

Living with Plants

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Investigations on How Landscape form Architecture

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Thanks to:

Morten Lund,

for always supporting me and make me positive to everthing.

Kengo Skorick:

*thank you for all your tutorials, you are super responsible to students and hard working,
always nice and patient to me. love you!*

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*you are ver kind, helpful, the no conditional love and support from you is precious to
me.*

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thank you for everthing

and all the students in my studio

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ABSTRACT

The thesis is about exploring the potential of living plant as an building envelop materials towards sunlight, aims to arise the thinking about making creative usage of natural living materials as a more sustainable building materials.

As a building envelope, the plant envelope is a kind of transparency materials, sunlight is a very important factor to affect plant envelope, which could make a diverse experience on space. I am most interested in how the sunlight affects the plant envelope, how we use the plant envelope to get specific space properties towards the sunlight.

I try to find the relationship between different plants and their soil foundations, and then use the system to test how it affects the sunlight in order to get useful architecture form to apply on building. Then I try to make my program based on the prototype form and specific context, aiming to solve problems in my context.

My site is a long dock on the sea in Saltholmen, the problem addressed in my context is how to make a dynamic intelligent interaction systems between the naural sea and the boating area through the design of a dock, which would be an urban transition structure in city leading people to the surrouding environment.

The final program is a sea dock design, at the same time, plays also a role of recreation sea parks to the people living in cities.

REFERENCE



Cheungvogl/Shinjuku Gardens

architecture practices about plants as walls in a parking garage in Tokyo, Japan
http://www.cheungvogl.com/shinjuku_gardens.htm



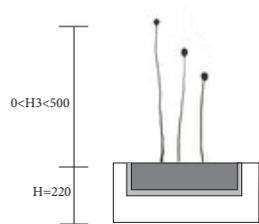
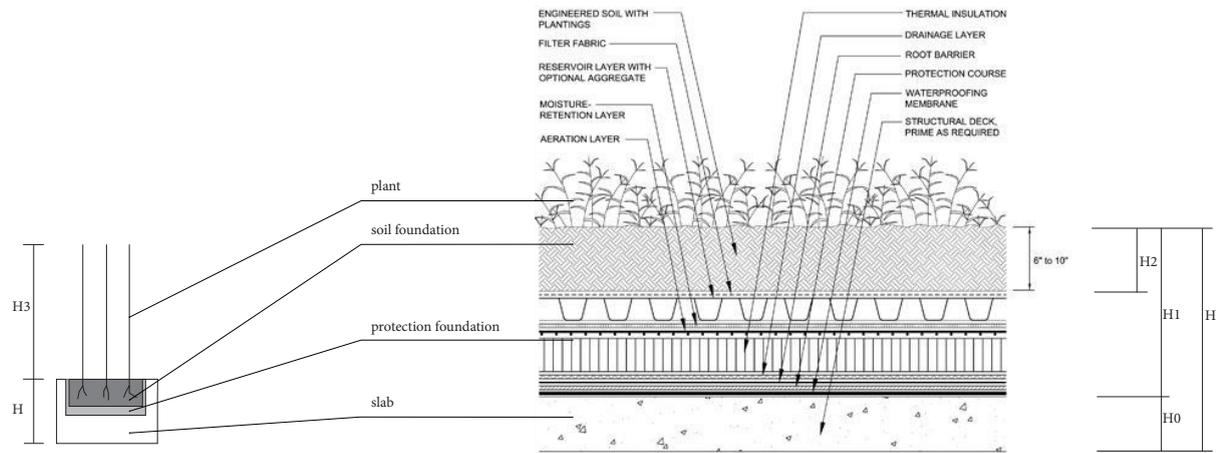
Cheungvogl/Shinjuku Gardens

plant as a kind of transparency building envelopes has
affects on the outer and inner space through sunlight.

STRUCTURE STUDY

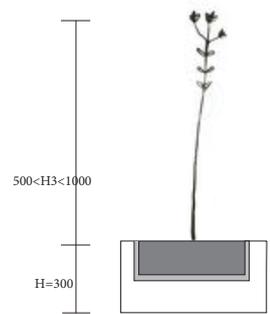
From the reference project, I started to study the structure of growing plants on buildings.

The thickness of soil foundation is depending on the height of plants, 4 groups of plants with different height was formed to control the foundation.



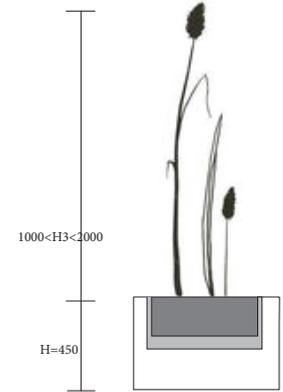
G1: SESUM HERBS

H3(height of plant): $0 < H3 < 500\text{mm}$
 thickness of foundation:
 $H2=60\text{mm}, H1=120, H0=100$
 $H=H1+H2=220\text{mm}$



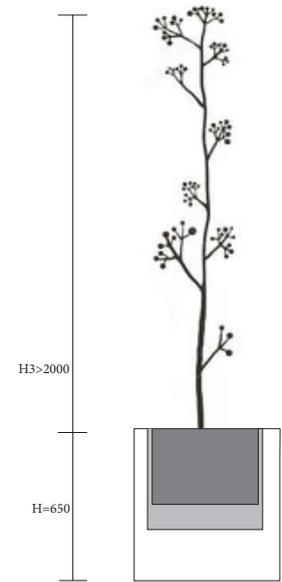
G2: SESUM HERBS PERENNIALS

H3(height of plant): $500 < H3 < 1000\text{mm}$
 thickness of foundation:
 $H2=120\text{mm}, H1=180, H0=120$
 $H=H1+H2=300\text{mm}$



G3: SESUM GRASSES SHRUBS

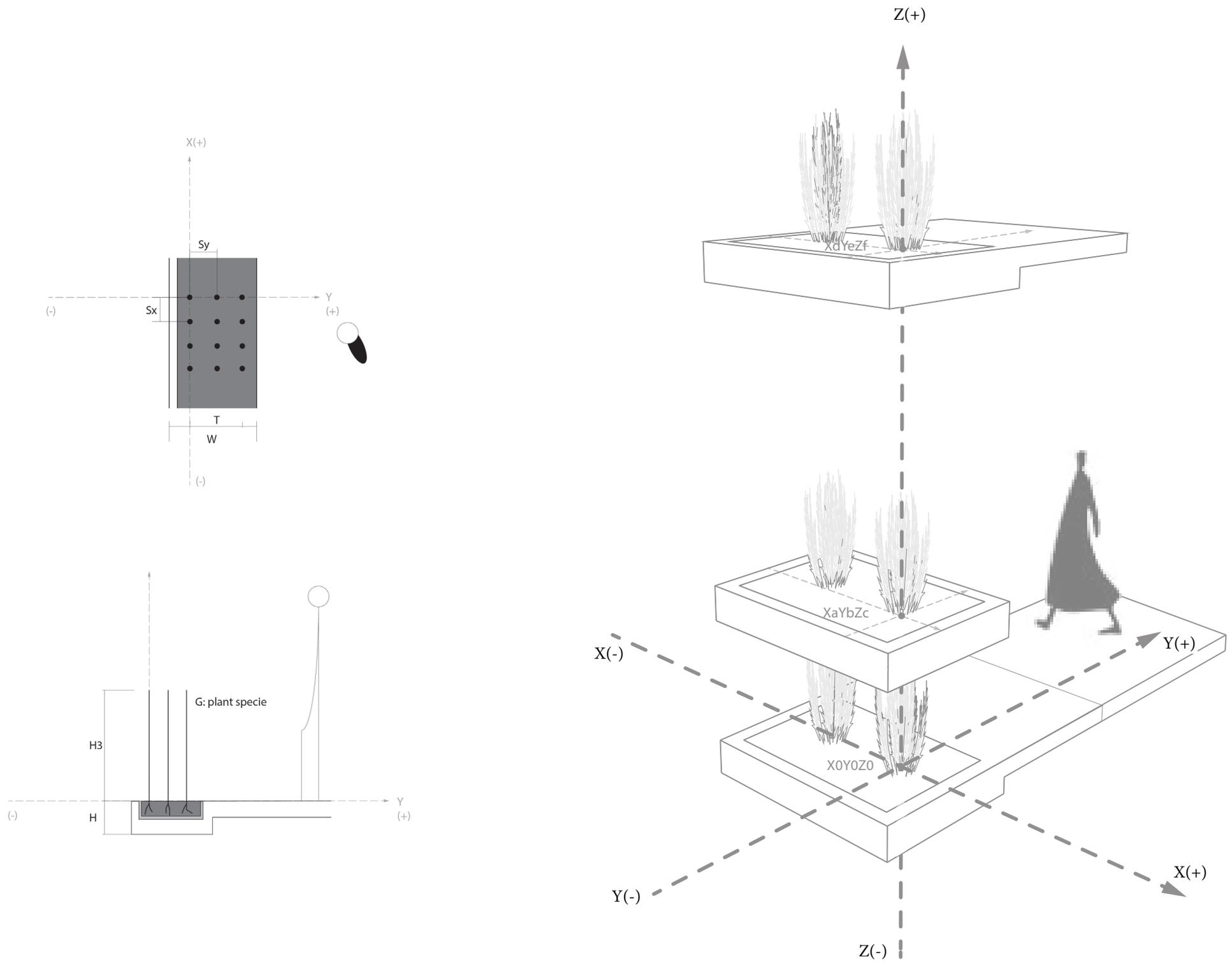
H3(height of plant): $1000 < H3 < 2000\text{mm}$
 thickness of foundation:
 $H2=180\text{mm}, H1=300, H0=150$
 $H=H1+H2=450\text{mm}$



G4: GRASSES SHRUBS TREES

H3(height of plant): $H3 > 2000\text{mm}$
 thickness of foundation:
 $H2=270\text{mm}, H1=450, H0=200$
 $H=H1+H2=650\text{mm}$

ARCHITECTURAL SYSTEM



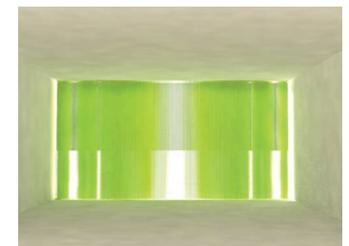
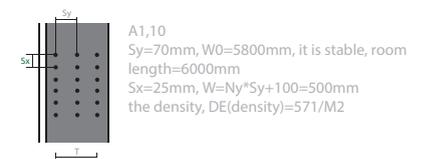
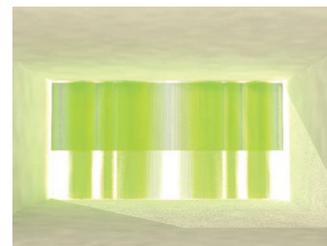
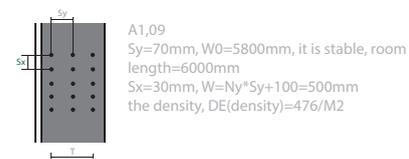
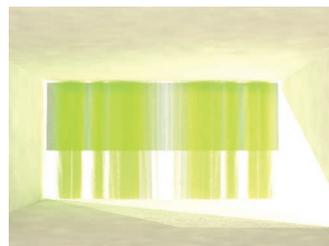
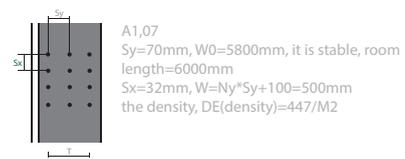
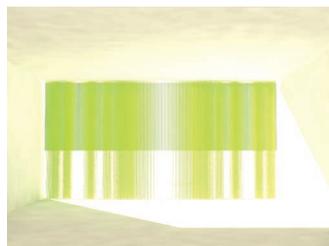
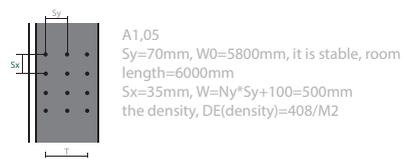
PROTOTYPE 1

a. testing S_x and S_y (density), T (thickness), H_3 (height)of the plant towards the sunlight

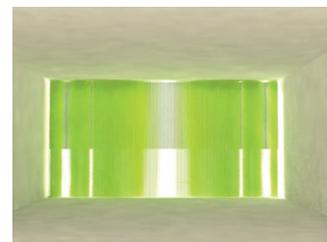
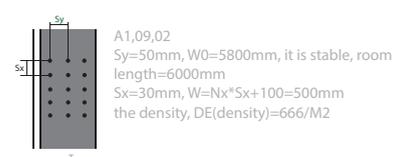
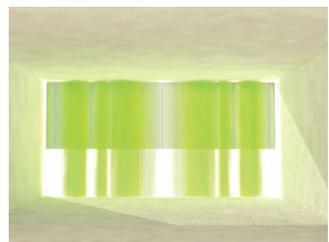
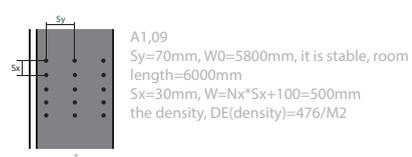
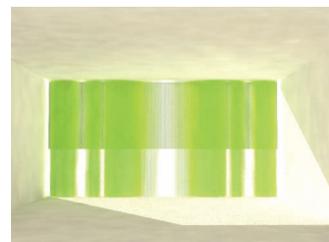
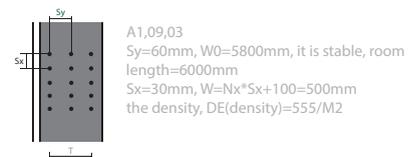
settings:

- . no consideration of G and H
- . south facade, 20th Sep. UTC+2, 11.00am
- . floor height:3000mm, plant height: 3000mm, fully covered the facade, R (plant radius)=3mm
- . using vertical lines to simulate the plants pattern, $S_{xmin}=S_{ymin}=20mm$

Testing effaction of S_x towards sunlight

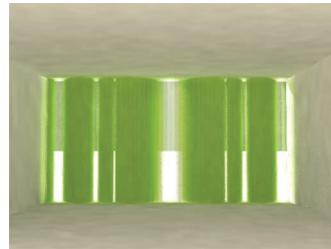
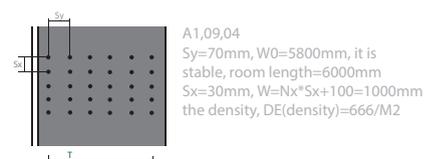
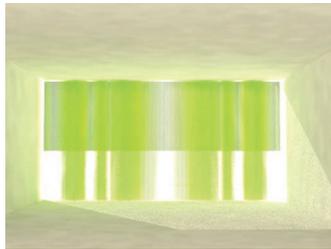


Testing effaction of S_y towards sunlight

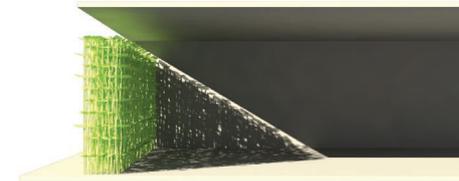
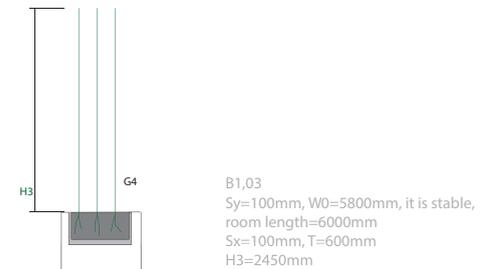
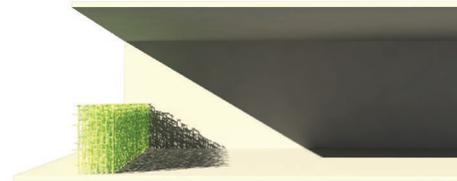
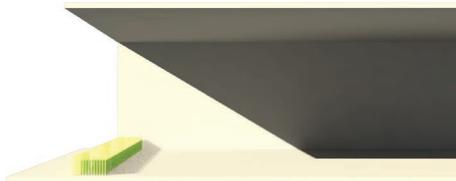


