# Design Realisation
## Reactivate Torino
## Urban Playground and Sports Complex
## Lester Cheung

# Content

## Brief

The Slow Movement advocates a cultural shift toward slowing down life's pace. It began with Carlo Petrini's protest against the opening of a McDonald's restaurant in Rome in 1986 that sparked the creation of the Slow Food Movement. Over time, this developed into a subculture in other areas. The "Slow" epithet has subsequently been applied to a variety of activities and aspects of culture.

Slow Living is also what came out from the movement. It is a lifestyle emphasising slower approaches to aspects of everyday life.

Slow Living means structuring your life around meaning and fulfilment, focusing on the quality of your life. It addresses the desire to lead a more balanced life and to pursue a more holistic sense of well-being in the fullest sense of the word.

Sport represents the fundamental premise for maintaining a good level of health and physical and mental well-being throughout life. This concept takes on a greater importance in today's world, where life, culture and work habits, also conditioned by technological progress that has gradually substituted muscular activity, have resulted in a sedentary lifestyle becoming such an extremely widespread phenomenon at all ages that it often causes physiological changes.

This project aims to promote physical exercise as enjoyment, as well as sensitising inhabitants about a correct lifestyle based on a combination of a balanced and healthy diet and regular physical exercise.

CITTA' DI TORINO

CENTRO UNIVERSITARIO SPORTIVO TORINO

CUS TORINO ANNIVERSARY 1946 · 2016

CUSI DELEGAZIONE LOMBARDIA

SITE:
Piazza Vincenzo Arbarello, Turin, Italy

DEFINED USERS:
Local Torinese

CLIENTS:
Città di Torino (Turin City Council)
Sport e tempo libero
(Department for Sport and Leisure)

REQUIREMENTS:
- a generous piazza
- a sports complex with multi-purpose spaces
- indoor and outdoor courts
- gym and changing facilities
- a swimming pool

ESTIMATED NUMBERS:
Maximum Capacity: 250

CONSULTANTS:

Unit 21 Design Tutors from
Bartlett School of Architecture UCL:

Abigail Ashton
Andrew Porter
Tom Holberton

Structural: Brian Eckersley
          from Eckersley O'Callaghan

Environmental: Max Fordham LLP

# Section 1

## Building Form, Systems, Planning and Context

## Introduction to Turin

Located in northern Italy, Turin is a city and an important business and cultural centre.

Turin was once the capital of Italy in the 1860s before it moved to Florence and Rome. Turin was known for its FIAT car manufacturing history, since the period of rapid industrialisation in the late 19th century, hence the title "City of Speed."

Turin is now home to the Slow Food Movement, which its mayor is introducing a weekly meat-free day.

Italy

Turin
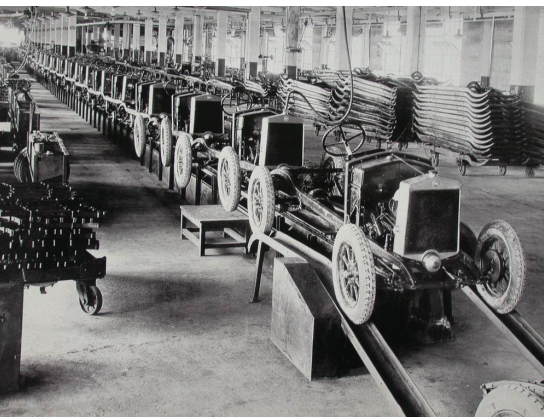
Through mapping the existing public swimming pools, sports complex, skating facilities and sporting grounds, it is found that these spaces are always very far from the centre. This makes doing sports in the city very inconvenient. ▶

Site

Sport Complex
'Skatable' Space
Sporting Ground
Public Pool
Park
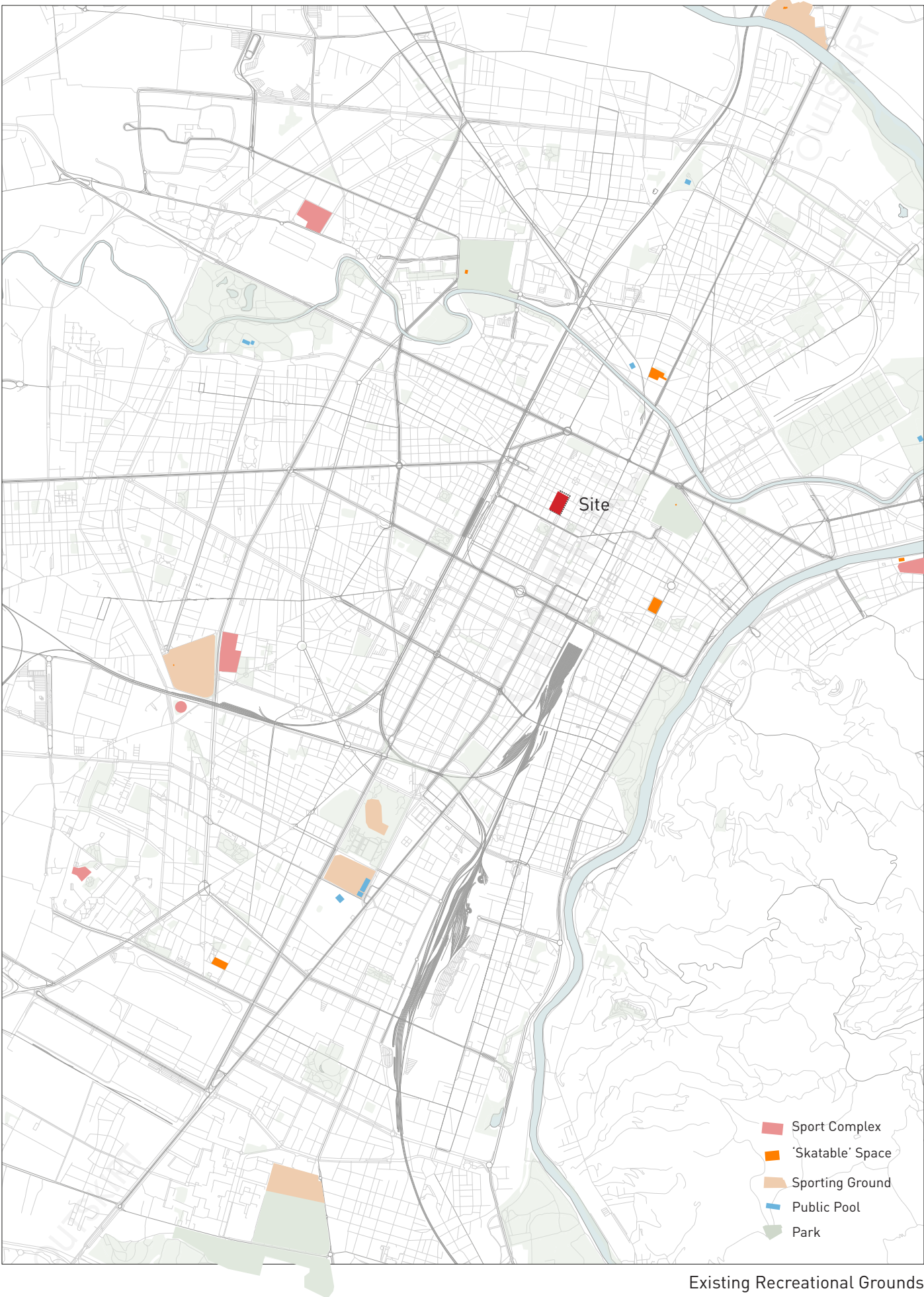
Existing Recreational Grounds

## Programme

Apart from cars and slow food, Turin is also home of two significant football teams in the world, Juventus and Torino F.C. The city has a rich sporting tradition, it held numerous sporting events, most renowned one being Winter Olympics and Paralympics in 2006.

The city was also awarded with the title of European Capital of Sport in 2015. The objects are to promote physical exercise as enjoyment and improving health.

**TORINO 2015 CAPITALE EUROPEA DELLO SPORT**

I would like to promote the slow, balanced and healthy lifestyle through encouraging and enabling sports.

People everyday are constantly living at a fast pace which is making them feel like their lives are chaotic – but with slow living they end up taking a step back and start enjoying life being conscious of sensory profusion, especially in the City of Speed.

The proposal is a pleasure garden/urban playground with a sports complex in the city centre of Turin, making sports more accessible for its inhabitants.

Concept Collage
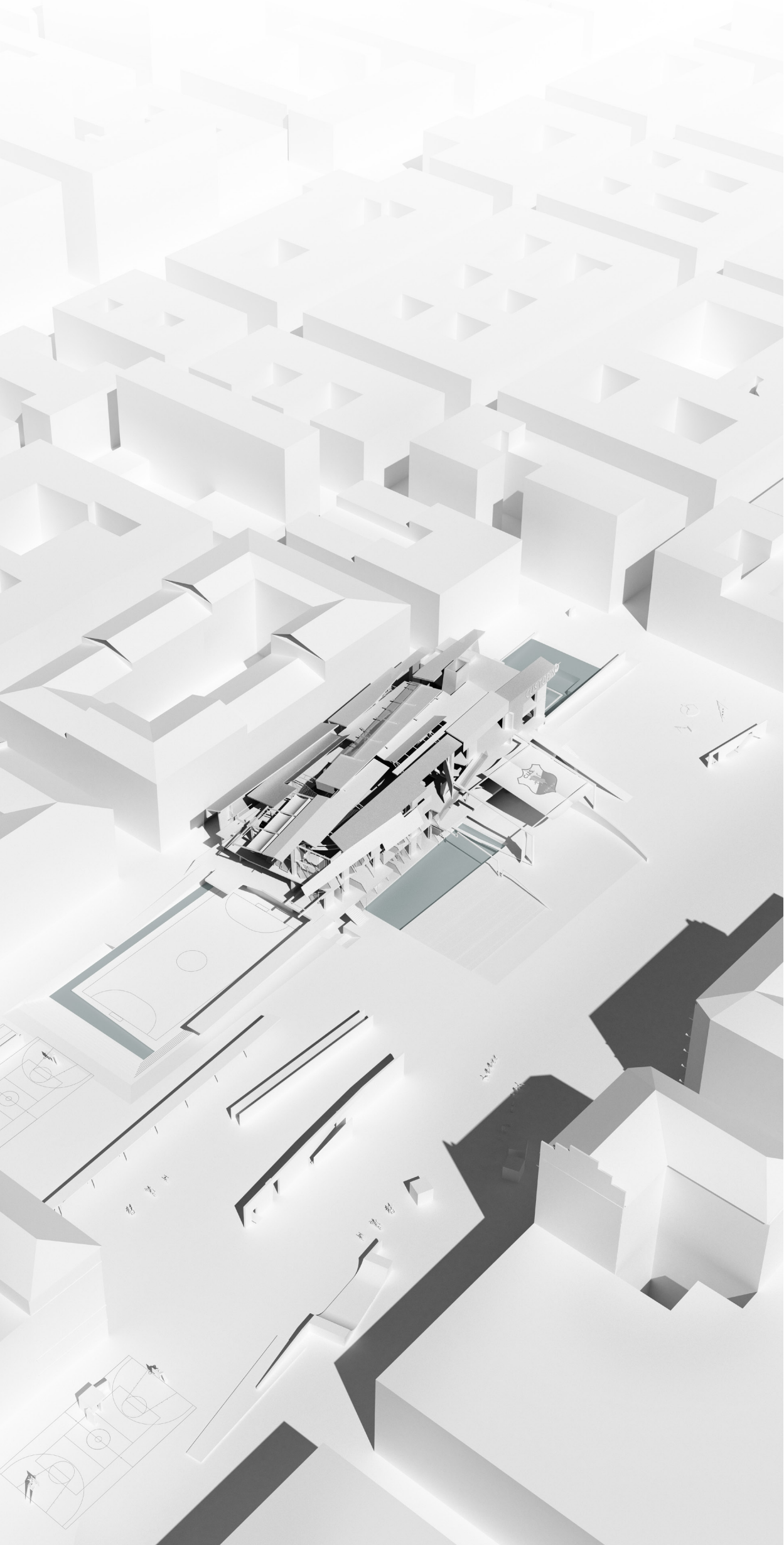
## Site Location

The site is located in between the two spines of the city, the new and the old, fast and slow, west and east. It is rare to find such large un-built area in the heart of the city, currently the space is underused and should not just be a parking lot.
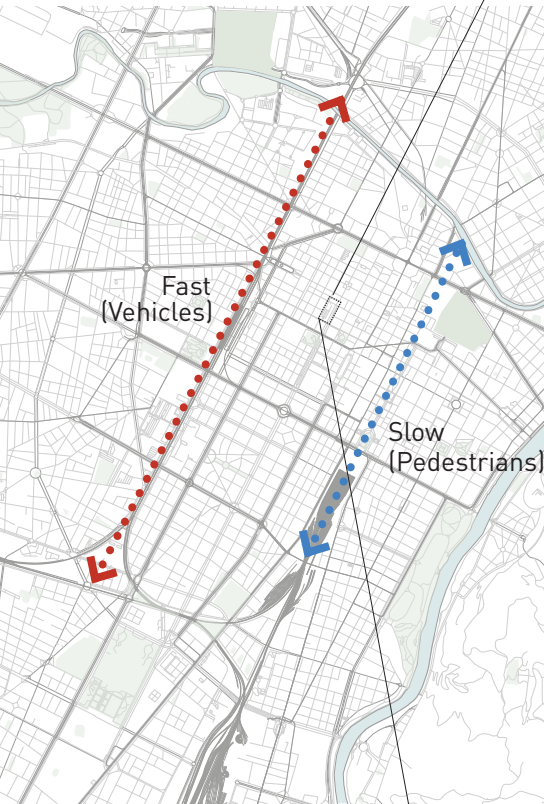


## Existing Condition

The piazza in the existing space is only a small portion, everywhere else is carparking. Below the piazza is currently an underground parking/ storage space, on the other side is currently a carpark, underneath houses the electrical substation. There are already plans upgrading the dated station.


Current Piazza


Underground Parking Entrance Ramp


Underground Parking/Storage Space


IREN Electrical Underground Substation


Existing Carpark above the electrical substation



Piazza

Carpark

Above Ground

Parking/ Storage

Below Ground

Electrical Substation

Aerial View

## Historical Context
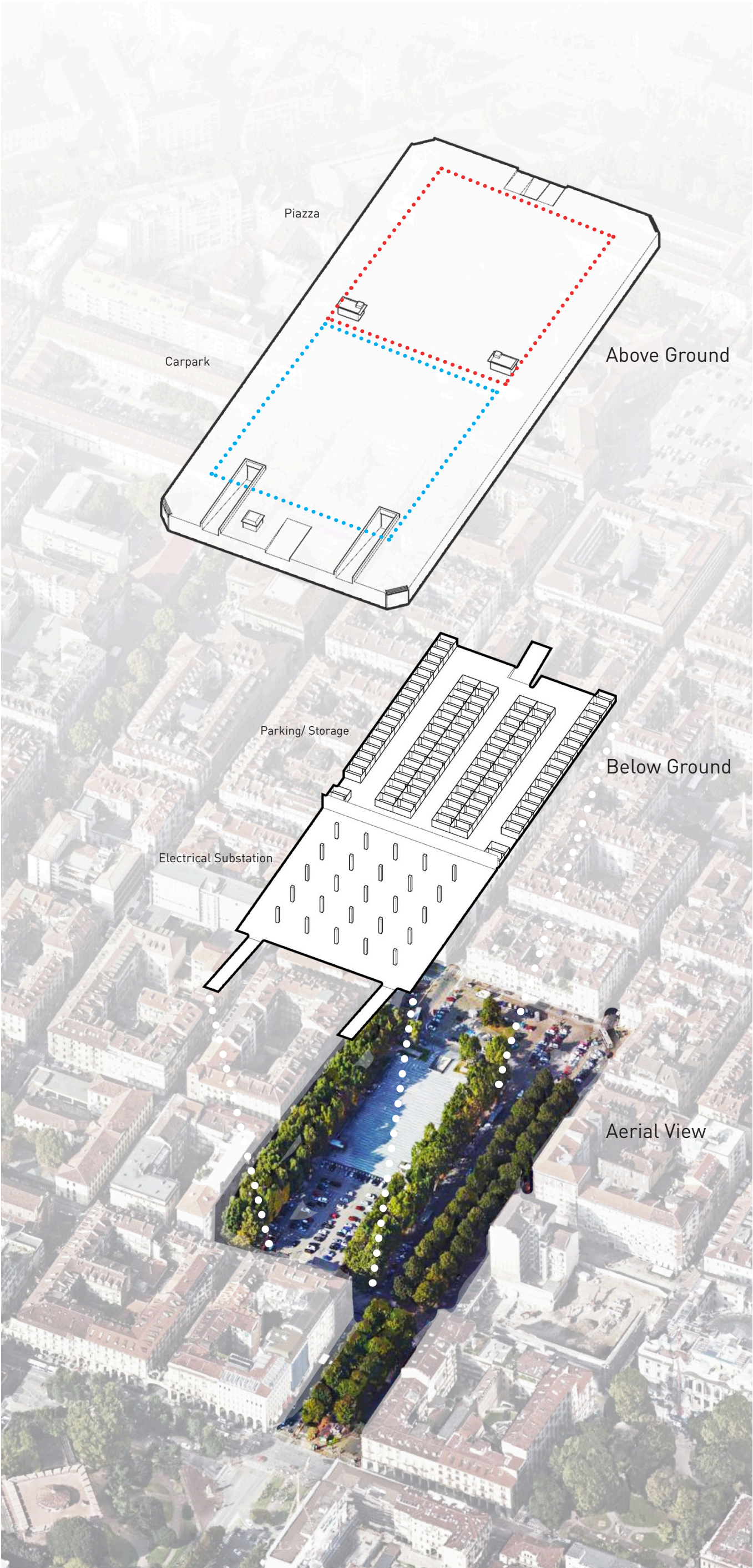
In 1897, the site, Piazza Arbarello (Garden of the Cittadella) was once the largest open-air gymnasium in Europe. It had fencing area and a playground equipped for athletic exercises, partially used by the students from the Sommeiller institute. The location held the National Gymnastics Competition of the Italian General Exposition in 1898. The site is the perfect spot to be used as an urban playground.
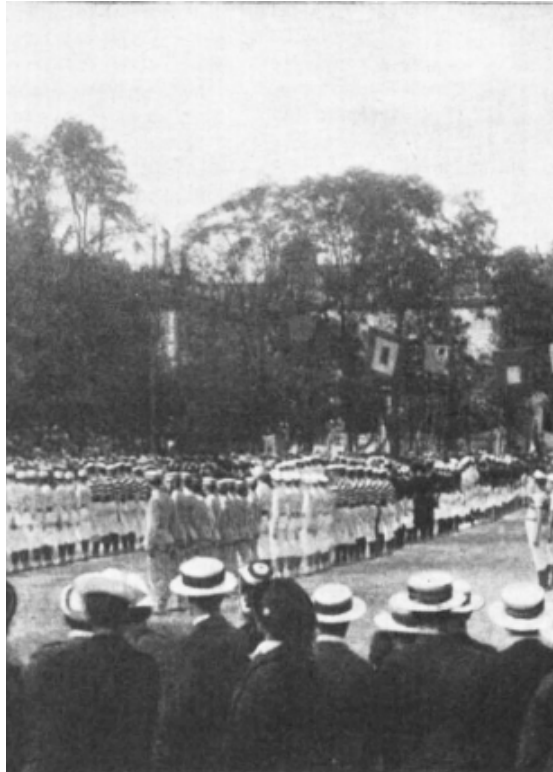








## Site Strategies

I propose to take away the existing carparks and dedicate the whole site for public leisure. I am going to pedestrianise the whole block for better human access. This will gain us 80% of the area for recreational space.


The Block



**Unbuilt Area**  100%



**Vehicle Roads**  33%



**Carparks**  25%



Exisiting
**Leisure Space**  10% → Proposed 90%
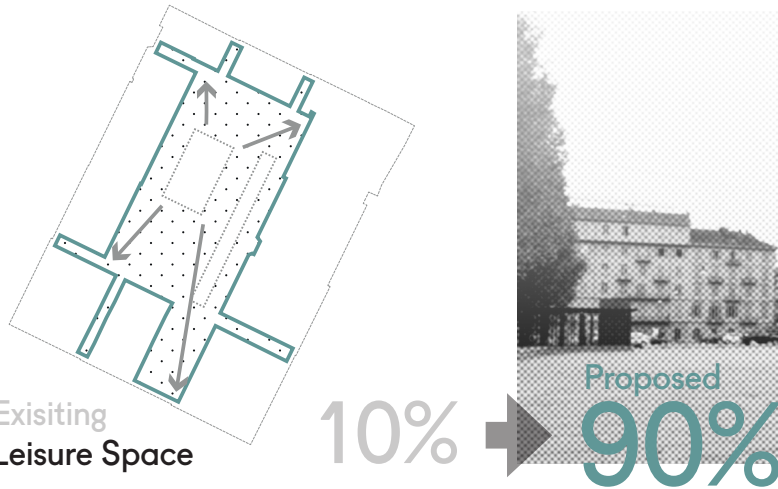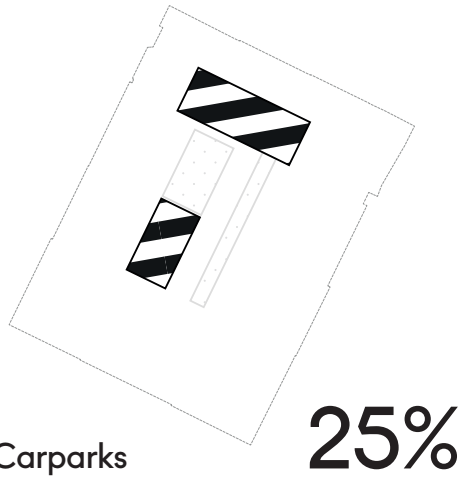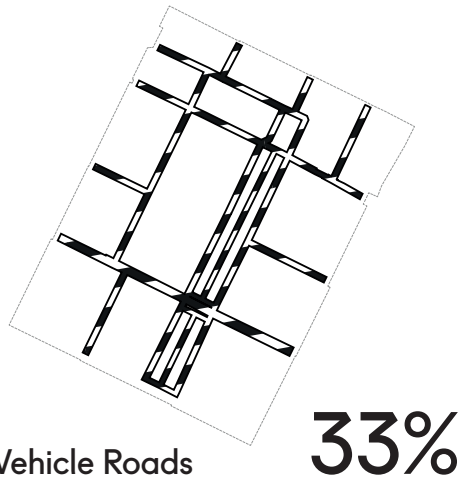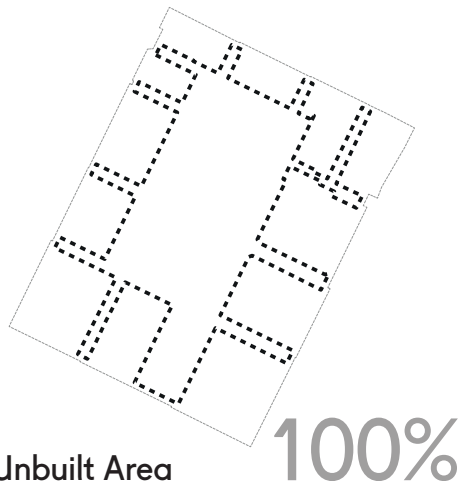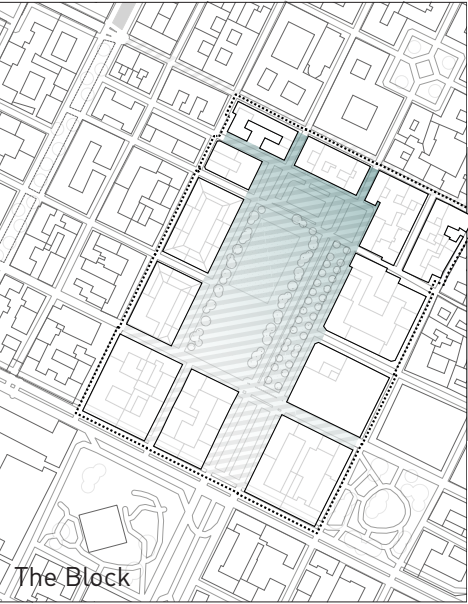
Below shows the massing diagrams for the sports complex to sit. The complex will be parked against an existing building, to create a generous piazza and for maximum sun gain.


Site Axis


Sense of Arrival
University
North
South
Entrance Plaza


Quiet
Kids
Experiential
Sporting
Loud
Fast   Slow
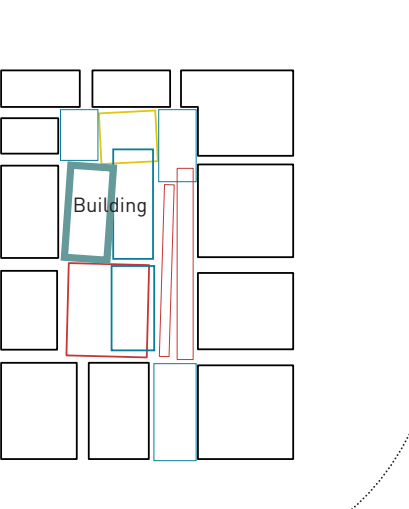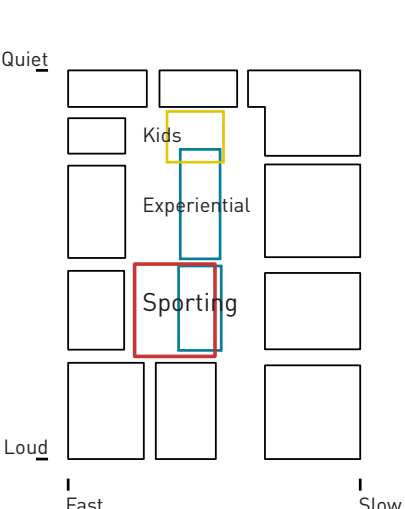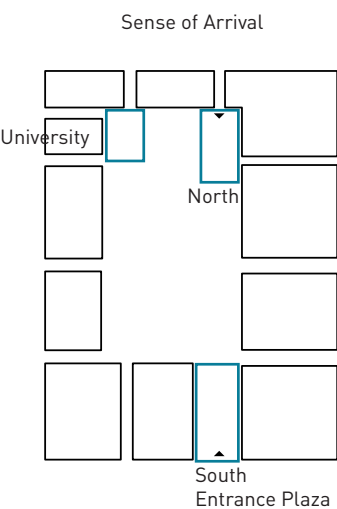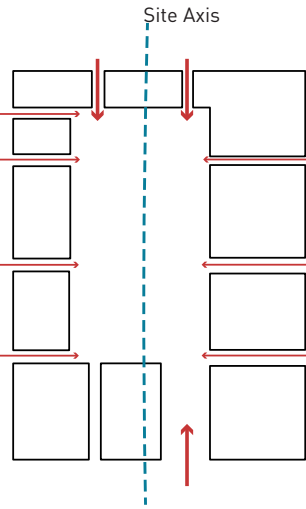

Building
Sunpath

## Key Moments

The project aims to reactivate the city and its citizens by promoting sports. Encouraging people to participate in sports and the building acts as a springboard for them.

It is knitted into the urban fabric, it is more than just a sports complex, instead, it is an urban playground. The piazza acts as a pleasure garden, there are facilities for all generations.
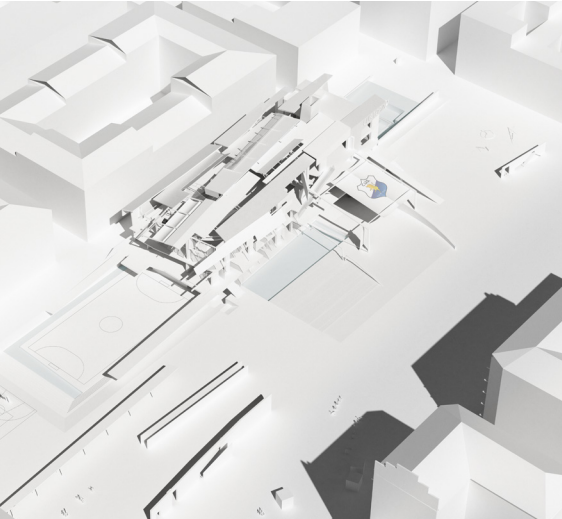
In the piazza, there are open-air gym equipment, large open space for Tai-Chi, dedicated skateboarding ramps, open-air theatre and more...

People are not forced to do sports, they can just come to relax. Sensory experience plays an important role within the project, there are key moments that I would like the public to be able to experience.

The architecture is enabling, it consists architectural elements that can manipulate the microclimate within, it's constantly changing.

Atmospheric quality are also considered, fog fountain is installed in the piazza. Allowing children to play as well as to cool down the piazza.

Within the building, there are experiential spaces in different levels. At the basement, people can look out to the outdoor pool, to get the experience of being underwater, without getting wet. Seeing mini-waterfall while exercising in the gym, listening to the sound of flowing water while resting. Having a shower in "the rain" not a cubicle. Jumping from an indoor space right into the outdoor pool.









Piazza in Summer                Piazza in Winter                Outdoor Swimlane                Enabling Architecture
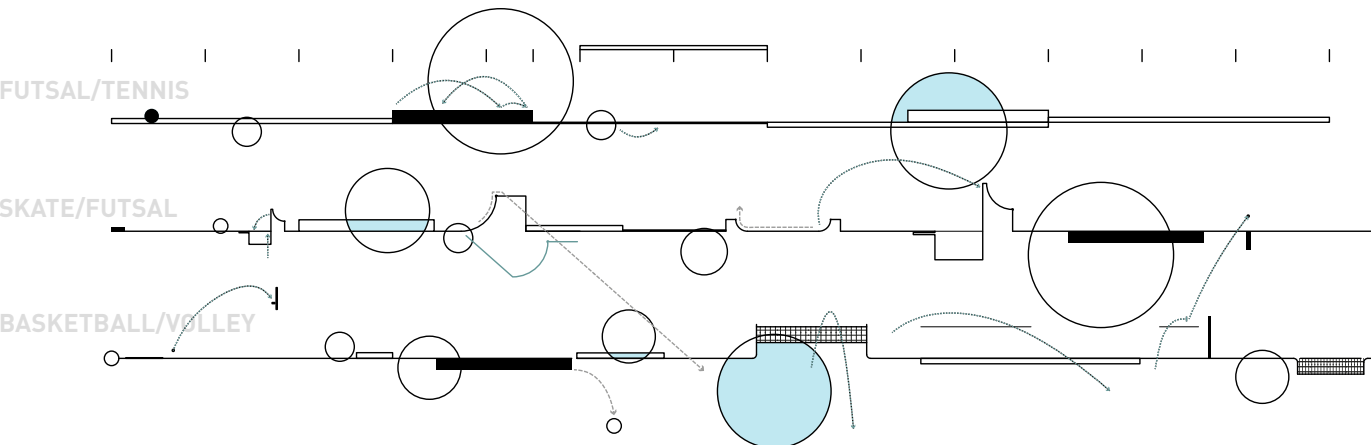
## Organisation and Requirement

The project is built for the City of Torino. It is going to be able divert the traffic from the existing CUS Torino sports complexes, as they are now too crowded both for the university students and the general public.
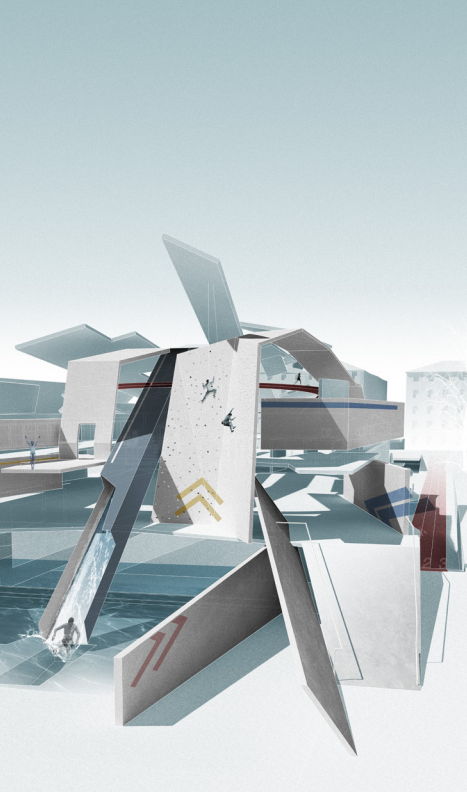
The sports complex will match the other CUS Torino complexes, it opens from 9am to 11pm-serving the local inhabitants of all ages, around 250 people per day.
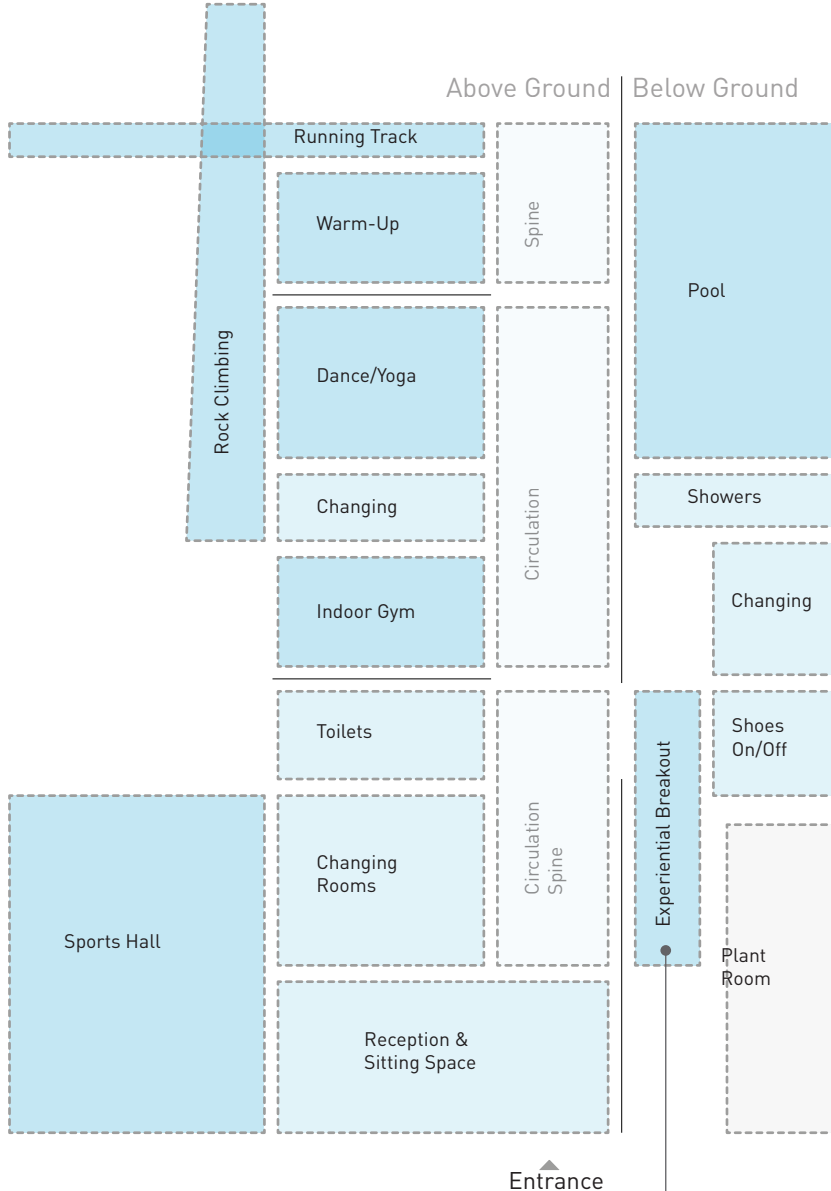
It will provide indoor and outdoor multipurpose courts, indoor and outdoor swimming pool, dance and yoga space, indoor long jump and running track, gym and changing facilities.

Below are the organogram showing sequence of spaces within the building



FUTSAL/TENNIS

SKATE/FUTSAL

BASKETBALL/VOLLEY
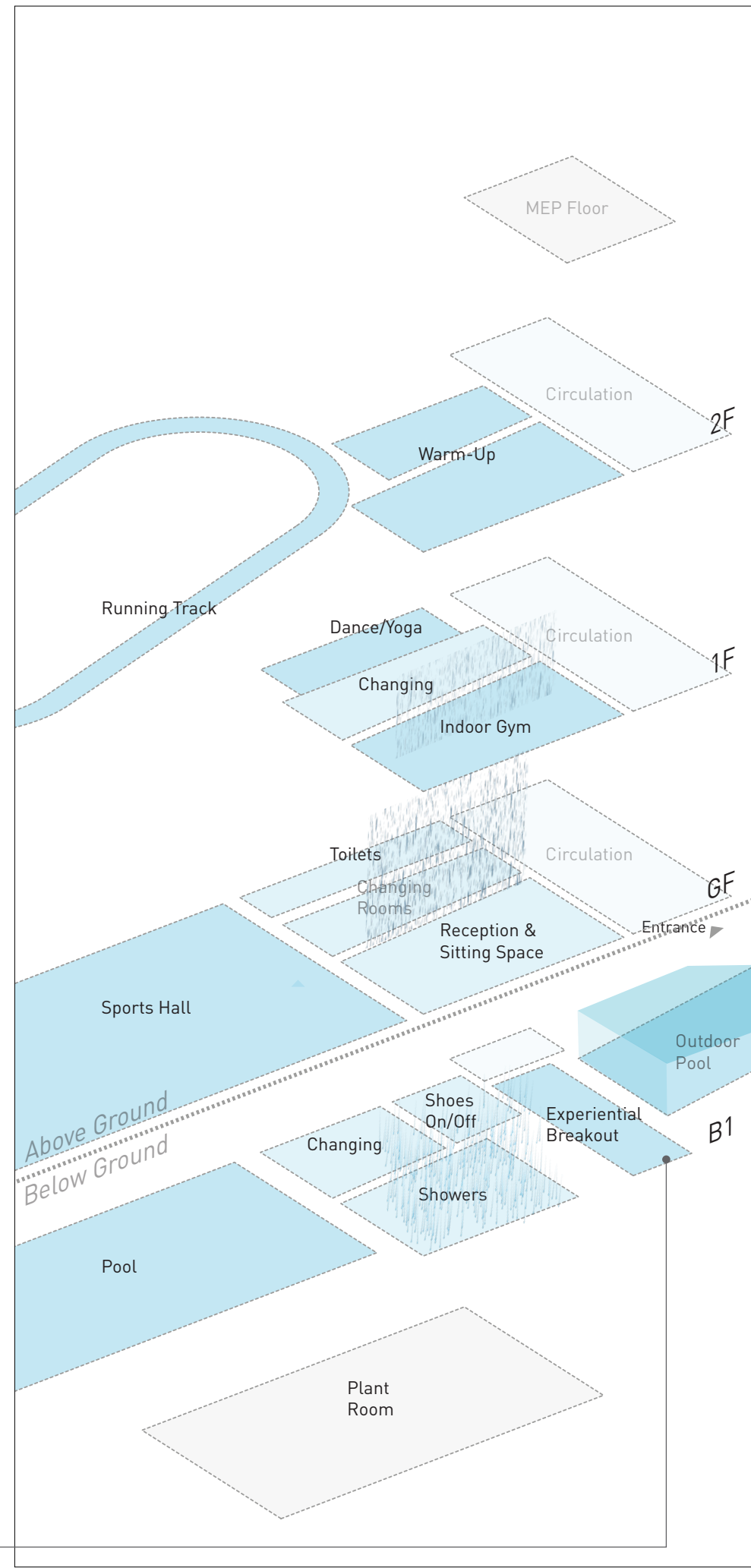
Timeline of Sports Events



Above Ground | Below Ground

| | |
|---|---|
| Running Track | |
| Warm-Up | Pool |
| Dance/Yoga | |
| Changing | Showers |
| Indoor Gym | Changing |
| Toilets | Shoes On/Off |
| Changing Rooms | Experiential Breakout |
| Reception & Sitting Space | Plant Room |

Rock Climbing

Spine

Circulation

Circulation Spine

Sports Hall

Entrance



MEP Floor

Circulation          2F

Warm-Up

Running Track          Dance/Yoga          Circulation          1F

Changing

Indoor Gym

Toilets          Circulation          GF

Changing Rooms

Reception & Sitting Space          Entrance

Sports Hall          Outdoor Pool

Above Ground          Shoes On/Off          Experiential Breakout          B1

Below Ground          Changing

Pool          Showers

Plant Room





Internal view of the sports hall          The experience being 'underwater'

## Design Development
## Preliminary Work

The language of this project mainly came from the aesthetics of the devices I made as they were very sharp and precise. Here the models are made with card and all hand-cut emphasising on the linearity, influenced by Turin being the city of speed, its planning grid and the linearity of the site.

It began by just throwing pieces of scrap offcuts together. The later ones were more considered in proportions however the process is very fluid, they were all done without fixed plans, since the results can be more interesting.

