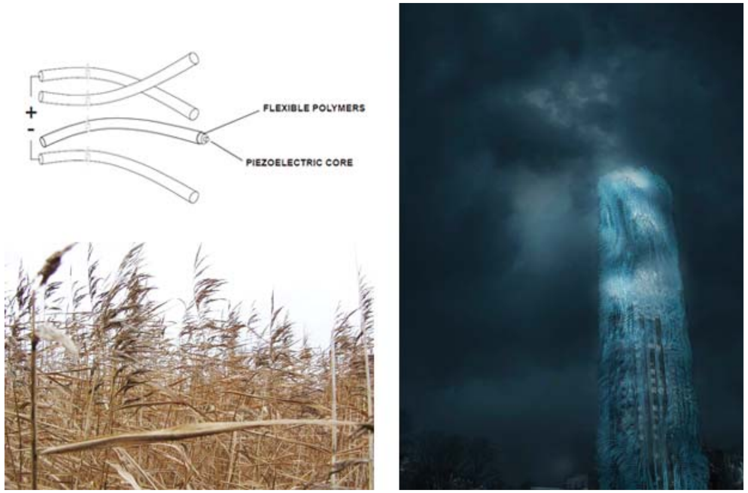
4.14 Horseshoe crab movement and downward force effect


4.15 Turning movement

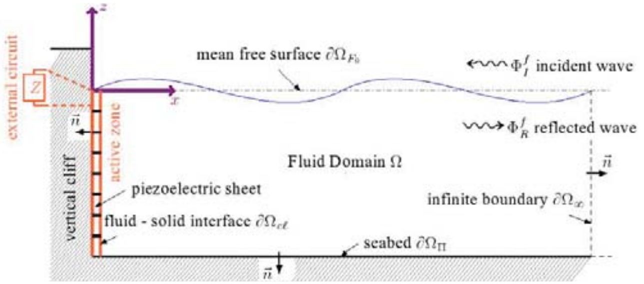

4.16 Unfolding skin



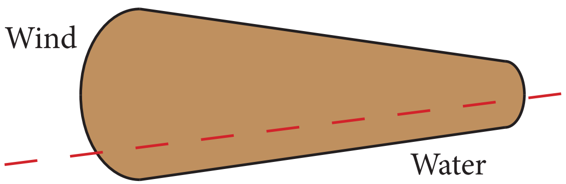
4.17 Piezo electric energy production by vibrition



4.18 Piezoelectric straws that look like sand reed



4.19 Piezoelectric sheet at a vertical wall



4.20 Building divided in 'wind' and 'water' side

The basics of this technology are small elements that start to vibrate when wind blows on the surface, this vibration generates current which can be stored in a battery or used directly.[1] By putting a lot of these elements perpendicular on the façade it can generate electricity and it fits the dynamic surroundings as well, it could take up a bit the look of sand reed.

On the other hand we have the water which periodically will hit the façade of the pavilion, these waves that are hitting the façade poses a lot of energy. There has been some investigation about gaining energy from waves; one of these techniques is to put plates on the ground of the sea which will move back and forth when a wave is hitting the plate. This movement captures power to drive a generator. This technique could be used in the façade which functions as a wave breaker, by dividing this façade in plates these plates could move back and forth when a wave breaks on them generating energy.[2] It could work as some kind of double skin where the first skin are the back and forth moving plates and the second one is the stable watertight skin which is actually breaking the wave. Wave power is an important addition to wind energy since it can solve the big limitation that comes with wind energy which is that the energy is only created when the wind is blowing. Waves are created by the wind off course but waves keep on rolling long after the wind has dropped down. The waves are some kind of storage system for the wind. Although in theory it is a nice way of generating electricity, in practice it might not be worth the trouble since the pavilion will only periodically be used as a wave breaker.

These wind and water aspects divide the building into two sides with different characteristics: on one side we have the wind which has an aerodynamic shape and is full of small `hairs´ which vibrate in the wind; and on the other side we have the water which has a steep wall to break incomming waves and is covered with small plates which will move back and forth when waves break on the façade.

4.4.5 Vision

The seperation into these two different sides could give a nice effect. On one side there is this dune like curved shape where the demountable facade elements could overlap eachother keeping room for windows in the space between, like some sort of excavation strips carved out of a dune. These facade elements might be movable to regulate the amount of sun or light comming into the building.