PROTOTYPE 1

Testing effaction of T towards sunlight

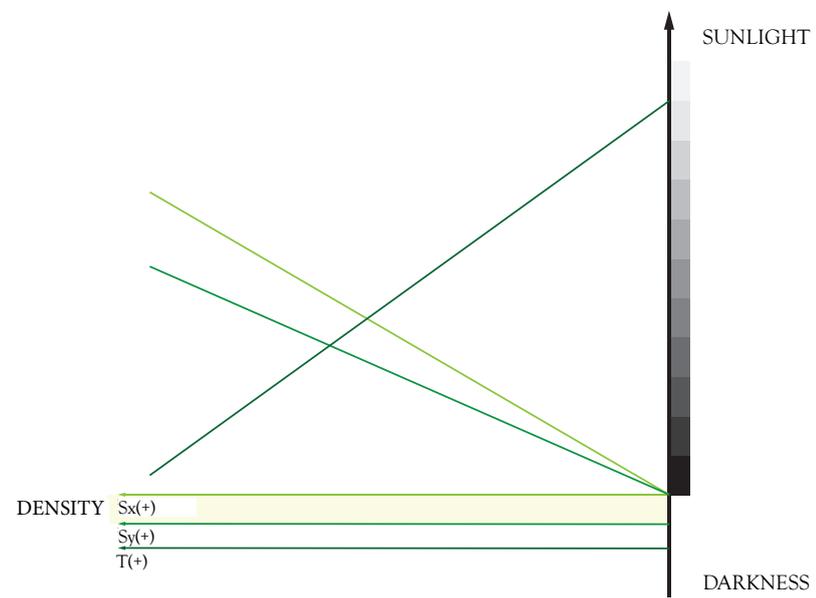


Testing effaction of H3 towards sunlight

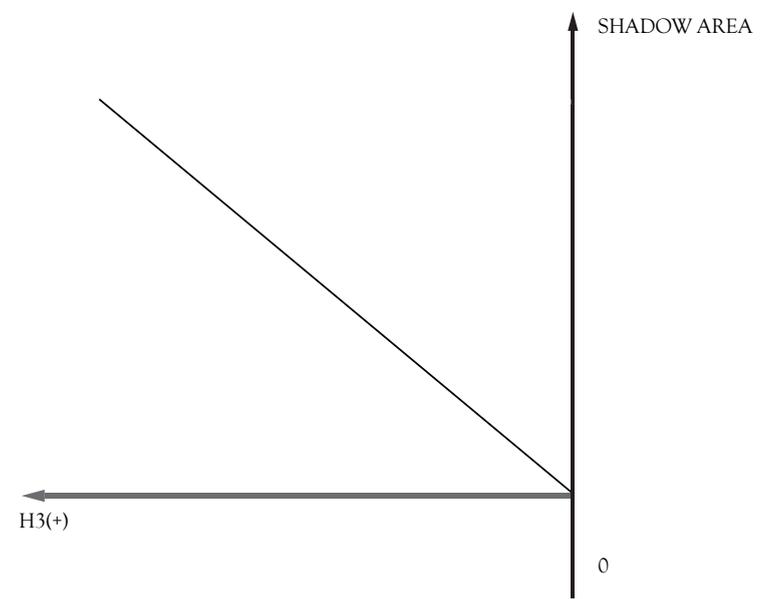


PROTOTYPE 1

Conclusion:



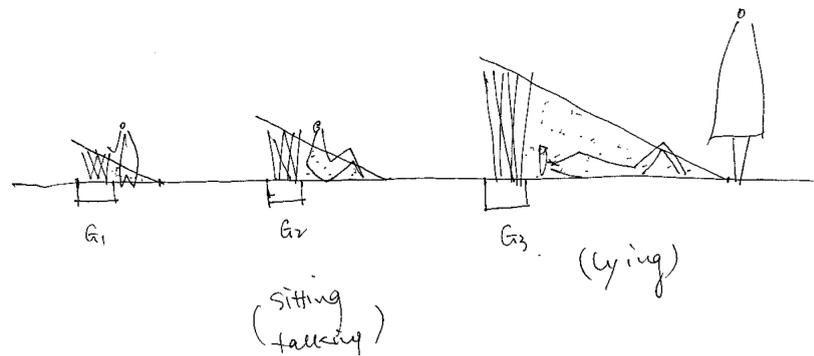
CONCLUSION
the degree of sunlighting of the shadow area by plant is depending on S_x and S_y (density), T (thickness)of the plant.



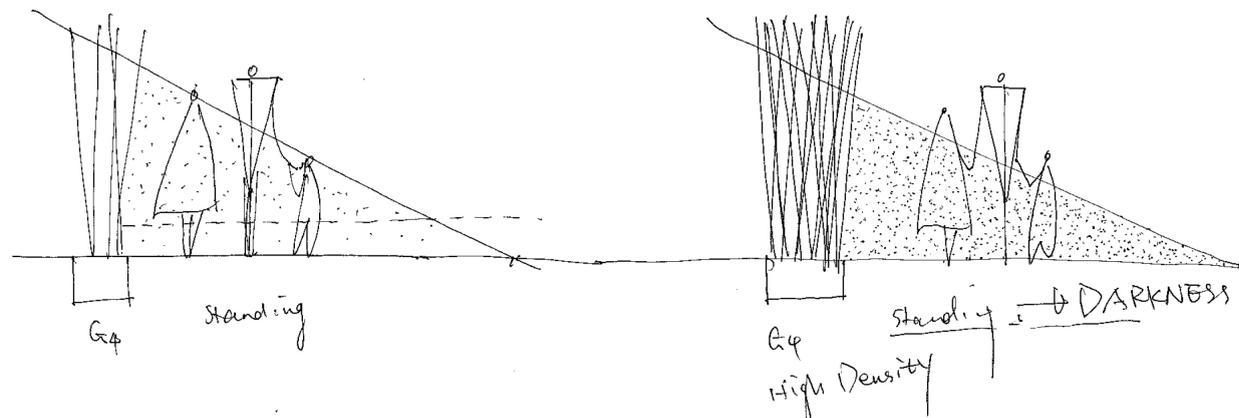
CONCLUSION
The area of shadows by the plant is depending on the H_3 (height)of the plant.

PROTOTYPE 1

Space Potential:

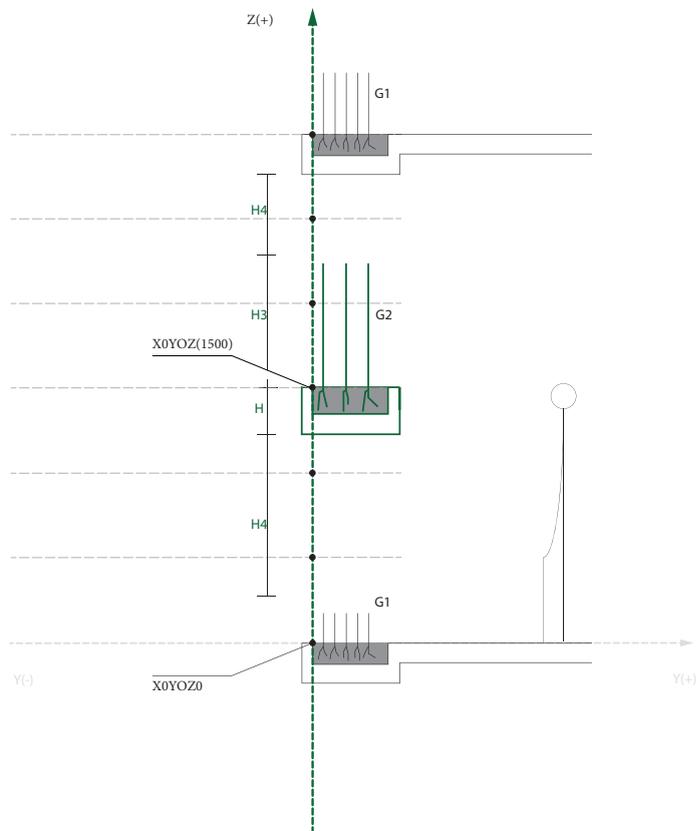


The function varies, as well as the people, such as child, adults, even disabled, and the body actions are all varies by the height of the plant through the filtered sunlight space.



The sunlight condition, such more filtered or less filtered, influences the feeling of people, also the function in terms of levels of sunlight, like offices, schools need more sunlight, and bedrooms not.

PROTOTYPE 2



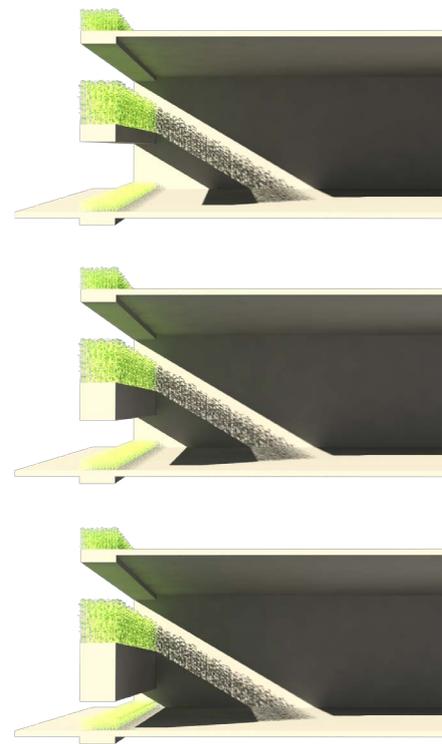
Testing H4, H (position along z direction) towards the sunlight

Basic form settings:

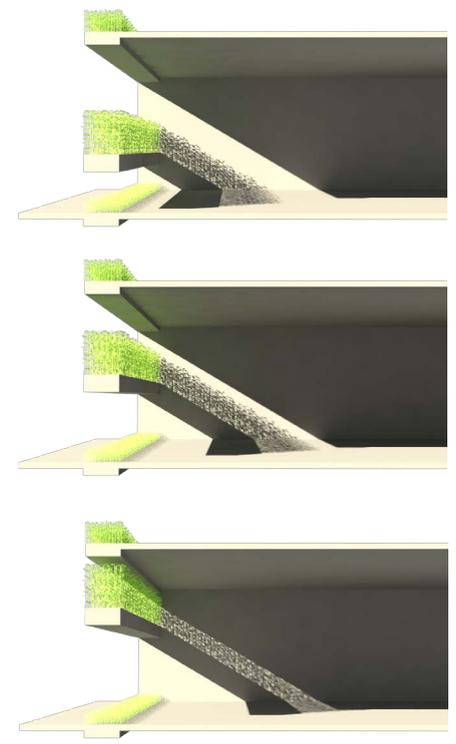
xoyozo: G1, xoyoz1500: G2, xoyoz3000: G1

. keep H, H3 of G2, testing H4

. keep H4 and H3, testing H by change thickness of foundation



Testing effaction of H(foundation) towards sunlight



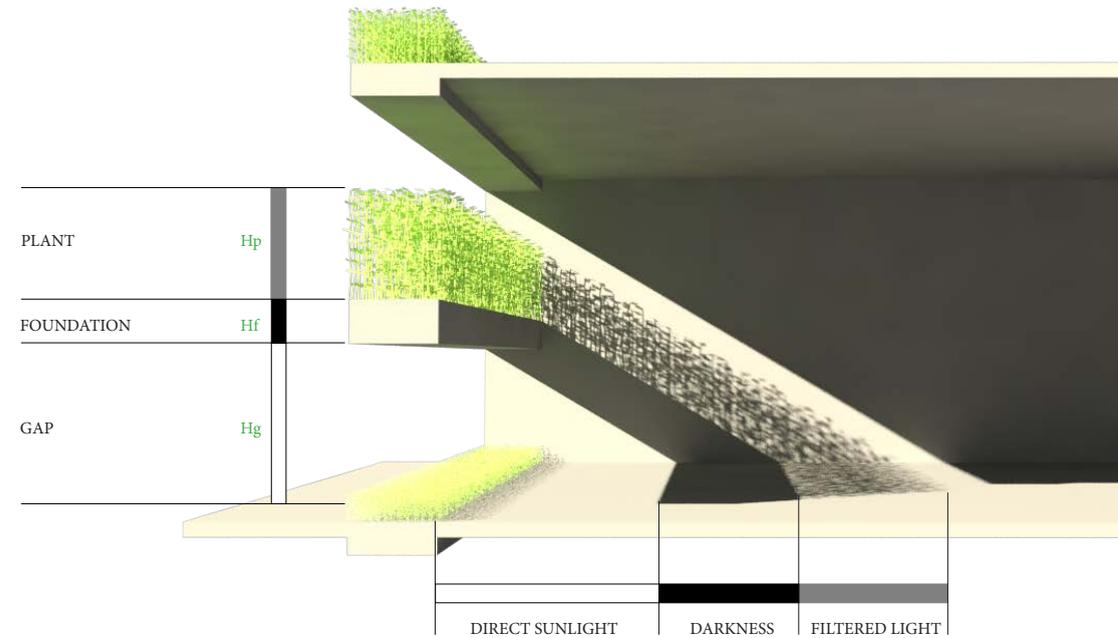
Testing effaction of H4(GAP) towards sunlight

PROTOTYPE 2

CONCLUSION 1:

Areas of different types of sunlight is depending on the height(H) of different elements of architecture system:

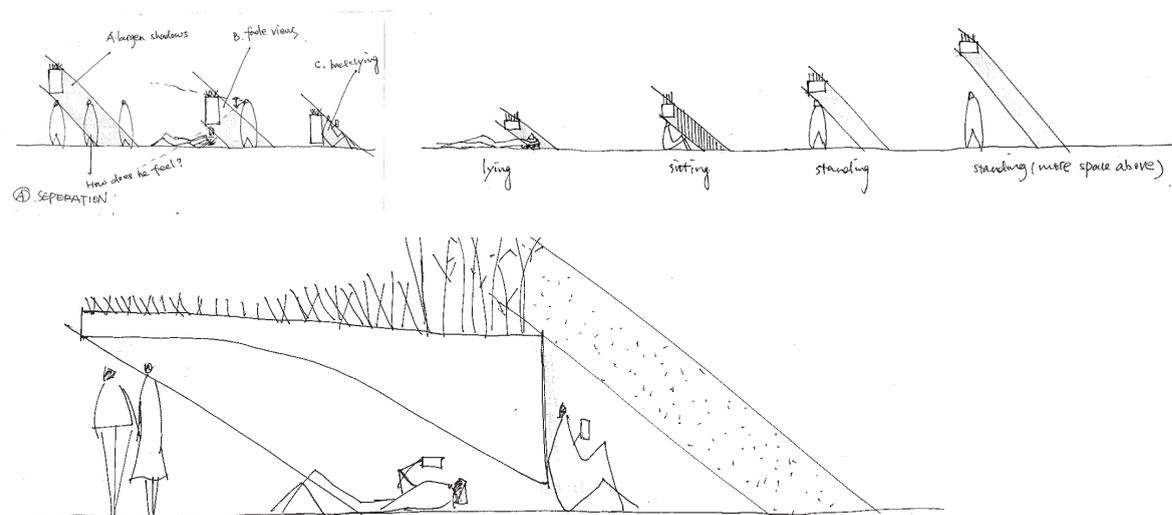
- . darkness is depending on the foundation
- . direct sunlight is depending on the gap between foundation and plant
- . filtered sunlight is depending on the plant



Spacial Potential:

the foundation function towards space:

