AMPHIBIOUS AND FLOATING RECREATION COMPLEX
ON SYLVAN BEACH, LA PORTE, USA
COLOPHON

AMPHIBIOUS AND FLOATING RECREATIONAL COMPLEX OF SYLVAN BEACH, LA PORTE, USA
Technology University of Delft
Master Architecture
Studio Delta Interventions
Graduation report P4

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1. INTRODUCTION

1-1. DELTA INTERVENTIONS

Delta landscapes are deliquescent landscapes, where land mingles with water, where the solid meets the fluid, the tactile the endless, the defined the undefined. They display natural dynamics and ecological richness, and are attractive places for settlement and culture, for industry, trade and tourism. Worldwide, they are the site of ceaseless processes of transformation and urbanization. Their dynamics, their variety and their beauty are a challenge for designers of cities, infrastructures and landscapes.

Due to a changing climate and new insights concerning sustainability, new interventions will be needed. In addition to safety and better water-systems, there is a need for stronger spatial identities and new cohesion between cities and their water-landscapes.

(Source: Delta Interventions Studio, TU Delft)

1-2. PERSONAL MOTIVATION

Estuaries are among the most productive natural habitats in the world, but at the same time the banks of many estuaries are also the most heavily populated areas of the world, there is about 60% of the world’s population living along estuaries and the coast. This overlap creates a lot of environment problems.

First of all, the biodiversity is reduced; secondly, human settlements face increasing flood risk. I think it is important to deal with this issue and to explore how architecture can contribute to a solution. That is why I chose the Delta Interventions studio in which the main focus is about dealing with problem such as floods in areas adjacent to water.
2. CONTEXT

2-1. GENERAL ANALYSIS OF GALVESTON BAY AREA

LOCATION

Galveston Bay, the research area of this studio, is located along the upper coast of Texas, connected to the Gulf of Mexico and surrounded by sub-tropic marshes and prairies on the mainland. The water in the Bay is a complex mixture of sea water and fresh water which supports a wide variety of marine life.
Galveston island was the door of the Bay, the start point of the development of the bay.

MAP ANALYSIS

1865

URBAN FABRIC

Galveston island was the door of the Bay, the start point of the development of the bay.

INFRASTRUCTURE

Railroad was the main transportation infrastructure at that time.

WATER INFRASTRUCTURE

The channel has been used to move goods to the sea since at least 1836.
The Great Storm in 1900 damaged Galveston island greatly, Houston became the new center. Found Oil field in 1903, economic boomed, workforce grew, more villages were developed.

Railroad expanded more along the west bay and Houston city was the center.

Galveston Dike was built
Galveston harbor is built
Clear lake harbor is built. Artificial island by dredged materials
Development of Crystal bay waterfront
1968

URBAN FABRIC
Houston continued to grow.

INFRASTRUCTURE
Cars replaced train, road fast developed.

WATER INFRASTRUCTURE
Extended the Galveston Dike
Constructed ship channels
More lake shore development
West of the Bay is occupied by cities

URBAN FABRIC

Rocks permeate Houston city greatly, it has became the major scenery of the west bay.

INFRASTRUCTURE

Proposed storm surge barrier systems are under discussion

WATER INFRASTRUCTURE
There are around 5 different waterscapes in the Galveston Bay area, which are waterway, river, lake, marsh and bay waterscape.

**Waterway**

The waterway provides a channel with a controlling depth of 3.7 meters, designed primarily for barge transportation. The water level is influenced by tides.

**River**

Most of the rivers of the bay area have the natural bank, while some which cross the city have the artificial bank such as concrete or gravel bank. The water level is influenced especially when heavy rain.

**Lake**

There are many lakes around the Galveston Bay area, some of it are closed water bodies, while some are connected with the bay, hence fluctuate because of tides.

**Marsh**

The marshes around the Galveston Bay is tidal marsh, which is a type of marsh that is found along coasts and estuaries. The flooding characteristics are determined by the tidal movement of the sea.

**Bay**

The depth of the bay is only around 2 meters, fluctuate a lot because of tides. When hurricane periods, the sea water can be pushed into the bay area causing serious storm surges.
Living in this busy metropolis, where is the place for people to release and relax?

Houston is the most populous city in Texas, the largest city in the Southern United States, and the fourth most populous city in the United States. And its population is still growing.

2-2. ENVIRONMENTAL PROBLEMS

POPULATION GROWTH

The beauty of Galveston Bay attracts people to build houses around it, as a result, many of the west shore have been occupied by individuals or industrial areas.
HURRICANE

Hurricane remains the most devastating problem for the cities around the Bay. It brings storm surge, strong wind, floods. Areas around water and the watershed have the most serious impact.

The four flood maps show the area where could be submerged in different categories storms.

(Source: http://www.texaswatchdog.org/) (Source: http://www.wunderground.com/)
OBSERVATION OF STORM SURGE IN GALVESTON BAY

Located in the subtropics area, hurricane makes landfall about once every six years around the Galveston bay.

