DESIGN PRACTICE I
PHASE 2
PROCESS BOOK

CIYING WANG

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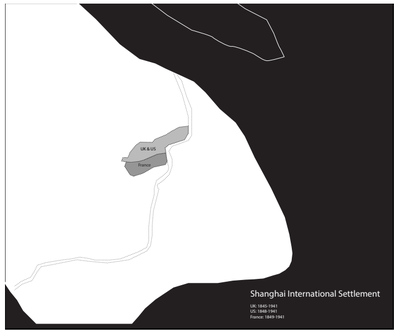
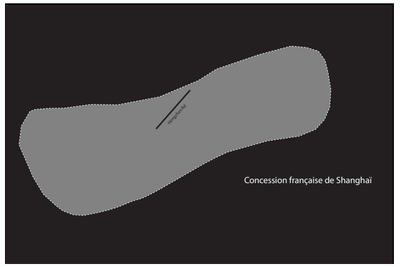




2015 Due to the rise of other newly-built commercial centres and the disadvantages of its geographical location, Hengshan Rd has been declining and pubs started to move away.

2000 Hengshan Rd reached its heyday. There were a maximum number of 100 pubs at the same time.

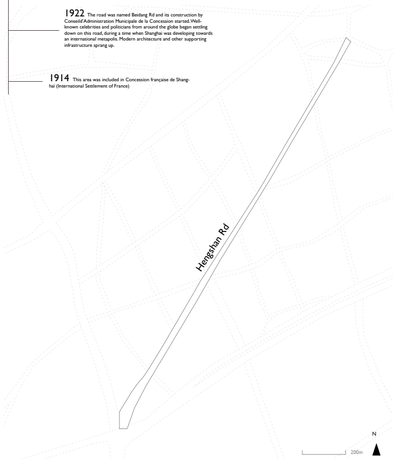
1990 In accordance with the trend of 'opening up', government of Shanghai set out to develop its leisure economy and oriented Hengshan Rd into a pub street. It soon became trendy and well-known.

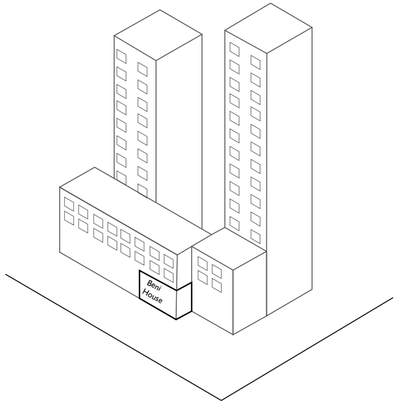
1949 People's Republic of China was established. The public started flooding into the area, during which many infrastructrue and architecture on the road was damaged in the riots .

1943 Ching-wei Wang became leader of the new regime and took back the international settlements in Shanghai.The road was renamed as Hengshan Rd.

1922 The road was named Beidang Rd and its construction by Conseil d'Administration Municipale de la Concession started.Well-known celebrities and politicians from around the globe began settling down on this road, during a time when Shanghai was developing towards an international metropolis. Modern architecture and other supporting infrastructure sprang up.

1914 This area was included in Concession française de Shanghai (International Settlement of France)





01 TYPOLOGY STUDY

The typology of this project is chosen as pubs. Shanghai, addressed by local residents as 'Oriental Paris', was among the first cities that embraced Western pub culture in the 1990s. The emergence of pubs in Shanghai was a response to local government's encouragement of free capital and media's enthusiastic advocation of better leisure and entertainment spaces. The functions of pubs were not only concrete and specific, but more symbolic and metaphorical, reflecting Shanghai's wish to manifest a cosmopolitan and reviving image in the global economy.

Hengshan Road's construction started in 1914 by French colonizers. The world wars saw the development and prosperity of this road, as politicians, architects, celebraties and businessmen from all over the world settled down here in seek for asylum or opportunities. This region experienced serious damage after the PRC was established and symbols of capitalism were targeted at. After 1990s when opening up policies were carried out and globlisation was embraced in China, this road was redeveloped and revived as a recreational and leisure center.

In its heyday Hengshan Rd had over 30 pubs open at the same time. Hitting the bars and pubs on this road was a symbol of fashion and open-mind for the generation who led the pub culture in 1990s and are still enjoying it today. These pubs not only convey geographic meanings, but also synthasizes the imaginations, expectations and illusions of people. Individual capitalism and opening-up policties went in hand in hand, producing not only leisure spaces themselves but also wide-spread information of leisure-based lifestyle in the West.

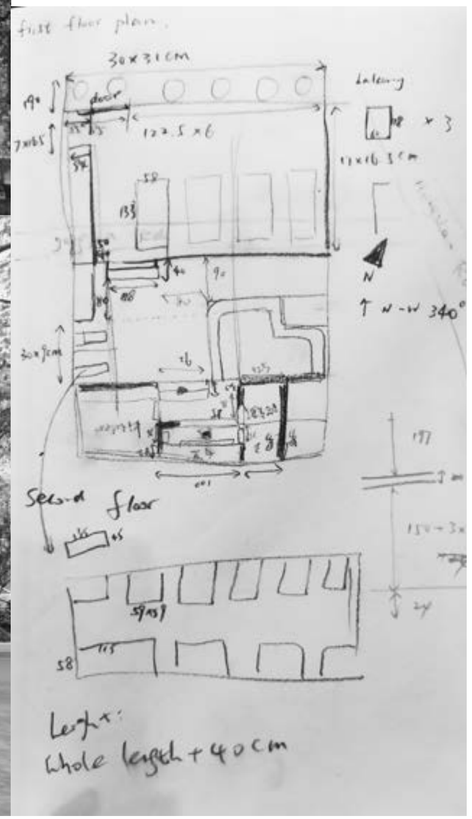
Jean Baudrillard points out in his book The System of Objects that the things consumed are never objects but rather relations themselves—relations that are simultaneously present and absent, included and excluded. It follows that conduct in pubs should be conidered as a kind of non-materialistic practice, and that consumption conduct is not 'passive' behavior that simply satisfies persosnal needs or desires but rather a pattern of 'active' relations. Not alcohol but relations are created and consumed in the operation of pubs. The design of pubs' architecture and interior spaces all ains at promoting this kind of consumption.

Entrance

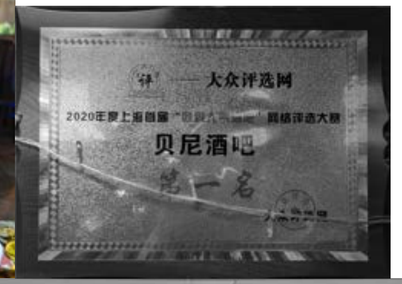
First Floor

Beni House opened in 1994 and was one of the first pubs built on Hengshan Rd. This pub is a freehouse operated by Guangliang O-yang, who has been the boss of this pub since its opening. The licence type of Beni House is business licence with approved catering service. The number of staff, when surveyed on 14/12/20, was 8 people including a bartender, a chef and 6 waiters. The business of Beni House was severely affected by Covid, but has been recovering gradually.

The busiest time, according to O-yang, is Friday night and Saturday night. Customers are mainly regular visitors who live or work nearby. He has several old friends who come here almost every week for 20 years.

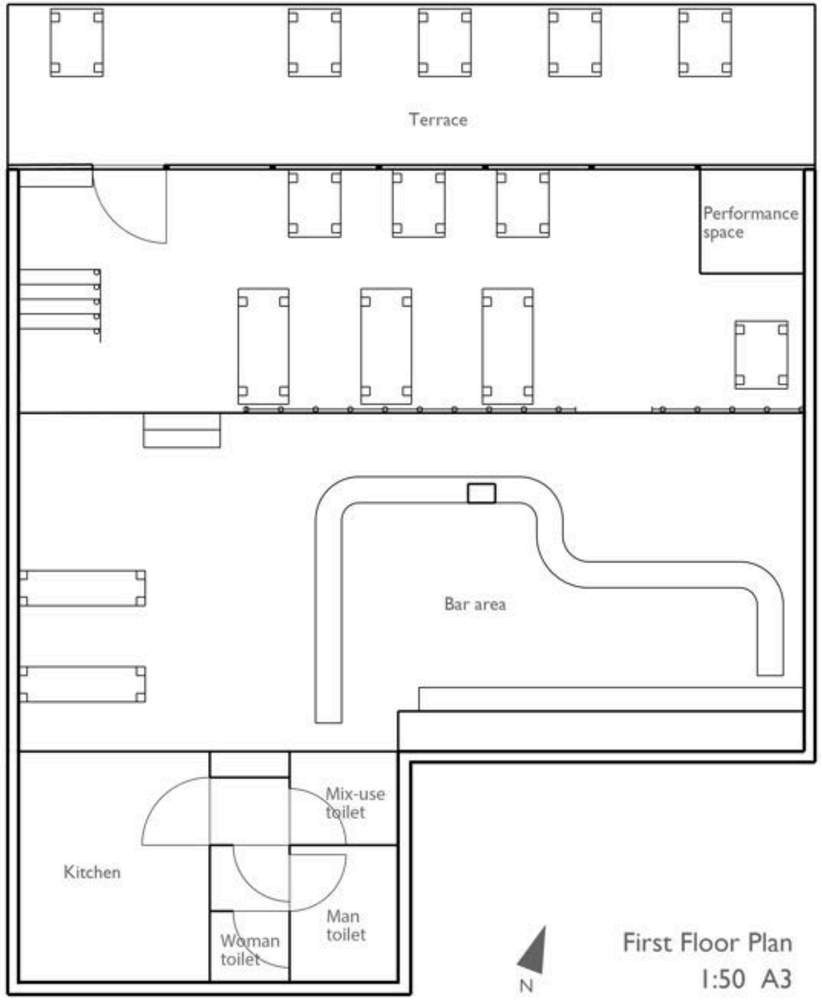


owner: Guangliang O-Yang

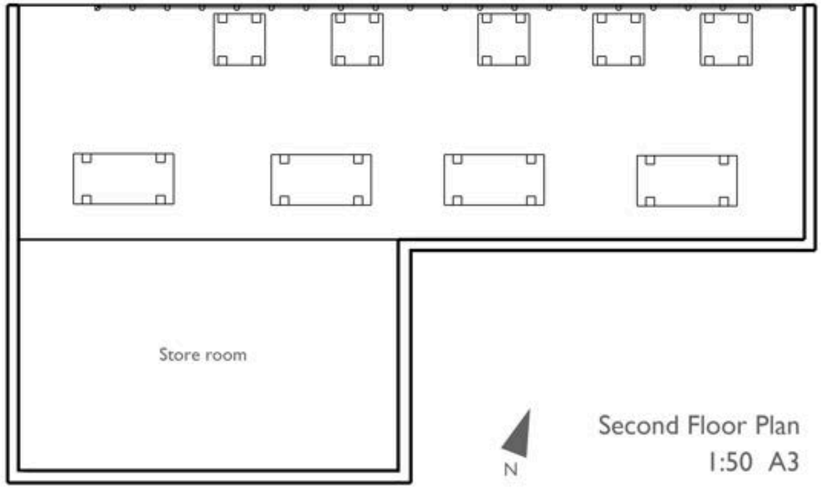


Business license.
Approved service: catering service (food and beverage)

Food distribution permit.



First Floor Plan
1:50 A3



Second Floor Plan
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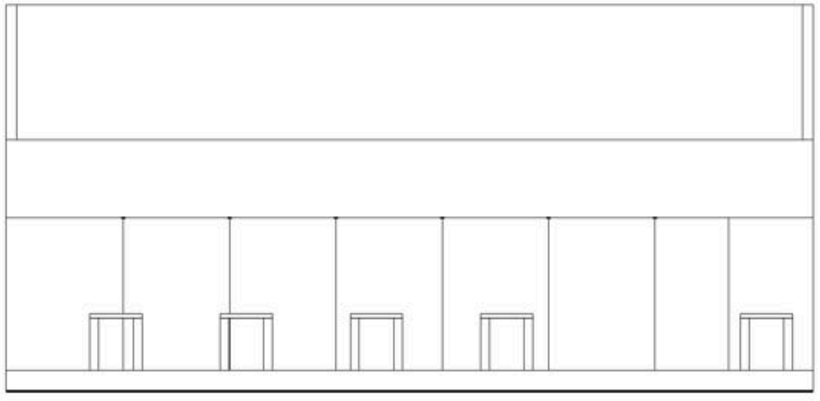
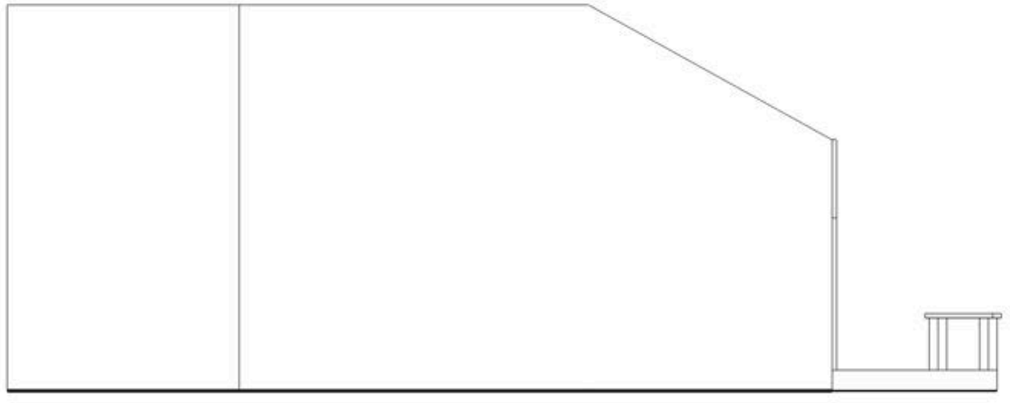


Front Elevation
1:50 A3



Side Elevation
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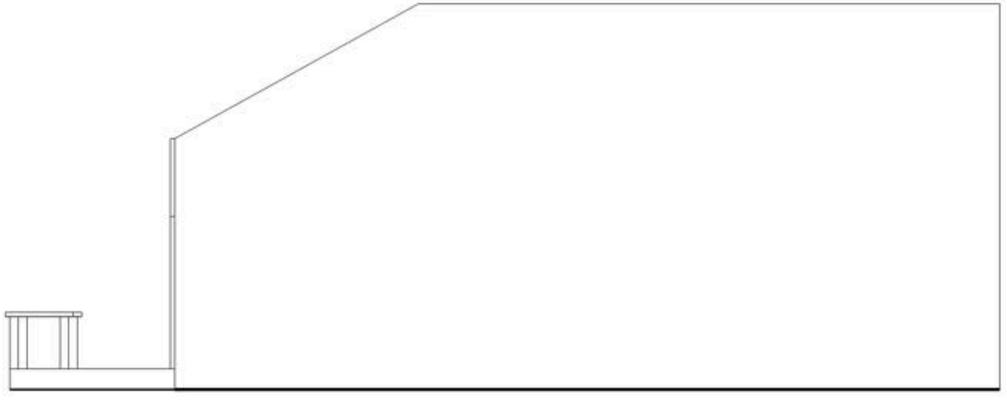
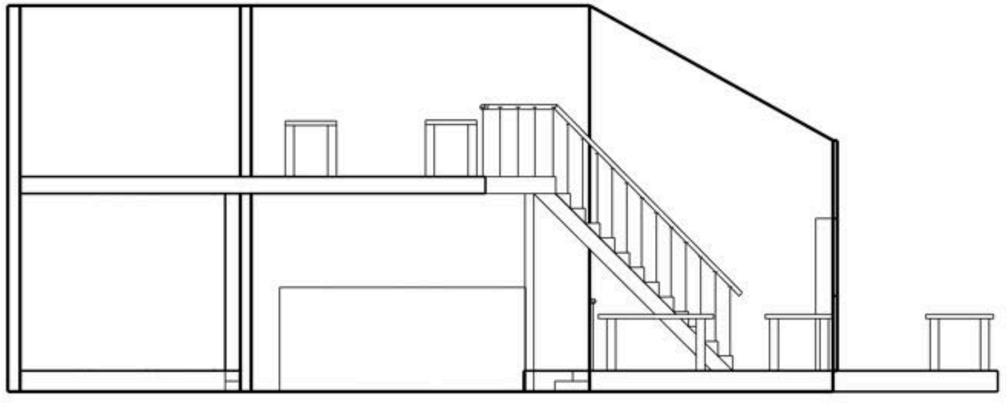


Side Elevation
1:50 A3



Section drawing
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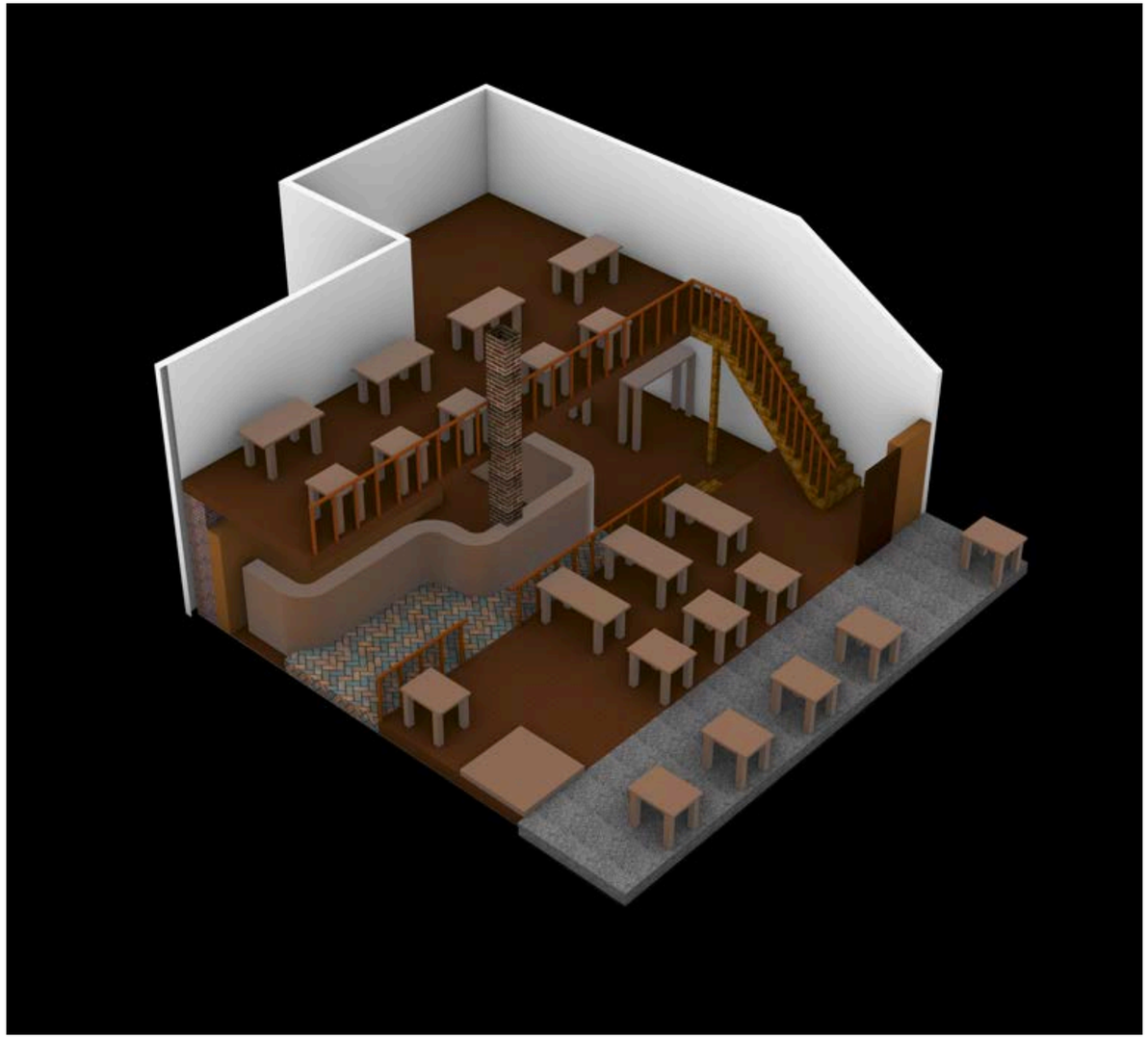


PUBS AS STAGE SETS

The common charaters of pubs that we often seem incude low-key exterior design, simplistic structure, dim and dark interior, carefully designed lighting, large wooden tables with expensive chairs, etc. According to Kuma Kengo and his book <View of Ten Types of Japanese Residences>, the features of pub-style residences can be summed up as:

- Exterior design: un-outspoken, conservative in appearence and rich in inside
- Functions: clear distinction of public and private spaces. Neglect of private spaces.
- Spaces: Sangharama-style living room
- Interior design: interesting little gadgets, emphasis on lighting
- Action: go home only for sleeping

Pubs, or public houses, rely mainly on their social functions. It follows Jean Baudrillard's theory of things consumed not being objects but being relations that people hit the pubs not necessarily for alcohol or football but more for social interactions, with one or a group of other people. However, there exist some distinctions between the west and east, where in one culture pubs may be places to hide from routines and responsibilities whereas in the other pubs are another spot to be scrutinized. There're some other interesting opinions Kuma:

1. Pubs exclude collectivity
Kuma thinks that different from clubs and karaoke bars where people enhance and facilitate relations withalcohol, pubs are actively excluding the metaphor of collectivity. This is quite contrary to common opinions that people go to bars mainly to hang out with friends they're familiar with.

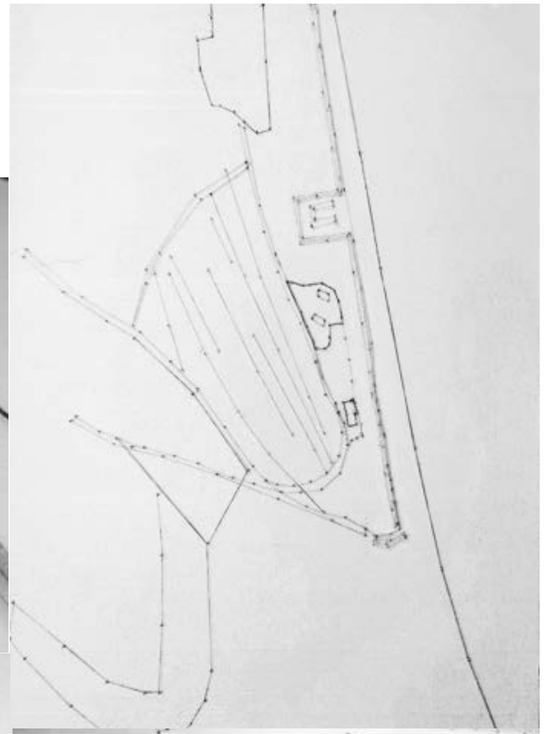
2. Pubs are for scrutinizing ourselves
People are not enjoying the spaces but are actually appreciating their own gestures in the pubs, according to Kuma. One basic function of pubs is that there's always an eye in them, and thus people can be away from where they're often at, and scrutinize themselves from another perspective.

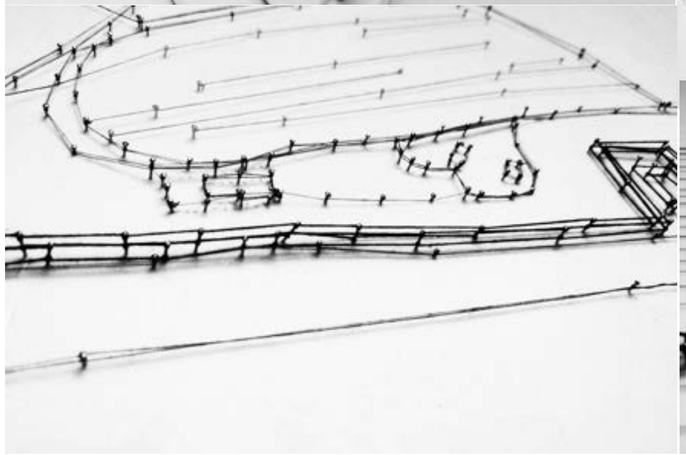
3. Pubs are essentially stage settings
Stages and pubs both belong to 'Sangharama space'. The settings should foil the atmosphere, and they can't be too much as to affect people's performances. Interior with meticulously picked furniture and carefully designed lighting make them casual but profound. Modest exteriors, neutral colors, plain white walls, brutalist designs are all trying not to steal the thumder of performers, who are immersing in their new characters.

