Downtown Connections: A Cultural Building Complex

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Colofon

Downtown Connections
A Cultural Building Complex

The content of this report is based on author’s research and design carried out at Delta Interventions Studio at Faculty of Architecture, Delft University of Technology.

Delft University of Technology
Master Architecture
Delta Interventions Studio
Graduation Report

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Cover
View from the south bank

Date
25 June, 2015
Content

Introduction

PART 1: Research
1. Context
2. Analysis
3. Downtown Houston
4. Design Site
5. Assignment

PART 2: Design
6. Urban Design
7. Architectural Design
8. Landscape Design

PART 3: Appendix
1. Reflection
2. Theory Thesis
PART 1: Research

01 Context
02 Houston Analyses
03 Downtown Houston
04 Design Site
05 Assignment
1.1 Global Deltas

1.2 Houston Texas- Galveston Bay Area

The Houston Texas - Galveston Bay Area is part of the upper Texas coastline of the United States. Over the last hundred and fifty years this region has developed from a sparsely settled agricultural and fishing hinterland into one of the most important industrial and urban concentration in the world. Its population, economy, and industrial infrastructure continue to grow at a remarkable rate. The pressure of population growth and industrial expansion have pushed urban and industrial development into previously undeveloped agricultural and wilderness areas, as well as low-lying coastal and riverine flood zones. As this process continues in a substantially unregulated manner, the region faces unprecedented ecological, life safety, and economic risks.
1.3 Flood risk & Challenges

The left map shows the flood risk of Houston and Galveston area within the 100-year storm surge. The areas along Galveston Bay and some rivers have great risk of inundation. Based on the study of the Rice University, Houston, like Galveston, is also threatened by flooding because of the sea-level rise rising. Sea level will pose increased hazards to coastal cities in various ways, especially the magnification of inundating storm surges that accompany hurricanes and other tropical storms. From the map of “Current Rates of Sea-level Rise”, the sea-level rises 25 inches per 100 years in Galveston.

On September 13, 2008 Hurricane Ike 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 that wreak havoc on infrastructure and washing away entire communities. 84 people lost their lives during this damage. The giant storm had a long-term impact on U.S economy.
2.1 3x3x3 Layer Analysis

- **Landscape**
  - 1850
  - 1905
  - 1986

- **Infrastructure**
  - 1850
  - 1905
  - 1986

- **Urban Fabric**
  - 1850
  - 1905
  - 1986

(credits: own edit based on group work)
Part 1. Research

2.2 3x3x3 Layer Analysis
Conclusions

(first ring grid system
connection Houston - Galveston
second ring)

(grid system new connection
(credits: own illustration))
2.3 Different Waterscapes
2.3 Different Waterscapes

Shore fishing sites can be found on many small lakes, as well as the bays and the Gulf of Mexico. Freshwater lakes contain a variety of fish to catch such as bass, catfish, sunfish and carp.

There are many bayous in Houston region. Buffalo Bayou is known as the “Mother Bayou,” flowing through Houston. It is fed by several significant tributary bayous, such as White Oak Bayou, Greens Bayou, and Brays Bayou. Along Buffalo Bayou is an area of Industrial production.

There is a series of islands in the upper Galveston Bay near Baytown and La Porte. Atkinson Island is the longest one and 150 acres in size. Wildlife on this island includes shore and wading birds, raccoons, and rattlesnakes. Visitation is restricted to boat access only.
A large area of wetlands spread over the Houston and Galveston region. Wetlands play a number of roles in the environment, principally water purification, flood control, and shoreline stability. It also serves as a home to a wide range of plant and animal life.

Along the Galveston Bay, there are several ports, such as the Port of Texas City, which is a major deepwater port in Texas City; the port of Galveston and the port of Houston. They together make this area become one of the world’s most important shipping hubs.

The Gulf of Mexico is an ocean basin. The Gulf coast offers a sparkling coastline with seaside towns and a large area of beaches that attract tons of people to visit. The nature environment along Gulf coast also inhabit a number of wildlife.
Part 1. Research
Downtown Houston was the original founding point of the city. In 1836, Allen brothers first landed in the area where the White Oak Bayou and Buffalo Bayou meet, now known as Allen’s Landing. After the Galveston Hurricane of 1900, Downtown attracted investors who seek a location close to the ports of Southwest Texas, because it got less struck by hurricanes than Galveston and other port cities. Subsequently, with the discovery of oil, shipping and oil industry stimulated settlement in Houston. From this forward, the area grew substantially, as many skyscrapers were constructed. Nowadays, Downtown Houston is the city’s central business district.
Part 1. Research

3.2 Buffalo Bayou

**Overview**

Buffalo Bayou has been a focal point in Houston's history since the Allen brothers founded the city. It is a shady, slow-moving river and a main waterway, known as the “Mother Bayou,” flowing through Houston. It flows approximately 53 miles (85 km) east through the Houston Ship Channel and into Galveston Bay and the Gulf of Mexico. In addition to drainage water impounded and released by Addicks and Barker Dams, the bayou is fed by natural springs, sewage treatment plants, surface runoff from streets, parking lots, and highways, and several significant tributary bayous, such as White Oak Bayou, Greens Bayou, and Brays Bayou. Buffalo Bayou runs through the north of Downtown area meeting White Oak Bayou at Allen’s Landing. Numerous historical sites, as well as ruins of old docks and facilities, can be seen along the banks of Buffalo Bayou.

**Buffalo Bayou Restoration**

With the development of the city, Buffalo Bayou has again become the centrepiece. Since issuing the 20-year master plan in 2002, the restoration of Buffalo Bayou has been carried out. The transformation of Buffalo Bayou Park from Shepherd to Sabine is underway, which includes restoration of natural landscape, new and upgraded trails for walkers and hikers, pedestrian bridges and also some festival area and picnic spots, etc. Once complete, 160 acres along 2.3 miles of the bayou will be restored. New destinations and natural amenities will revitalise the once neglected bayou into an active and vibrant waterfront.