Aside from physical models. a lot of work has also gone through to get the right diagram of the plan.
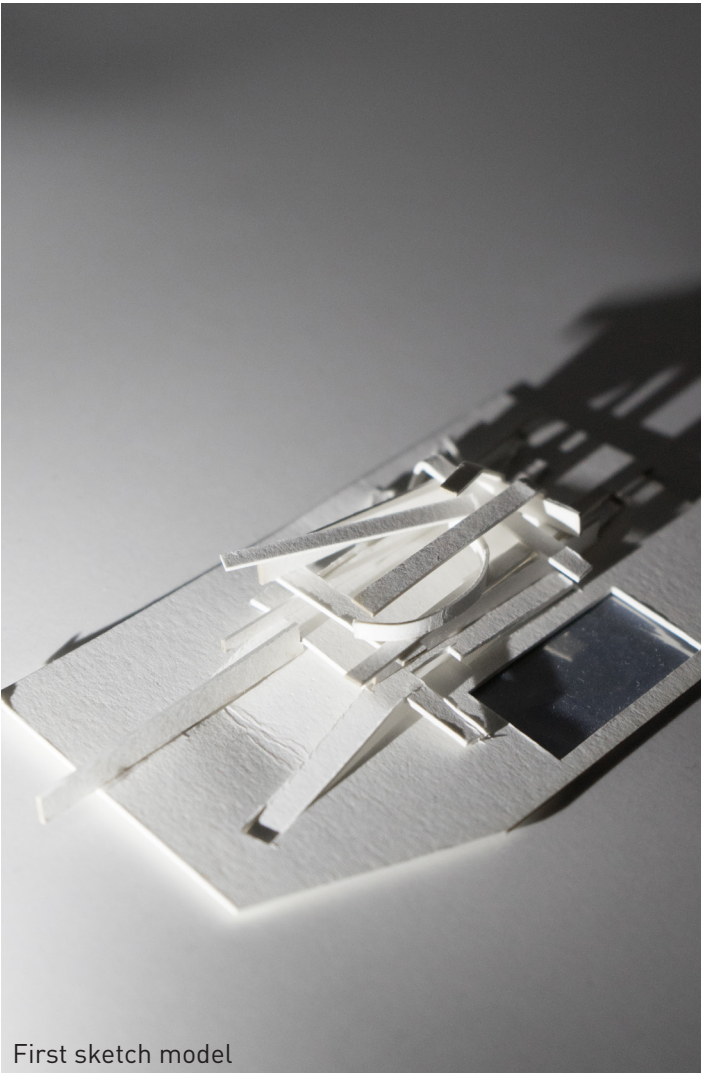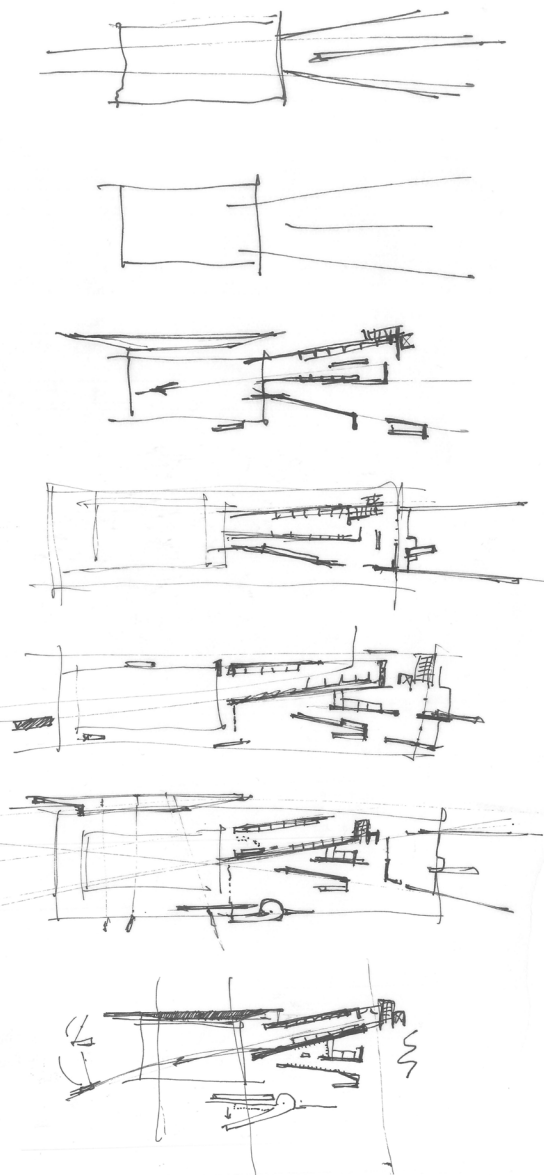


First sketch model
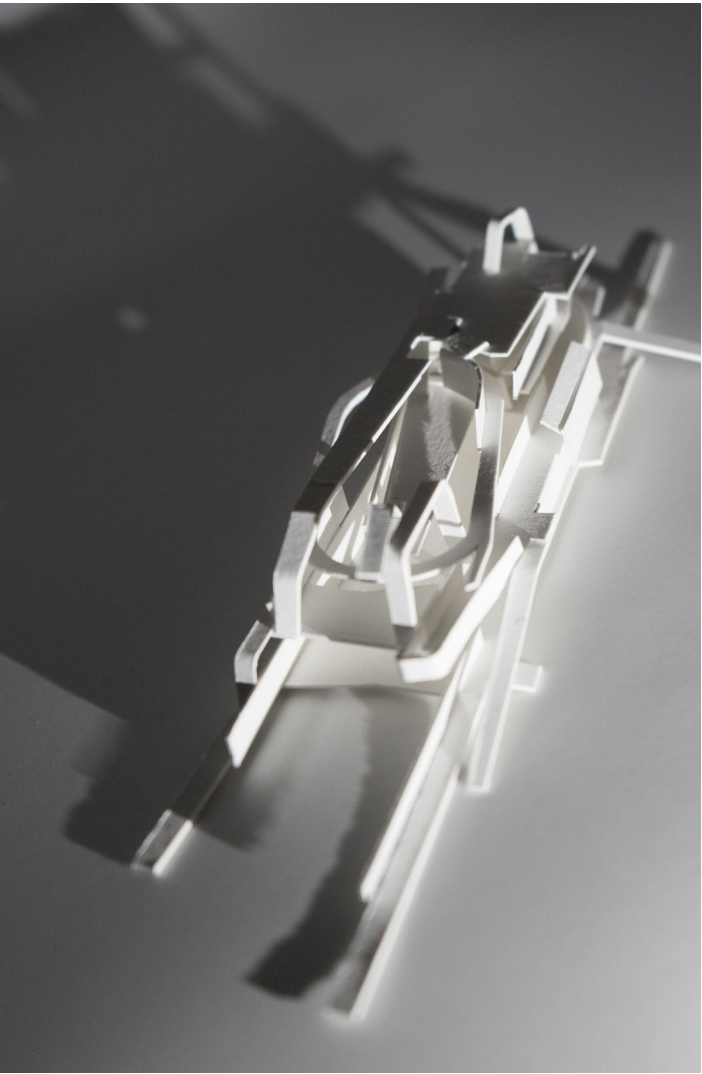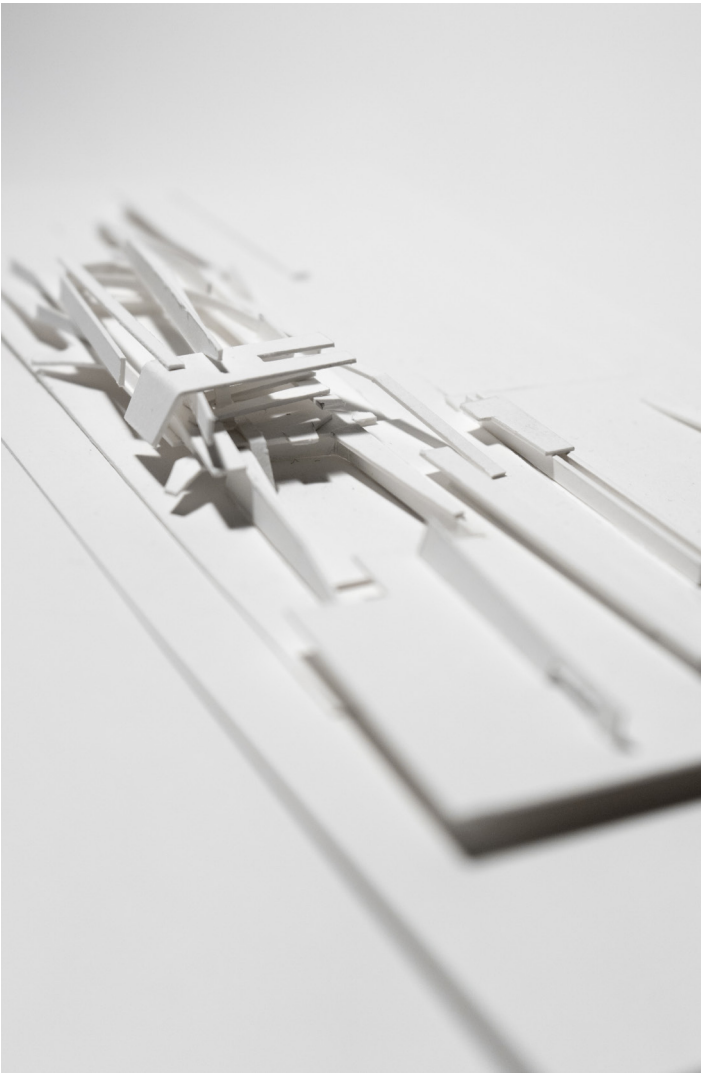
## 1:500 Card Model

The design was later developed into a model of a larger scale 1:500, the proportion of spaces within the building being more thought out. The first model was made as such shown on the right, however it did not have a roof as I was working from the bottom upwards, in plan.

After I have got the plan working, I then move on to designing the roofscape of the building. The roofscape was built on the previous unfinished model. Below shows the design process and images on the right shows the final model.
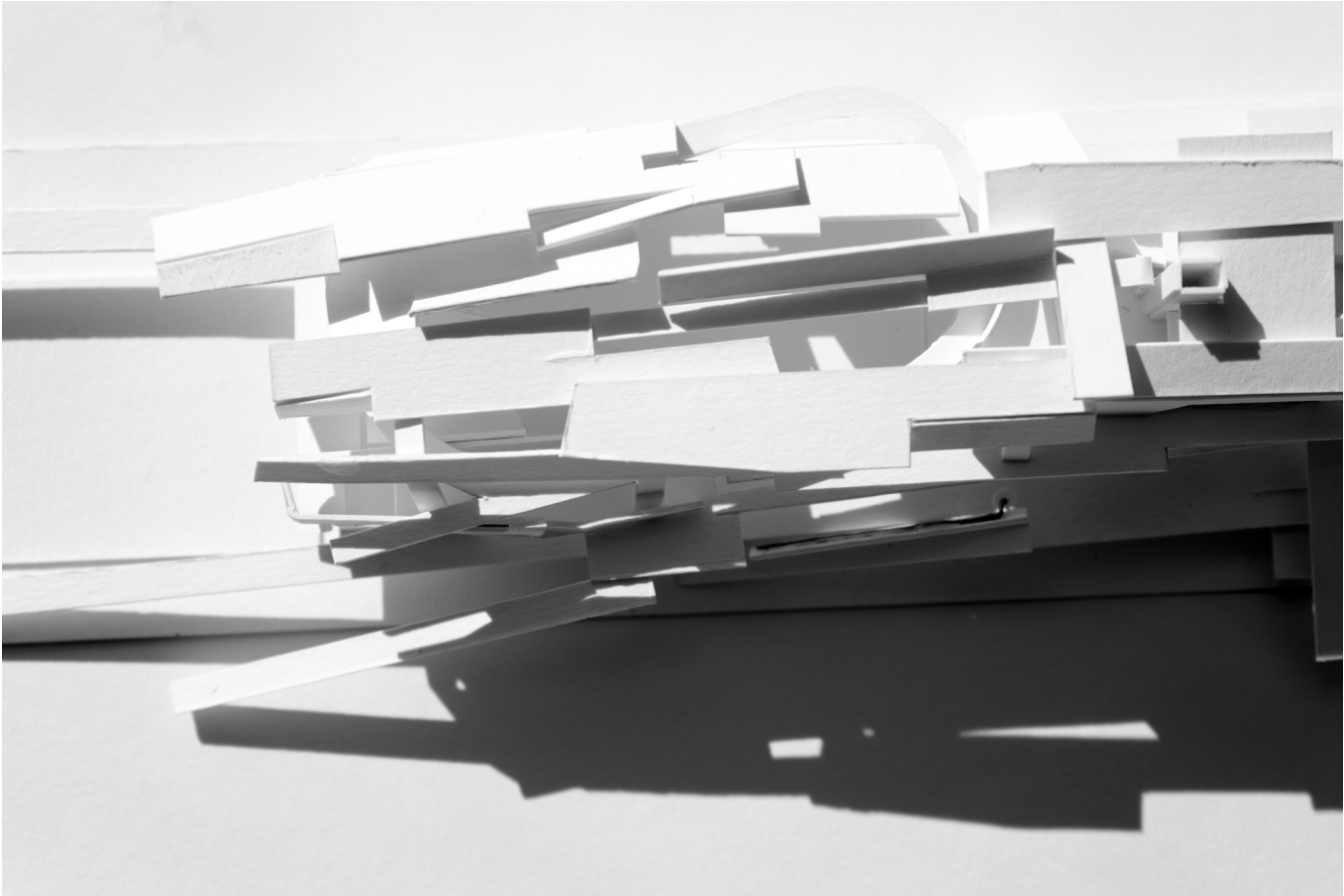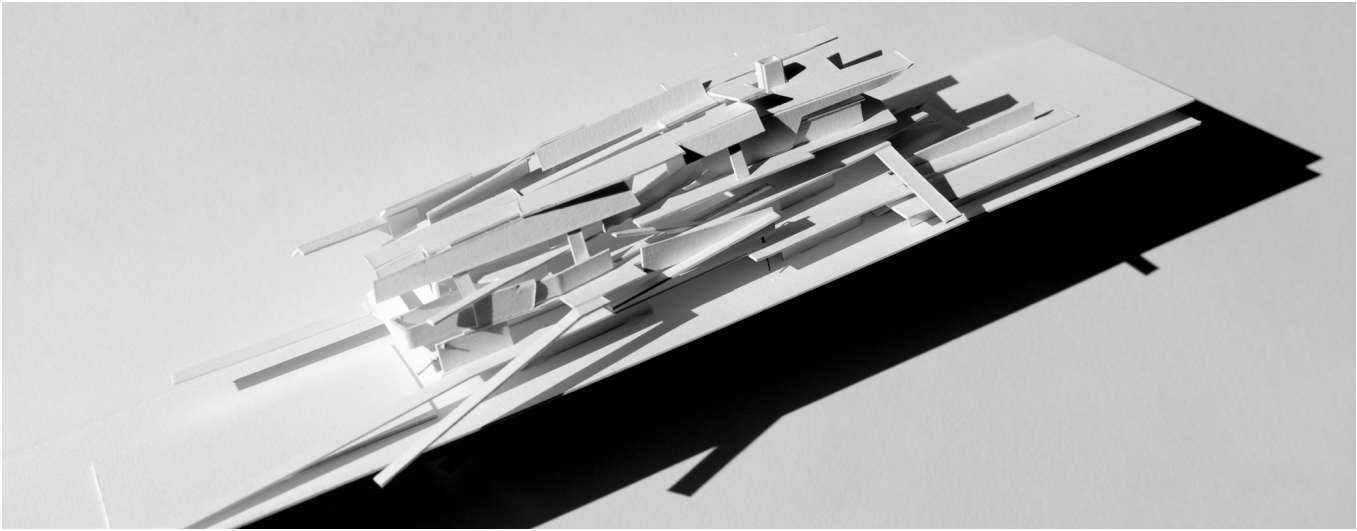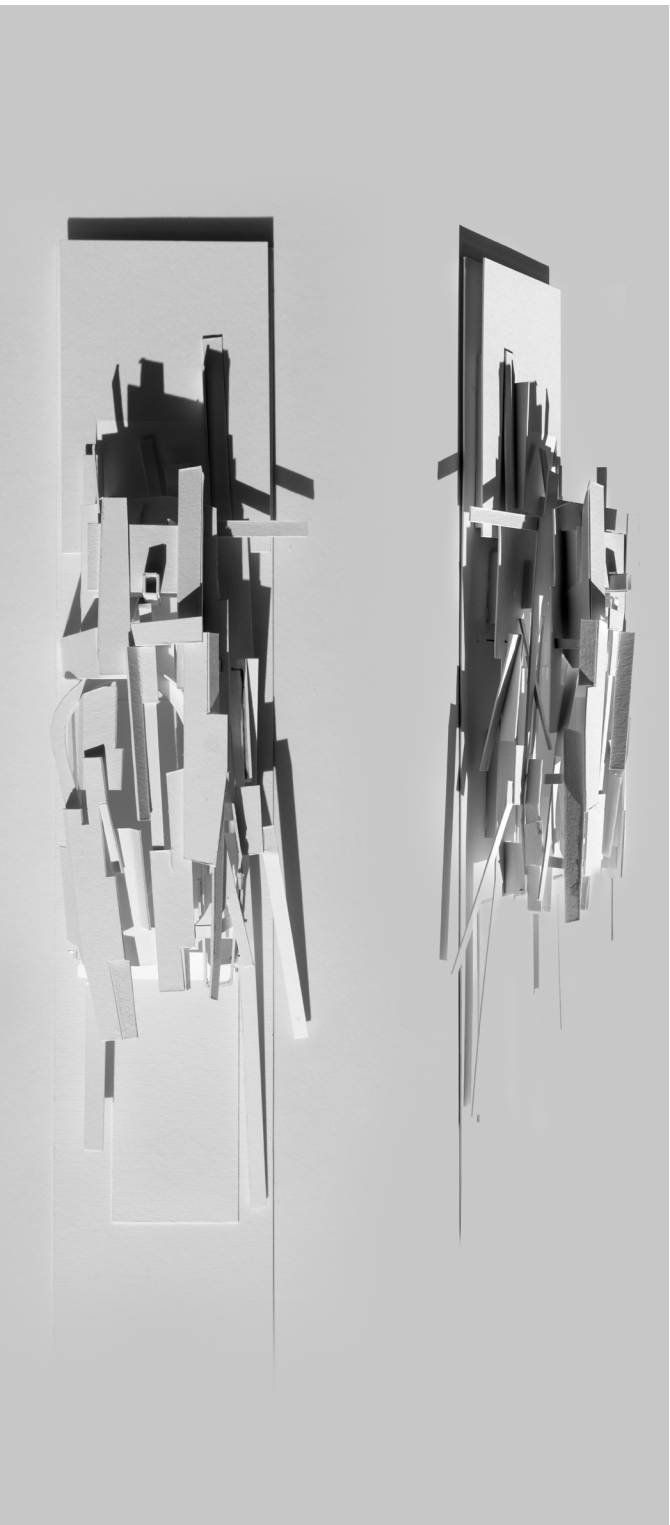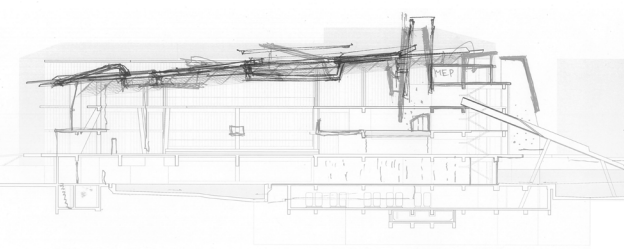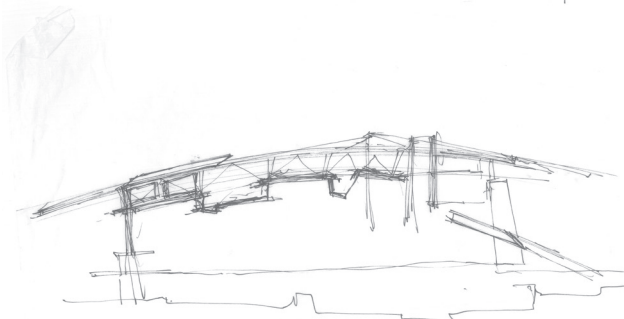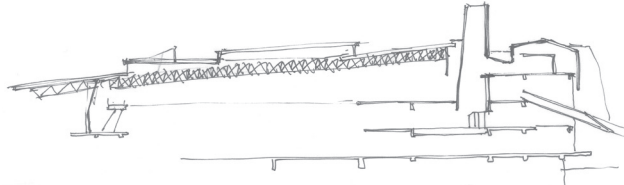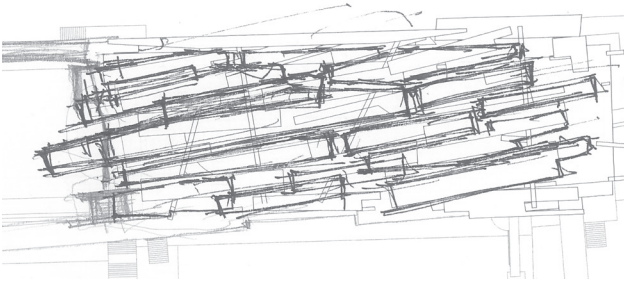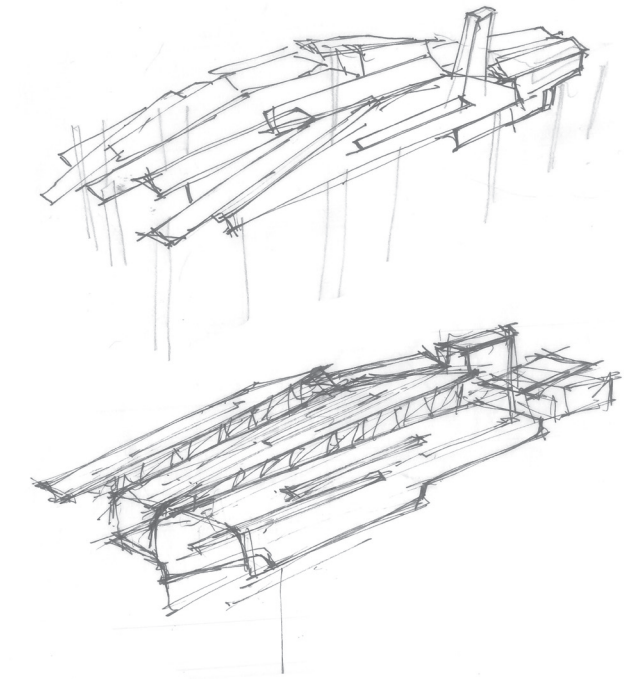
## Environmental Strategy

Turin is located on the humid subtropical climate zone, in contrast to the Mediterranean climate characteristic of the coast of Italy.

Winters are moderately cold but dry, summers are quite hot in the city centre. Temperature can be as high as 31°C and down to -6°C.

Rain falls mostly during spring and autumn; during the hottest months.

According to the weather data, Turin does not receive a lot of wind, which is challenging to create natural ventilation in the building.

Since my building is a sports complex, the occupants will be generating a lot of heat, therefore ventilation is an important issue.

The sports complex is designed to be semi-open, in order to attract as much people to come into the building, as well as, understanding the fact that it can get really hot in Turin.

As a semi-open building, its ability to **adapt** is required for it to be successful. The strategy is to make the architectural elements move- such as, opening the windows when it is very hot; activating the heating system and close all the windows to save energy during the winter.

The augmented elements will be able to manipulate the microclimate within the building.

Hottest: 31°C          Coldest: -6°C



Dry Bulb Temperature (C) - Hourly
TORINO_ITA
1 JAN 1:00 - 31 DEC 24:00



Sun Path Diagram in 3D
with Dry-Bulb Temperature



Wind-Rose
TORINO_ITA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 48.89% of the time = 4283 hours.



Tilting Roofscape for optimum opening for light and air

Sliding Walls to create opening for ventilation

Rotating windows programmed to open up to a certain percentage

Airflow direction

Getting as much daylight as possible to the basement pool

## Environmental Tactics

I wanted to open the building as much as possible, therefore the roof is not able to close entirely. There are gaps that let the light in and let the hot air out, however it will have to deal with the problem of rain and harsh sunlight.

I am looking into retractable mechanism that allows me to cover these gaps when it is needed. Retractable glass panel will move into position when the rain comes, providing shelter from rain without losing the income of sunlight.

Retractable canopy is used to provide shade in the hot summer, also to diffuse light so the sportsmen do not get strong sunlight in their eyes. When it is not in used, the canopy is tucked under one of the roof panel.

Gap Spacing      2m          3m          6m          3m
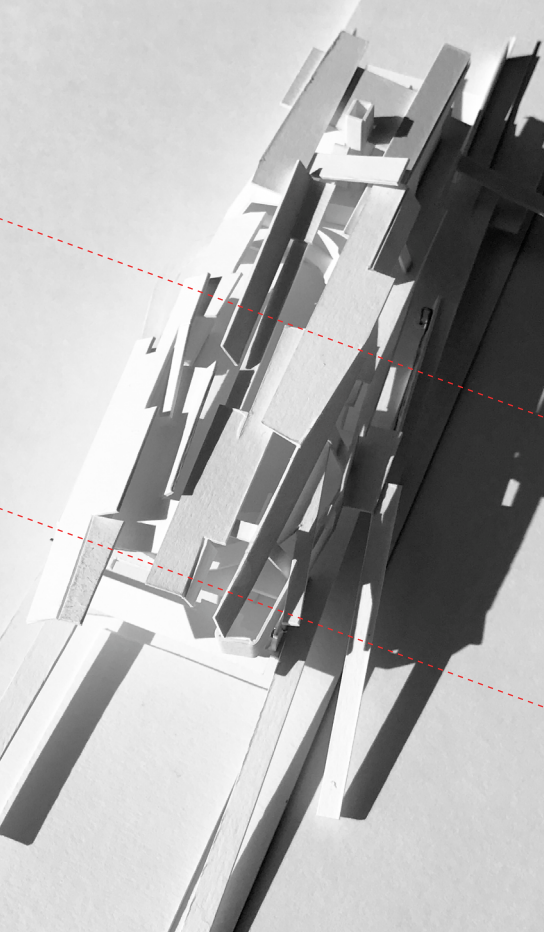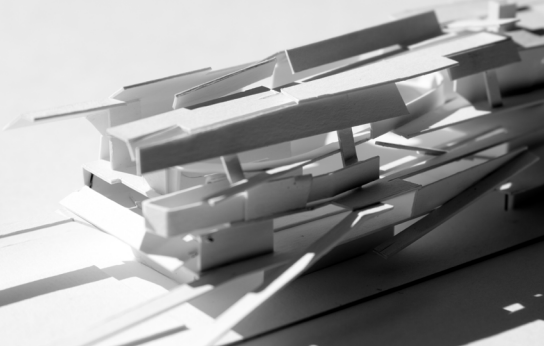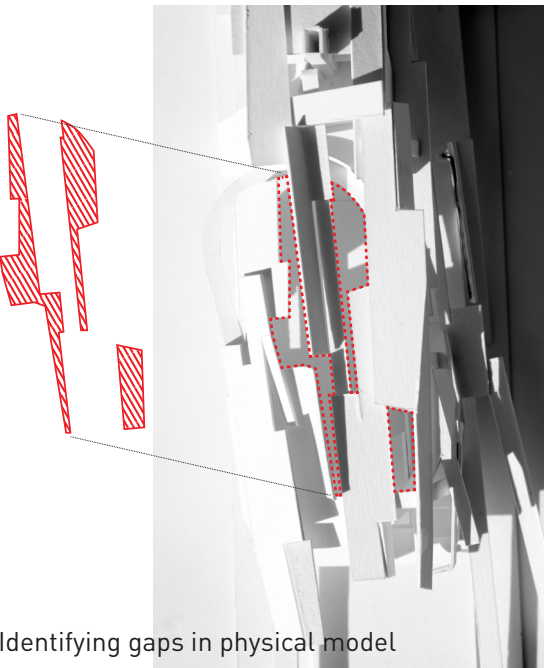


Identifying gaps in physical model





Section showing solutions against rain and sun



Early model testing the flap mechanism.



For the largest gap (6m), a retractable canopy is used, that is adequate to provide shade and shelter. The structure is supported by thick RC columns.
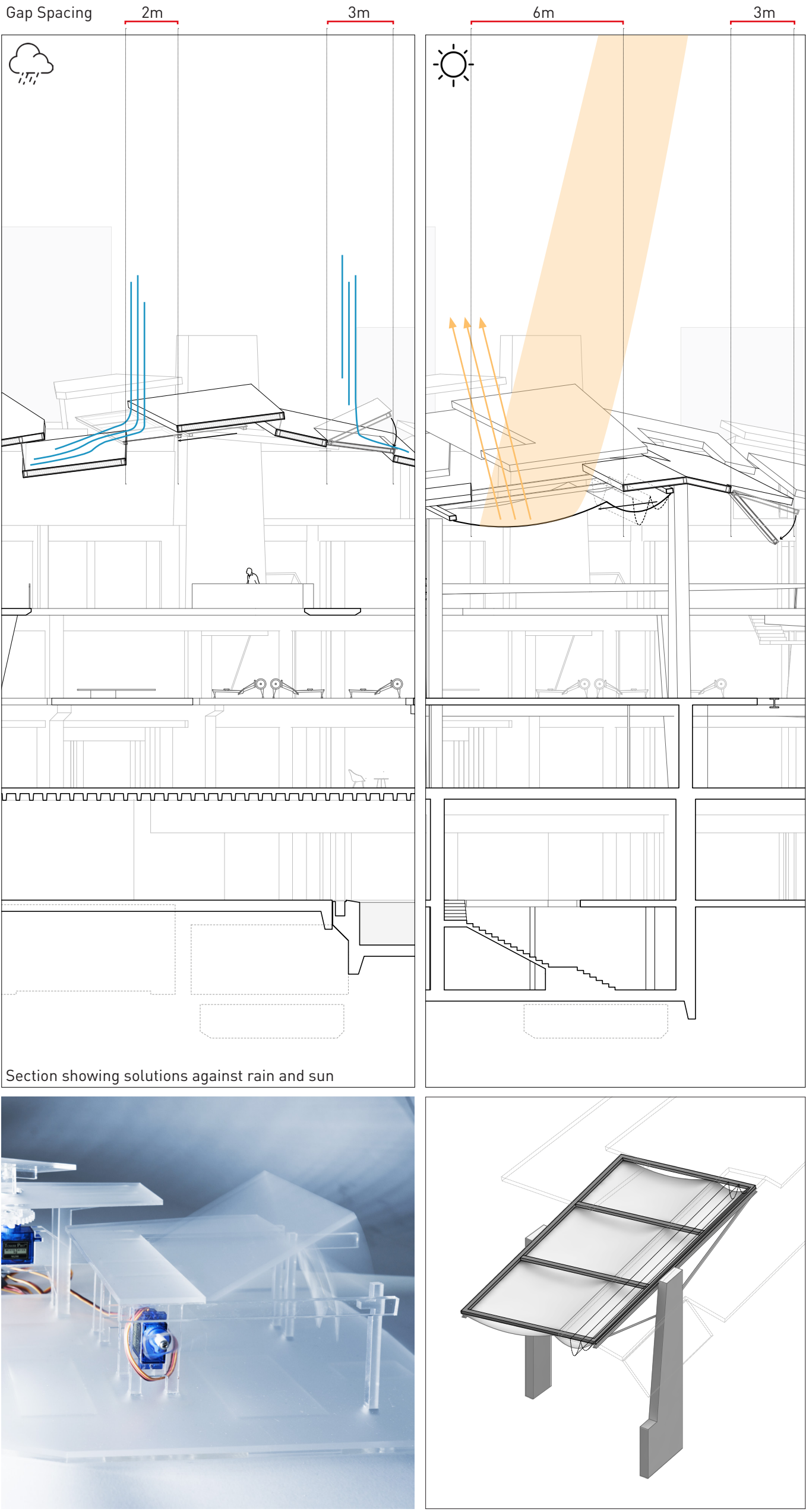
## Envelope:
## Open, Semi-open and Enclosed

The sport complex does not have a define line of envelope, technically it is a semi-open building. The idea is to create an 'envelope' formed by dynamic roofscape and spontaneous facade.

The back of the building (North) will be more enclosed than the sports hall as the there will be less heat generated by the occupants in that area.

The swimming pool has to be entirely enclosed to prevent energy and heat loss during the winter as well as not disturbing the whole mechanical ventilation system and the ozone generated down there.

|||||||  Buffer Zone
———  Enclosed

Ground Floor

First Floor

Second Floor

Basement Floor 1
Swimming Pool
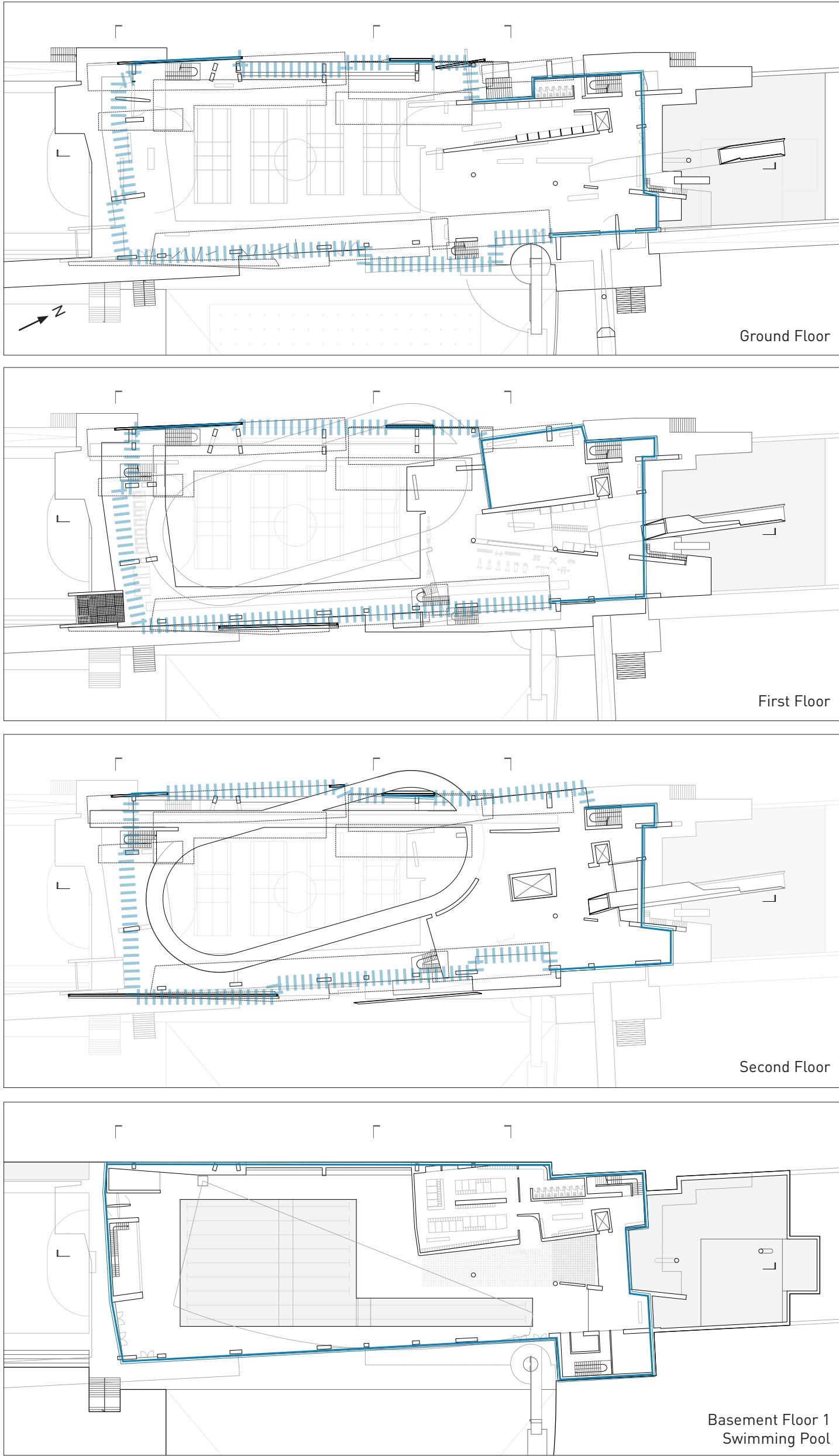
## Structural Strategy

Reinforced Concrete is intended to be used for the primary structural framework. The roof is intended to be held with a spaceframe structure that sits on top of the concrete columns. Steel frames will be used in the areas that consist glass floors.