Beni Bar second floor

Figure 1. Wolf Gutjahr / Johann Wolfgang von Goethe / FAUST / Tragödie in zwei Teilen / Theater Freiburg / 06.2012

02
SITE & COMMUNITY STUDY

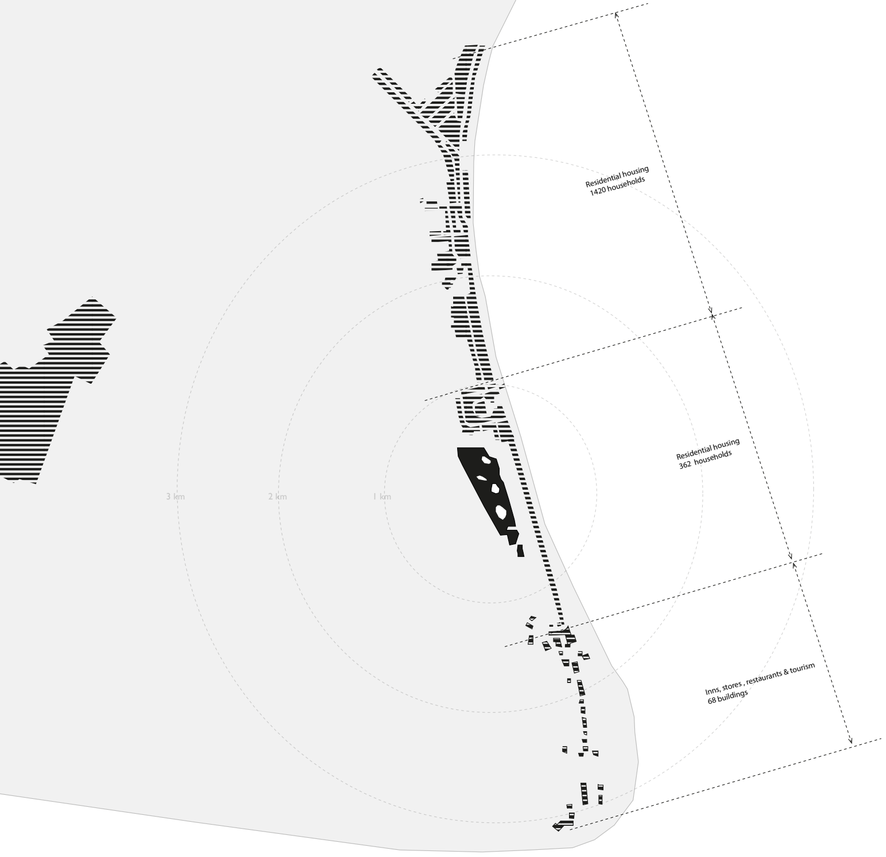


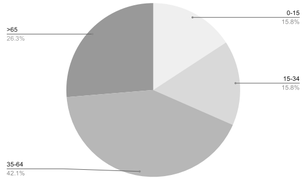


pinned models of the site

Communities

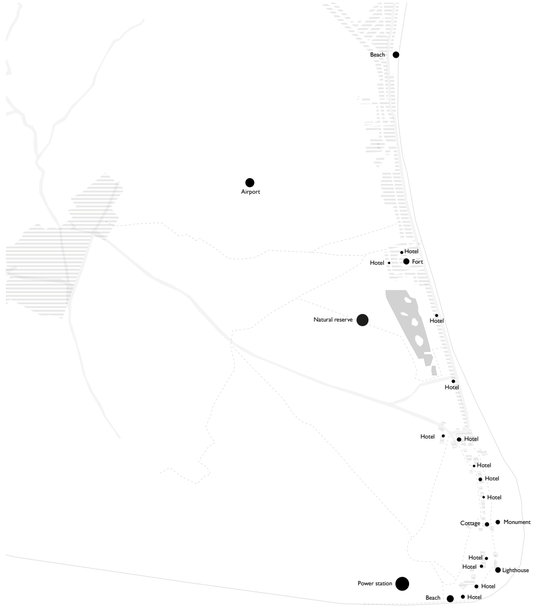
Local communities near the quarry are concentrated around the fortress to the north of the site, and along the road near the seashore. Within the 1km diameter of the site there're around 350 households, and among the population 26% are over 65 and 46% are 36-65 years old. It can be found that local services, compared to tourist services, are limited to a few local stores, a therapy centre and several bars and restaurants. Local communities with an aging population within walking distance of the site, therefore, can be potentially considered as the target community for this project.



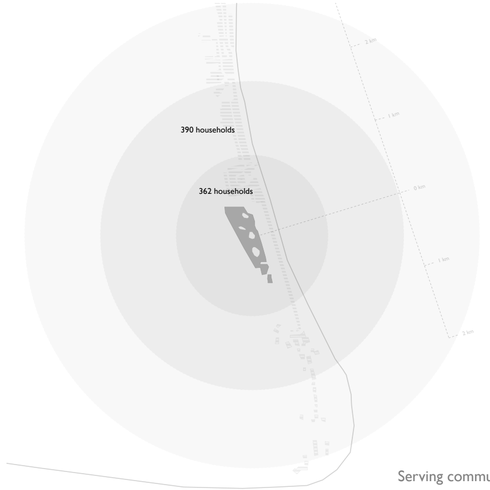


Population -age group

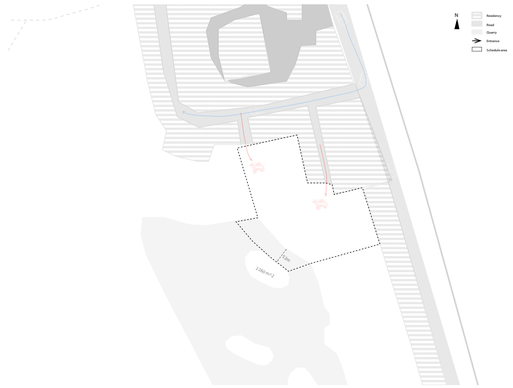
local services



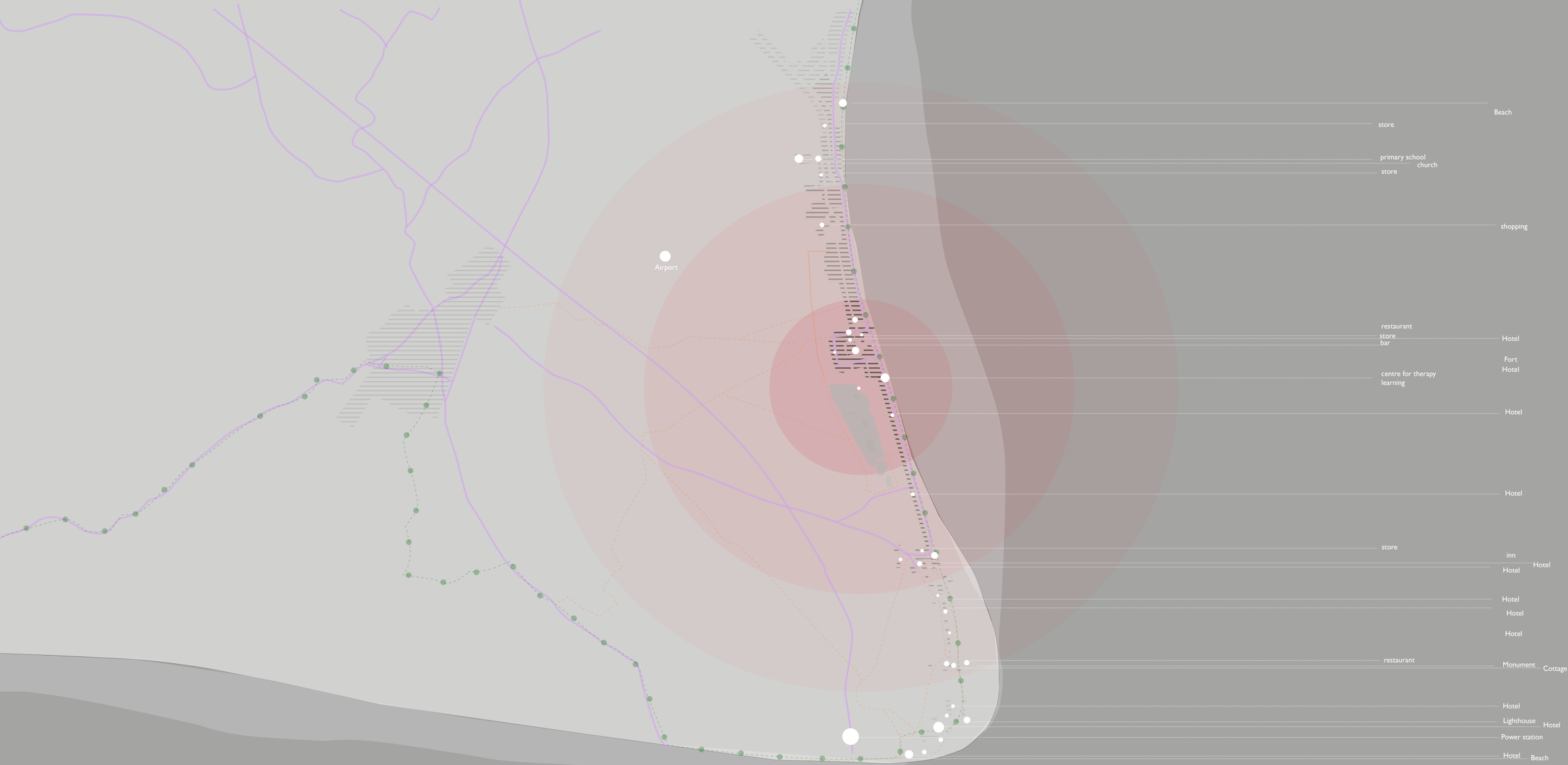
Tourist services



Serving community



Siting & Entrance


Beach
store
primary school
church
store
shopping
Airport
restaurant
store
bar
Hotel
Fort
Hotel
centre for therapy
learning
Hotel
Hotel
store
inn
Hotel
Hotel
Hotel
Hotel
Hotel
restaurant
Monument
Cottage
Hotel
Lighthouse
Hotel
Power station
Hotel
Beach

RESIDENCE

QUARRY

SHINGLE BEACH

SEASIDE ROAD

PROJECT SITE

RSPB DUNGENESS

It is hoped that the project will not exceed the surrounding residential buildings so as not to interrupt the skyline when looking from the seaside roads

SECTION VIEW OF PROJECT AND SITE 1:1000 A3

‘ESCAPE’

In Latin, ‘escape’ means ‘to get out of one’s cloak’. It is made up of the Latin prefix ex-, which means “out of,” and the Latin word cappa, which means “head covering” or “cloak.”If you were being held captive by someone gripping the coat or cloak you were wearing, you might be able to get away by slipping out of it. This is what the meaning of escape is based on.

In Hesse’s <steppenwolf>, Harry Haller has two very different personalities at the same time, which causes pain and confusion. In most cases he appears well-educated, gentle and calm, but he sometimes has a irresistable desire to be free-spirited, pleasure-seeking and aggresive, which represents his ‘wolf’ side.

Harry one day stumbles upon a young woman named Hermine in a bar, who teaches him how to dance and asks to direct everything in his life. Harry, however, find it extremely liberating and freeing in a subservience to commands. Hermine and Paolo, a jazz player in the bar, introduce Haller to a brand new life, which is dominated by intuitions and physical pleasure.

In ancient Rome, ‘Popinae’ were a type of wine bar generally frequented by the lower-classes and slaves, and were simply furnished with stools and tables. The popinae were seen by respectable Romans as places of crime and violence because of their association with gambling and prostitution. In ancient China, pubs are were all classes of people are mixed together, including politicians, poets, robbers and vagrants. People who ask about gossips or politcial conspiracies often come to bars.

The functions of pubs have changed over time. Today, chatting and relaxing are very important parts of pub life. Pubs are places to let out suppressed sides of people, who put on masks during the day but inside they just want to binge, shout and dance. Maybe there’s a constant conflict between outside constraints of civilisations and the inner needs which are not always acceptable but are real. Pubs temporarily soothe the conflict.

People are ‘freed’ for a while. They seem to have escaped from realities, but they have in fact just fallen into another place inside the system, where they are desinated to ‘relax‘ and ‘refuel’ , in order to prepare for another day. There is maybe no way to escape, but only ways towards other destinations in a loop.

Figure 3. Colourscape project in London

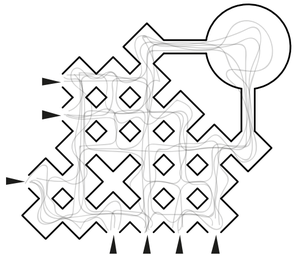
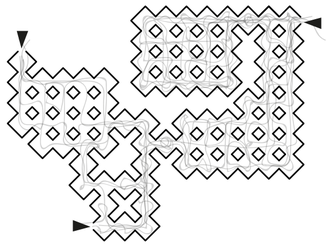
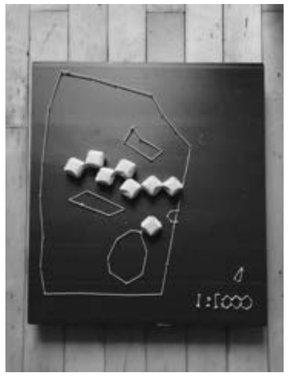


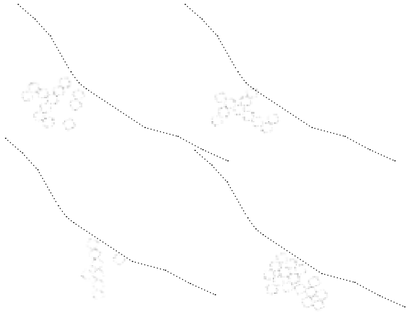
Figure 4. Colourscape project in London

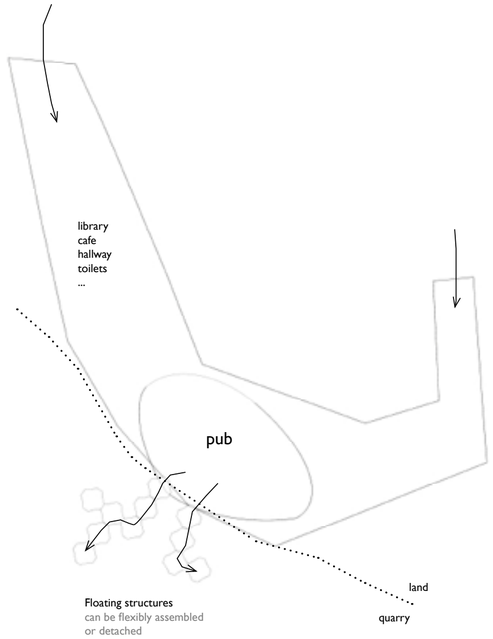


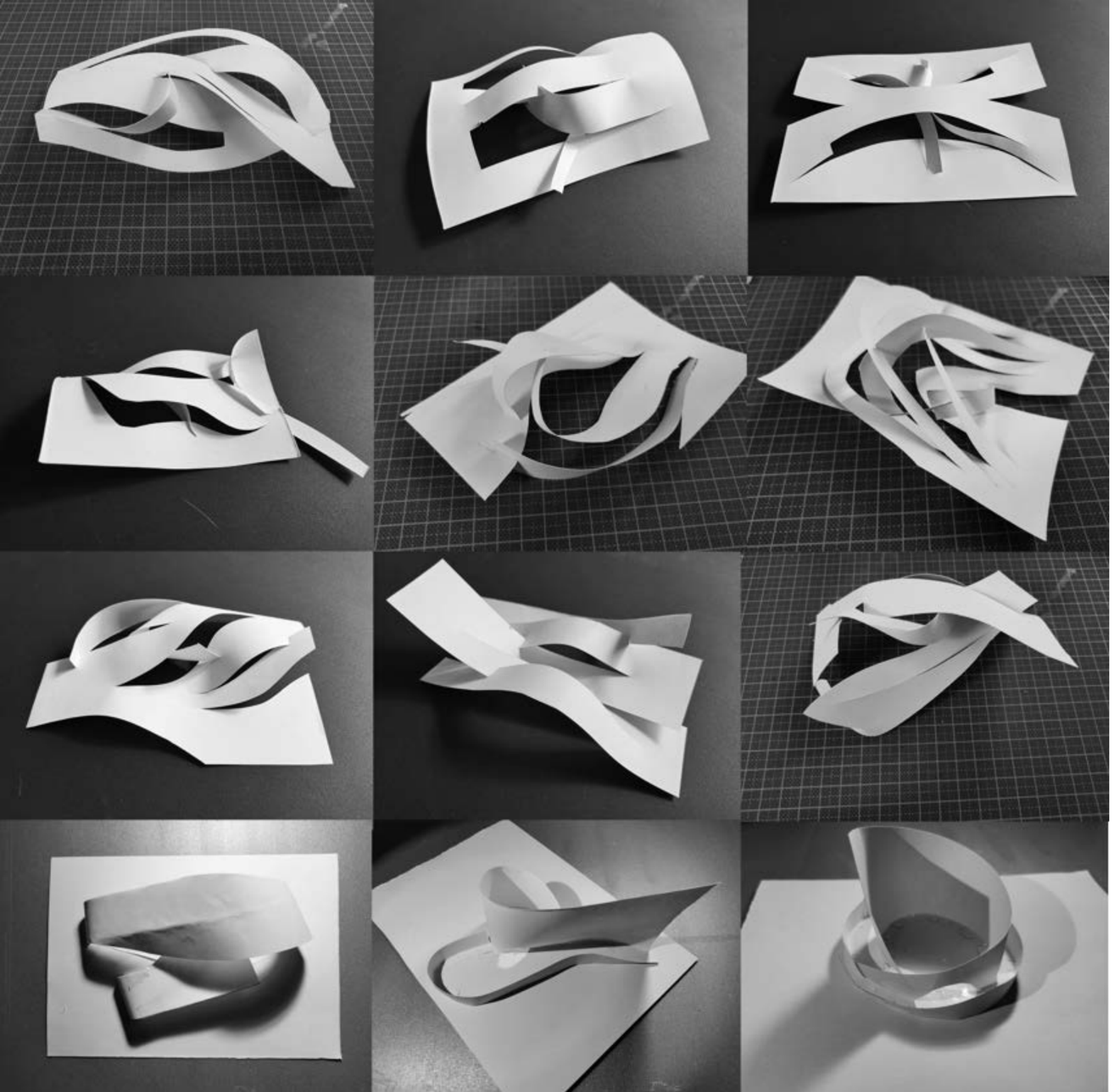
Case study: Colourscape

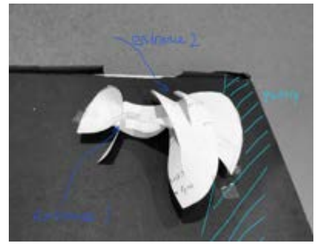
The colourscape music festival in 2016 exhibited a structure featuring in the connection of inflated cabins. Various possibilities can be generated by connecting the units in different ways, not only can visitors go through different routes, but the interaction patterns can be very different as well. The action of walking through the labyrinth-like structures and gradually deprived of senses from outside environment provides a strong feeling of alienation. The re-sizing and re-arrangement of units can form the distinction of private and public spaces.



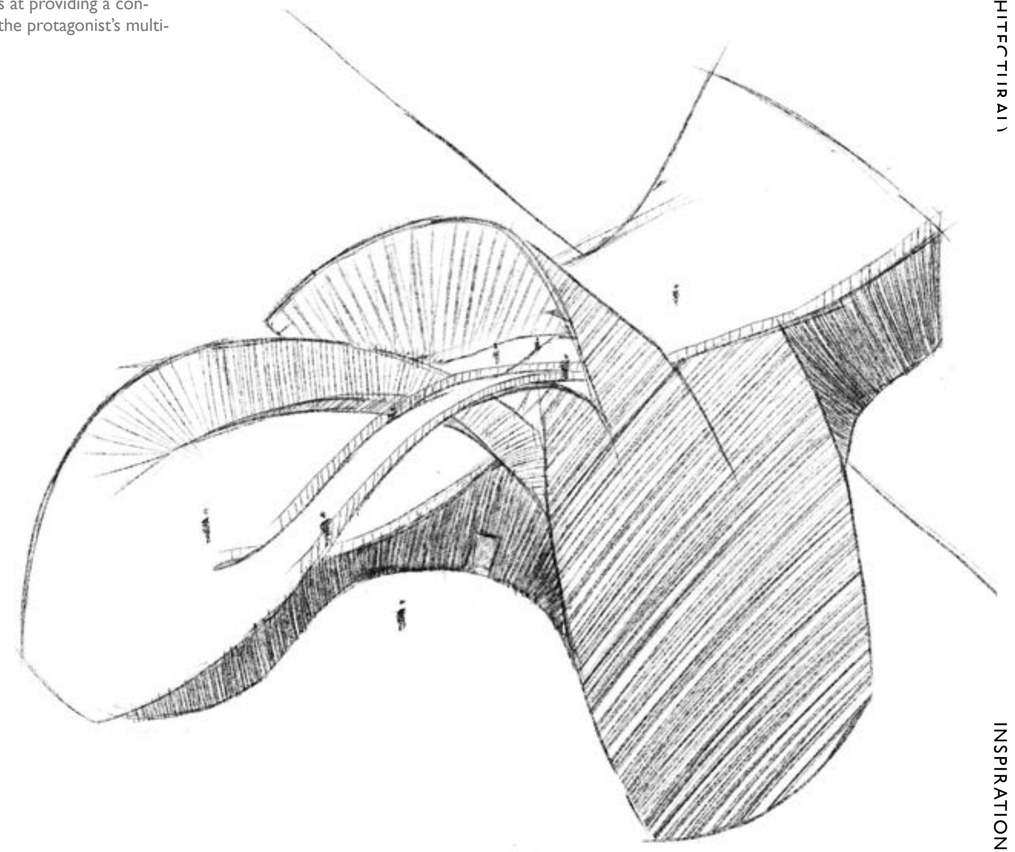


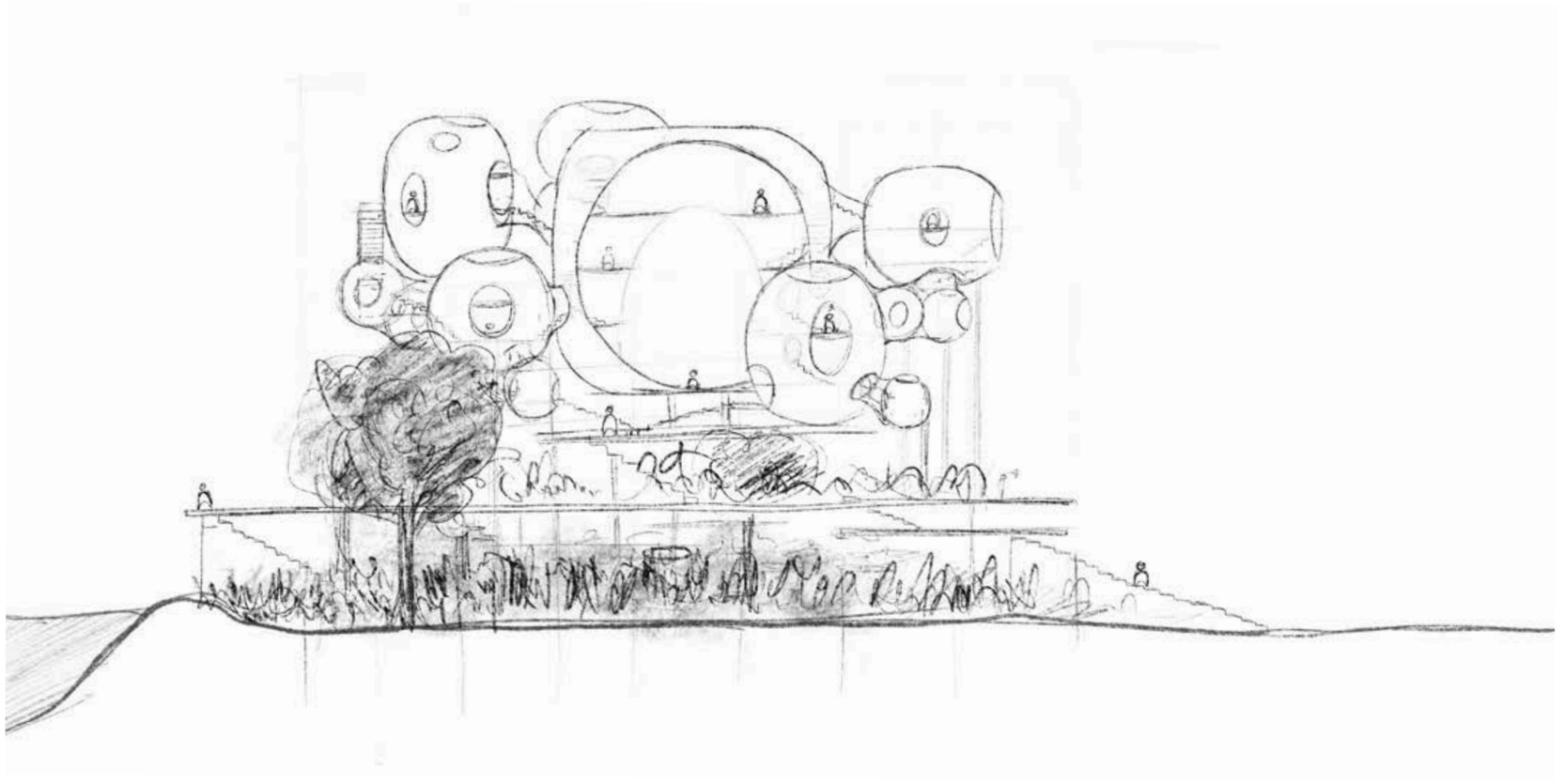




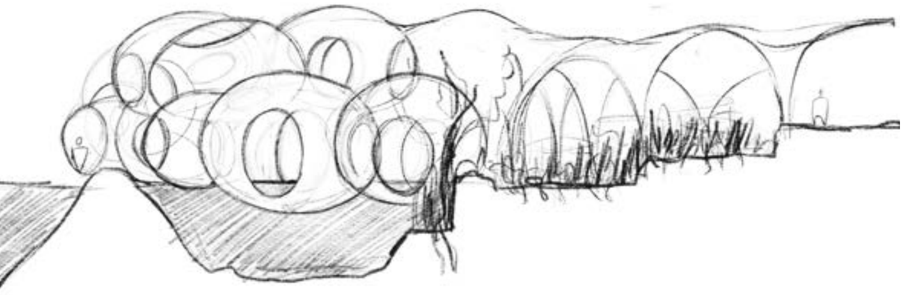


An origami-inspired idea aims at providing a contrast of spaces, representing the protagonist's multiple identity.