**Flood Risk**

<table>
<thead>
<tr>
<th>Flood Frequency</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% (10-year)</td>
<td>27.10'</td>
</tr>
<tr>
<td>2% (50-year)</td>
<td>32.60'</td>
</tr>
<tr>
<td>1% (100-year)</td>
<td>35.30'</td>
</tr>
<tr>
<td>0.2% (500-year)</td>
<td>41.30'</td>
</tr>
</tbody>
</table>

Historical Storm

- **Date**: 9/11/1998
  **Event**: Frances
  **Elevation**: 30.40'

- **Date**: 6/5/2001
  **Event**: Allison
  **Elevation**: 35.00' (11.7m)

- **Date**: 9/13/2008
  **Event**: Ike
  **Elevation**: 27.80'

- **Date**: 4/28/2009
  **Event**: 21.60'

**Tropical Storm Allison**

In 2009, Tropical Storm Allison hit White Oak and Buffalo Bayou area, which resulted in an inundation of Downtown.

**Cycling path under highways**

![Cycling path under highways](http://swagroup.com)
The Downtown area is bounded by Interstate highway 10 to the North, US 59 highway to the East and Interstate Highway 45 to the South and West. The Downtown area is constructed in a 100 x 100 m grid with wide roads and sidewalks. The light rail goes through the Main Street, connecting the North Transit Centre and the Fanin Center. There is an extensive network of pedestrian tunnels and skywalks connecting the buildings of the district. The tunnel system is home to many restaurants, shops and services.
Part 1. Research

- **Districts**
The Historic District was the original town center of Houston and dates from the 19th century. The center of the historic district is the Market Square, where the original city hall building stood. The district includes the Harris County courts complex, and the University of Houston–Downtown is on the edge of the district.

**Market Square Park**

When Market Square Park reopened three years ago beckoning visitors with green space, a dog park and even a Niko Niko's cafe, it became a catalyst for new projects and brought a renewed focus on the north side of Downtown.

**University of Houston–Downtown**

The building is recognized as part of the National Register of Historic Places, is a Recorded Texas Historic Landmark, and considered a Contributing Building in Downtown Houston’s Main Street/Market Square Historic District.

**Skyline district**

Skyline District – Includes many skyscrapers and forms the base of Downtown’s employment

**Bank of America Center**

**JP Morgan Chase Tower**

**Heritage Plaza**

**One Shell Plaza**

---

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Part 1. Research

St. Joseph Medical Center

St. Joseph Medical Center (SJMC) is a general acute care hospital in Houston, Texas owned by Iasis Healthcare. Established in 1887, SJMC was the first hospital in Houston. The hospital was the largest in the city until the Texas Medical Center was established.

Sport & Convention district

Downtown Houston has three major league sports venues. Minute Maid Park (formerly Enron Field), which opened in 2000, is home to the MLB Astros and the Toyota Center home to the NBA Rockets opened in 2003. BBVA Compass Stadium which seats 22,039 opened in 2012 and is home to the MLS Dynamo and to the collegiate football team Texas Southern Tigers.
The Downtown Houston Theater District is one of the largest in the country as measured by the number of theater seats. Houston is one of only five cities in the United States with permanent professional resident companies in all of the major performing art disciplines of opera, ballet, music, and theater. Venues in the theater district include the Wortham Center (opera and ballet), the Alley Theatre (theater), the Hobby Center (resident and traveling musical theater, concerts, events), the Bayou Music Center (concerts and events) and Jones Hall (symphony).

GreenStreet
GreenStreet, formerly known as Houston Pavilions, is a commercial development in Downtown Houston, Texas, United States. GreenStreet features an inviting and synergistic experience for guests to enjoy their favorite eateries, entertainment and shopping options.
• Floodplain
Intense rainfall is responsible for many types of flooding across Harris County. Basically, Harris County contains four types of floodplains, each with its own flooding characteristics. But, there is also a fifth “scenario” that occurs in many areas due to the extraordinary intensity of some of the rainfall. In this fifth scenario, it’s not necessarily an identifiable floodplain, but rather the street drainage system’s inability to move stormwater to the nearest channel. There is simply too much rain in too short a time period.

Valley floodplains are generally located in the northwestern portion of the county. The ground in the area is more “defined,” with creek valleys. Flooding can be very deep and usually extends for a few days.

There is only ONE major river floodplain in Harris County. It is along the San Jacinto River. The floodplain is large, deep and swift, and flooding conditions may sometimes last a week or more.

Shallow floodplains exist throughout much of the county and affect thousands of residences and businesses. When the channel capacity is exceeded, flooding begins, but usually lasts hours, rather than days.
**Type D: Coastal Floodplain**

The diagram below shows coastal flooding when unusually high tides or hurricane surge can flood low-lying structures. Ground subsidence can result in more frequent and severe coastal flooding.

**Conclusion**

The Harris County Flood Control District defines 4 floodplain types and 1 exceptional scenario. From this view, Downtown is in the Shallow Floodplain, which means when the Buffalo Bayou’s channel capacity is exceeded, flooding begins, but usually lasts hours, rather than days. The north area of Downtown is in the bayou floodplain, especially the area around the confluence of Buffalo Bayou and White Oak Bayou.

This type of flooding isn’t restricted to any one area of the county. It can happen anywhere. When intense local rainfall exceeds storm sewer or roadside ditch capacity, the water can “pond” in the streets deep enough to flood residences that are not even near a creek or bayou. The water will seek a path to the channel by flowing overland (sheetflow). When residences and other structures are in the path, additional flooding occurs. This type of flooding is not identified on Flood Insurance Rate Maps, which is another reason why flood insurance is so important to everyone.
Based on the research, there are many problems in Downtown Houston: The streets are designed for vehicle traffic and some sidewalks are missing. The pedestrian system has not been established well. Besides, the waterfront space of Buffalo Bayou has not been utilized. A long distance of the bayou in Downtown is covered by several highways, which result in a large area of leftover space. In addition, new interventions are needed to reduce the risk of flooding in the area along Buffalo Bayou. Lack of green space is also a problem which related to the public life of Houstonians. New attractions that accommodate various activities should be added, making Downtown a more appealing tourist destination and also contributing to a better street life.
How to take advantage of Buffalo Bayou to create a New Attraction in Downtown Houston to make it more lively?