RC Floor Plates

GF +2.00

1F +6.00

2F +10.00

Lightweight Roofing

Spaceframe Structure

Concrete Framework

Underside of
Ground Floorslab

Plan at Basement Level
BF -3.00

Long Section: 2 metre
deep beam across

Short Section: Ribbed Slab between beams

Airplane Hanger 1963
Konrad Wachsmann

Ribbed Slab System
in Construction
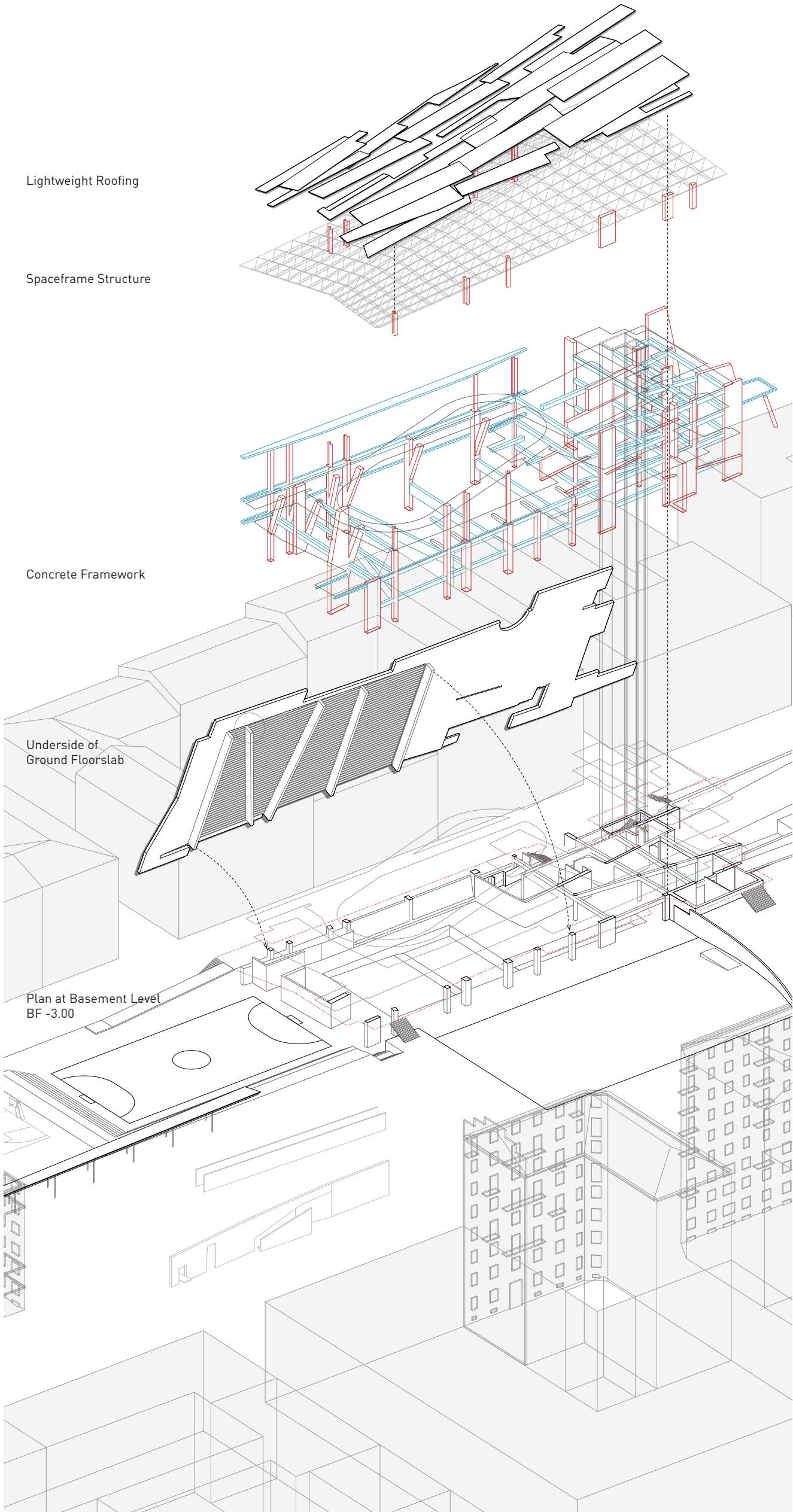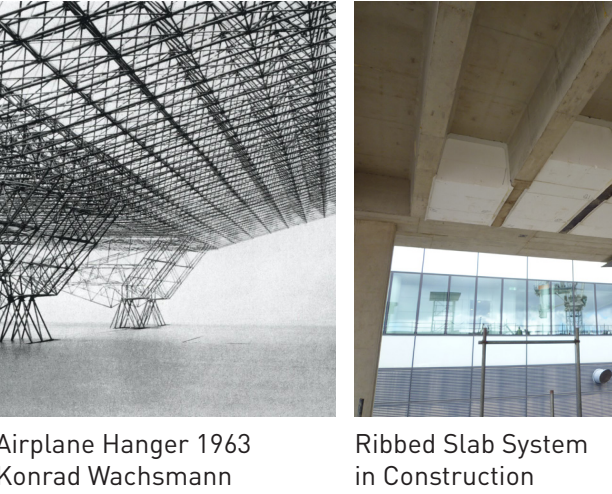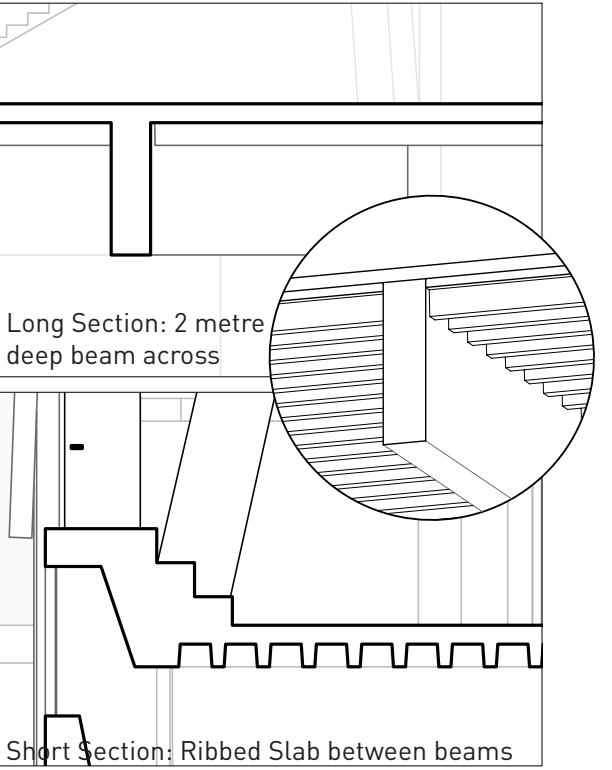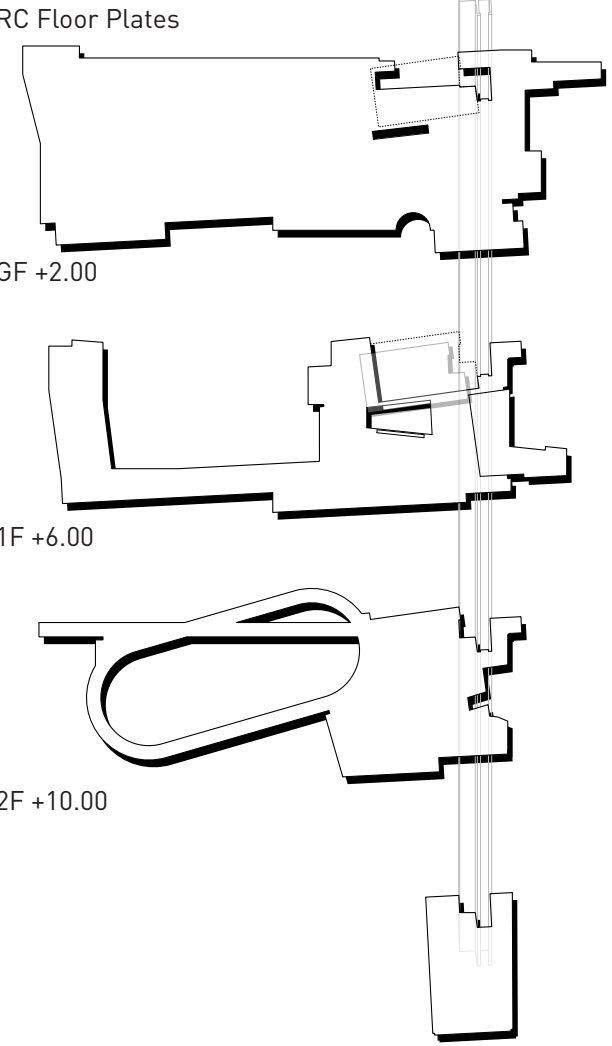
## Augmented Elements
## Physical Testing

Since the first project, I have been working on interactive mechanisms. As mentioned on previous pages, the building has to be able to adapt to different weather conditions with its architectural elements.

Here I started to investigate on moving mechanism by physically modelling and computer coding, and looking to implement the mechanisms in the actual design.

The model investigates 4 different motions:
- rotating
- retracting
- tilting
- flapping

The motions are powered by basic servo motors. Programmed with Arduino, the servo rotates in place when a signal is received.

In this model, infrared sensors are used as the input signal, the detection of obstacles activates the servo motors.




Arduino board


Sensors (Infrared)

Rotating

Tilting

Flapping

Retracting

Servo Motor

```
s1.write (180);
s2.write (0);
s3.write (180);
s4.write (0);
s5.write (180);
```
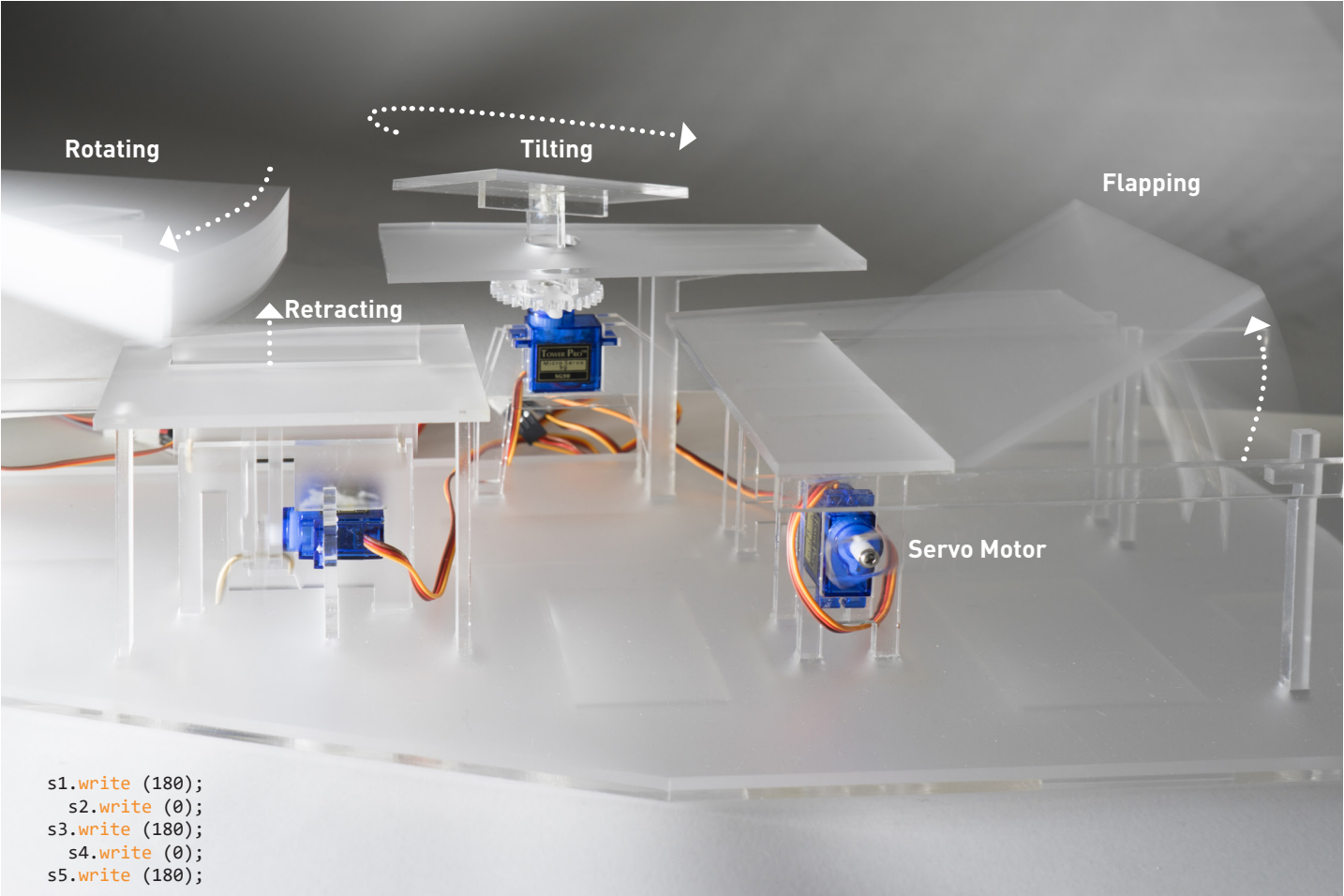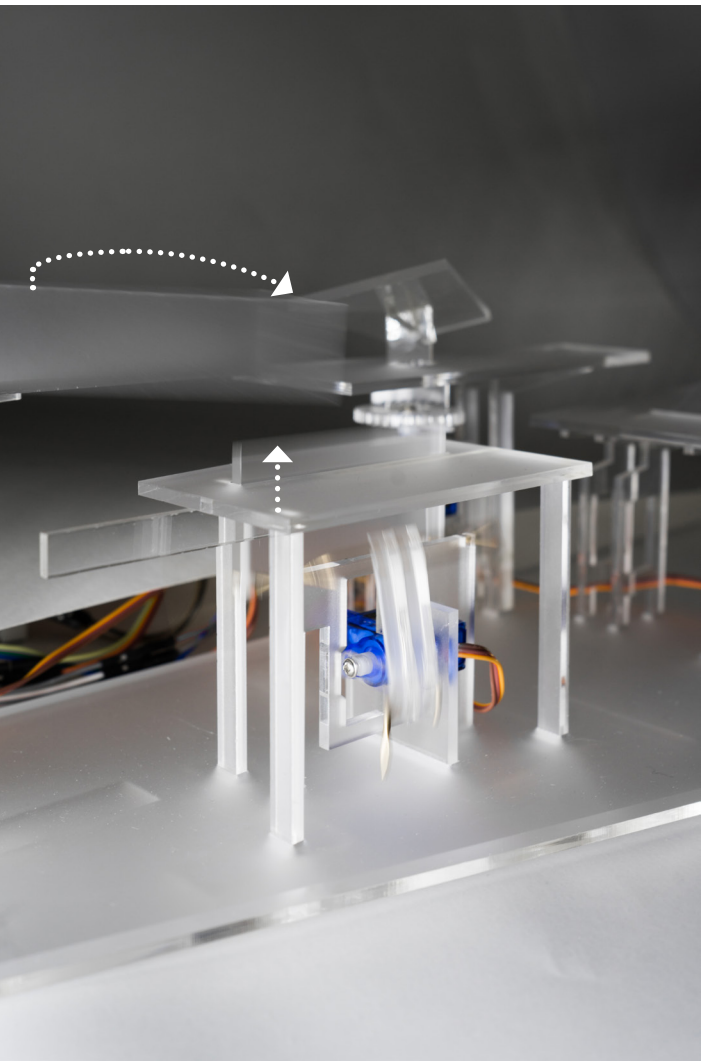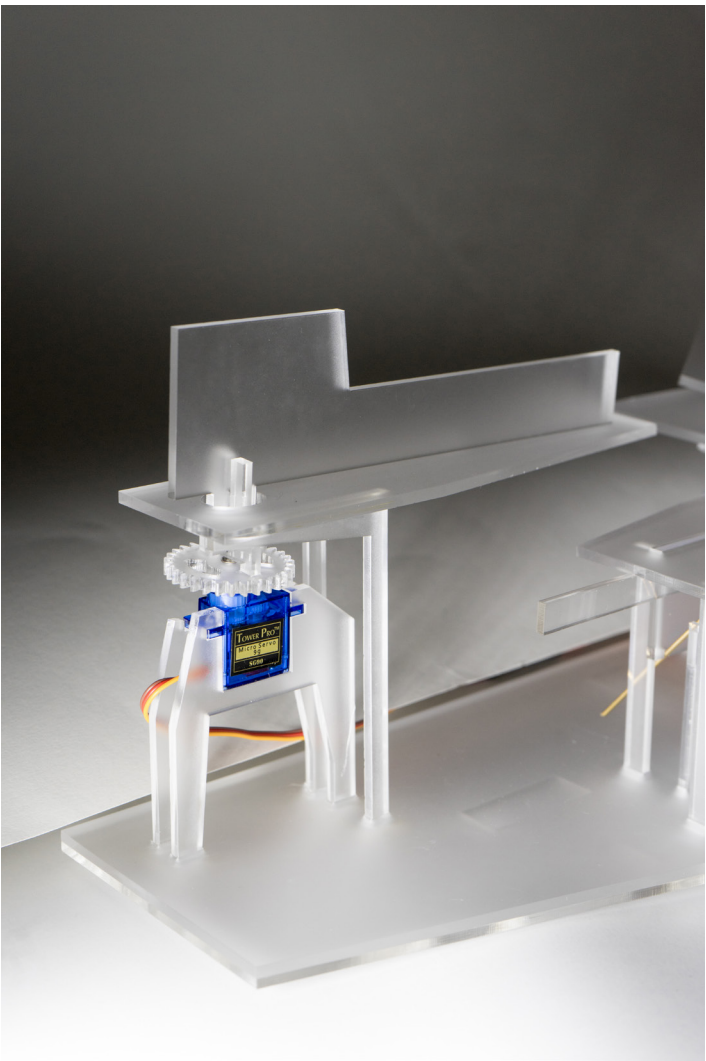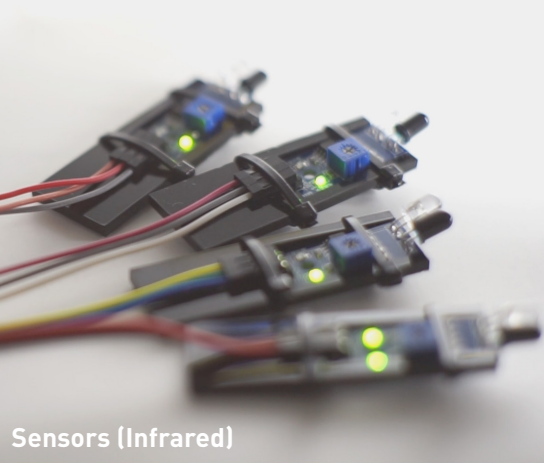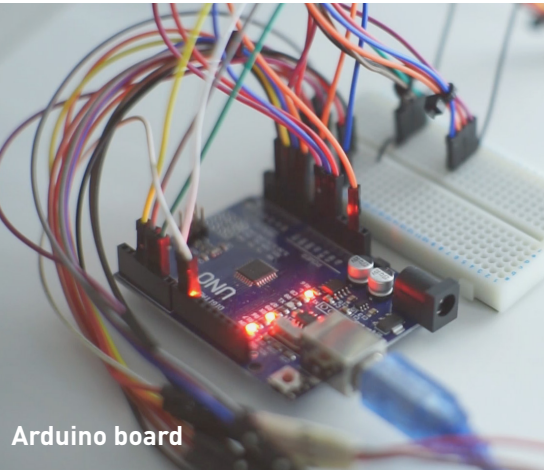
**Side Project - Expandable Library**

Using the same programme, I have also designed an expandable library for relocation of an existing bookstore in the site.

The space will expand as more people step into it, revealing more books behind the walls, to create a more comfortable space for reading.

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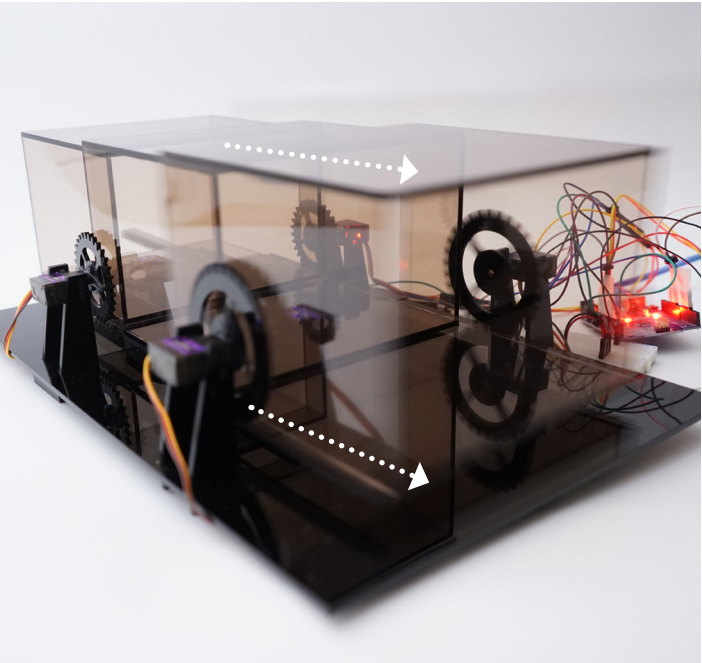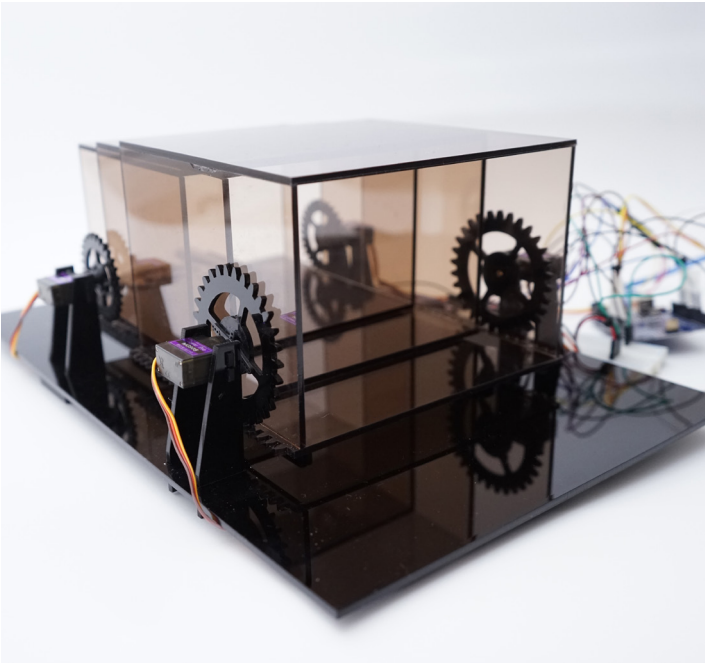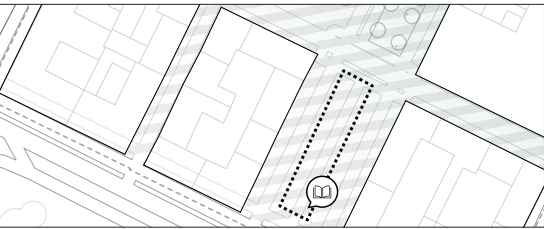
## Digital Experimentations

**Programming for Openings**
Grasshopper allows me to experiment with augmented elements digitally. The windows on the ground floor are programmed to open up to a certain percentage of gaps in the facade, that will allow us to control of wind circulation coming into the building. Data such as temperature, humidity and wind speed can be used as inputs, the row of windows can be programmed to adjust themselves in order to achieve the optimum comfort for the users.


First set of windows to experiment located on Ground Floor

Rhinoceros 3D

Grasshopper

Full Grasshopper Script

Openings

Openings

Coverage in Elevation

Coverage in Elevation
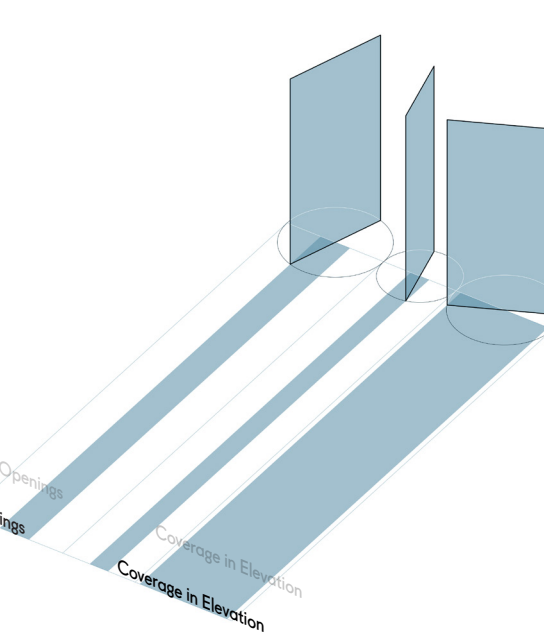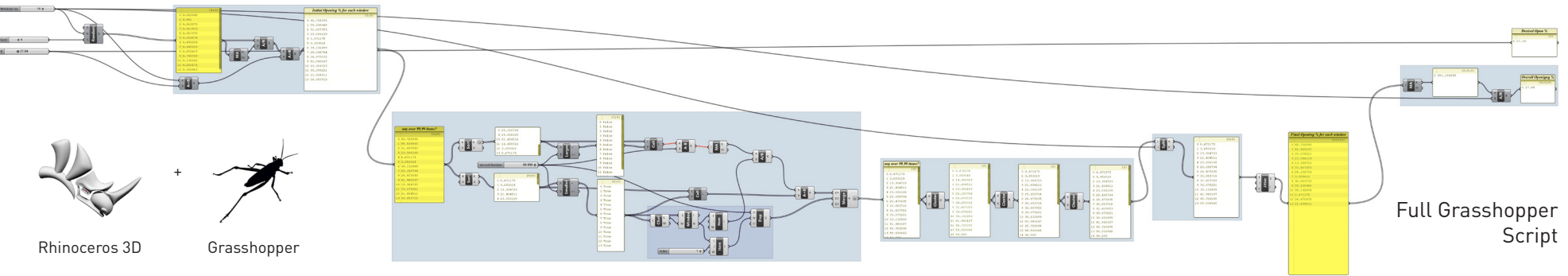
Using this case with 3 windows to show the principle of the script. First began with 3 random numbers and 1 user-defined data that is the desired opening percentage in elevation. The 3 numbers are then fed to generate 3 different degrees of rotate for 3 windows but at the same time maintain the accurate overall openings in the among the total width of the elevation.

Openings: 38%

Openings: 49%

17
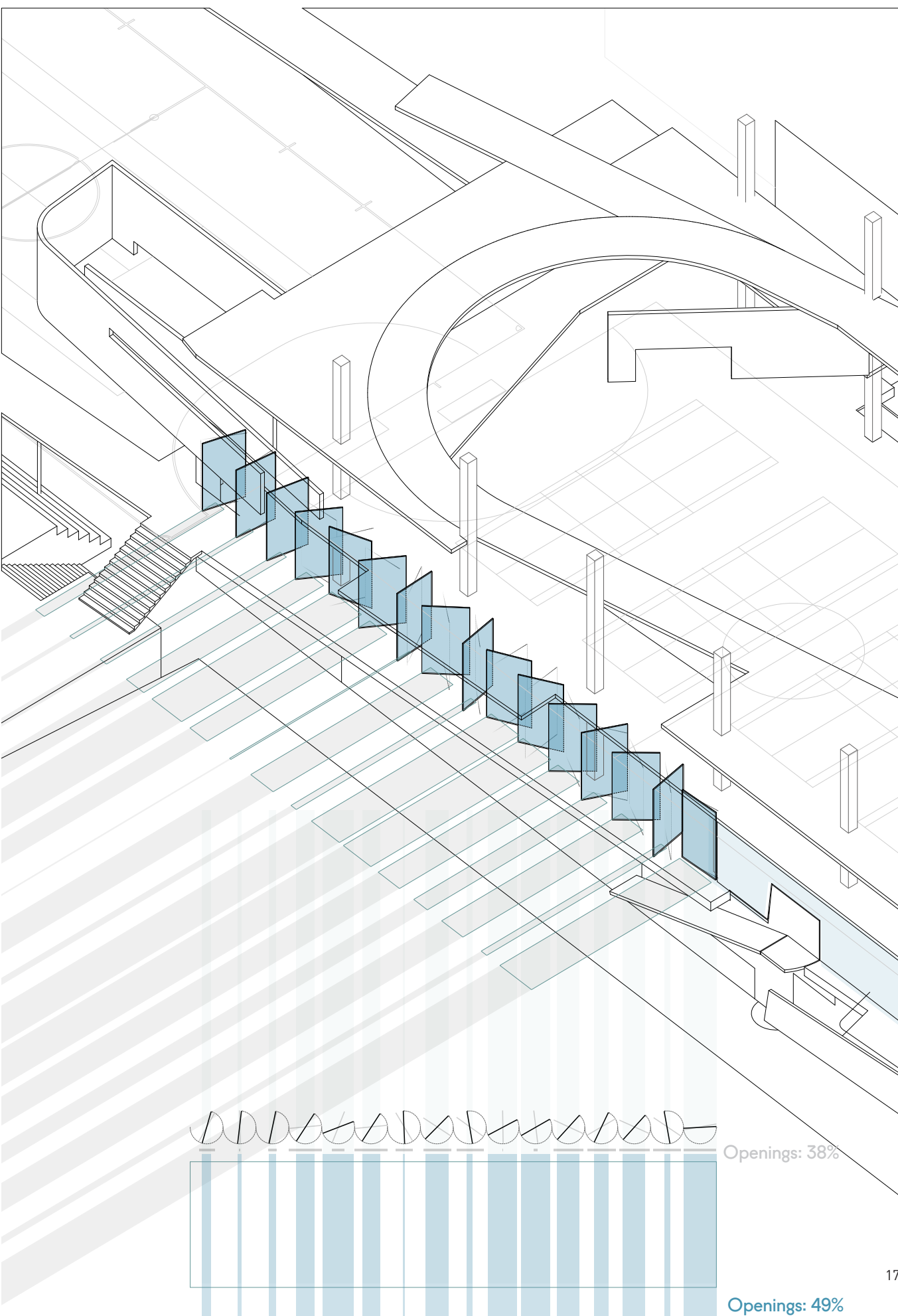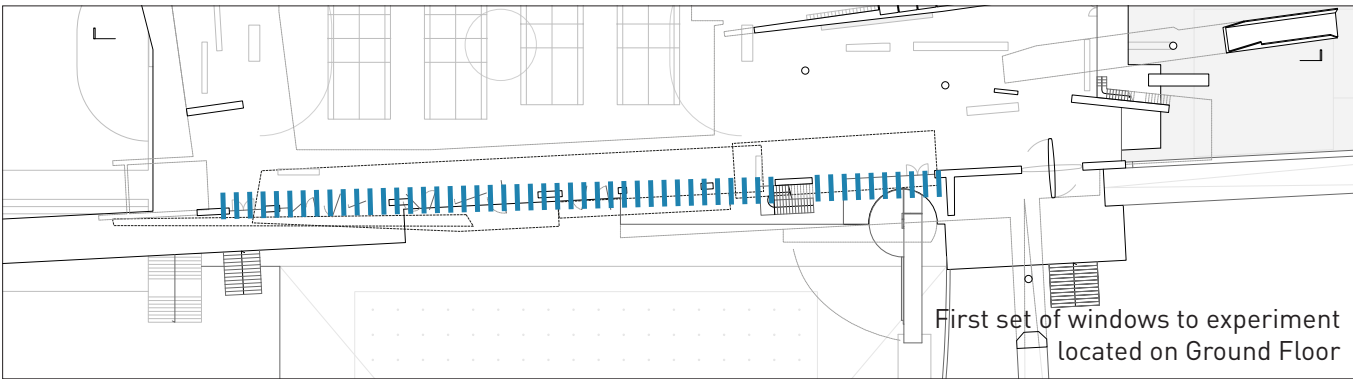
## Fire and Accessibility Strategies

As a sports complex, it can get quite crowded in the building, hence multiple fire-exits are located on the ground floor, the furtherest distance will not exceed 25metres from the centre of the 5-a-side football court.


to GF

Ramp to B

to GF
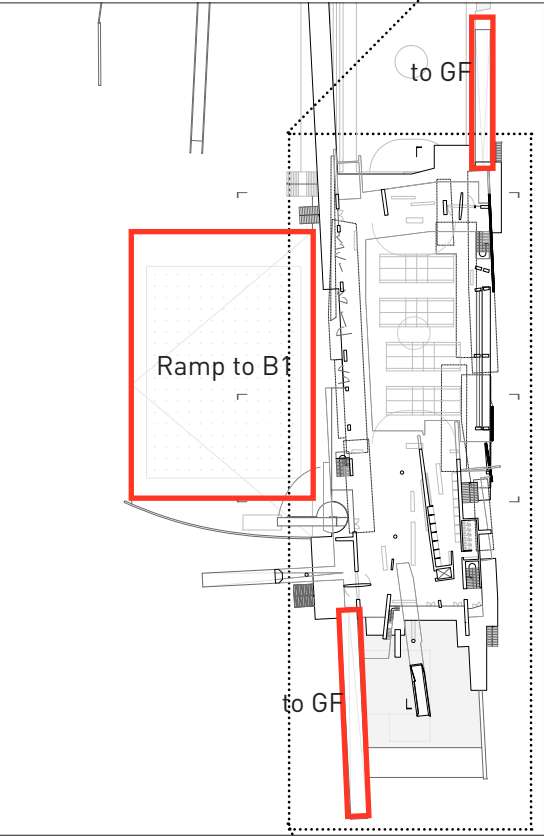
The complex is accessible to everyone, the design in cooperates ramps that lead to the ground and basement levels. The ramps are all 1:12 which is the suitable for disabled wheelchair users.
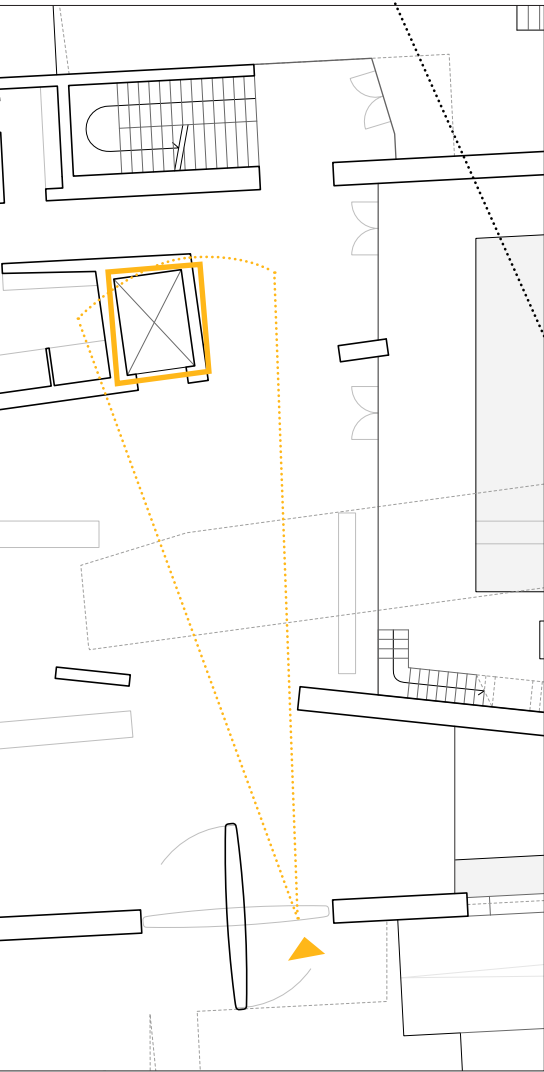


The core is located at the end of the building, it can clearly be seen as it is very close to the spine, visible from the moment you step into the building.


**03**
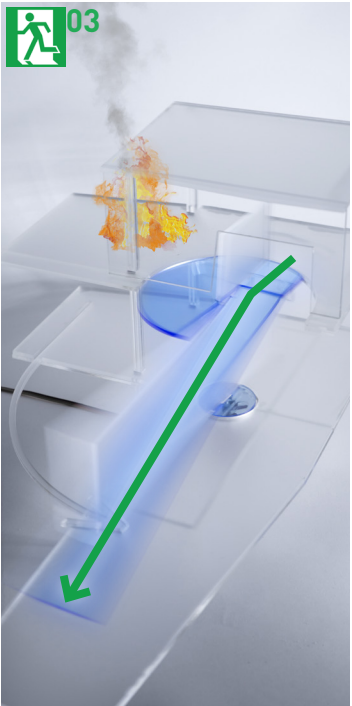
One of the fire exit (EXIT03) is designed as a slide to play but it can act as an evacuation slide (like on airplanes) that go straight out of the building. Programmed to rotate into position when a fire is detected.
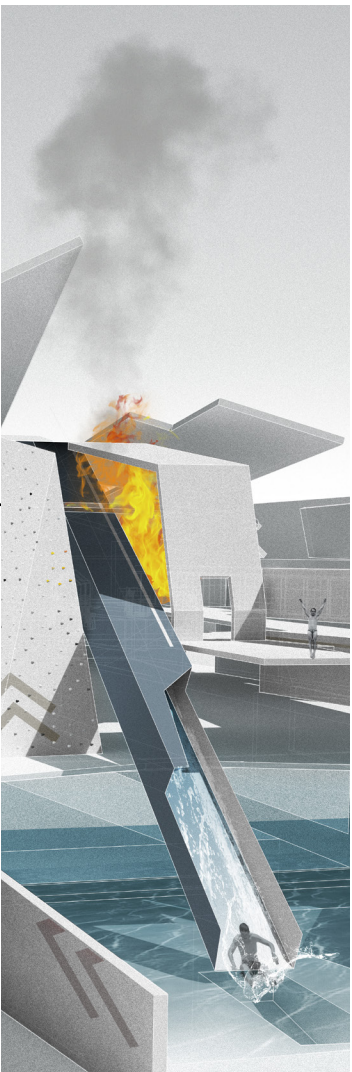


There is a water slide on the north end of the building to the outdoor pool. People can just slide down from the second floor or just jump out from the ground floor into the water in the case of an fire emergency.


**05**    **06**

25m    25m

25m

35m

**03**

**04**

**01**    **02**

FIRE EXIT

🏃 **USCITA**

| | |
|---|---|
| 🟥 | 1:12 Ramp |
| 🟦 | 'Envelope' |
| 🟧 | Vertical Circulation |
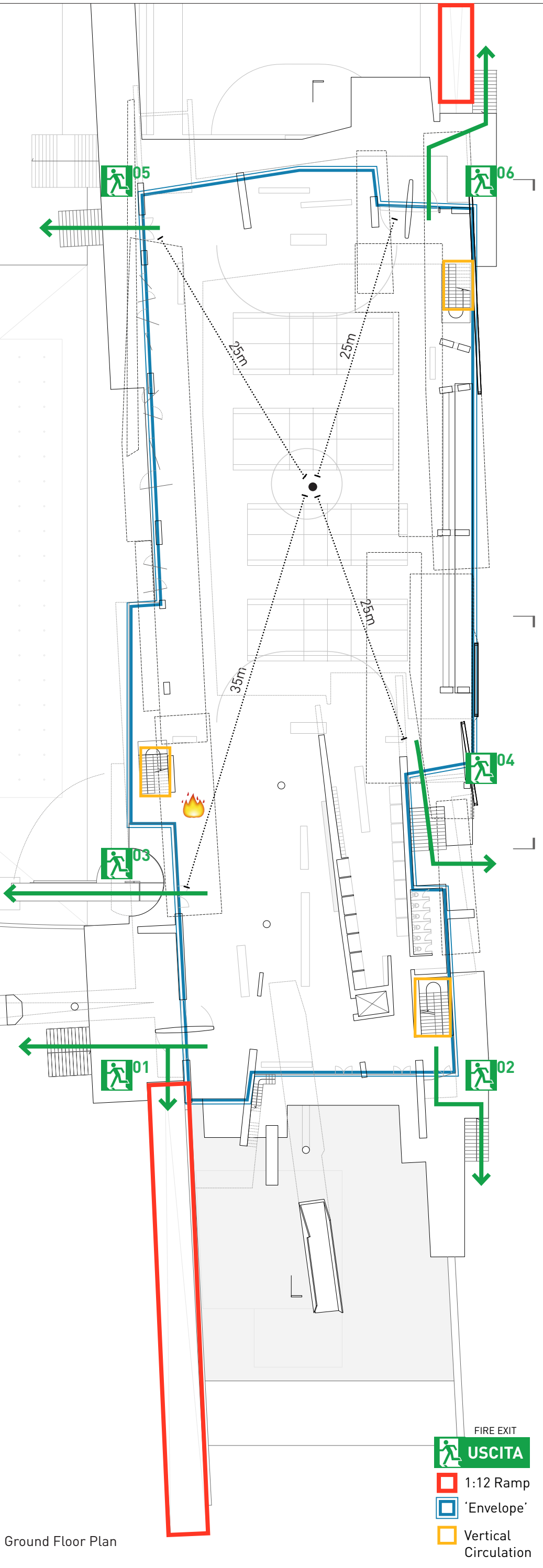
Ground Floor Plan

## M&E and Sanitation System

A whole basement level (B2) is dedicated for plant rooms that is required just for the swimming pools. A set of staircase is lead from the indoor pool down to B2 for servicing.

There has to be water treatment plants for both indoor and outdoor pools. Ozone generators are used for eliminating odors, chlorine, iron, and bacteria. Makeup water tanks for recovering water volume, backwash holding tank is used in the water filtration process. A compressor room is required to operate the facility. The elevator pit is inevitably down at the same level.