- separation
- shading

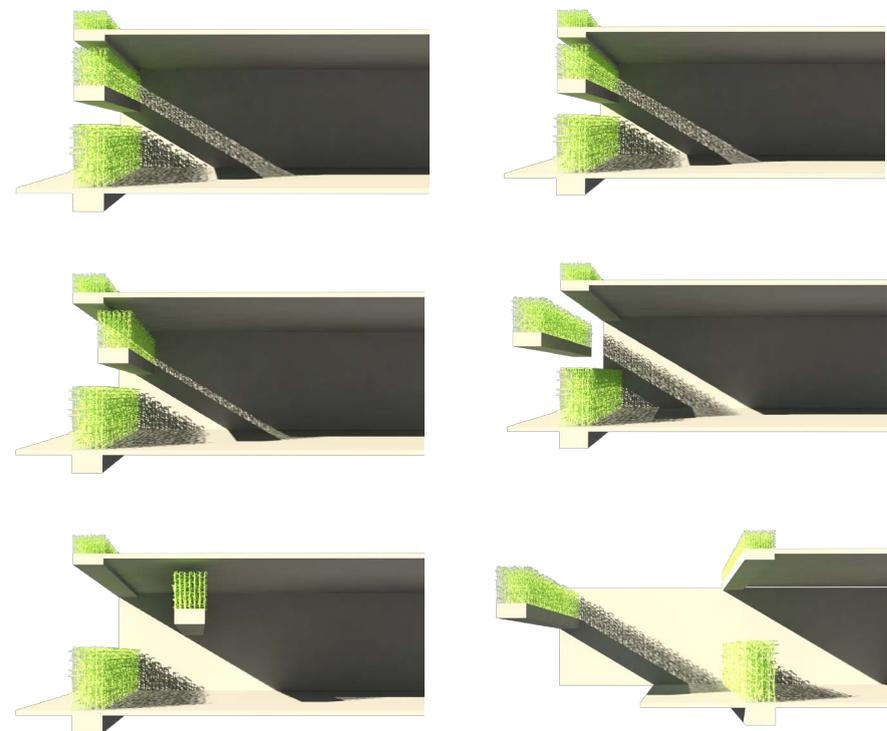
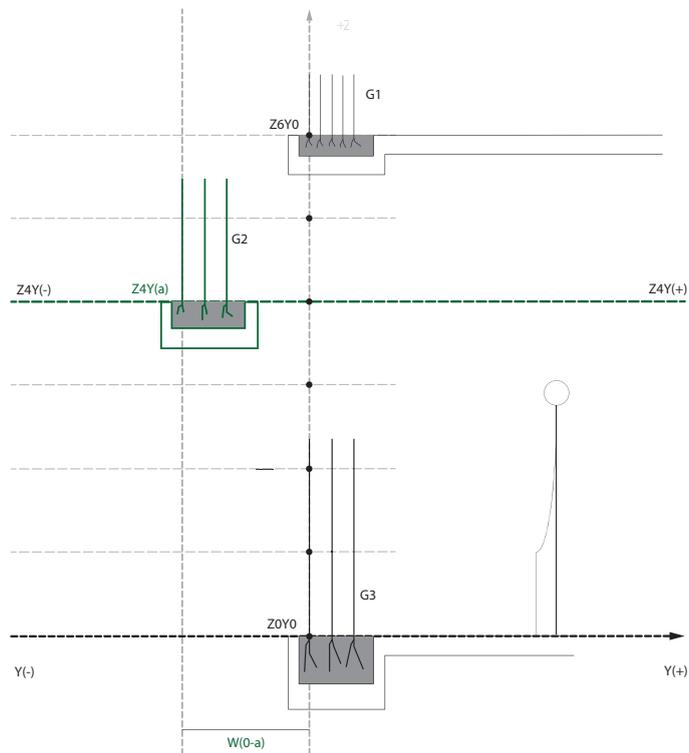


PROTOTYPE 2

b. testing **W**(position along y direction)
K(position along x direction)
H4,H(position along z direction)towards the sunlight

settings:

- . south facade, 20th Sep. UTC+2, 11.00am
- . floor height:3000mm



Testing **W**(position along y direction)
towards the sunlight

Basic form settings:

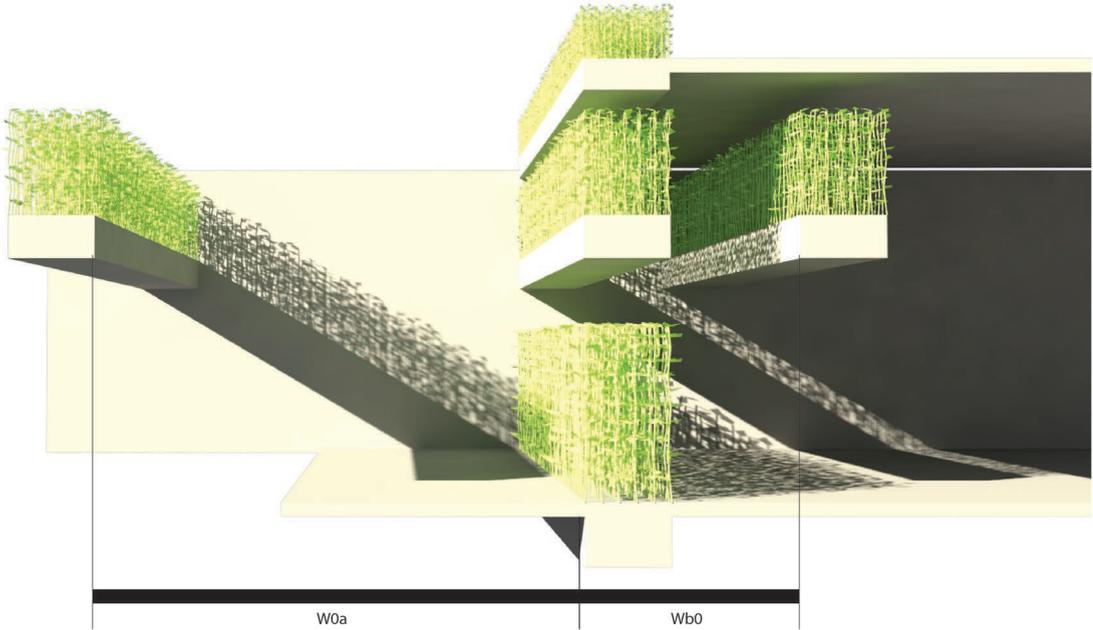
xoyozo: G3, xoyoz2000: G2, xoyoz3000: G1

- . all elements move along the y direction, testing the y direction effaction of gap to direct sunlight
- . foundation move, plant stay, testing y direction effaction of foundation to darkness
- . plant move, foundation stay, testing y direction effaction of plant to filtered sunlight

Testing effaction of **W** towards sunlight

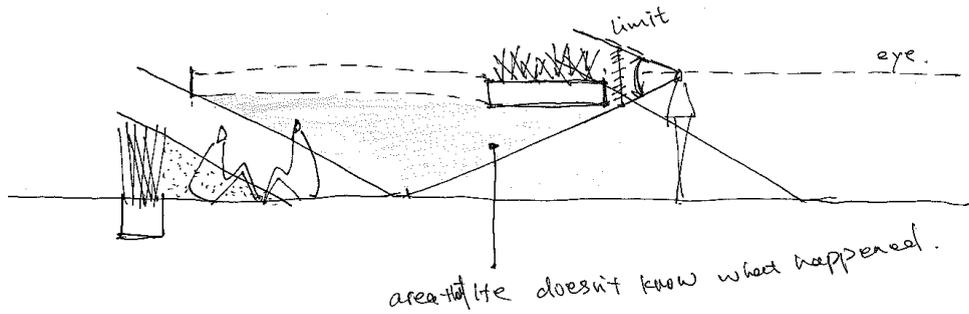
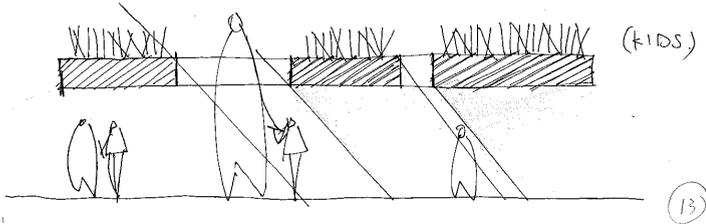
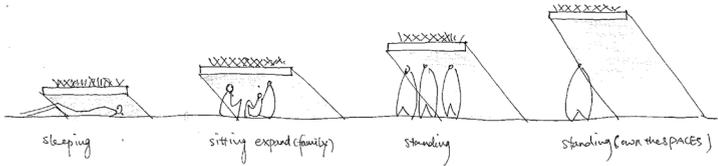
PROTOTYPE 2

CONCLUSION 2:
the space size on xy plane with differen sunlight condition is depending on the Wab of the elements.



Spacial Potential:

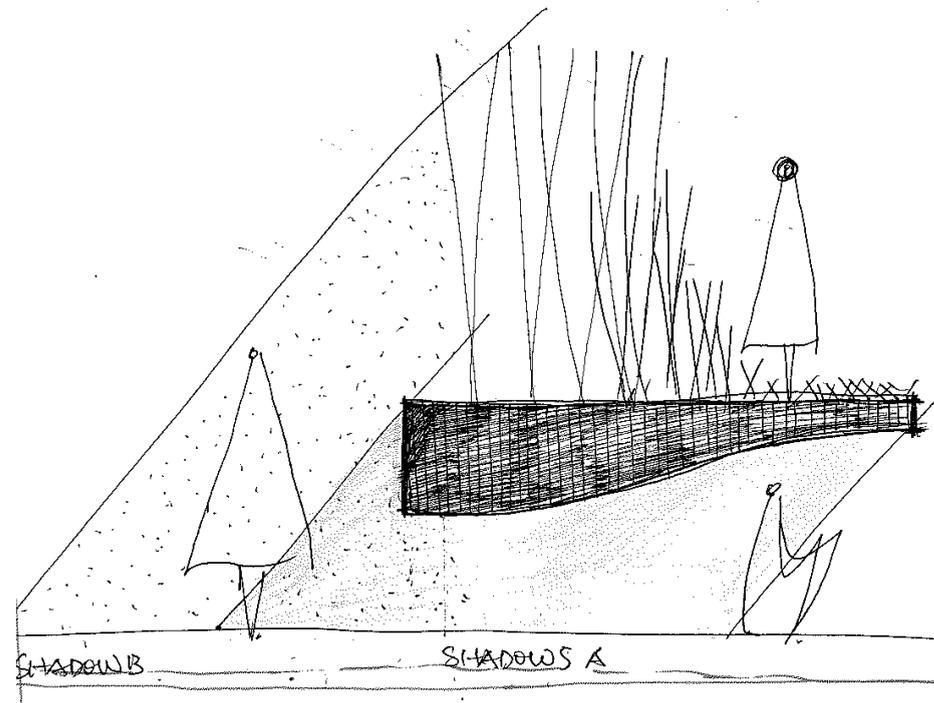
the function towards space:
forming different size of space on xy plane with different sunlight condition, darkness, filtered sunlight and direct sunlight



PROTOTYPE 3

prototype 3a: testing relationship among foundation, people and sunlight, darkness.

In prototype 3, the former prototype1,2 will be further developed in order to find the relationship among architecture system, sunlight, and space, people.

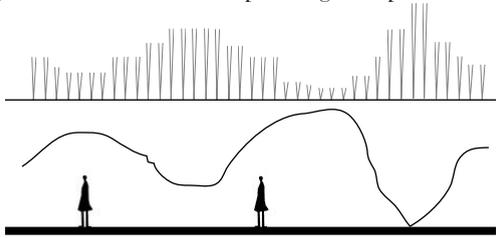


Prototype 3a

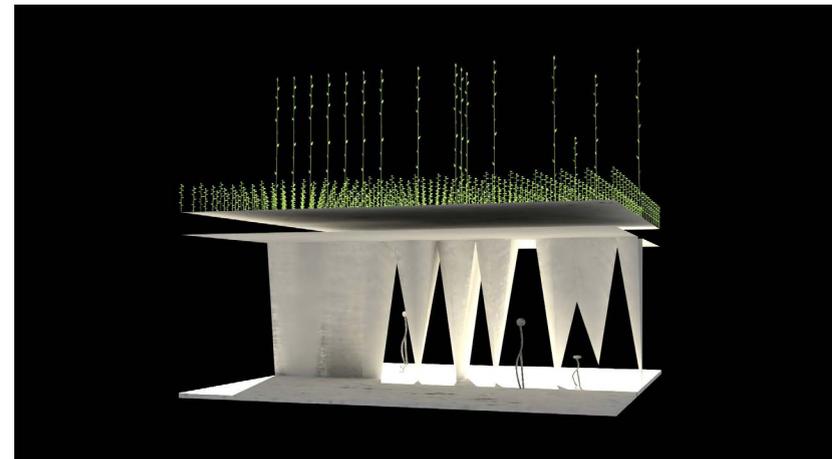
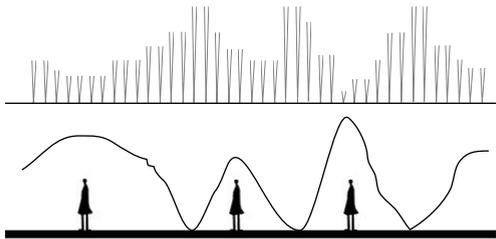
First, I try to make it more clear that the relationship between soil foundation and plants above, in order to get the proper space for people.

Following the logic of architecture system: the height of soil foundation is depending on the height of the plant above, and the available direct sunlight space is depending on the architecture system position, then I tried some options to test the system to see what kind of useful space and function we could get.

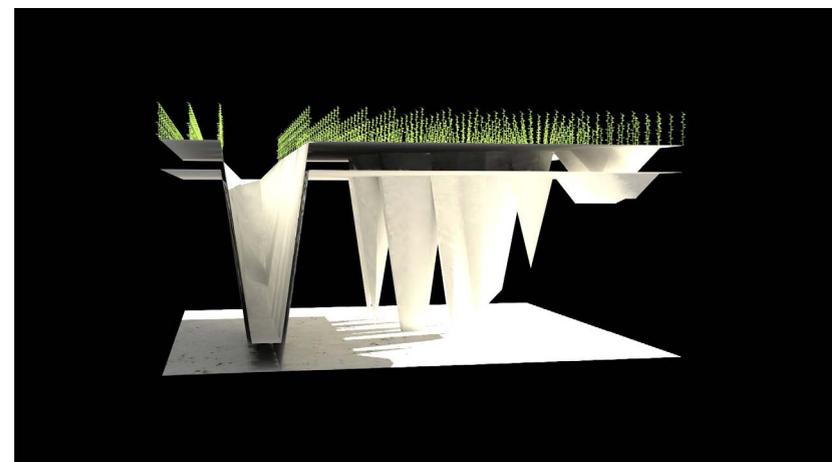
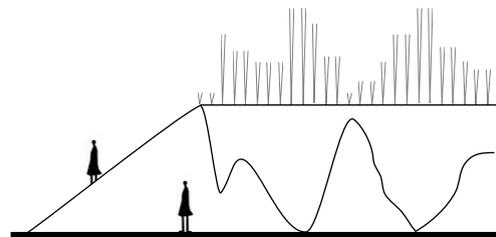
conclusion 1: creating different size of the sapce by forming the height of the foundation through control the plants grown on it. Also, it has a function on seperating the space.



conclusion 2: in some condition, when the height of the soil foundation is the same height of the floor, then it becomes an supporting structure for the whole system.



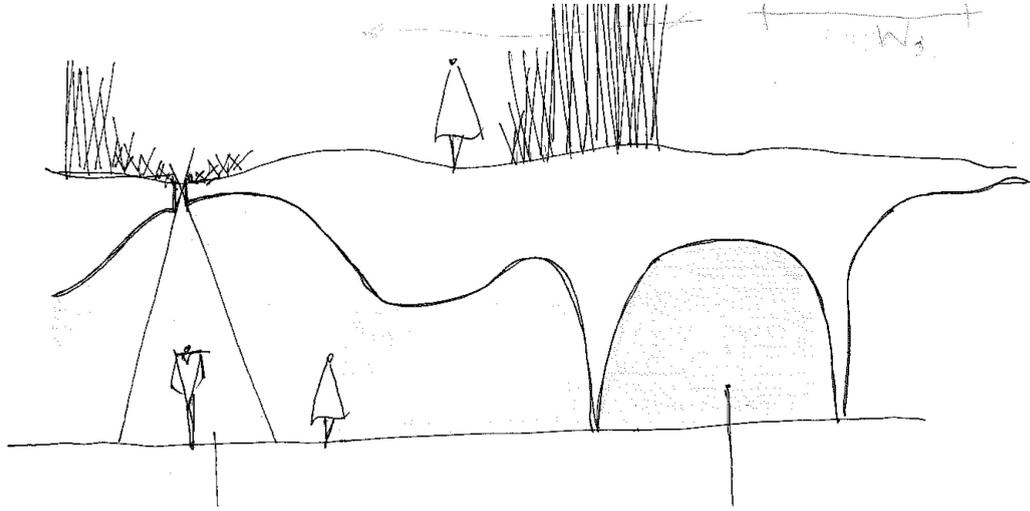
conclusion 3: when the soil foundation come to the ground, and we do not grow plant on it as left picture shows, then we could get an vertical access to the upper floor.