3.5 Research Question
4.1 Choice of the Design Site

The design site is located on the north bank of Buffalo Bayou. It is currently owned by the United States Postal Service and houses a post office distribution facility and office building that have been deemed obsolete to USPS operation. Being defined by the massive highways and the bayou, this area is underused and lacks connections with the central Downtown. From the urban view, this site is a leftover space. In addition, due to several bridges cross over the river channel, the waterfront area of Buffalo Bayou has lost its value to be a green public space for people. Moreover, this area is in 500 year floodplain, facing the flood risk caused by high water levels of the bayou resulting from hurricanes and intensive rainfall.
4.2 Street View Analysis

1. Altitude difference between site, railway and Louisiana Street

2. Fence & retaining wall set an unfriendly boundary

3. Outdated building & random parking make this area without any visibility

4. Limited pedestrian area, the wide street has views of water & green area

5. Unaccessible waterfront

6. Narrow and unsuitable access to waterfront at the corner of Franklin & Bagby Street, next to the freeway

7. Franklin Street separates the site from green area along binnen bapou

8. Congress Ave interrupts the continuity of green area

9. Leftover space under freeway
4.3 Sub-Research Question

1. What kinds of architectural programs could activate the site?
2. How to take advantage of the Buffalo Bayou?
This document defines an overall long-term vision for Houston's Downtown in 2025. While this study was completed in 2004, before the completion of Discovery Green and other key developments, the overall vision and recommendations are still pertinent.
**Attractions and Community Venues**

Downtown has firmly cemented its role as the region’s home of major cultural performance and event facilities. Its impressive array of regional attractions ranges from premier fine arts performance halls in the Theater District to the new sports and convention facilities on the east side. Still, Downtown must seek opportunities to become a greater part of Houstonians’ lives by adding other types of attractions that will be visited during the day and on a potentially more regular basis than the existing venues. These new attractions will have the added benefit of enriching Downtown’s texture for out-of-town visitors as well, making Houston a more appealing tourist destination. Finally, the activity generated by these new facilities will create synergy with Downtown’s other uses, especially retail, and contribute another dimension to “street life.”

**Expand and Refine the Theater District**
- Make continuous efforts to ensure that Theater District facilities do not lag behind national counterparts in quality or capabilities.
- Add small-scale performance venues and support spaces that provide more spontaneity, energy and urban diversity.
- At Bayou Place Phase II, consider arts-related uses, high-rise residential development and removal of the overhead structure above Bagby so that the street can become a key civic corridor.
- If Buffalo Bayou improvements and U.S. Postal Service plans allow, redevelop the existing post office site as a mixed-use extension of the Theater District along the bayou.
- Similarly, examine the Bob Casey Federal Courthouse site as a potential location for performance venues or support spaces if a new federal courthouse is built.
- Study the potential for creating a cultural park for the Theater District by closing Texas Avenue and Prairie Street (made possible by a redesigned I-45 North) while improving access to public spaces.
- Work with property owners to add entertainment, such as an IMAX theater, to the area around the Downtown Aquarium.

**Promote and Enhance the Convention and Sports District**
- Tie a new regional visitor center along Avenida de las Americas into Downtown’s historic attractions.
- Encourage coordinated development of the “superblock” area on the west side of the George R. Brown Convention Center with a major civic green space enhanced by entertainment venues and retail, defined by high-rise residential and served by visitor-friendly parking.
- Enhance Avenida de las Americas as a key civic corridor.

**Design a Signature Freeway Bridge over the bayou.** (see page 31)
- Use the freeway realignment to create more park space and a recreational corridor.

**Improve the bayou’s environment and usage potential with other projects and development opportunities**
- Make Buffalo Bayou the centerpiece of a transformed Theater District with a cultural park and development on the post office site.
- Emphasize mixed-use residential development from the Theater District to the East End.

(credits: Downtown Development Framework)
Part 1. Research

4.5 Theory Thesis

1. Linear Space

2. Node Space

3. Combination Space

Reclaiming Leftover Spaces

The potential of waterfront space under elevated highways

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Delft University of Technology, Department of Urbanism
12th Graduation Lab Urbanism Conference
October 31st 2014

Abstract – The automobile has had a major impact on the city of twentieth century. The adoption and construction of elevated highways spread as the expansion of city and the growth of population, creating multi-layered cities. The massive highway system provides an easy means of connectivity between cities, countries and neighborhoods, while at the same time, as they cut through cities, acres of wasted spaces have been created. (Trancik, 1986) The spaces along and under highways are often underutilized and related to the words “unsafe” “barrier-filled” and “undesirable”. Recent decades, cities are beginning to take advantage of these wasted spaces as part of urban renewal. Several successful projects come into the public eye, which not only rescue infrastructure from demolition but also satisfy people’s requirements of more public spaces.

This paper chooses the waterfront spaces under elevated highways as the research subject and attempts to investigate the potential reclaim strategies for this kind of leftover space. Firstly, the paper will assess the current situation and problems of spaces under highways. This is followed by a typological study of different kinds of composition of urban stream and highway. Subsequently, several practical projects that transform the leftover spaces into active public space successfully will be discussed. At last, a comparable analysis of the examples brings out different approaches for utilizing the waterfront space under elevated highways.

The outcomes of this review paper contribute to the author’s graduation project and promote relevance of this topic. By discovering the potential of waterfront spaces under highways and discussing different reclaim strategies for the transformation of these spaces, it could be helpful for designers dealing with this issue.