MEP Floor (3F)
Elevator Overrun

Half Basement Level
B1

Basement Plant Room
B2


Ozone Generator


Water Filtration

01  Access from Pool Storage (Above)
02  Ozone Generator Room
03  Compressor Room
04  Multipurpose Indoor Pool
05  Pool Divider
06  Filtration Plant for Indoor Pool
07  Filtration Plant for Outdoor Pool
08  Makeup Water Tank
09  Backwash Holding Tank (Underneath)
10  Elevator Pit
11  Outdoor Pool
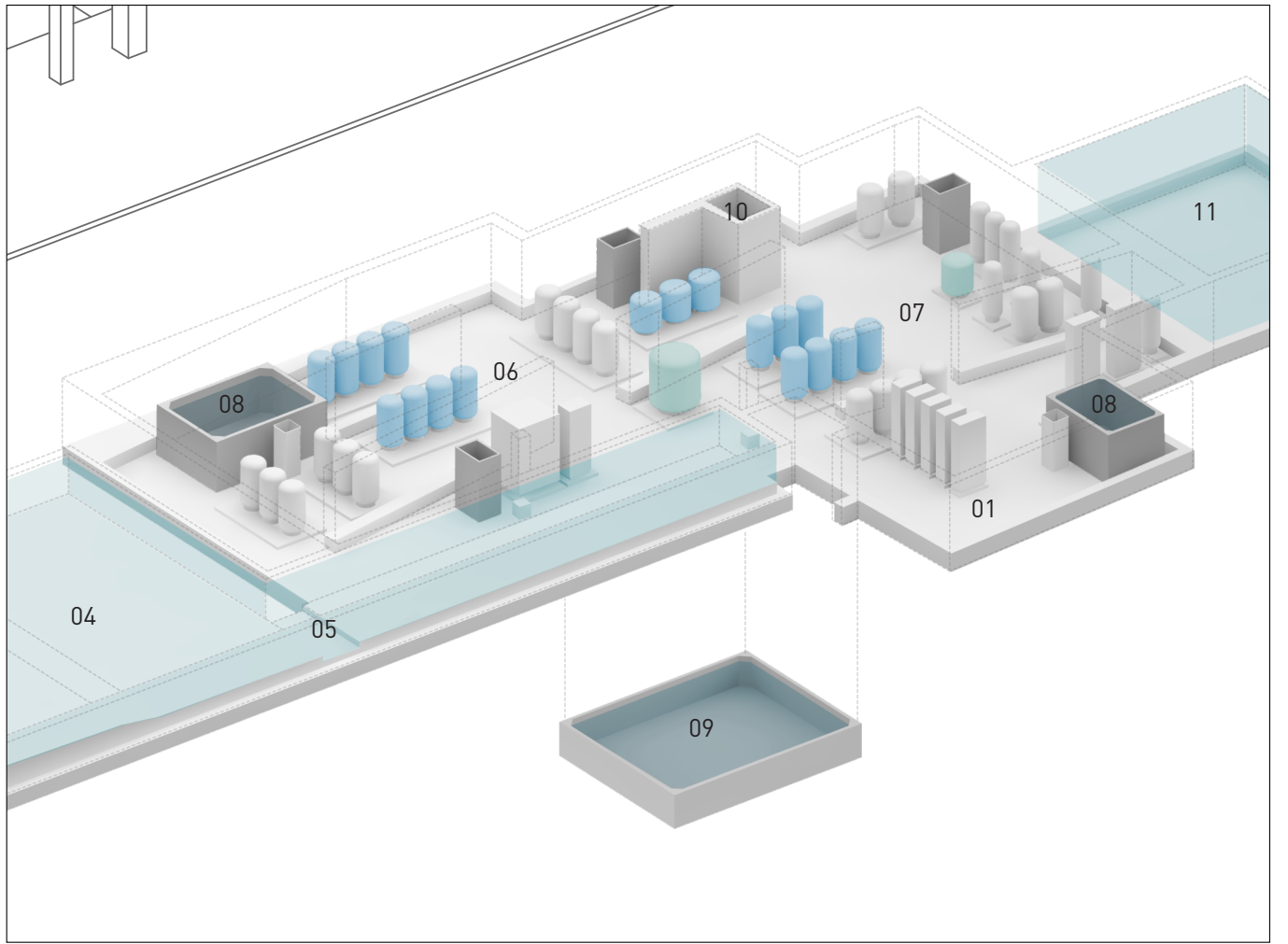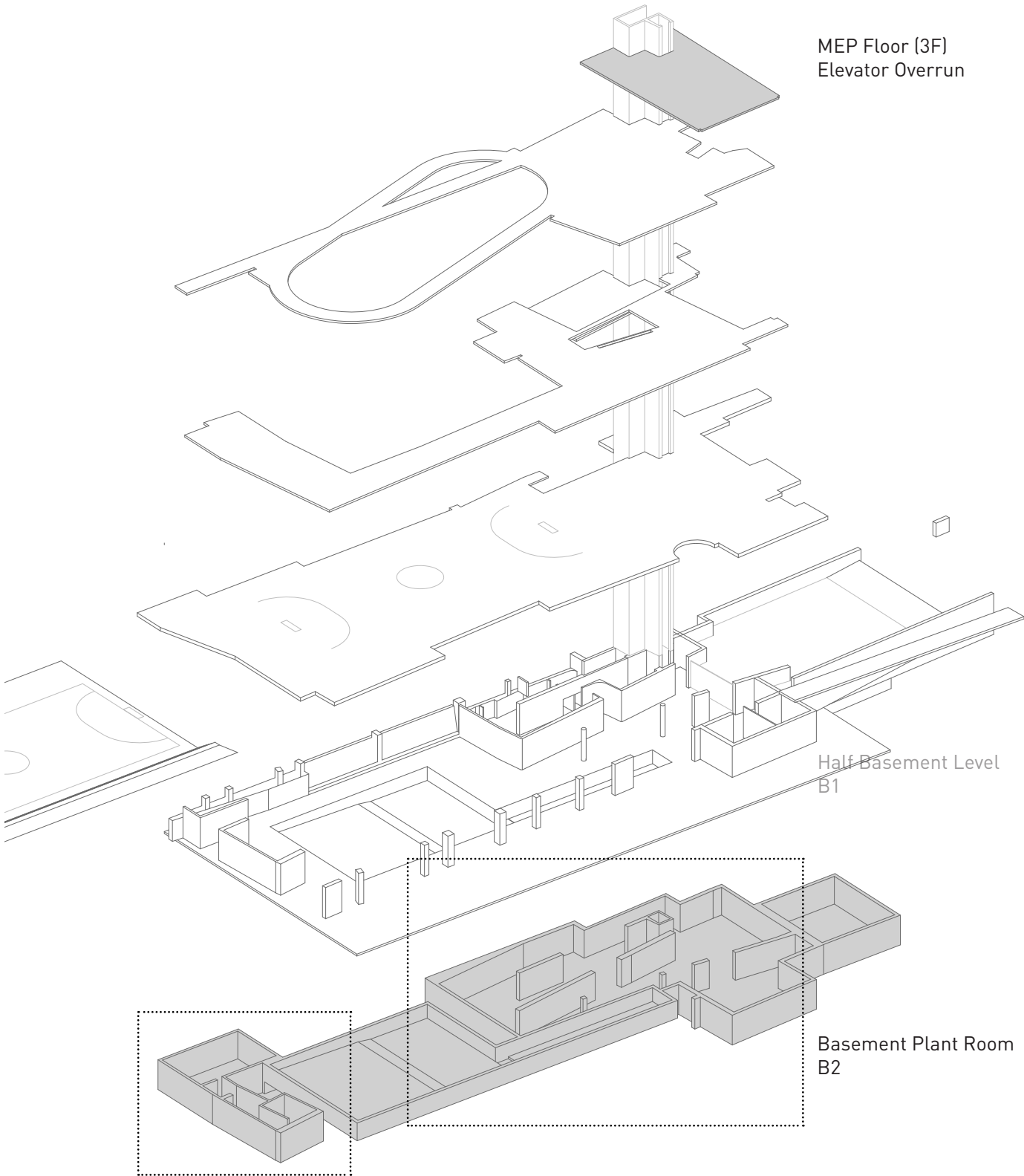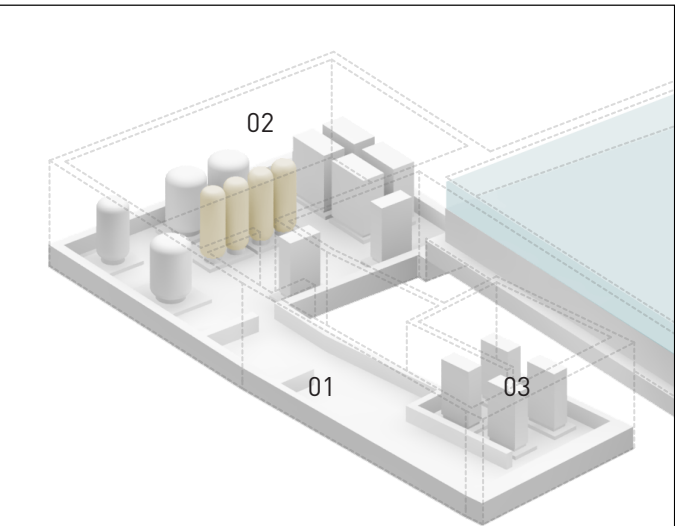
## Health and Safety

Within the building, I try to avoid having too many balustrades to express the idea of being free from restrictions, ethos of performing sports. I have identified some area of safety hazards can cause serious injuries, some protection will be given for the users, in a minimal way.

On the second floor is the Sky Track, the track is laid with rubber material for the purpose of running as well as a sign for the user. The change in flooring material tells the users that they are within danger zone.



Tartan Rubber
(Danger Zone)

Polished Concrete
(Safe Zone)
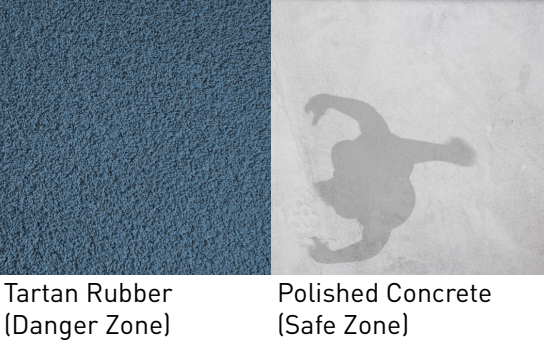
Once they cross the threshold, they are liable for their own injuries. A liability waiver is required to sign by the users to acknowledge the risks involved in their participation in the sports complex.
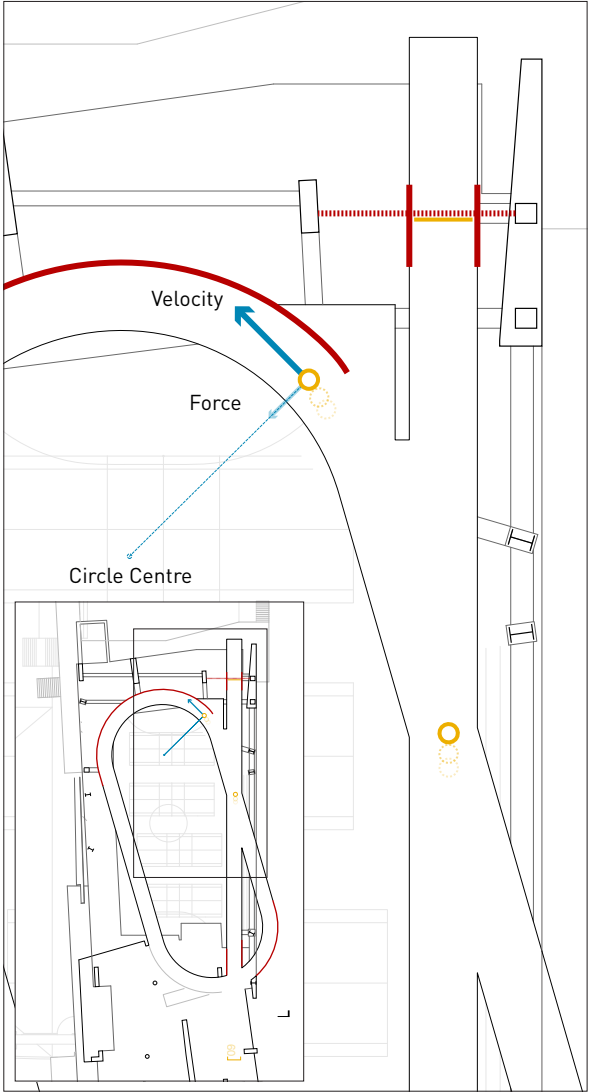


The most dangerous area is located on the second floor. The sportsmen will be running on the Sky Track. Balustrades are only placed on the outer perimeter at the curve of the track, due to the fact that centripetal force will be throwing them away from the centre, hence the outer is more important.
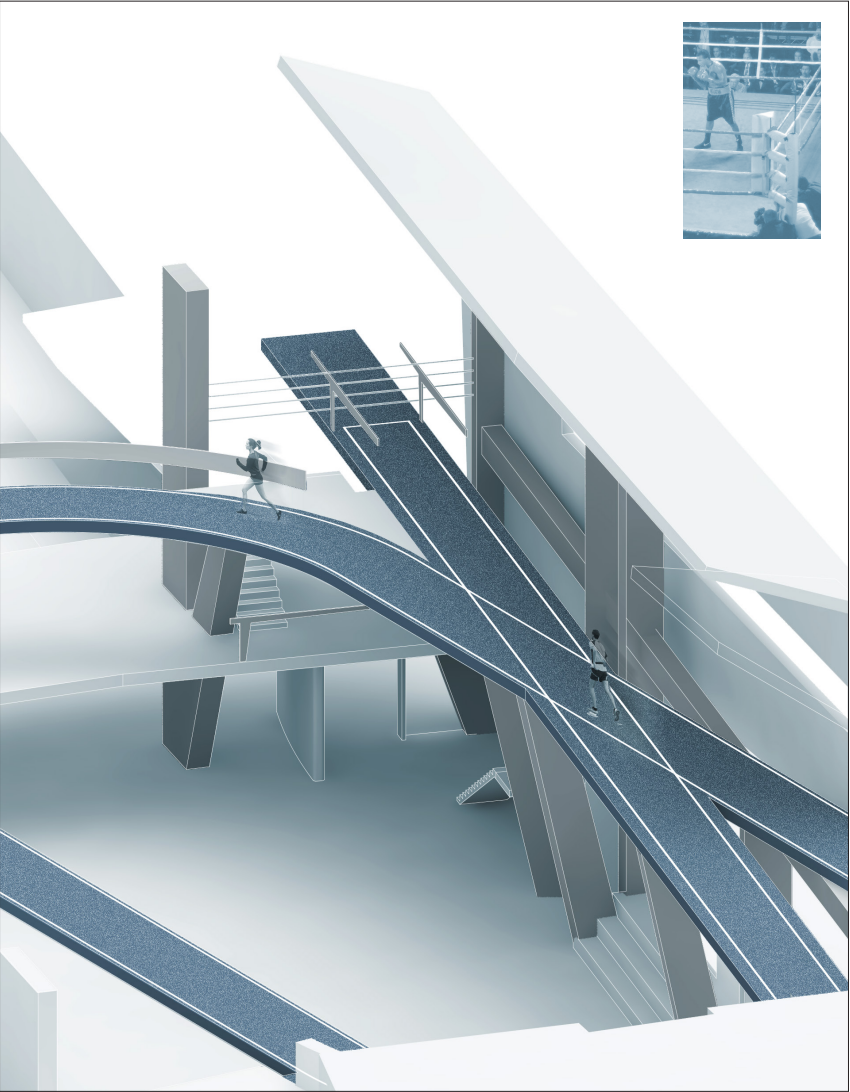
Boxing ring ropes are installed at the end of the straight track (for the 60m sprint), in order to slow down the sprinter, prevent them from flying off the building. There will be no balustrade for the straight sections of the track assuming they do not suddenly change running direction.

Balustrades are installed at the bottom landing of a set of stairs.



### WAIVER OF LIABILITY

RELEASE AND WAIVER OF LIABILITY, ASSUMPTION OF RISK, AND INDEMNITY AND PARENTAL CONSENT AGREEMENT ("AGREEMENT")

Release and Waiver of Liability and Indemnity Agreement

The location of lifeguard is positioned to be able to scan the whole pool area, even the longest part without anything blocking. According to UK National Pool Lifeguard Qualification, they are required to scan the designated area in 10 seconds, with the lifeguard no further than 20 seconds away from any swimmer who may get into difficulty.



The tactic to reduce the amount of balustrade is to place seating and gym machines near the edge, that gives a sense of blocking, the accent of an end.
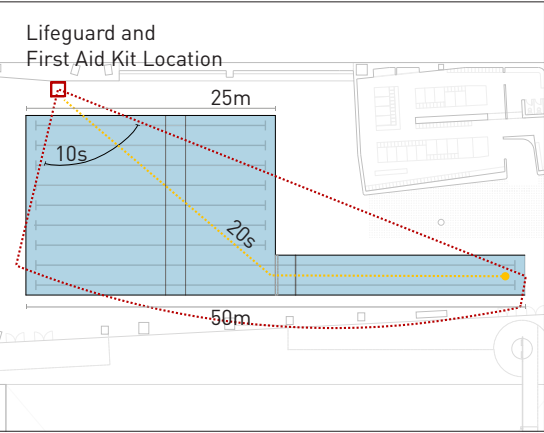


Faculty of Architecture and Urbanism, University of São Paulo (FAU-USP) by João Vilanova Artigas and Carlos Cascaldi
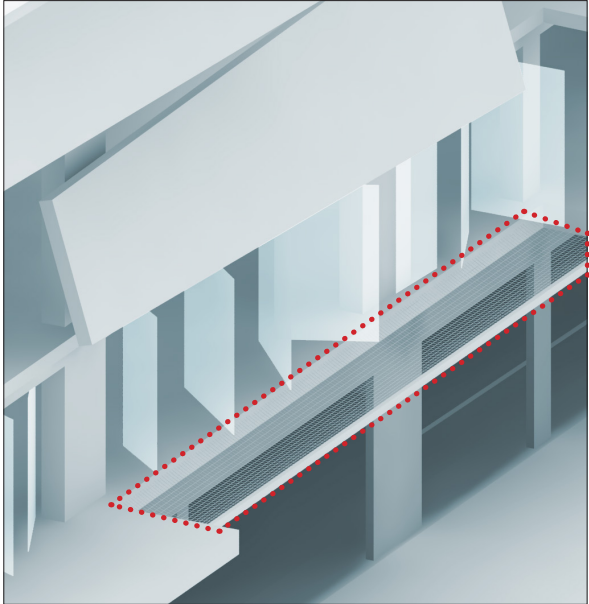


Safety nets are installed to prevent people from walking straight out of the rotating windows.



## Health and Safety in Construction

Protections like safe boots, gloves and helmet , should always be worn on site. During the removal of the existing underground carpark, face protections, safety glasses and ear plugs should also equipped.

Heavy duty machineries are required in order to deliver this project. Regular check-ups and maintenance are crucial to avoid mechanical failure.

The site is closely surrounded by residential and commercial buildings. Notices have to be given out to the neighbourhood and soundproof have to be prepared beforehand.

# Section 2

## Building Construction

# Building Overview
# Material Strategy



Waterslide on the north will be built with reinforced concrete, Epoxy Seal will be coated to provide a smooth finish for sliding.

The top floor will be simply cement screed flooring as large area will just be space for resting

The track will be laid with Tartan rubber just like any outdoor running track (but in blue). This was done to define the danger zone in the building.

Glass floor supported by steel structure will be used for the 6.5m diving platform. People walking towards the entrance will be able to look up and see the diver.

Frosted glass will be used for the floor of the 1/F changing room, the glass will reveal the constant flow of water as it travels down to the ground floor.

This is the landing 'pit' for the long jumping. Instead of sand, this is a steel structure with safety net acting as the pit.

The dancing studio/ yoga room will be laid with hard wood flooring since that space is sealed.

The original idea was to have traditional timber sports flooring, however considering the building will not be entirely enclosed, hence rubber flooring is chosen, for better lifespan of the floor.

I intent the flooring of the whole grond floor to be laid with rubber sports flooring. The unify floor will create a smooth transition as people move between spaces within the building.

Acrylic wall for looking out towards the north outdoor pool

Mosaic tiles for the lining of the swimming pool. Granite tiles will be used for the poolside area for quick feet-drying.

## Seamless Rubber Flooring

PolyTurf Plus Pad and Pour from Tarkett Sports will be used for the ground and first floor. It is a seamless sports floor that is designed to be weatherproof and withstand heavy bleachers with maximum durability. Sheet rubber flooring was considered but it can possibly flake in the constantly changing weather conditions.



1:50 AT A3

**Tarkett** SPORTS





Application:



1 Recycled Rubber Shock Pad
2 Seal Layer (not visible)
3 Formulated Elastomeric Resin
4 Chemically Bonded Game Lines
5 Aliphatic Coating (not visible)
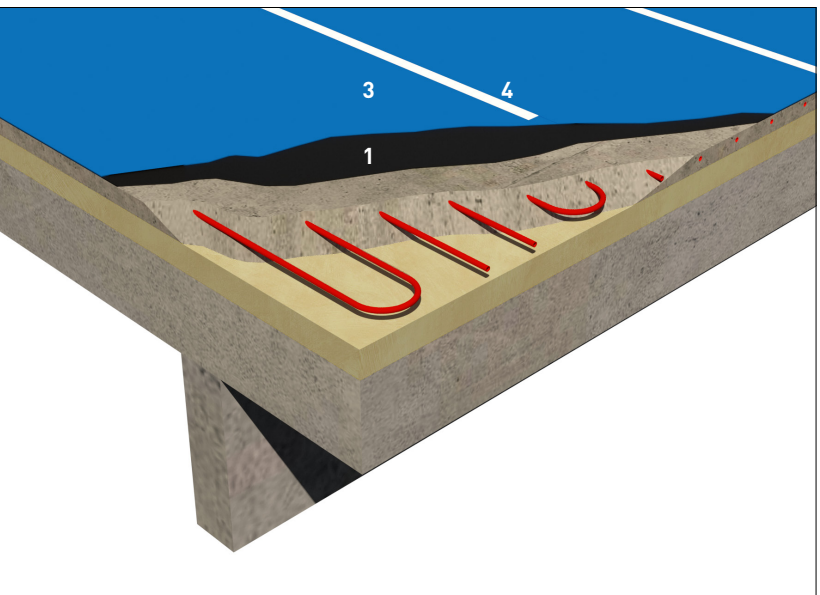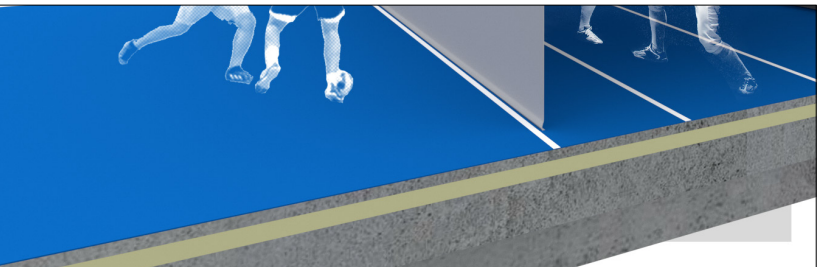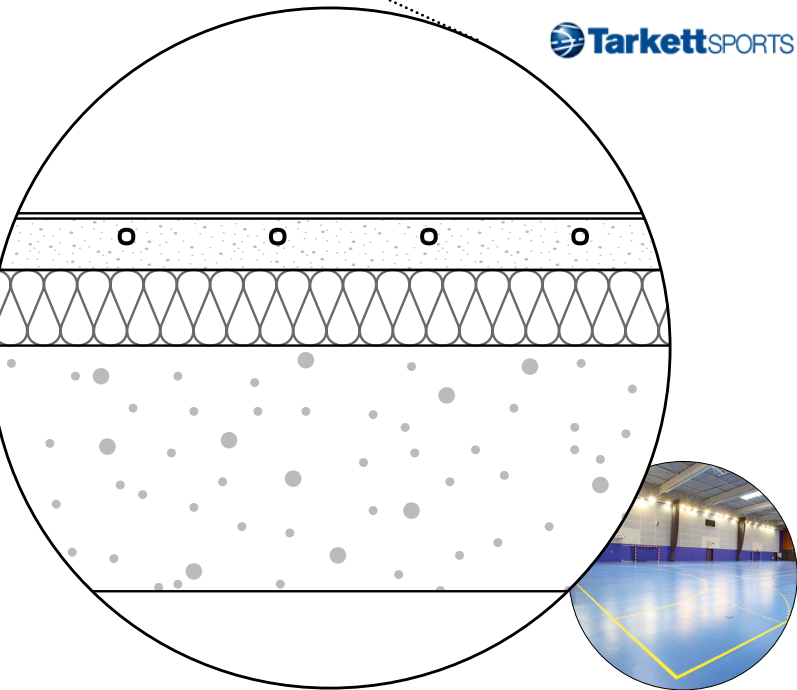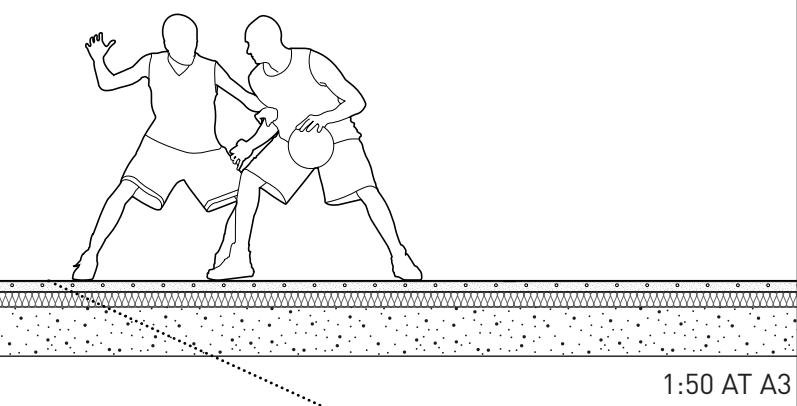
1. Lay out the shock pad (4mm) base layer above the screed, to provide cushioning and shock absorption.
2. Pour a seal layer above it to seal pores of the pad.
3. Pour elastomeric resin for extra durability
4. Paint game lines with Polyurethane marking paint.
5. Roller apply or spray an aliphatic coating to provide stain resistance.

## Dance and Yoga Studio



1:30 AT A3
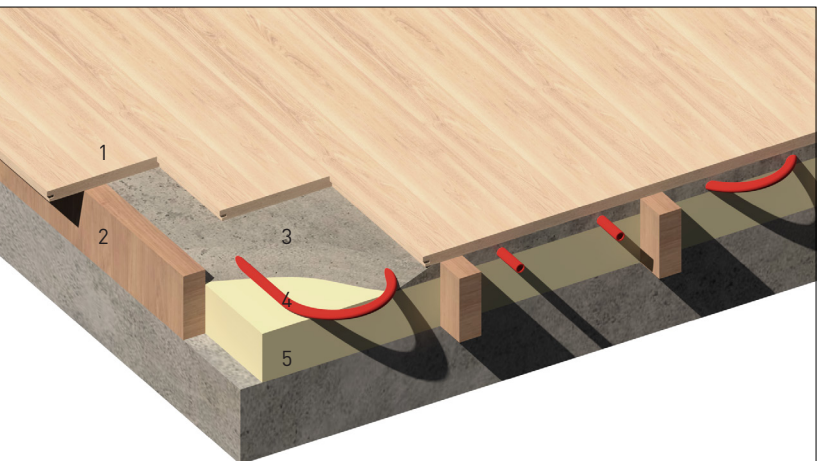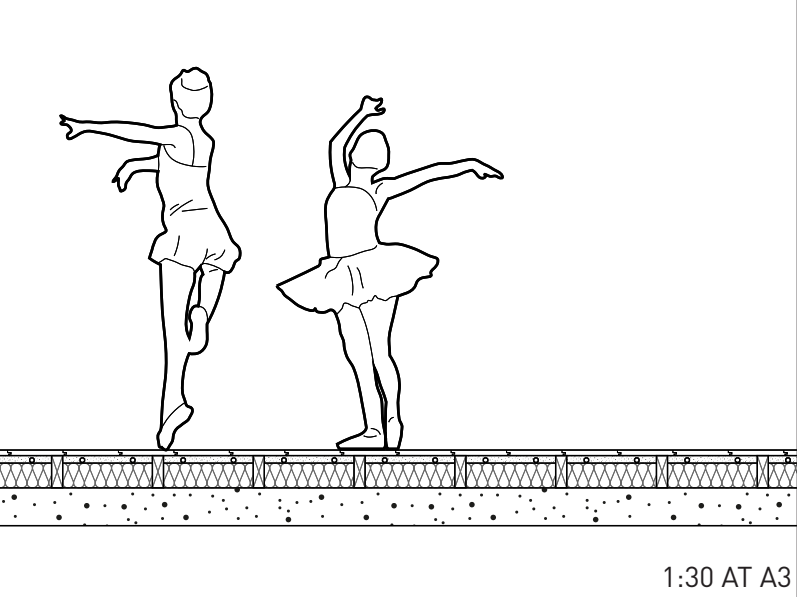


1 Timber T&G Flooring
2 Timber Joist
3 30mm Screed
4 Radiant Floor Heating
5 Insulation

## Glass Diving Platform with steel support



1:4 AT A3
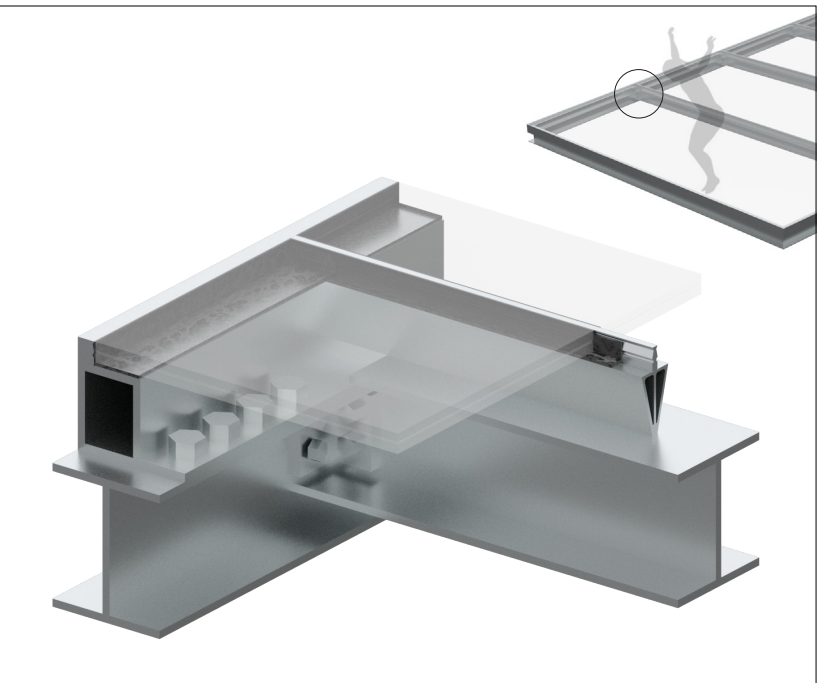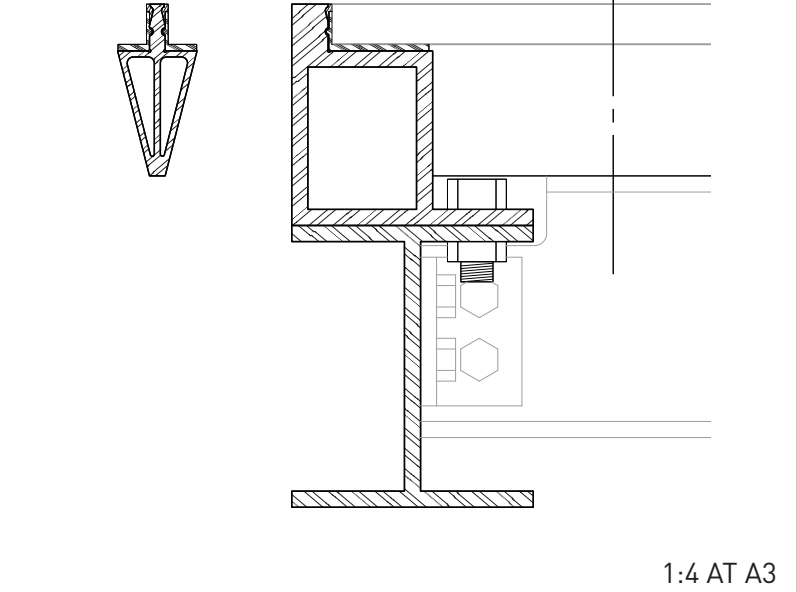
## Roof Structure

There have been consideration for using simple steel truss system and spaceframe structure for the roof, however they are only suitable for roofs of flat pane. I would like to have my roofscape more dynamic, so I have to design my own structure to my roofscape.
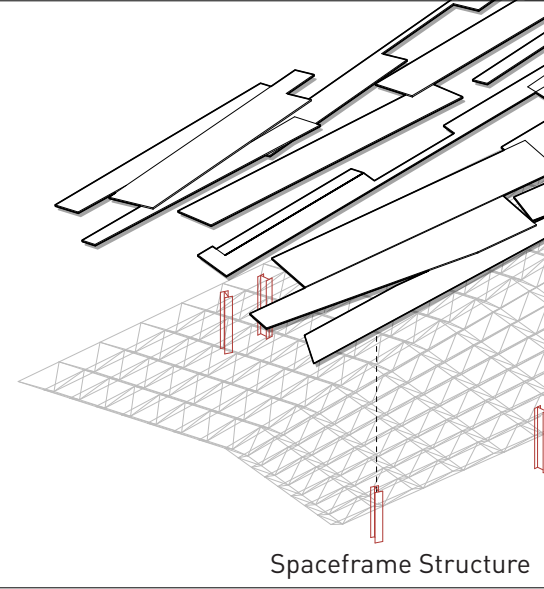


Spaceframe Structure
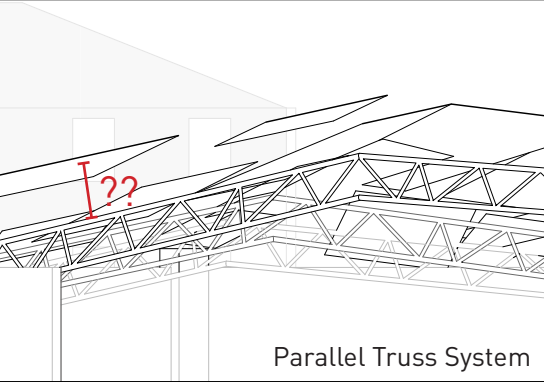


Parallel Truss System

My roofscape design consists a dozen of roof panel with gaps in between, and the idea is that each panel has got its own structural frame, and when all roofs connect together, it become one roof structure. There will not be any problem about the separation of the panels away from the supporting structure found in both original proposed schemes.
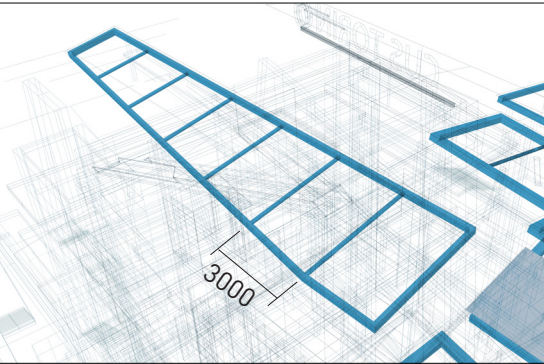


A simple script is written to generate the substructure of each roof panel. I am able to change different parameters such as the width of the steel channel, without the need of redrawing everything when there are amendments.



| | |
|---|---|
| Top Surface | |
| Border Offset | ◇ 100 |
| Top Material Thickness | ◇ 25 |
| Internal Offset | ◇ 150 |
| Thickness | 300 ◇ |
| Pipe Radius | 80 ◇ |
| Sub-Structure | ◇ 3000 |
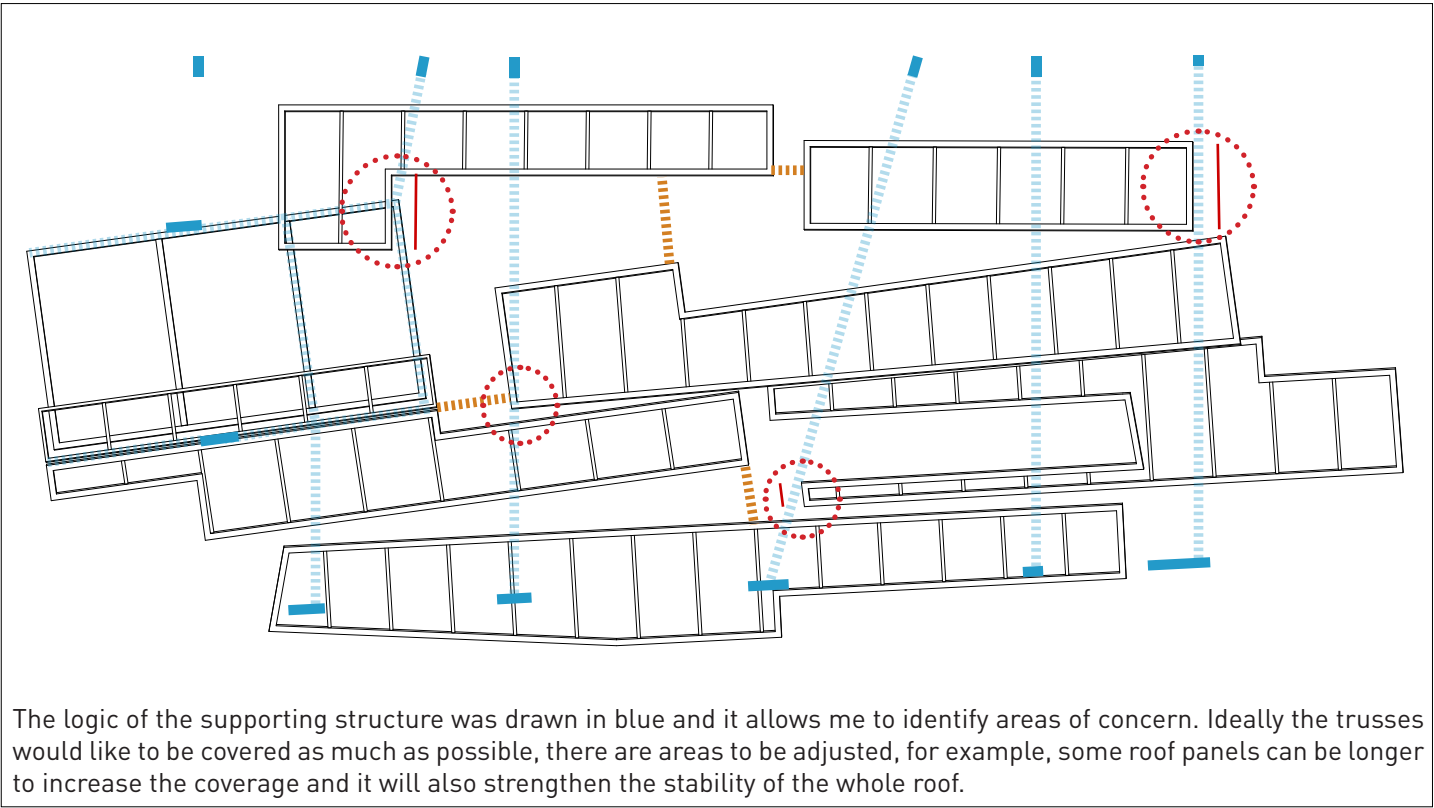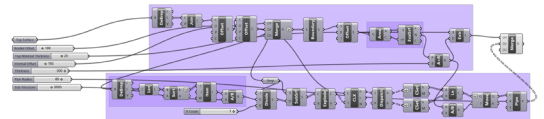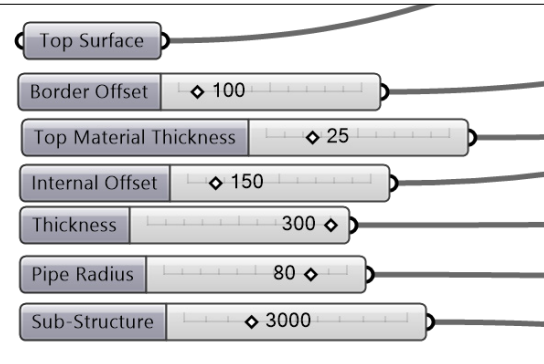


The logic of the supporting structure was drawn in blue and it allows me to identify areas of concern. Ideally the trusses would like to be covered as much as possible, there are areas to be adjusted, for example, some roof panels can be longer to increase the coverage and it will also strengthen the stability of the whole roof.
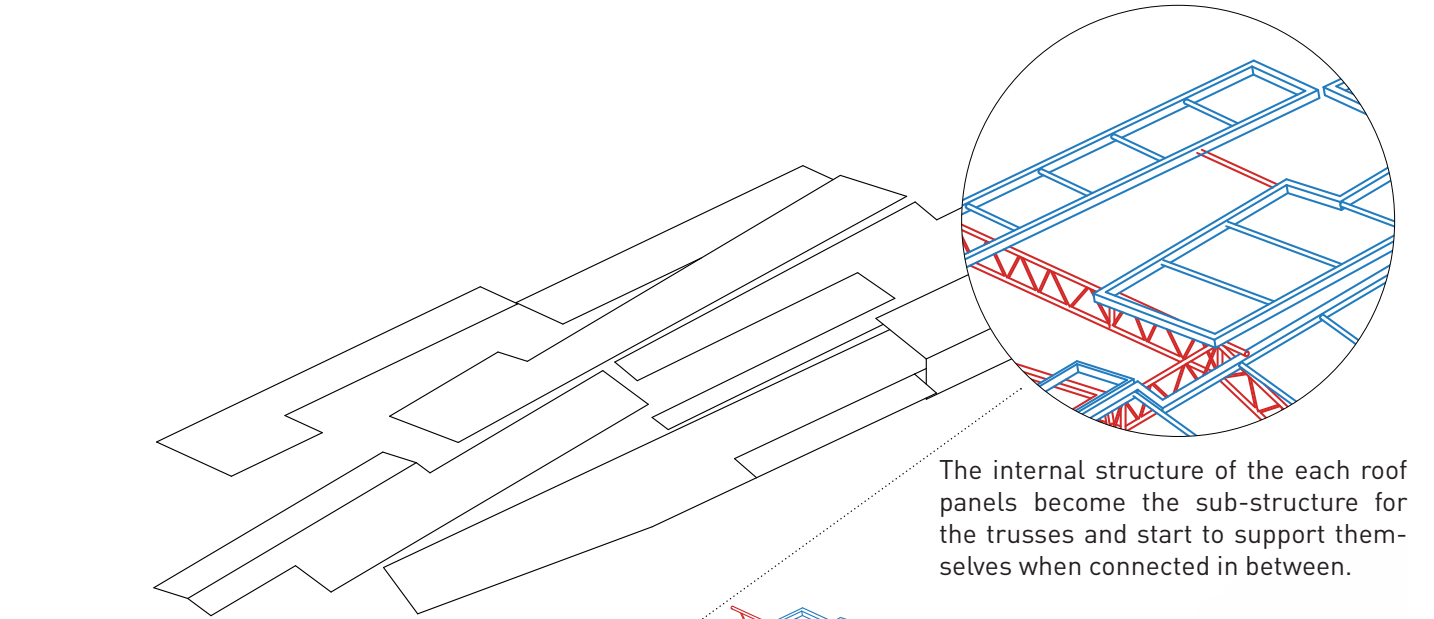
The internal structure of the each roof panels become the sub-structure for the trusses and start to support themselves when connected in between.