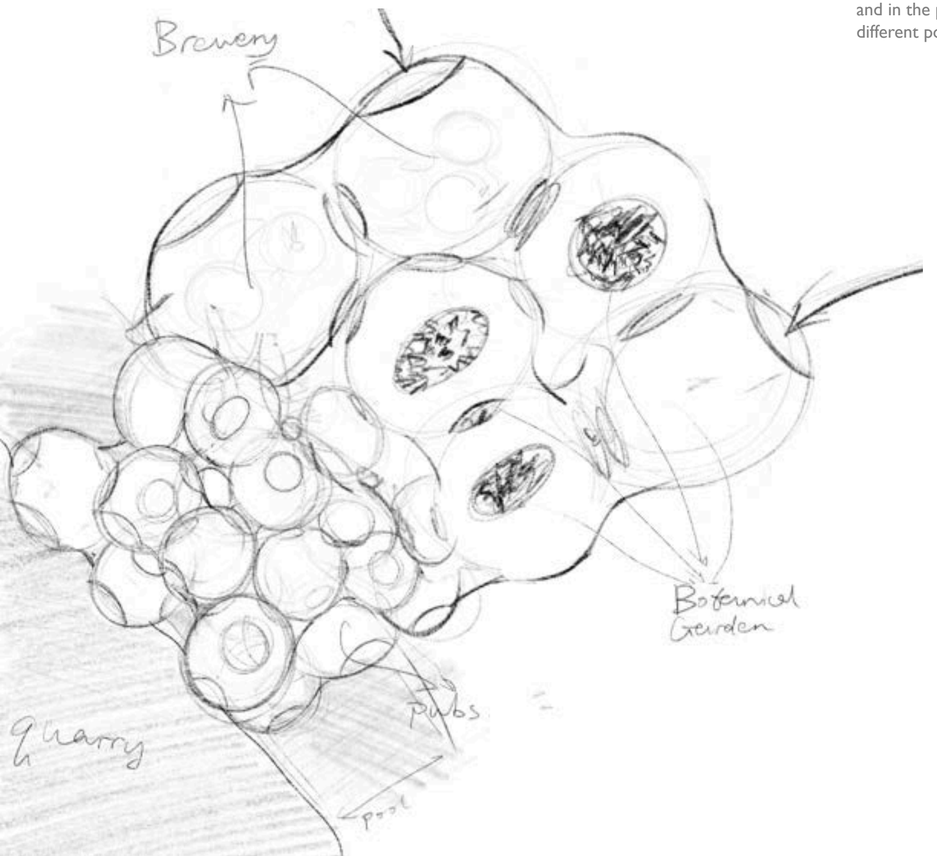


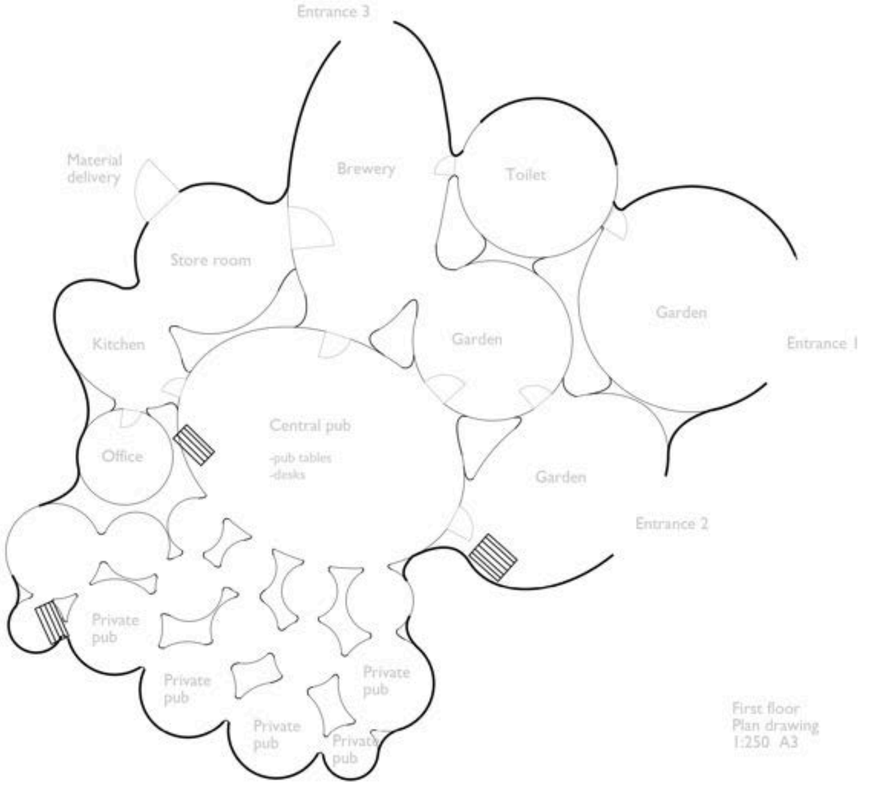


The individual units of colorscape are re-sized and re-arranged. People in the rooms when we look up or observe from faraway are like on stages.



This design features in 'colorscape' units of various sizes that function as gardens, breweries and pubs, and in the piling up of units which forms spaces of different possibilities.





03
RESEARCH : BREWERIES

The incorporation of a brewery into the pub may help complete the energy circle of the project and make it more passive. The products during the production of beers, such as spent hops, grains and yeast, can be recycled in the garden, and the steam during brewing can be recovered to produce heat for the building. The brewery might also help foster a sense of community by bringing local people together and developing local beer industry.

The case study for brewery research is Kamikatz Public House designed by Hiroshi Nakamura & NAP. On the premise that a paradigm shift for production and sales processes is essential in achieving zero waste, a private-sector business inspired by the principles of this town launched this project with the concept of integrating a shop that sells household sundries, food, and beer by weight, brewery, and a pub. As the word "pub" comes from "public house," the architects decided to bring the principles of the community, the wisdom and ways of the people towards waste to form through architecture. Our aim was to create a public house so that the community could feel pride in their actions.

Functions are positioned in chronological order in the linear building o create continuity of production and consumption—from the raw material warehouse to the brewery and then to the pub where the beer will be served. To make the pub a local symbol when looking up from the town, the windows comprising fittings from abandoned houses were set eight meters high. The elevated ceiling effectively ventilates the warm air that stagnates above during summer, while the double layer of window fittings trap air and enhance insulation. The ceiling fan circulates heat from the carbon-neutral radiation heater that makes effective use of branches from the forest.

Not only the architecture conserves energy and resources, and reduces harmful emissions though reuse, reduce, and recycle, it is starting to enhance a circulation of the regional economy as well as tourism. Moreover, by embodying the town's vision within everyday life, the locals who gather at this pub are beginning to truly realize that their actions are fun and creative. The town was also inspired by this and newly established a display shelf for construction materials at the recycle center.

Figure 5. Picture source: https://www.archdaily.com/892767/kamikatz-public-house-hiroshi-nakamura-and-nap

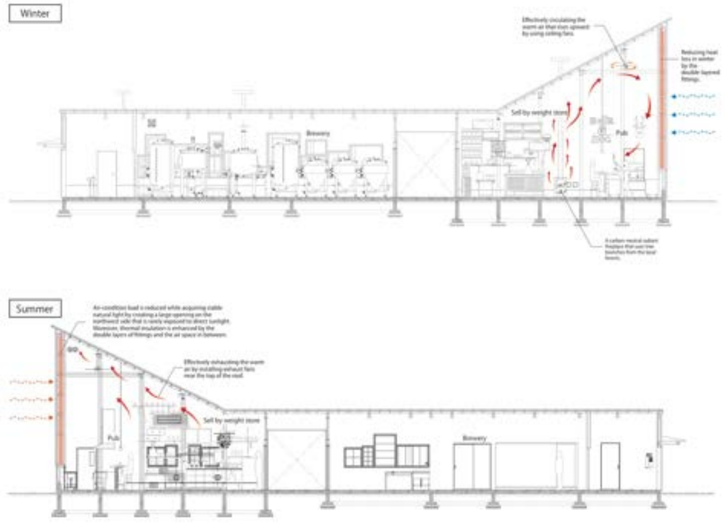
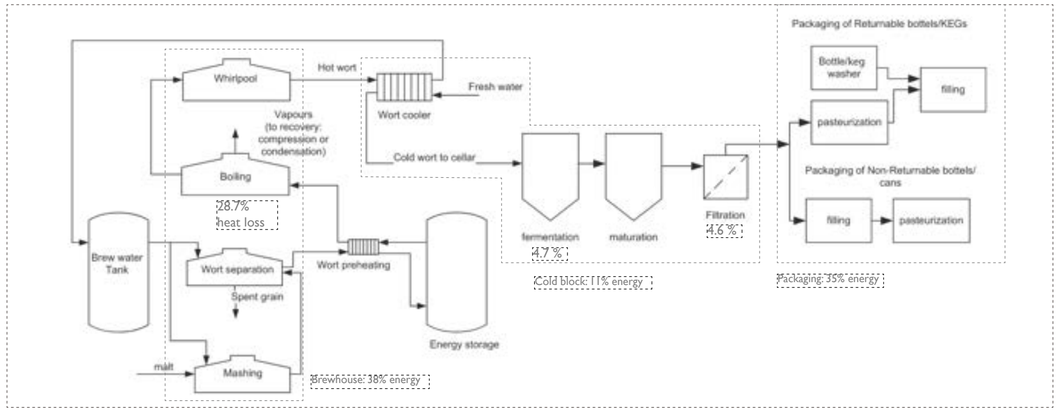
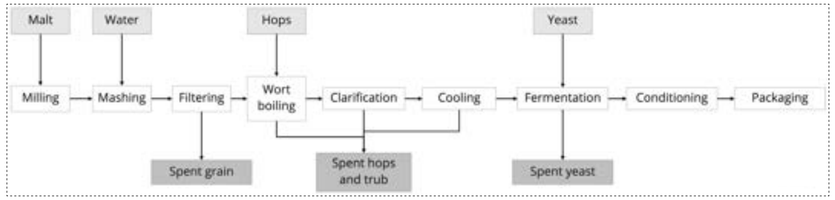


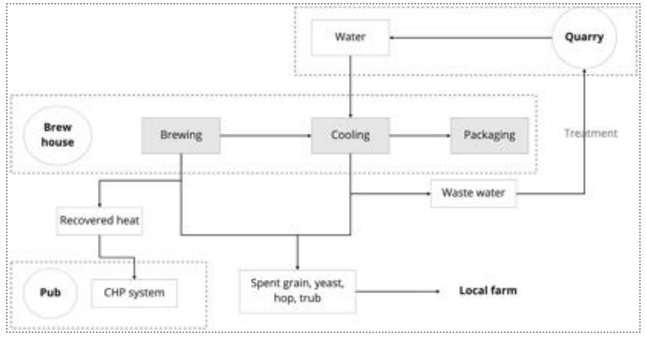
Figure 6
Kamikatz Public House / Hiroshi Nakamura & NAP
Rise & Win Brewing Co. BBQ & General Store



Energy consumption of a typical brewery

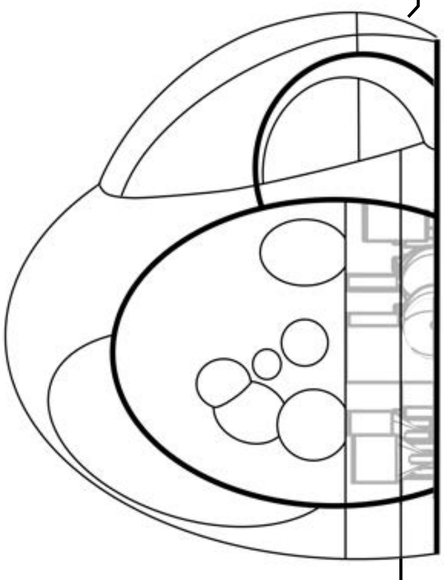


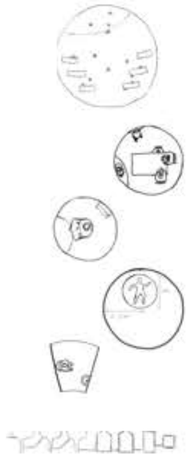
Brewery waste & product in the brew house



Energy balance of pubs, breweries & quarry

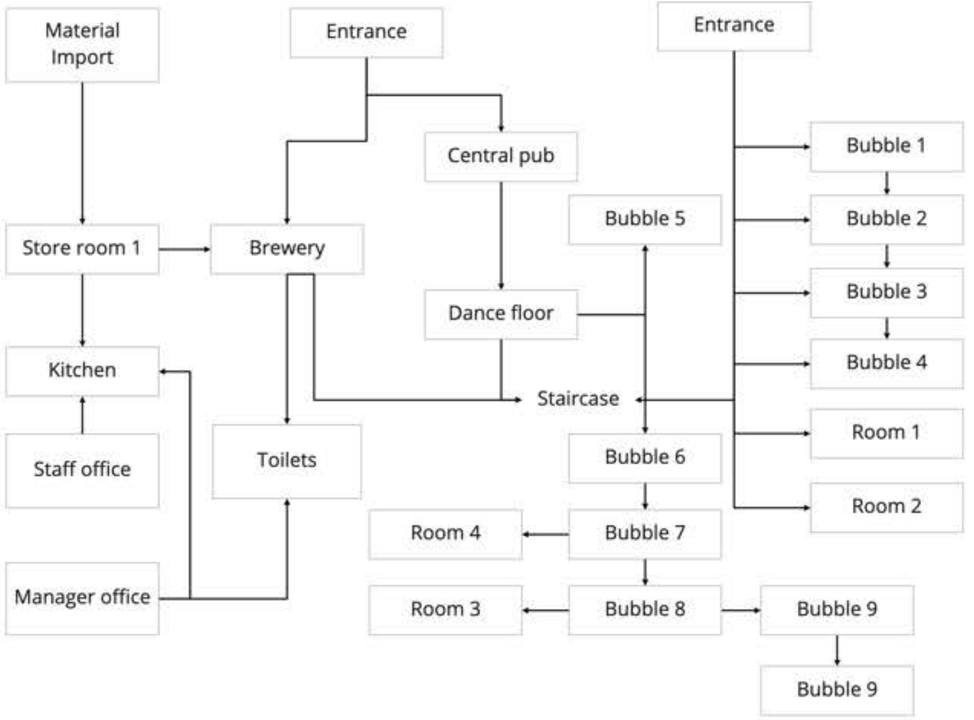
PART II
DESIGN ITERATION
ARCHITECTURAL



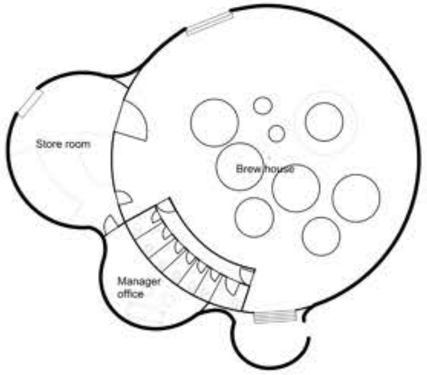


SPACE TYPE	FUNCTION	OCCUPANCY	SIZE & NUMBER
Central Pub Space	- Dance floor - Bar counter - Dining tables - Live music	- max 100 people - 1.4 m^2 / ppl (from CIBSE)	Area = 314 m^2 Number = 1
Semi-private pubs	- Small gatherings - Private conversations	- 4 to 8 people - 1.4 m^2 / ppl	Area = 28.3 m^2 Number = 4
Private pubs	- Observe	- 1 people - 10 m^2 / ppl	Radius = 2m Area=12.6m^2 Number = 10
Rooms	- Private rooms with living equipments - For hang-over guests to stay overnight	-1 people	Radius = 2.5m Area = 19.6 m^2 Number = 10
Toilets	- Toilets	- 10 people	Number = 2
Brewery	- Production of beers - Recovered heat from breweing provide CHP for pubs		Microbrewery 4500 barrels / year 200 m^2
Kitchen	- Import ingredients & ready-made food - Provide light food - Dish washing (machine)	-5 people	Area = 100 m^2 Number = 1
Store room 1	- Storage of brewing crops, food, ingredients		Area = 80 m^2 Number = 1
Store Room 2	- Storage of other equipments, including machines		Area = 80m^3 Number = 1

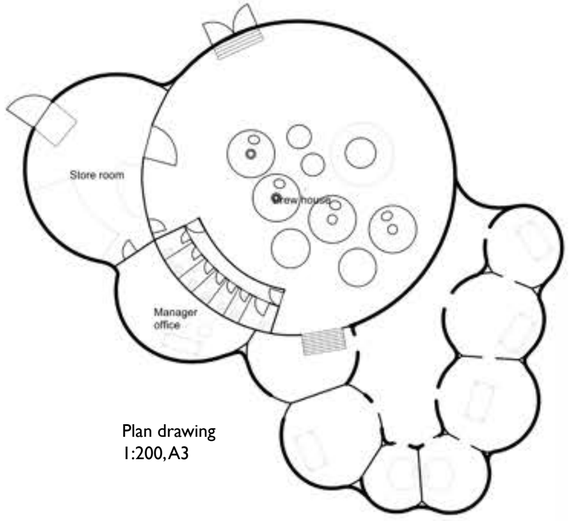
The arrangements of spaces of various sizes and functions aim at catering people in different states.



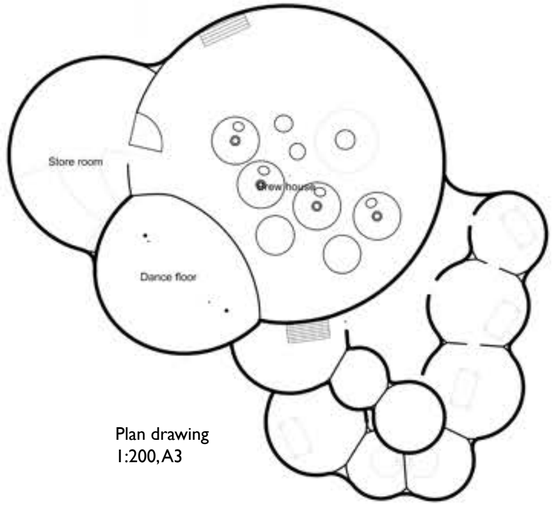
Adjacency diagram



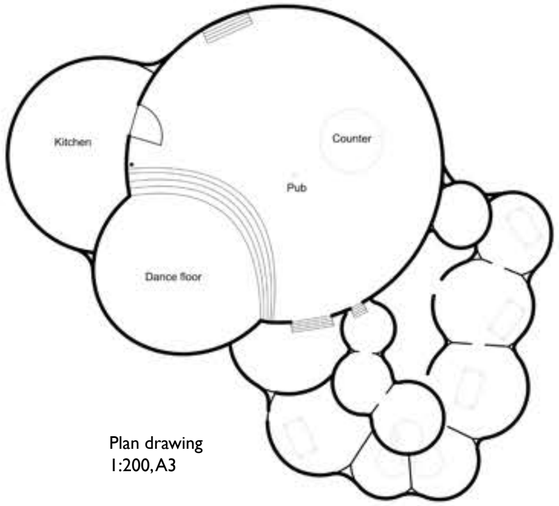
Plan drawing
1:200, A3



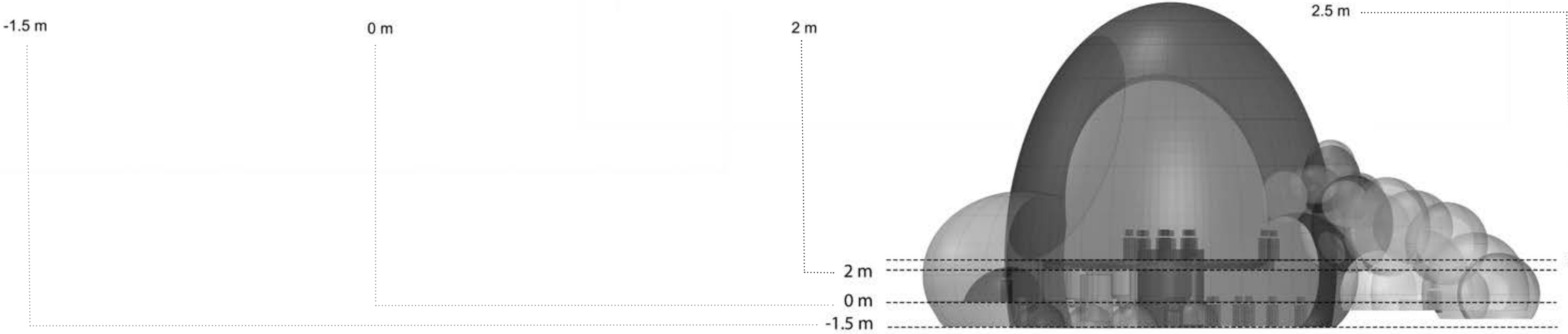
Plan drawing
1:200, A3



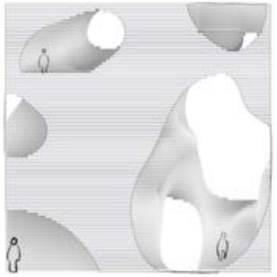
Plan drawing
1:200, A3

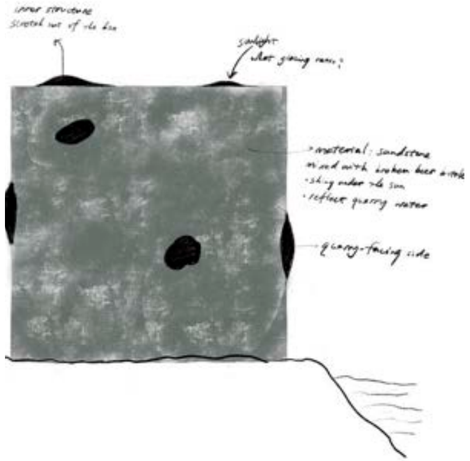


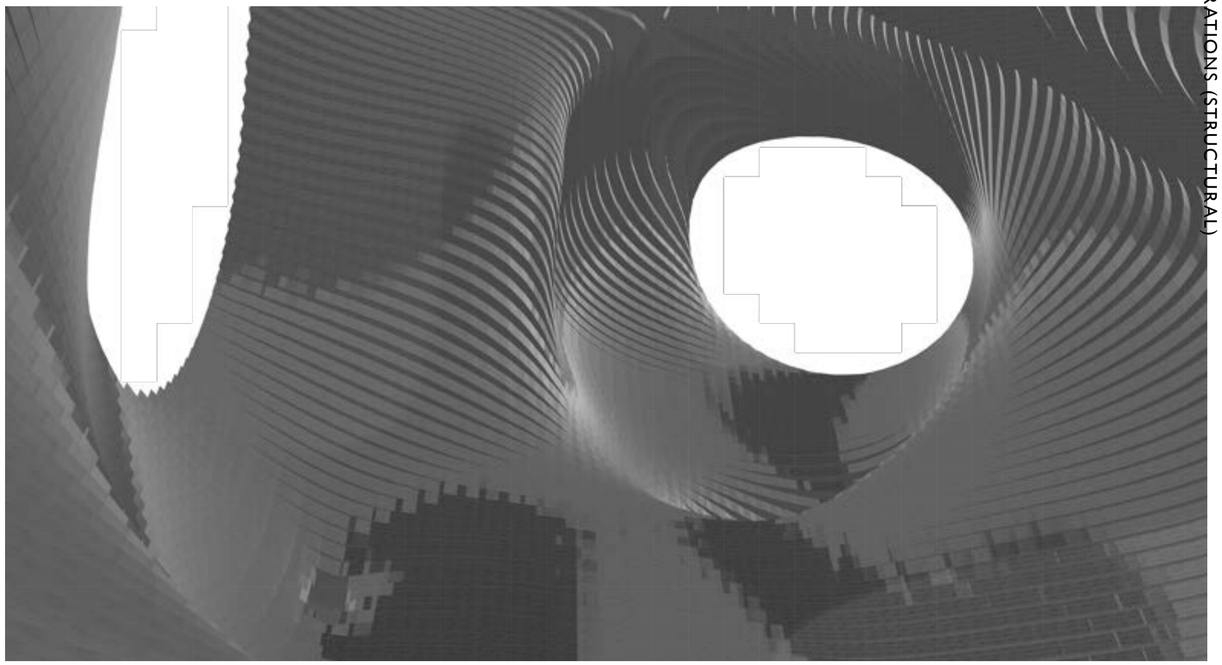
Plan drawing
1:200, A3



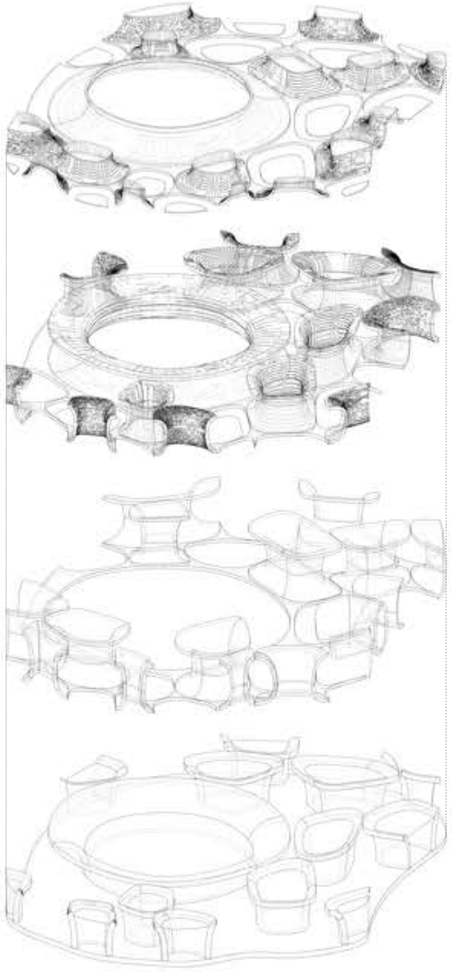
The idea of 'bubbles' then led to the question whether the voids can be formed from inside the spaces. Minimal surfaces are then of research interest. The study into gyroid structures leads to the system where volume is generated by connecting the shell with its bounding box. The structure consists of sliced 10cm thick boards that are piled up togther. When walking inside, there's no distinction between walls, floors and ceilings. However, the overall structure can be bulky as half of the volume is structural elements.