Key words – leftover spaces; waterfront space; under highways; reclaim; design strategies;

1. Introduction: Leftover space defined, problem statement and approach

With the expansion of cities and the growth of traffic, highway has become a significant element of urban patterns. The construction of highways in urban areas results in leftover spaces. The spaces disconnect the neighborhood, break the pedestrian links and affect the way we experience the city. (Trancik, 1986) In today’s cities, architects, urban planners and landscape architects have a major responsibility to discover and redesign the leftover space that have emerged in the process of urban development. Therefore, understanding the identity of these city gaps is the precondition for future planning and design.

Leftover space has been defined in many ways, such as “space of uncertainty” (Cupers and Miessen, 2002), “no man’s land” (Gorth and Corijn, 2005) and “urban voids” (Akkerman and Cornfeld, 2010). In Roger Trancik’s book “Finding Lost Space”, the leftover space is defined as “undesirable urban areas that are in need of redesign – antispaces, making no positive contribution to the surroundings or users. They are ill-defined, without measurable boundaries, and fail to connect elements in a coherent way.” (1986, p.3) According to these descriptions, leftover spaces could be abandoned old dockyards, unused sunken plaza, superfluous parking lots, land for greening but not developed and the space underneath the bridges and highways. Among all these leftover spaces, space under elevated highways has been discussed frequently in recent decades, which is also the focus of this paper. More specifically, the waterfront area that below elevated highways.
How to take advantage of Buffalo Bayou to create a New Attraction in Downtown Houston to make it more lively?

Redevelopment Plan for the Post Office Site

A Mixed-use Extension of Theater District along the bayou

- add smaller-scale performance venues
- create a cultural park for the Theater District
- add entertainment, such as IMAX Theater
- cultural facilities that appeal to and affordable for families
- make Buffalo Bayou the centerpiece of a transformed Theater District

05 Assignment
PART 2: Design

06 Urban Design /Redevelopment Plan of U.S Post Office Site
07 Architecture Design /Performing Arts Center
08 Landscape Design /Cultural Park
5.1 Case Studies

- **Hafen City**
  Hamburg, Germany

- **11th Street Bridge Park**
  OMA + OLIN, Washington D.C, US

- **Rimini Seascape**
  JDS, Rimini, Italy

- **Slussen Masterplan**
  Foster + Partner, Stockholm, Sweden

- **Buffalo Bayou Promenade**
  SWA group, Houston, US
Remove Roads

Remove several roads that cross over the Bayou to open the waterfront space.

Establish New Connections

Establish new roads to improve connections between West and East, North and South.

Integrated Development

Add building blocks and some small roads.
5.3 Master Plan

- Pedestrian & Cycling Bridge
- Terrace Deck
- Performing Arts Center
- Terraced Cultural Park
- Exhibition Hall
- Football & Basketball Fields
- Student Housing
- Collective Housing
- Ground Parking
5.4 Comparison

- Road Network
- Green Space
- Bayou Continuity

Before

After
Part 2. Design

- Building Typologies
- Public Life
- Channel Capacity
Downtown Connections - A Cultural Building Complex

Part 2. Design

Architectural Design

07 Architectural Design

7.1 Design Area
7.2 Choice of Performing Arts Center

*Merging Grids*

By developing the master plan, a new grid system has been set up on the North bank of Buffalo Bayou, which is distinct from the original Downtown grids. The location of the Performing Arts Centre becomes a hinge point of these two separated grid systems. Therefore, the design of Performing Arts Centre to mediate these grids is quite important in the whole redevelopment plan.
7.3 Design Concept

Improve the connections between the site and the central downtown by providing cultural venues and reclaiming Buffalo Bayou.

Passage connects waterfront and residential area.

The two building masses are connected to form the whole Performing Arts Center.
7.4 Programmes

Performing Arts Center

Education
- 2850 m²
  - Arts Studio
    - 900 m²
  - Exhibition
    - 800 m²
  - Art Library
    - 700 m²
  - Rehearsal Room
    - 300 m²
  - Dressing Room
    - 150 m²

Theater
- 5200 m²
  - Foyer
    - 2000 m²
  - Theater (700 seats)
    - 1500 m²
  - Entrance Hall
    - 600 m²
  - Storage
    - 600 m²
  - Dressing Room
    - 200 m²

Commerce
- 1600 m²
  - Cafe
    - 600 m²
  - Retail
    - 500 m²
  - Kiosk
    - 500 m²

Administration
- 1350 m²
  - Office
    - 600 m²
  - Staff Cloakroom
    - 150 m²
  - Technical Units
    - 600 m²

Others
- 5300 m²
  - Parking
    - 4000 m²
  - Traffic
    - 900 m²
  - WC
    - 400 m²
7.5 Case Studies

- **RELAXX sport and leisure center**
  - South Korea

- **Asan Cultural Arts Center**
  - South Korea

- **Dadong Arts Center**
  - Taiwan

- **Urban Mediaspace**

- **Wagner Noël Performing Arts Center**

- **The Royal Playhouse**
  - Copenhagen
The overall massing and arrangement of buildings is determined by its context, both urban and natural. There were several main driving factors that contribute to the building composition and shape. First, all the building mass are arranged based on the new road network of the redevelopment plan. At the meeting point of this new grid system and the original Downtown grid system, the building has been rotated to the axis of Downtown, while the connection between this one and the adjacent building also established. In this way, the grids are represented in the building itself. Another major factor is the natural bayou. Follow the contour of Buffalo Bayou, the south edges of cultural buildings have been shaped. During the design, further shaping steps have been taken considering the view, function and relationship with surroundings.
Part 2. Design

1. basic volume
2. cut out the south edge
3. ramp & deck connection
4. shape the back side & insert the atrium
5. slope roofs & create the canopy
7.7 Site Plan

- Central Sunk Square
- Main Entrance of Performing Arts Center
- Parking Garage Entrance
- Amphitheatre
- Cultural Square
- Terrace Deck
- Bicycle Trails
- Fishing Pier
- Pedestrian & Cycling Bridge
7.8 Floor Plans