Roof Surface

Supporting Roof Structure

Columns Locations

— Longitudinal Structure
— Latitudinal Structure

## Roofscape Detailing
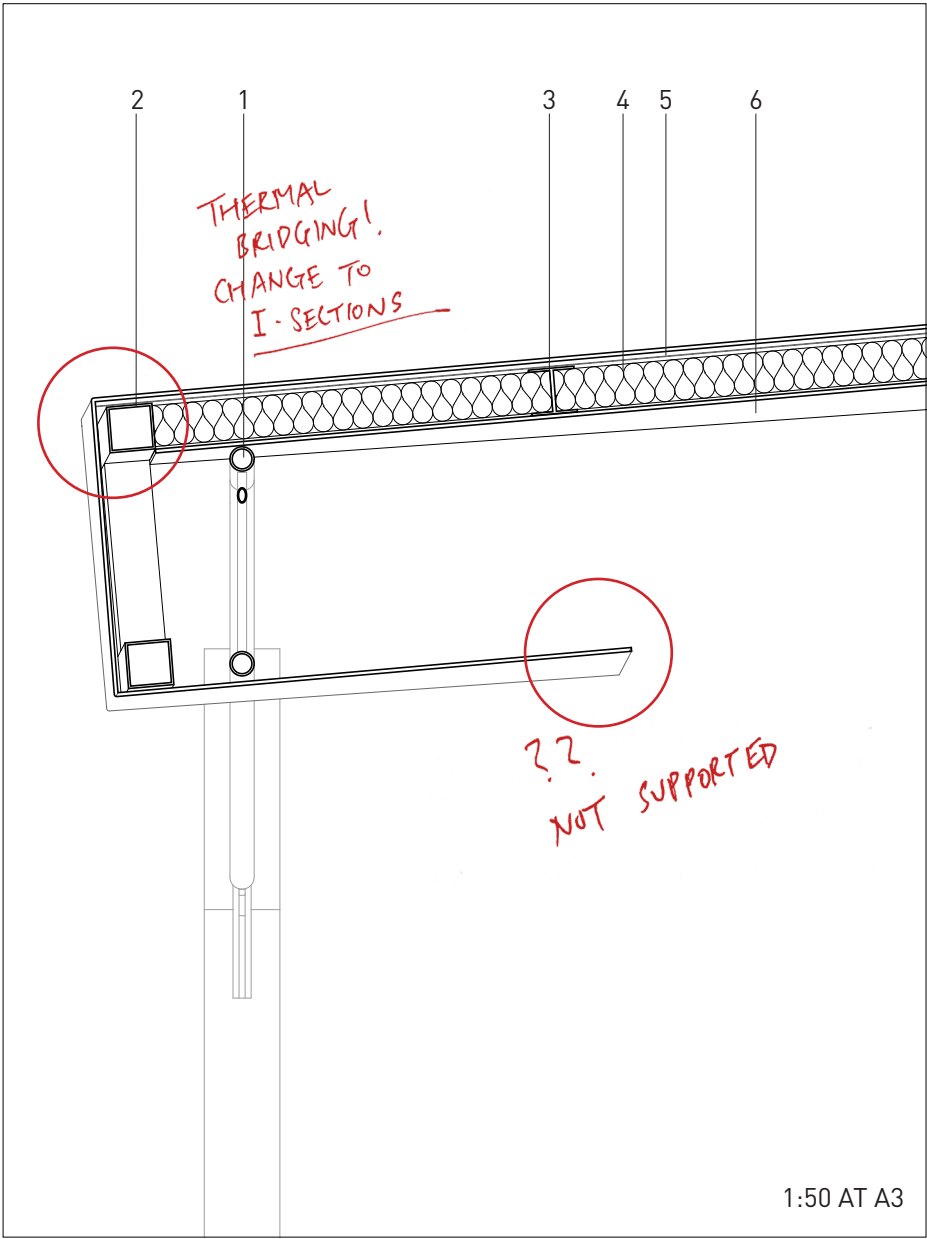


THERMAL BRIDGING! CHANGE TO I-SECTIONS

?? NOT SUPPORTED

1:50 AT A3



**Roof Panel**

Although my building is not entirely enclosed, I will also need to provide some insulation. The detail drawing might not make sense because it does not have a define line saying what is inside/outside.

The top material will be Zinc metal, rubber will be poured on to it to create a seamless surface (same as the flooring) and to hide the welding marks.

1 Tubular Steel Parallel Truss
2 Galvanised Steel Frame
3 Steel I-Section Beam
4 Insulation
5 Waterproofing Membrane
6 Plasterboard Soffit
7 Zinc Sheet Metal



Front Section    Side Section    1:20 AT A3
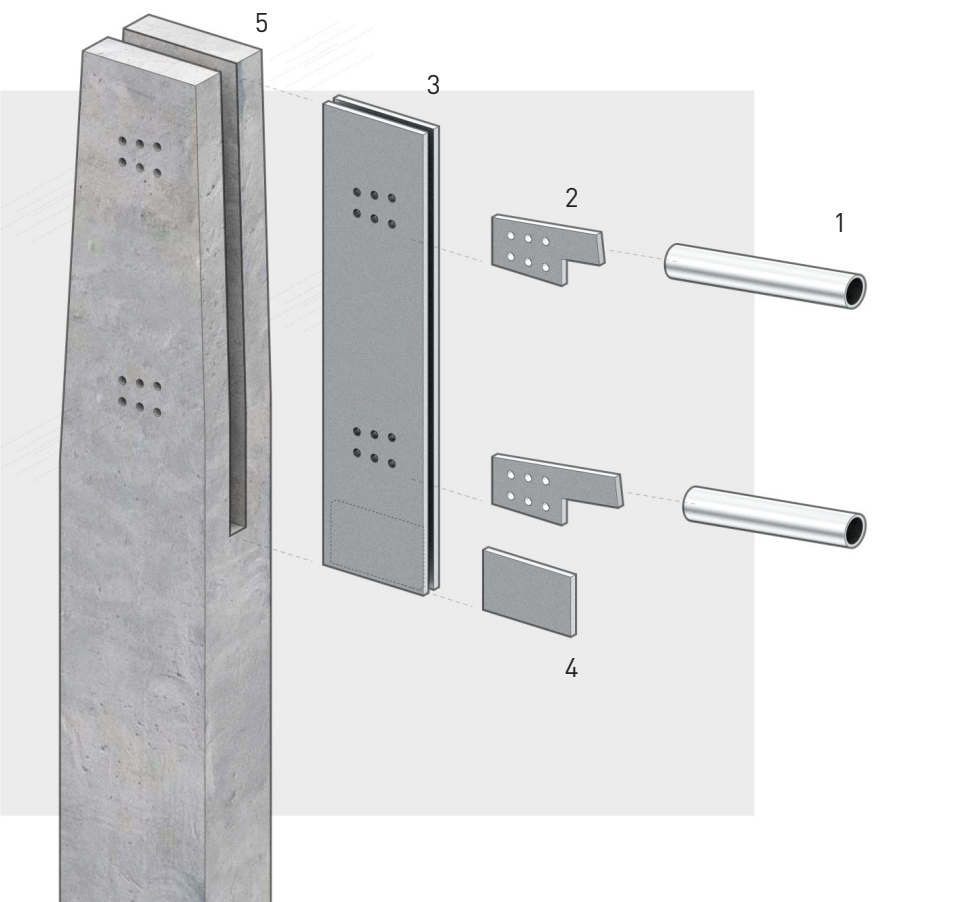


**Truss to Column Connection**

The top of the reinforced concrete column will be casted with a 120mm slit down the middle. That slot is reserved for the steel plates connection with the trusses. 2 pieces of 0.5x2m steel plate will sandwich the end of the truss and the bottom spacer. At the end they will all tied together with the column with a dozen of 20mm through bolt.

1 Tubular Steel Parallel Truss
2 Truss end Steel Plate
3 0.5x2m Steel Plate
4 Steel Spacer Plate (40mm)
5 RC Column with 120mm slit

## Acrylic Wall Study:
## Underwater Experience

Acrylic is the chosen material to put against the water in the basement, where there is an experiential space for relaxation. Glass had been considered however it will cost a lot to produce such large piece of thick glass, and being laminated to 300mm, there will be strong distortion to the view.

The (visible) height of the acrylic is 4.8metres however the water will only go up to 2.5m. The acrylic will receive around 71000N of water pressure. According to the engineer Brian Eckersley, 100mm of acrylic is strong enough for the purpose.

Sea life centres use acrylic for their panoramic view to the aquariums.

Width of the acrylic wall (L): 8.6 metres
Height of Wall (h): 4.8 m
Height of Water (h-y): 2.5 m
Density of Water (ρ): 1000 kg/m³
Gravity (g): 9.8 m/s²

Pressure = Force / Area
$$F = P \times A$$

Area = Height x Width
$$A = h \times L$$

$$P = \frac{F}{A}$$

$$F = P \times A$$

$$dF = P \times dA$$

$$F = \int dF = \int P dA$$

$$F = \int \rho g y L dy$$

$$= \rho g y \int_{y=0}^{y=h} y \, dy$$

$$= \rho g L \frac{y^2}{2} \Big|_{y=0}^{y=h}$$

$$= \rho g L \left[ \left(\frac{1.3^2}{2}\right) - \left(\frac{0^2}{2}\right) \right]$$

$$= (1000)(9.8)(8.6)\left(\frac{1.3^2}{2}\right)$$

$$F = 71,216.6 \ N$$

Ground Floor +2.00

Exterior

B1 Floor -3.00
Pool Entrance

B2 Floor -7.00
Plant Room Level

1:50 AT A3

1 2 3 4

1 100mm Acrylic
2 Stainless Steel U Channel holding acrylic in place
3 Waterproof sheet over metal channel
4 Cavity Drainage Channel

1:10 AT A3
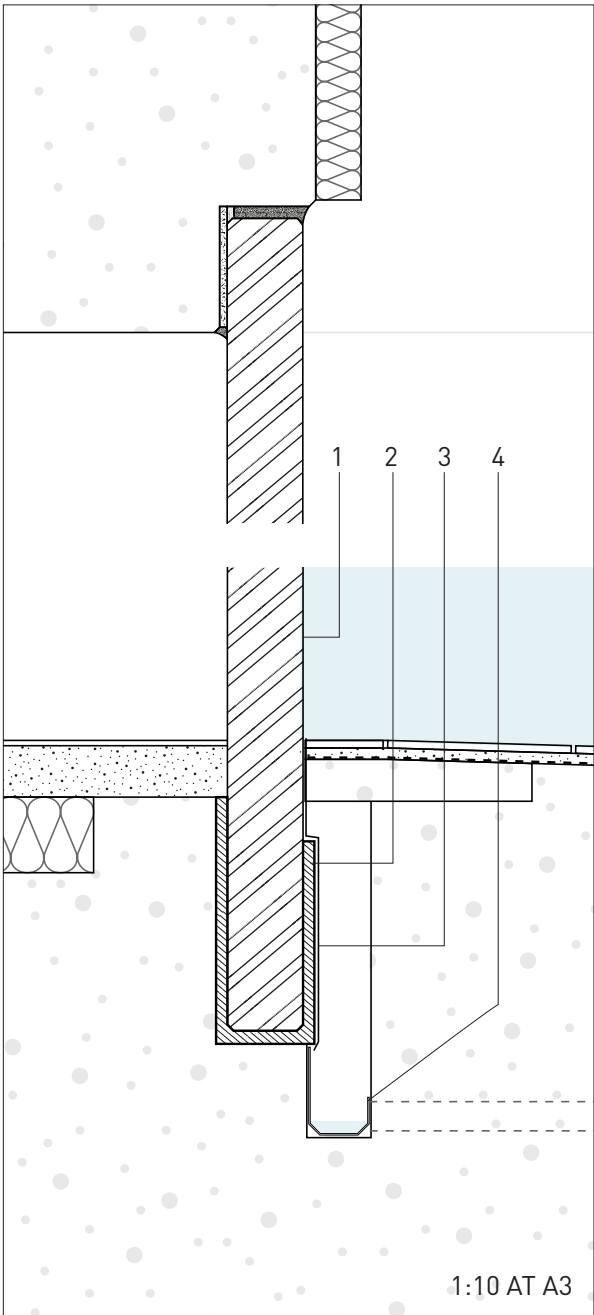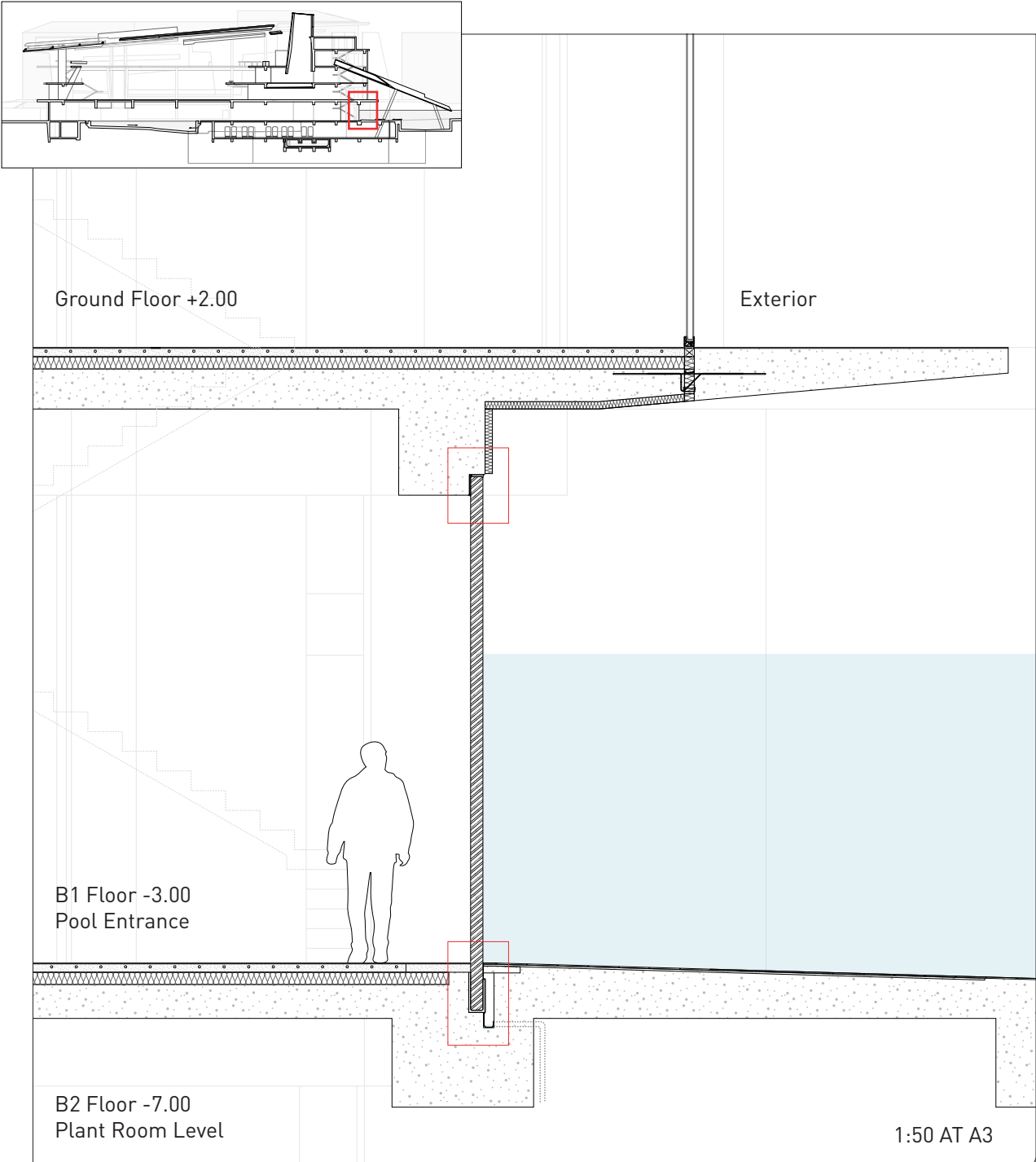
## Insulated Pool Study

As mentioned, the basement level has to be entirely enclosed during the winter to prevent heat loss. The swimming pool is heated to 25-28°C in the winter, and it is in 'direct' contact with the soil, hence all the slabs have to be insulated to reduce heat loss. In the summer the row of pivoting windows can be opened up for fresh air.

Waterproofing is an important issue, first is to prevent water leaking from the pool and second to avoid water ingress from the soil.

The pool is installed by applying a liquidproof membrane to the walls, then a layer of screed and glazed tiles are laid for the internal finish.
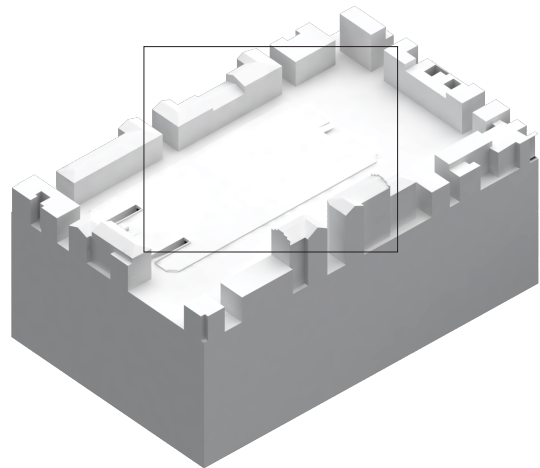
To prevent water ingress, cavity channel and damp proof membranes are used. Any leakage will go down to the cavity drain and the water will then feed into the pool's filtration system for other uses.

1 Waterproofing Membrane
2 Underwater Light Fitting
3 Edging Tile, Non-Slip
4 PVC Channel Grating
5 Screed
6 Reinforced Concrete
7 Insulation 100mm
8 Glazed Tile 244 X 119 X 6mm
9 Cove Skirting, Glazed 244 X R33 X 6mm
10 Platon P8 DPM Cavity Wall Membrane
11 Platon P20 DPM Cavity Drain Floor Membrane
12 Tape
13 Cavity Drainage Channel
14 Drainage Outlet
15 Cavity Drainage Pump
16 Radiant Floor Heating
17 Thermal Break

Covered Sports Hall

Exterior

Indoor Swimming pool

15   14

1:50 AT A3

1 2 3 4   5 6 7

8
5
1
6
9
7
10
11
12

16 5 7   17

In   Out
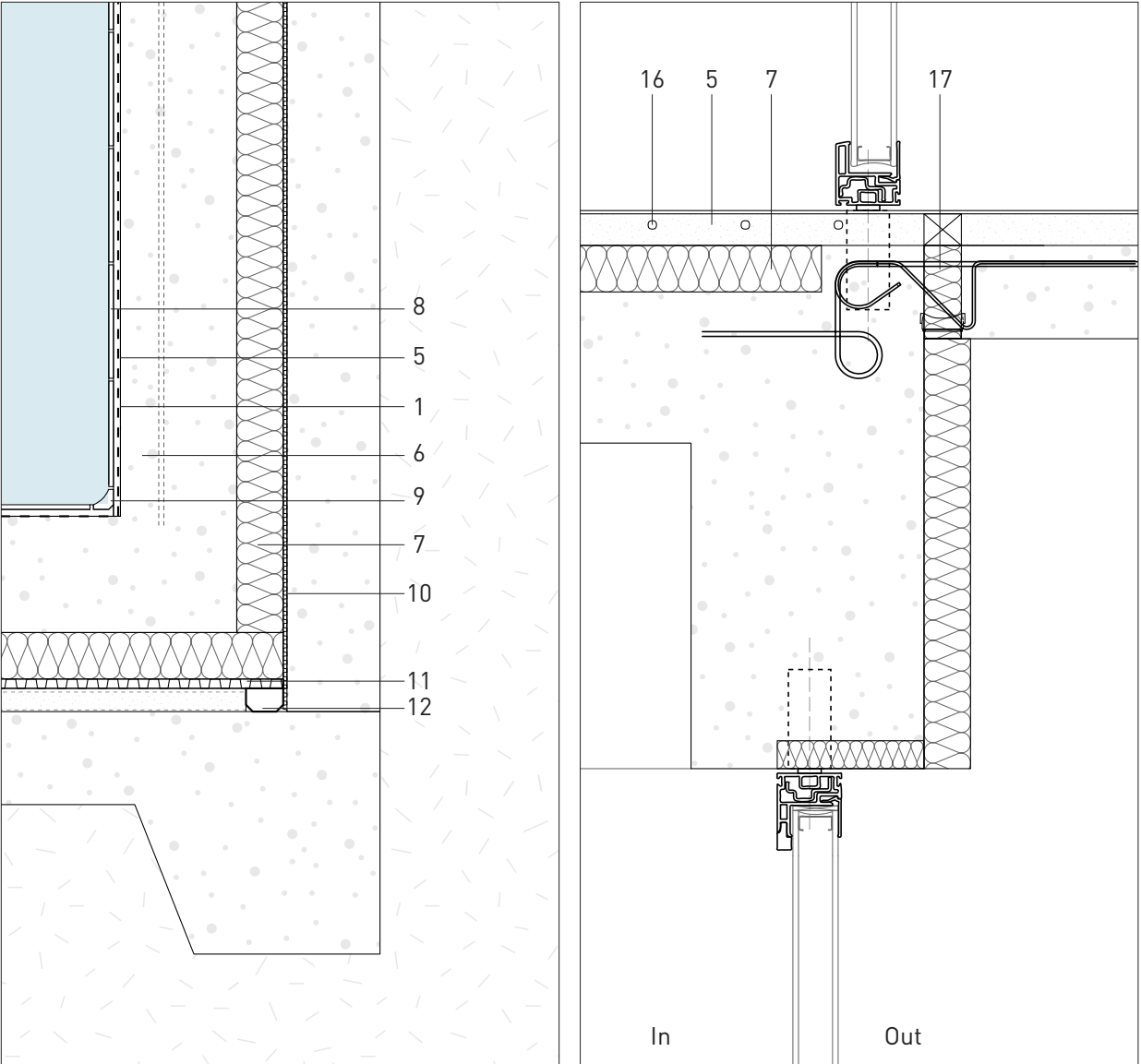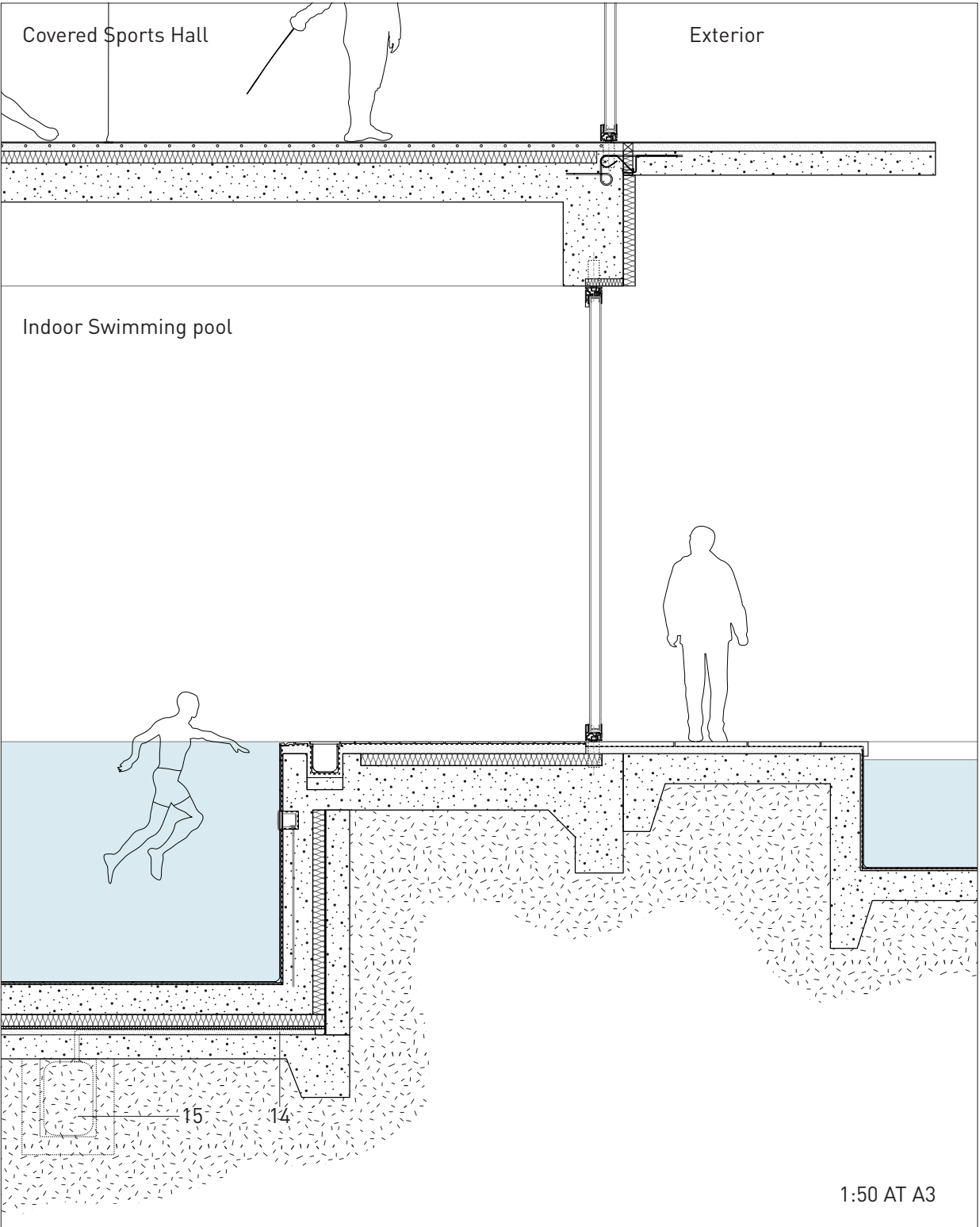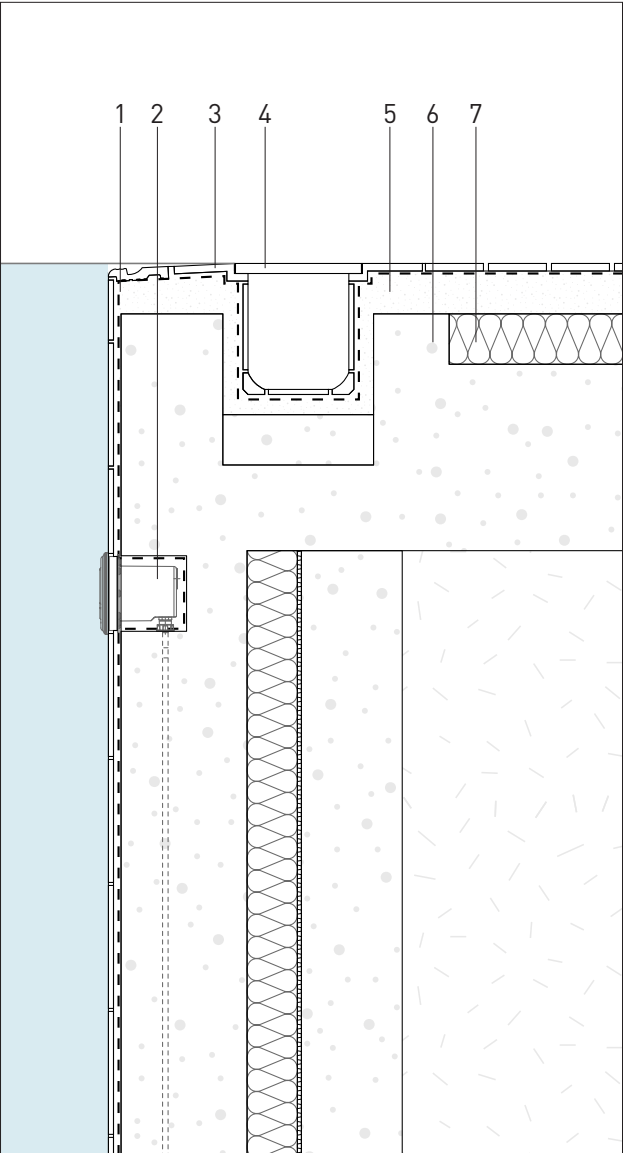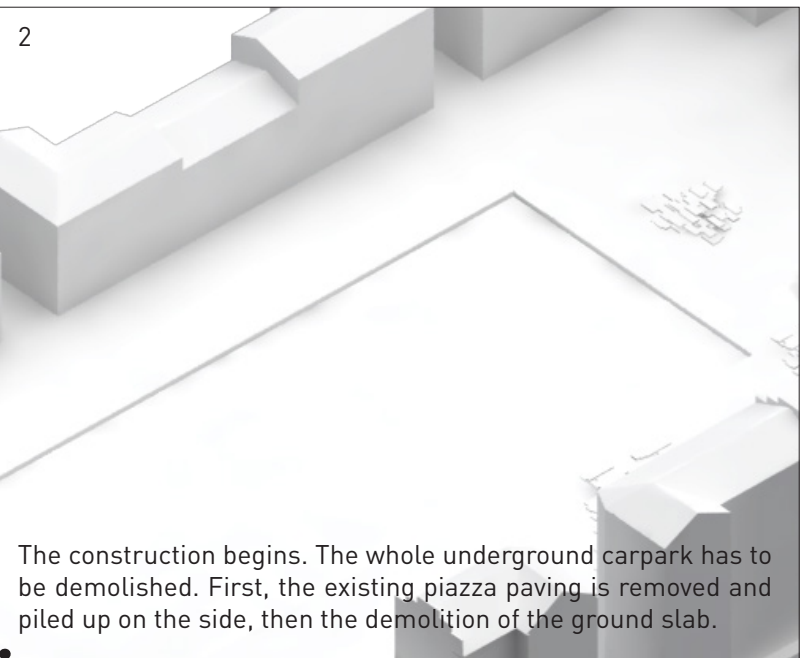
## Construction Sequence

**1**



All the vehicles are evacuated from the site. Hoardings are erected around the perimeter of the whole piazza, leaving access for the existing properties.
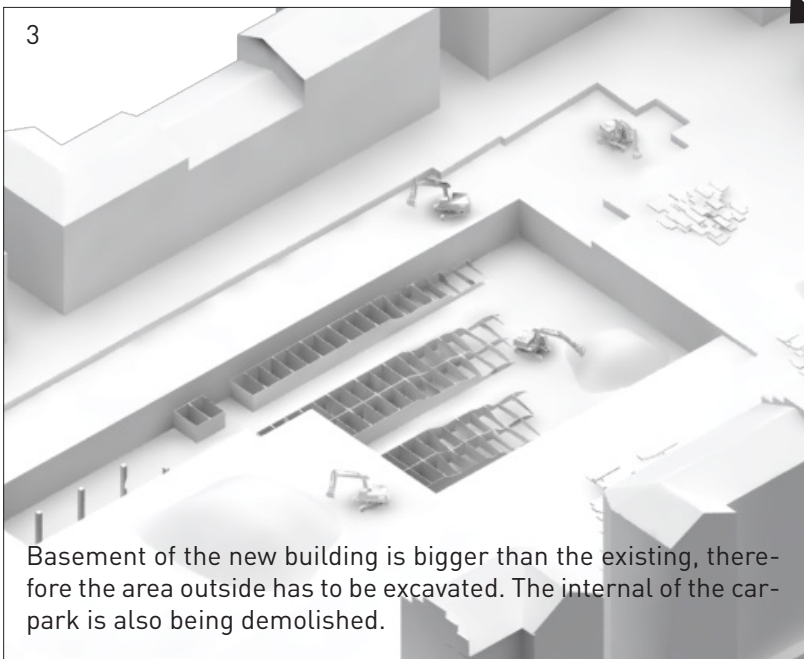
**2**
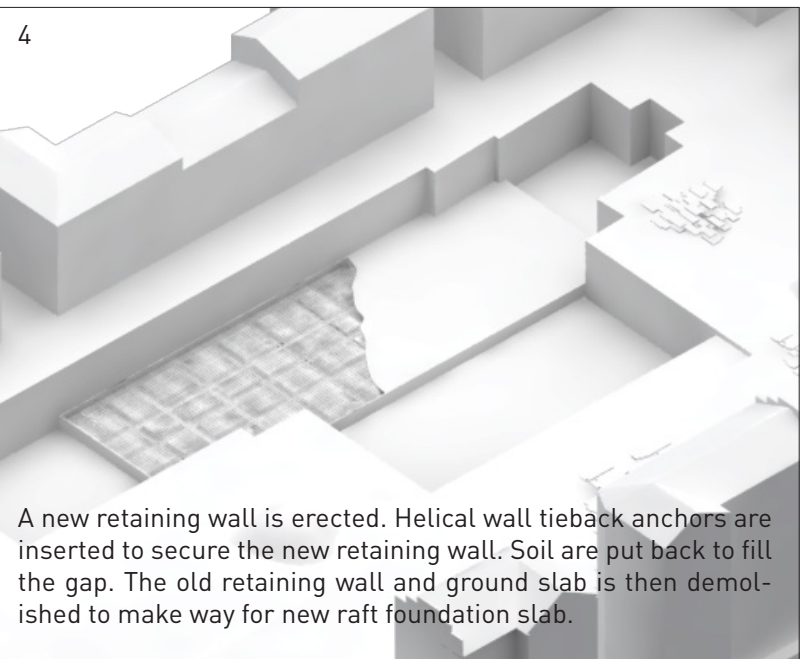


The construction begins. The whole underground carpark has to be demolished. First, the existing piazza paving is removed and piled up on the side, then the demolition of the ground slab.

**3**
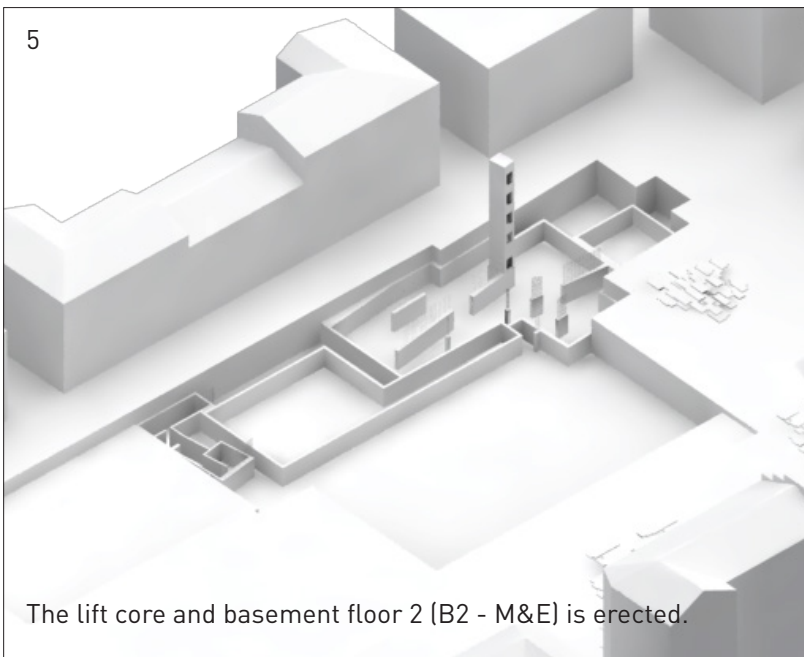


Basement of the new building is bigger than the existing, therefore the area outside has to be excavated. The internal of the carpark is also being demolished.

**4**
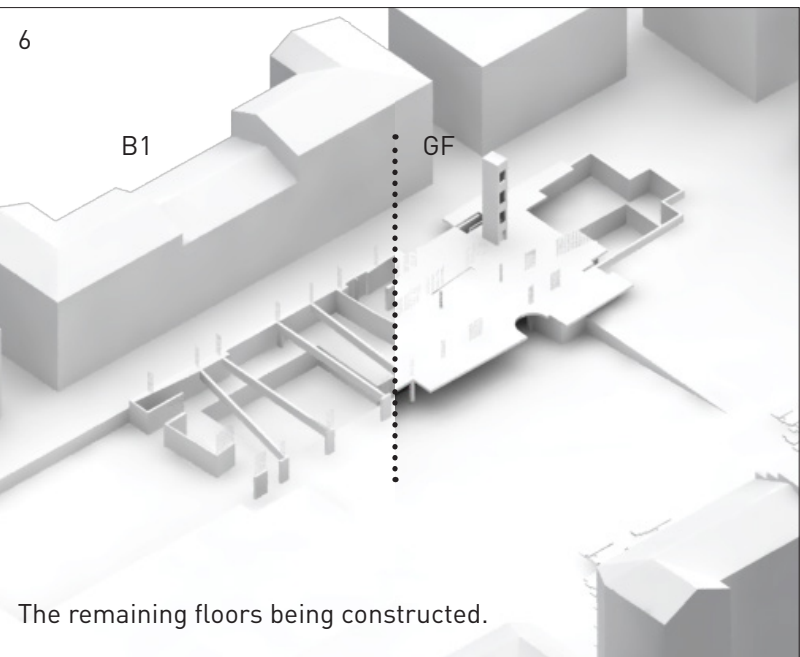


A new retaining wall is erected. Helical wall tieback anchors are inserted to secure the new retaining wall. Soil are put back to fill the gap. The old retaining wall and ground slab is then demolished to make way for new raft foundation slab.

**5**
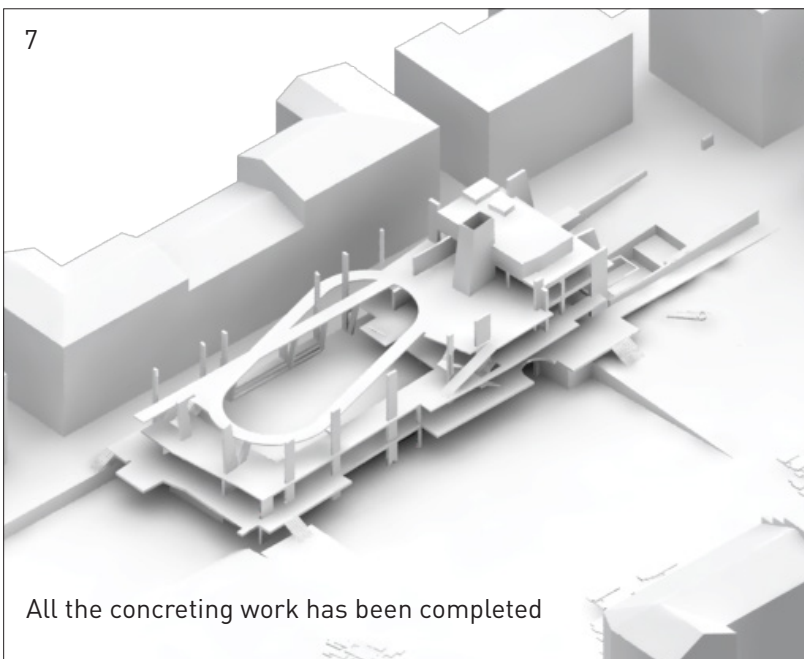


The lift core and basement floor 2 (B2 - M&E) is erected.

**6**

B1          GF
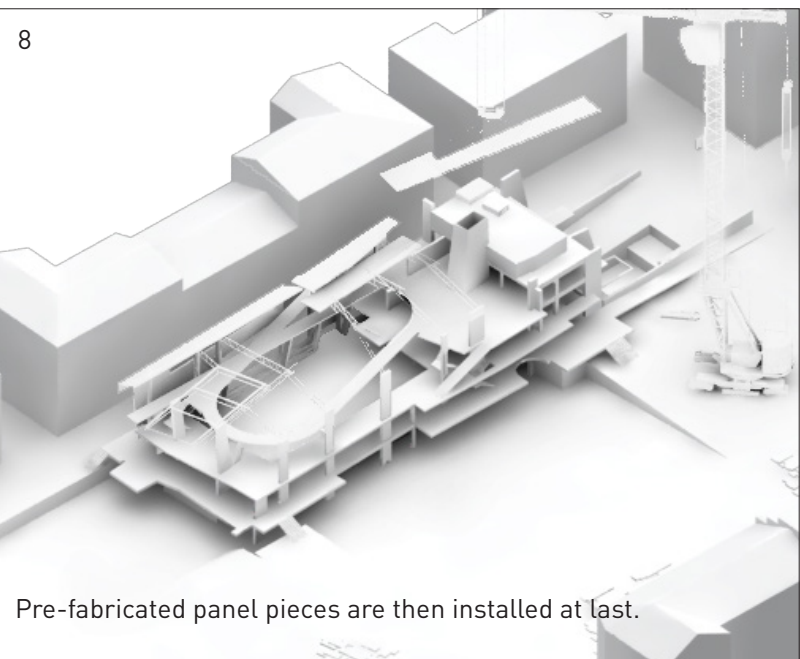


The remaining floors being constructed.