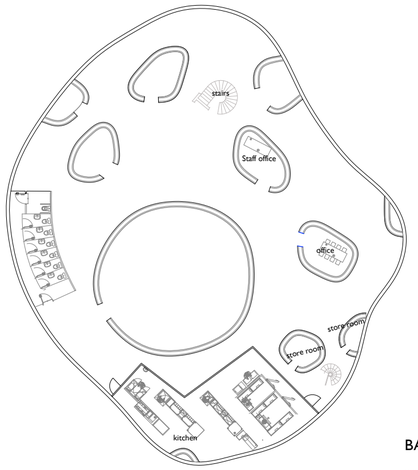




Taichung Opera House is researched as a case study. Its structure is then applied to the project. The structure is formed by defining the voronoi-shape plan , constructing volumns and mirroring the structure vertically. A variety of spaces can be naturally formed either within the 'columns' or outside. Some seating spaces face the exterior, and some face the central dance space.

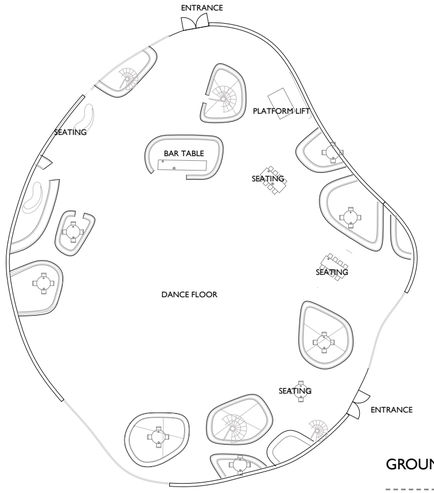


FLOOR PLAN
1:400 A3



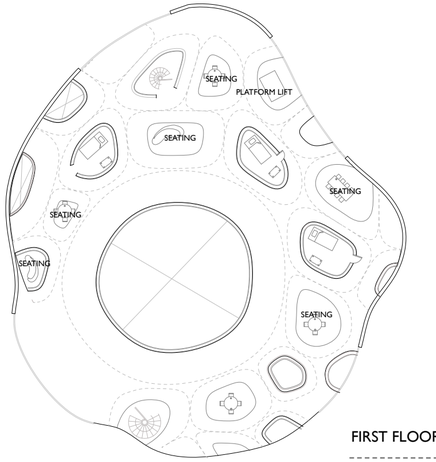
BASEMENT

-3.0 m



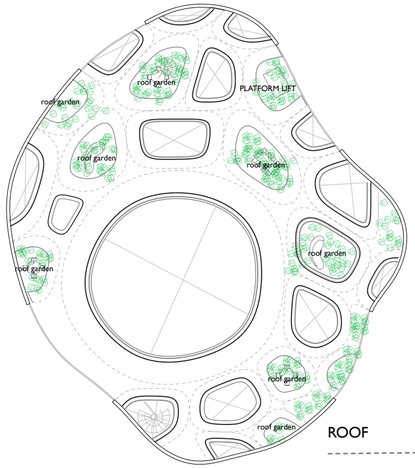
GROUND FLOOR

0.5 m



FIRST FLOOR

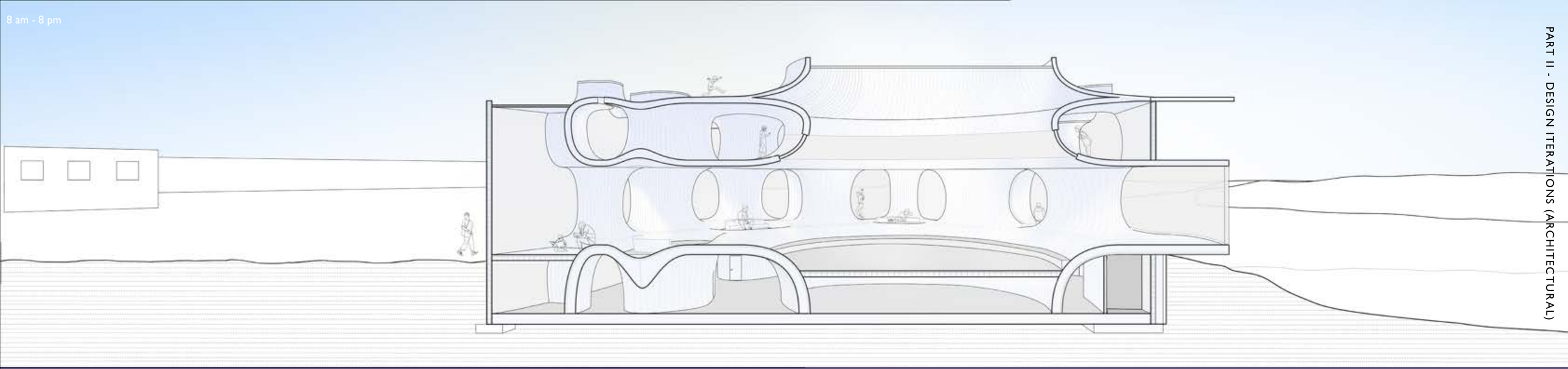
3.5 m



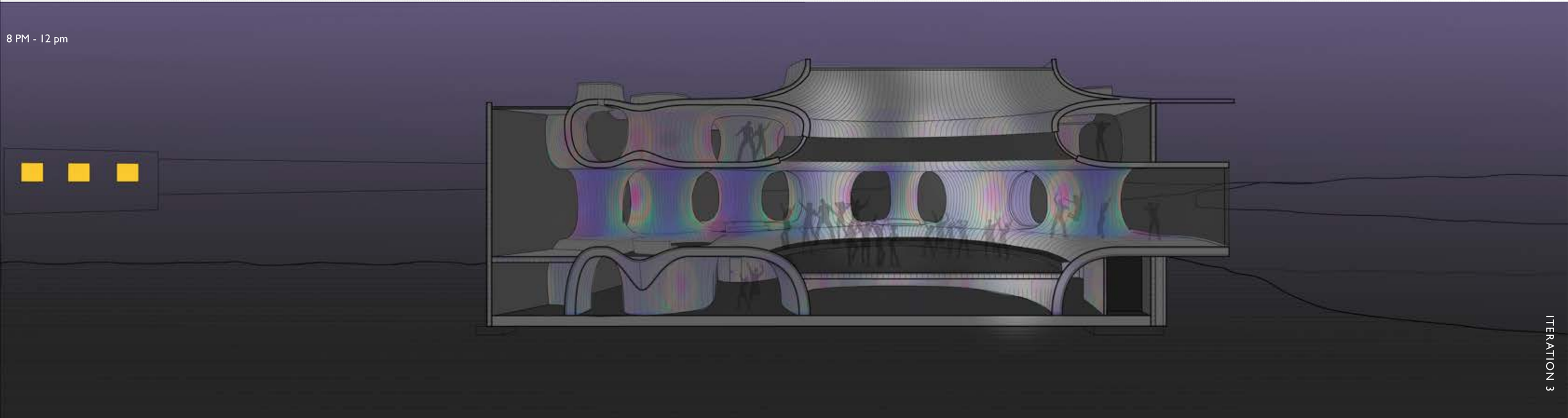
ROOF

7.1 m

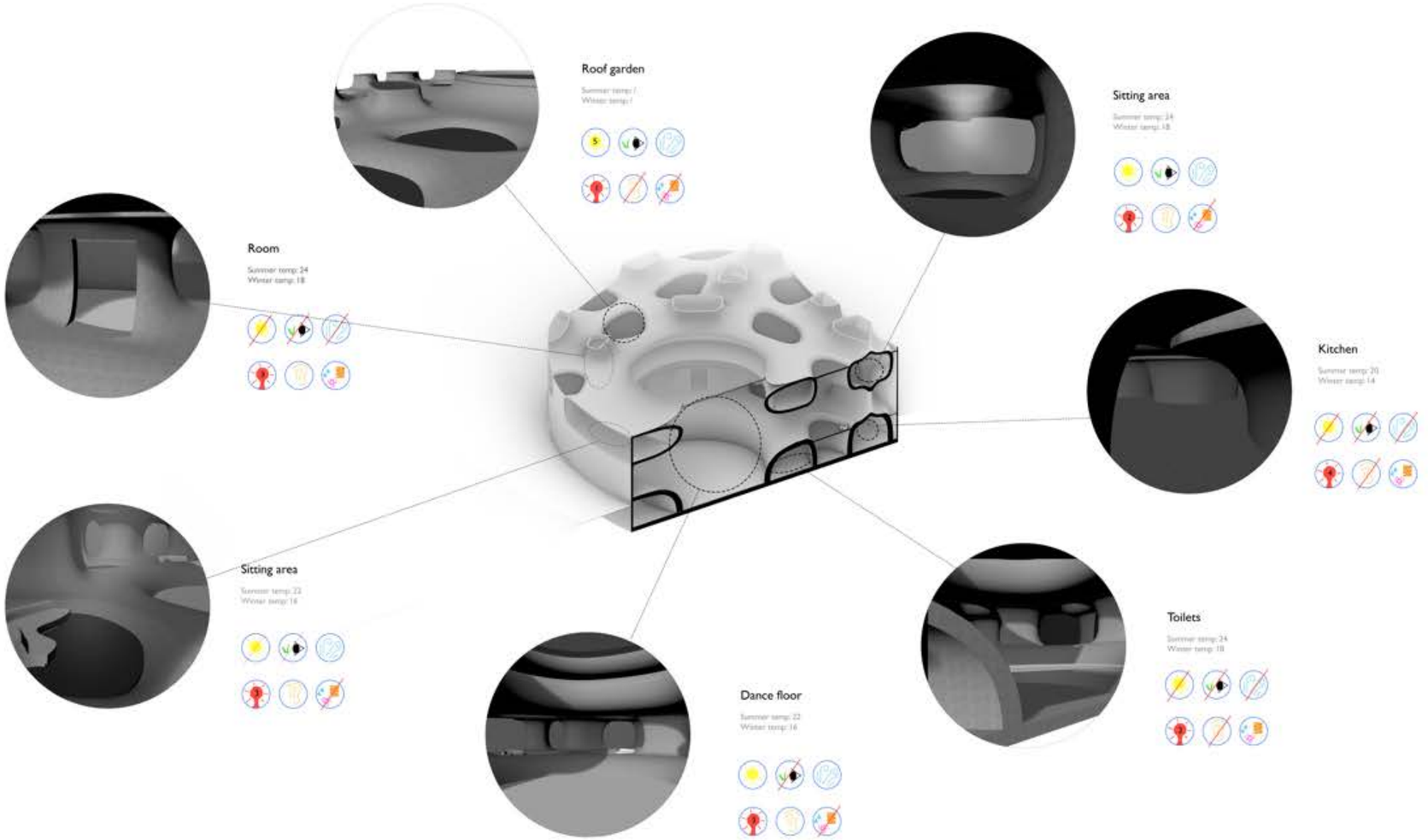
8 am - 8 pm



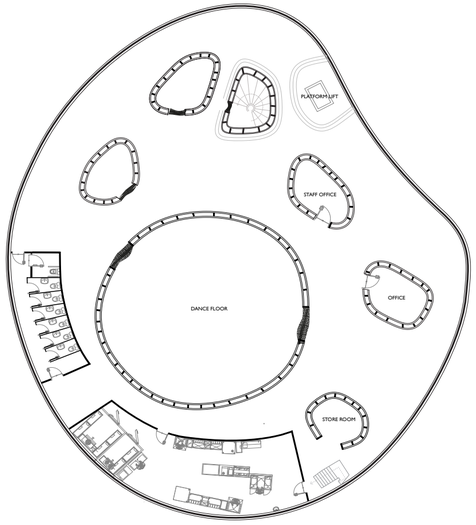
8 PM - 12 pm



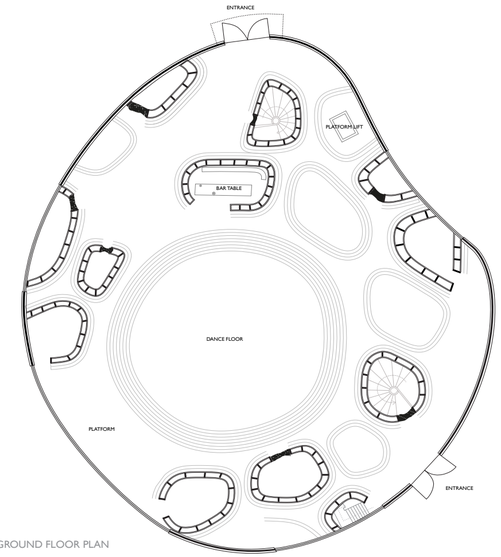
Two structural systems, concrete structures and stressed-skin structures, are compared. Stressed-skin systems are applied to the projet for their advantages of being more light-weight and having more potentials of incorporating various surfaces. The glazing ratios of the project are also adjusted to meet the passive design standard.



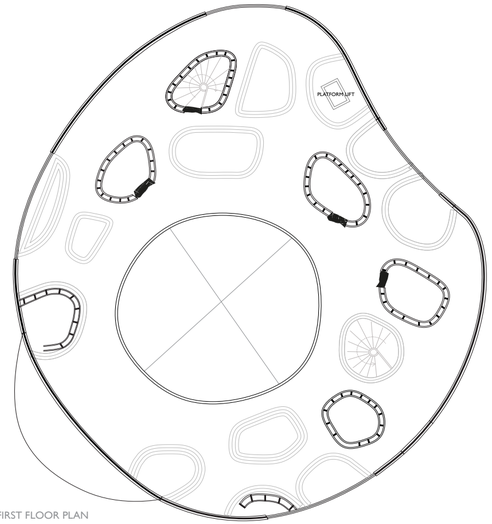
Environmental benchmark set for each zone



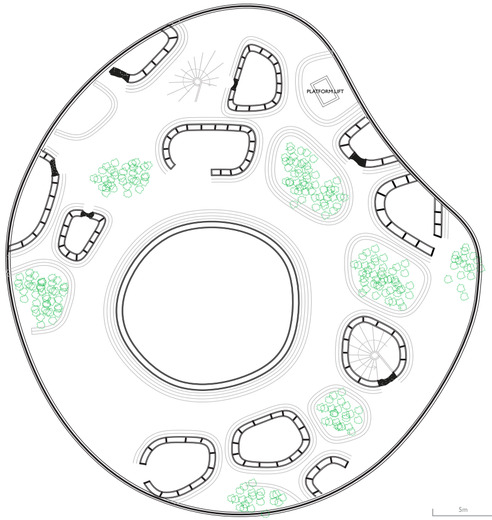
BASEMENT PLAN



GROUND FLOOR PLAN



FIRST FLOOR PLAN

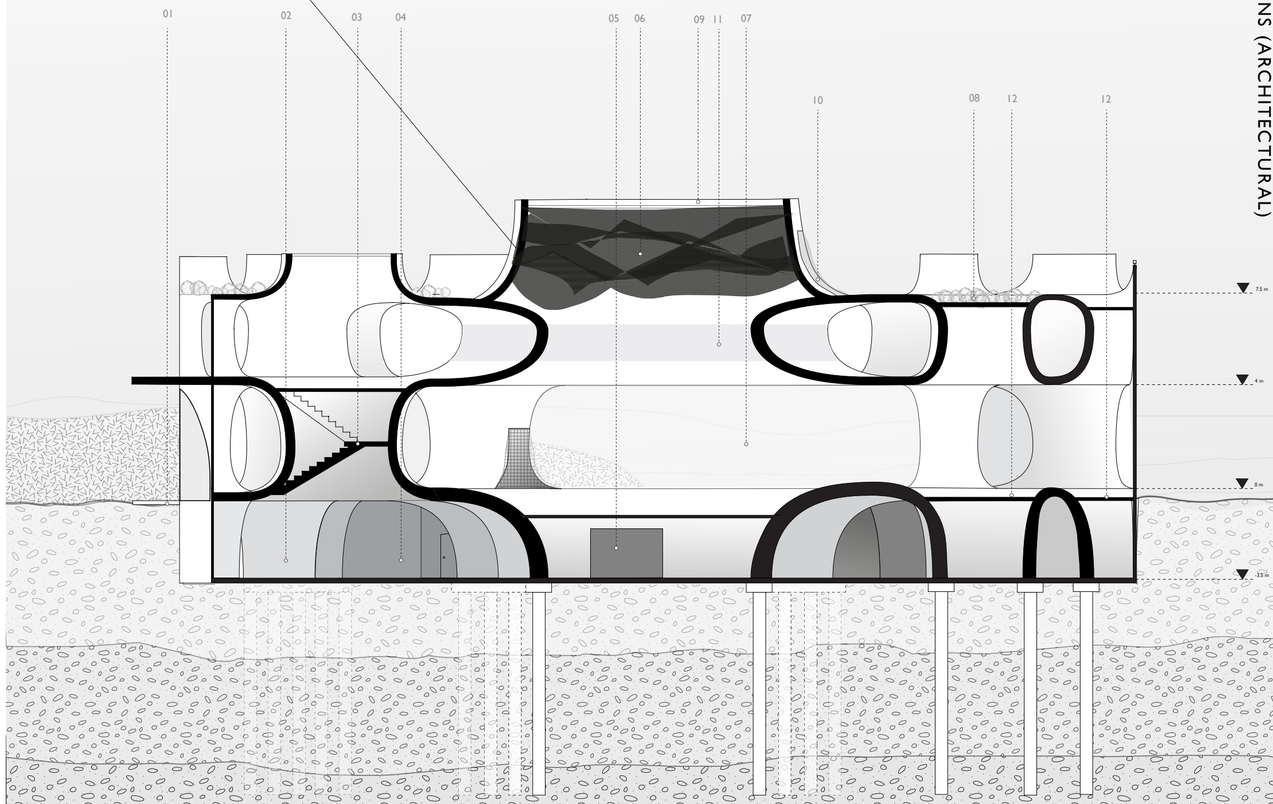


ROOF GARDEN

N

GROUND PLAN
50cm x 50cm, 1:200

01 South entrance
02 Store room
03 Stairs in columns
04 Kitchen
05 Toilets
06 Climbing net
07 Glazing facing the quarry
08 Roof Garden
09 Roof ceiling
10 Entrnace to roof
11 Glazing
12 Seating area



PART II - DESIGN ITERATIONS (ARCHITECTURAL)

ITERATION 4

SECTION DRAWING
50cm x 50cm, 1:100

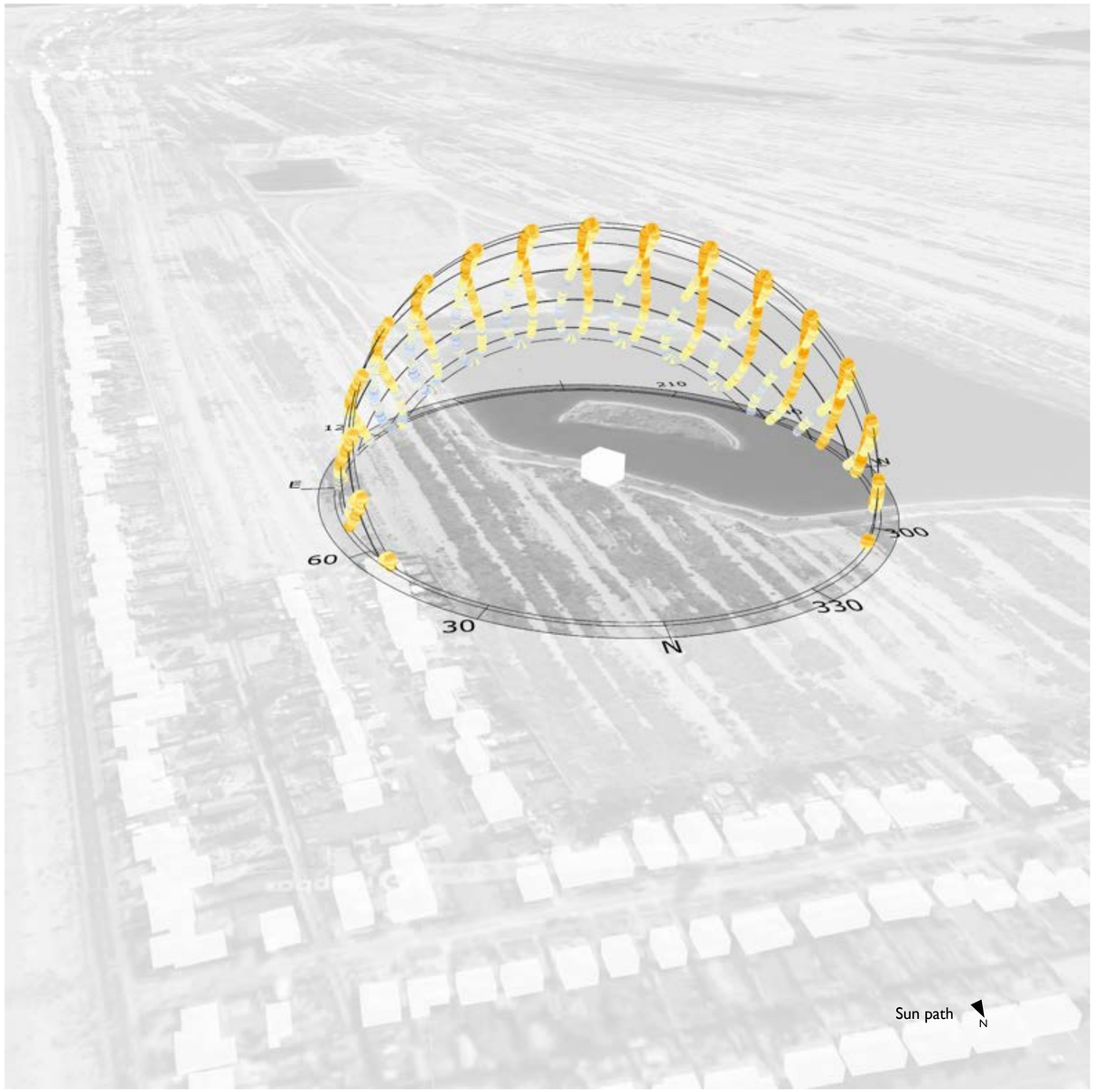
PART III
DESIGN ITERATION
ENVIRONMENTAL

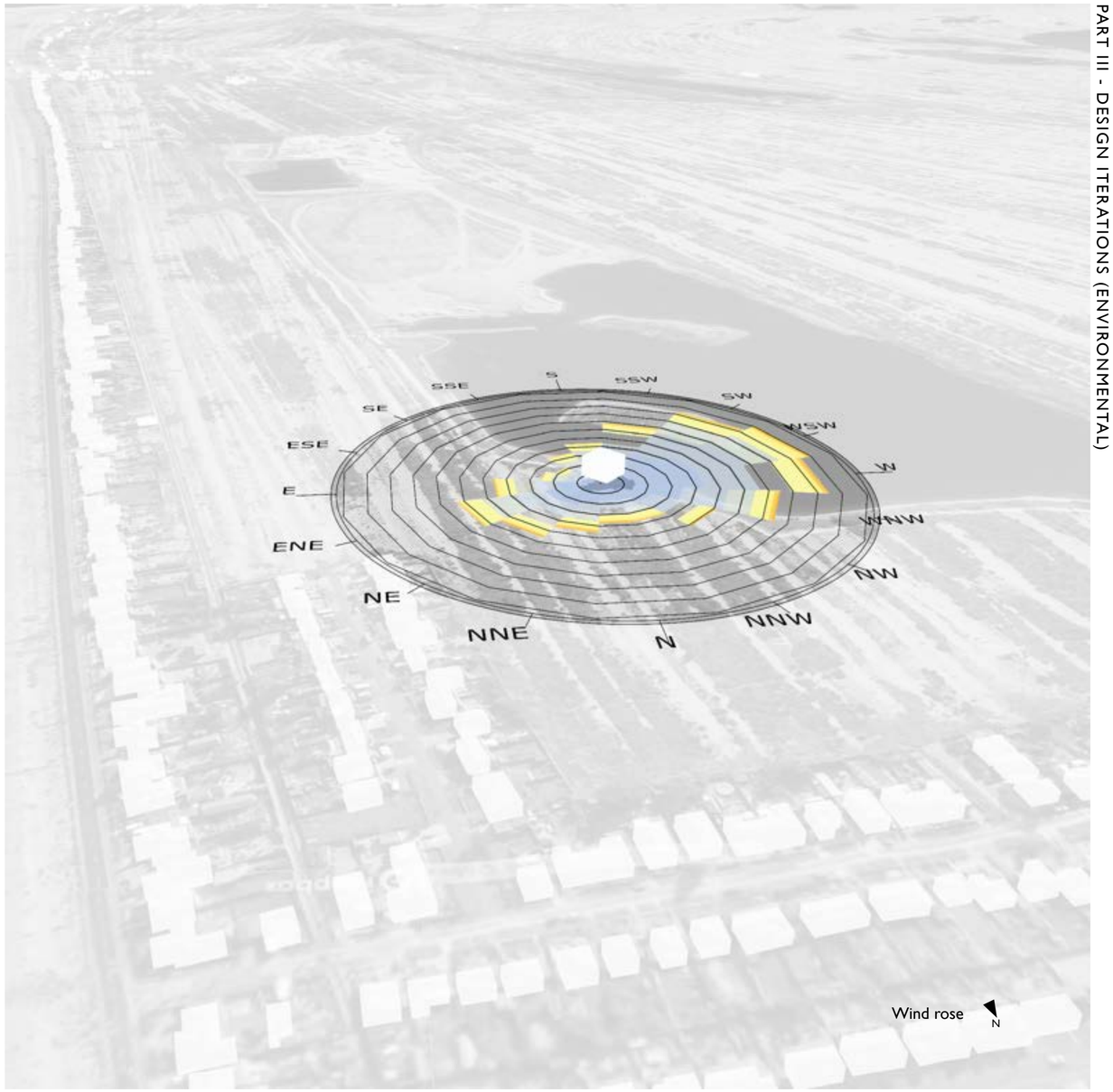
DAYLIGHT FACTOR

RADIATION

WIND CFD

ENERGY PERFORMANCE


210
E
60
30
N
330
300
Sun path
N


SSE
S
SSW
SW
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WSW
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ENE
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NE
NNW
NNE
N
Wind rose
N

ENVIRONMENTAL ANALYSIS FOR DESIGN ITERATION 1

The process of environmental analysis is intertwined with architectural and structural design. The first iteration of design features in a series of 'bubbles' emerging from the quarry. The construction strategy of interest is the 'superadobe' method, which was developed by Nader Khalili and has been applied in the project 'Hormuz 2'. Its main material is earthbags and barbed wires. Its material gives it high thermal mass and thus ability to preserve heat, and its form as 'earthships' enables it to be half buried under ground and make use of ground heat. and the adoption of local materials gives it connection to its surroundings.