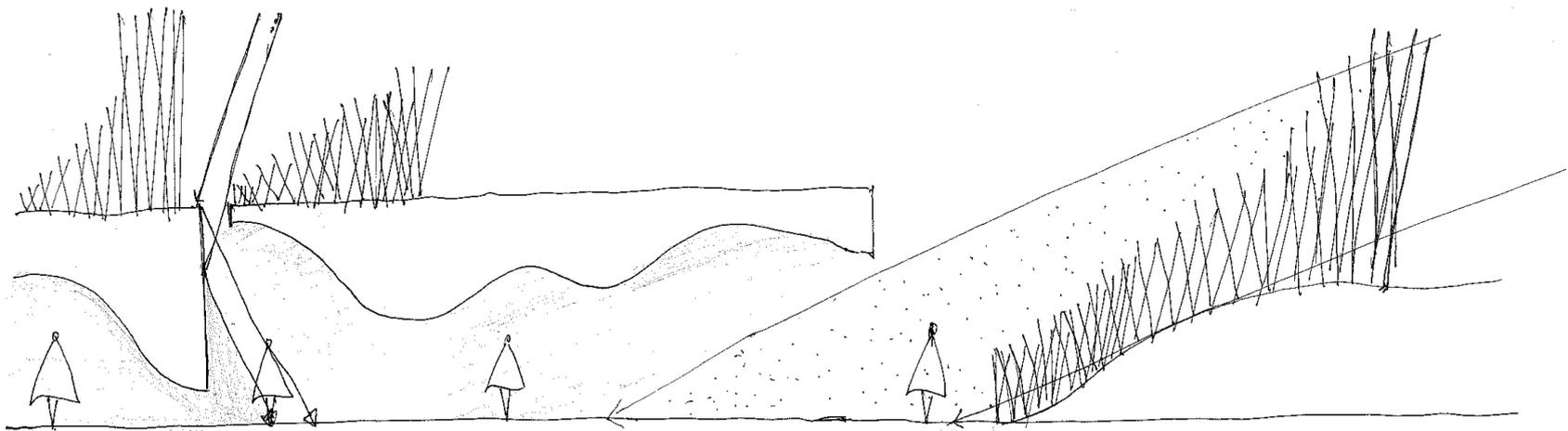
PROTOTYPE 3

Combination 3a

an study on the combinations of the foundation and plants together and to see the space properties towards sunlight.



no plants means no foundations, then we could get a direct sunlight into the space, especially in a dark space it would be more interesting.



by making the sunlight reflects on the foundation to get space bright.
Also, having a large amount of plants spreading out in the space, which could also get a large amount of filtered sunlight.

CONTEXT

Saltholmen is an island before, now because of the railway it was connected with the mainland, now it is rather a peninsula.

Around Saltholmen area, there are also other island around, and in terms of the variety of watersports activities, and tours to the southern archipelago, transportation becomes very important for Saltholmen. There are many man-made transport connections for different aims: the long railways to the ferry terminal and parking around, the terrace standing in water for boating and preventing the seawater, small wood bridge connecting islands, stone walking paths into the sea for swimming.

They are all architectural methods to deal with the connections between nature and man-made structure with a specific function.

For me, in Saltholmen, exploring how to build a connection among nature, man-made structure and human activities is very specific focus towards the site.

CONTEXT ANALYSIS

Saltholmen is an island before, now because of the railway it was connected with the mainland, now it is rather a peninsula.

Around Saltholmen area, there are also other island around, and in terms of the variety of watersports activities, and tours to the southern archipelago, transportation becomes very important for Saltholmen. There are many man-made transport connections for different aims: the long railways to the ferry terminal and parking around, the terrace standing in water for boating and preventing the seawater, small wood bridge connecting islands, stone walking paths into the sea for swimming.

They are all architectural methods to deal with the connections between nature and man-made structure with a specific function.

For me, in Saltholmen, exploring how to build a connection among nature, man-made structure and human activities is very specific focus towards the site.



- harbour, swimming
- offices
- restaurant
- ▲ boat repair, construction
- ferry terminal
- human-made transportation connection

Boat Harbors around Gothenburg, there are many beautiful islands on the west, and from the saltholmen terminal people could take ferry to reach the island and have a tour on there. not only the beautiful island to see around, but also activities kayaking, sea fishing, sailing, canoe and swimming, bathing happen normally in this area.

boat repair man-made land for railways, connecting the island with the mainland.

1903, the company was formed Langedrag, which had renewed the area from Langedrag to Saltholmen, including a seaside resort.

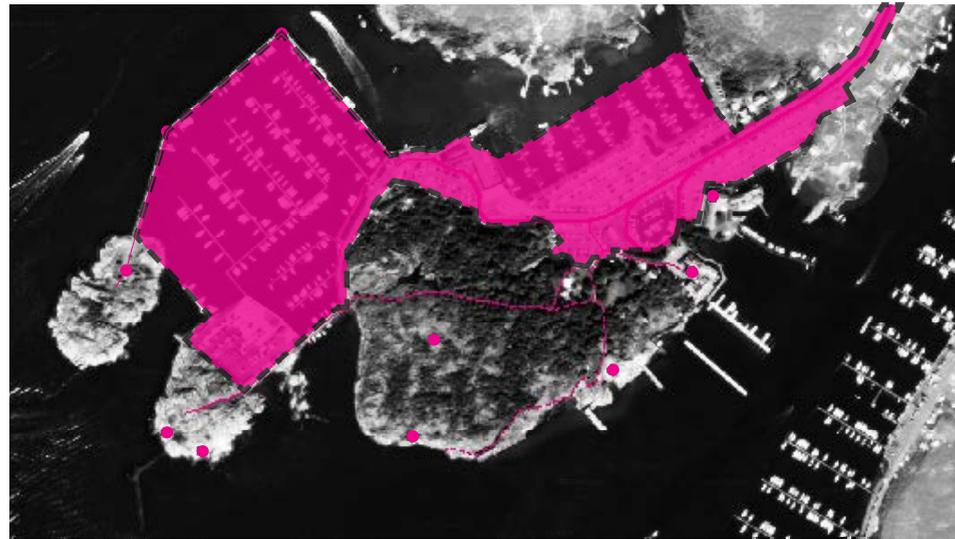
before: kayaking organisation
now: offices

1906-1908 tramway was built, 30min from city center

PROBLEM TOWARDS CONTEXT

Around Saltholmen area, there are also other island around, and in terms of the variety of watersports activities, and tours to the southern archipelago, transportation becomes very important for Saltholmen. The long railways to the ferry terminal and car parking around are the main connection to the beautiful sea-close area and island around, also there are several paths to the sea.

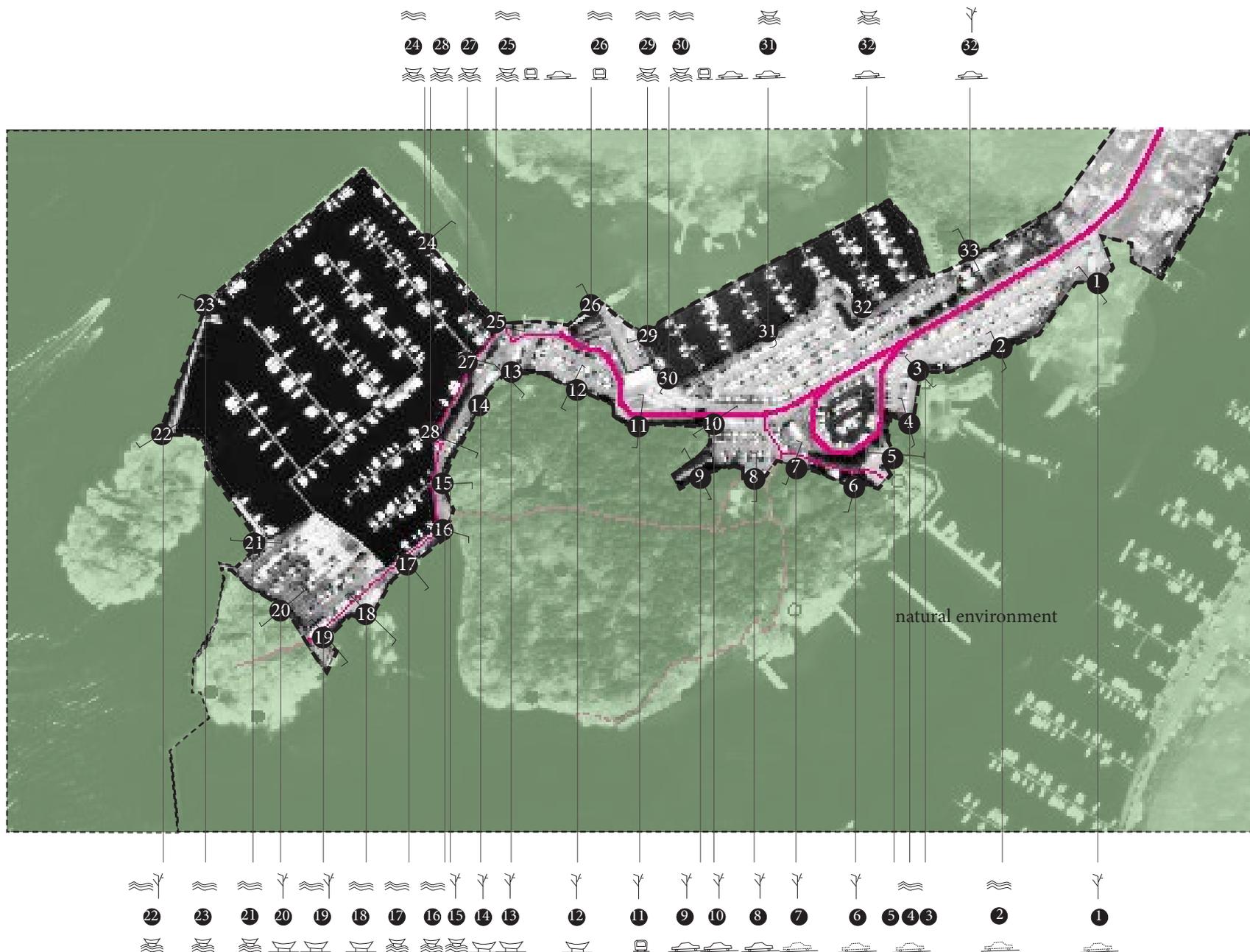
However, as too much parking area on site, it is very hard to find the way to the island and seaside, also the parking area make the beautiful seaside invisible. When people go around there, it is very confused about the paths to the nature around.



THE CHOICE OF SITE

The black dot line defines the boundary, between man-made construction and nature, next I try to analysis the connection between them by set the 33 spot on the boundary, to see what kind of nature and human-made construction, also the physical connection

- natural environment
- man-made transport construction



THE CHOICE OF SITE

selected valuable boundaries

The black dot line defines the boundary, between man-made construction and nature, next I try to analysis the connection between them by set the 33 spot on the boundary, to see what kind of nature and human-made construction, also the physical connection structure they are.

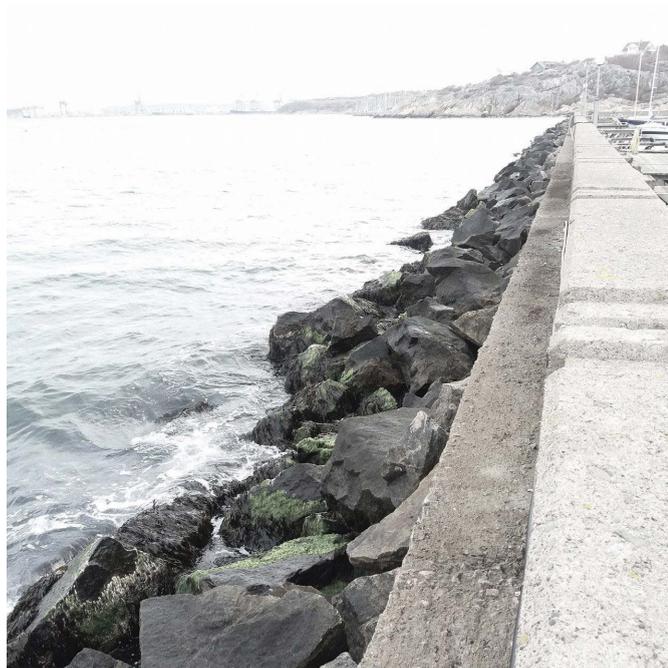
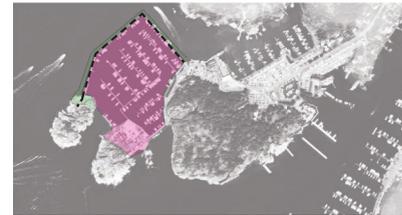


- 22 23 24 25 16 17 18 19 26 07 08 09 10
- ≈ The dock ≈ ≈ walking path ≈ ≈ ferry terminal ≈ ④ ≈ entrance to forest ≈

SELECTED SITE, DOCK 22 23 24 25

Saltholmen is an island before, now because of the railway it was connected with the mainland, now it is rather a peninsula.

Around Saltholmen area, there are also other island around, and in terms of the variety of watersports activities, and tours to the southern archipelago, transportation becomes very important for Saltholmen. The long railways to the ferry terminal and car parking around are the main connection to the beautiful sea-close area and island around, also there are several paths to the sea.



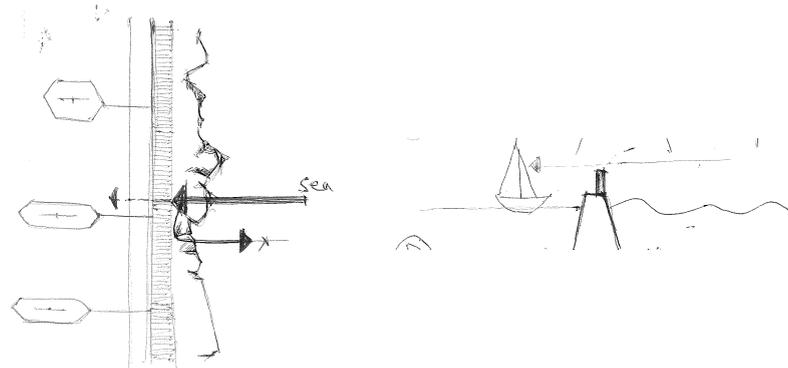
ATTITUDE TOWARDS EXISTING BOUNDARY

The non-urban is no longer a remainder but a potentially active territory capable of being transformed into large metropolitan parks, and as such it needs to be structured, not only to prevent it but to activate it. This gives these boundary spaces a crucial role in defining the value of the transition, and potential to define hubs of connection between the urban and the natural areas of access to spaces for sports, culture, leisure and relaxation.

The program is a design for the boundary between sea and boating area, which is the dock, it should propose an intelligent dynamic interaction between two different systems. At the same time, as an transition space from structural boating area to sea natural relaxation space.

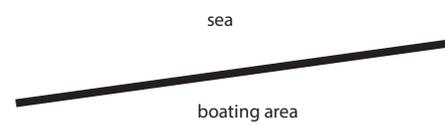
≡ attitude to the sea: new boundary design should **prevent waves**, be **accessible to sea** as well
making the boundary into a **relaxation natural space** towards sea

≡ attitude to boating area: new boundary design should be **accessible to boating** area, **keep proper privacy** as well.

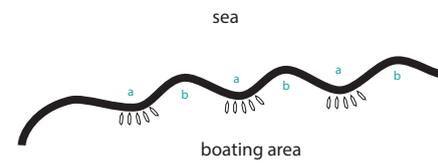


STRATEGY TOWARDS EXISTING BOUNDARY

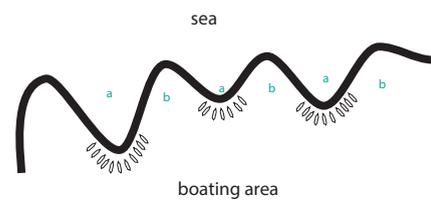
FORMATION 1 towards dynamic balance and interaction between sea and boating area.
accessible to the sea, boating area.



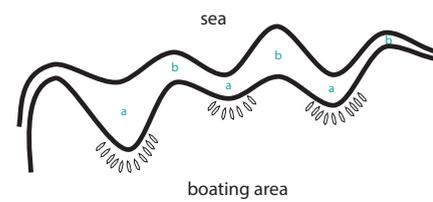
01 The original dock is a straight form, which separate the sea and boating area.



