The structure of the report is also the structure of the whole process of designing and researching. It is like a chain with triangular links which are overlapping and connect with each other. Each ‘triangle’ is the main topic of one character which corresponds to one scale or aspect. There are six triangles in total corresponding to: Delta; Galveston; Urban Design; Architecture; Structure and Climate. One triangle includes three aspects to research and design. The concept of each aspect should be coherent with each other.
Galveston Bay is the 7th largest estuary in the United States, located along the upper coast of Texas. It is connected to the Gulf of Mexico and is surrounded by sub-tropic marshes and prairies on the mainland. (Eubanks, 2006) The water in the Bay is a complex mixture of sea water and fresh water which supports a wide variety of marine life. (Wikipedia)

A number of cities and towns, such as Houston city, Texas city and Galveston city etc., are separated around the bay. The bay is also surrounded by different waterscapes and wetlands which provide a complex ecosystem and valuable resources for the area. Galveston Bay provides numerous ecological services, economic benefits, recreational opportunities, transportation linkages, and aesthetic rewards to the people that live, work, and play around the bay. (Lisa A. Gonzalez, 2013)
HURRICANE

Every year, about one hundred tropical disturbances roam the open Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. About fifteen of these become tropical depressions, areas of low pressure with closed wind patterns. Of the fifteen, ten become tropical storms, and six become hurricanes. About every fifty years, one of these extremely intense hurricanes will strike the United States, with disastrous consequences. (David Roth, 2010) Many American coastal cities are threatened by the hurricanes, with millions of Americans living at water’s edge, exposed to high risk of winds and flooding.

If taking into account storm frequency and typical storm tracks, as well as the population living at or below the elevation of a potential storm surge. The Houston-Galveston city area belongs to the top 5 vulnerable cities of the State. Typically, hurricanes will strike the Texas coast once every nine to 16 years, while tropical storms are more common than that. (Andrew Freedman, 2012) Among these the Galveston Hurricane in 1990 was the deadliest weather disaster in United States history. It had estimated winds of 145 miles per hour (233 km/h) at landfall, making it a Category 4 storm on the Saffir–Simpson Hurricane Scale. The most recent one is the Hurricane Ike on September 13, 2008, it struck the Upper Texas Coast, causing extensive damage with sustained winds of 110 mph (175 km/h), a 22 ft. (6.8 m) storm surge, and widespread coastal flooding. Ike was a powerful Category 2 storm at landfall, it was a large storm, and it drove a storm surge onshore that was more typical of a Category 4 storm. (Andrew Freedman, 2012)

The map on the right is the 100-year-storm of Galveston Bay. About 19,000 people of 22 cities are in the 5’ of sea level and 350,000 people are in the inundation zone. There are 48 cities are in the 25’ of the sea level.

Memorial to Great Storm of 1900 with “Ike” looming - Photo by Johnny Hanson: Houston Chronicle “Best Images from Hurricane Ike”

Fire destroys homes along the beach on Galveston Island, Texas as Hurricane Ike approaches. (Sept. 12, 2013) Photo Credit: AP

100 year storm surge, SWA Group, Houston, Coastal Roulette: Planning Resilient Communities for Galveston Bay, 2012
City Profile

Galveston city sits in a barrier island facing of the Gulf of Mexico along the Texas Gulf coast. Fifty miles south of Houston, Texas' biggest city, the island measures 27 miles long by 3 miles wide on its widest point. Given its location and barrier island status, Galveston Island is critical in the protection of the estuary system behind it, Galveston Bay. (Tanveerul, I., William M. and William S.)

Transportation Infrastructure

There are three main access points to the island. The main access is the Interstate 45 causeway to the north of the island connected to the Broadway St. of Galveston city. Broadway St. and the Blue Water Hwy. The second one is the Blue Water Hwy. built a toll bridge on the western end, but it doesn’t have the capacity or traffic of the first. And lastly one is a ferry service at the east end that connects directly to Port Bolivar and then straight to Highway 87, but it is only available during the summer time.