<table>
<thead>
<tr>
<th>Hurricane</th>
<th>Cat</th>
<th>Landfall Location</th>
<th>Peak surge open coast</th>
<th>Peak Surge North Bay</th>
<th>Peak Surge South Bay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carla (1961)</td>
<td>5</td>
<td>180 km West</td>
<td>3 meter</td>
<td>4 meter</td>
<td>3 meter</td>
</tr>
<tr>
<td>Alicia (1983)</td>
<td>3</td>
<td>50 km West</td>
<td>2.5 meter</td>
<td>4 meter</td>
<td>3 meter</td>
</tr>
<tr>
<td>Ike (2008)</td>
<td>2</td>
<td>0 km</td>
<td>4.5 meter</td>
<td>4.5 meter</td>
<td>3.5 meter</td>
</tr>
<tr>
<td>“Surprise” (1943)</td>
<td>2</td>
<td>30 km East</td>
<td>unknown</td>
<td>-1.5 meter</td>
<td>-1.5 meter</td>
</tr>
<tr>
<td>Cindy (1963)</td>
<td>2</td>
<td>50 km East</td>
<td>0.8 meter</td>
<td>-1 meter</td>
<td>1 meter</td>
</tr>
<tr>
<td>Rita (2005)</td>
<td>5</td>
<td>120 km East</td>
<td>1.5 meter</td>
<td>1 meter</td>
<td>1.3 meter</td>
</tr>
<tr>
<td>Andrew (1992)</td>
<td>3</td>
<td>200 km East</td>
<td>-</td>
<td>-1.5 meter</td>
<td>1.5 meter</td>
</tr>
</tbody>
</table>

(Source: Hurricane Surge Risk Reduction For Galveston Bay, Kasper J. Stoeten, 2013)
IKE DIKE PROJECT

The Ike Dike is a proposed coastal barrier that, when completed, would protect the Galveston Bay. The project is proposed by Dr. Bill Merrell of Texas A&M University at Galveston.

The project would be a dramatic enhancement of the existing Galveston Seawall, complete with floodgates, which would protect more of Galveston, the Bolivar Peninsula, the Galveston Bay Area, and Houston.

The barrier would extend across Galveston Island and the Bolivar Peninsula and would provide a barrier against all Gulf surges into the bay. The Ike Dike would be able to withstand 10,000 year storms.
H-GAPS
HOUSTON-GALVESTON AREA PROTECTION SYSTEM

Besides the IKE DIKE project to stop the storm surge into the bay, there are barrier systems inside the bay which is now developing, the HGAPS, Houston-Galveston Area Protection System. It is proposed by SSPEED Center, Rice University.

In the HGAPS project, the existing barriers such as Galveston levee is integrated, and the natural resource such as oyster reef is considered. And the dredged material from digging the ship channel can also be a resource.

(Source: SSPEED Center)
EFFECT OF THE BARRIER SYSTEMS

The Ike Dike can effectively reduces flood risk by keeping the surge out of Galveston Bay. While the HGAPS can decrease the wind setup in the bay, hence protect the areas around the bay.

The area I want to investigate and develop my project is the intremedia place between Houston and the Bay.

Nowadays, many areas, especially places along water, have been urbanized. Waterfronts are now occupied by industries, individual plots etc. People are forced to away from water.

By improving the relation between individuals and the Bay, people can have healthier outdoor life and have more chance to know the environment hence to protect it.
THE DOOR OF HOUSTON “LA PORRTE”

La Porte, a bay city only 30 Km away from downtown Houston. It is situated at the intermediate location between Houston and Galveston Bay. That is why it is called La Porte - the door in French.

SYLVAN BEACH

The beach park of La Porte is one of the only areas in upper west side of the bay which has public access. It’s special geographical location makes the park an important recreational space during history.

(Source: Bing map)
### 3-2. HISTORY RESEARCH

**HISTORY: THE GLORY AND DECLINE OF SYLVAN BEACH**

<table>
<thead>
<tr>
<th>The Early Year</th>
<th>The Boom Year</th>
<th>Decline</th>
<th>Renewal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1892</td>
<td>1900</td>
<td>1939-1945</td>
<td>1954</td>
</tr>
<tr>
<td>City of La Porte (“the door” in French) was incorporated</td>
<td>The Great Storm damaged Galveston island greatly</td>
<td>World War II</td>
<td>Harris County purchased Sylvan Park and reconstructed the pavilion.</td>
</tr>
<tr>
<td>Sylvan Grove was constructed (now Sylvan Beach).</td>
<td>By 1900, majority of Sylvan Beach’s visitor was from Houston. It was a place for people to escape from the busy city.</td>
<td>The money to maintain was simply not there.</td>
<td>1956 First annual Sylvan Beach Festival was lunched till now.</td>
</tr>
<tr>
<td>1893</td>
<td>1905</td>
<td>1946 - 1953</td>
<td></td>
</tr>
<tr>
<td>Sylvan Hotel opened adjacent to the park, First Festival was held in the park.</td>
<td>Train started to arrive Sylvan Beach Depot.</td>
<td>After the WWII, storm damaged the park in 1943.</td>
<td></td>
</tr>
<tr>
<td>1894</td>
<td>1909</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railroad was extended to La Porte</td>
<td>G.D. Samuels bought Sylvan Beach. He enlarged the pavillion, add gateway, built over 100 cottages for overnight visitors to rent.</td>
<td>The park was left behind.</td>
<td></td>
</tr>
<tr>
<td>1898</td>
<td>1915</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Sylvan Beach” was named</td>
<td>The Sylvan Beach Depot became the biggest train depot in La Porte.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1899</td>
<td>1916</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Houston ship channel from Houston to Galveston was constructed making La Porte “the door” of Texas.</td>
<td>Sylvan Beach opened.</td>
<td>A storm damaged the park.</td>
<td></td>
</tr>
<tr>
<td>1901</td>
<td>Mid-1920s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sylvan Beach Depot was built.</td>
<td>Car replaced the train. During this period, There can see 10,000 to 20,000 visitors visit the park during weekend.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1903</td>
<td>1920s-1930s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Found Oil field, economic boomed workforce grew. Sylvan Beach, became a popular place for picnic.</td>
<td>The Golden Age of Sylvan Beach new owner E.L. Crain built Ferris wheel, marry-go-roung etc. in the park. Old houstionians called this period the golden age.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1905</td>
<td>1926</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1915</td>
<td>1954</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1916</td>
<td>1956</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
OLD ACTIVITIES