02 The curve line naturally forms two different spaces, but also connects them in some way.

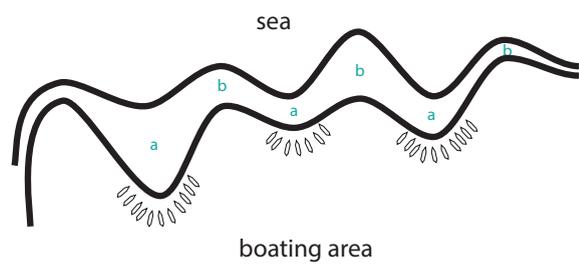


03 The formed spaces could varies from small to big.

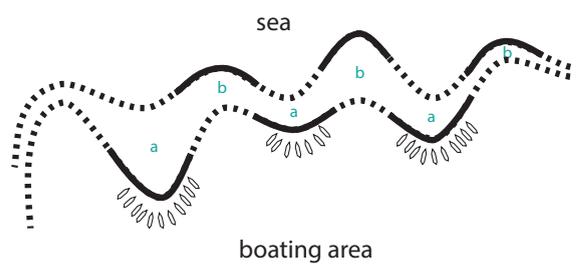


04 The formed spaces could varies from small to big.

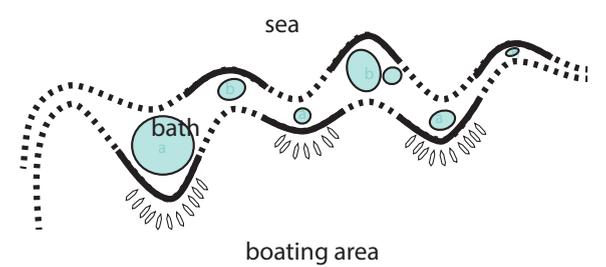
FORMATION 2 towards **Preventing Waves**



05 The spaces could gather together to make a rhythm of human experiences.

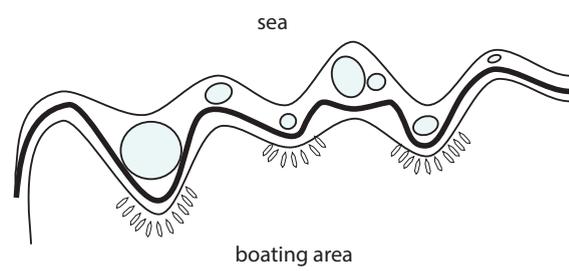


06 some part are thicker soil foundation, and others are normal in order to create a diverse sea wave condition.

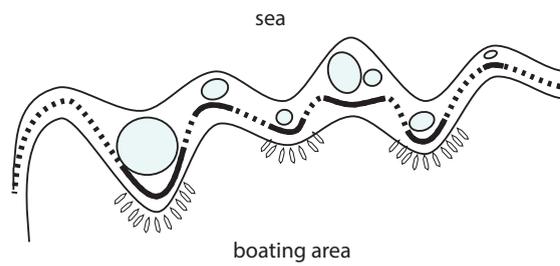


07 sea swimming pool are located inside the structure.

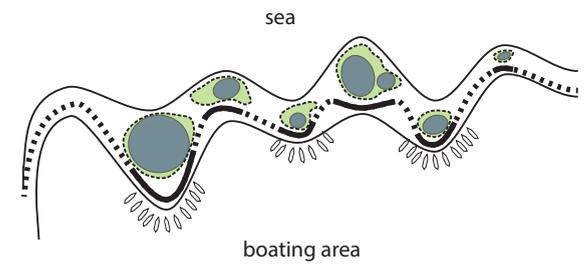
FORMATION 3 towards **keep proper privacy of boating area**



08 there is a two paths, one is for the recreation area, the other is for the people who boating on the sea.

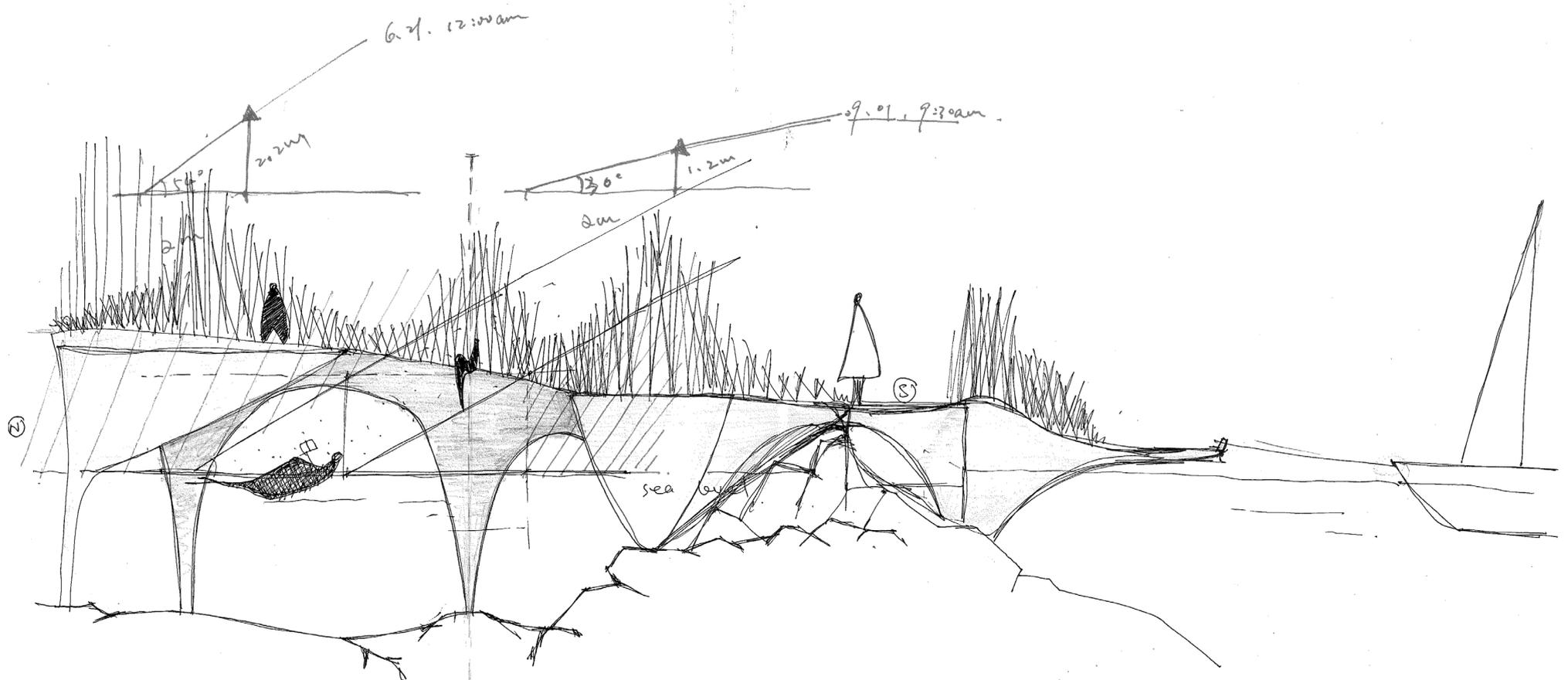


09 the paths are seperated by the plants above, some part are no accessibility, some are a little accessibility, and others are accessible.



10 and the sea swimming pool are surrounded by the plants around to creat a relax atmosphere by the sunlight through the plants.

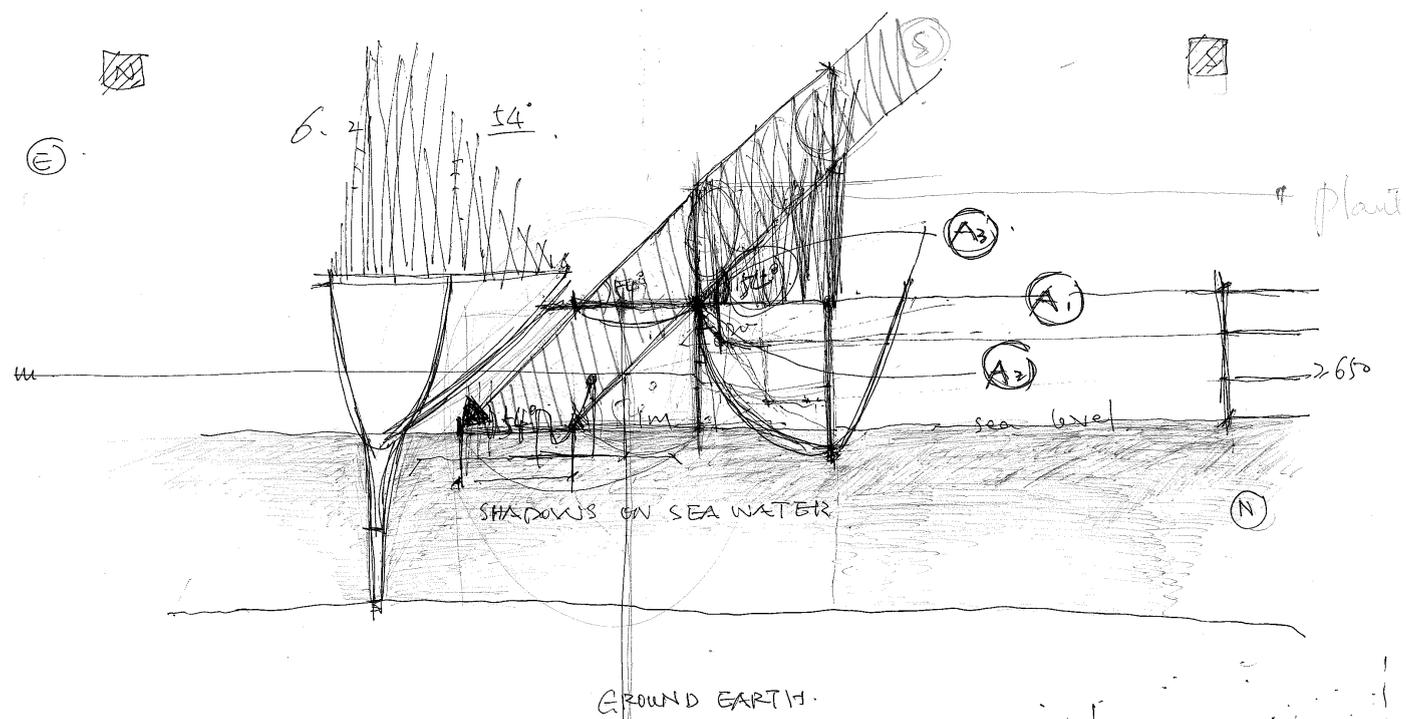
SKETCH GERNERAL PLAN, CROSS SECTION



SEA SWIMMING POOL DESIGN

The single sea swimming pool design is focusing on the phenomenon of sunlight change during the day during summer time in gothenburg(MAY.-SEP.) shown by the water, combining the previous investigation.

I choose to put my main energy to the single swimming pool design rather than the general formation of the whole boundary, instead, I just choose a single swimming pool to show how I put my investigation into it.



CONCEPT



new design parameter: water waves



sunlight

LOGIC

Ld, length of darkness

Ls, length of shadows

H3, height of plant(around)

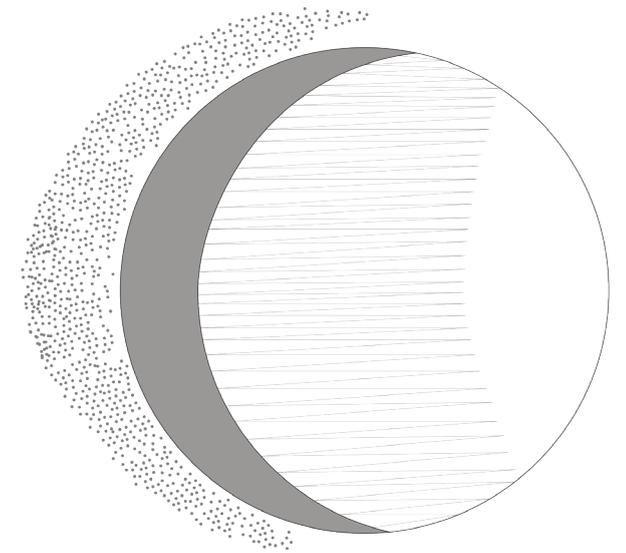
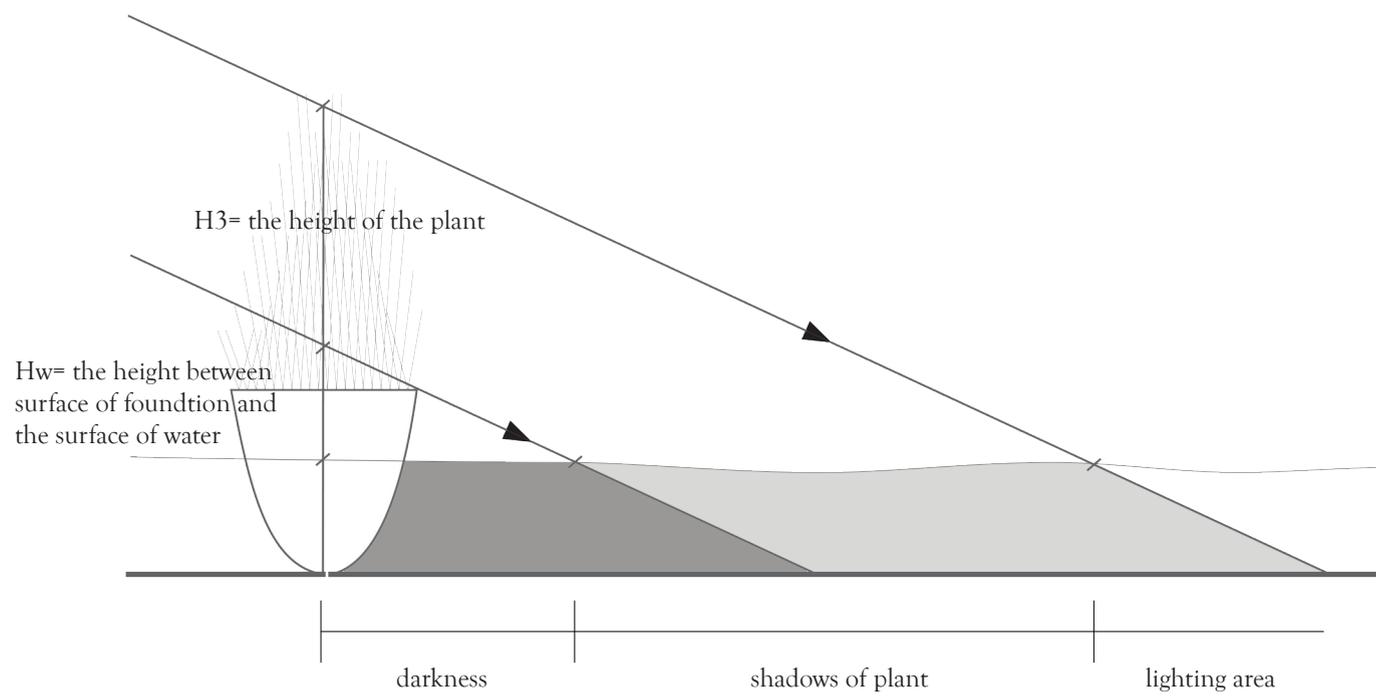
Hw, height from foundation surface to water surface

L=12m radius of swimming pool

a, solar altitude

$$Ld = Hw * \cot a$$

$$Ls = H3 * \cot a$$



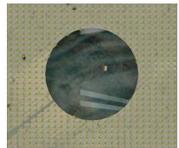
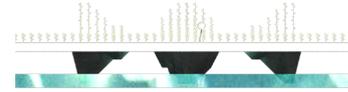
SUNLIGHT CONDITION STUDY

06,21

Testing Model Settings:

The diagram below shows the sun direction and solar altitude at every hour on 21th Jun, Göteborg

The Radium of test swimming pool is 3m, the height to the sea surface is 1.2m.