• Ground Floor Plan
Part 2. Design

- First Floor Plan
Part 2. Design

Downtown Connections - A Cultural Building Complex

Second Floor Plan

- first floor seats: 365
- second floor seats: 172
- movable seats: 72

In total: 609 seats

• Second Floor Plan
7.9 Sections

- **A-A Section**

- **B-B Section**
7.10 Materialisation

- Aluminium Panel
- Stone Brick
- Stone
- Concrete Paving Tiles
- Rocks
- Heavy
- Light
7.11 Sequence
Downtown Connections - A Cultural Building Complex
Part 2. Design
7.12 Construction

- **slope roof**

Concrete filled structural hollow sections can achieve 120 minutes fire resistance. Intumescent coatings materials expand when subjected to fire and form an insulating foam. It can achieve up to 120 minutes fire resistance.
7.13 Calculations

- **I-beam**

---

**LOAD**

- Beam own weight (BG1) - (0.14*9.8) in kN

<table>
<thead>
<tr>
<th>Area (I-beam) mm²²</th>
<th>211.7</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>BG1= beam own weight * 1.2 in kN</th>
<th>18,191,0736</th>
</tr>
</thead>
<tbody>
<tr>
<td>per meter in kN</td>
<td>309</td>
</tr>
<tr>
<td>Concrete slab+finishing layer+ceiling installations</td>
<td>265.8</td>
</tr>
<tr>
<td>Concrete slabs in kN</td>
<td>72</td>
</tr>
<tr>
<td>Ceiling and installations in kN</td>
<td>36</td>
</tr>
<tr>
<td>BG2= variable load * 1.5</td>
<td>448.56</td>
</tr>
<tr>
<td>per meter in kN</td>
<td>51,558,62069</td>
</tr>
</tbody>
</table>

**TOTAL LOAD in kN**

| q (TOTAL LOAD PER METER in kN) | 98,649,5869 |

**ULTIMATE THRESHOLD STATE**

- **MAXIMUM MOMENT**

- Mfd=1/4 q * l²/2 in Nm² (fixed) 311,1160142

- Mfd=1/8 q * l²/2 in Nm² (hinged) 933,3480425

- **RESENTENT MOMENT**

- W=1/60 h²/2 in mm³ 126,739,583,3

- Q(1/12w*h²)/3 in mm² 728,575,26042

- **QUADRATIC SURFACE MOMENT**

- d=1/12w*h² in mm² 194,973,5877

- **BENDING STRENGTH**

- Sigma = Mfd/W in N/mm²

- Fixed: 64,991,8559

- Hinged: 0.276501089

**CHECK STIFFNESS BEAM**

- Total bending variable load in mm

- U=0.95

- U=0.95

- Norm bending in mm

- UNorm=0.003

- 26.1

- Check: U.C = U/H/UNorm

- 0.9508037271

- 0.95 < 1
7.12 Calculations

- **column**

### Total Load Column

\[ P_d = \text{gamma} \cdot P_e + \text{gamma} \cdot Q \]

\[ \text{Permanent load} = 4679,240349 \]

\[ \text{Variable load} = 2907,164434 \]

### Pressure Tension (N/mm²)

\[ \sigma_c = \frac{P_d}{A} \]

\[ \sigma_c = 24,21703825 \]

### Column Pressure Unity Check

\[ U.C. = \frac{\sigma_c}{0.8 \cdot f_c} \]

\[ U.C. = 0.8648942233 \]

### Snapping Point

\[ \text{Critical snapping point} (N) = 144528439.8 \]

\[ \text{Snapping number bigger than} 5 = 30,88715882 \]
• west facade (education building)
  
  controllable shading system for west facade
  
  controllable glass louvers + fixed shading at corner
  
• south facade (theatre)
  
  Theatre South Facade Fragment
7.15 Details

1. roof construction:
   6mm aluminum composite sheet
   supporting structure,
   sealing layer,
   12.5mm plasterboard,
   150mm thermal insulation
   vapour barrier
   12.5mm plasterboard
   100mm corrugated steel deck
2. primary structure:
   200mm steel I-beam in truss
3. sandwich insulation panel
4. extruded aluminium facade post
5. steel bracket for suspended facade
6. secondary structure: steel sheet bent to shape
7. 45mm acoustic ceiling
8. double glazing: 8mm float glass + 16mm cavity + 8mm safety glass
9. glass louvre
10. purlin: 140/60mm steel RHS
11. toughened safety glass
   top-hung opening
12. floor construction:
   90mm screed with underfloor heating and cooling tubes;
   40mm insulation
   150mm reinforced concrete bonded to corrugated deck
13. bottom fixing steel bracket
14. 20mm closing strip
15. glass parapet: 2x12mm toughened glass
16. wood handrail
17. column: 500mm steel CHS
18. 590mm steel I-beam
19. 30mm fibrous concrete soffit
20. aluminium section with drainage hole

• facade & floor 1:20
• Floor plan over facade fragment 1:20

1. glass louver
2. double glazing: 8mm float glass + 16mm cavity + 8mm safety glass
3. vertical louver carrier
4. extruded aluminium facade post
5. steel bracket for suspended facade
6. 200mm steel I-beam in truss
7. 20mm closing strip
**Downtown Connections - A Cultural Building Complex**

**Part 2. Design**

- **Details 1:10**
  - steel bracket for suspended facade
  - glass louver
  - coated-aluminium movable glazing bracket
  - long lever
  - short lever
  - bottom fixing steel bracket

*Details 1:10*
7.16 Climate Design

- Natural ventilation (foyer)
- Mechanical ventilation (auditorium & office)
- Solar shading system
- Photovoltaic modules
- Water cooling

• Climate design concept
### 00010, Temperature, water, degrees Celsius,

<table>
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<th>YEAR</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
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<td>16.5</td>
<td>18.8</td>
<td>21.8</td>
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<td>26.5</td>
<td>22.9</td>
<td>18.5</td>
<td>15.3</td>
</tr>
</tbody>
</table>

- **bayou water cooling system schematic**

**Summer**

**Winter**

*Diagram showing summer and winter conditions with heat pump in cooling and heating modes, respectively.*
Part 2. Design