**7**



All the concreting work has been completed

**8**



Pre-fabricated panel pieces are then installed at last.
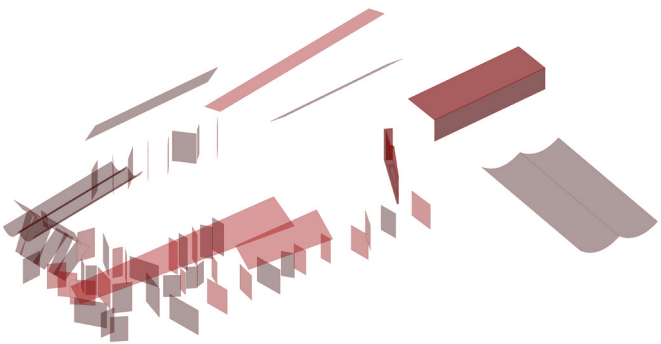


# Section 3

## Building Performance

Playzones

2/F

16-18°C
18-20°C

1/F

18-20°C
18-20°C
16°C
18-20°C

22-30°C

Enclosed

Open

22°C
18-20°C
14-16°C (min. 12°C)
18°C

G/F

25°C

B1

Active sports
Min: 12°C    Ideal for: Young to Adults

Social use or sedentary activity
Min: 18°C    Ideal for: Toddler or Elderly

Ideal for changing room
Min: 20°C

## Thermal Comfort for all



The project is designed for all generations, therefore the building has to be able to adapt and suit users of any age.

A series of "Playzones" are identified for alternative uses and different kinds of users. They are labelled with a specific temperature range, tailored to the age group or the specific activities carried out in the area.

Sport England recommends sports hall to have a minimum temperature in the range from 12 to 16 degrees. The figure is used to set for the main football in my building. Then the other spaces around the court can have a different temperature, ie, warmer space for the elderly. This can be achieved by having multiple radiant floor heating system, even on the same level.

Below is the block plan diagram, showing the encloseness of different spaces within the building.



Aerobics

Fencing

Intense Football

Changing

Kids Area

Resting/ Elderly
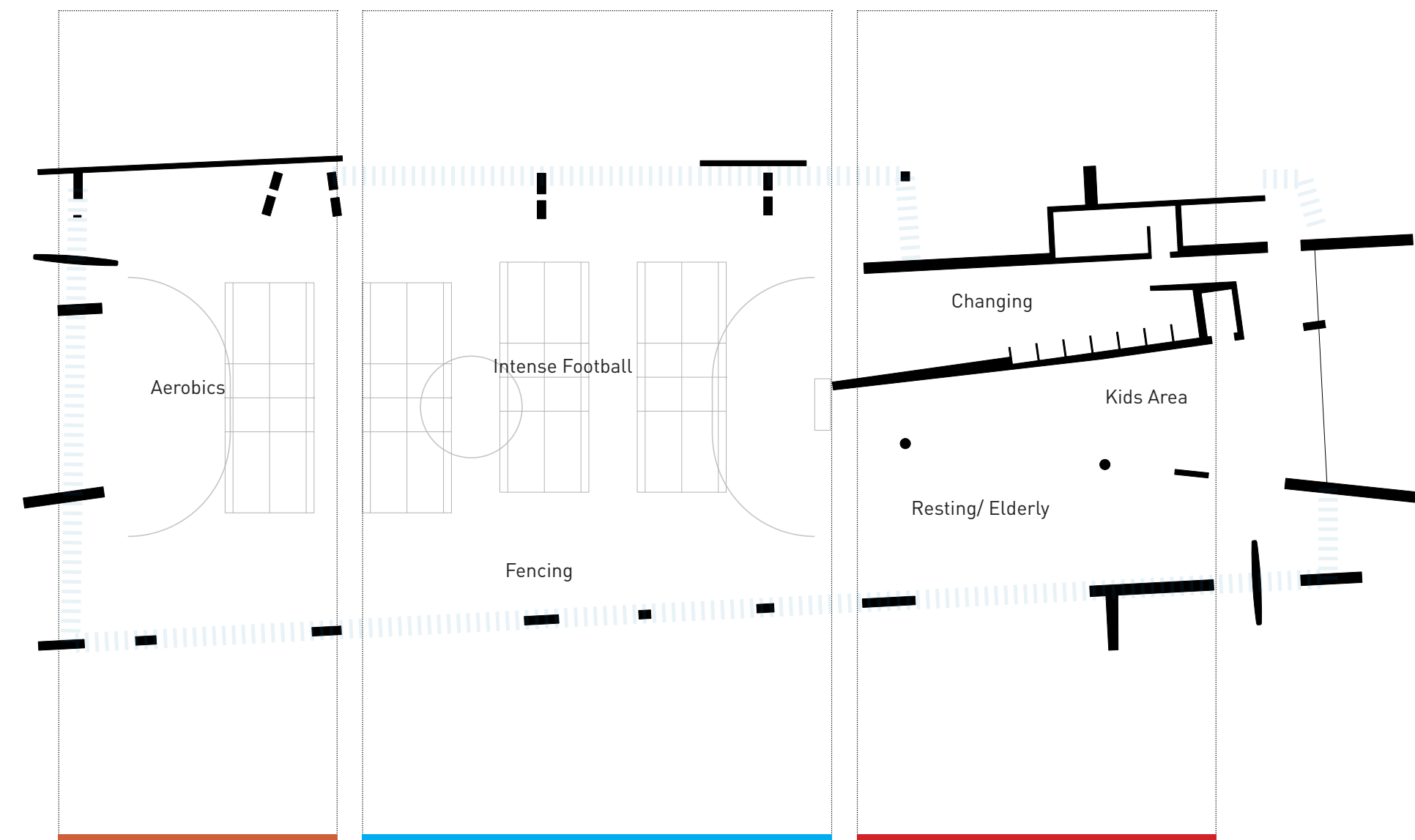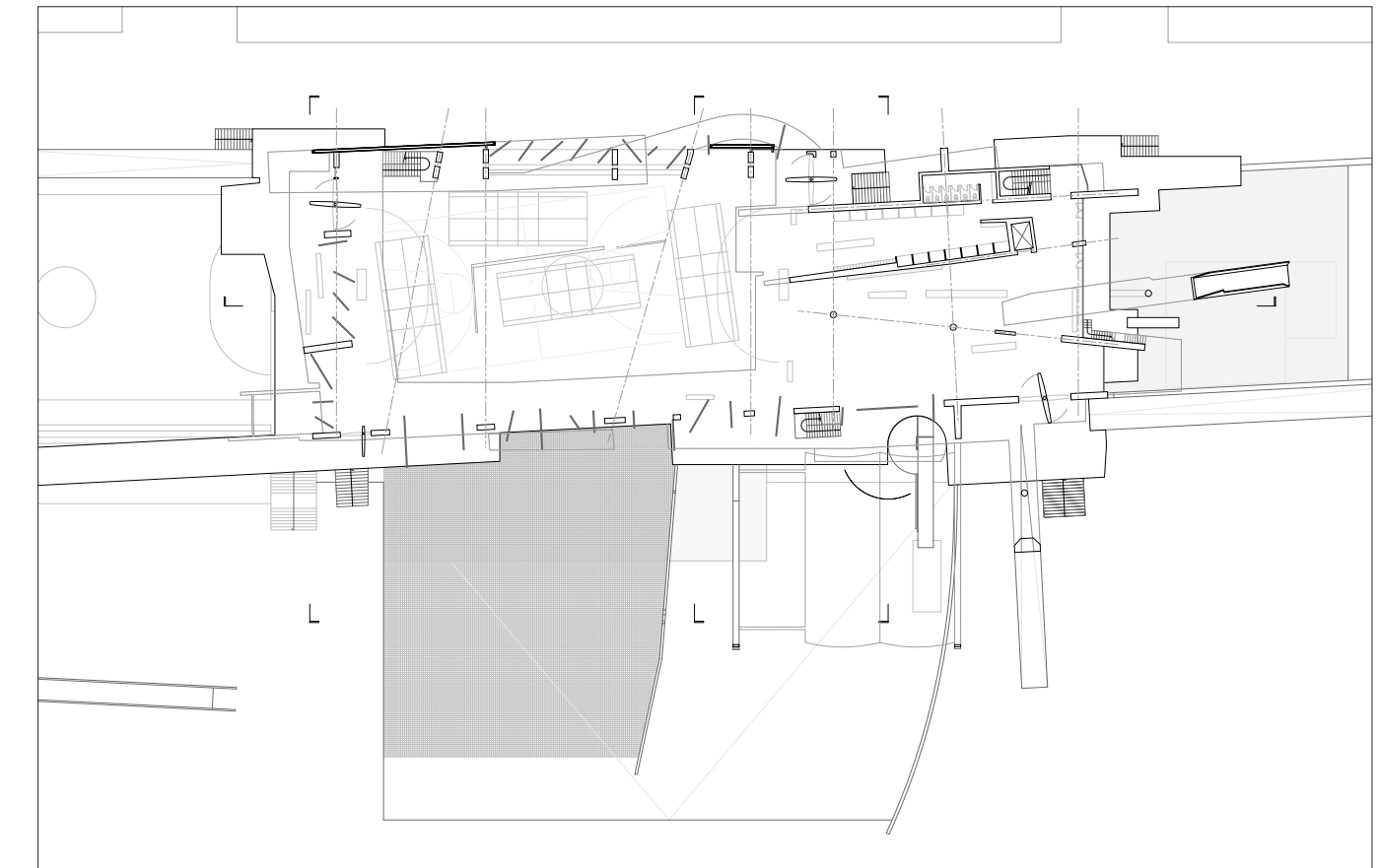
This area is the south end of the building, hence it will be receiving a good amount of sunlight, which will to be relatively warmer. Although it is majorly in contact with the outdoor (meaning it can be quite cold in winter), the back wall is going to provide some insulation, and the area can be closed up with mechanical doors and windows.

This zone is around two-thirds of the main court, where intense exercise/ football/ badminton matches will be carried out in the space, hence it can be as low as 12°C because the players will be generating a lot of heat by themselves. In the plan, you can see it is hugely exposed to the exterior, this is to allow the people/the building to lose heat to the exterior during the hot summer. And of course, the space can be closed when it's too cold.

This area of the building is allocated to be the warmer zone, area in front is the resting area and the back dedicated for changing facilities. The front area can be doubled as space for toddlers and elderly for performing physical exercise. There is no other areas in the building better than this since it is majorly "protected", ie such as having solid walls at the back. The area is comparatively more enclosed hence the thermal comfort is easier to maintain and control.

Another benefit is the reception being in the area, so there will be staff around to look after the toddlers and elderly. The area is for rather slow or sedentary activities.

## Temperature Control

The minimum temperture for the changing room is set to be 22°C, ideally to achieve within the range from 22-25°C. Throughout the year, there will be 11% of time ideal (changing) temperture, however, 79% of time is colder than 22°C, hence the space has to be heated.



aim to achieve 22-25°C

There are 8760 hours in a year, however my building only opens from 9am to 11pm everyday, that leaves me a total of 5110 opening hours per year. Out-of-hours data is removed in my analysis since no one will be using the building at 3am on the coldest day in Turin.



**79% of the year is colder than 22°C**

Spaces like changing room will not always be occupied, hence, I would like to divide that area in to two for radiant heating system, one layout for the changing cubicles (walls), another one for the open area (floor). It is because the energy required to only heat up the cubicles is less than 1/5th of the area. In this case it is more effecient to transfer heat to the human body (when they are naked) rather than to air.

At the same time the space has to be insulated to prevent heat loss, however I do not wish to put any extra walls to close it up. Air curtains wil be installed above the "threshold" (boundary) as I want to create a seamless transition when people move across changing room and the court.



Air curtain

One changing cubicle

Air curtain

Minimum 22°C

Cold air from court

Radiant heating for the cubicles will be turned on when temperature is under 22°C.

The floor heating will be turned on when the outdoor temperature drops under 16°C.

Air curtain will be on when any heating system is running in the space.

The same princple will apply to all the zones, each zone will have an independent radiant floor heating layout, in which the temperature for each zone can be easily controlled. For exmaple, if there is the need for the whole football court, it can be heated up to the same degree even though it is across two zones, or vice versa when it is not in use.

There was this idea of putting air curtains all around the perimeter of the zones, however it will also means that a lot of energy will be used to keep them running. Therefore, the another strategy is to use real thick curtains. In this case, this will form another zone between the exterior and the heated zones, in some sense it is trapping a layer of air between them. Air as an poor conductor of heat transfer, so it will be benefitcial to have this layer.



Radiant Floor Heating System

Air Cutrain

Climate Curtain
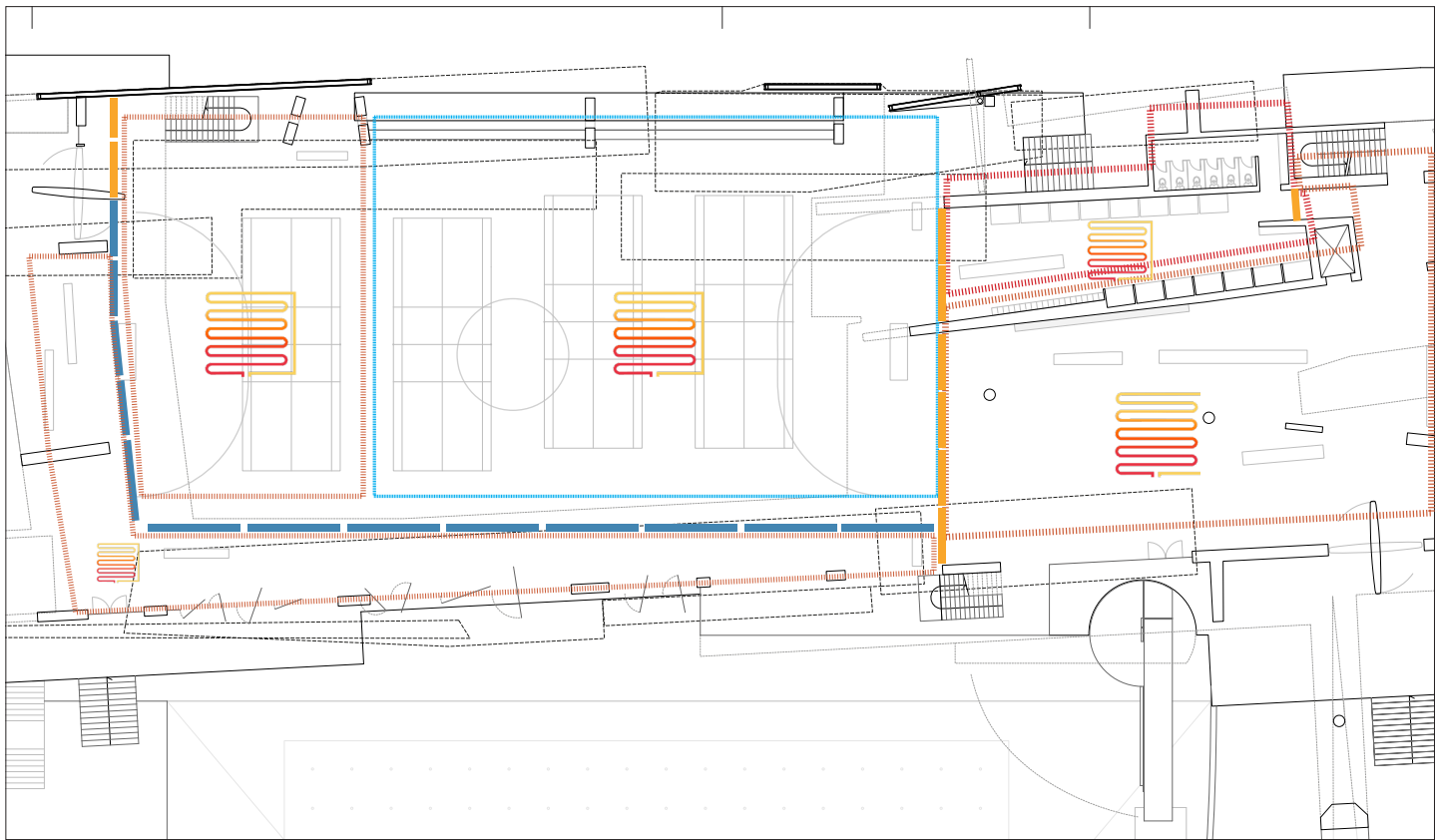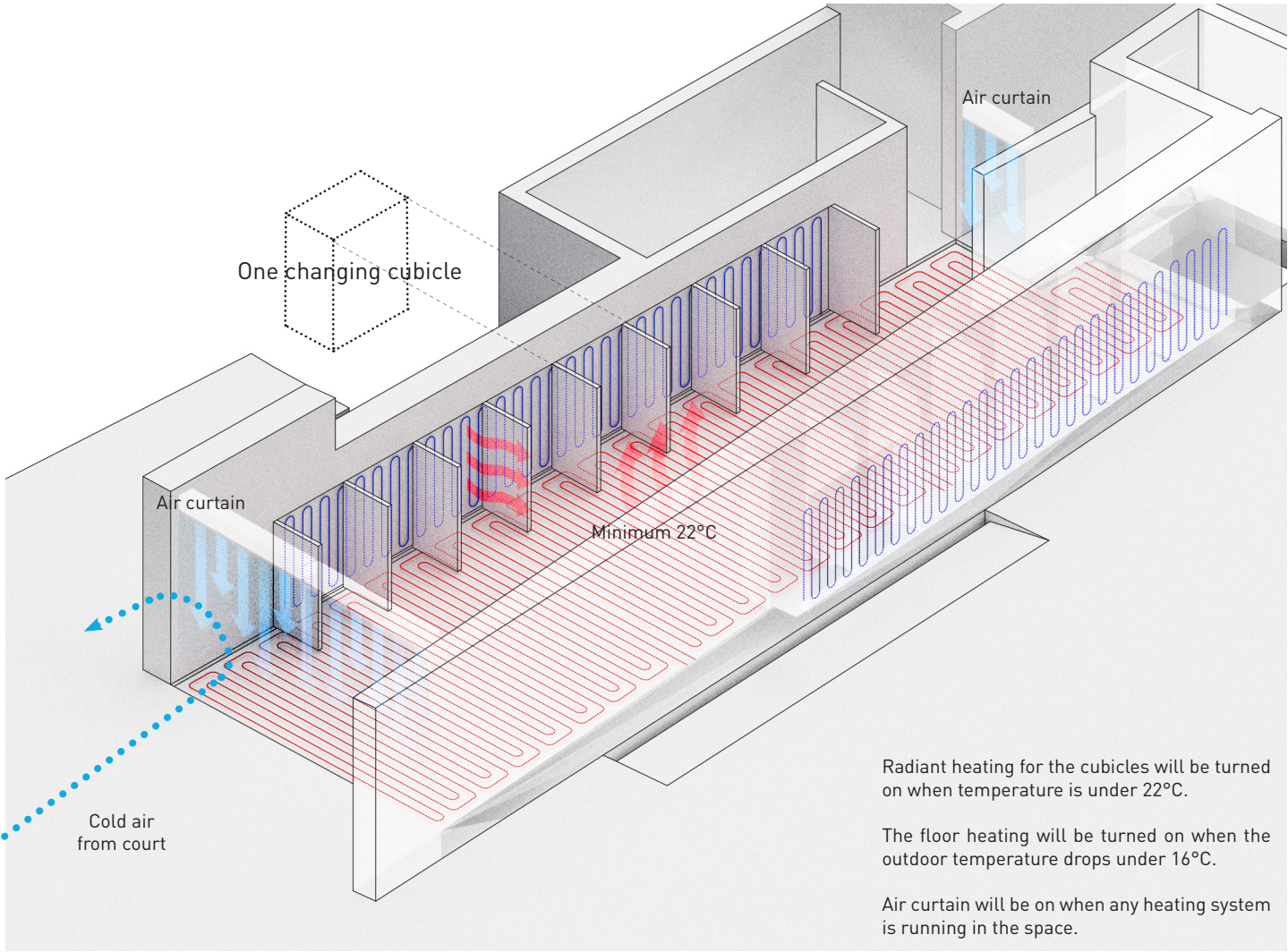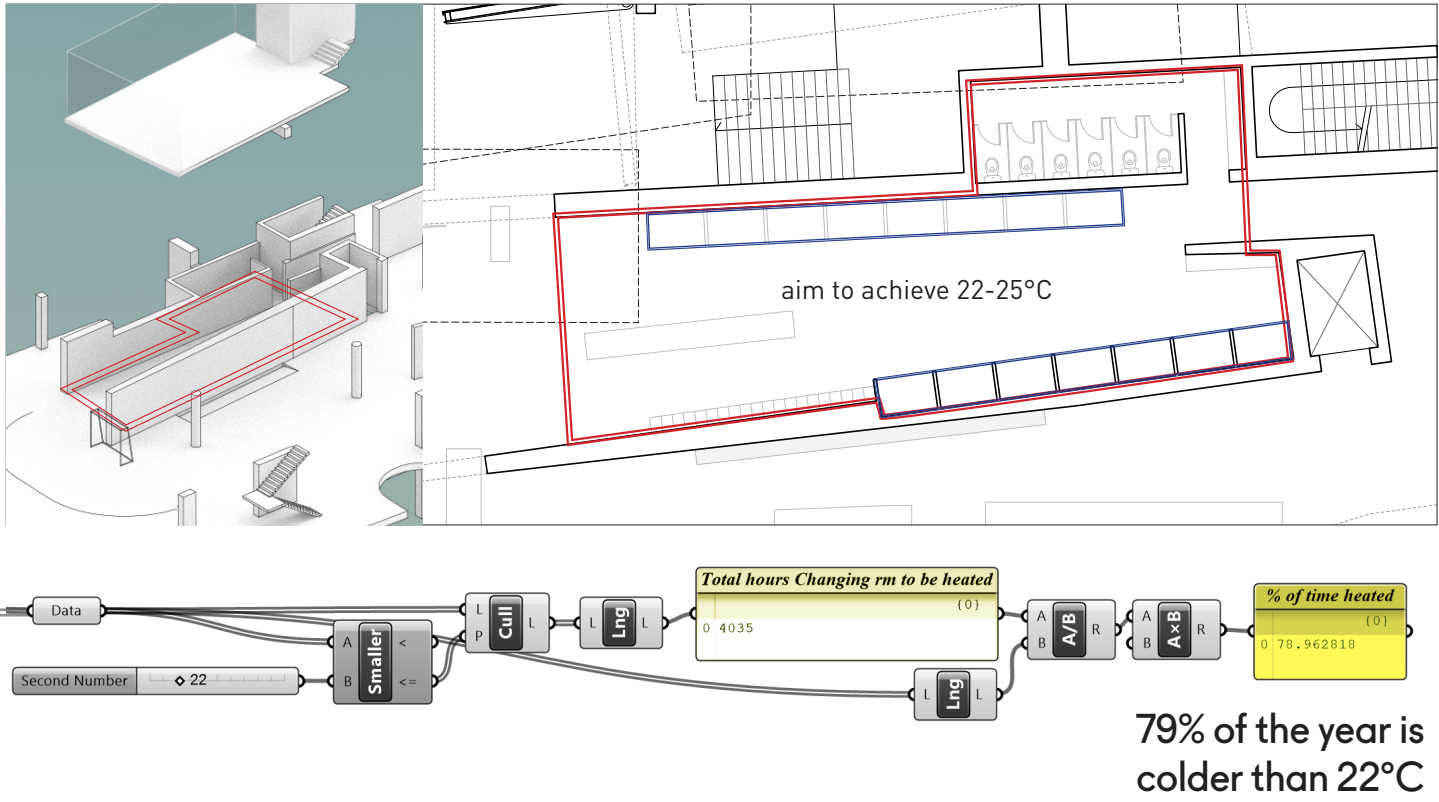
## Climate Curtain

Some research has gone to look into thick curtains, and I have found out there are industrial products called climate curtains. These are used in warehouses with cold storage, install at the entrances.

So called climte curtains is simply dense vinyl fabric sandwiching insulation fibres. The insulation is the 3M product Thinsulate, which allows the curtain to be really thin.

I would like to use this product in the building, they will be rolled up when it is not required. And when it is really cold in winter, they will be released and come down automatically.

Since it is a really dense material, it can also act as a barrier for sound or just blocking the football. Once it comes down, it divdes the spaces, the football match can carry on on the left and some athletes can have fencing training on the right.



1:30 AT A3
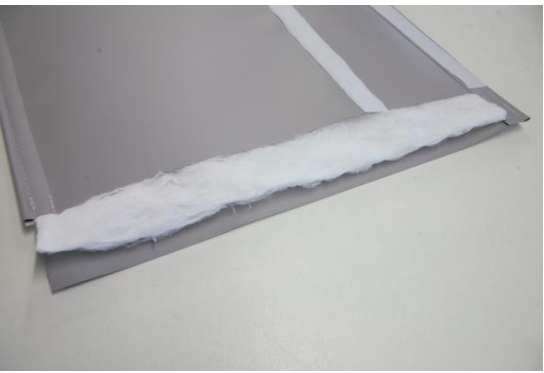




**3M Thinsulate _Ultra_ INSULATION**
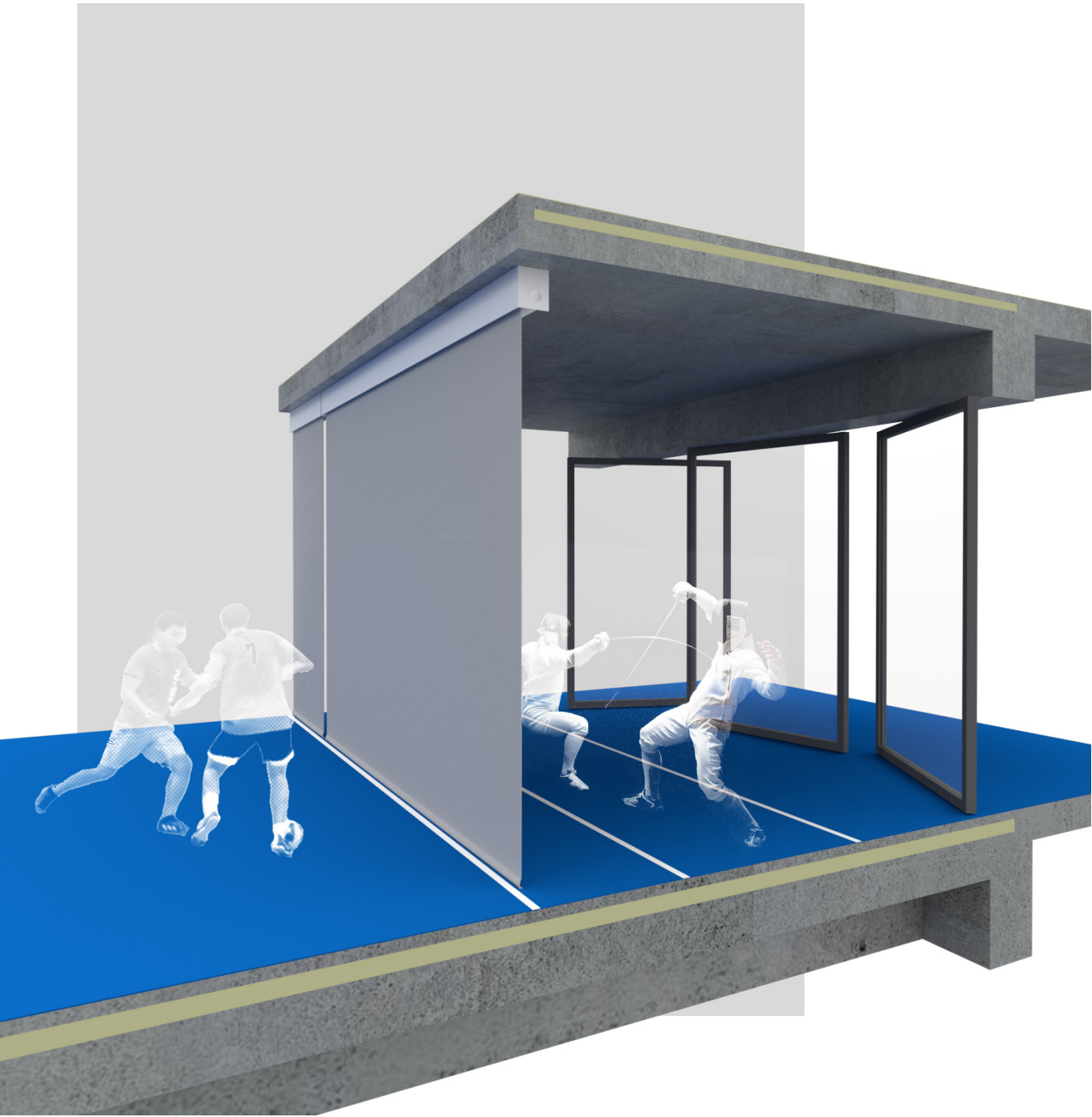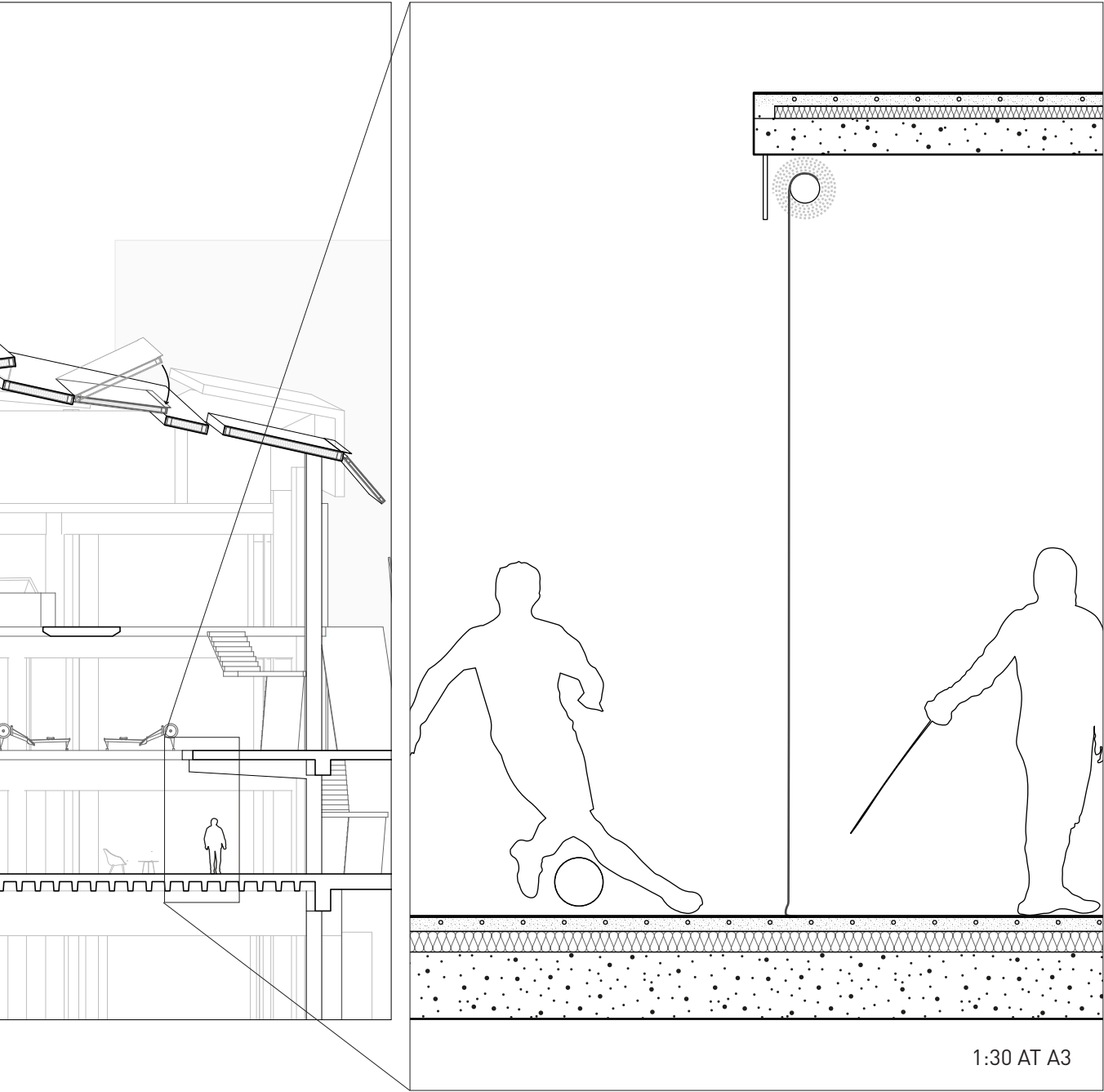
## Programming for Openings

On this page, I will explain the process of programming the windows to open at a certain degree, being able to control the system as a whole, to decide how much I want the building to be opened. Grasshopper is used for scripting.

Situation:
- There are 14 number of windows
- I want the building to open 27.94%

The most straightforward way is to open every single window at 27.94%, but in that way, all windows will be rotated at the same angle and it is not very interesting. I would like them to be rotated at different angle but achieving the right openess in the whole system.

(n)=number of windows

Step 1:
- Generate (n) numbers of random numbers from 0 to 1
- Input desired opening % (x) of the windows.

Step 2:
- Divide themselves from the Mass addition of those random numbers to find out its own partition (percentage) in the sum

Step 3:
- Multiply its partition by the desired % (x) to generate an opening % of windows

**\*However, due to some random numbers having larger partition, there might be a case of windows opening over 100%, hence the excessed % has to be average out in other windows in order to reach the desired opening %(x)\*** -> Step 4

Step 4:
- List out all items (% per window) and check if there are any items over 100%

if NO - then the list become the opening % for each windows straightaway

if YES - add up the excessed value and split equally to be added up onto values under 100

Step 5:
- The data will go through 3 extra times to eliminate any value over 100% that is generated in the process

Step 6: - Remove unnessecary data

Step 7: - Shuffle (Jitter) the data as it was in ascending order according to value

Step 8: Final opening % per window generated
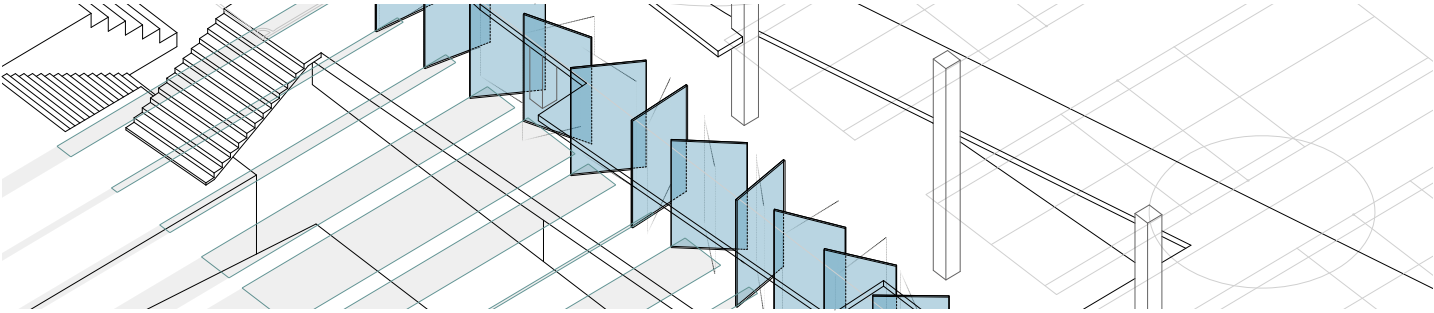


Grasshopper Script:
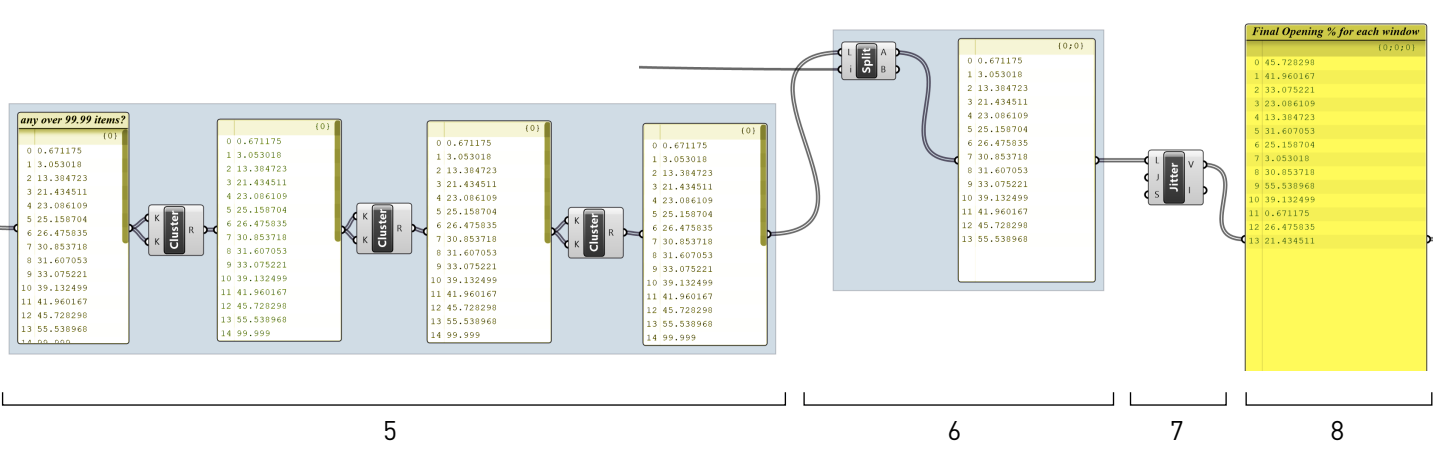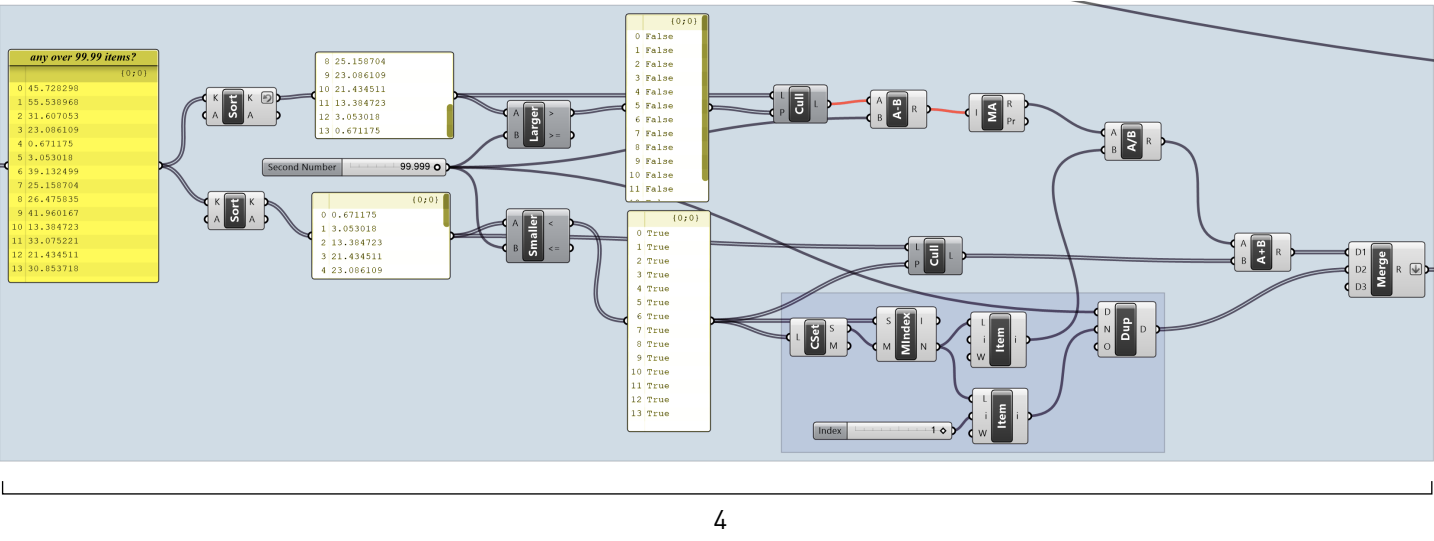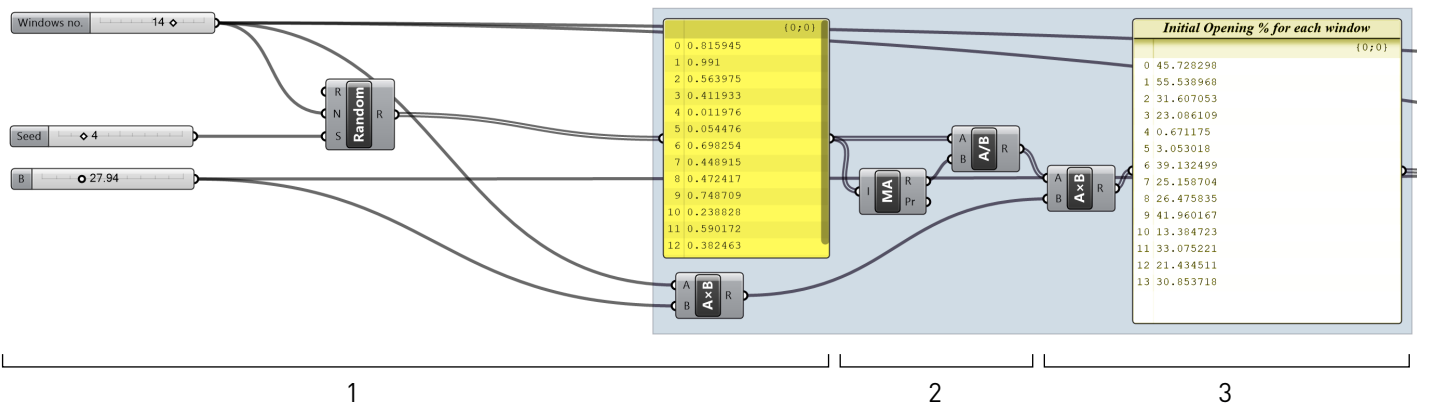
In order to tell the window to open at a certain percetage, the data has to be converted into degrees for rotation.