04:11 sunrise



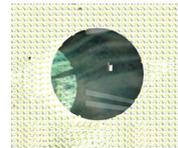
SOLAR ALTITUDE= 0



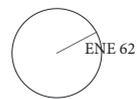
05:00



4



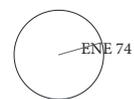
06:00



11



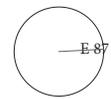
07:00



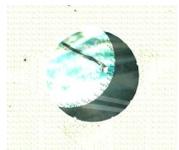
18



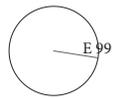
08:00



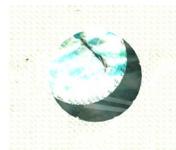
26



09:00



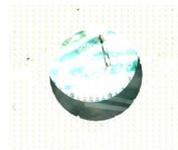
34



10:00



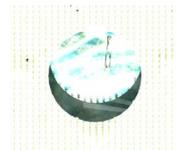
42



11:00



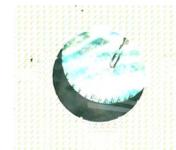
48



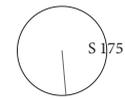
12:00



53



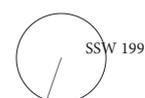
13:00



56



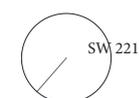
14:00



55



15:00



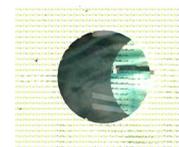
51



16:00



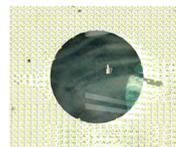
45



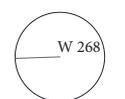
17:00



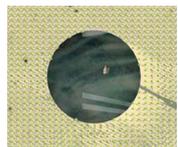
37



18:00



30



19:00



21



20:00



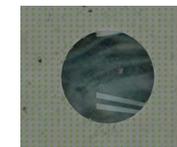
14



21:00



7



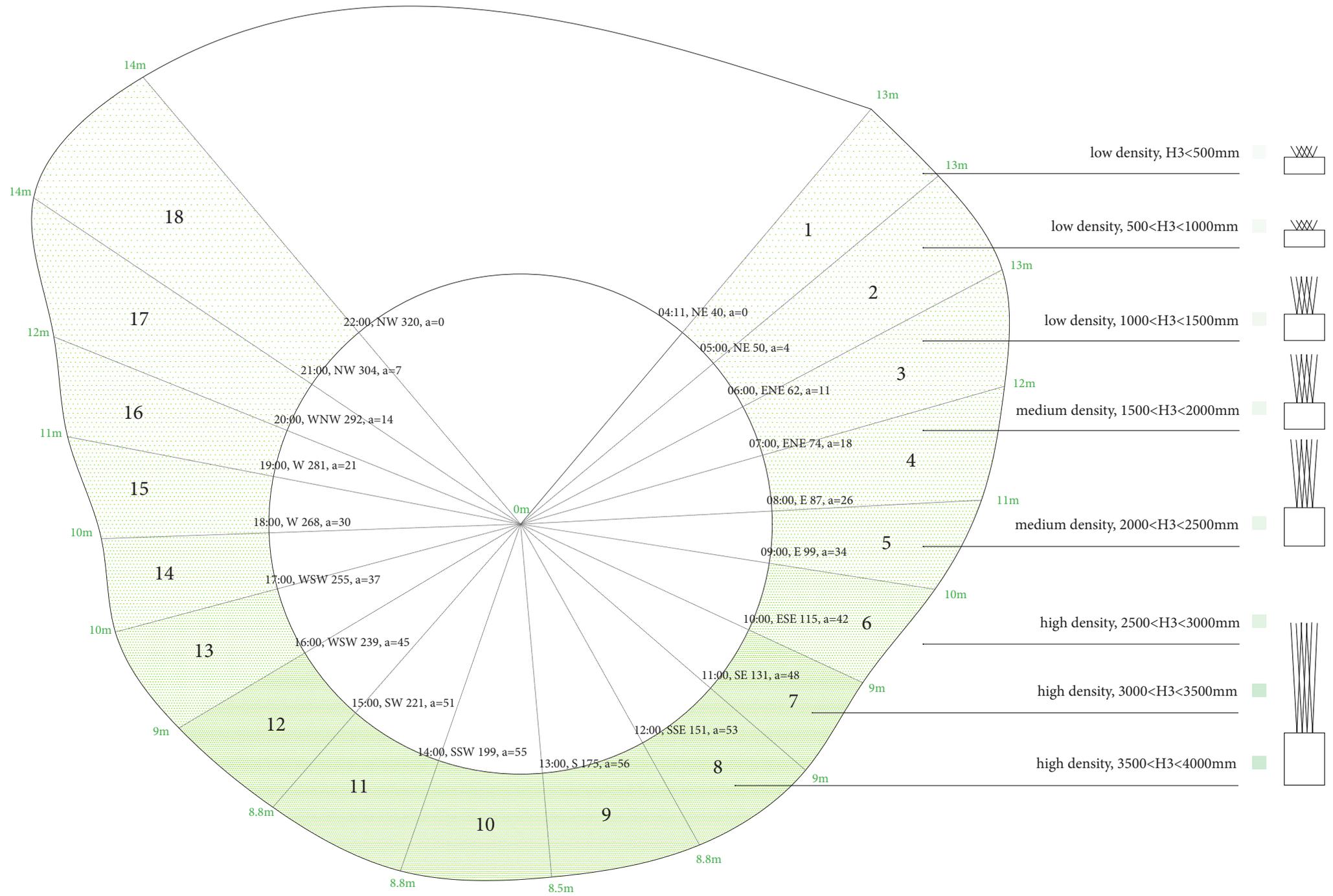
22:17 sunset



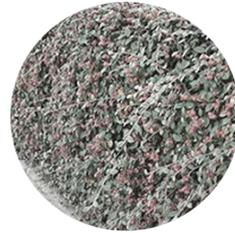
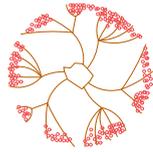
0

STUDY ON DENSITY, HEIGHT OF PLANTS

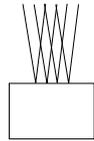
The diagrams below shows the location of plants with different height and density. The outer line is calculated by the logic from last page, if the plants grows inside the outer line, then we could get a certain of shadows into the round pool, and the density is gradually becoming higher and higher from the area8, area18 to area11, area 8,9,10,11 are the same density.



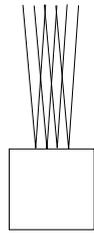
STUDY ON PLANT SPECIES



COTONEASTER



SHRUBS



PENISETUM



LILAC

FIVE SITUATIONS

5:00 am, SUNRISE STORY

9:00 am, FUN STORY

12:00 am, CONTRASTING STORY

16:00 am, MET STORY

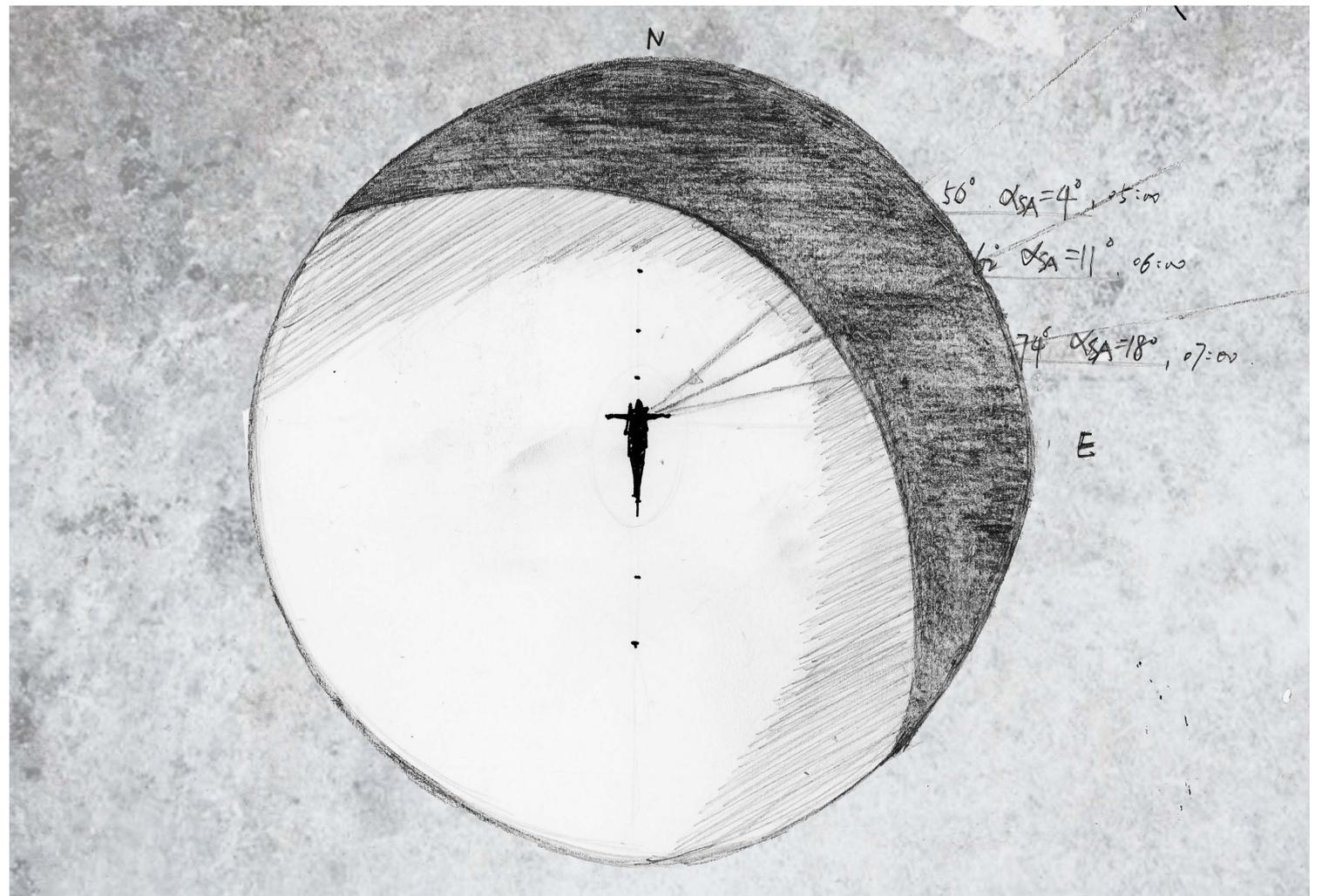
19:00 am, HOPE

TIME
05:00, 06.21 Göteborg, early morning

EXPERIENCE
calm

STORY
you get up early in the morning,
feel like still tired,
then you decided to go around
you come to here,
into the water
the light from the sun gradually swallow you
the wind flows your face
flows the plants wave
you just standing there
watching the light
feel like peaceful
hopeful

.
. .
. .
. .
. .
. .



TIME

09:00, 06.21 Göteborg, morning

EXPERIENCE:

fun, curious, playing with the sunlight

STORY

you come to the pool
the sun is becoming stronger, stronger
then you swim
from darkness
to shadows of plants
then to the lighting water

.
.
you met someone
she swims, hidden into the darkness
you turns around to find her
but she disappears

in the darkness



TIME

12:00, 06.21 Göteborg, noon

EXPERIENCE:

contrasting

STORY

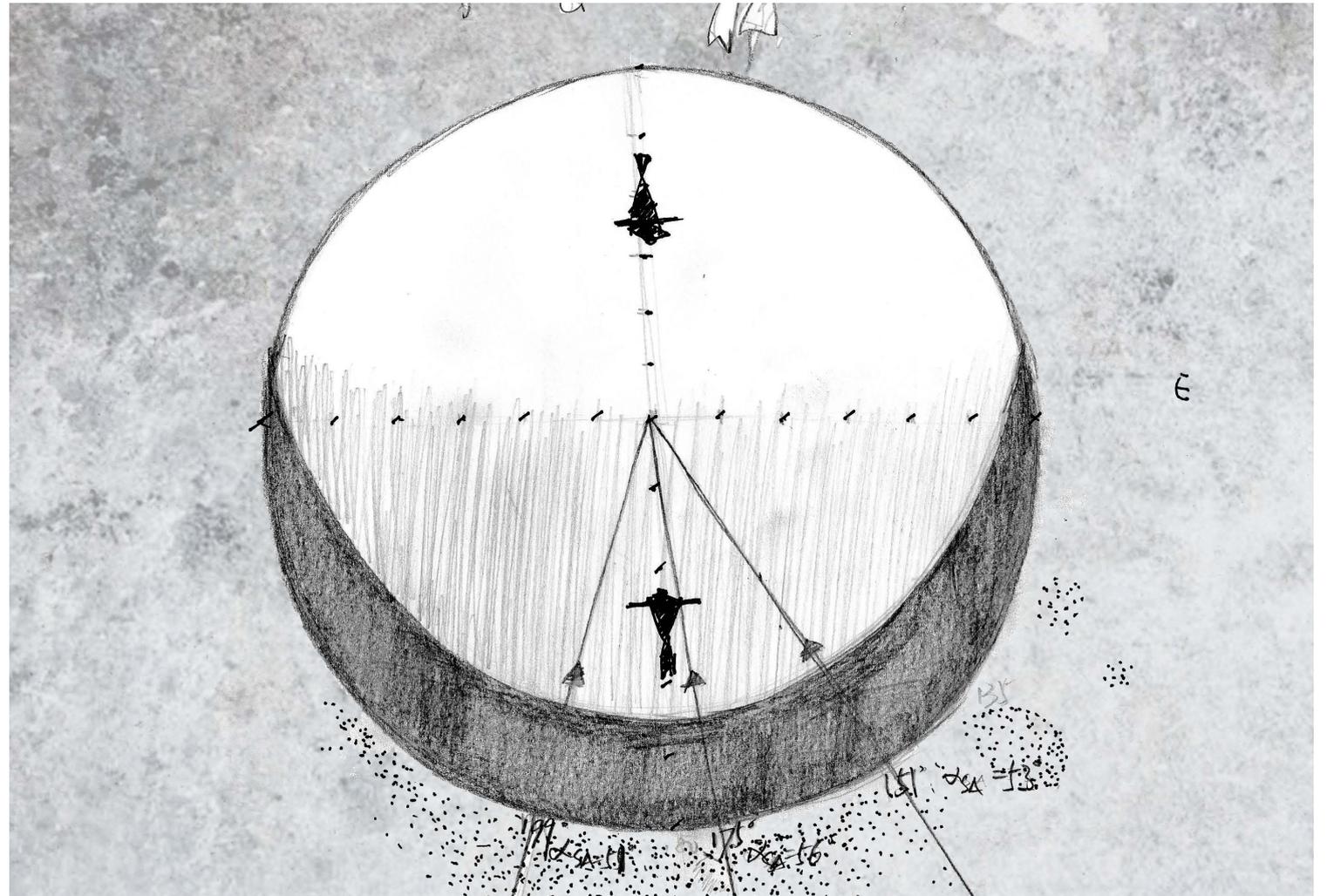
sun feels like a hot ball
you hidden into the large darkness shadows
cooling your heart
safe, in your arms

.
you close your eyes for a while

someone is far away from you in the sun
feel like different

you are curious
attending forward to it

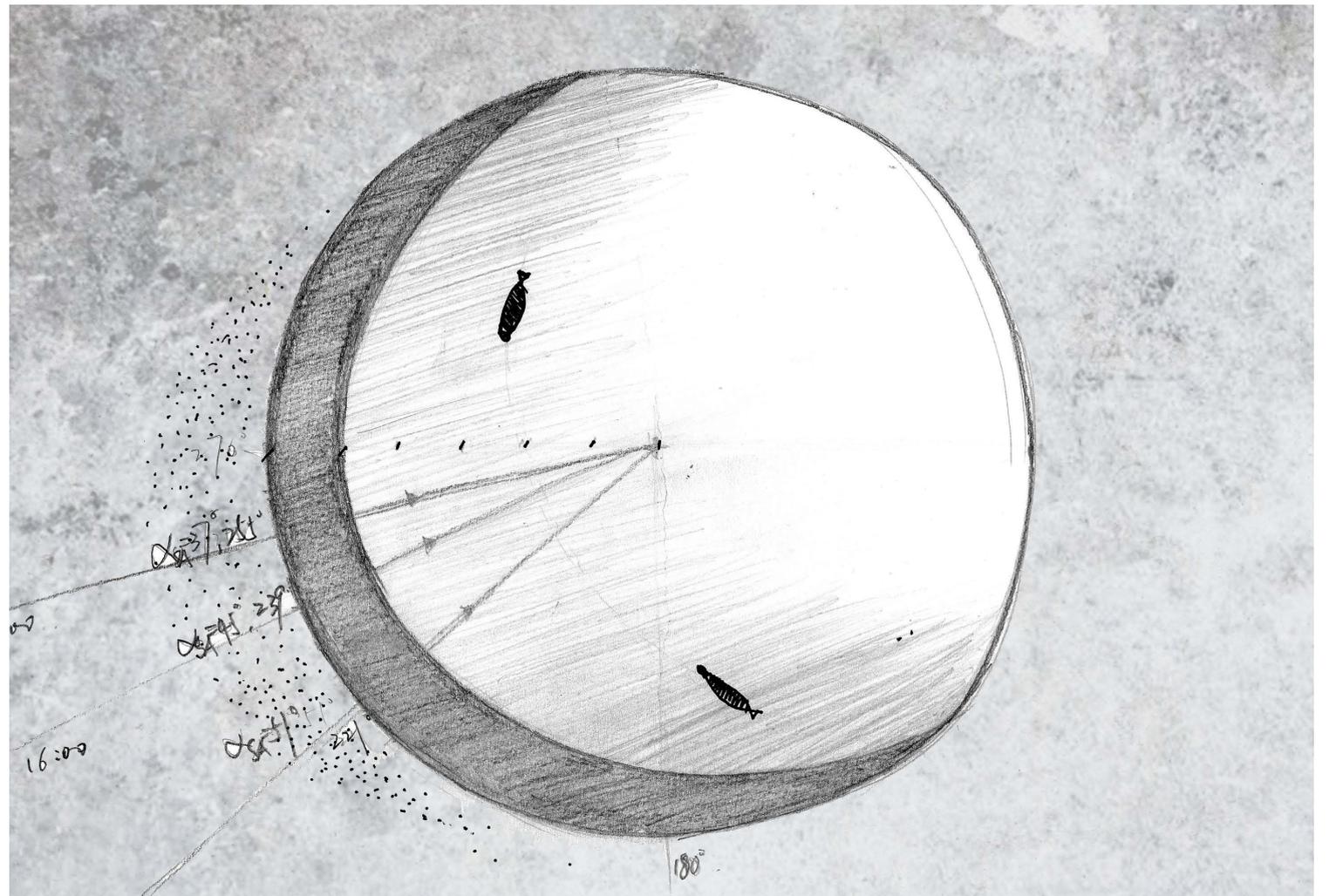
.
. .
. .
. .
. .