7.17 Collage

• bird eye view
• view from the south bank
7.17 Physical Model

- physical model 1:1000
- process physical models
8.1 Cultural Park Design

- Pedestrian & Cycling Bridge
- Cultural Square
- Amphitheatre
- Bicycle Trail
- George Bush Monument
- Kayak Launches
- Fishing Pier
- Pedestrian & Cycling Bridge
Part 2. Design

8.2 Flood Defense Level

Diagram showing flood defense levels:
- 13m
- 9m
- 6m
- 3m
8.3 Pedestrian & Cycling Bridge Design

- Bridge Structure Scheme

- Bridge Structure Fragment Model 1:100

Terrace view to Cultural Square

Terrace view to Kayaking place
• space under the bridge
Part 2. Design

• heavy rainy day
Appendix

001 Reflection
002 Theory Thesis
1. The relationship between the theme of the graduation lab and the subject

Delta landscape is naturally constant changing. They are the site of ceaseless processes of transformation and urbanisation. Due to the climate change and new insights concerning sustainability, there is a stronger need for new interventions. Delta Interventions is an interdisciplinary graduation studio focusing on deals with transformations in delta landscapes on different scales. As architecture students in this studio, we pay more attention on the design of architectonic objects in various waterscapes.

I chose Houston Texas - Galveston Bay area from the two given study areas (another one is IJsselmeer area in Netherlands). As the world’s largest petrochemical cluster and the most rapid expanding city of the United States, the Houston area is faced with a severe flood risk caused by high water levels resulting from hurricanes as well as flash floods from rainfall. The project focuses on the urban bayou waterscape, more specifically, the Buffalo Bayou area in Downtown Houston. From a broad view, the project is seeking ways to integrate the natural and built environment, through which transform and strengthen the identity of delta. In this case, the project aims to take advantage of Buffalo Bayou to create a new attraction in Downtown so as to make it more lively.

2. The relationship between research and design

Delta Interventions studio emphasises research and design. “Research by design” is the chosen method. Translating the research results into design concept is the main theme throughout the process. Since students are free to choose the subject in Delta Interventions, the early research was used to determine the exact assignment. Before putting forward the design, the research of Houston’s historical development and different waterscapes provided a general understanding and contributed to the choice of design site. Subsequently, further literature study, site analyses and the development of theory paper narrowed down the topic. After this, research and design worked together. More research were required during the design process, in return, these research stimulated the design constantly.

3. The relationship between the methodical line of approach of the graduation lab and the method chosen by the student in this framework

It’s important to look back and review the project when it’s about to be completed. Various approaches were used during the process, which support the design from different aspects.

Water-related design is the main theme in Delta Interventions studio. However, before starting the design, understanding the context of Houston Texas - Galveston Bay area was the first step. Through several mapping workshops, especially the 3x3x3 layer analysis (fig.1) I got a first impression and some essential knowledge of Houston. The layer model consists of three time period in three aspects: landscape, infrastructure and urban fabric. By understanding this process of delta transforming, one would intervene the delta with more respects of natural contexts.
Moreover, I did research on how water can be experienced based on analyses of Alvaro Siza’s Boa Nova Restaurant. From various aspects such as frame the view, promenade, materialisation, an overview of the relationship between water and architectural design has been achieved. The analysis of different waterscapes in Houston and redesign of the case-study building at this stage also built some preliminary ideas for future design. (fig.2)

With the interests in the urban bayou area, the scope of research was zoomed in to Downtown Houston. The research question “How to take advantage of the Buffalo Bayou to create a new attraction in Downtown Houston to make it more lively?” was asked by then. To answer this question, further analysis of Downtown Houston has been carried out. The literature study of “Downtown Houston Development Framework” ensured the design proposal base on the needs of Downtown Houston. The redevelopment plan that transform the design site into a mix-use extension of the theatre district is part of the 20-year development plan of Downtown Houston. In addition, taking the water aspects into account, the new development plan integrated water-related cultural venues and the terraced waterfront public space into the existing urban context. Therefore, this project answered the initial research question from three levels: urban (a redevelopment plan of U.S post office site); architecture (a water-related performing arts centre design); landscape(a waterfront cultural park design). (fig.3)

fig.2 different waterscapes (credits: own illustration from “Aspects of Water-related Design” booklet)

fig.3 diagram shows the relationship between research and design (credits: own illustration)
4. The relationship between the project and the wider social context

This project deals with the water issues in the urban bayou area in Downtown Houston. How to create new water interventions that protect the city and also fits the urban context has been addressed through the design process. The mixed-use extension plan of the theatre district transforms the current underused site into a lively place that benefits Houstonians’ lives. By constructing a series of cultural buildings and the cultural park, the northern bank of Buffalo Bayou will become a new attraction that visited during the day and on a potentially more regular basis than the existing venues. These attractions will have the added benefit of enriching Downtown’s texture for out-of-town visitors as well, making Houston a more appealing tourist destination. Moreover, in terms of the flood defence, the waterfront cultural park design gives more space for water while the cultural buildings are also designed to incorporate water, through which the safety of this urban bayou area will be improved.

As the local groups that devote to Downtown development are seeking redevelopment plan for the post office site, this graduation project would be one of the proposals that to be discussed and give an inspiration for the future development. The design of the water-related cultural building and the waterfront park would also be references when develop other urban bayou area.
Theory Thesis

Reclaiming Leftover Spaces
The potential of waterfront space under elevated highways

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Abstract – The automobile has had a major impact on the city of twentieth century. The adoption and construction of elevated highways spread as the expansion of city and the growth of population, creating multi-layered cities. The massive highway system provides an easy means of connectivity between cities, countries and neighborhoods, while at the same time, as they cut through cities, acres of wasted spaces have been created. (Trancik, 1986) The spaces along and under highways are often underutilized and related to the words “unsafe” “barrier-filled” and “undesirable”. Recent decades, cities are beginning to take advantage of these wasted spaces as part of urban renewal. Several successful projects come into the public eye, which not only rescue infrastructure from demolition but also satisfy people’s requirements of more public spaces.