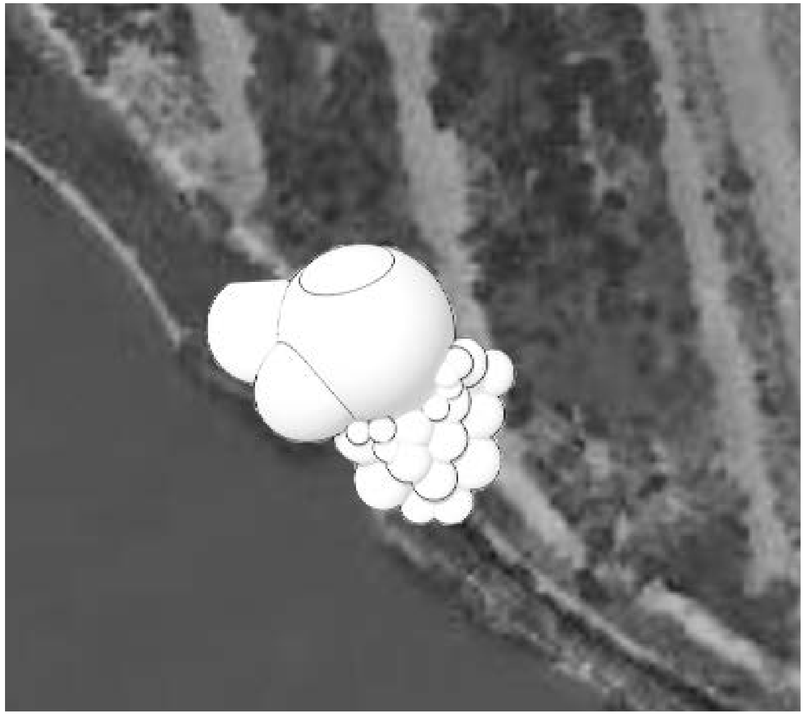
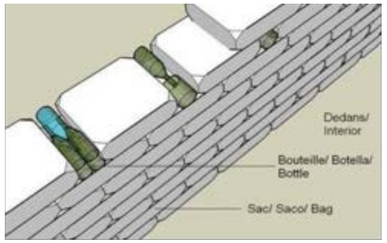


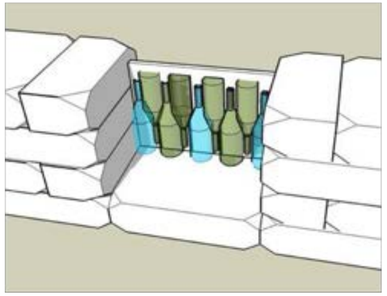
Figure 7. Hormuz 2 by ZAV Architects, constructed with superadobe method

Figure 8. Superadobe method contruction process



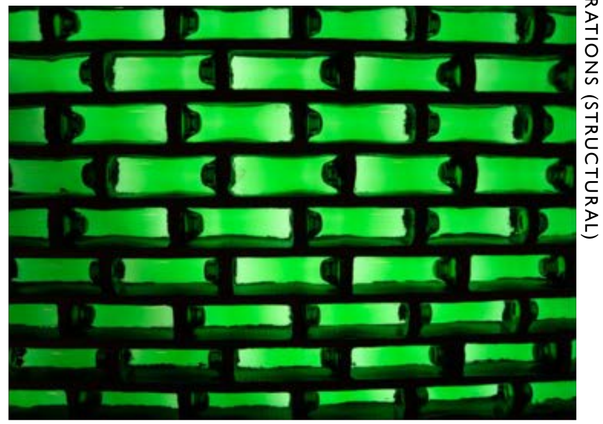
www. EarthbagBuilding.com

Larger bottles should be on the outside and paved with plaster , to prevent animals or insects nesting in the pockets.



If more light is desired than ventilation, glass bottles can also be anchored with clay-rich plaster inside a wall opening. The spaces should be filled around the bottles with thick fiber-reinforced clayey earth.

Figure 9. Bottles integrated in earthbags as glazings and ventilation



Instead of having beers as lighting components of the adobe structure, they themselves can also serve as structural components. WOBO bottle developed by Heineken can be interlocked with each other as building blocks.

Figure 10. WOBO bottles as construction bricks

Bottles can function as both construction structure (WOBO bottle) and double glazings integrated in the structure.

Daylight Factor Target

The British Standard for daylight in buildings (BS EN 17037) has introduced 4 criteria for assessment of daylight in interior spaces: 1. Daylight provision; 2. Exposure to sunlight; 3. View to the outside; 4. Protection from glare.

1. Daylight Provision
BS EN 17037 has set the Target Illuminance and Minimum Target Illuminance:

Level of recommendation for vertical and inclided daylight opening	Target illuminance (lux)	Fraction of space %	Minimum target illuminance (lux)	Fraction of space	Fraction of daylight hours
Minimum	300	50%	100	95%	50%
Medium	500	50%	300	95%	50%50%
High	700	50%	500	95%	

The median external diffuse illuminance in Dungeness is12977 lux. Therefore the target daylight factor for this project is 300/12977=2.3%, which should be reached above 50% of the space. The minimum target daylight factor is 100/12977=0.8%, which should be reached above 95% of the space.

2. Exposure to sunlight
BS EN 17037 has recommended the daily sunlight exposure on a selected date bewteen 01/02 and 21/03:

Level of recommendation for exposure to sunlight	Sunlight exposure
Minimum	1.5 h
Medium	3.0 h
High	4.0 h

Solar exposure is determined at a reference point located on the inner surface of the aperture at the centre ofthe opening width 1.2m above floor.

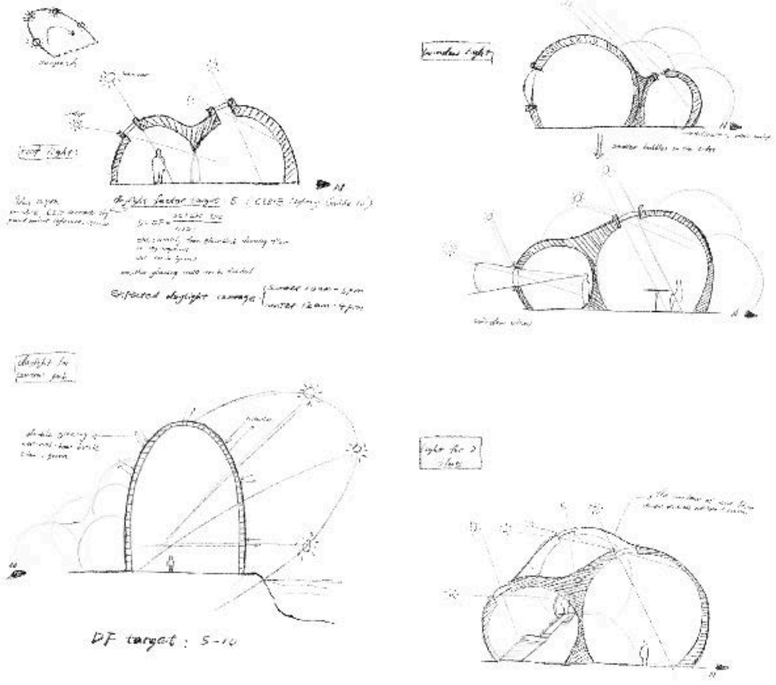
3. View to the outside
The view quality depends on: the size of daylight openings; the width of openings; the outside distance of view; the number of layers.

BS EN 17037 has assessed the view outwards from a given position:

Level of recommendation for view out	Horizontal sight angle	Outside distance of the view	Number of layers to be seen at least 75% of utilized area: sky, landscape ground
Minimum	>14	>6m	At least landscape layer
Medium	>28	>20m	Landscape layer & one additional layer is included in the same view opening
High	>54	>50m	All layers are included in the same view opening

For this project, a medium level of recommendation for view out is chosen as the condition for private and semi-private 'bubbles' and a high level is chosen for private rooms. The glazing ratio and orientation is therefore varied in different spaces.

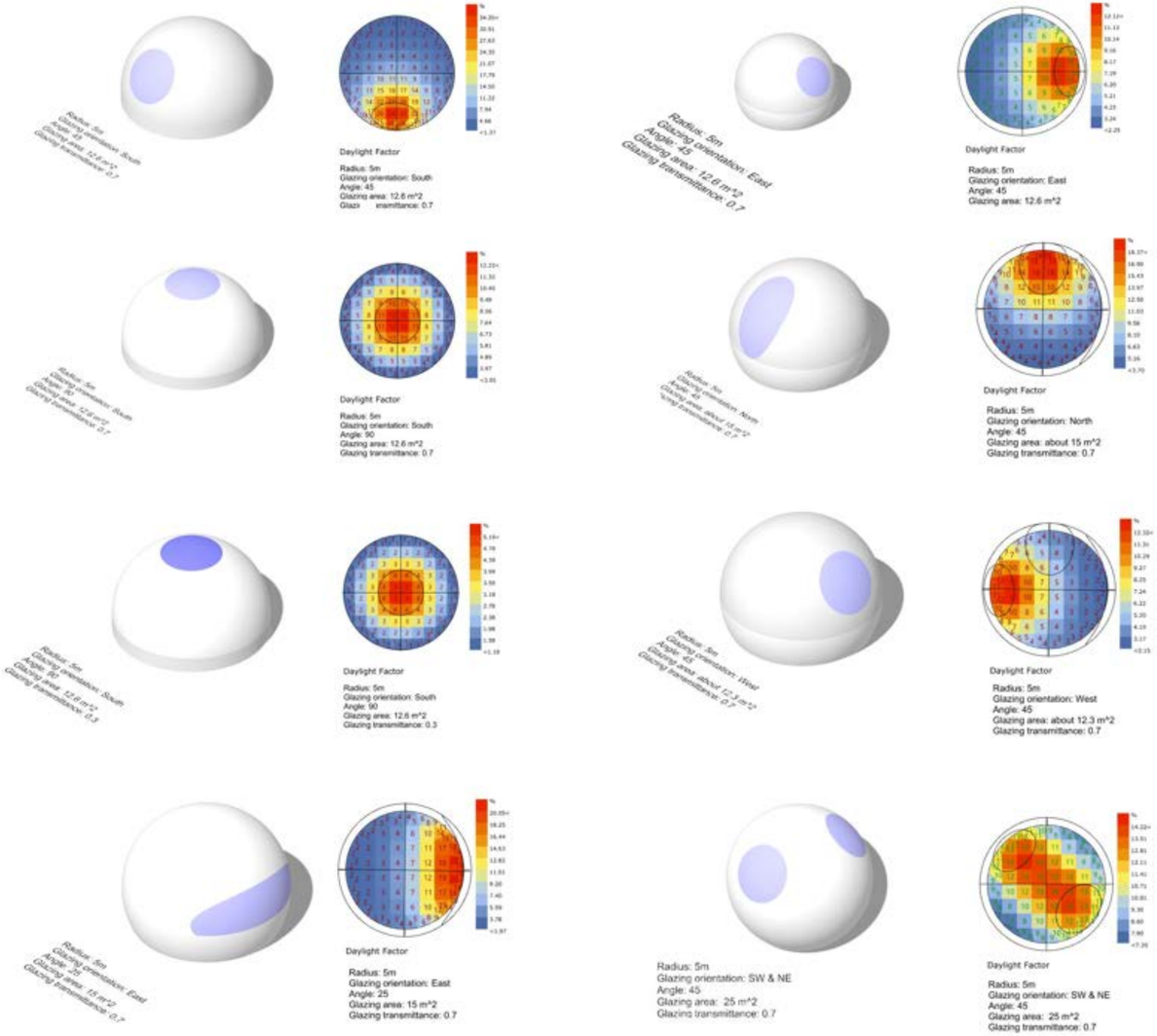
To enable every space to receive ideal daylight, the bubbles will be lined up towards the south so that all spaces can receive ideal daylight and sunlight. The positions and sizes of the bubbles should be designed according to the principle that they shouldn't block the daylight of the other bubbles, and the ratios and orientations of the glazings in all spaces should be designed so that ideal environmental benchmark can be met repectively. The daylight criteria set for each space (designed according to BS EN 17037) can be shown as:



Optimisation of daylight and sunlight in each bubble.

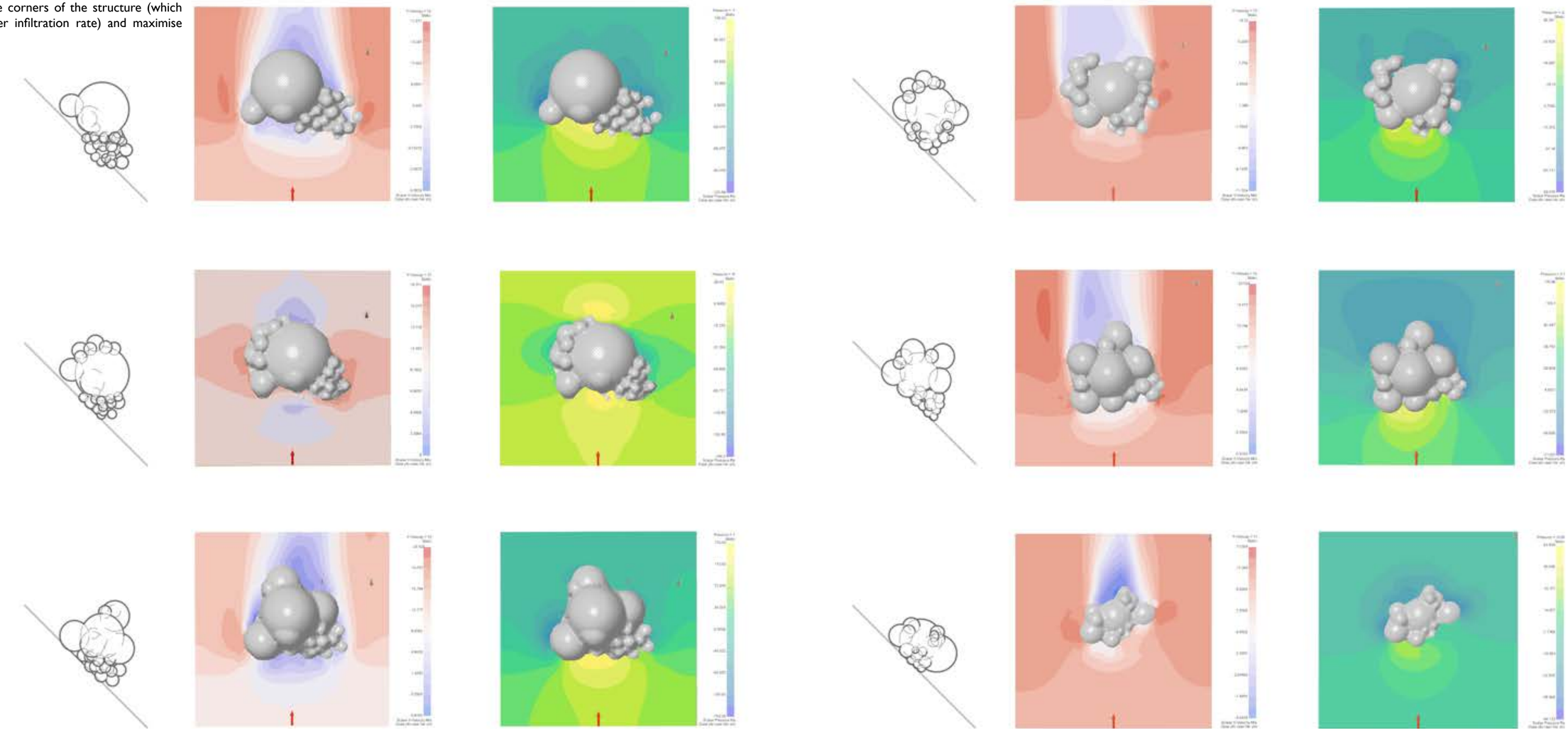
Daylight factor analysis for each 'bubble'

Optimisation of lighting performance for each space



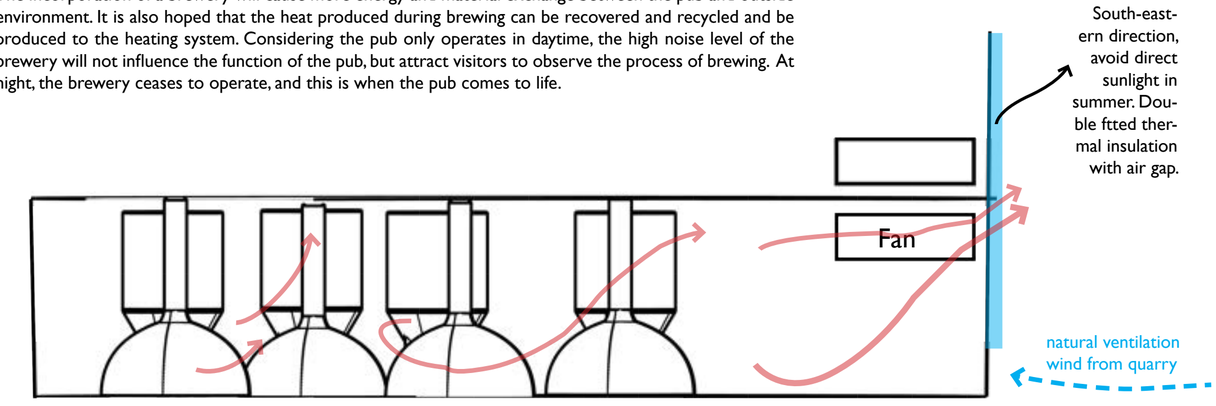
Wind Analysis

A CFD test is carried out to simulate the wind conditions under various configurations of bubble structures, trying to minimise the danger of high wind speed around the corners of the structure (which might cause larger infiltration rate) and maximise wind comfort.

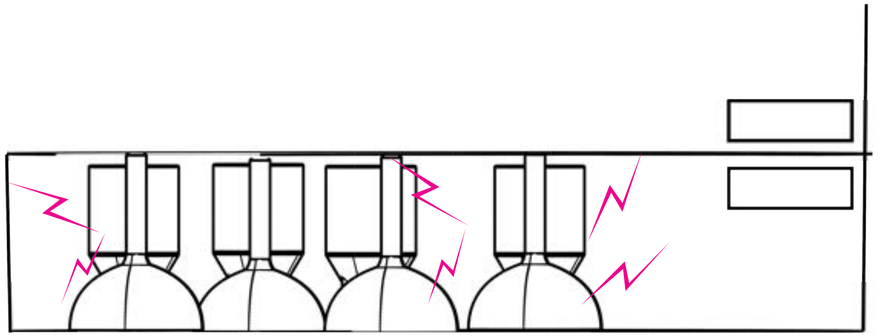


Energy & Noise

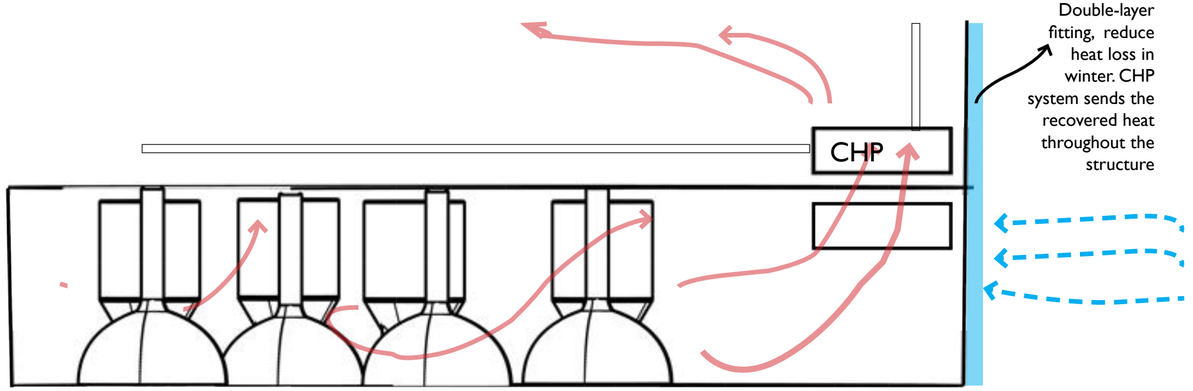
The incorporation of a brewery will cause more energy and material exchange between the pub and outside environment. It is also hoped that the heat produced during brewing can be recovered and recycled and be produced to the heating system. Considering the pub only operates in daytime, the high noise level of the brewery will not influence the function of the pub, but attract visitors to observe the process of brewing. At night, the brewery ceases to operate, and this is when the pub comes to life.



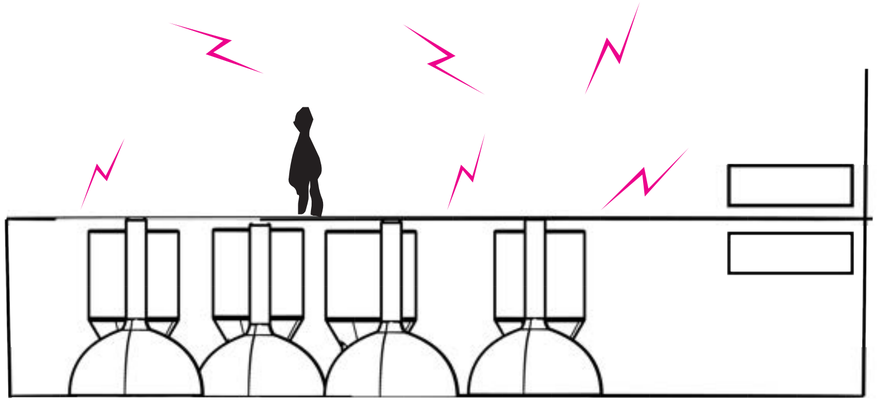
Summer



Daytime
Brewery is fully operated, creating noises



Winter

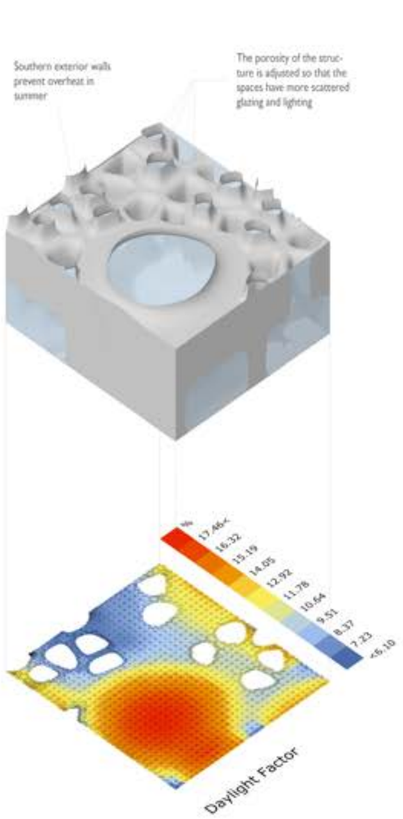


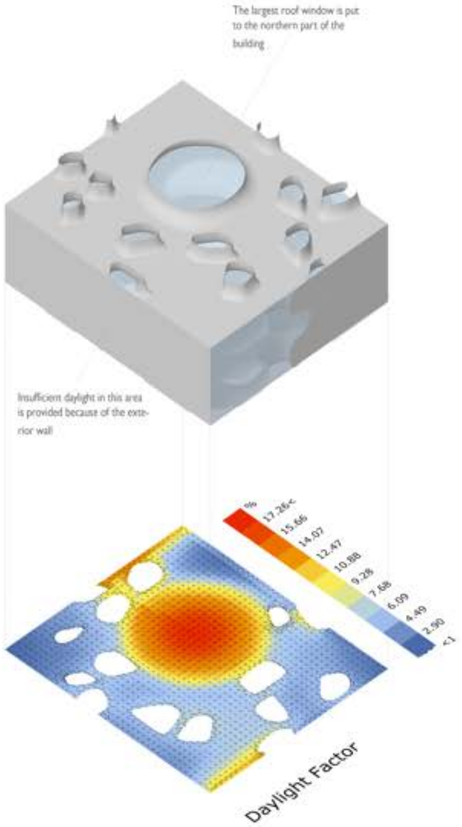
Night time
Brewery falls silent, and pub comes alive

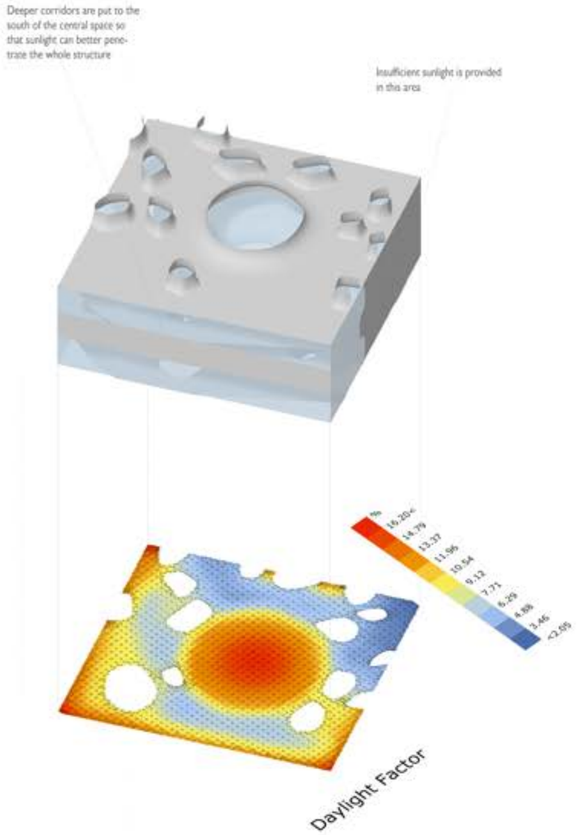
ENVIRONMENTAL ANALYSIS FOR DESIGN ITERATION 3

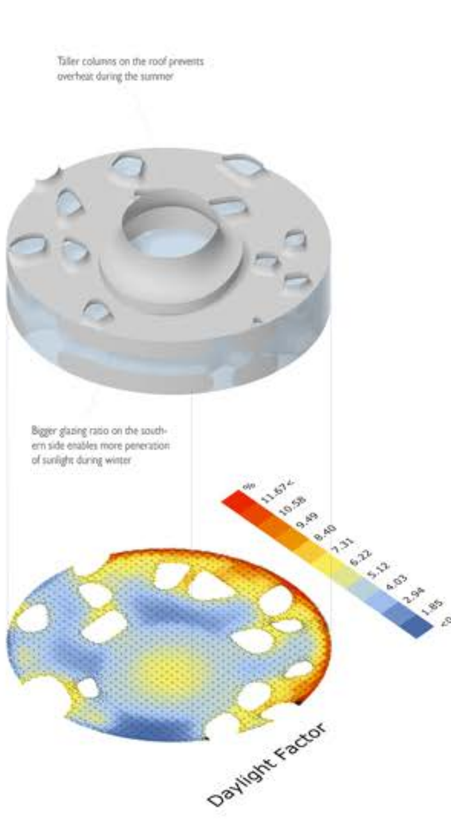
The research of bubbles led to the quetsion of whether the curvy spaces can be formed inside the space, instead of outside. Gyroid structres and minimal surfaces are studies, and design iteration 3 is proposed. Spaces of various qualities, such as sound, lighting and temperature, can be naturally formed inside the voronoi-generated strucure, and thus different experiences can be created. Varied standards and targets are set for different spaces, as shown in the diagram.