TIME
16:00, 06.21 Göteborg, afternoon

EXPERIENCE:
meet

STORY
you swim
from the most darkness
to the most lighting
. . .
you meet her
in the most lighting place



TIME

19:00, 06.21 Göteborg, early morning

EXPERIENCE:

hope

STORY

it become gradually dark

a bit cool

a bit windy

a bit sun out from the west

.

.

someone is standing in the lighting water

it seems a direction

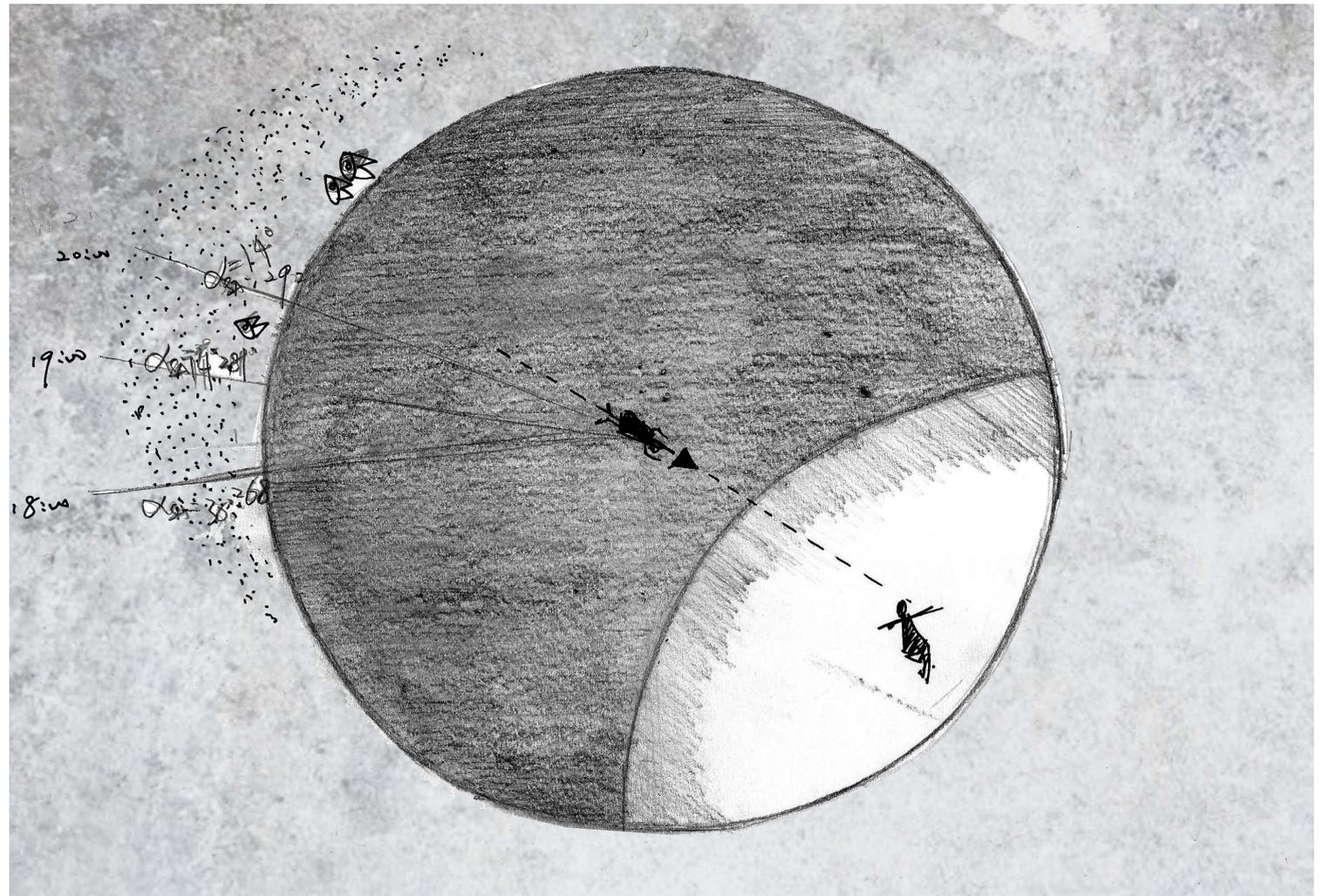
seems a hope

you want to catch it

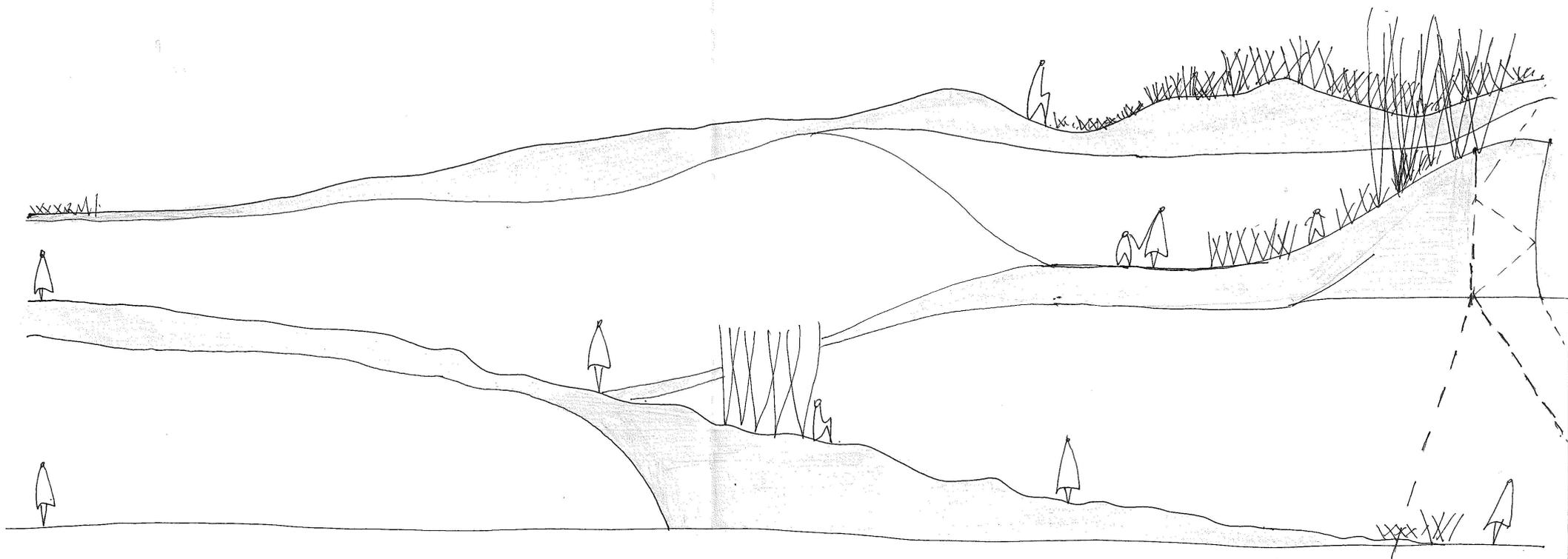
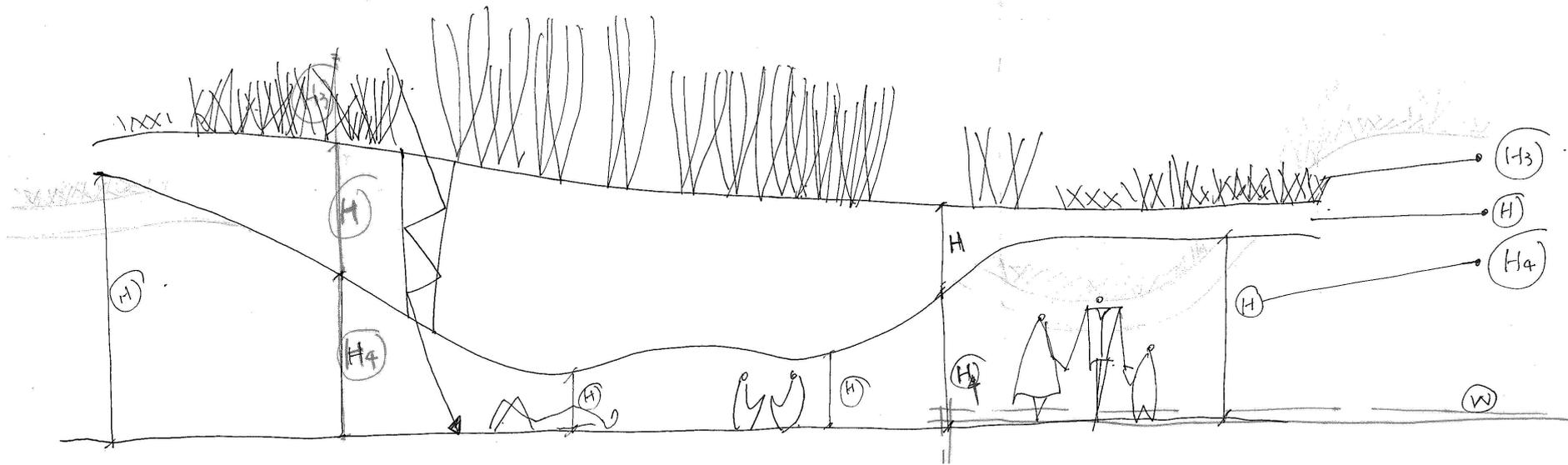
you desire swim to the light

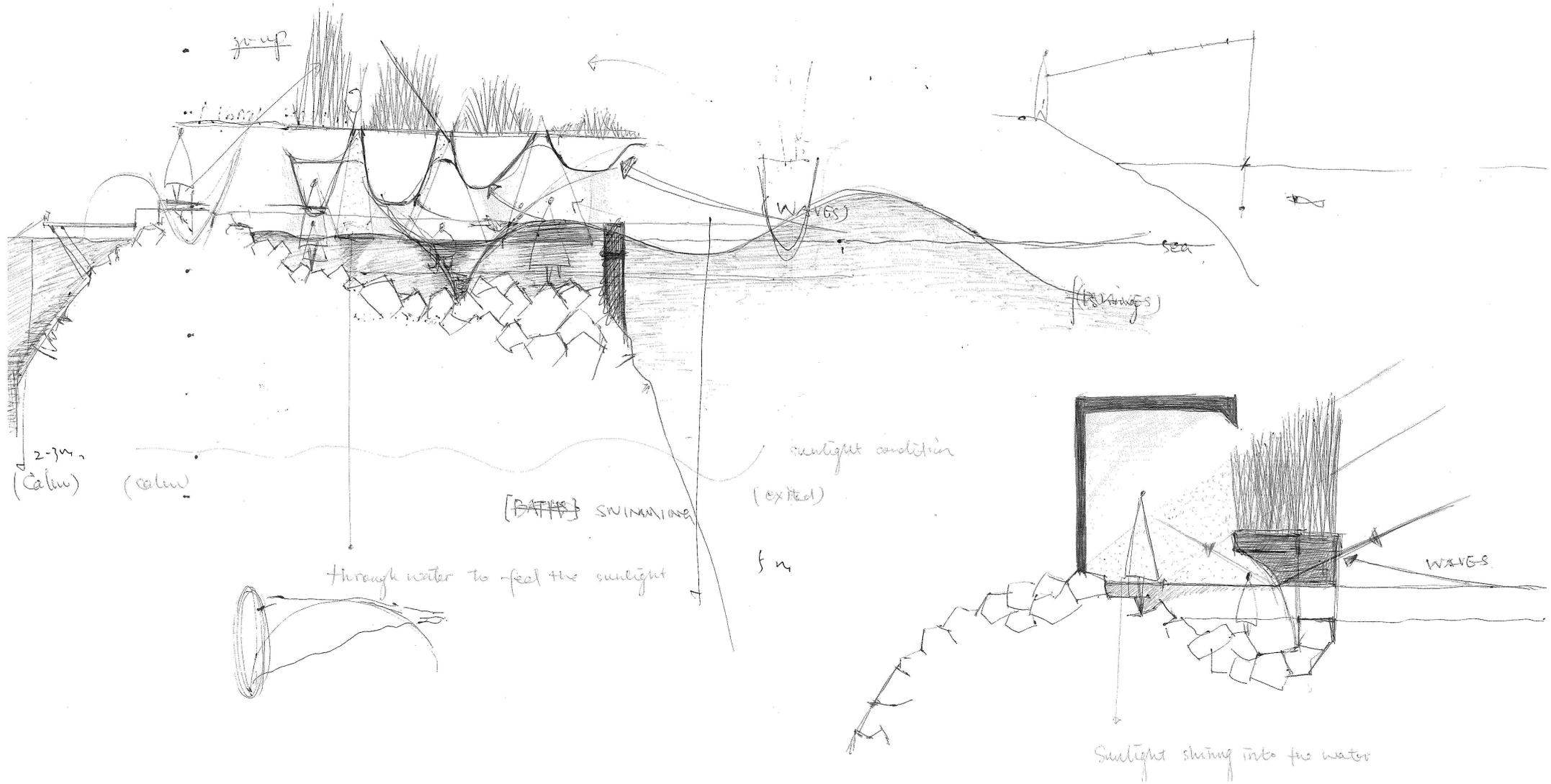
.

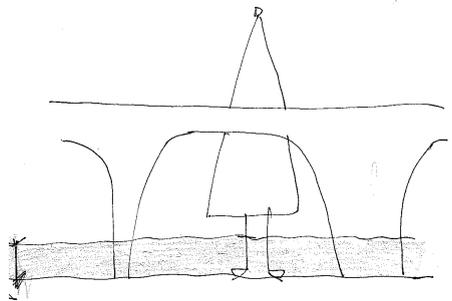
meet some hope



SKETCH

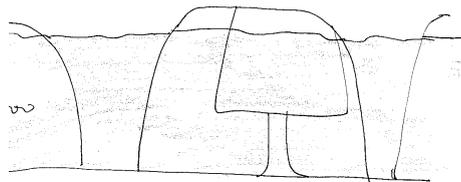
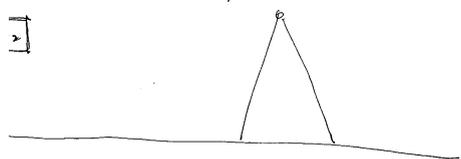
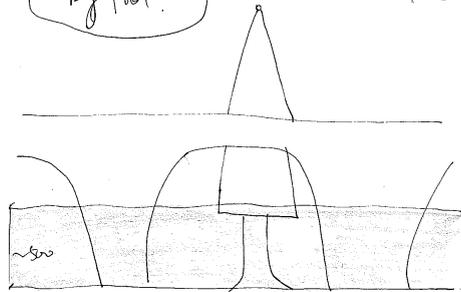






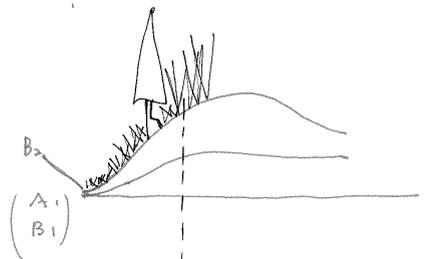
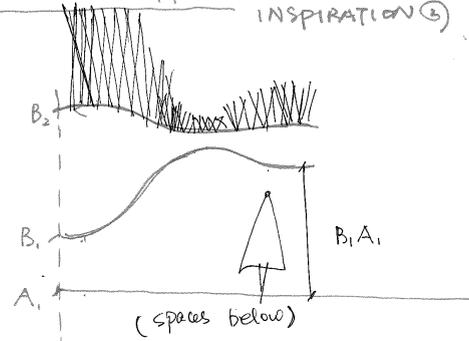
just playing with water

big Pool → Children playing

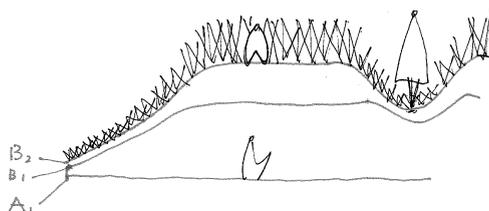


(PATH)

~~BASED PROTOTYPE~~ FORMATION INSPIRATION ③



(walking up paths)

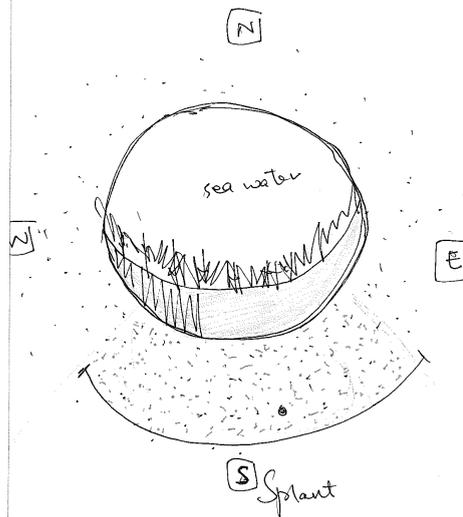


(spaces upon) B2

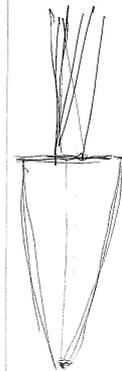
Structure analysis for human behaviours & potential spaces.