This paper chooses the waterfront spaces under elevated highways as the research subject and attempts to investigate the potential reclaim strategies for this kind of leftover space. Firstly, the paper will assess the current situation and problems of spaces under highways. This is followed by a typological study of different kinds of composition of urban stream and highway. Subsequently, several practical projects that transform the leftover spaces into active public space successfully will be discussed. At last, a comparable analysis of the examples brings out different approaches for utilizing the waterfront space under elevated highways.

The outcomes of this review paper contribute to the author’s graduation project and promote relevance of this topic. By discovering the potential of waterfront spaces under highways and discussing different reclaim strategies for the transformation of these spaces, it could be helpful for designers dealing with this issue.

Key words – leftover spaces; waterfront space; under highways; reclaim; design strategies;

1. Introduction: Leftover space defined, problem statement and approach

With the expansion of cities and the growth of traffic, highway has become a significant element of urban patterns. The construction of highways in urban areas results in leftover spaces. The spaces disconnect the neighborhood, break the pedestrian links and affect the way we experience the city. (Trancik, 1986) In today’s cities, architects, urban planners and landscape architects have a major responsibility to discover and redesign the leftover space that have emerged in the process of urban development. Therefore, understanding the identity of these city gaps is the precondition for future planning and design.

Leftover space has been defined in many ways, such as “space of uncertainty” (Cupers and Miessen, 2002), “no man’s land”(Gorth and Corjin, 2005) and “urban voids”(Akkerman and Cornfeld, 2010). In Roger Trancik’s book “Finding Lost Space”, the leftover space is defined as “undesirable urban areas that are in need of redesign – antispace, making no positive contribution to the surroundings or users. They are ill-defined, without measurable boundaries, and fail to connect elements in a coherent way.” (1986, p.3) According to these descriptions, leftover spaces could be abandoned old dockyards, unused sunken plaza, superfluous parking lots, land for greening but not developed and the space underneath the bridges and highways. Among all these leftover spaces, space under elevated highways has been discussed frequently in recent decades, which is also the focus of this paper. More specifically, the waterfront area that below elevated highways.
Compare to other types of highway, though elevated highways occupy the least amount of land and provide a maximum street crossover and pedestrian flow at ground level, the magnitude structure produces unwanted view. Moreover, it isolates the residential area and destructs waterfront. (Halprin, 1966) In terms of the waterfront space under elevated highways, less sunshine under bridge decks and hardened soil around the foundation provide an unsuitable environment for plants growing. Meanwhile, noise and pollution produced by motor vehicles as well as the inaccessibility make the waterfront area that is supposed to be a welcomed public space loses its value. These undesirable features together with the unclear territoriality of spaces along and under highways sometimes lead to land misuses. Dumping debris, illegal trade and abandoning of cars have tagged this kind of space with the word “dangerous”. All these inappropriate use of the space under elevated highways would cause social and economical problems and influence the adjacent properties further. (Halprin, 1966)

Nevertheless, these leftover spaces have great potential for cities. They offer tremendous opportunities for designers to redevelop the urban area by discovering hidden resources. In order to reveal the potential of waterfront spaces under elevated highways and its contribution to urban development, three different types of spatial relationship between highway and urban stream will be elaborated on first in the next chapter. This is followed by a review of examples that related to each type showing different strategies for reclaiming these spaces. Further in the conclusions, recommendations can be for the future redevelopment of different types of waterfront spaces under highways.

2. Characteristics of spaces under elevated highways

Generally speaking, the space under highways is determined by the bridge deck and the ground. However, in practice, the space that enclosed by the complicated structures can all be seen as spaces under highways. (Xiao, 2011) The main elements of spaces under elevated highways including the ground, roof and column. Different spatial elements create different experience for people. Considering the material and height of the ground, it can be divided into static and dynamic places. The roof is actually the bridge deck here, which can protect people from raining and strong sunlight. Columns define different spaces while provide visual contacts. The spaces under elevated highways have a sense of enclosure on the one hand. On the other hand, they are open to the city.

As highways go through the city center and associate with urban stream in many cities, the waterfront spaces under elevated highways are meaningful to be probed into. Based on the spatial relationship between highways and water, there could be three types in general.

2.1 Linear Space

In the first situation, the urban stream is parallel to the highway, which defines a linear space along water while under the bridge deck. Linear space has the quality of directness, continuity and extension. (Booth, 2012) The sequence of columns that support the deck and the flow of river mutually reinforce these characteristics of linear space. In terms of the length, the type of composition between highways and urban stream makes the waterfront space has the largest interface with the highway's structure. In the other words, the waterfront area is largely influenced by highways in this situation. Therefore, the accessibility of waterfront area should be well organized in the reclaiming plan. From
the view of visual direct and movement, linear space shows great value to public activities. The uninterrupted and extended linear space seize people’s eye to lead to an end point or notable interruption. Besides directing visual attention, the straight line is best used to accommodate transit where the intention is non-stop. (Booth, 2012) Take these characteristics into consideration, the paralleled space between highways and water could be used for some dynamic activities such as cycling and jogging.

2.2 Node Space
The second type is the node space. The urban stream is perpendicular to the highway creating a cross node. Comparing to the other two types, the flyover has the least affects on the waterfront space in this situation. However, this node would interrupt the continuity of the whole waterfront area if not well designed. One of the five elements in Kevin Lynch’s metal map in his book The Image of The City is node. Nodes are points within the city, strategically located, which is often the main focal point to which individual is traveling to or from. There are often junctions – a crossing or converging of paths. They often have a physical element such as a popular hangout for the individual or a plaza area. (Lynch, 1960) While nodes are not physical constructions, they define and shape how people and systems flow through a space. Differ from linear space that stimulate people’s movement, node space slows down the speed. Social interactions occur in spaces where movement is at a pedestrian scale. (Galloway and Kang, 2010) Node space provides places for gathering and staying. Therefore, the node space that determined by highway and urban stream has the potential to be a plaza or exhibition place where people meeting and walking around.