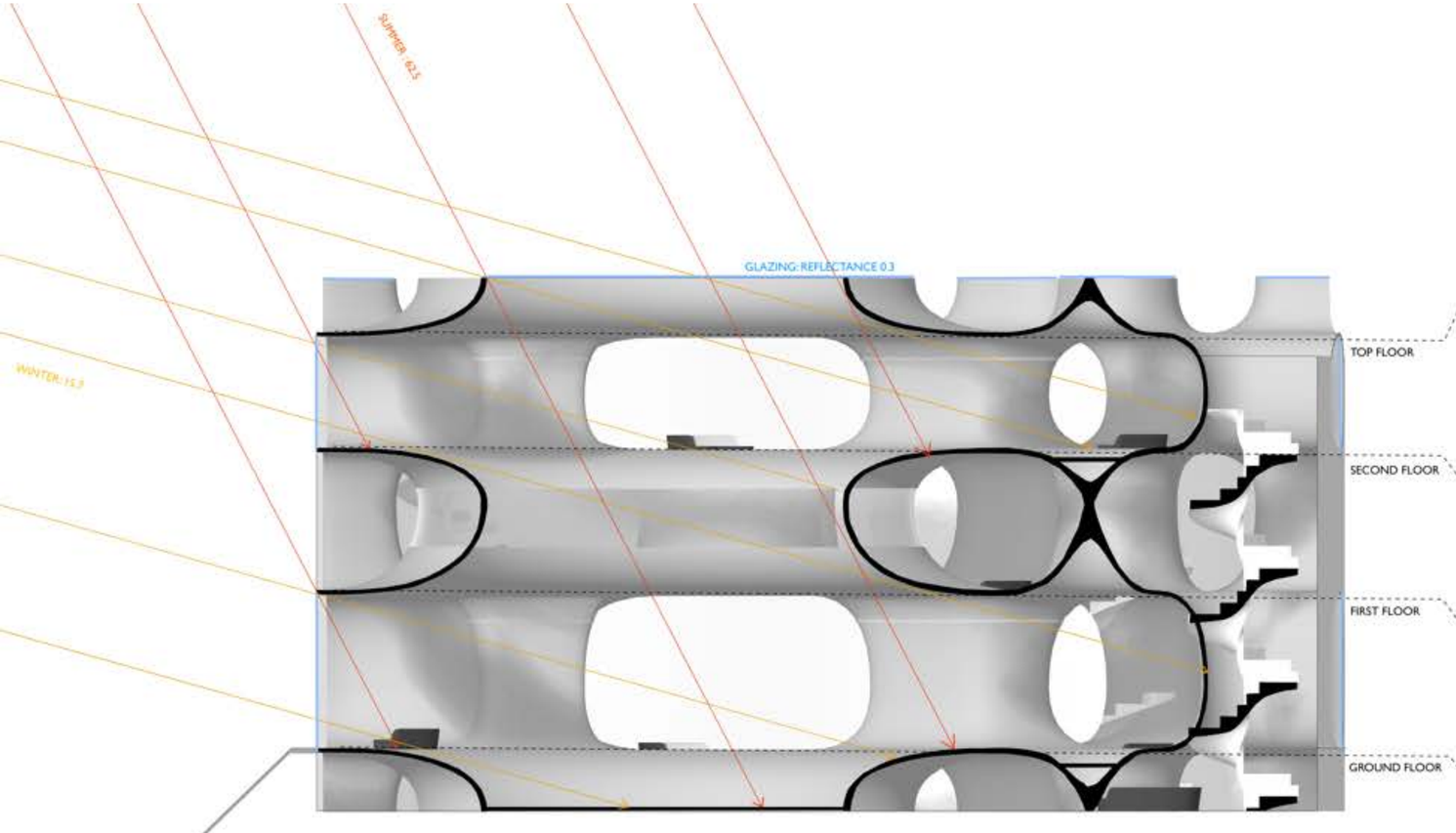
This project generally operates at night, therefore the priority of the environmental strategy is to absorb as much solar heat as possible during the day, and a high-thermal-mass structure can store the heat and release it at night. It is also important to ensure that the glazing ratio reaches a balance where ideal sunshine can penetrate the spaces and not too much heat will be lost due to convecton at night. Iterative energy and daylight simulations are carried out to explore the optimal environmental performance of the project.

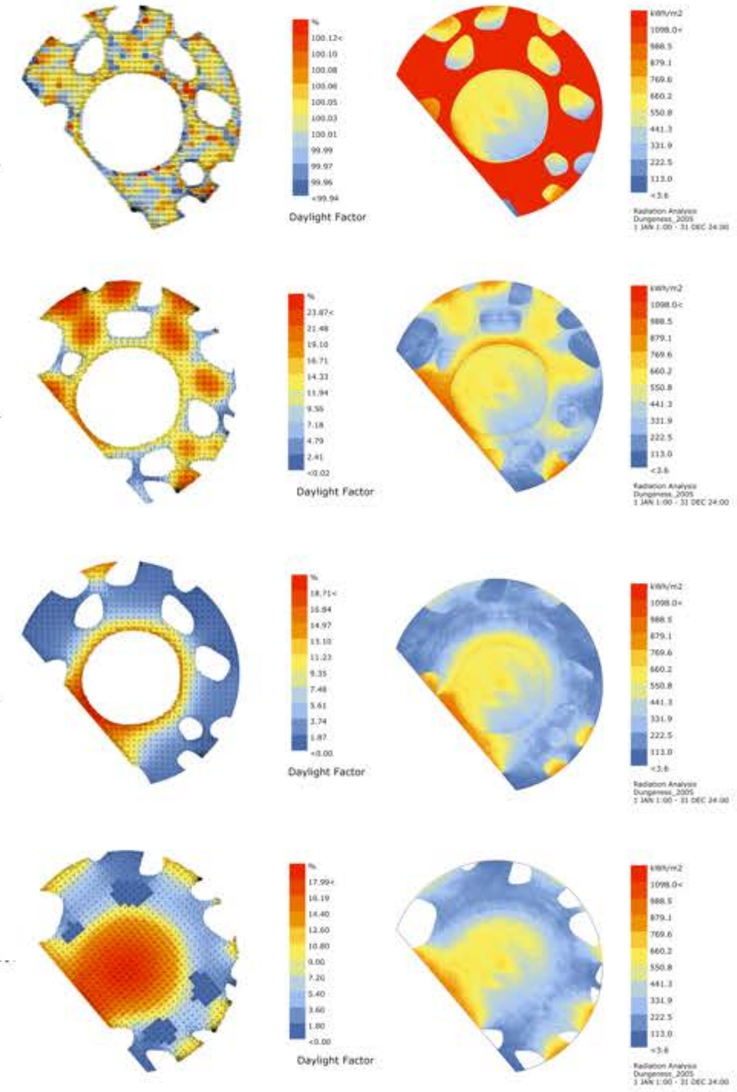












DAYLIGHT FACTOR ANALYSIS

RADIATION ANALYSIS

Daylight Analysis

The median external diffuse illuminance in Dungeness is12977 lux. Therefore the target daylight factor for this project is 300/12977=2.3%, which should be reached above 50% of the space. The minimum target daylight factor is 100/12977=0.8%, which should be reached above 95% of the space. The target of this project is to enable the central space to receive large amount of daylight while not be overheated. From this analysis ideal daylight can be achieved in most spaces, but some spaces might have received unnecessary daylight which causes large heat loss due to the large glazing ratios. It is suggested from the diagram that the glazings can be proportionately reduced.

Simulation - V1

This structure is simulated in grasshopper. The first iteration uses a concrete system, and below is the rest of the settings:
- original glazing ratio
- double glazed windows
- typical activity of pubs
- typical occupancy density
- typical lighting & equipment power
- natural ventilation
- air flow rate meets health standard
- heating only when temperature drops below winter set point

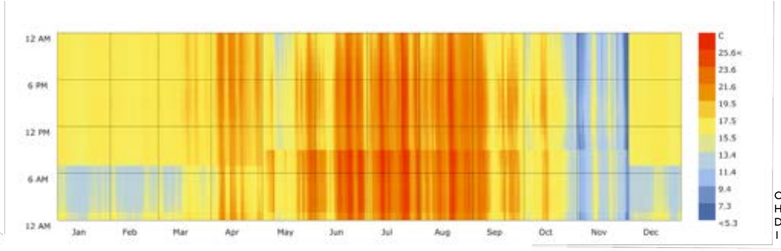
		unit	thickness (m)	density	conductivity	specific heat	thermal absorptance	solar absorptance	visible absorptance	solar gain coefficiet	visible transmittance	U value
construction	wall	concrete	0.3	2400	1.13	1000	0.9	0.7	0.7			3.77
	roof	concrete	0.2	2400	1.13	1000	0.9	0.7	0.7			5.65
	floor	concrete	0.15	2400	1.13	1000	0.9	0.7	0.7			7.53
	window	double-glazed window								0.76	0.7	3.12

	occupancy density (1)	number of people	mechanical vent	lighting power density(2)	equipment power density(3)	infiltration rate(4)	ventilation (5)	air flow rate
activity	9.3 m2/person	96.4	/	1.1 W/m2	10.2 W/m2	0.0001m3/(m2 façade)	0.01m3/person	0.96 m3/s

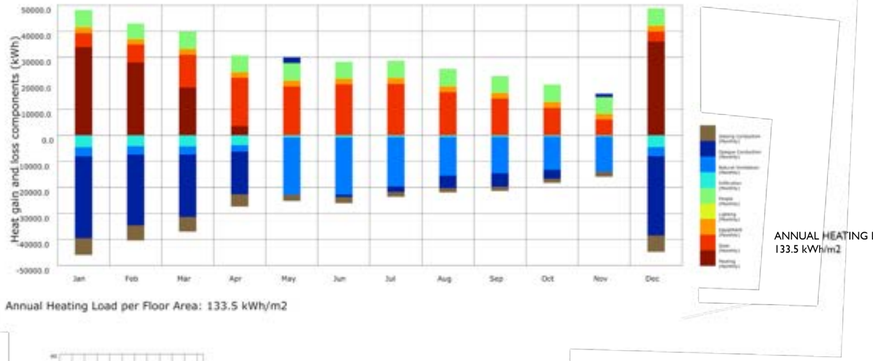

(activity schedule)

(heating set point winter)

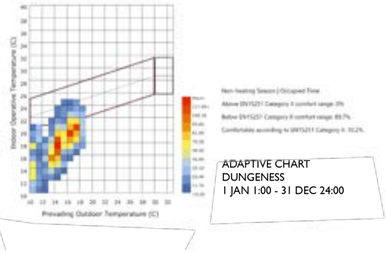
1. ASHRAE 90.1-2013 averaged occupancy density for restaurants & school
2. ASHRAE 90.1-2013 acceptable lighting power densities for restaurants
3. ASHRAE 90.1-2013 acceptable equipment power densities for restaurants
4. infiltration (tight building)
5. CIBSE Guide A ventilation fix per person



OPERATIVE TEMPERATURE FOR ZONES -
HOURLY
DUNGENESS
1 JAN 1:00 - 31 DEC 24:00



ANNUAL HEATING LOAD PER FLOOR AREA:
133.5 kWh/m2



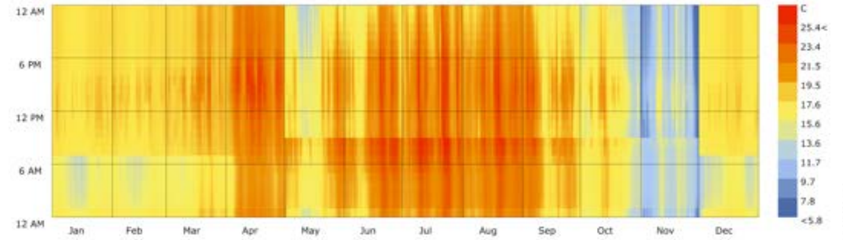
ADAPTIVE CHART
DUNGENESS
1 JAN 1:00 - 31 DEC 24:00

The result of the annual heating load is 133.5 kWh/m2, which is far larger than the maximum loads for passive houses (15 kWh/m2). During non-heating seasons the prevailing indoor temperatures are generally falling out of the comfort range, indicating that the structure is not effectively storing heat. The simulation implies that concrete materials alone cannot provide satisfactory indoor environment, and that insulation materials need to be provided.

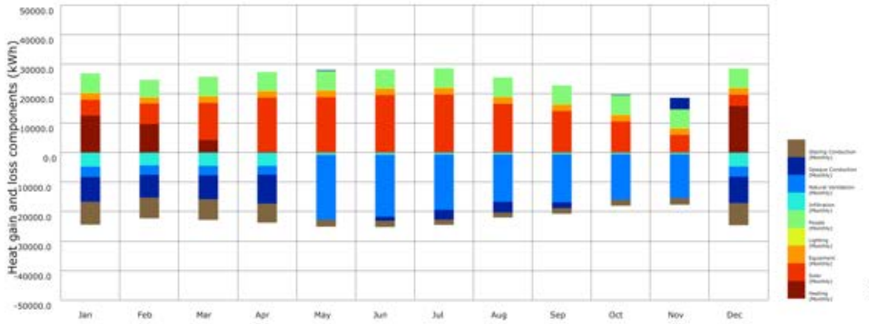
Simulation - V2

The second iteration keeps the original activity settings, but adds insulation maerials (EPS) to the concrete structure.

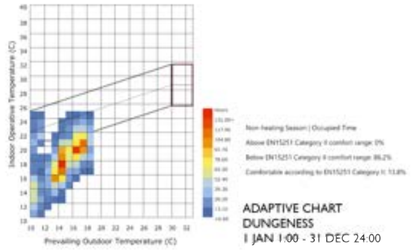
	mat	thickness (m)	density	conductivity	specific heat	thermal absorptance	solar absorptance	visible light absorptance	solar gain coefficiet (SHGC)	visible transmittance	U value
wall	concrete	0.3	2400	1.13	1000	0.9	0.7	0.7			0.43
	insulation (EPS)	0.06	50	0.03	1200	0.9	0.7	0.7			
roof	concrete	0.2	2400	1.13	1000	0.9	0.7	0.7			0.53
	insulation (EPS)	0.06	50	0.03	1200	0.9	0.7	0.7			
floor	concrete	0.15	2400	1.13	1000	0.9	0.7	0.7			0.65
	insulation board	0.05	43	0.030	1210	0.9	0.7	0.7			
window	double-glazed window								0.76	0.7	3.12



OPERATIVE TEMPERATURE FOR ZONES -
HOURLY
DUNGENESS
1 JAN 1:00 - 31 DEC 24:00



ANNUAL HEATING LOAD PER FLOOR AREA:
47.5 kWh/m2



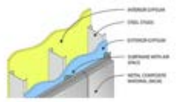
ADAPTIVE CHART
DUNGENESS
1 JAN 1:00 - 31 DEC 24:00

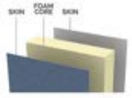
The annual heating load is brought down to 47.5 kWh/m2 by applying insulation boards.

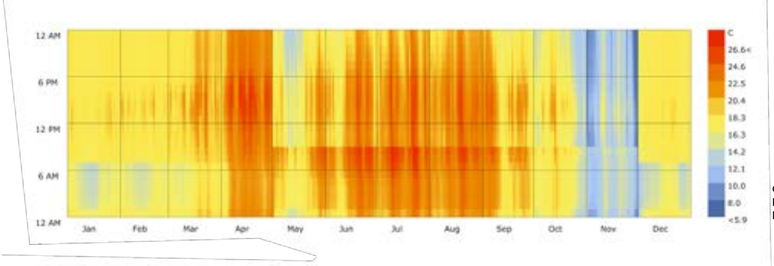
Simulation - V3

A stressed-skin structure is studied and it's found that it is more lightweight than a concrete system, it has less embodied carbon footprint and more possibilities of surface materials can be achieved. However, it is unclear whether this system can thermally compare to a concrete structure, which is known for its high thermal mass. The simulated material is a sandwiched panel made of aluminium and polyurethane foam.

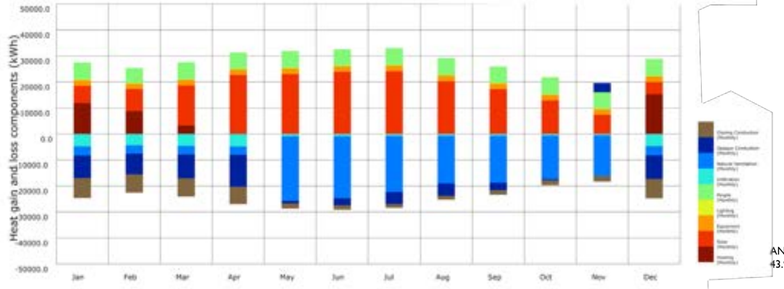
	mat	thickness (m)	density	conductivity	specific heat	thermal absorptance	solar absorptance	visible light absorptance	U value
wall	aluminium	0.01	2740	221	896	0.9	0.3	0.7	0.07
	Polyurethane foam	0.3	50	0.03	1200	0.9	0.7	0.7	
	aluminium	0.01	2740	221	896	0.9	0.3	0.7	
roof	aluminium	0.01	2740	221	896	0.9	0.3	0.7	0.12
	Polyurethane foam	0.2	50	0.03	1200	0.9	0.7	0.7	
	aluminium	0.01	2740	221	896	0.9	0.3	0.7	
floor	aluminium	0.01	2740	221	896	0.9	0.3	0.7	0.16
	Polyurethane foam	0.15	50	0.03	1200	0.9	0.7	0.7	



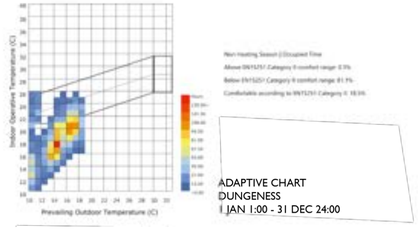




OPERATIVE TEMPERATURE FOR ZONES - HOURLY
DUNGENESS
1 JAN 1:00 - 31 DEC 24:00



ANNUAL HEATING LOAD PER FLOOR AREA:
43.9 kWh/m2



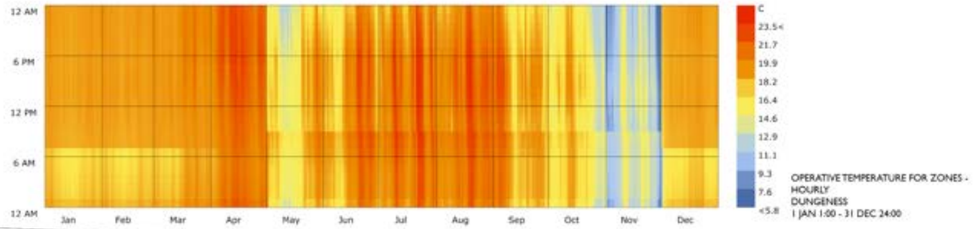
ADAPTIVE CHART
DUNGENESS
1 JAN 1:00 - 31 DEC 24:00

The result of the simulation is similar to iteration 2, with an annual heating load of 43.9 kWh/m2. This shows from the environmental viewpoint stressed-skin systems can achieve similar effects as concrete systems if proper materials are chosen. Stressed-skin systems also have the edge of being lightweight and easy to install. However, it can be observed from the heat gain & loss graph that the glazing conduction during winter is large, which can be a contributor to large heating loads.

Simulation - V4

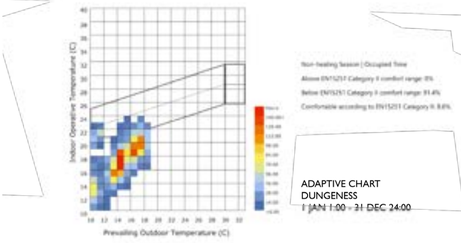
To reduce heat loss by glazing conduction, the windows are changed to triple-glazed windows and thus their U values are reduced to 0.9 W/m2K. The glazing ratios of both the roofs and the walls are reduced to half. In addition, the heating season is extended to November to April, considering that the temperatures are falling below the comfort range in non-heating seasons according to the adaptive charts. The rest of the settings remain the same as simulation v3.

	mat	solar gain coefficiet (SHGC)	visible transmittance	U value
window	double-glazed window	0.76	0.7	0.9