Activities

(Copyspace: Old Sylvan beach and the pavilions, Ann Ulloth Malone, Dan Becker, 2014)
OLD FACILITIES

Especially in the Golden age of Sylvan Beach, investor introduced various recreational facilities to attract more visitors, from the old photos we can see how vibrant the place used to be. Even after 1943 storm and WWII, Circuses still occasionally set up at Sylvan Beach.

(Source: Old Sylvan beach and the pavilions, Ann Uloth Malone, Dan Becker, 2014)
PIER

1890s First pier at Sylvan Beach

Around 1900 Bathhouse was added on pier

(Source: Old Sylvan beach and the pavilions, Ann Ulloth Malone, Dan Becker, 2014)
COTTAGES

1920s~1930s

HOTEL

Opened in 1901

RESTAURANT

1920s ~ 1930s

1930s
accommodations
and services in La
Porte downtown

(Source: Old Sylvan beach and the pavilions, Ann Ulloa Malone, Dan Becker, 2014)
OLD PAVILION

Especially in the Golden age of Sylvan Beach, investor introduced various recreational facilities to attract more visitors, from the old photos we can see how vibrant the place used to be.

(Source: Old Sylvan beach and the pavilions, Ann Uloth Malone, Dan Becker, 2014)
ENTRANCES

1908

1910

1930

1930s

1960

(Source: Old Sylvan beach and the pavilions, Ann Uloth Malone, Dan Becker, 2014)
DIFFERENT MODELS OF TRANSPORTATION

<table>
<thead>
<tr>
<th>Boats</th>
<th>Train (1895~mid 1920s)</th>
<th>Hackney</th>
<th>Car (after 1920s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boats brought people from Houston to Sylvan Beach via Buffalo Bayou</td>
<td>After trainservice came to La Porte in 1895, boat was less use.</td>
<td>Hackneys were line up for transportation after the train.</td>
<td>Car replaced the train around mid 1920s. During this period, there can see 10,000 to 20,000 visitors visit the park during weekend.</td>
</tr>
</tbody>
</table>

(Source: Old Sylvan beach and the pavilions, Ann Uloth Malone, Dan Becker, 2014)
Sylvan Beach used to be one of the popular tourist destinations. It attracted not only tourists from Houston or Galveston, but visitors from all over the nation.
The beach is too small and one of the beach is not in use. Front part of the fishing pier is not in use. Landscape of the park is occupied by parking space. Lacking of attractive activities. Lacking of beautiful waterfront environment.
3-3. OPPORTUNITIES

BAY ATTRACTIONS

Sylvan Beach can a destination and the first stop for people to experience the bay. The ferry system can integrate with more other stop along the bay.
Ferry is the best transportation to explore the Bay, it provides the shortest distance between different spots along the Bay, and it can arrive spaces where cars can not approach, such as islands, marshes.
4. THEME OF THE PROJECT

4-1. WATER LEVEL DIFFERENCES AND WIND FORCE

There are two primary problems to build at Sylvan Beach Park, which are all about the natural forces, water and wind. Constructing a building at waterfront, tidal fluctuations is always an issue. The level of water can be very different within short times. Especially when there is hurricane that brings wind set ups, the height of tide can be few meters. Besides the high water level during hurricanes, the strong wind force can be also a significant problem. The power of wind sometimes can destroy a building that is not well designed.

To response to the tidal fluctuations of the Bay and the possible flooding and strong wind during storms, I have investigated in solutions such as floating, amphibious architecture, wind resistant architectures and other relevant strategies.
4-2. TIDAL FLUCTUATION IN THE ABY

To apply the tidal fluctuations in my design, the water levels should be analyzed, below are highest and lowest water levels each month.