A City of Charm

Galveston is a city full of history and stories. Though it seems that Galveston Island is a dangerous place, a lot of people have lived there their whole life. They really care about this place. The population of Galveston city has decreased recent years, while the numbers of tourists has been fast increasing. Despite this, most of people chose to stay on the island. Many of them are living in the historical houses which has been survived from many hurricanes and certificated by the government. The marks of Hurricanes can be seen in a lot of places of the city. The Hurricane is an indispensable part of islanders’ memory. What’s more the tourism of Galveston develops very well due to its history, natural resources and the stories about hurricane.

For Tom Curtis, director of research communications at the University of Texas Medical Branch, Galveston is pleasantly full of contradictions, pride, character, and characters: 'If Galveston didn’t exist, Tennessee Williams would have had to invent it.' (Rod Davis,2002)
CHAPTER 2

The topic of this chapter is ‘Galveston City’: History, urban and hurricane. By studying the history I find that there are two clues in the history of Galveston city: urban development and hurricane prevention. The city developed with the seawall and strongly influenced by the hurricane. During the research on the city, two boundaries caught my attention: Galveston seawall and the 25th street. So I choose the intersection of the two boundaries as my site.
TWO BOUNDARIES
SEA WALL
LINEAR DISTRIBUTION
TRAFFIC SYSTEM

The City’s most heavily trafficked thoroughfares are Seawall Boulevard, Broadway Boulevard, and 61st Street.

Seawall Boulevard provides an east/west connection for Island residents and experiences heavy tourist-related pedestrian and vehicular traffic.

Broadway Boulevard is the primary access corridor into Downtown from the mainland. It is also a historic avenue with a lot of historical buildings along its both sides.

61st Street serves as the conduit for travel from I-45 to the West End, and can experience significant traffic in the summertime and on holiday weekends. 61st Street is also a major evacuation route for the West End.

PROBLEM

As for public transit the Island originally had 7 working trolley routes, but after Hurricane Ike, the infrastructure suffered even great damage but return to operations quickly. Right now the system faces problems with low ridership attributed mainly to reduced accessibility and unreliable and limited service. In order to support the tourist industry and provide a higher quality of life, the island transit system must undergo a thorough restructuration to improve its quality. (Shannon Van Zandt, 2012)
CITY ZONING

The diagram on the right shows that the main commercial areas are mainly separated along the Seawall Boulevard and secondly Broadway Boulevard.

Figure 1-4 are the land suitability analysis for Galveston Island. Deeper shades of color indicate higher land suitability for the determined use. (Galveston City State of the Community Report, 2012)

Conclusion

Galveston city area where is protected by the seawall is more suitable for both single family and multifamily housing which is consistent with the location of the older neighborhoods.

The narrow strip of land along the seawall is also good for commercial uses because of its relationship to the water and possible tourist traffic.

Industry should be located towards the north and along the gulf and the bay to further the geographical advantages of the port adjacent to the bay and the gulf. (Galveston City State of the Community Report, 2012)
Local people’s major activity is spreading along the 16km trail on the seawall. And the seawall area is also one of the most famous tourism attraction in Galveston. A lot of ‘activity-lines’ are in turn arranged along the seawall.
Consider reducing the speed limit on Seawall Boulevard to increase pedestrian safety while further reducing the local perception of the Seawall Boulevard as a thoroughfare.

City of Galveston Comprehensive Plan, Adopted October 27, 2011, Engineering, Inc. for the City of Galveston, Texas.
25TH STREET
CONNECTION & BALANCE
BOUNDARY

The 25th street can be seen as the boundary of the modern part and the historical part of Galveston City.
In history downtown Galveston was the center of all activity, and banks, merchants, public buildings, and churches radiated from strand area. (Denise Alexander, 2010)

Today downtown Galveston is still the central of main attractions which offers an intriguing selection of shops, restaurants, galleries, and museums within a perfect radius for self-guided tours.