OPERATIVE TEMPERATURE FOR ZONES - HOURLY
DUNGENESS
1 JAN 1:00 - 31 DEC 24:00

ANNUAL HEATING LOAD PER FLOOR AREA:
22.1 kWh/m2

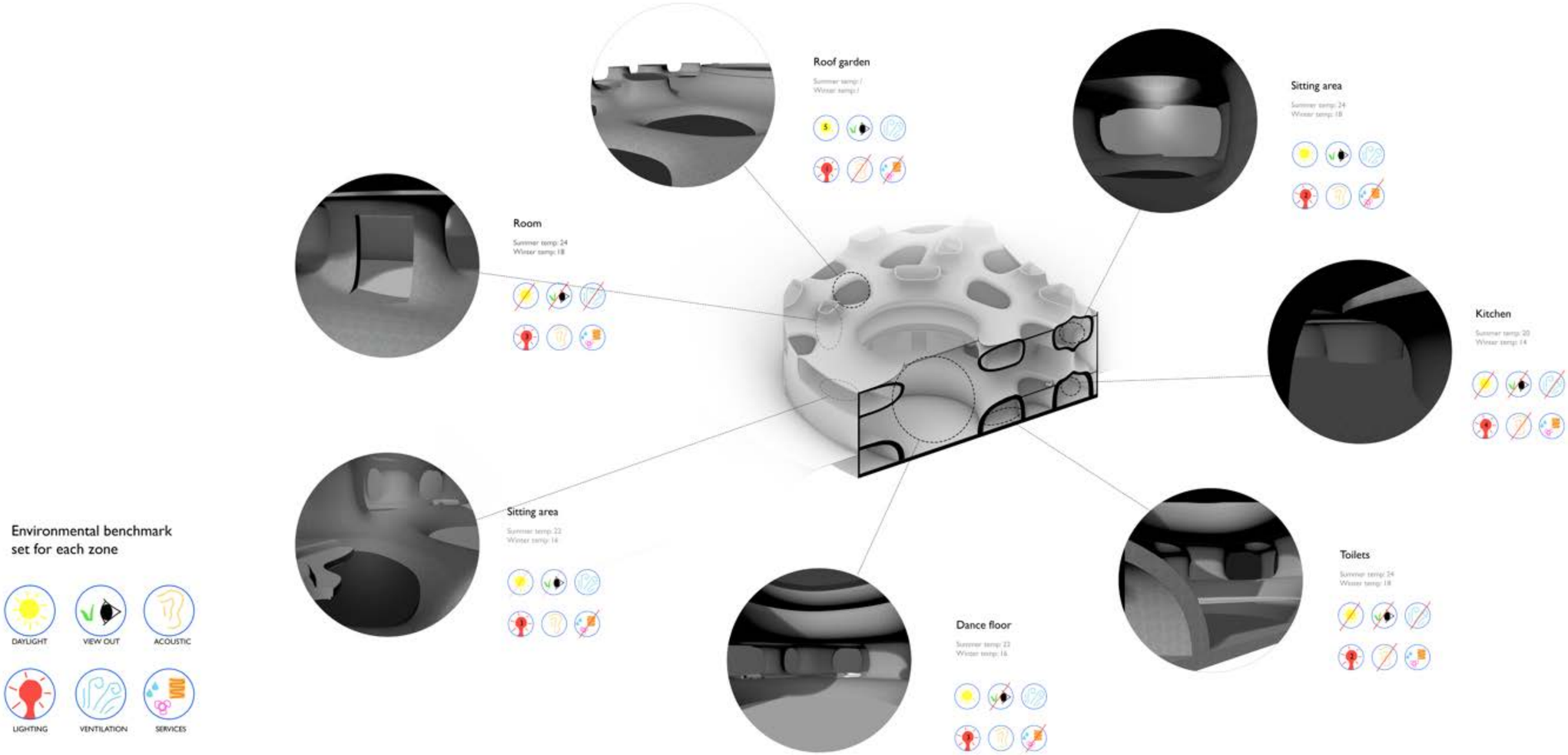


ADAPTIVE CHART
DUNGENESS
1 JAN 1:00 - 31 DEC 24:00

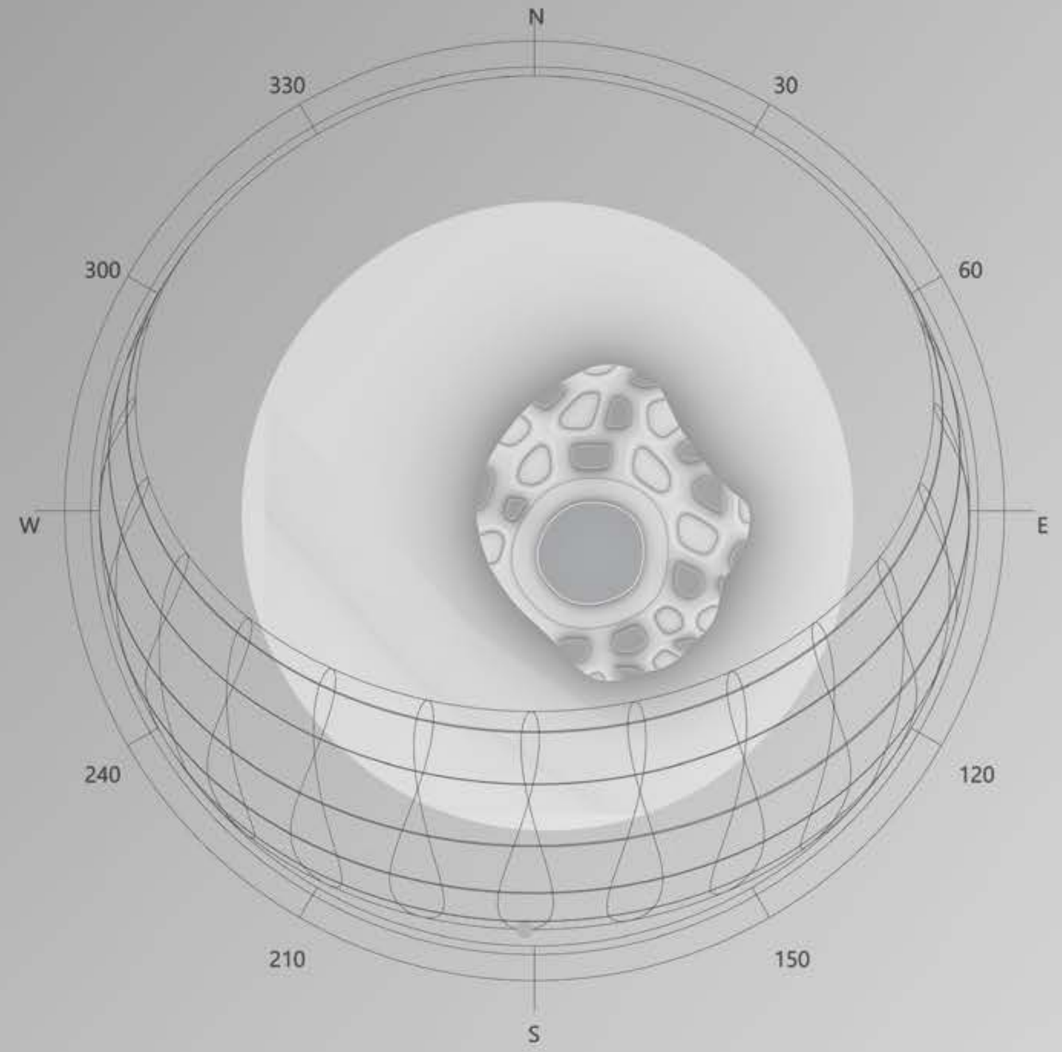
The annual heating load is reduced to 22.1 kWh/m2 even when the heating season is prolonged. The glazing conduction heat loss is greatly reduced, as can be observed from the heat loss & gain graph, which indicates by reducing the U values of glazings and havng fewer windows, the heat loss can be effectively cut down and less heating is needed.

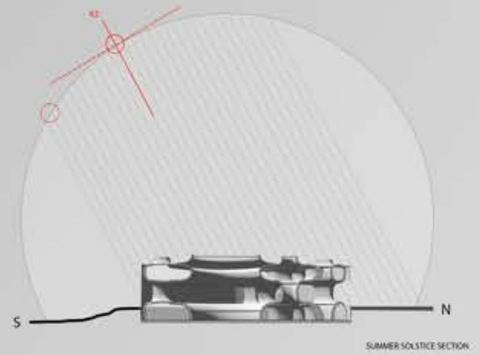
ENVIRONMENTAL ANALYSIS FOR DESIGN ITERATION 4

Iteration 4 is based on preivious design

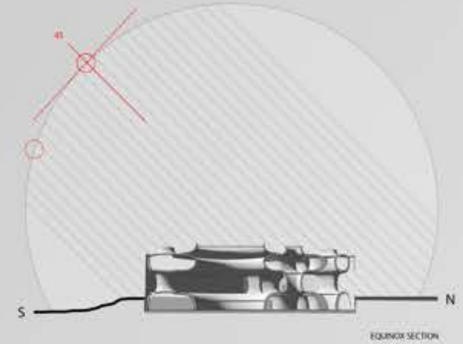


Sunpath Diagram

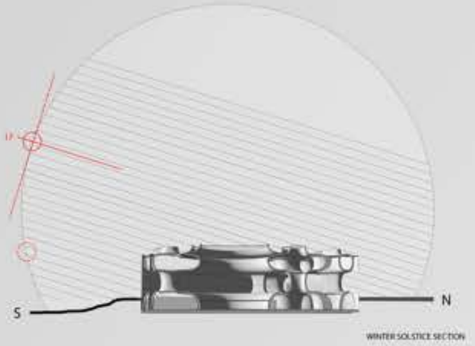




SUMMER SOLSTICE SECTION



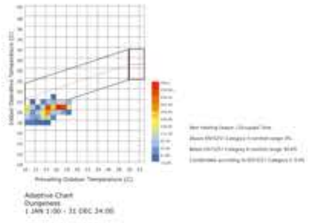
EQUINOX SECTION

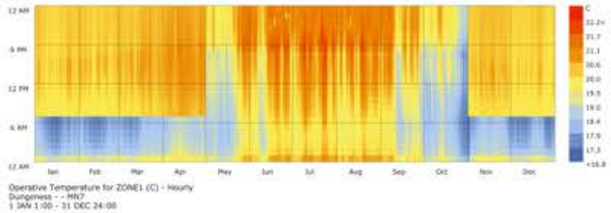


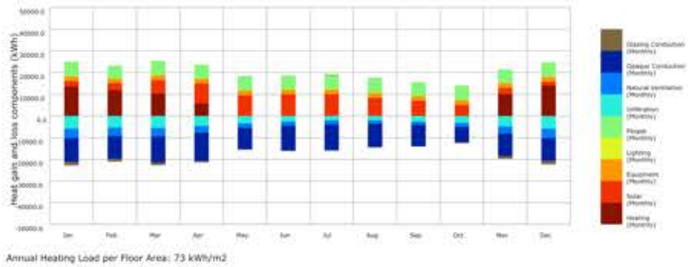
WINTER SOLSTICE SECTION

ENERGY SIMULATION OF THE LATEST ITERATION

The final structure has adopted a stressed-skin system consisting of steel ribs and aluminium panels. The construction remains the previous iteration, and some thermal mass is added to the roof considerng the effect of roof garden. The temperature setpoints are changed so that the temperatures can fall into the comfort range more often. However, the heating loads also increases accordingly. It is considered more important to remain the indoor environment comfortable for occupants, and as a result the heating load is increased to 73 kWh/m2, and the standard of passive design can not be satisfied. Some mechanical heating system is therefore necessary. Considering the proximity of this project to the quarry, water-based heat pumps can be promising.

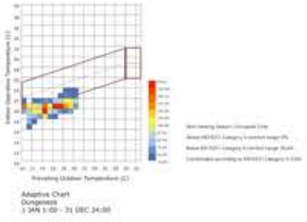


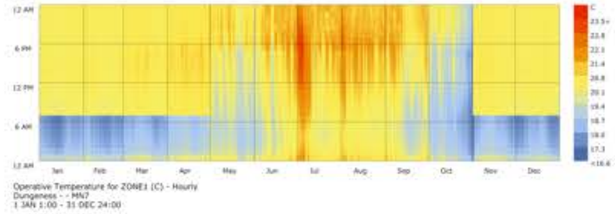


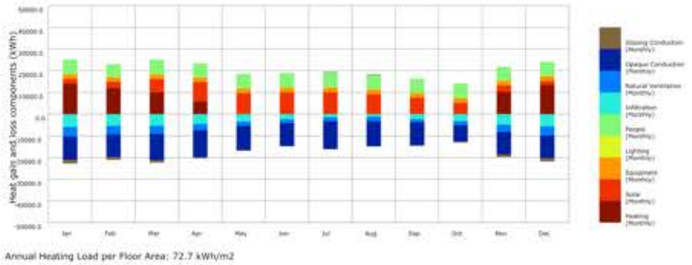


Annual Heating Load per Floor Area: 73 kWh/m2

Energy simulation is also run against the climate condition of 2040. It can be observed that the operative temperatures are generally lower throughout the year. However, the heating load is not greatly changed.







Annual Heating Load per Floor Area: 72.7 kWh/m2

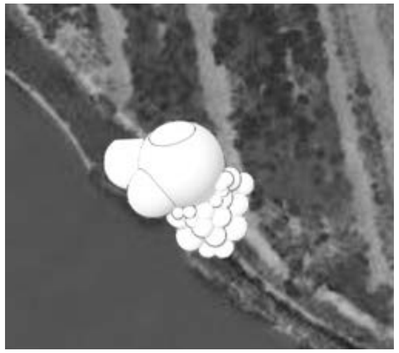
PART IV
DESIGN ITERATION
STRUCTURAL

SUPER ADOBE METHOD

LAYERED GYROID STRUCTURE

CONCRETE STUCTURE

STRESSED-SKIN SYSTEM



The first iteration of architectural design features in a series of 'bubbles' emerging from the quarry. Several strategies of dome construction have been explored, and among them the 'superadobe' method applied in the project 'Hormuz 2' was of great interest. Its main material is earthbags and barbed wires, which are easily accessible from local sites and can be assembled on-site. Its material gives it high thermal mass and thus ability to preserve heat, and the adoption of local materials gives it connection to its surroundings.

Figure 11. Hormuz 2 by ZAV Architects

Presence in Hormuz 2 by ZAV Architects, Hormuz island of Iran
Superadobe method (developed by architect Nader Khalili). It involves filling sandbags with layers of earth and cement then reinforcing them with barbed wire. Material is rammed earth and sand.

Figure 12. TECLA by Mario Cucipella Architects

TECLA I by Mario Cucinella Architects and
WASP, Massa Lombarda
3D-print with raw earth.

Figure 13. Tvisongur Sound Sculpture by Lukas Kuhne

Tvisongur Sound Sculpture Iceland by Lukas
Kühne Constructed - Poured concrete

Figure 14. Patricia and Phillip Frost Museum of Science

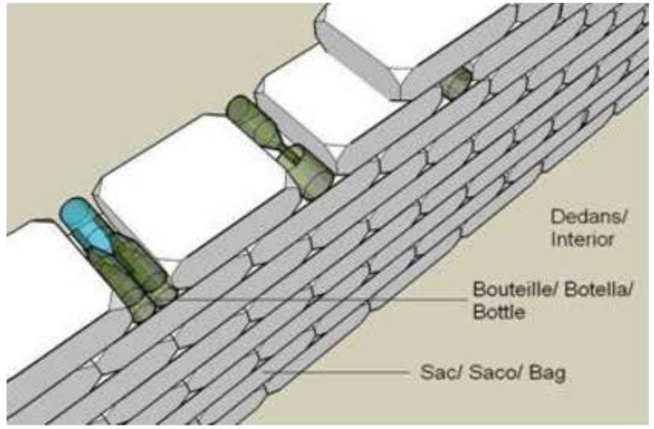
Patricia and Phillip Frost Museum of Science, Miami
Prefabricated concrete construction

Figure 15. Superadobe construction method

Hyperadobe construction method. www.calearth.org

SuperAdobe is a form of earth bag architecture developed by architect and CalEarth founder Nader Khalili. Using long sandbags ("SuperAdobe Bags"), barbed wire, on-site earth and a few tools, Khalili devised a revolutionary building system that integrates traditional earth architecture with contemporary global safety requirements, and passes severe earthquake code tests in California.

The waste bottles in the pub can potentially serve as structural components. Empty glass bottles incorporated in earthbags can provide ideal double glazings and drainage tubes. WOBO bottles designed by Heineken can be assembled and be used as bricks.



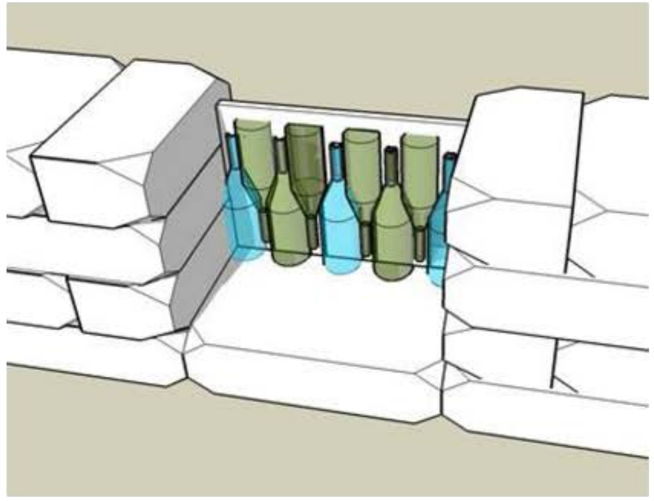


Figure 16. Superadobe construction method

www. EarthbagBuilding.com

Larger bottles should be on the outside and paved with plaster , to prevent animals or insects nesting in the pockets.

If more light is desired than ventilation, glass bottles can also be anchored with clay-rich plaster inside a wall opening. The spaces should be filled around the bottles with thick fiber-reinforced clayey earth.

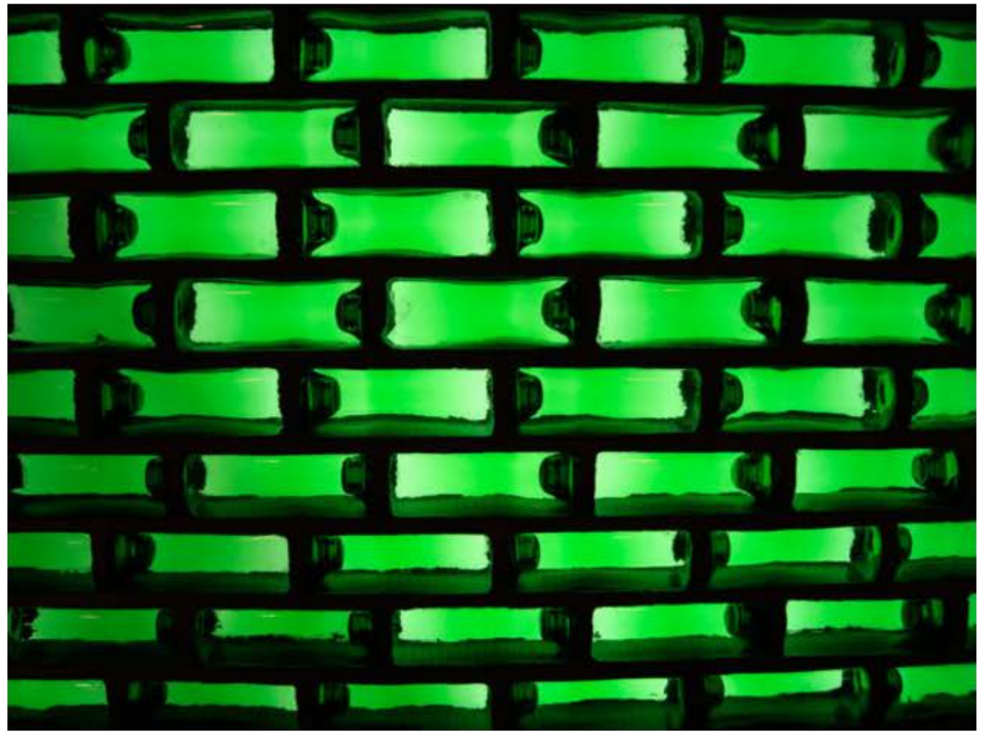


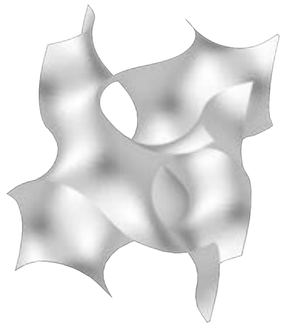
Figure 17. Superadobe construction method

Instead of having beers as lighting components of the adobe structure, they themselves can also serve as structural components. WOBO bottle developed by Heineken can be interlocked with each other as building blocks.

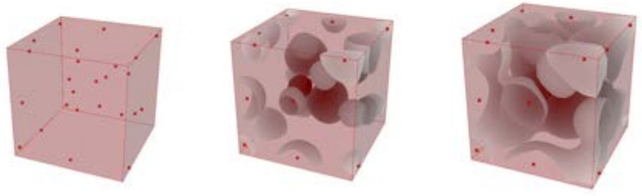
MINIMAL SURFACE

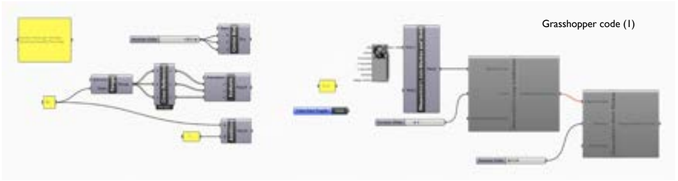
The key concepts of this project, 'escape' and 'performance', are generated from the typology study and research. This project aims at providing detachment from daily life where people can put on new identities. This design proposes 'small spaces inside large space', where spaces of various qualities, including sizes, lighting and temperature, can cater to people's different needs. The central and largest space which enables the mutual scrutiny of people who are in dance floor or are in other spaces, should be like a stage set. The exploration of 'bubble' structures then leads to the question of whether the 'bubbles' can be formed inside of the structure, rather than outside, and thus a constrast of linear exterior and curvy interior can potentially serve as an analogy of the inconsistency lies in the protagonist's personality. Gyroid structure, an infinitely triply periodic minimal surface discovered by Alan Schoen in 1970, has many promising mechanical properties and has found its applications in various engineering fields.

Minimal surface, which includes gyroid structure, has the potential to naturally form a variey of spaces.
Grasshopper code (1) is written, where equations of gyroid equations can be manually set up and experimented with. The simplist gyroid structure equation is *sin(x)cos(y)+sin(y)cos(z)+sin(z)cos(x)=0*, and the coefficients can be adjusted to generate structures with different porosity levels.

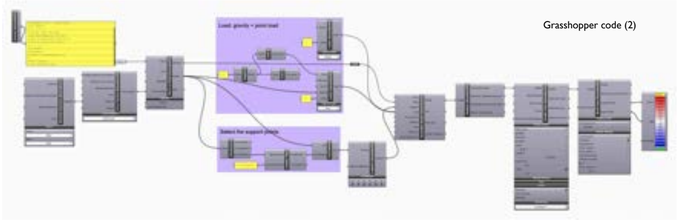


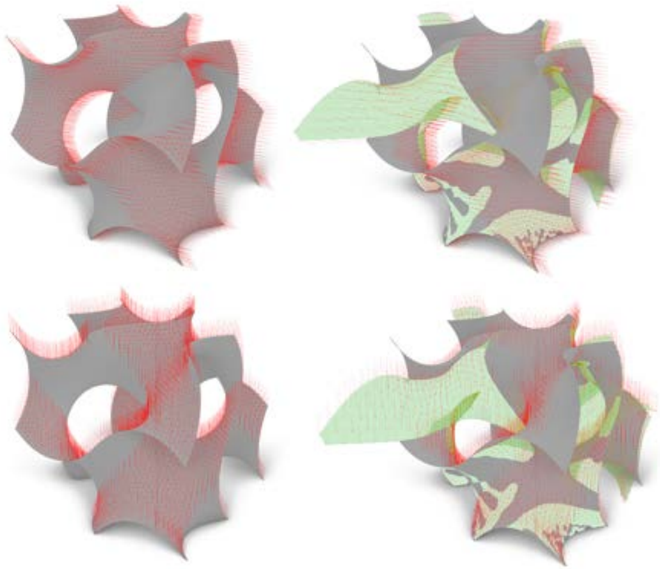
Grasshopper code (1) limits the flexibility of the structure's number of pores and diversity of surfaces. It is then updated and improved in Grasshopper code (3), where the positions and numebers of holes as well as values of isosurface can be set up and adjusted. The order of constructing the structure is: (1) set up the positions and number of centers or pores ; (2) set up the diameters of pores; (3) adjust the parameters of porosity.

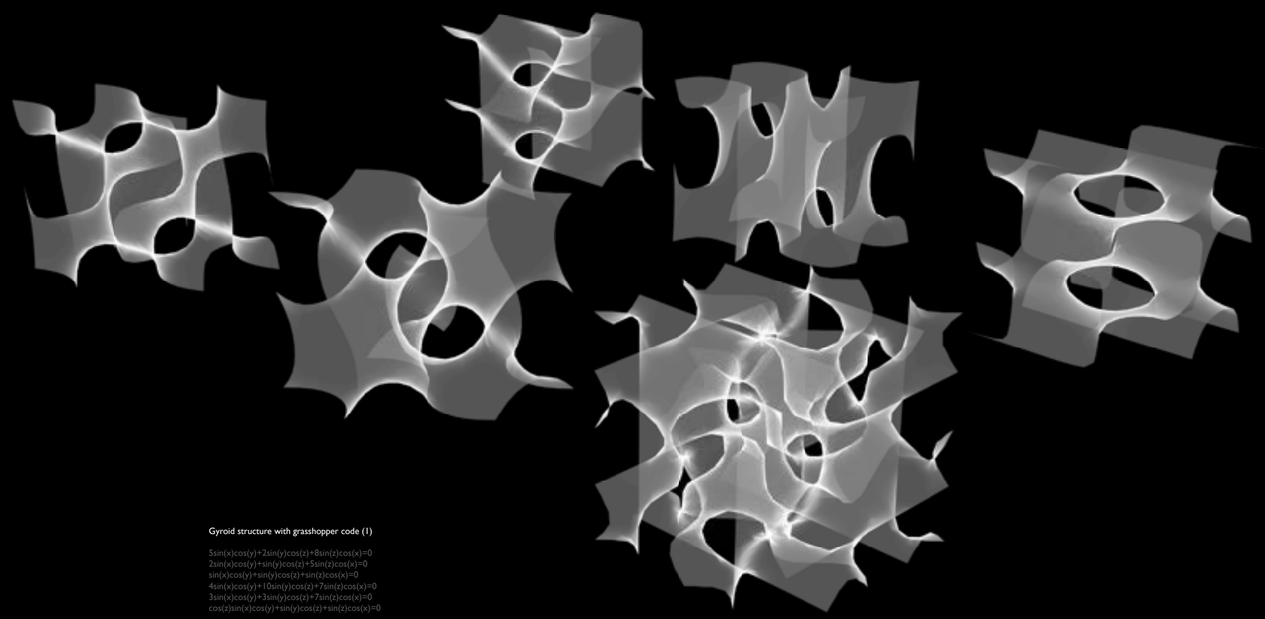




The structural properties of the basic gyroid structure are anayzed with karamba in grasshopper code (2). Gravity and vertical / horizontal loads are applied to the structure in order to test its rigidity under bending loads. It can be observed that the high-stress areas are uniformly distributed across the structure, indicating the structure's good transfer of load and energy.