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest tide</td>
<td>0.498</td>
<td>0.486</td>
<td>0.8</td>
<td>0.742</td>
<td>0.759</td>
<td>0.85</td>
<td>0.45</td>
<td>0.715</td>
<td>0.683</td>
<td>0.805</td>
<td>0.766</td>
<td>0.625</td>
</tr>
<tr>
<td>Lowest tide</td>
<td>-0.638</td>
<td>-0.328</td>
<td>-0.466</td>
<td>-0.642</td>
<td>-0.357</td>
<td>-0.15</td>
<td>-0.237</td>
<td>-0.14</td>
<td>-0.004</td>
<td>-0.354</td>
<td>-0.442</td>
<td>0.509</td>
</tr>
</tbody>
</table>

In usual days, the highest tide is around +0.5 to +0.8 and the lowest tide is around 0 to -0.5. The height difference in one day is approximately 1 meter.

(Source: http://tidesandcurrents.noaa.gov)
4-3. FLOATING BUILDING

The origin of floating house is converted from ships, after World War II, there was a serious shortage of residential buildings. To resolve this problem, the ships on river became one of the solutions, people without house on land then accommodated themselves in the ships. After a few years of development, the houseboat was invented. It is a house which usually built on concrete barges, they can be always found on canals or waterways in some big cities in the Netherlands. Because of the symbol of freedom, the houseboats have their popularity.
Recent years, the floating constructions have increased greatly and have had more supplied spaces. The technique of constructing on concrete barge now are also utilized on floating gardens, roads, parking spaces, or even prisons. The foundation of the floating house is made by floating caisson, which can be traditional concrete, foam or plastic.

But because the floating properties are directly touched the water, dwellers can acutely experience the rolling of building, the creaking sound from ice, or the noise produces by the wave slapping the house. Therefore, although the romantic image of floating house is so attractive for some, but still many people do not like to choose it as their home.
Fortunately, many solutions can be utilized on solving those problems. For example, attaching the floating house to mooring poles can at the same time increase the stability of the house but remain the flexibility of rising or falling with the water levels.

A great advantage of floating properties is that it is always above the water level, which means the buildings can remain dry and will not be attacked by water. To adapt the fluctuation of the building, the system of passage, pipes and cables have to be flexible as well. They hence can follow the movement of the water. And to ensure the quality of water, the distance between the building and water should be at least one meter, which allows the flow of water.

To clarify whether a floating house is a moveable property such as a boat or a real estate, the mobility is one identity. When the floating house is attached to land or mooring poles, it is considered as a regular dwelling and has to be regulated under the housing regulation.
4-4. AMPHIBIOUS BUILDING

When a house is settled on land but can also float on water, it is defined as the type of amphibious house. Usually the location is a place where is easy to flood such as the neighborhood of river or the flood relief area, the land as a detention basin. Despite the amphibious have also the character of floating, but there are actually some differences on their design. The foundation or caisson of amphibious house can be exposed when there is no flood, so it is sometimes hidden in the ground, made smaller. The other character is that the caisson of amphibious house is stronger compared to floating dwellings, this is because that sometimes the building have to sit on land without the upward force of water. The significant difference is the connection between building and public infrastructure, which includes roads, sewers, main electricity etc. The amphibious house in the Netherlands is designed for situation that high water level does not happen too often but when it happens the water level is extreme high. The infrastructure in the Netherlands are usually not designed to cope with these exceptional circumstance, so when the extreme flooding do occur, the house will be isolated.

The number of mooring pole is another factor, when there is only one pole, the house can remain in the same place, but can still be rotated. But when there are two or more mooring poles, the property can only be moved up and down. The height of the mooring pole is designed according to the fluctuation of water level. Sometimes the height of pole can be 5 meter or higher, hence become a major feature of the house. But recently the pole is hidden inside the building.
Overhead door in the windward allowed pressure to build inside the structure, thus, outward forces were combined with internal pressure inside the building. This failure mode is common when large plate glass windows or overhead doors in the windward wall fail or are left open.

The flow of air approached the building from an angle directed into the corner producing large uplift pressures at the roof corner. Corners of roofs are especially vulnerable to local wind effects.

Overhead door in the windward allowed pressure to build inside the structure, thus, outward forces were combined with internal pressure inside the building. This failure mode is common when large plate glass windows or overhead doors in the windward wall fail or are left open.

Source: Guidelines for Design of Low-Rise Buildings Subjected to Lateral Forces, Ajaya Kumar Gupta, Peter James Moss
Improper connection of the house to the footings it can be blown away. Avoid a low pitched roof, use a hip roof or a high pitched gable roof.

When cyclones are accompanied with heavy rain for a long duration, the buildings can be damaged due to flooding.

Improper connection of the house to the footings it can be blown away. Avoid a low pitched roof, use a hip roof or a high pitched gable roof.

Roofing materials not anchored can be blown away.

Light weight verandah roofs are more susceptible to damage due to high wind speed.

The value of wind pressure actually to be considered on various elements depends on
> Aerodynamics of flow around buildings.
> The windward vertical faces being subjected to pressure.
> The leeward and lateral faces getting suction effects
> The sloping roofs getting pressures or suction effects depending on the slope.
> The projecting window shades, roof projections at eave levels are subjected to uplift pressures.

(Source: Cyclone resistant building architecture, Ankush Agarwal)
4-7. WIND RESISTANT STRUCTURE

Lightweight flat roofs are easily blown off in high winds. In order to lessen the effect of the uplifting forces on the roof, the roof Pitch should not be less than 22°.