1 Prigg (2013) http://www.dailymail.co.uk
2 Athanassoulis and Mamis (2013)

On the other side of the building there is this big strong wall made of robust natural stone maybe that should give the impression of an inpenetrable element. Small windows randomly placed could enhance this feeling. The two head facades of the building are the two connector pieces connecting the one side to the other. The Dynamic element should come back troughout the whole design, every side should be able to open up in some way and interact with its surroundings.

5. Conclusion

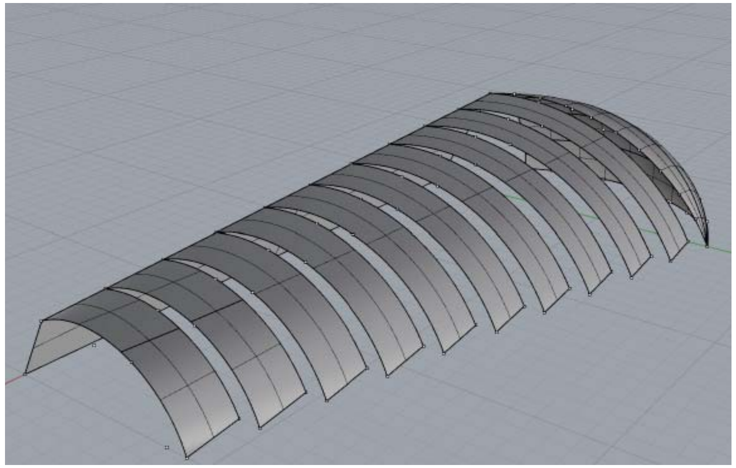
The blocking of the sand flow to the dunes by building in front of these dunes can be solved by making the building moveable, by doing this multiple parts of the dunes are blocked periodically instead of one part permanently. Another way of maximizing the sand stream to the dunes is by implementing an aerodynamic design, this way the sand can easily move over or along the building.

The dunes could further be protected against the sea by letting the pavilion break waves. The best way to do that is by rotating the building 90 degrees so that a large façade is facing the sea. This rotation is integrated in the moving movement of the building and will only be used in times of storm.

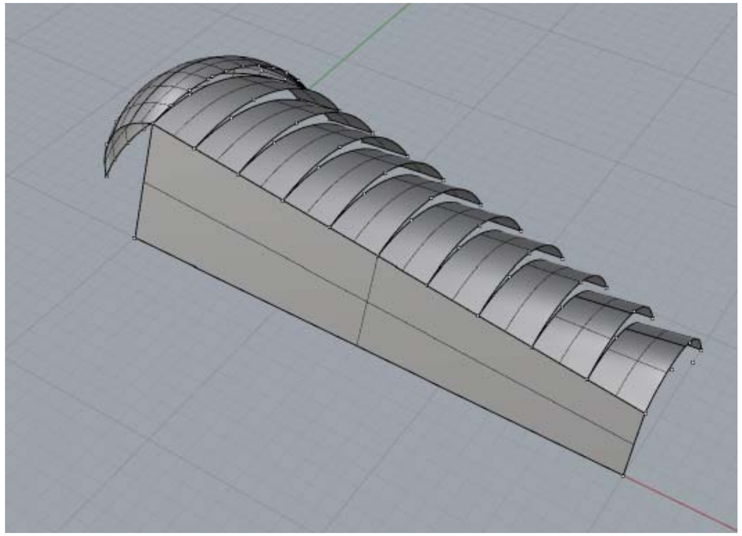
The best location is Egmond aan zee because of its touristic character and the relative small beach in front of it which results in repeating dune degradation. Another important factor is that the natural movement of the coastline has a strong inland direction which means that sand sedimentation is important in this area.

The building has gotten an aerodynamic shape which fits the natural surroundings perfectly, furthermore the piezoelectric elements on the façade makes the building look like a dune with sand reed on it. The moving factor suits the dynamic character as well, the building is not standing in one place, but it is moving along with the nature.

The research is not complete and will continue in the next semester. The fragmentation of the building needs to be researched ass well as what materials are suited for the location and how everything can be connected in a waterproof way. The shape is still in a concept stage, this needs a quick boost in the coming weeks where a more definitive shape should be gained and all the problem spots should be solved such as both heads of the building.



4.21 Wind side of the pavilion



4.22 Water side of the pavilion

6. Literature list

Athanassoulis, G.A. & Mamis, K.I. (2013) *Modeling and analysis of a cliff-mounted piezoelectric sea-wave energy absorption system.* Coupled systems mechanics 2(1)

Bergen (2009) Jaarrond exploitatie van jaarrond strandpaviljoens gemeent Bergen.