25th Street, also known as Rosenberg Avenue, is a north/south corridor that is both a commercial and residential street and serves as a connection between the Downtown and the Seawall.

IU-2.6 Enhance 25th Street as an Important link Between Downtown and the Seawall Corridor.
City of Galveston Comprehensive Plan, Adopted October 27, 2011, Engineering, Inc. for the City of Galveston, Texas.

PROBLEM_ The areas on both side of the 25th street have equal value to develop. But the map shows that the real situation is quite unbalanced on two ends.
SITE

The site is on the intersection of the two boundaries.
CHAPTER 3

The topic of this chapter is ‘urban design’: hurricane, urban and architecture & landscape. The ‘urban design’ chapter is to answer the three urban scale research questions of this three aspects. I set my position of using water adaptive strategy for Galveston City after the research. And then come to the urban design process. From the urban aspect the research question is how to extend the urban life of Galveston city and tourism activities to the waterfront? My proposal is creating a recreational system onto the sea. The system can be seen as an artificial landscape on the sea combined with buildings. So the research question on ‘Architecture & Landscape’ aspect is how to provide different layers of water related experiences? The research question on hurricane aspect is how do different parts of the recreational system deal with flood threat depending on its character? The urban design is the result of all the three aspects.
URBAN & WATER
EXTENSION . MULTIPLE . ADAPTIVE
WATER ADAPRIVE ON DEMAND_for both urban and architecture scale

Abstract
The paper describes that the strategy of urban and building design for water front city should develop more on the direction of water adaptive comparing with water defensive. This position was proved in three progressive aspects: welcome water; expend to the waterside; go onto the water. The paper want to prove that it is necessary and the future trend for the waterfront cities to develop with water to meet the future demand. So as the conclusion, the Galveston city can use the same strategy. Instead of hiding the city behind the seawall, the city may have another choice: go on to the water and develop a water adaptive system to build a close connection of city and water.

Key Words: water adaptive; urban strategy; wet feet architecture; future challenge

People were attracted by water, but at the same time they are afraid of water due to the damage it brought. ‘The innate force within water represents the essence of Yin and Yang where good cannot exist without evil.’ (Maggie Toy,1995) Building the high levees, seawalls and sand bags used to be an effective way to defend the flood, but it brutally separating the city and water. What’s more, because of the climate changing and water level raising, the ‘isolation strategy’ is not sustainable and cannot meet the future challenge and people’s demand.

Waterfront city were keep finding another ways to deal with water in history. For instance, in 1992 the Department of City Planning issued the New York City Comprehensive Waterfront Plan, the first time in the history of New York that a long range vision was offered for the entire shoreline. ‘A bold rethinking of the water’s edge as a place not only for commerce and industry but also for people to live and play, the plan proposed ways to reinvent the shoreline for public access and productive uses.’(Amanda M. Burden,2011) And now living with water is taken into consideration more seriously than before. A lot of works both on technical and political aspects have been done in recent years. It is time for waterfront cities to welcome water and even go onto the water. And it is also the time for their architecture to live with wet feet. (H2OLLAND: Architecture with wet feet)

GALVESTON
The map shows the movement of people’s leisure activities. Red point stands for tourist and blue point stands for local residents. Tourists’ movement mainly focus around the attractions while the residents’ movement mainly focus around the green areas or parks near their neighborhood. Most of the activities are far from the sea.

The seawall area is a local favorite for both tourists and local residents. But people’s major activity is spreading too long along the 16km trail on the seawall. The water related activities are still limited. Though there are several piers and pier buildings expend to the seaside on the beach and the, there are little places which can provide people with a close interaction with the sea.
POSITIVE
People are attracted by the water, but at the same time they are afraid of water due to the damage it brought. Building the high seawall used to be an effective way to defend the flood, but it brutally separating the city and water. Nowadays 'water adaptive' strategy is gradually taking the place of 'water defensive' strategy. Galveston City should be brave to go onto the water and find then the solutions actively.