Situation:
- The width of the window is 2 meters.
- I want it to open 20% (80% closed).

Scaling the width of window (2m) by 80%, we get the width of 1.6m of blocked elevation.

Using cosine in trigonometric function in maths, we can obtain acute angle theta(θ) from dividing the adjacent by hypotenuse.

Adjacent length = Blocked width = 1.6m
Hypotenuse = Window width = 2.0m

$$\cos\theta = \frac{(0.8)x}{x}$$

$$\theta = 36.9$$

$$\cos^{-1}(0.8) = \theta$$

20% Opening in Elevation

## Operable Roofscape

Not only the facades are open, the roof of the building never entirely covering the spaces inside. The idea is to open up the building as much as possible, to create a sense of welcoming as well as to allow heat to dissipate outside and let sunlight into the building.

On the next pages, I will be explaining each roof elements and their mechanisms.

Roofscape Coverage

Second Floor Coverage
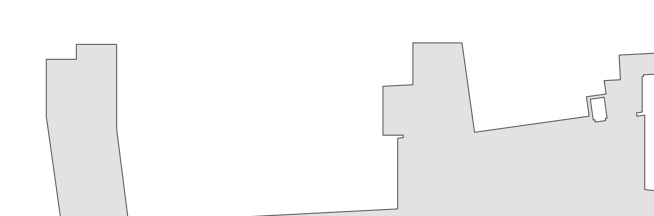
First Floor Coverage
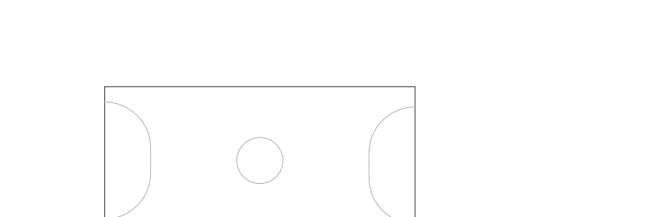
Football Court
(Area aim to cover)
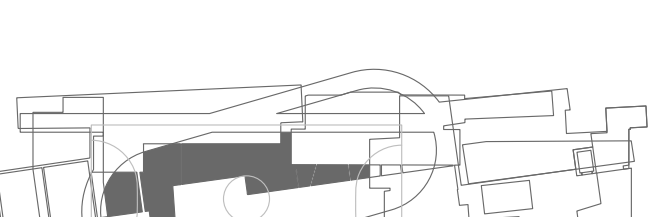
Footprint Superimposed
revealing gaps in plan
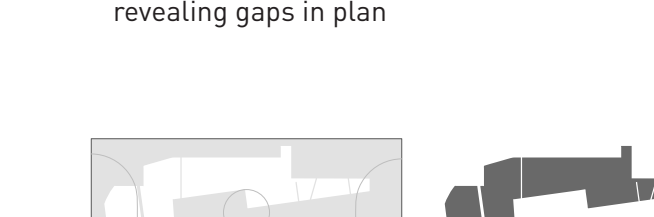
74.1% Court Coverage
when opened
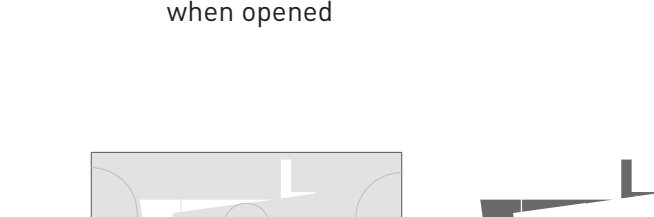
25.9% of gaps in roof

92.4% Court Coverage
when everything is
closed

7.6% of gaps in roof

Design change in the game markings of court, it will now follow the the logic of the roofscape. Badminton courts will be rearrange according to the covered area.
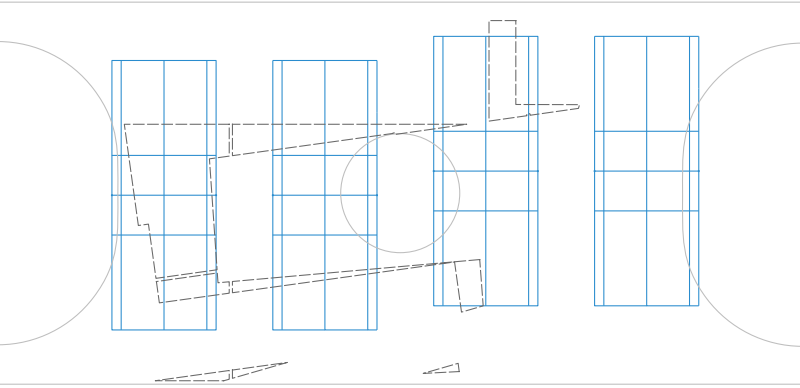
Original Badminton Courts Arrangement
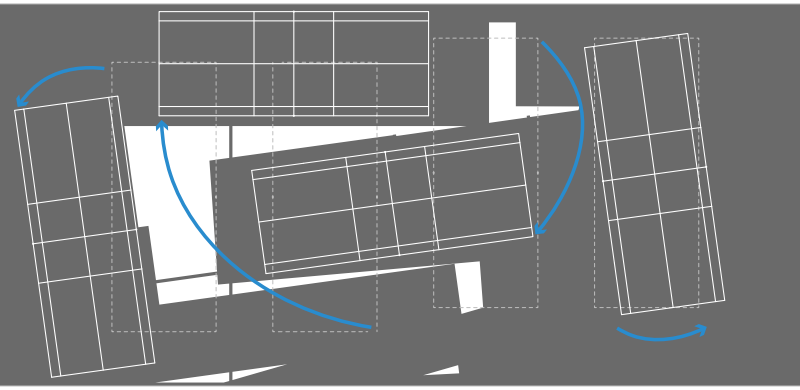
Rearranging Badminton Courts within the covered area
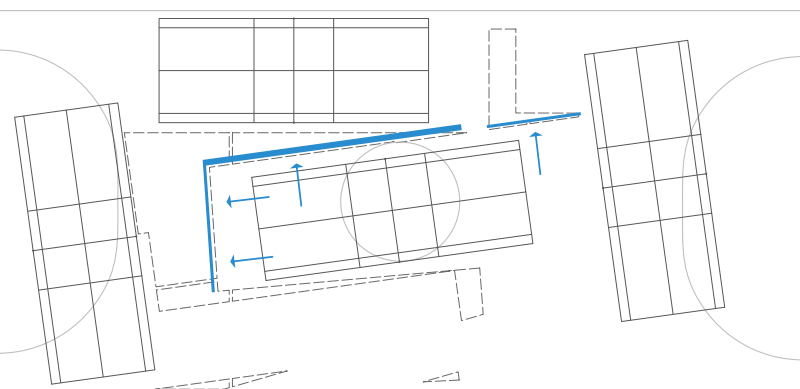
Drainage placement in accordance to open roofscape
and its inclined direction

## Rotating Roof

Breaking it down into each mechanical roof panels, they all have different scripts due to their augmented movement. The first exama- ple is the rotating panels. The roof is inclined, therefore I can no longer use the same way how I calculate for the rotating windows, as the rain will be dropping straight from the sky (in Z-axis). The inclination of the roof changes the whole equation since I am after precise results, so i have to take that into account. Benefit for having the inclined roof is that it is possible to provide 100% shelter against the rain and leav- ing some gaps for air get out.

Since rain is only dropping in Z axis, then I do not need to worry about the inclined angle, therefore using Cosine function can get me the rotation degree, as done in the script for the pivoting windows.

$$\cos\theta = \frac{0.6x}{x}$$

When the roof is 100% closed for rain, that is where the panel is level at x-axis, it is also when a gap is created with the edge of the in- clined roof, that hot air can escape. Dividing the height of that gap by the projected wifth of the panel, we get the % of opening for air. In thi case, it is around 20% when θ is 0 degree.

Therefore, another script is written to control that 20% of ventilation/opening. By repara- metrise the remaining angle of rotation (α) with that 20% gap, then the roof panel can be com- pletely closed for both rain and air.

When θ reaches 0 degree, the second script can be activated by the toggle.

The roof is calibrated to close entirely at 0 de- gree rotation, therefore when it wants to close for rain, the angle it needs to rotate is θ + α (inclined angle of roof).

1 Flexible Rubber Strip
2 Rotation Axle R115
3 Linear Actuator
4 Steel Attachment L-Plate
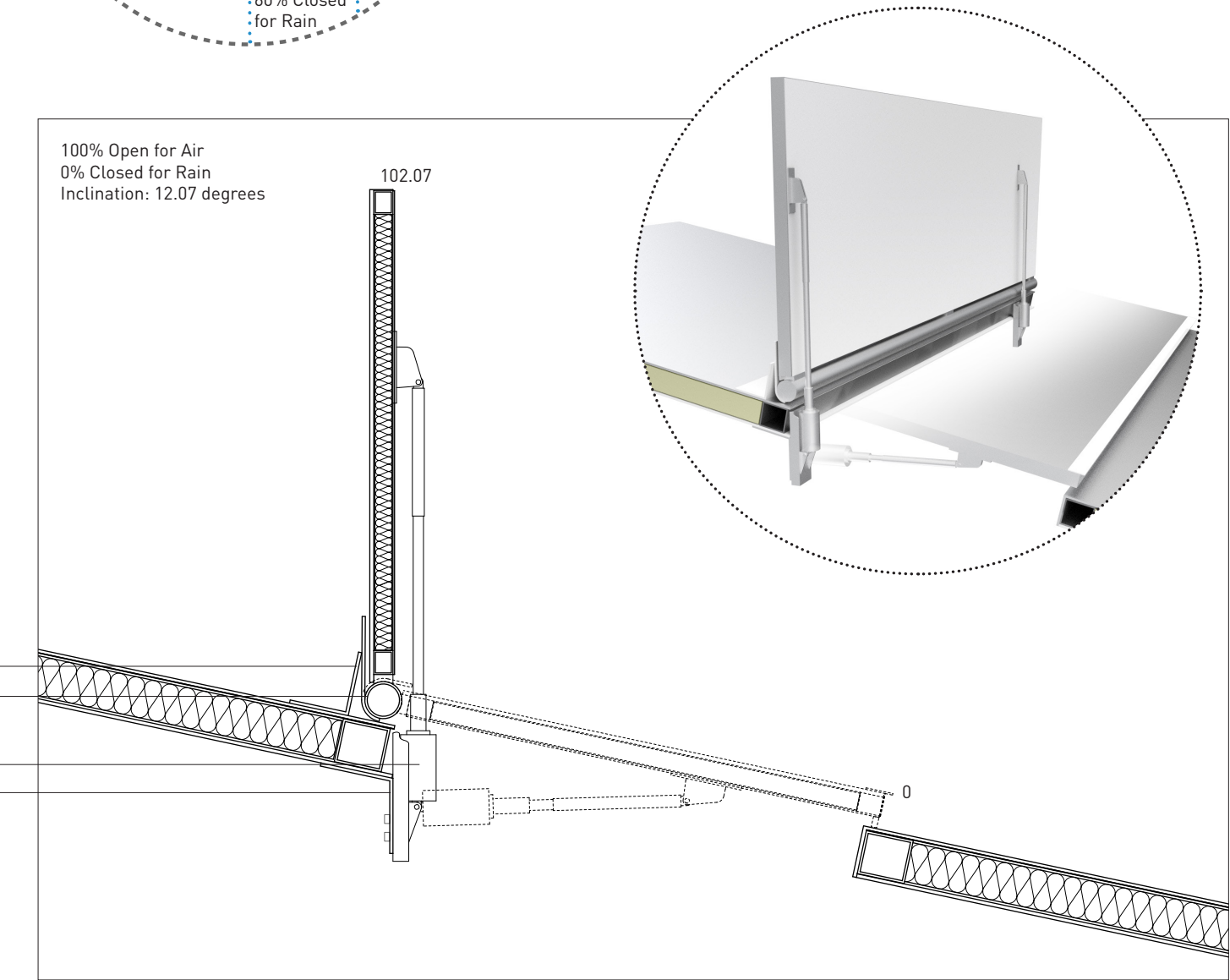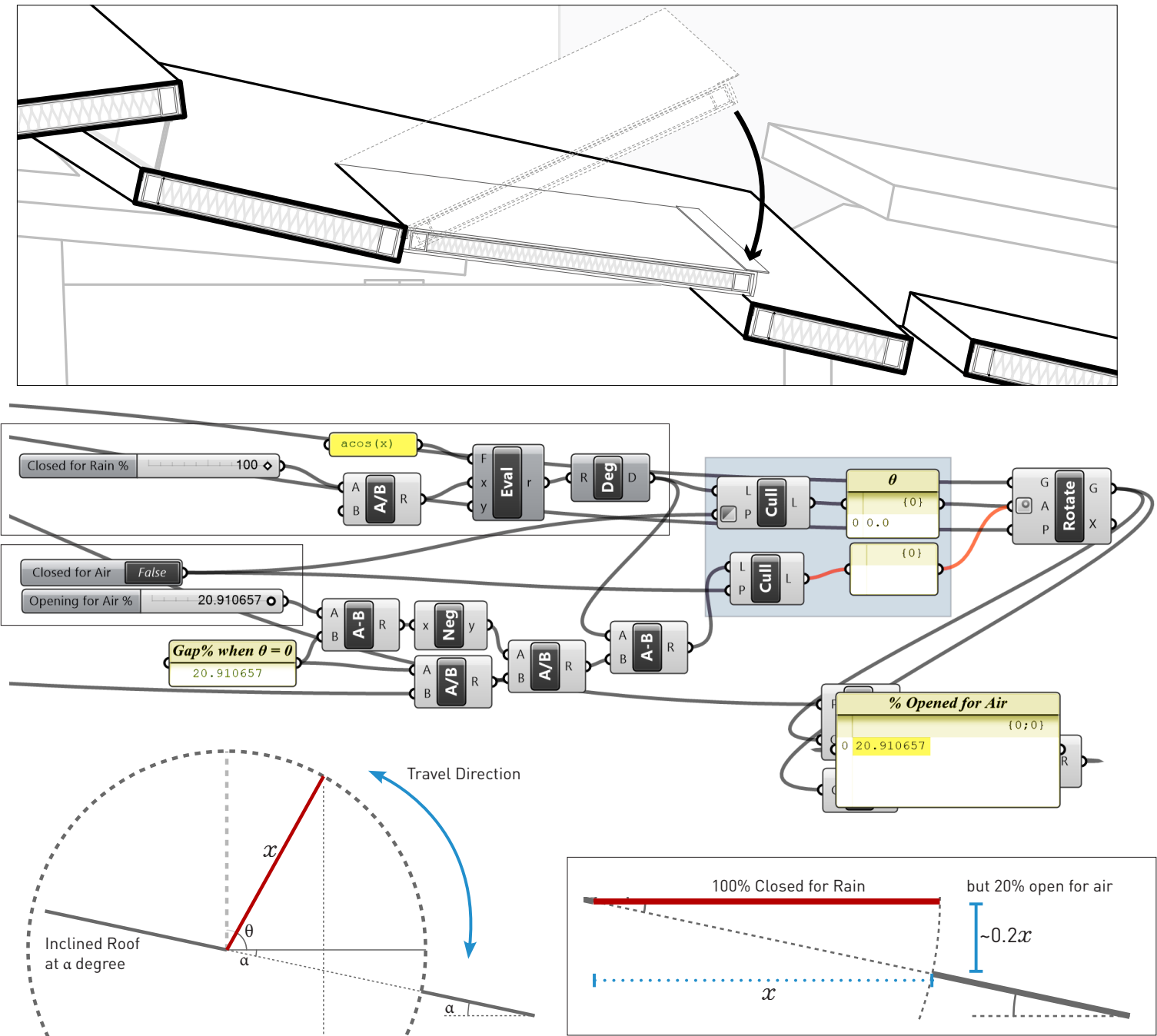
## Sliding Roof

Comparing to the rotating elements, the ret- racable components are way more straight- forward. This component is the retractable roof system. Let say we would like to have 33% opening in the roof (67% closed), the roof panel only has to travel 67% of its own length down, regardless of the inclined roofscape.

For retractable components, there will always have to be a track that it runs on and follows. Equipped with 2 chain actuators, there are two main tracks on each ends of the sliding pan- el, as well as supporting track(s) in the middle section to hold up the heavy panel.
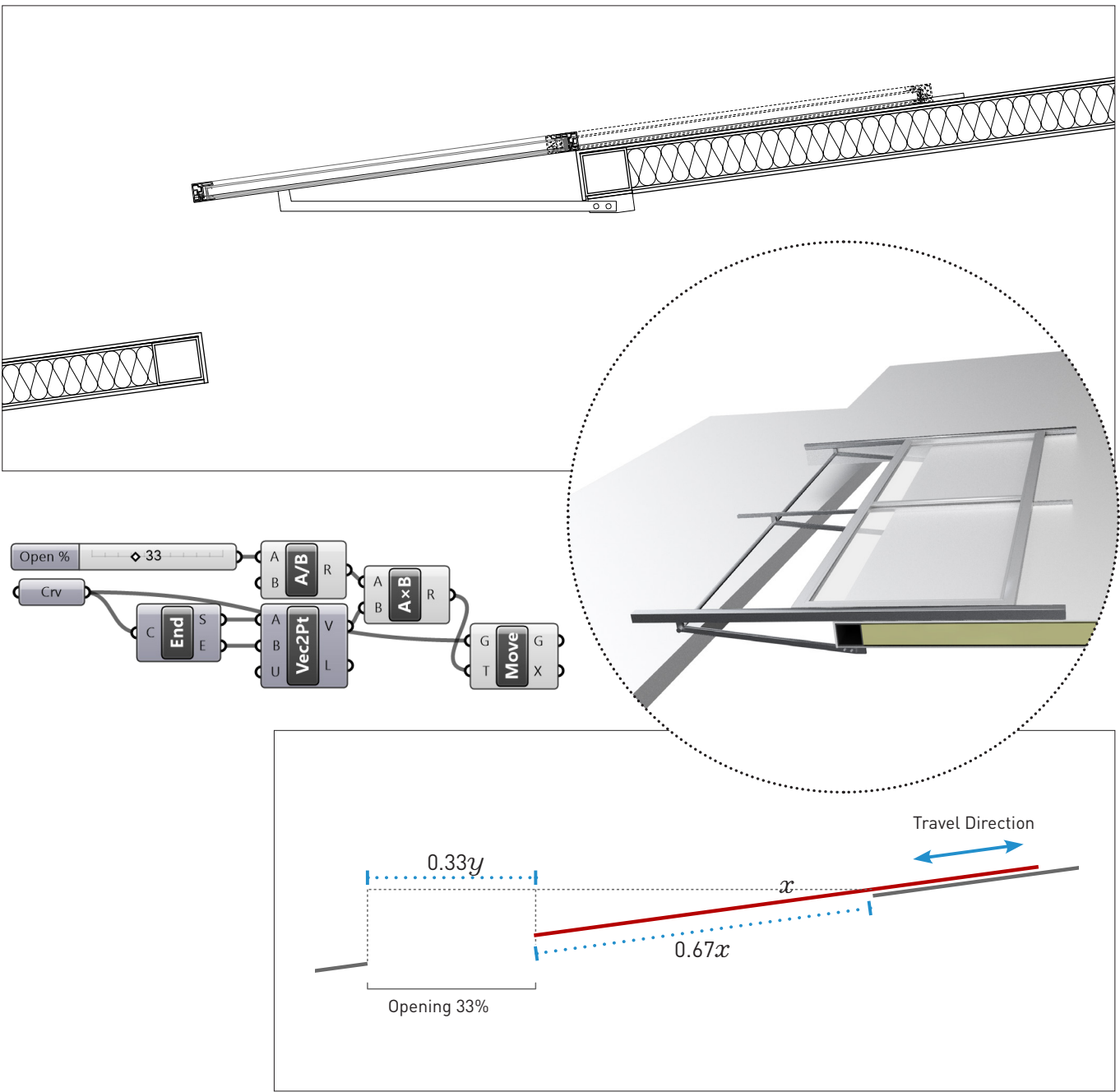
## Retractable Canopy

For the retractable canopy, it is the same prin- ciple with the sliding roof, their traveling dis- tance/percentage is equal to the roof coverage.

x equals to the total length of the canopy when it is flatten out.

To programme this in grasshopper is slightly complicated as I am mimiking the behaviour of canopies. When canopies are retracted, the middle section will drop down due to gravity. Here I have set its maximum drop height to be 2 meters. The canopy initial position is tucked right under an existing solid roof, on a higher place so it doesnt affect the head space. When the roof needs to be closed, the rods will follow the track direction to go downwards, reach the desired coverage.
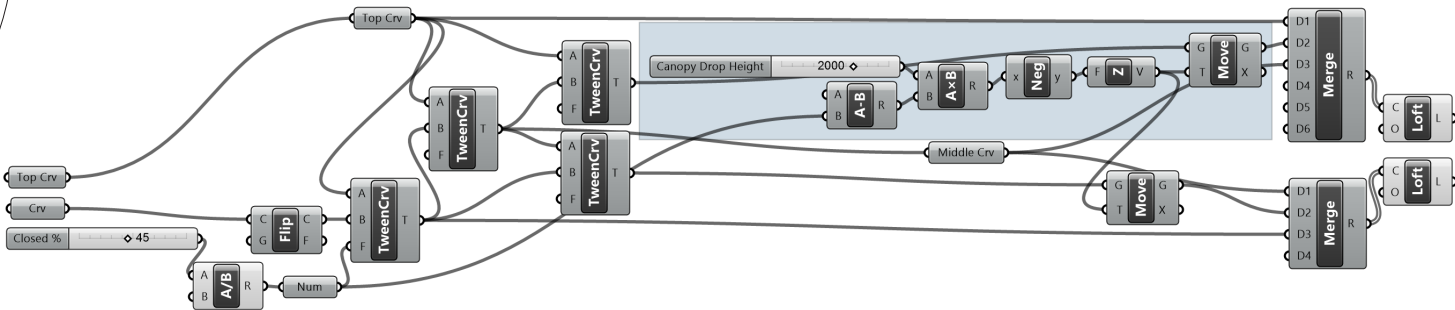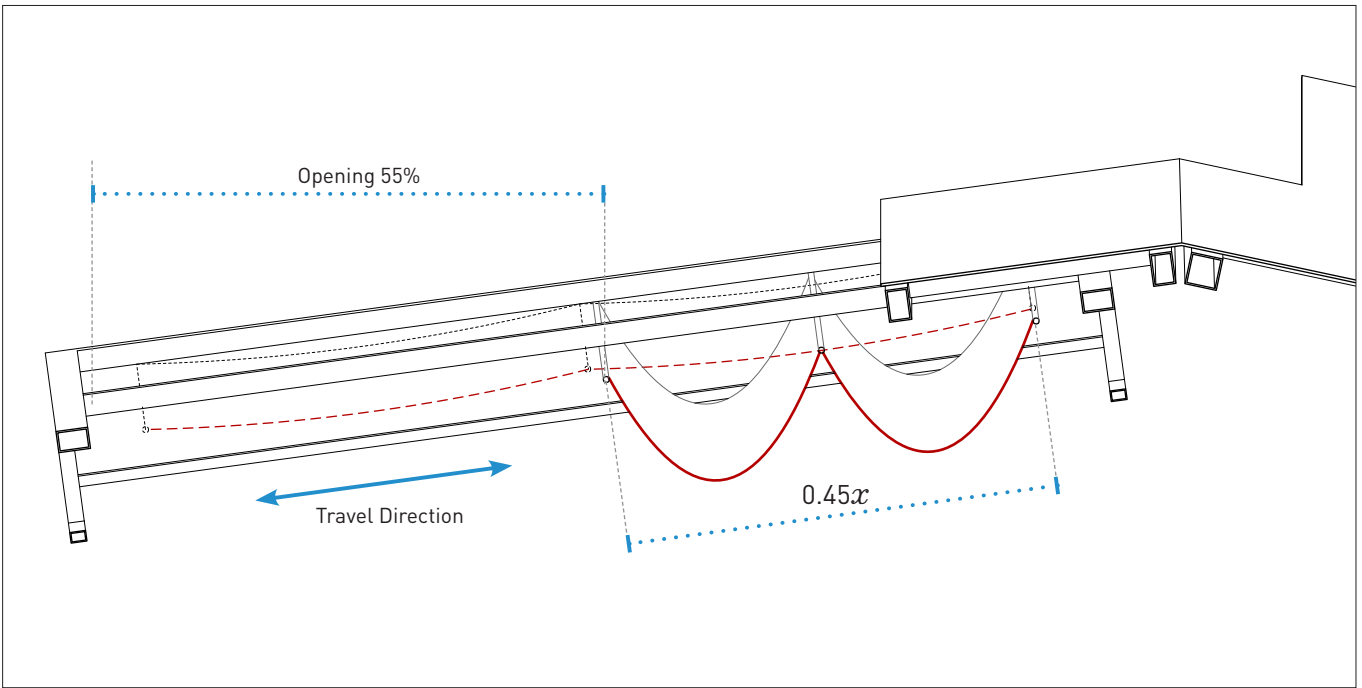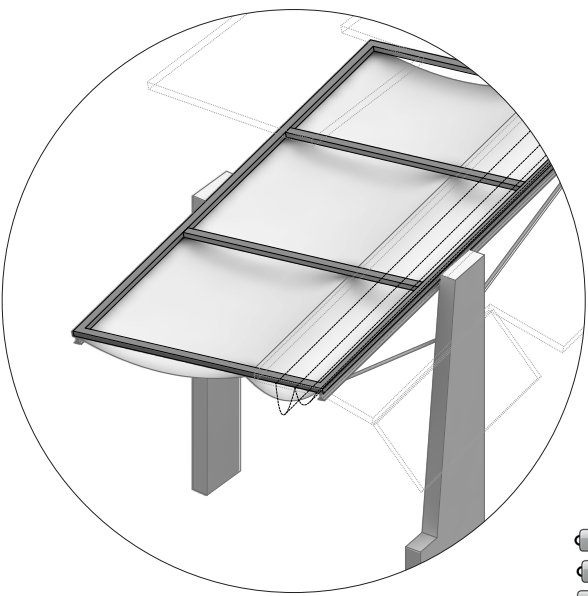
# Calculating Heat Loss

To calculate heatloss, I am taking the 5-a-side football court work with, as it is a simple box model to demostrate the principle. I can then use it as the guide to estimate the heatloss of the whole building.

I am setting the height of the box to be 15metres, roughly the height of the sports hall, so that the box is similar proportion of the building. The height is very important since it can change the result dramatically.

The box has 6 surfaces that it will transfer heat to, top and bottom (roof and ground) and 4 sides (4 elevations). The ground and North elevation do not have any adjustable intervention, therefore their heat loss will remain constant.



Roof

North

South
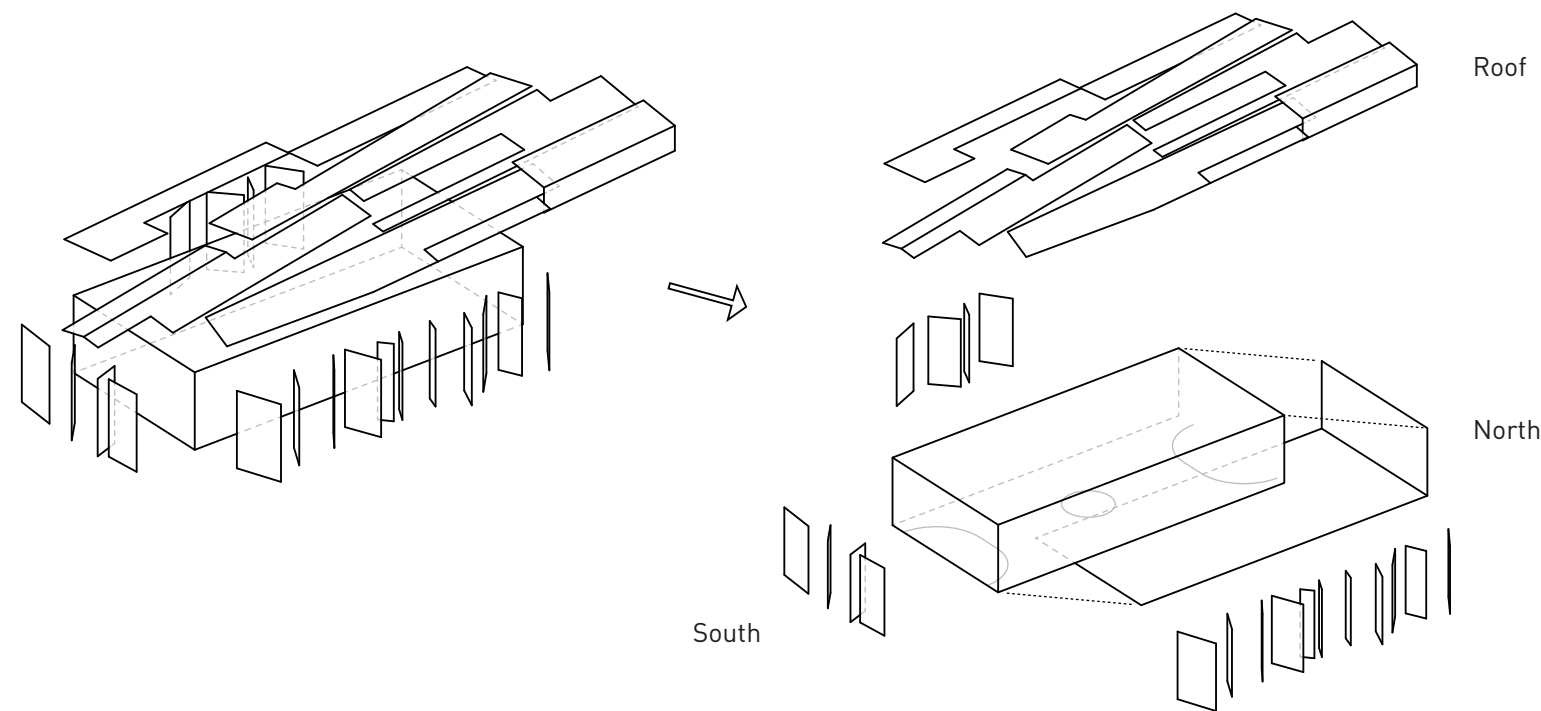
When all elements are 100% Open, 94.5% of the heat is lost to below 4 sides. 5.5% lost to the floor and North.



South Elevation
accounted for 20%
(Void 19.5% + Columns 0.5%)

West Elevation
accounted for 22.3%
(Void 21% + Walls 1.3%)

Roof (Top Surface)
accounted for 16.1%
(Void 13.8% + Panel 2.3%)

East Elevation
accounted for 36.1%
(Void 35.7% + Columns 0.4%)

When all elements opened
**94.5% heat loss** to Air
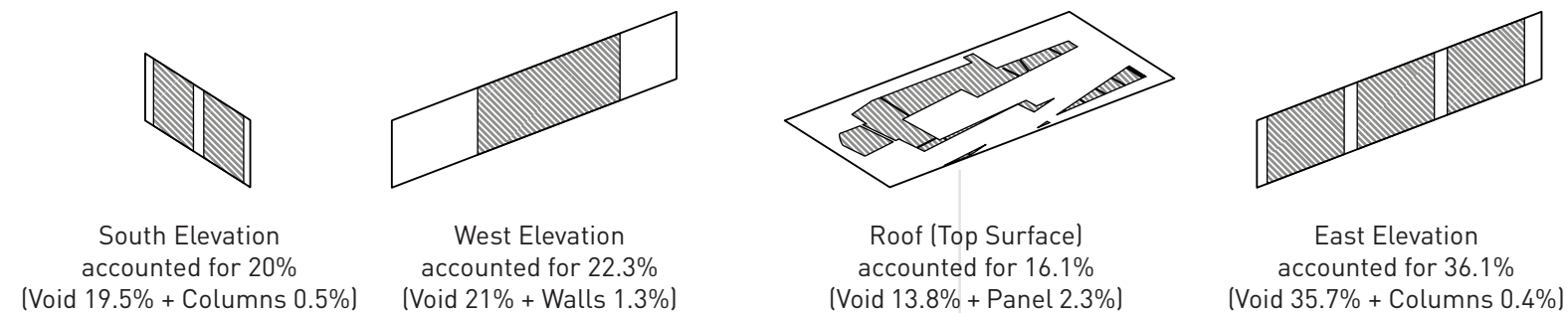
Therefore, when the building is opened, 90% of the heatloss of the building is lost to air via the void, the remain 4.5% is lost to other surfaces.

When all elements are Closed, there will still be gaps on the roof.

Therefore all the heat will be lost through the roof. Through calculations, the building will lose 15% of its heat to the void.

So, 15% of heat loss is minimum and **inevitable** with such roof in the design.

*Note that the percentage is just the proportion of heat lost to **air** in the state (either open or closed), because 100% (all) of the heat will be lost at the end (to all architectural elements).*

Therefore, a number must be set up as the **maximum allowance** for heat loss, and it has to be in the form of energy unit. For example, on the coldest day of Turin, it is required xxx J or Watt to heat up the court and if we are going to lose 15% and it will cost a lot.

Void in Roof
accounted for 15%
of total heat loss

When all elements closed
**15% heat loss** to Air

---

Heat loss (Q) is calculated by multiplying the area (A) of surfaces, the U-value of materials (U) and temperature difference between outdoor and indoor (ΔT).

The outdoor temperature is set to be 0 degrees, and the minimum football court temperature is 12 degrees, this gives us a temperature difference (ΔT) of 12.

Each material has got their own U-Value, and I have designated as following: (W/m$^2$K)

Walls/Roof with Insulation: 0.35
Pivoting Double Glazed Window (Low-E, Argon-filled): 1
Concrete Floor with Insulation: 0.25
Void (ie. an air gap/hole): 6

Since there will be area that is empty (ie a hole/an air gap, so a U-value is made up for these voids, the number is based on Single-Glazed being 5.6)

$$Q = UA\Delta T$$

Since the elevations and roofs are adjustable, therefore the degree of closeness/insulation also changes along.

The script below is showing the maximum heatloss when all elements are opened in the building. It is written to calculate the heatloss accurately, whether it is open or closed.

Taking the top of the script as an exmaple, it is the East elevation with the row of pivoting winwos. Firstly, the percentage of openess of the windows is fed through. In this case, when its totally open, that means the whole surface area is void. Then the area is multiplied by the U-value of air and ΔT will get the heatloss result.

Demonstrated previously, I am able to control the openess of the pivoting windows. Therefore, in that sense, I will also be able to control the amount of heatloss, since the elevation area and the degree of openness (/closeness) are correlated.

It is calculated that,
when the building achieves maximum openness (in 12 degree temp. diff.), it loses 103kW

when the building achieves maximum enclosure (in 12 degree temp. diff.), it loses 27.5kW

Therefore closing up the building reduces **up to 73%** of energy consumption.
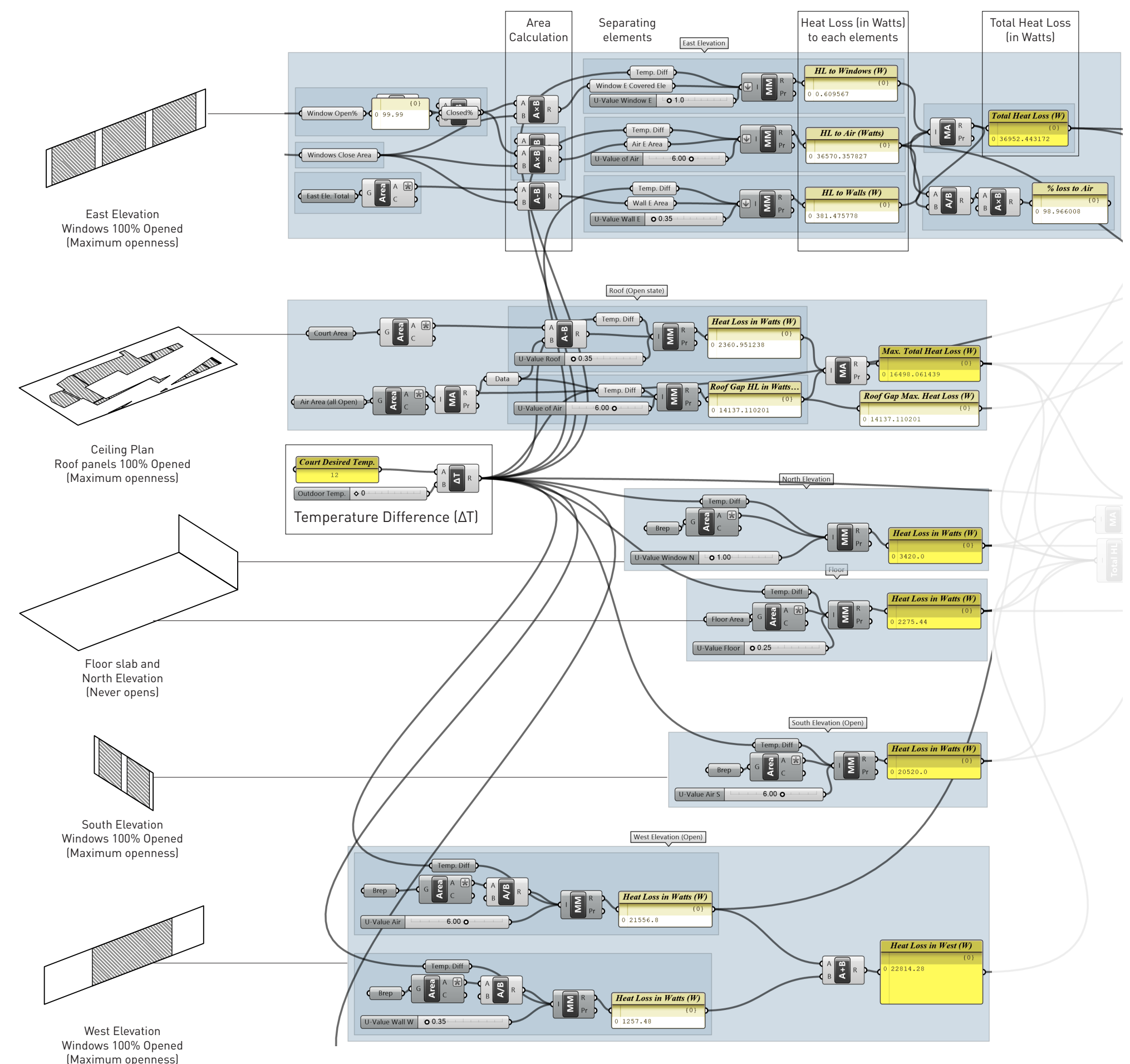
## Minimising Heat Loss
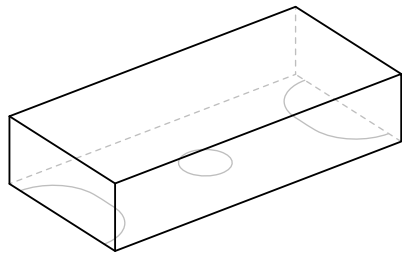
The football court is used for calculations of energy consumption. The dimension of the court is 40m by 19m, the height is set for 2 meters, because I only intend to heat up the space up to a person's height, anymore would be a waste of energy.
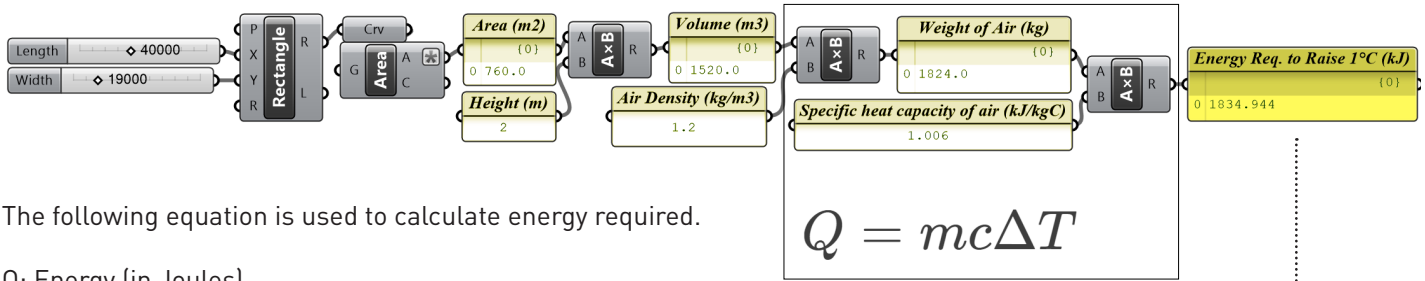
The following equation is used to calculate energy required.

$$Q = mc\Delta T$$

Q: Energy (in Joules)
m: Mass of Air (Volume of Box * Density of Air)
c: Specific Heat Capacity of Air (1.006 kJ/kg°C at 16°C)
ΔT: Change in Temperature (set to 1°C)

1835kJ of energy required to heat up the court by 1°C.