Hip roofs (four side sloping roof) are best, they have been found to be more cyclone resistant than gable roofs. Avoid a low pitched roof, use a hip roof or a high pitched gable roof.
Openings in load bearing walls should not be within a distance of (the storey height upto eave level / 6) from inner corner for the purpose of providing lateral support to cross walls. Openings should have strong holdfasts as well as closing/locking arrangement.

Source: School of Architecture & Interior Design. SRM University.
CONCLUSION AND ARCHITECTURE CONCEPT

The research on water and wind resistant buildings provides me knowledge to develop my project. To respond to the environment of Galveston Bay, a new type of architectural idea should be generate. It should be a place where people can stay safe, comfortable, a building where water cannot submerge it, wind cannot blow alway its roof, break its windows. **A building which is “water and wind resistant”**.
5. STRATEGIES

Strengthen the connection between city and Bay

Respond to the historical pavilion

Provide Parking space at entrance and service area

Link the park together by loop route

Restore “the sylvan” to protect the park and provide shading
Combine separate beach together at safer area

Locate Service buildings at the junction of the park and beach and bay

Utilize the front part of the pier for swimmer and connect to the service area

Provide splash pool and swimming pool for safer and stable water activities
5-3. ZONING

ENTRANCE AREA

- Entrance plaza
- Parking space

NATURE RESTORATION

- Camping space
- Jogging track
- Bike path
- Cottages
- Lawn

WATER FRONT SERVICE AREA

- Kyayk, bike rental
- Shop
- Information center
- Exhibition room
- Restaurant
- Bathhouse
- Beach
- Pool
- Ferry Station
5-4. MASTER PLAN

The recreation complex is placed on the intersection of the beach, swim pool, main avenue and waterfront walkway. The location is very directed and easy accessible for visitors.
CIRCULATION

PARK AVENUE

PARKING CIRCULATION

WATERFRONT WALKWAY

POOL WALKWAY

BUILDING EXTERIOR WALKWAY

To FISH PIER
6. Design

6-1. MASS DEVELOPMENT

To make the building a wind resistant building, I applying the four-sided sloping structure. The shape can decrease the wind effect on building greatly.

Because the building is located in between land, beach and bay, there is waterfront walkway needed. So the building is separated into two parts, one on land, the other on water.

This gives the project a very interesting characteristic. The one on land can represent buildings on land but which will encounter flooding sometimes; the one on water represents building in water environment which will fluctuate with water.

On land:
As a amphibious building

On water:
As a floating building
6-2. FOUNDATION

The foundation of floating building is totally different from common on land buildings. Its foundation is more like ships, which can provide buoyancy but at the same time have to support its superstructure.

Here I apply steel frames and trusses to construct the substructure. At the outside of the steel foundation is covered by steel sheet which forms a waterproof air tank that can provide buoyancy.

Adding weight in foundation can make the floating building more stable and not easy to tilt over when the wind force is strong on the upper part of the building. The lower the center of gravity can be, the more stable the building can stay.
In between spaces of the steel frame, there are floating material - EPS and ballast tank installed. The ballast tanks are connected with pipes and pumps that can pump in or out water to adjust the stability of the building. While the EPS can help the building remain float when there is leakage.
Wooden truss

Because the special four-side sliding shape of the building, the structure supporting the building has to fulfill the height difference from one side to the other end. So I apply wooden truss structure system to achieve this. There are some advantages why I choose wooden truss explained below.

Truss can span widely, so the interior of the building can be spacious without too much columns.

Advantages of wooden truss:
1. Wooden trusses are capable of spanning greater distances than traditional joist framing. This results in more design flexibility and fewer intermediate supports, such as columns.

2. Trusses are engineered to specific sizes. Because of their precise engineering, trusses require less material than joists constructed on site. This leads to lighter loads for wall framing, which can cut costs and help speed up the project.

There are many types of truss system, they are framed in different ways.

To come out with a truss structure that can fit in the project, I made some models to test the stability and the spatial effect of the trusses.

After the test, I found that the one composed by scissor truss with three hinges can provide more interior space and has more aesthetic quality.
COMPOSITION OF TRUSSES

The trusses are spaced 3 meter apart from each other. The height of each trusses are different, the tallest one is 12 meter, while at the tail part of the building the height of the structure is one 1 meter.
PART B (FLOATING PART)
For the building it is very important that the much stronger wind resistance is taken into account. The cables not only represent the continuity of the two buildings, but more importantly, they provide very strong forces to confront winds.

For every four to five trusses, a set of wind bracing is placed.
PHYSICAL MODEL

By making the physical model, I can test the stability of the structure, and see how the space inside the structure can be arranged.
6-4. FACADE

Facade is another major issue of the building. As I analysed before, there are many aspects that can fail a building during strong wind. For instance, large openings at windward allows pressure to build inside the structure, thus, outward forces were combined with internal pressure inside the building, which can lift up the roof and causes significant damages.

So the facade of the recreational complex has to be very closed during storm weather. But it has to be very open when the weather is nice to welcome visitors who come to the park.

Pre-fab wood sandwich panel with wooden vertical strip cladding

After the wall panels are assembled, the wooden cap then be covered on top of the seams between each panel. It makes the continuity of the facade.
The setting of opening is closely related to the program of the building.
The facade is assembled on the timber truss, each prefab panel is stacked on top of another panel and fixed and nailed with the timber trussed by aluminum and wooden profiles.
[ WEATHER PROTECTION ]

To provide the building strong and seamless shell, the opening of facade is protected by two system - floataway door and folding louver.