URBAN SCALE RESEARCH QUESTION

URBAN
How to extend the urban life of Galveston City and tourism activities to the waterfront?

PROPOSAL
The proposal of the project is extending the urban life of Galveston City and tourism activities to the waterfront. Providing public spaces and buildings for the citizens to interact and tourists to enjoy their holiday. Thus people’s activities are gathered at a specific recreational system instead of spreading them too thin along the trail on the seawall. At the same time, the balance of 25th district will be retrieve. The system is an artificial landscape built on the pier over the sea combined with numbers of public buildings.

URBAN SCALE RESEARCH QUESTION

ARCHITECTURE & LANDSCAPE
How to provide different layers of water related experiences?

HURRICANE
How do different parts of the recreational system deal with flood threat depending on its character?
STRATEGY

The project will be divided into different height to provide water-related experiences in different layers.

The landpart of the buildings will connect the water part buildings by bridges to gain more ways of people access.

The main part of the spaces on the water will be elevated above the seawall 2.5 to 3 meters to meet the future demand. The lower layer can be resilient: floating or easy to recover.
URBAN DESIGN
SITE STUDY

1. Menard Park
2. McGuire Dent Recreational Center
3. Parking Space
4. Pleasure Pier Gift Shop

Historical Sites
5. Historical Pleasure Pier
6. Murdoch’s Gift Shop
7. Balinese Room
8. Hotel Galvez

- hotel
- Restaurant
The whole system has two entrances. One entrance at the urban center area, another is the tourist center area. The existing parking lot can be shared by both entrances. The main part of the new recreational pier is designed as a circle around the historical pleasure pier providing a continuous system for people’s activities: walking, running, cycling, etc. The two branches lead to the areas which are relatively private: swimming pool and boathouse hotel area. Two swimming pools are added at the boathouse hotel area to make this area more public. And this area can also work as the water barrier for the gallery area behind.
The new pier is mainly constructed by wood including three height levels with 2~2.5 height differences. Different height levels are built by wood in different color.
CHAPTER 4

The topic of this chapter is ‘Architecture’: hurricane, urban, architecture & landscape and public space quality. I choose the urban center as my main project to develop. Hurricane prevention strategy for architecture should coherent with the concept for urban scale: go on to the water, resilient strategy not defensive strategy. The project is a public building: urban center. It is the future city living room of Galveston. So it should be open enough and the public space quality should be guaranteed from all aspects. And my research question on architecture scale is: how to integrate Galveston urban center with the landscape from both exterior and interior?
URBAN CENTER

MAIN PROJECT

important connection of the city and the recreational system

LAND PART/WATER PART
EXISTING RECREATION CENTER STUDY

FUNCTION DIVISION

All the facilities in the park and the recreation center are owned by the government of Galveston. The Recreation Center is free for any resident, employee, or long term visitor of Galveston with a valid state ID. Besides all the facilities, the center also offers yoga course, guitar course, art course, crafts course, computer course, box exercise etc. They also provide after-school programs for youth. In addition, the center also provides guiding tour for the tourists. Among all the visitors, 80% are local citizens and 20% are tourists.

PROBLEM

The facilities in the center is abundant but the number and the space is quite limited. For example there are only 8 computers in the computer lab and 2 table tennis tables. Almost all the courses are taken place in the multi-function room with different time tables. There should be more rooms and facilities for more people and flexible usage. The outdoor stage is seldom used and it blocks the view from the recreation center.
URBAN CENTER

The urban center is separated into two parts: land part and water part which are connected by the bridge over the Seawall Boulevard. The urban center can be seen as a strong connection of the city and the recreational system. Both two parts choose the same design method to keep the continuity of the architecture. The form of two parts are sloped green roof.