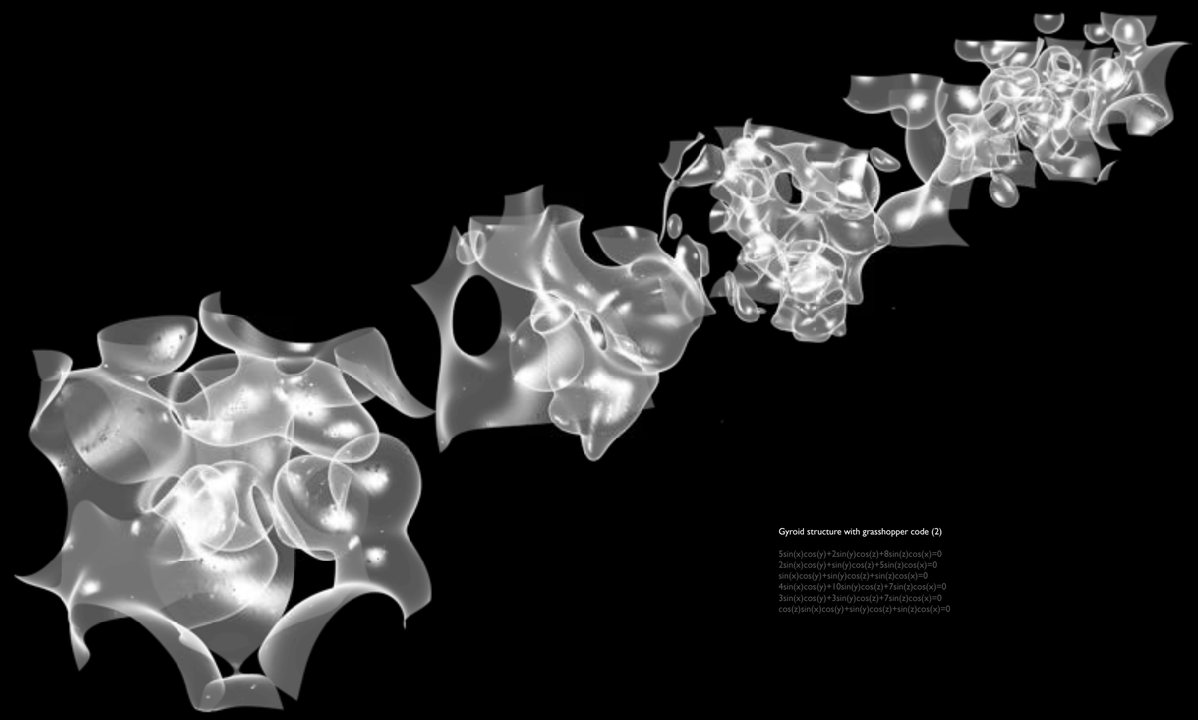






Gyroid structure with grasshopper code (1)

5sin(x)cos(y)+2sin(y)cos(z)+8sin(z)cos(x)=0
2sin(x)cos(y)+sin(y)cos(z)+5sin(z)cos(x)=0
sin(x)cos(y)+sin(y)cos(z)+sin(z)cos(x)=0
4sin(x)cos(y)+10sin(y)cos(z)+7sin(z)cos(x)=0
3sin(x)cos(y)+3sin(y)cos(z)+7sin(z)cos(x)=0
cos(z)sin(x)cos(y)+sin(y)cos(z)+sin(z)cos(x)=0



Gyroid structure with grasshopper code (2)

5sin(x)cos(y)+2sin(y)cos(z)+8sin(z)cos(x)=0
2sin(x)cos(y)+sin(y)cos(z)+5sin(z)cos(x)=0
sin(x)cos(y)+sin(y)cos(z)+sin(z)cos(x)=0
4sin(x)cos(y)+10sin(y)cos(z)+7sin(z)cos(x)=0
3sin(x)cos(y)+3sin(y)cos(z)+7sin(z)cos(x)=0
cos(z)sin(x)cos(y)+sin(y)cos(z)+sin(z)cos(x)=0

The gyroid structure is combined with its bounding box to create a volume, and is sliced into 10cm thick boards which are stacked togther. Similar to Termite Pavilion, the structure creates an immersive experience where there's no distinction between floors, ceilings and walls. However, the structure can be bulky and might have large carbon footprint.

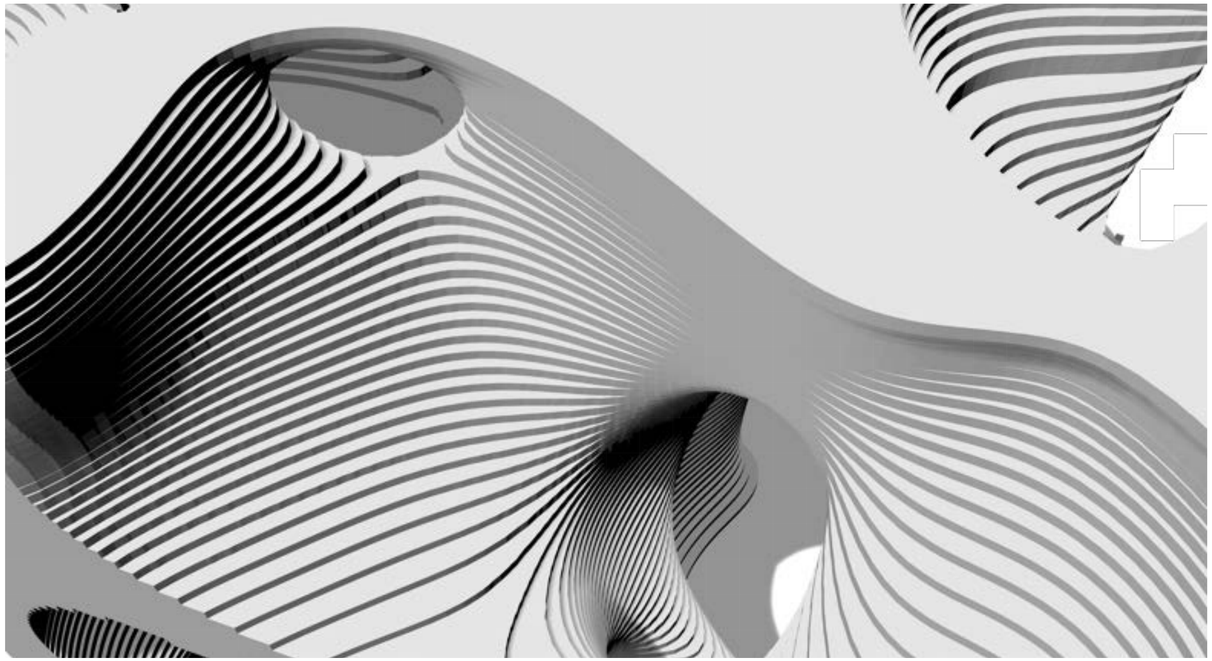


Figure 18. The termite pavilion

Taichung Opera House designed by Toyo Ito is served as a case study for this project. The procedures of defining voronoi, offsetting curves and meshing faces have been written in the grasshopper code. By adopting a similar strategy I can generate the structure of my project by defining the spaces, forming surfaces and bounding the surfaces with external walls.

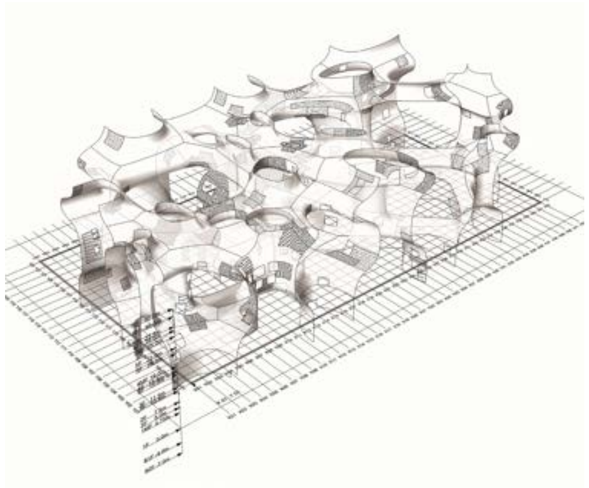
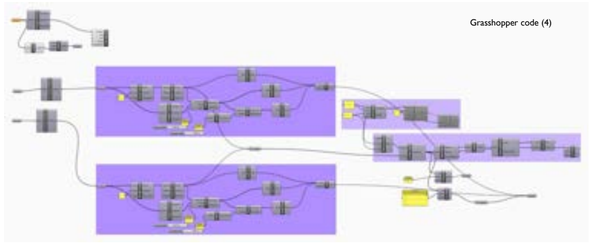
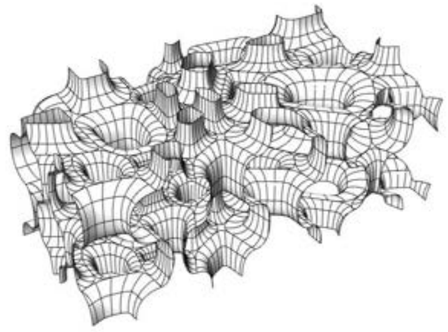
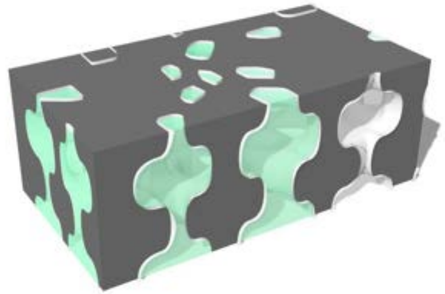


Figure 19. Model of Taichung Opera House

Figure 20 . Model of Taichung Opera House







CONSTRUCTION METHOD OF TAICHUNG OPERA HOUSE

The structural system is developed together with the construction method to realize the freeform geometry in rational and efficient manner. the freeform concrete surfaces are shotcrete (spray concrete). it is commonly utilized for tunnel construction and suitable for curved surface. it can be shot horizontally or vertically. rather than constructing doubly curved formwork that is expensive and time consuming on site, the temporary structure in the void creates faceted surfaces that best-fit the finished surface. between the temporary steel work,expanded metal mesh is expanded metal mesh spans between the temporary steel work to act as faceted formwork. 150 mm thick concrete can be shot at one time. the surface layer of 25 mm is shot separately without large aggregate to achieve smooth surface finish. concrete thickness varies between 200 mm at the top floor and 350 mm at the bottom. (https://www.designboom.com/architecture/toyo-ito-taichung-metropolitan-opera/)

Typically, an expanded metal mesh is used as a permanent back shutter to which the reinforcing mesh is affixed. the concrete is sprayed onto the expanded metal and the reinforcement is fully enclosed. The concrete is typically sprayed using one of two methods. with the dry process, the dry constituents of the concrete are mixed in a portable batching plant and the water is added to the mix at the nozzle. with the wet process, The water is added to the batching plant and premixed with the dry constituents and the wet concrete is sprayed from the nozzle. The benefits of the wet process are that there is greater control over the concrete mix as the concrete is often mixed off site by ready-mix contractors and delivered in lorries. it is common practice to apply the concrete in two layers. The first thick layer is usually applied using the wet process. Once sufficiently cured, a second, thin finishing layer is then applied using the dry process.

It is essential that the finished product is cured appropriately to mitigate shrinkage and to ensure that design strength is achieved. spraying concrete is a messy process. some concrete will rebound and some will pass through the expanded metal back shutter. It may be necessary to install temporary protection to avoid polluting the surrounding area.

Figure 21a . Construction of Taichung Opera House

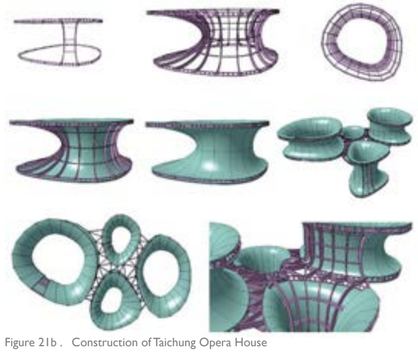


Figure 21b . Construction of Taichung Opera House

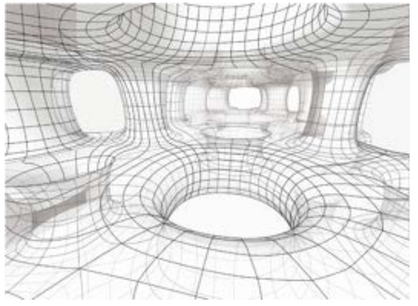
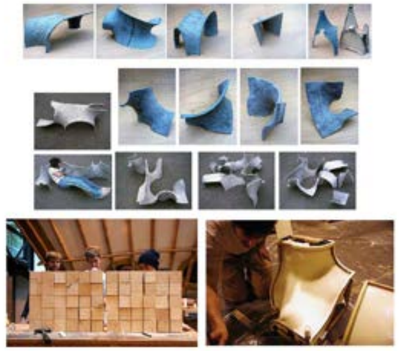


Figure 21c . Construction of Taichung Opera House

SHIN EGASHIRA TWISTED CONCRETE WORKSHOP

The workshop looks at experimenting with materials and design techniques.The work had two stages: first research on the potentials of the technique of casting double curvature surfaces in concrete. Second stage was to design and produce a piece using the learned techniques.



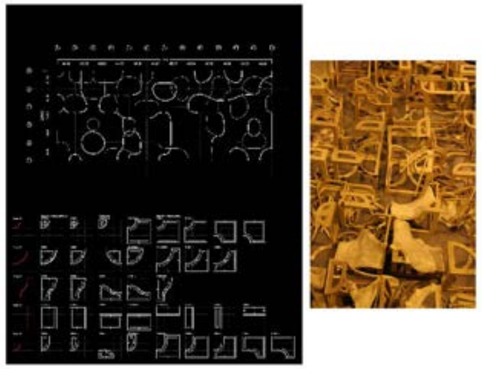
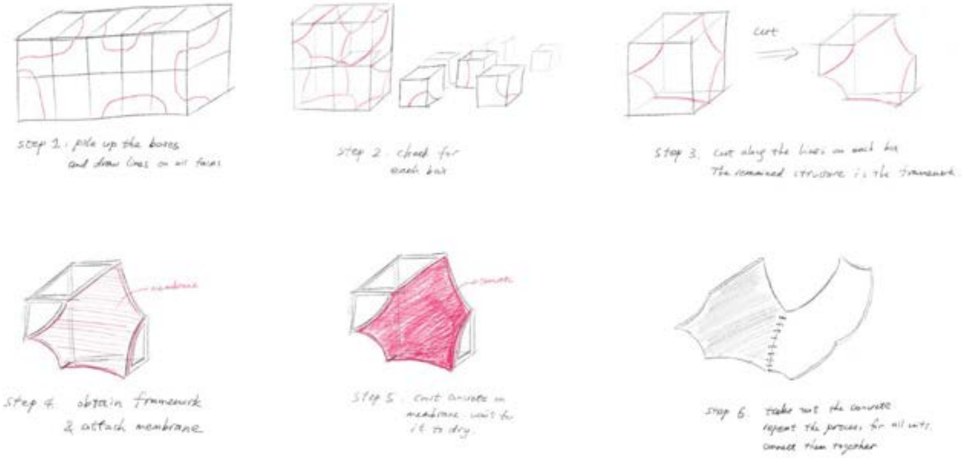


Figure 22 . Twisted concrete workshop led by Shin Egashira

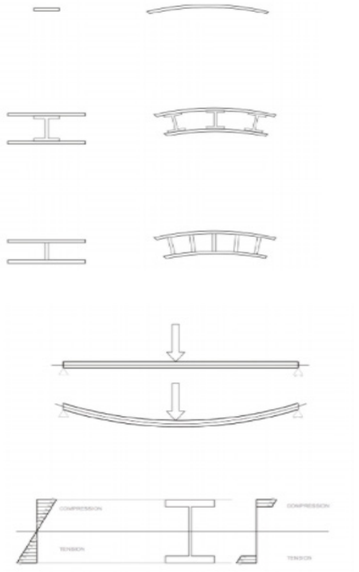


Construction process of twisted concrete that can be applied to the project.

STRESSED-SKIN SYSTEM

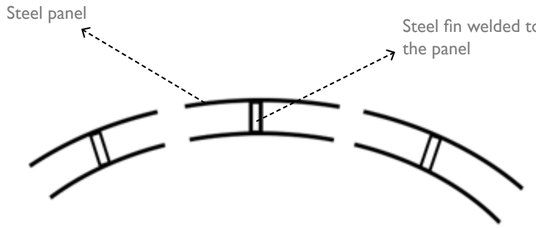
Stressed steel skin systems uses the skin structurally, which can make effective use of the strength of panel material and improve the shear strength of the structure. It is more efficient than individual structural members with a skin applied where the skin does not work together with the structural elements.

One advantage of a stressed-skin system over a concrete system is that it uses less material, it is lighter, and embodies less embodied carbon. Moreover, more surface materials, including fabric, can be incorporated and provide different experiences in spaces.

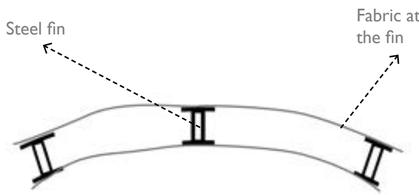


The stressed skin is composed of steel fins welded to a skin of panel material. In this project, some parts of the panels will be solid materials, and some will be fabric.

The stressed skin can be pre-fabricated in elements, and brought to site installed in components. Therefore the construction and installation can be rapid on site.



Stressed-skin column plan (rigid)



Stressed-skin column plan (fabric)

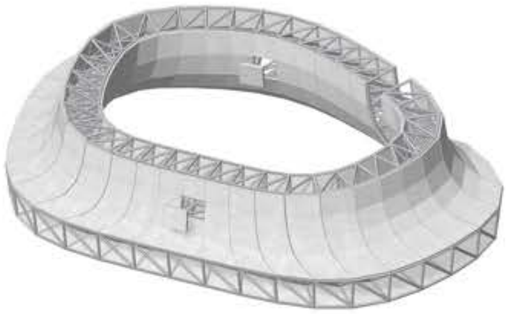
Figure 23a . Drawing studio by Peter Cook

Figure 23b . Drawing studio by Peter Cook

All-steel prefabricated 'semi-monocoque construction' - fine art studio - Arts University Bournemouth (AUB) - CRAB studio / Peter Cook - 2016

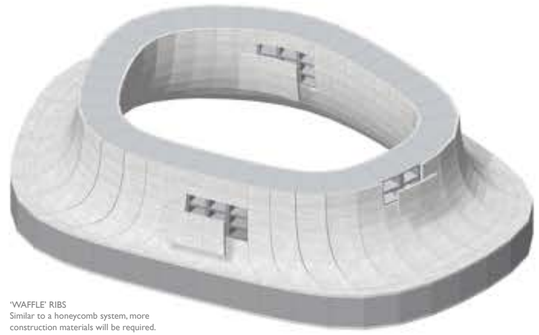
The Drawing Studio's external skin is formed from 17 painted steel panels, which were prefabricated in a factory before being welded together on site to form a smooth and waterproof enclosure. It's bright blue colouring is intended to signpost the northern end of the campus.

The cavernous interior echoes for the form of the exterior but is painted a stark white. Its form was developed using a material called GRG – glass reinforced gypsum – which creates an insulation and service cavity between the shell and inner wall.

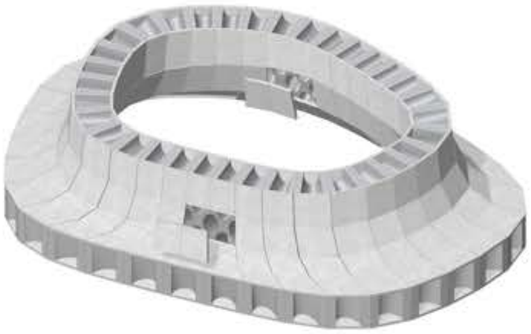


STRUCTURE: STRESSED-SKIN SYSTEM

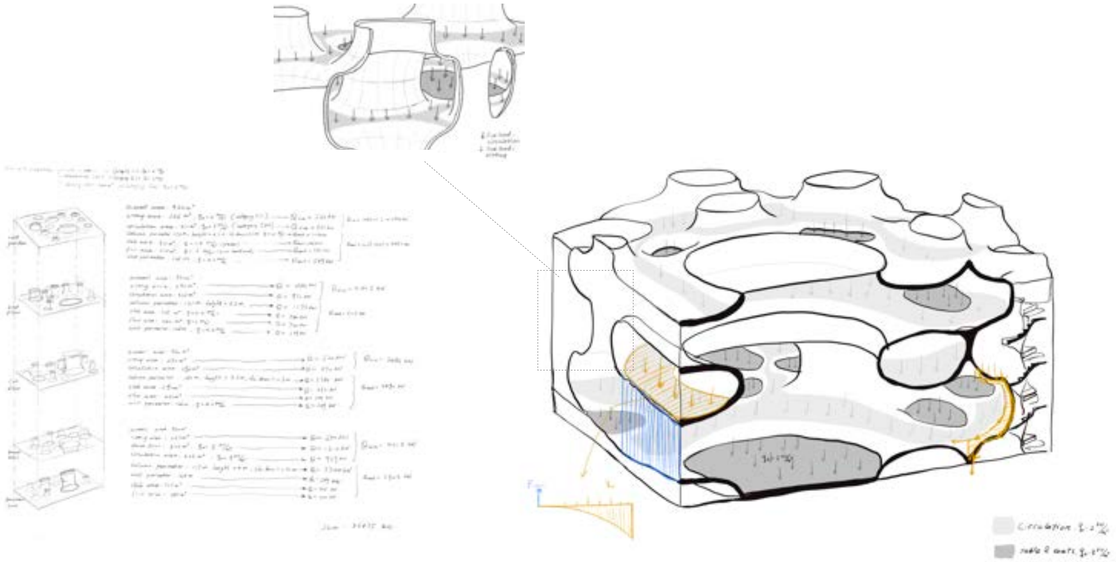
Shell structures, instead of 'layer' structures, can be achieved with these systems Several strageties of stressed-skin systems are explored.



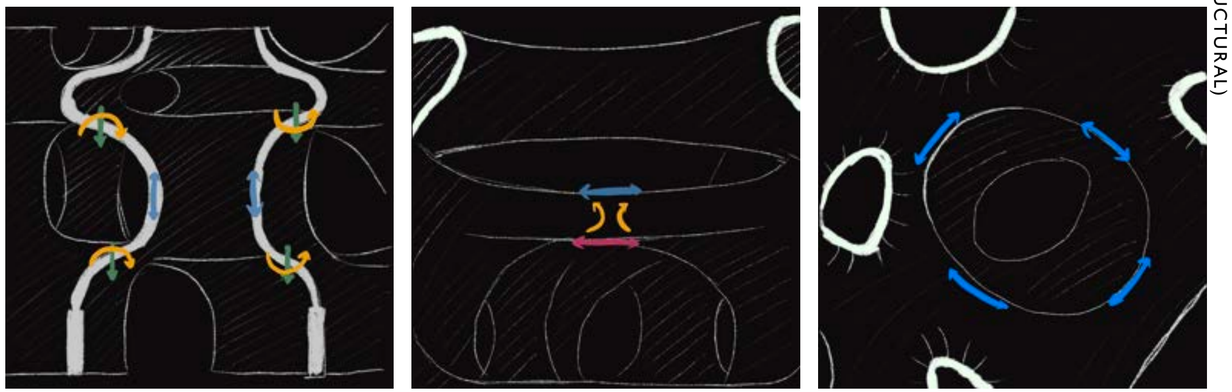
'WAFFLE' RIBS
Similar to a honeycomb system, more construction materials will be required.



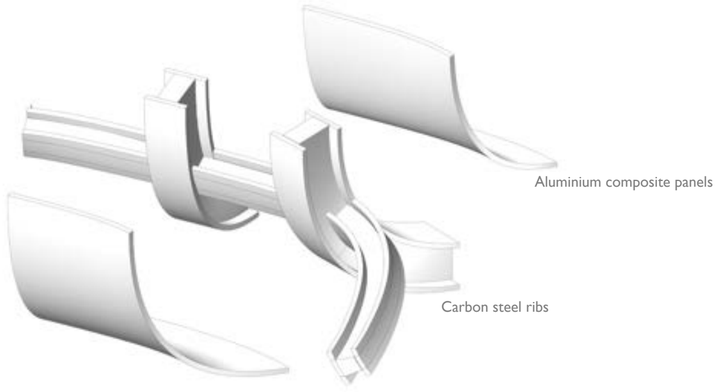
I-SECTION SYSTEM
I-section ribs made of steel can have ideal strength and continuous surfaces can be achieved.



Preliminary load calculation



Preliminary structural analysis



Stressed-skin components

dead load												live load						sum
column		slab		wall		other						sit		circulation		dance		
unit weight	area	unit weight	area	load (kN/m)	perimeter (m)	kitchen load (kN/m2)	kitchen area	toilet load (kN/m2)	toilet area	office load (kN/m2)	office area	load (kN/m2)	area	load (kN/m2)	area	load (kN/m2)	area	
50	332.5	50	0	4.6	118.5	3	97.2	3	45.7	2.5	66.5	2	87.5	3	109.9	5	288.6	19537.75
50	701.1	50	155.3	4.6	118.5							2	155.3	3	99.8	5	332.2	4270028
50	713.4	50	197.2	4.6	134.2							2	135.2	3	123.5	5	0	6123086
						earth & plant load (kN/m2)	earth & plant area	glazing load	glazing area									
50	352.2	50	103.9	4.6	134.2	8	103.9	10	378.5			2	103.9	3	106.2	5	0	28564.92
																		10441216 kN

Load Calculation

Picture source

Figure 1 . http://www.wsd2013.com/wolf-gutjahr/

Figure 3&4. http://www.londontown.com/LondonEvents/Colourscape-Music-Festival/65923/imagesPage/33924

Figure 5 & 6. https://www.archdaily.com/892767/kamikatz-public-house-hiroshi-nakamura-and-nap

Figure 7. https://www.archdaily.com/952361/presence-in-hormuz-2-zav-architects#:~:text=Presence%20in%20Hormuz%20is%20a,local%20community%20of%20the%20island.

Figgure 8. https://www.calearth.org/intro-superadobe

Figure 9. https://www.calearth.org/tour

Figure 10. https://heinekencollection.com/en/stories/the-story-behind-the-wobo

Figure 11. https://www.archdaily.com/952361/presence-in-hormuz-2-zav-architects#:~:text=Presence%20in%20Hormuz%20is%20a,local%20community%20of%20the%20island.

Figure 12. https://www.mcarchitects.it/tecla-2

Figure 13. http://www.sonicwonders.org/sound-sculpture-tvisongur/

Figure 14. https://frost.fiu.edu/

Figure 15. https://www.calearth.org/intro-superadobe

Figure 16. https://www.calearth.org/tour

Figure 17. https://heinekencollection.com/en/stories/the-story-behind-the-wobo

Figure 19. https://archello.com/story/20307/attachments/photos-videos/4

Figure 20. https://archello.com/story/20307/attachments/photos-videos/4

Figure 21 a, b & c. https://www.designboom.com/architecture/toyo-ito-taichung-metropolitan-opera/)

Figure 22. http://www.shinegashira.com/archives/154

Figure 23. https://www.dezeen.com/2016/03/04/peter-cook-crab-drawing-studio-arts-university-bournemouth-bright-blue-first-building-uk/