FOLDING LOUVER

The louvers can be folded to upper side of the windows without block the view of, and it is also a sunshading system which can be adjusted according to the angle of sunlight.

While during hurricanes, the louvers can be a strong protection for the glass panel.
TILT DOOR (FLOATAWAY DOOR)

Floataway door is one kind of tilt door, it is a motorized door system that can be lifted up to overhead place and leave clear space below.

I choose this kind of door because it not only can be a enclosure during storms but also can become eave during its opening. It is especially useful for Galveston Bay area, a subtropical area with sometime too much sunlight for people.
OPERATION OF THE FLOATAWAY DOOR

The image below shows how the door is operated. By moving the motorized trolley upwards or downwards, the door can be towed to open or close.
TILT DOOR TYPE A

Tilt door close during winter, which becomes hinge door.

Tilt door completely closed during storm.
TILT DOOR TYPE B

Tilt door close during winter, which becomes window opening.

Tilt door completely closed during storm.
Because the four-sided shape of the building, there is wide sliding roof that can provide extra space. At the east side of the building, I apply green roof on this part, which allows people to walk on and sit down. The green roof faces directly toward the Bay, it is the best viewpoint where people can enjoy the bay scenery without any barrier.

Green roof can continue the greenery of the park, making the building merged with its surrounding.

Green roof provides more weight on the tail part of the building, which helps the floating building to balance more.
On top of the roof, there are skylights which can provide sunlight to the interior. The set points of the skylight is followed with the program inside the buildings.

Skylights that provide sunlight to the shop, rental stores below.  
Skylights that provide sunlight to the restaurant lobby below.  
Lighting the passage below.
The position of the building is a recreational complex which can fulfill functions that meets the needs of tourists who visit the park. So there will be some basic services such as information center, toilet, shower room for swimmer etc. Another important service is the ferry terminal. The site will be a node for people from Houston to other parts of Galveston.

<table>
<thead>
<tr>
<th>Program</th>
<th>Sqm</th>
<th>Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Retail center</td>
<td>257</td>
<td>100 bikes, 50 kayaks</td>
</tr>
<tr>
<td>2. Shop</td>
<td>133</td>
<td></td>
</tr>
<tr>
<td>3. Information center</td>
<td>42</td>
<td>Office, boat ticket sale</td>
</tr>
<tr>
<td>4. Toilet</td>
<td>64.5</td>
<td>17 toilets, 7 urinals</td>
</tr>
<tr>
<td>5. Shower room</td>
<td>80</td>
<td>28 shower rooms</td>
</tr>
<tr>
<td>6. Kitchen</td>
<td>25.5</td>
<td></td>
</tr>
<tr>
<td>7. Restaurant</td>
<td>245</td>
<td>120 seats</td>
</tr>
<tr>
<td>8. Snack bar</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>9. Waiting hall</td>
<td>75</td>
<td>50 seats</td>
</tr>
<tr>
<td>10. Cafe</td>
<td>75</td>
<td>40 seats</td>
</tr>
<tr>
<td>11. Garden</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>12. Machinery room</td>
<td>13.5</td>
<td>Heat Pump</td>
</tr>
<tr>
<td>13. Beach equipment rent</td>
<td>13.5</td>
<td></td>
</tr>
</tbody>
</table>
6-7. CIRCULATION

The Building is positioned in line with the main road of La Porte. It is toward the east side of the bay. To strengthen the connection between city and the bay, the main entrance route to the beach park as well as the route inside the building will in line with the main road of La Porte - Fairmont Parkway.

Inside the recreational complex, there is a main corridor which is about 5 meters wide to guide visitors to all the spaces of the building, and guide people to walk through the building to reach the bay from the door at the sea side end of the building. Beside the main corridor, there is a narrower corridor which is a service route where people can be guided to the toilet, shower, snack bar etc., it is at the north side of the building.
The windows and skylight provide most of the light during day time. They both have sunshading system installed in front.
In summer, the average outdoor temperature is around 30 °C in Galveston bay area. The warm air is extracted from outdoor via the air source heat pump. The air first is pre-cooled in the heat pump, then can be transported to the interior area by supply air ducts.

In winter, the average outdoor temperature is around 13 °C in Galveston bay area. The cold outdoor air is first sucked in by the heat pump and pre-heated. After this process, the heated air is then distributed throughout the space by the air handler and supply air ducts.

Also, the heated exhaust air can be sucked out through ducts to the vents on the upper part of west facade.
MECHINICAL VENTILATION SYSTEM

The mechanical ventilation system is combined with the heating and cooling system. The ventilation ducts are installed along the upper part of the building, which transports pre-cooled or heated fresh air from the heat pump to other places in the building. Then the used dirty air is sucked out by the ventilation ducts to the outdoor.