For the water part, the roof can expand the connection of the building and the seawall passage and lead people to the nice view of the sea. For the land part, the site used to be a park which used to provide multiple activities for the local people. The sloped green roof will be the extension and strength of the existing park and public activity instead of reducing them. Two parts echoes each other on two sides.
**FUNCTION**

**WATER PART**

**East part_Sports Center_5000m²**
- Full size basketball gym X 2
- Table tennis table X 8
- Billiard table X 8
- Fitness center_770m²
- Office/Storage room_650m²

**West part_1600m²**
- Lecture Hall_245m²
- Restaurant_500m²
- Office X 5_70m² X 5 = 350m²
- Washroom/shower room_290m²

**LAND PART_7200m²**

**Library_650m²**
**Urban living room_420m²**
**Rehearsal room X 2_355m² / 255m²**
**Activity room_180m²**
**Meeting room X 2_5m X 6.5m = 32.5m² X 2 = 65m²**
**Computer room_10m X 7.5m = 75m²**
**Exhibition room X 2_7m X 10m = 70m² / 7.5m X 8.5m = 63.75m²**
**Chess room_7m X 10m = 70m²**
**Café_270m²**

**Office X 4_70m² X 4 = 280m²**
**Storage room X 8_80m² X 8 = 640m²**
**Washroom_100m²**
LANDSCAP AND ARCHITECTURE
The urban center is an important link of the city and the recreational system. The artificial pier system on the water and the park on the land can both be seen as the landscape below the urban center which can be called lower layer landscape. And the sloped green roof can be seen as the upper layer landscape which forms the building. The building is not isolated, it is close related to the landscape.

ARCHITECTURE SCALE RESEARCH QUESTION
How to integrate Galveston urban center with the landscape from both exterior and interior?

MAIN PART: LAND PART
In this case, both of the water part and land part are elevated higher than the seawall to avoid the water problem. So they are facing the same level hurricane challenge: wind problem. But the land part has more complicated landscape and function than the water part. So the land part of urban center will be the main part to develop.
CONCEPT
Layer 1: Landscape

**Site**

- sea
- highway & seawall
- park

**Lower Layer Landscape**

- landscape above water
- landscape on the land

**Upper Layer Landscape**

**TWO LAYERS OF LANDSCAPE**

The two layers of landscape are connected on one end and open on the other. This reflects the character of public building and the water adaptive strategy.

**Strategy**

- Unification of space and flood prevention strategy

- Open water adaptive

- Close water defensive
The two layers of landscape define two kinds of public territories: inner public territory and outer public territory. The lower layer of landscape is created to connect these two territories. The landscape also defines different kinds of public spaces: linear public space, central public space. The division of spaces defines people’s activities and the function of the building.
The form of landscape enclosed three different kinds of public space: outer central spaces, inner central spaces and linear spaces. The trees define the main order of the space and become the central landscape strip. All the spaces are distributed around this landscape strip.

Inner central spaces define the main entrance of the building and have more movements. They are the spaces where smaller building cores distributed: meeting room, computer room, washroom, rest room, exhibition room. Small curves define the position of these smaller gathering spaces.

The rest spaces are large integral gathering spaces which make people stay with specific purpose: library, café, rehearsal room, urban living room.
Layer 3 - **Structure**

The interior building cores and columns are like plants growing on the existing landscape. Building systems co-exist with landscape systems. And the buildings should follow the order which is set by landscape.

Layer 4 - **Building**

The interior building cores and columns are like plants growing on the existing landscape. Building systems co-exist with landscape systems. And the buildings should follow the order which is set by landscape.
After the main body of the building is formed, the outer layer comes last: roof windows and facade. Roof windows are added to catch the light and the outer façade is the last layer to design. It has the function of enclosing the whole system. The last two layers come last which means they are the most flexible elements of the building. They should be adjustable to fit different situations of the building.
HURRICANE
WALL

The building can be seen has a double layer wall system: The transparency, flexible outer wall and the isolated inner wall of each building/room. There are three kinds of inner buildings: solid core with solid concrete load bearing wall which is also the main structure of the building; glass core with removable glass façade; isolated concrete building which is solid enough to resist the hurricane.