Delta commissie (2008) *Samen werken met water; Toelichting op door de deltacommissie gebruikte klimaatscenario's.* Deltacommissie: Den Haag

Deltares. Interactive program Open Earth. Retrieved 23-12-2013 From http://test.kustviewer.lizard.net/kml/

Ecomare (2012) De erosie van de Nederlandse kust. Retrieved 23-12-2013 From http://www.zeeinzicht.nl/vleet/index.php?id=4292&template=template-vleetned&language=0&item=De-erosie-van-de-Nederlandse-kust

ENW (2013) *Bedreigingen en faalmechanismen.* Retrieved 23-12-2013 From http://www.enwinfo.nl/asp/content.asp?DocumentID=4#anchor4

Haney, P. (2011) *Aerodynamic drag.* Retrieved 23-12-2013 From http://www.insideracingtechnology.com/tech102drag.htm

Hoedemaker, A.Th.M (2008) *Zandvoort strand en duin.* RBOI: Rotterdam

Jong, E. de (2010) *Een analyse van het windklimaat in Nederland.* Universiteid van Amsterdam: Amsterdam

Ministerie van verkeer en waterstaat (2000) *3e kustnota; Traditie, trends en toekomst.* Snoek - Ducaju & zoon: Gent

Prigg, M. *Is the 'hairy skyscraper' the future of cities? Radical eco-design covered in energy generating fibres revealed.* Retrieved 23-12-2013 From http://www.dailymail.co.uk/sciencetech/article-2328938/Is-hairy-skyscraper-future-cities--Radical-eco-design-covered-energy-generating-fibres-revealed.html

USGS (2004) *Coasts: sand and dunes.* Retrieved 23-12-2013 From http://geomaps.wr.usgs.gov/parks/coast/dunes/

Vosatka, E.D. (1970) *Observation on the swimming, righting and burrowing movements of young horseshoe crabs, limulus polyphemus.* Ohio journal of science 70(5)

Waterloopkundig laboratorium Delft (1982) *Rekenmodel voor de verwachting van duinafslag tijdens stormvloed.* Waterloopkundig laboratorium: Delft

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Reflection

The design is a beach pavilion in front of the dunes which still allows sand from the sea to reach these dunes, and in addition will protect the dunes form the sea in times of storm by breaking waves. In order to reach this the pavilion is moving up and down to let the sand pass by. It is equipped with moving façade elements which can be used as a terrace in nice weather or as protection façade during storm. All these moving elements make this building very technical and constructional interesting; this suits in my opinion perfectly within the studio of Architectural Engineering.

The relation between the research and design is minimal, the analyses of the behavior of dunes was very useful since it led to a defined problem statement which my design tries to resolve. However further research was merely done by research by design which gave me a couple of possibilities for every dilemma I faced. In the end however the design has nothing to do with any of the alternatives I made. This has to do with the fact that after the P2 I changed the moving axis of the building from horizontal to vertical. This vertical moving axis was not included in my research; all of the research was done with the intention of moving in a horizontal way and thus superfluous. There was no need for knowledge about aero dynamics or ways of making a pavilion moveable in a horizontal way anymore. The part about wave breaking is somewhat useful; it defines the best orientation for this purpose which is also used in the design.

The overall research methodology in the studio is research by design. This is being used to generate a tool box of alternatives and possibilities for given problems which can be utilized when making your design. My main research method was research by design as well, but the end product of my research was not really a toolbox of possibilities, it was actually a global design which was being shaped by a set of choices which lead to a number of new problems with different alternatives and new choices etc. it was already a kind of design, but only the problems and possibilities I faced during this research by design where addressed which is also the reason why it was mostly unusable for my design; because the choice of moving horizontally was made in the very beginning and the foundation for the whole research.

Although research by design was a nice research methodology to get a good research about the aspects that where interesting at that moment, it was not very helpful to me in the end since the basic principles of my research (moving in a horizontal way) and my design (moving in a vertical way) where too different from each other.

The design gives a way on how to build in front of dunes without weakening them. It is a solution to the problem that all beach pavilions face: sand sedimentation. In addition it also gives a solution to dune erosion which is the biggest fail mechanism for dunes. The building can be placed anywhere, the basic principles can be used for different designs and the structure of the building itself is so strong that it can shipped as a whole and moved from location to location if needed.