NATURAL VENTILATION SYSTEM

When the outdoor climate is moderate, the building can be ventilated by natural cross ventilation and stack effect. The tilt door can be opened to create a very open semi-outdoor corridor, and the windows on both sides of the building can also be opened by hand or motorized system. The skylights on roof and the upper windows of the west facade provide openings for warm and dirty air to go out.
FACADE
ENTRANCE AREA

CAFE & WAITING HALL
Before start the design of the graduation project, we had a exercise to redesign a existing building. I choose a building in Taiwan, called Joungdu tourist center. It is a tourist center of a wetland park, situated next to water.

In this exercise I redesign it as a semi-floating building, only a part of the building can flutuate with water.

The Joungdu tourist center is a service point of the Joungdu wetland park, which is located next to the Love River. Love River is a river connected with the sea in the southern Taiwan. The river is influenced by the tidal changes from the sea. And the wetland park is linked with the river by two water ways, which means the water in the park can also flutuate.
BUILDING ANALYSIS - FRAME THE VIEW

By applying the frames the view approach, the relation between the building and the environment can be seen. The building is surrounded by the water, whereas the further landscape is the mountain.
The building is located on the waterfront of the wetland. There is wooden platform and stair provided to access the water from the building. There are water level differences caused by the tides.
The new site I choose to place the building is on the bay close to the west bank of the bay. The building will be placed just on water. To adjust it to the new environment, the floor of the ground floor becomes floating platform, which can fluctuate with the tides.
From the sections can clear see how the floating platform fluctuate. Although the platform of the ground floor can float, but the maximum height will be 2.5 meter distance between the platform and 1st floor, ensuring there is enough space to passing by.
REDESIGN - PERSPECTIVES
APPENDIX --- RESEARCH PAPER

This paper is a research report that I did during the graduation design, it is about different ideas relavent to regeneration of urban waterfront areas.

A better architectural solution for urban waterfront areas during its regeneration

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Introduction

The waterfronts such as along low lying coastal areas, river bank, lakeshore are always the most popular space for human settlement. Human beings prefer to live close to water since the beginning of history because of the demand for water resource, the need for water transportation, or the appreciation of water landscape. “Water is an indispensable natural resource that is a renewable, but limited. It uses the aims of agricultural, industrial, energy generation, household, transportation, recreational and environmental.”(Umut Pekin Timur, 2013)

While the water front is also the area where has the highest biodiversity of an environment. It is the habitats of various kinds of wild lives, an area where animals can approach to obtain water etc. When the settlement of human being and the habitat of wildlife overlapping problems then emerge. Always, human construction brings great ecological damage to the environment. The existing natural waterfront is replaced by concrete revetment, the concrete revetment although can provide solid protection to the land area, but the natural slope is gone, the tidal zones disappear. Beside of the construction methods along waterfront can lead to damage of nature, the type of building is also another threat to this vulnerable area. Because of the necessity of transportation through water way, waterfront areas are usually selected to set up factories, especially heavy industries, which will produce great air pollution and water pollution. Consequently, it results in great loss of natural habitats, causing extinction of native vegetation and wild life. The expansion of human settlement and global urbanization are aggravating the plight of this situation. Urbanization is thought to depress biodiversity for many taxa (Kowarik 1995, McIntyre 2000, Marzluff 2001). Especially urban land expansion is occurring fast in areas adjacent to biodiversity hotspots and faster in low-elevation, biodiversity-rich coastal zones than in other areas. (Urbanization, Biodiversity and Ecosystem)

In additional to the impact on other species by constructing along waterfront area, recently human beings who live in waterfront area are also facing dilemmas. Naturally, the formation of shore and bank is by the power of water. This principle has never changed since ancient times. The natural shape of river is never fixed. Even though it is now concreted by human constructions, the power of water still exist. When the strength of water is stronger than the resistance of the building structures, disaster happens. Those houses, foundations, factories can be destroyed significantly. Especially we are now living under an unstable climate condition. There have been a lot of tragic disasters caused by extreme
weather conditions. The extreme rainfall, hurricanes etc. could bring powerful storm surge which causes flooding, great financial loss and casualties. Facing these environmental dilemmas, could human beings find solutions to response?

The ever changing urban waterfront

Despite the disadvantages that the power of water can bring to a space, the fine of water still fascinate people to close to it. Water is so attractive that can give people the feeling of relaxation from its visual landscape effects. “Water in urban areas is aesthetic effects as well as functional effects. These are climatic comfort, noise control, circulation effects and recreational aims.” (Umut Pekin Timur, 2013)

Water is also important to the formation of a city. Akköse (2007) described, “three factors are more important in forming the cities. The first of these is the natural structure of the city, the second of these is physical structure of the city, and the other one is social structure of the city. These three factors constitute system of the city in interaction with each other. In the natural structure of the city, the water element of presence or absence influences the process and the image of the city. Water resources such as sea, river or lake are added value in different ways.” (Umut Pekin Timur , 2013)

Until World War II, waterfront area such as port areas were very active because of the loading-offloading activities of ship. While after World War II, the growing port activities need to find new areas because of developments in maritime industry. As a result, the port activities were moved out of the city. And the old ports then were abandoned. Besides, the changing of transport pattern and the construction of highways also caused the depression of many waterfront areas. In these areas there are several problems. The pollutions caused by industrial activities, the gap created by railroads between waterfront and city etc. But the local craving of restore the aesthetic scenery of the waterfront has never stopped.