The outer wall reflects the public character of the urban center. It is transparent and flexible, the exterior landscape can be seen clearly continue to the interior of the building. The interior building cores and columns are like plants growing on the landscape.
HURRICANE

The structure of the building should be strong enough for the wind resistance and protect the big roof from overturning. The solid core is the main structure to fix the roof together with the column.

When the hurricane came, there will an early warning several days before. All the flexible walls and facilities can be removed to the solid core and isolated concrete building and be well protected. And the rest which is built as exterior elements are left to resist the hurricane. A net system insulated along the facade around the building will be pulled down and fix on the floor to protect the interior of building from hitting by the fragments of buildings or boats.

Thus can meet the demands of reducing damage and recover easily and quickly.
LAND PART
LAND PART

The space is divided in a flexible way: it is divided by landscape, material, height difference.
isolated building
CHAPTER 5

The topic of this chapter is ‘Structure’: hurricane, architecture & landscape, Structure. Depending on the hurricane prevention strategy for the building on chapter four, the structure of the building should be strong enough for the wind resistance and protect the big roof from overturning. The way of building the façade should also fit the hurricane prevention strategy: solid, folding or removable. The interior of building should be built in an exterior way to be solid. And the branch column is the response of both structure and ‘architecture & landscape’.
Geologic Wonders of Texas

Galveston Island

Rock Sediment and Soil Facts

Galveston Island is known as a sandy barrier island because it is made up mostly of sandsized particles, with lesser amounts of finer mudand larger gravelsized sediments. (Resource from Website of The University of Texas at Austin. Shallow Foundation are used when the soil strata affected by the building could resist the superimposed stress without causing excessive settlements.

FOUNDATIONS

Ribbed Raft Foundation

1. Soil condition of Galveston

‘Galveston Island is known as a sandy barrier island because it is made up mostly of sandsized particles, with lesser amounts of finer mud and larger gravelsized sediments.’ -Resource from Website of The University of Texas at Austin. Shallow Foundation are used when the soil strata affected by the building could resist the superimposed stress without causing excessive settlements.

2. Economical and functional support system

One of these advantages is the ability of the foundation to support high column loads. When a building has several columns that support high loading conditions, placing a ribbed mat foundation can be more economical than placing several spread footings. Generally, when more than 50% of the building plan area is covered by footings, a ribbed mat foundation can be the most cost-effective solution. (Bowles, 1977)

3. Hurricane

The integral heavy foundation can fix the building better form overturn in the hurricane.
SUPPORTING STRUCTURE

**Solid Core:** built by load bearing wall

**Column:** Branch column

Upper end fixed to the beam
Lower end pinned to the foundation

\[ K = 0.7 \]
The tree column meet the concept of public space quality and hurricane prevention both well. Since the land part of the building is protected by the seawall and the water part of the building is elevated. There won't be much water problem for the building but the wind. The structure of the building should be solid enough to protect the roof from overturning. The branch column can provide a stronger column than normal one. What's more the space quality is improved by the branch column. It can be a symbol of 'landscape go inside' and provide more exterior sense to interior.
a/b. bended column deformation will happen easily.

c. missing the supporting angle. The angle for the branch column is important for supporting heavy load and preventing column from being warped by the hurricane.

d. strongest structure

Chosen column
A combination of c and d multi-steel-tube column with one column in the middle support the joint of structure.
Column a has longer branches (4m) which are more easily bent than column b.

Smaller supporting angle makes stronger column.