2.3 Combination Space
The third one can be seen as a combination of the two situations discussed above. Because of the big scale and the complicacy, this composition of highways and urban stream often plays an important role as urban node. The cross and stacked bridge decks result in a fragmented waterfront space. On account of each fragment, it could be treated as either linear space or node space. However, how to connect these pieces of waterfront area becomes a key issue. The fragments are influenced by the complicated structure system and also have effects on each other. In order to achieve a complete spatial image and make positive contribution to the city’s public life, the transition between dynamic space and static space and the continuity of public activities should be addressed.

3. Case studies

3.1 Riverside Park South, New York
The Riverside Park South is located on the west side of Manhattan, New York. The elevated Miller highway used to be a barrier between Hudson River and the residential area. In 1991, Donald Trump gained the city’s approval for his project by agreeing to build several smaller buildings and a 21.5 acre public park. Thus, Trump Place and Riverside Park South were born. The development consists of six phases aiming to create a green link in Manhattan’s west side.

To enhance the park’s riverfront experience, the linear landscape at Riverside Park South are divided into distinct zones, episodes in an environmental, recreational and cultural narrative, while providing plenty of room for the in-between. The current park design includes some athletic facilities such as basketball courts, handball courts and soccer field that invite people to hone their skills. A circulation system of esplanades, marshland, boardwalks, native planting habitats, and bike paths tie the individual places together. As discussed in the previous chapter, the accessibility of waterfront is important when the river is parallel to the highway. In this case, the main public access to Riverside Park South is at the 72nd Street, which servers as a node connecting Riverside Park to the north and Riverside Park South as well as the residential area to the west.

The Riverside Park South, adjacent to and beneath the highway, represents a project that transforms a leftover space to a transition zone between urban and nature. The design of the park offers places for different urban activities while ensures the continuity of activities by taking advantage of the linear space.

Fig.2. Riverside Park South
(source: http://worldlandscapearchitect.com)
3.2 A8ernA, Amsterdam
A8ernA project is located in a small village called Koog aan de Zaan, near Amsterdam. In the early seventies, the highway A8 was constructed on columns in order to cross the River Zaan, which produced a brutal cut in the urban tissue. After being ignored for more than 30 years, the space under the bridge deck finally got the opportunity to be transformed. The A8ernA project is an attempt to restore the connection between both sides of town and to activate the space under the road.

Based on a collection of wishes and suggestions from community, the transformation plan provides various places for activities such as skating, dancing, playing soccer and basketball, shopping and rowing. The optimistic interventions stimulate urban life under the highway and at the same time, by designing the eastern end they create new connection with the river. Before, the dense construction along the river-banks prevents public interaction with the River Zaan. Through introducing the mini harbor that is excavated from the land under the highway, the river connects to Main Street. A jetty extends from the land allowing access to the first two columns in the stream. The panorama deck offers nice views over the river. The small square harbor becomes a popular place for people rowing.

Using a mini harbor to deal with the node of elevated highway and river is ingenious. It takes advantage of the river to provide a gathering place, which makes the space under highway A8 an attraction spot rather than an interruption along the waterfront.

3.3 Buffalo Bayou Park, Houston
Buffalo Bayou Park can be classified into the third type we listed in the last chapter. It is located in Downtown Houston. The complicated and massive elevated highways cross over the Buffalo Bayou used to result in a large area of wasteland. As the waterway that literally gave birth to the city in 1863, Buffalo Bayou plays an important role for the city’s image. Therefore, the city of Houston carried out the project to convert the neglect area into an urban park.

The long planned project extends from downtown Houston westward to Shepherd Drive, with an area of 160 acres. The design makes a good combination of the linear space and the node space. There are ten-foot wide trails on both sides of the bayou and three new pedestrian bridges that give more space for people cycling and jogging and have made the park more accessible. These pedestrian and bicycle links allow citizens to make a complete loop without traversing city streets. Additionally, these biking and jogging trails also connect a series of gathering places, such as the Eleanor Tinsley Park, the Houston Police Offices’ Memorial and the Lee and Joe Jamail Skatepark. A number of plants have replaced the original invasive vegetation and stairs and ramps have been added to connect the waterfront with the city. There is also a lighting system to guarantee the safety at night. With beautiful natural scenery and downtown’s skyline view, the Buffalo Bayou Park attracts more and more people, and becomes a more interactive space providing community events and venues.

Buffalo Bayou project set an example of an integrated reclaiming plan that combines infrastructure, nature and recreational space. The idea of connectivity puts together the fragmented spaces that were broken up by infrastructures, and fills in the gaps in urban continuity.

4. Conclusions
Reviewing the research provided in the previous sections one can conclude that the waterfront space under elevated highways has a great potential to be changed into a positive urban space. Based on the spatial analysis and the study of three successful projects, define a spatial type should be the first step for utilizing the leftover space. The characteristics of the space determine possible activities that take place in them. Linear space enhances people’s movement, so activities like cycling and jogging are suitable for it. While node space serves as a focal point that gather people, which probably accommo-
date facilities like basketball court and plaza. Combining the spatial type with the need of the public, one can figure out the desired activity, which is the second step. Public interaction and activity are necessities within the urban realm of the city. The degree to which these activities take place is largely determined by the desirability of urban spaces that make up the city. (Gehl, 1980) Therefore, further design for the places that accommodate various activities will be the final step. Through design for the landscape and facilities, the space would be more attractive and accessible to the city. Additionally, all the design should take the urban context into account. An integrated design is important to create these desirable sites of urban activities.

5. Recommendations

The leftover space provides exceptional opportunity to reshape an urban center. (Trancik 1968) Waterfront space under elevated highways as one of the leftover spaces has an important effect on urban development. With more and more cities pay attention to the urban public space; this kind of leftover space should be rethink. Due to the time and reading limit, the paper is only focus on design strategies that based on spatial analysis. However, in practice, there will be more retraining factors, such as land-use policies and budget. The information gathered through this paper will be used as the theoretical framework for the author’s graduation project. During the design process, the strategies discussed in this paper will be further examined.

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