With the increasing environmental awareness and as a consequence of the pressure for upgrade in urban areas, waterfronts were rediscovered in the city. So, phenomenon of waterfront regeneration emerged. Urban waterfront regeneration projects have become an effective tool for urban planning and politics an international dimension since 1980’s (Sairinen & Kumpulainen, 2006; Goddard, 2002). Some expressions are “waterfront regeneration” (e.g. in Wood and Handley, 1999; McCarthy 1996), “waterfront revitalization” (e.g. in Goodwin, 1999; Hoyle, 2001), “waterfront rehabilitation” (e.g. in Hoyle & Pinder, 1981: 83), and “waterfront redevelopment” (e.g. in Gospodini, 2001; Gordon 1999)
These regeneration projects include residential, recreational, commercial, retail, service and tourist facilities, and residential, recreational and tourist-related uses were often the cases. Some examples are Baltimore’s Inner Harbour regeneration, the Inner Harbour Baltimore. Besides, waterfront regeneration is viewed as a standard catalyst of inner area regeneration for any city or town in the mid 1980-1990’s (Goddard, 2002).

The reasons of the progress of waterfront regeneration are such: increasing amount of leisure time, the need for more recreational area, the need to conserve historical and architectural heritage etc.

**Opportunities to apply a better solution for waterfront areas**

Even till now, there are still so many cities are now promoting the waterfront regeneration. But whether it is toward a better direction? Or it is again destroy the waterfront? According to the famous quote “to create is to destroy”, we can see no matter what kind of constructing, there is always destruction along with. During the process of building, the preparation of site, the digging of land and the embedding of foundation, the original environment is actually destroyed greatly. Is there a method of construction can prevent this consequence? Fortunately, now there may be an answer – the floating construction, a structure that float on water by floating foundation.

The emerging of floating house could be traced back to the development of the Netherlands.

In the Netherlands, areas where adjacent to water are mainly influenced by the North Sea or rivers. To provide people a dry and safe place to live in is a long term challenge for the Dutch government and the professionals. The old measures of protecting people from threaten of water were enclosing land with dykes, or building on mounds. But these methods do not guarantee the safety in some extreme cases, for example, when the water levels are higher than the dykes or mounds. People were then searching for flood-proof constructions to minimize the possible damages by flooding. To address the issue of flooding, in 2008, the Dutch government released a renaissance in urban design, there were programs such as the “Mooi Nederland” (beautiful Netherlands) launched by the Ministry of Housing, Spatial Planning and the Environment, and the program by the Netherlands Architecture Fund. There also is a policy introduced for new residential developments: 10 percent of area should be for water storage, which contributes to strong argument and more possibilities of water buildings, which means when water storage area overlap the building construction
area, the water dwellings can be formed. All these actions indicate that the Dutch urban planning has entered a revolutionary phase.

After the World War II, there was a serious shortage of residential buildings. To resolve this problem, many unused river barges were transformed into dwellings to accommodate people who lack of living space on the ground. This is the original prototype of the Dutch floating home. Many advantages were found in this floating property, for instance, the mobility of the ship house represent the long term freedom of its dwellers. But at the back side, the status of the ship house is unclear, this movable property is considered as a ship rather than a real house. And also some technical weak points such as sinking or leakage can be found in it, although all these problems can be resolved easily by various new building technologies.

After a few years of development, the houseboat was invented. It is a house which usually built on concrete barges, they can be always found on canals or waterways in some big cities in the Netherlands. Because of the symbol of freedom, the houseboats have their popularity.

Recent years, the floating constructions have increased greatly and have had more supplied spaces. The technic of constructing on concrete barge now are also utilized on constructing floating gardens, roads, parking spaces, or even prisons. The foundation of the floating construction is made by floating caisson, which can be traditional concrete, foam or plastic.

A great advantage of floating properties is that it is always above the water level, which means the buildings can remain dry and will not be attacked by water. To adapt the fluctuation of the building, the system of passage, pipes and cables have to be flexible as well. They hence can follow the movement of the water. And to ensure the quality of water, the distance between the building and water should be at least one meter, which allows the flow of water.

**Conclusion**

In the Netherlands, people have went through a series of disasters such as flooding, loss of lands, forcing the people have to figure out approaches to cope with. The construction of dikes, water barriers although do block the water out currently, but the nature power is unpredictable. Because of the recent extreme climates, the Dutch government has announced a new policy which is that there should be at least 10 percent surface water in a new residential neighborhood. It not only reserves more space for water but also encourages the design of different kinds of water constructions. And because the popularity of living close to water, which guarantees their value, many project developers are willing to develop and invest on water.
and environmental problem in waterfront area are still remaining in many cities around the world, coastal erosion, loss of natural habitats, damage of buildings by surges etc., so by introducing and applying floating constructions, we can at least manage the extent of damage in these area. First of all, rather than rooted in the ground, the foundation of floating structures is floating on the water, hence decreasing the interference of waterfront. And the passages which lead people enter to the floating properties can be restricted by trails on piles, preserving spaces below for wild life and decreasing the interference to the environment.

Since there are already so many disasters because of the inappropriate use of waterfront areas, now it is the time to exploit better solutions.

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