The thicker branches make the column stronger.
hidden LED strip light

removable troffer
easy to maintenance, clean and replace.

light strip
Main beam connections

ROOF STRUCTURE

Braced Structural Frames
The size of the unit is 9m X 10.5m. This frame system provides more efficient resistance against the earthquake and wind forces.

Beam
The sizes of the main beams on both direction are the same. The beams are continue on the W-E direction to form the 4m cantilever on both sides. The diagonal bracing also work as the secondary beams.
Composite Floor

The profiled metal sheets are used only as permanent formwork to enable fast progress and immediate provision of floors. Reinforcement is in the form of round bars. The floor acts like a ribbed concrete slab. With sufficient concrete cover to the reinforcing bars, the floor slab is, however, fire resistant. The concrete slab acts as a horizontal plate resisting wind forces.

Ceiling Construction

ROOF STRUCTURE

The roof of the building is green roof with round roof windows on the top of the branch column.
The roof window can be opened for the natural ventilation. One roof window unit includes 8 fan-shaped window pieces and one central fixed window installed on the intersection of the structure to hold the fan-shaped window pieces. The fan-shaped window pieces are divided into singular group and even group. When the window opens the singular group open first and then the even group.

**ROOF WINDOW SYSTEM**

- wood shutter to view blocking and air conditioning
- gravel strip
- central fixed window
- suspended concrete panel
- hidden roof light installed on two sides of the beams
- lifting devices installed on the top of the beams
- air conditioning duct

**Device Illustration**
The rain on the roof window is collected by the groove fixed along the even facade pieces and conducted to the ring of gravel on the roof which is connected to the drainage layer of the green roof.

The roof window is sealed by the spring element which has the similar operation principle with swing door. It is fixed on the wall and connects the window piece. It can be pushed down when the window opens and return while the window is closing. It can connect to the window closely during the whole process to seal the system.
The sun-shading system is combined with the structure above the column. It is a fan-shaped device fixed on the bracing beam. When sun-shading system opens, the device opens from both two sides which look like a folding fan. The shading material is unfolded by the shifting bars on two sides which follow the circular sliding rail. The sliding rail is installed on the ring spaces around the branch column. The coverage of sunshades can also be adjusted depending on needs. The material used for sunshade is light-weight, light-transmitting and ventilated.
The flexible facade breaks the boundary of interior and exterior which makes the spaces and landscape continue freely. As more facade units open, more public the building becomes. The space inside can also extend to the outside easily, such as the cafe area.
FACADE SYSTEM

The facade is hanging on the cantilever of the beam. It can be removed easily or folded and hidden in the roof before the facade.
The whole facade is hanging on the cantilever of the beams by the φ10 wire rope. One vertical line of the facade can be seen as an unit. The singular units with pulleys are mainly lifted for the daily use and the even units with sliding rails stay as the frame to fix the moving units. Both of the two units can be lifted for the specific situation.

One unit of the facade consists several pieces of 1.6m×2m facade elements. When the facade closed the lower piece is hanging on the upper piece. When the facade open the lowest piece move first and lifted the the rest up one by one by the steel elements on the bottom.
FACADE TESTING MODEL STUDY_unsolved problems

1. How to deal with the influence to the façades caused by horizontal wind load? How to make sure the bottom façade piece clench exactly right when there exists wind load.

2. How should the pulleys and the tracks be designed to make sure the sliding smooth?

3. How to make sure the bottom façade piece vertical when it slides upwards? There are some cases where bottom façade piece roll over when testing the model devices. This will affect the regular sliding of the façades in spite of the façade units on both sides for fixation.