08:00 ~ 16:00

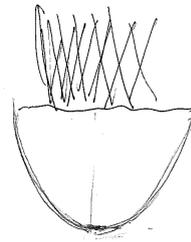
SHADOWS



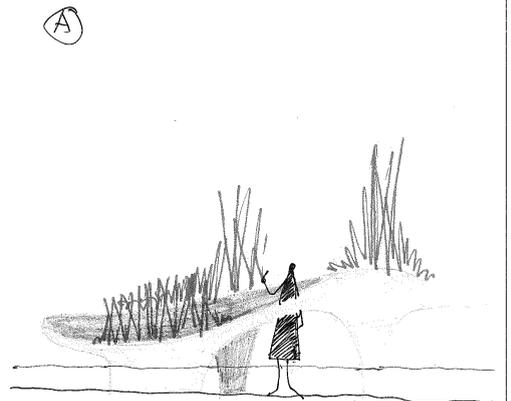
$H_3 \text{ SPLANT} > H_3 \text{ E} \approx H_3 \text{ W}$



S

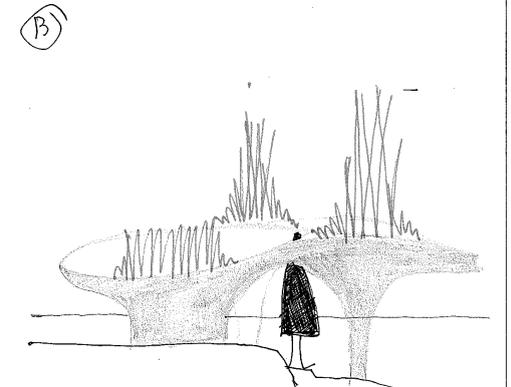


E, W



EARTH

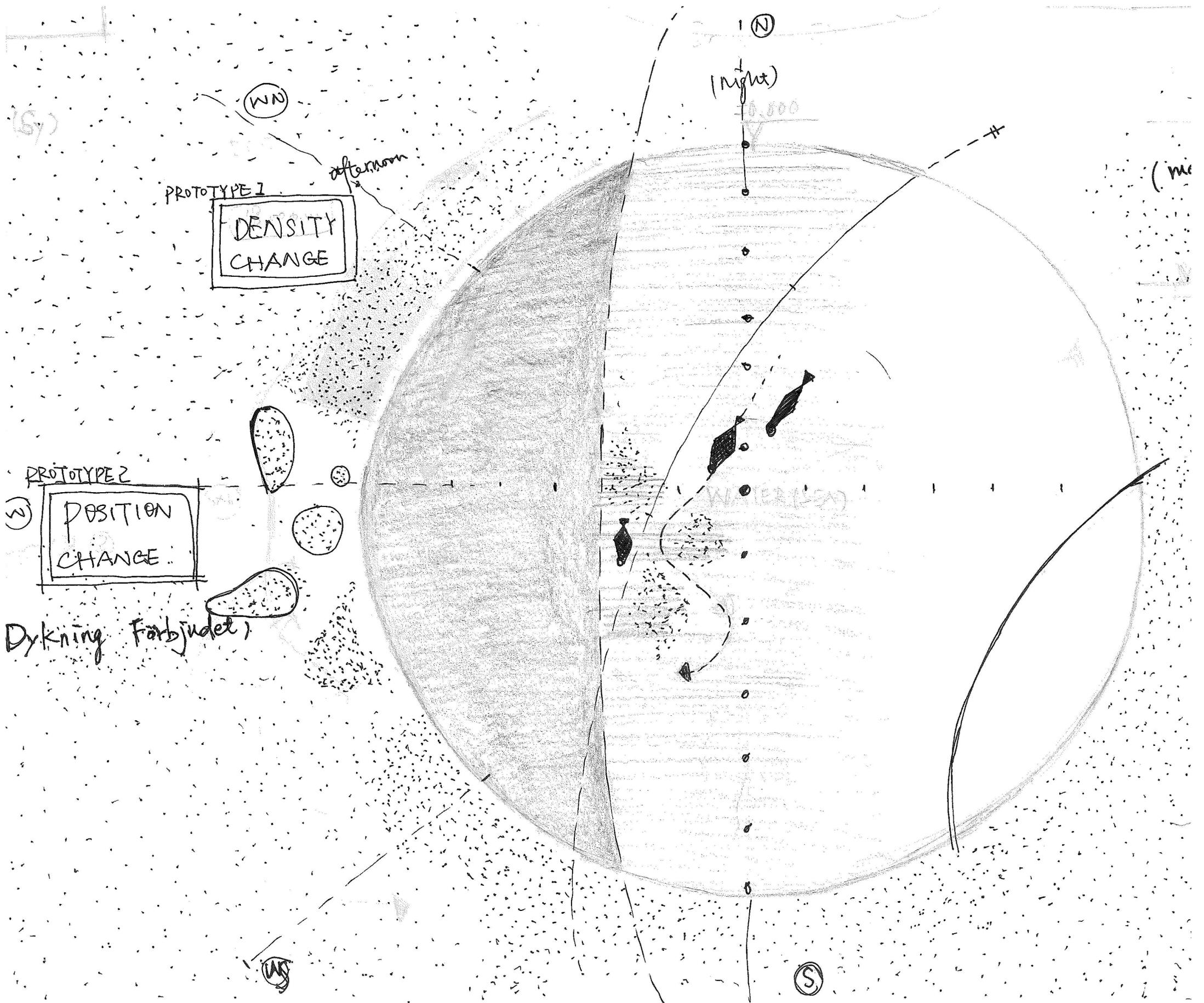
N S

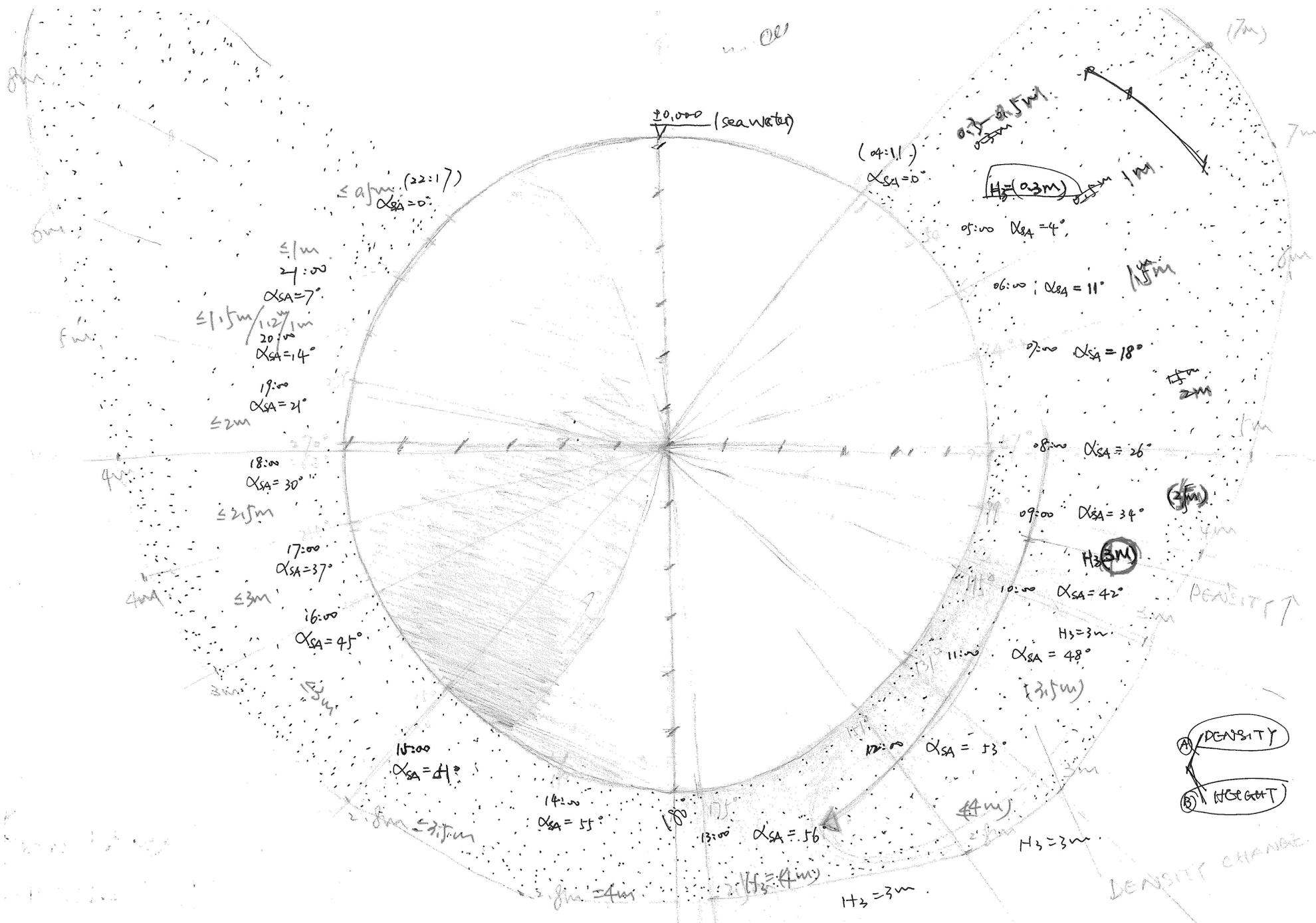


EARTH

N S

SH





04:11 Sun Rise

05:00, NE 56°, $\alpha_{SA} = 4^\circ$, $\cot \alpha_{SA} = 14.3007$, $0 \leq H_w \leq 0.5m$, $H \approx 0.3m$

06:00, NE 62°, $\alpha_{SA} = 11^\circ$, $\cot \alpha_{SA} = 5.1446$

07:00, NE 74°, $\alpha_{SA} = 18^\circ$, $\cot \alpha_{SA} = 3.0777$

08:00, E 87°, $\alpha_{SA} = 26^\circ$, $\cot \alpha_{SA} = 2.0503$

09:00, E 99°, $\alpha_{SA} = 34^\circ$, $\cot \alpha_{SA} = 1.4826$

10:00, ESE 115°, $\alpha_{SA} = 42^\circ$, $\cot \alpha_{SA} = 1.1106$

11:00, SE 131°, $\alpha_{SA} = 48^\circ$, $\cot \alpha_{SA} = 0.9004$

12:00, SSE 151°, $\alpha_{SA} = 53^\circ$, $\cot \alpha_{SA} = 0.7536$

13:00, S 175°, $\alpha_{SA} = 56^\circ$, $\cot \alpha_{SA} = 0.6745$

14:00, SSW 199°, $\alpha_{SA} = 55^\circ$, $\cot \alpha_{SA} = 0.7002$

15:00, SW 221°, $\alpha_{SA} = 51^\circ$, $\cot \alpha_{SA} = 0.8098$

16:00, WSW 239°, $\alpha_{SA} = 45^\circ$, $\cot \alpha_{SA} = 1$

17:00, WSW 255°, $\alpha_{SA} = 37^\circ$, $\cot \alpha_{SA} = 1.327$

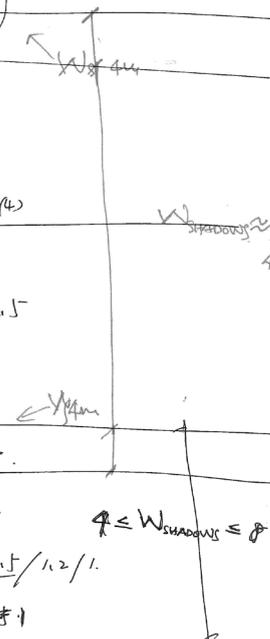
18:00, W 268°, $\alpha_{SA} = 30^\circ$, $\cot \alpha_{SA} = 1.732$

19:00, W 281°, $\alpha_{SA} = 21^\circ$, $\cot \alpha_{SA} = 2.6051$

20:00, WNW 292°, $\alpha_{SA} = 14^\circ$, $\cot \alpha_{SA} = 4.0108$

21:00, NW 304°, $\alpha_{SA} = 7^\circ$, $\cot \alpha_{SA} = 8.1443$

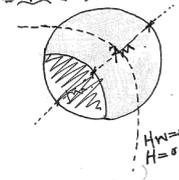
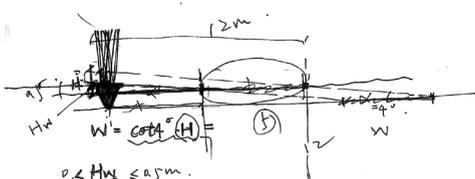
22:00, NW 320°, $\alpha_{SA} = 0^\circ$, Sun Set



04:11, NE 40°, $\alpha_{SA} = 0^\circ$

05:00, NE 56°, $\alpha_{SA} = 4^\circ$

$\cot \alpha_{SA} = 14.3007$

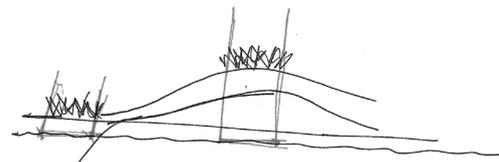


06:00, NE 62°, $\alpha_{SA} = 11^\circ$

$\cot \alpha_{SA} = 5.1446$

$W = \cot 11^\circ \cdot H = 5.1446 \cdot H =$

$0.5 \leq H_w \leq 1.2m$



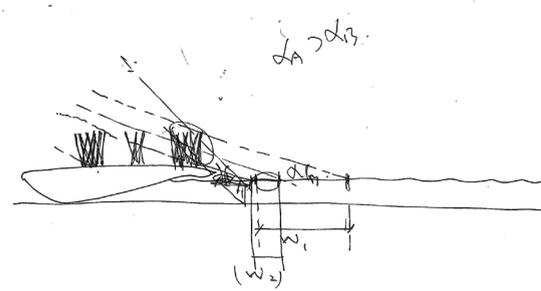
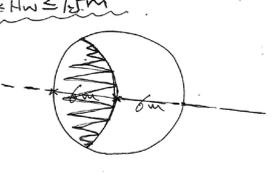
09:00, 99°E, $\alpha_{SA} = 34^\circ$

$\cot 34^\circ = 1.4826$

$W = \cot 34^\circ \cdot H =$

$(H = 3-4m)$

$1 \leq H_w \leq 1.5m$



SOLAR ALTITUDE:
 太阳高度对植物高度选择的研究。
 以神木植物在(0~4m)之间的研究。
 能拥有-昼面(即阴影落在swimming pool
 里面;从而避免阴影长度和面积。



CONCLUSION

I started the thesis just from my own interests - landscape, I love to just sit around the natural plants, feel them, touch them, everything is so calm and beautiful, that is where I really want to stay. The reason is so simple for me, but the thesis is a super surprise for me, as when I first started from the little plants, I have not thought that I would ended up with a pool on the sea. Everything happened in the thesis time is kind of gift for me, thanks to everyone I met during the half year.

The thesis is not a answer for any specific questions in architecture field, but it provides toolbox for future discussions and possible questions, and it is very important for myself, it is a foundation for my possible future projects, I want to study more on it.