4. Heat preservation of the façades needs to be further dealt with.

5. Under special circumstance where even units also need to be opened, how to make sure they slide smooth with fixation on both sides also needs to be further investigated.
SOLID CORE

The concrete solid core is also the main structure of the building. The function of this solid core is wash room (ground floor) and auxiliary function room (first floor), so there is no openings on the wall. The door of the wash room is hidden in the wall which is only closed when the hurricane comes. The load bearing wall is set a little behind to achieve a separating appearance with the ceiling by the shadow.
concrete wall 230mm
thermal insulation 100mm
concrete wall 230mm

steel hidden door

a-a cross-cut

concrete stair detail

230mm exposed concrete wall

steel tube in precast concrete element

a wall opening filled with epoxy resin

80/30/70 precast concrete tread
GLASS CORE

Contrary to the solid core, the glass core gives the feeling of light and transparency. The function of the glass cores is meeting room and computer room. The glass core is made of removable suspended glass facade. Spended curtains are used to block the view when needed. When the room is not occupied the curtain are opened to make the view go through.
view from glass core
wooden ceiling door for maintenance and removing the glass facade.

GLASS CORE

Removing Facade Steps

1. Unscrew

2. Lift

3. Curtain close

4. Remove
CHAPTER 6

The topic of this chapter is 'Climate': structure, public space quality, architecture & landscape. The character of the building and the façade strategy decide the climate concept together. And the combination of ventilation fans and roof windows with column shows a strong connection of structure and climate.
The building has three climate systems: main system, regulating system and supporting system. Ground collectors are used to build the systems which are installed 2 meters below the foundation of the building.

**Main system:**
Ground collector and concrete floor as thermal mass consists the heat exchange system.

**Regulating system:**
Ground heat pump system to provide extra cooling or heating to the floor if needed.

**Supporting system:**
Roof heat collector with air conduct combined with air – water heat pump helps to provide extra heat to the main system. Thereof windows can be opened in varying degrees to realize natural ventilation.
WINTRE SUNNY DAY

The floor is heated on two sides. Roof window shutter and façade shutter are open to allow the solar radiation to heat the floor. At the same time the heat in the ground is transferred to the floor by heat exchanger. Heat pump can also help to heat the floor if necessary. The heat collected by the roof window can be stored in the ground collector. The hot water in the building is provided by the water-water heat pump. Some of the roof windows are opened to a very small degree to help realize natural ventilation in the room.
WINTER CLOUDY DAY

Roof window shutter and façade shutter are open. The heat collecting system on the roof is closed. The heat in the ground which is stored in the sunny day is transferred to the floor by heat exchanger. Heat pump can also help to heat the floor if necessary. The hot water in the building is provided by the water-water heat pump. Some of the roof windows are opened to a very small degree to help realize natural ventilation in the room.
SUMMER SUNNY DAY

Roof window shutter and façade shutter are closed to reduce the solar radiation. The heat on the floor is transferred to the ground by heat exchanger and heat pump can help to cool the floor if necessary. The heat collected by the roof window is transferred to the water by air-water heat pump which can be stored in the hot water tank. Some of the roof windows and fans on the roof are opened to help realize natural ventilation in the room.
SUMMER CLOUDY DAY

Roof window shutter and façade shutter are open. The heat on the floor is transferred to the ground by heat exchanger and heat pump can help to cool the floor if necessary. The heat collecting system on the roof is closed. The hot water in the building is provided by the water-water heat pump. Some of the roof windows and fans on the roof are opened to help realize natural ventilation in the room.
SOLID CORE CLIMATE DESIGN

Different ventilation strategies are used in different parts of the building. Natural ventilation is mainly used in the main body of the building which is mainly achieved by opening the facades and roof windows. The exhausting fan is combined with column and roof window to support the ventilation and cooling if needed.

Number of fans needed in the main body of the building:

\[
430 \times 50 / 3600 = 5.97 \text{m}^3/\text{s} \quad 5.97 / 3 \text{m}^3/\text{s} = 2
\]

The solid core share the same ground climate system with the main part of the building. In the solid core the air inlet machine is combined with floor. Thus the solid core can keep solid while at the same time achieve ventilation and get enough sunlight at the same time. Due to the special function, the rehearsal room has extra cooling machine inside.