The following calculation is set up for me to find ways to reduce energy consumption from running the building.

The optimum temperature of the football court is 12 to 16°C. I only intend to heat up the court to the minimum requirement of 12°C, as it has been calculated that it will double the energy consumption if heated to 16.

Therefore when the outdoor dry-bulb temperature drops under 12°C, the radiant floor heating system will automatically turned on. The script is only showing the energy spent on heating up the court.

According to weather data, there are 2139 hours (out of 5110) that is under 12°C, that is 42% of time in a year, 153 days equivalent, requires heating for the football court.

During these 'cold' days, obviously the building would like to be as enclosed as possible. However, from previous calculation (page 36), there will always be 15% of inevitable heatloss through the roof gaps even when the building maximised its enclosure. That is also been taken into account, where an extra portion of energy will be adding to the equation. (Efficiency: 85%)
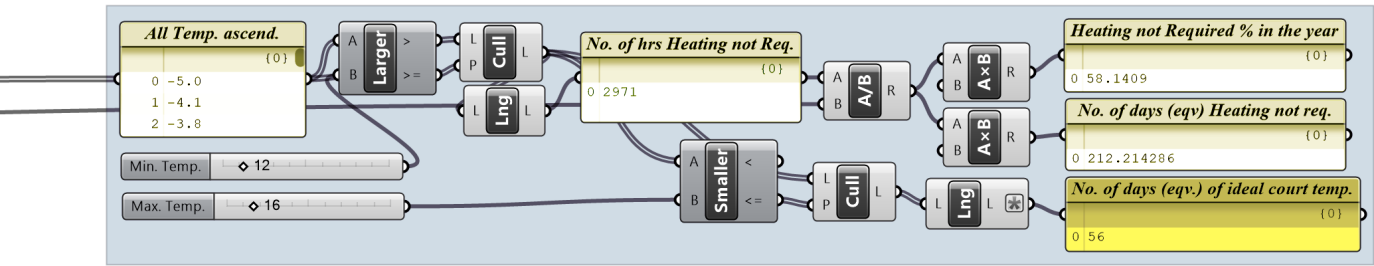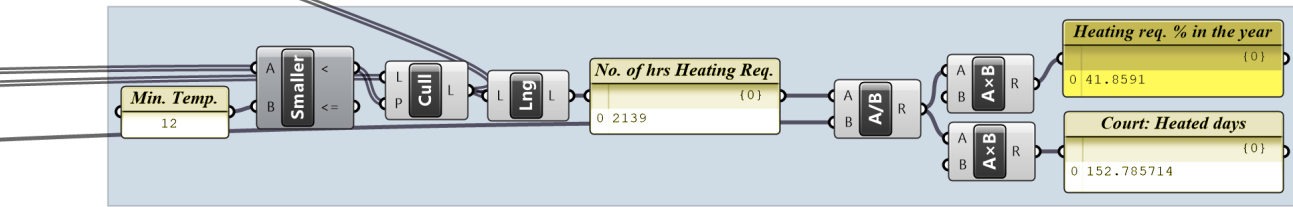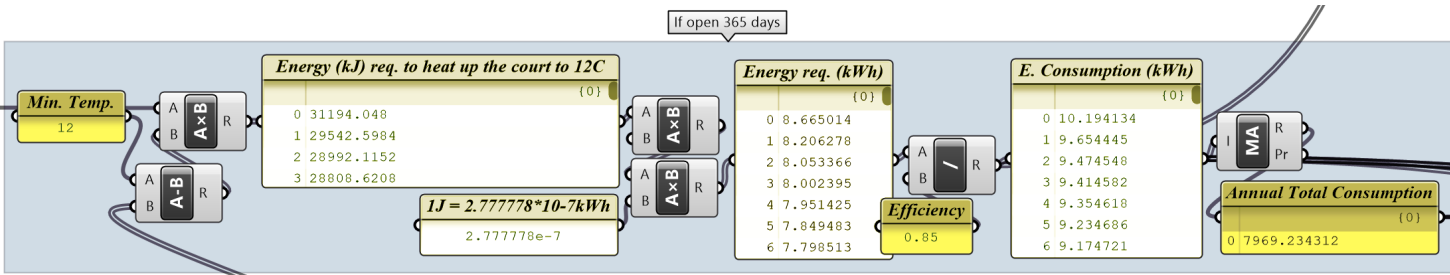
I am looking to close the building on the coldest days in Turin since it is costly to heat up the building, also the fact that my building doesn't entirely close up, that will just waste a lot of energy.

According to the Italian law, there are 11 days of public holidays in a year. I picked out the coldest 11 days in Turin, that means the most energy demanding 154 hours. (Building only opens 14 hours a day)

By picking them out, it's found that each of the 154 hours requires a minimum of 7kWh energy consumption. As I am trying to reduce the energy, I then use the figure as my maximum allowance for energy supply to the football court. By limiting the output to 7kWh max, it gives me 2 extra closed days, which it can be used for annual maintenance for the building.

### 11 Italian public holidays + 2 days for Maintenance = 13 building closing days

### Closing down for **13 days** can **save 17%** energy on heating

It is considered a lot when it is just 13 among 153 'cold' days.
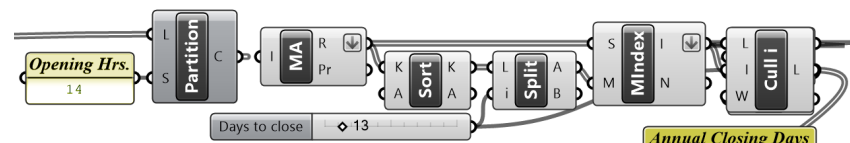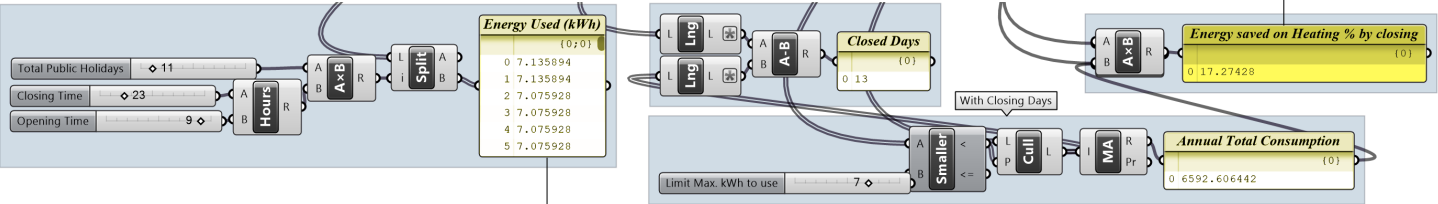
The coldest 13 days were picked up by added up the temperature of every opening hours during in every single day of the year.

In order to fully utilise the building, the closing days will not match the public holidays, as those will be the days that people would like to do sports.

January consists 9 coldest days amongst the 13, the calender below shows the closing dates of the building and the list of other days. The 6th of January is a public holiday in Italy and the weather data shows that it is not cold, therefore the building can stay open on that day.

| December | January |
|---|---|
| 28 | 29 | 30 | 31 | 01 | 02 | 03 |
| 04 | 05 | 06 | 07 | 08 | 09 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 |

Other closing dates: 19/2 (Maintenance), 30/11(Maintenance) and 9/12

## Minimising Energy Consumption

As mentioned before, human will also emit heat to surroundings. It is calculated that 10 football players has 0.14kWh in an hour contributing to heat up the space. That means 40 extra hours of no heating, saving an extra 0.047% of energy! It is not a lot but it is saving some money and the earth.

## Cooling Strategy

### Turin's Highest: 31°C
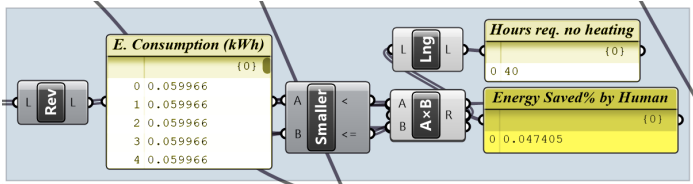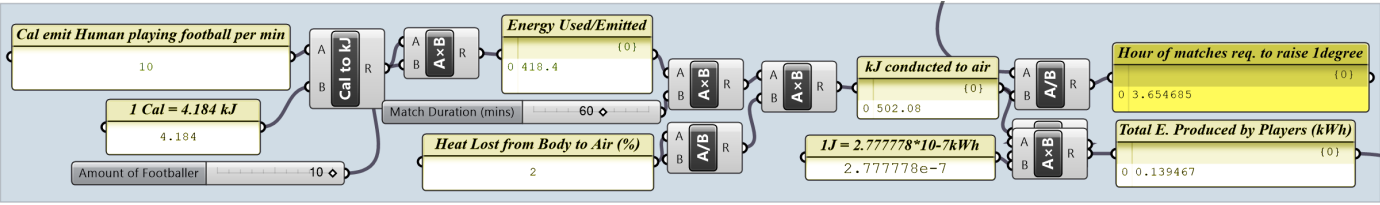
Instead of just keeping the users warm in the building, I will also need to keep them cool during the Italian hot summer. Therefore air conditioning is needed.

First I hooked up the weather data to obtain the hourly temperature, then it's found that the highest can be 31°C.

Data is then fed to calculate the exact amount of energy required to raise/lower the temperture

Reversed Sort List to show hourly tempertures in descending order
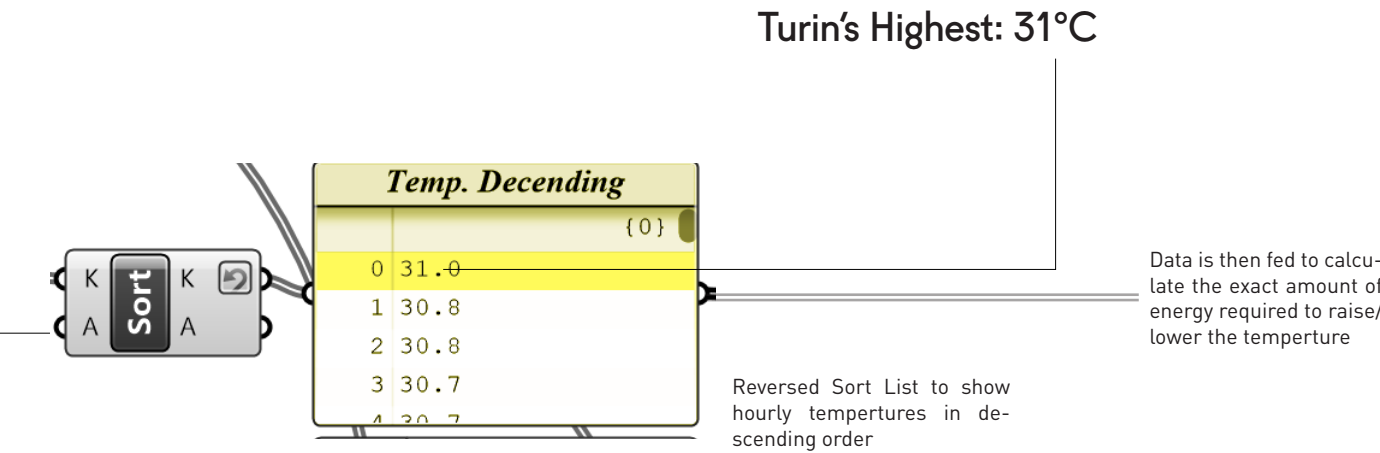
Generally, the maximum temperature of thermal comfort is 28°C. Using it as the guide, I picked out the days that have high temperature range from 28-31°C. The hottest 2 weeks in Turin lie greatly from 22nd June to 22nd August.

Mentioned previously, the desired temperature of the main court is 12-16°C, however, the number can be flexible. According to Sport England, the optimum temperature to play badminton is 16°C, and the max. of indoor temp. shall not exceed 20°C. Based on these figures, I have done multiple calculations to find out the best option for minimising energy spend on cooling, using legitimate weather data.

Script above only showing the calculation process of Option A & B
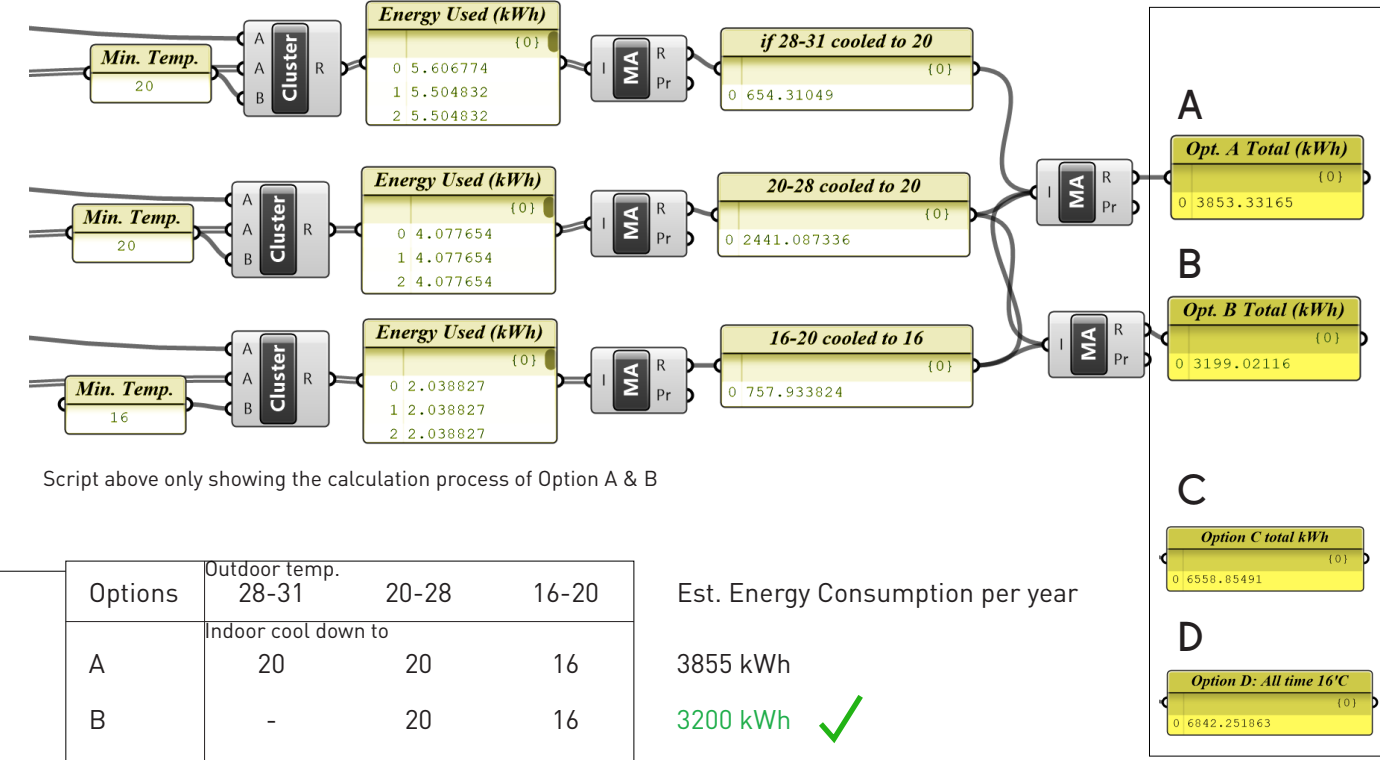
4 options were proposed for cooling strategy.

Option B was chosen for its lowest energy consumption. Therefore the following rule will be applied for building:

When the outdoor temperature is 16-20°C, the football court will be cooled down to 16°C.

When it's 20-28°C outside, it will be 20°C.

For temperature above 28°C, there will be **no air-con**. The public are encouraged to undertake another sport, i.e. swimming in the pools! That also reduces the chance of people having heat strokes playing intensive sports in hot weather.

Calculation shows that it would have been doubled if days 20-28°C is also cooled down to 16°C, (shown in Option C). Therefore the 20°C mark is set to be achieved, it is still an acceptable temperature for badminton.

| Options | Outdoor temp. | | | |
|---|---|---|---|---|
| | 28-31 | 20-28 | 16-20 | Est. Energy Consumption per year |
| | Indoor cool down to | | | |
| A | 20 | 20 | 16 | 3855 kWh |
| B | - | 20 | 16 | 3200 kWh ✓ |
| C | 20 | 16 | 16 | 6560 kWh |
| D | 16 | 16 | 16 | 6840 kWh |

For example: Option A:
When outdoor temperature is from 20 to 31°C, the air con will cool the building down to 20°C, and bring 16-20 to 16°C.

Final Decision - Option B:

When the outdoor temperature is

| 28-31 | 20-28 | 16-20 |
|---|---|---|

Indoor temperature will be:

~28        20        16

Sports you are encouraged to taken

## Natural Ventilation

Due to Turin's geographic location, it does not receive a lot of wind, and its wind direction is never constant.

From the original massing diagram, I have parked my building to one side of the site and created a huge piazza in front of it. Compare the space in the piazza and the existing street scale, the wind should always end up gathering in the piazza, as they only flow from high pressure zone to low. I therefore speculate the prevailing wind direction that they will be coming from the piazza, blowing from the East, through the building and escape on the West side.

The East facade faces the piazza. therefore it is designed to show a sense of welcoming to the public. This facade consists the most pivoting windows, that they can all be opened up. When 100% opened, there are virtually nothing blocking the public coming into the building, and that was the idea of it. Hence the spectators seating are located on the West side of the court.

The pivoting windows not only open up to people but also to air. They are programmed to able to control the building permeability for wind.

Behind the spectators seating is another set of pivoting windows, designed as the outlet of air. The outlet is strategically placed on a **higher** ground to increase the airflow across the hall.

There is no doubt that the building requires mechanical ventilation, our environmental consultant, Katie, from Max Fordham, insisted. However I would like to reduce the usage of it (for lower energy consumption), and the following calculation shows that it is possible.

Sport England recommends that no less than **1.5 air changes per hour** in a conventional sports hall.

By that means, for my hall with the dimension of 40m x 20m x 15m, it would required 12,000*1.5= 18,000 $m^3$ of air added/removed in the space in an hour. (18,000 $m^3$/hr)

With the formula V=kAv
V = Air Flow Rate ($m^3$/s)
k = Coefficient of Effectiveness
A = Area of Inlet Opening ($m^2$)
v = External Wind Velocity (m/s)

Provided that I have all the data for k, A and v, the air flow rate V can easily be worked out, converting the seconds into hours can get me the right number.

k is 0.6 when the wind is blowing perpendicular to the elevation. When the opening area of both sides equal. the ratio of outlet/inlet will be 1, that ratio will multiply to the k.



Main bldg.



East Facade



West

East



Outlet

Inlet
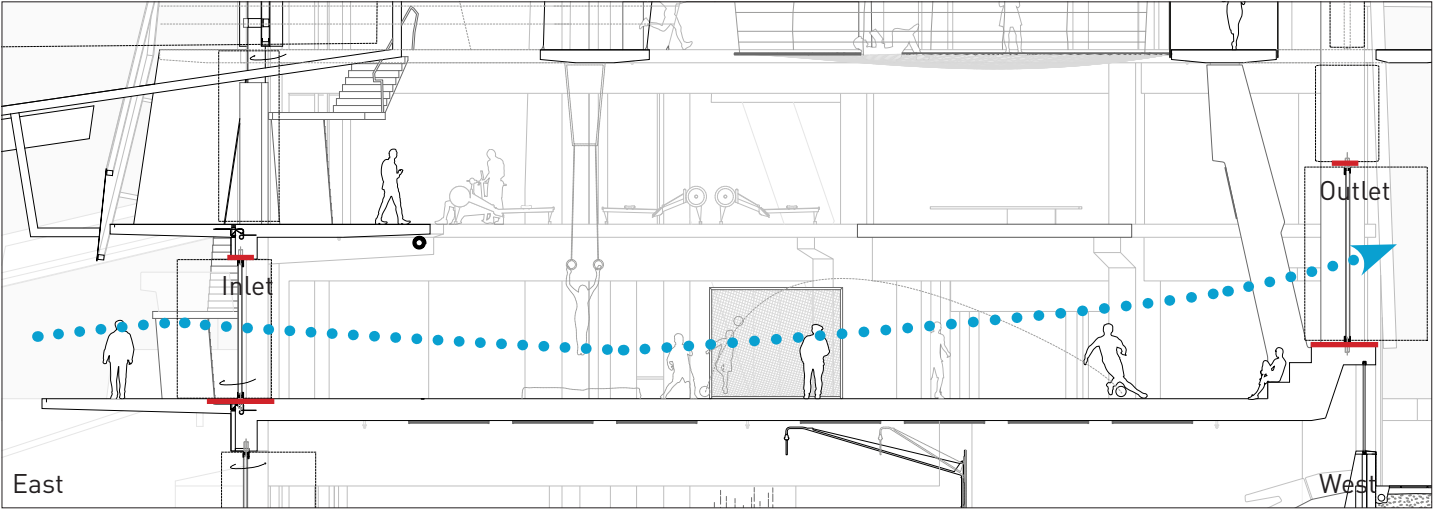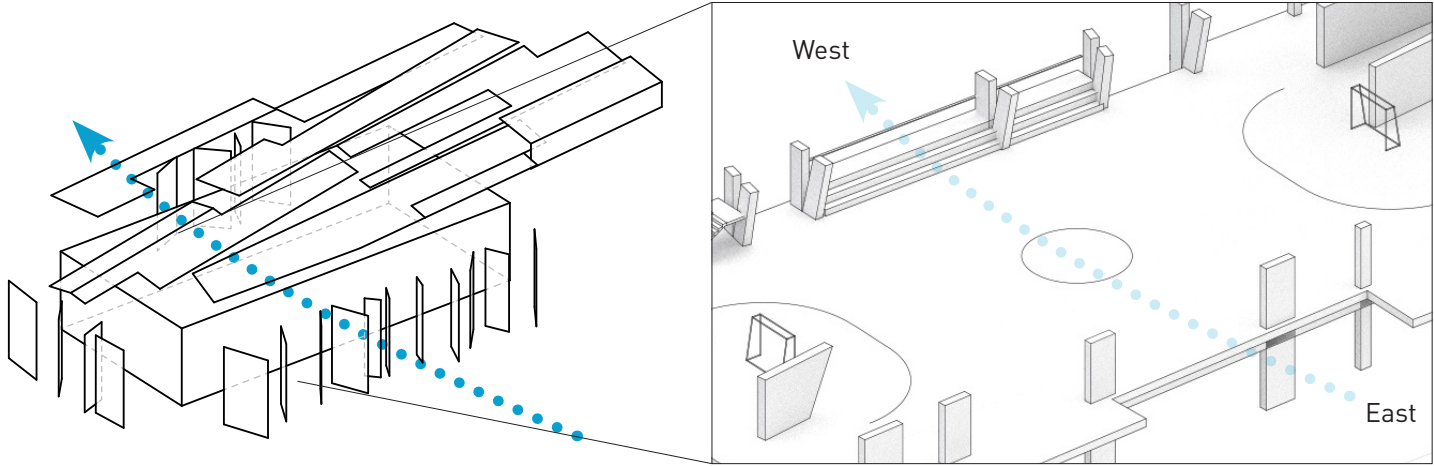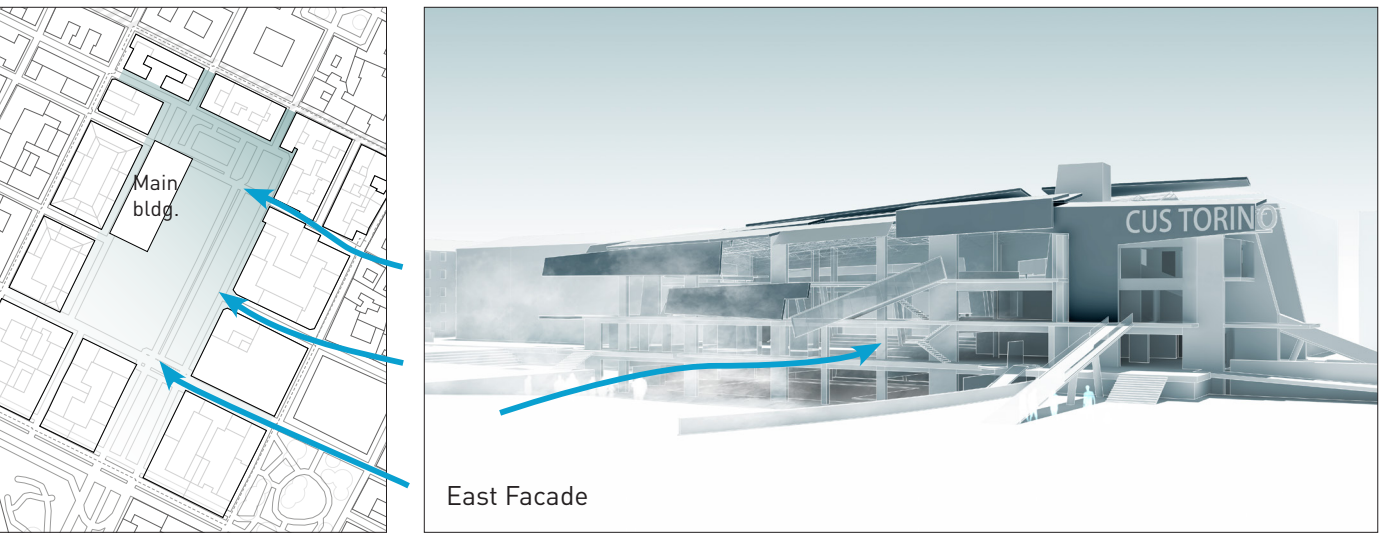
East

West

$$V = kAv$$

Cross ventilation happens when there are windows set opposite to each other. In the case of my building, they are the East and West elevations.

As mentioned, wind flows from high to low pressure zone. By that means, there will be greater flow of air if the outlet opening is larger than the inlet. However, that does not mean the wind velocity can increase, it just 'reduce less' of the external wind speed.

The maximum inlet and outlet openings is set as they are just the elevation area of the windows. I have designed it that, when both side 100% opened, the East elevation (inlet) has larger opening than the West (outlet). The ratio of them would be 0.68 (Out/In), that people can play football with moderate breeze (7m/s) indoor when the external is in high wind (17m/s), even when the windows are wide open.

Diagram (Plan)

Outlet Area = O

V = Air Flow Rate

Inlet Area = I

v = wind velocity

Wind direction 90° perpendicular
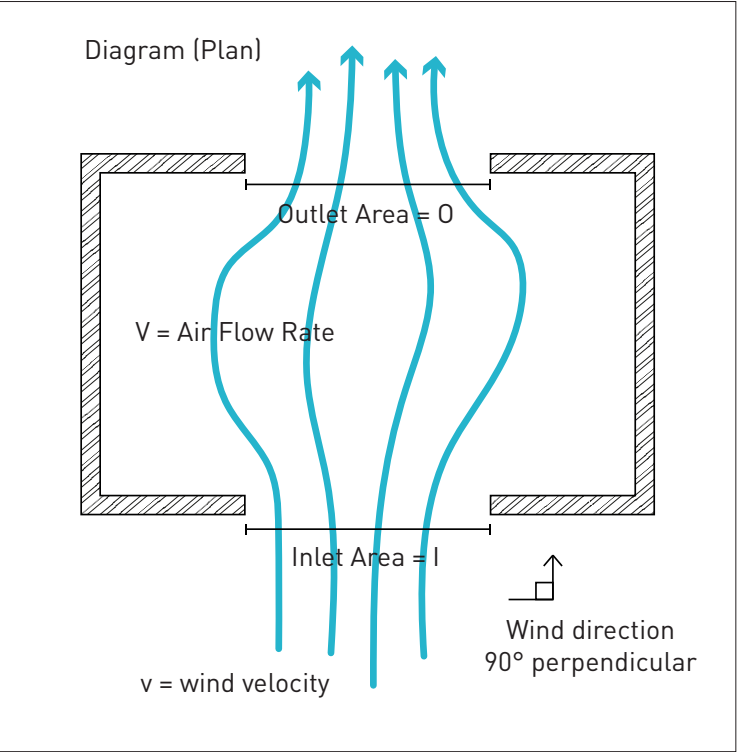
## Sports Hall Air Change

In order to achieve **natural** ventilation of 1.5 air change per hr, minimum requirement as below:

External Wind Speed: 1.078m/s
East Elevation: 1% Open
West Elevation: 100% Open

However there might be times that the outdoor temperature is too cold and it can't afford to lose heat for air change.

For example at 10pm on the 30th December (not a closing day) but it belongs to the days that heating is highly required.

The external wind speed of this hour is 1.3m/s, which fulfils the min. req.. Calculation shows that the West elevation needs to open 82.9% (and East ele. 1%). However the outdoor temperature is -0.5°C (very cold)

The opening % is too big that it will be losing a lot of heat energy to air (refer to the script in page 39.), it is **not sustainable** to sacrifice heated air for natural ventilation, therefore, in this case, **mechanical** ventilation will be activated.



External Wind Speed       Sports Hall

1.08m/s ······▶ Natural Ventilation ✓

0.76m/s ······▶ Natural Ventilation ✗ ······▶ Mechanical Ventilation

(less than 1.5 air change)         is required
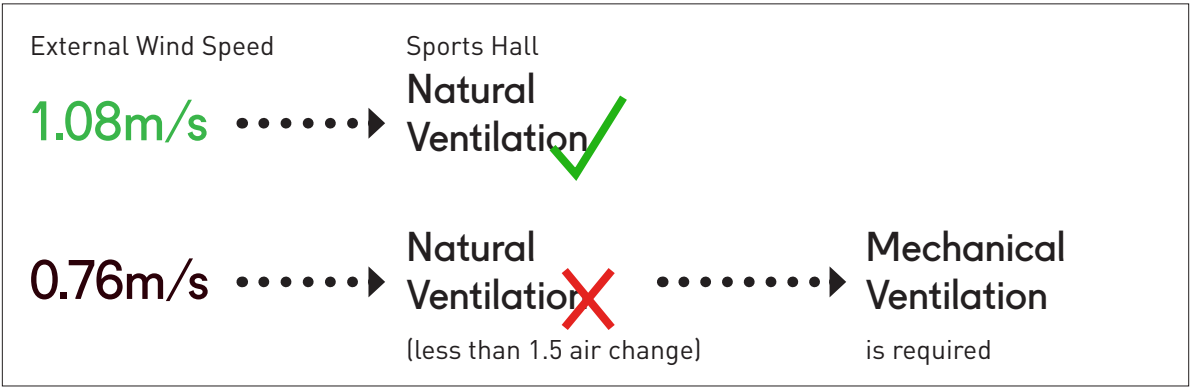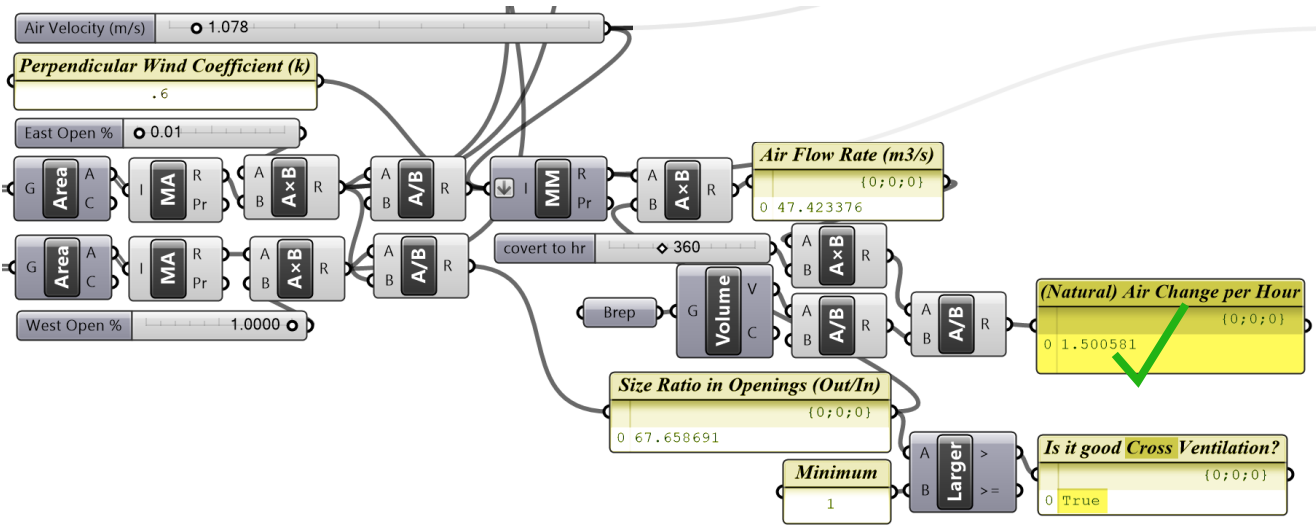
## Wind Speed Control

According to Sport England design guide, the air velocities in badminton playing area should not exceed 0.1 m/s. It is calculated that 44% of time in a year that the wind speed is lower/equal to 0.1m/s. During that period, the building can be entirely open, without worrying shuttlecocks being blown away by wind.

Also the fact that the windows will close up during winter season, wind is expected to be blocked, that increases the chance of playing badminton to 74% throughout the whole year.

Openings in a building has an effect on the internal wind speed. The table on the right is created according to graphs that I researched.

If I can control the size of the openings in my building, that means I can manipulate the internal wind speed to suit the specific needs.



**44%** of time in Turin has no wind.

External / Internal Wind Speed Ratio

| Ratio of $\frac{Inlet}{Total\ Opening}$ | 10% | 30% | 50% | 70% | 90% |
|---|---|---|---|---|---|
| Internal Wind Speed as % of External wind speed | 33% | 43% | 40% | 31% | 17% |

By that means, if the inlet and outlet are the same size, ratio of inlet/total will be 50%, when the external wind speed is 0.5m/s, the internal will only get 40%, that is 0.2m/s.

By creating a large inlet and small outlet, I am able to maintain the internal wind speed within 0.1m/s even when the external is 0.57m/s. It is done by opening east to 100% and closing the West windows to 17% (90% ratio in difference). Sport England recommends a 'Badminton Button' to limit air velocity, and the script shows that it is possible to do so.



badminton

Windows Open       Windows Closed

0.57m/s ······▶ 0.1m/s ✓
External Wind Speed       Internal

Winter Time: 30.12.2021     11am     Overall     100% enclosure
Outdoor Temperature: 1.3°C
Indoor Temperature: 12°C

Insulation Panel
100% closed

CUS TORIN

Winter Time: 30.12.2021     11am
Sun Azimuth, Altitude: 163.9°, 21.5°

Roof Canopy
100% closed to trap heat

Insulation Panel
100% closed

Autumn Time: 01.11.2021     12pm     Overall     46.52% openness
Outdoor Temperature: 14.6°C
Indoor Temperature: 13°C

East: 86.52% open

CUS TORIN

East Elevation
86.52% open

Autumn Time: 01.11.2021     12pm
Sun Azimuth, Altitude: 188.8°, 37.3°

Solid panel to block sunlight

Summer Time: 25.06.2022     10am     Overall     100% openness
Outdoor Temperature: 25.9°C
Indoor Temperature: 20°C

Insulation Panel
100% open for sunlight

Roof Insulation Panel
100% open

CUS TORIN

Theatre Canopy
100% open for sunlight

Summer Time: 25.06.2022     10am
Sun Azimuth, Altitude: 141.4°, 65.6°

Roof Canopy
100% open for fresh air

Rotates in Horizontal axis
increases usable floor area

# Transformation



Date: 6 Jan 2022          1pm
Outdoor Temperature: 1.9°C
Indoor Temperature: 12°C
External Wind Speed: 0.3m/s
Internal Wind Speed: 0.0m/s

Overall  Openness          0%
East ele. (G/f)            0%
West ele.                  0%

Date: 18 Feb 2022          3pm
Outdoor Temperature: 4.1°C
Indoor Temperature: 12°C
External Wind Speed: 0.0m/s
Internal Wind Speed: 0.0m/s

Overall  Openness          2.46%
East ele. (G/f)            4.57%
West ele.                  1.7%

Date: 28 March 2022        1pm
Outdoor Temperature: 12°C
Indoor Temperature: 12°C
External Wind Speed: 0.0m/s
Internal Wind Speed: 0.0m/s

Overall  Openness          11.07%
East ele. (G/f)            20.58%
West ele.                  7.66%

Date: 15 April 2022        2pm
Outdoor Temperature: 16.7°C
Indoor Temperature: 16°C
External Wind Speed: 5.5m/s
Internal Wind Speed: 1.34m/s

Overall  Openness          17.63%
East ele. (G/f)            32.79%
West ele.                  12.20%

Date: 04 August 2022       2pm
Outdoor Temperature: 30.3°C
Indoor Temperature: 28°C
External Wind Speed: 1.2m/s
Internal Wind Speed: 0.43m/s

Overall  Openness          100%
East ele. (G/f)            100%
West ele.                  100%

Date: 12 July 2022         3pm
Outdoor Temperature: 24.8°C
Indoor Temperature: 20°C
External Wind Speed: 1.0m/s
Internal Wind Speed: 0.3m/s

Overall  Openness          72.92%
East ele. (G/f)            100%
West ele.                  61.5%

Date: 23 June 2022         10am
Outdoor Temperature: 25.9°C
Indoor Temperature: 20°C
External Wind Speed: 2.9m/s
Internal Wind Speed: 0.7m/s

Overall  Openness          53.68%
East ele. (G/f)            99.83%
West ele.                  37.14%

Date: 20 May 2022          6pm
Outdoor Temperature: 19.1°C
Indoor Temperature: 16°C
External Wind Speed: 2.6m/s
Internal Wind Speed: 0.63m/s

Overall  Openness          20.5%
East ele. (G/f)            38.13%
West ele.                  14.19%

Date: 23 Sep 2022          1pm
Outdoor Temperature: 20.2°C
Indoor Temperature: 20°C
External Wind Speed: 0.0m/s
Internal Wind Speed: 0.0m/s

Overall  Openness          79.06%
East ele. (G/f)            100%
West ele.                  70.29%

Date: 14 Oct 2022          10am
Outdoor Temperature: 17.1°C
Indoor Temperature: 16°C
External Wind Speed: 0.0m/s
Internal Wind Speed: 0.0m/s

Overall  Openness          31.57%
East ele. (G/f)            58.71%
West ele.                  21.85%

Date: 11 Nov 2022          2pm
Outdoor Temperature: 8.8°C
Indoor Temperature: 12°C
External Wind Speed: 0.3m/s
Internal Wind Speed: 0.07m/s

Overall  Openness          23.37%
East ele. (G/f)            43.46%
West ele.                  16.17%

Date: 27 Dec 2022          12pm
Outdoor Temperature: 5.9°C
Indoor Temperature: 12°C
External Wind Speed: 1.0m/s
Internal Wind Speed: 0.24m/s

Overall  Openness          4.51%
East ele. (G/f)            8.39%
West ele.                  3.12%

## Client, Context and Funding

Turin was awarded the European Capital of Sports 2015 by ACES Europe (European Capitals and Cities of Sport Federation), it was a great opportunity for the city to ask for investment from local, regional or national governments, and have the opportunity to participate in different EU grants with other cities.

The candidature revealed the city's sport development plan from 2011-2016. It did not just stopped in 2016, there was another city development plan for 2016-2021 (sports included) published. Numerous of objectives were established, such as to enhancement of open areas and facilities and many more. And Piazza Arbello (the site) managed to benefit from it.



Mech. 2016 03358/002

Sports Development Plan 2011-2016    Turin Development Plan 2016-2021

In 2012, the public space Piazza Arbarello was redeveloped from run-down skate park. Since then it has been an open space for the area.
In 2015, the sport association Trio LIbero proposed to activate the piazza by 'constructing' a basketball court in it, it was backed with 334 signatures from the locals. As the European Capital of Sports 2015, the City Council approved the proposal. The project was funded by a banking foundation and some local shops.

The project was a successful case of active citizenship, realising the space with private means and resources and then transfer it back to the City. The space provided a sporting ground for the children and 15 schools (within 4 km of the site). Numerous basketball events were held in the piazza since then.

Recently, there are new plans to regenerate the Piazza Arbarello and the avenue Corso Siccardi next to it. In 2017, it has been approved that Corso Siccardi will turned into a cycle-pedestrian path as part of the city-scale cycling network, in connection to the already-pedestrianised Via Garibaldi. The funding for the cycling path is also funded by the same banking foundation.

Since the area is already in the state of being developed, this proposal aim to grab this chance, to also pedestrianise the whole area.

Compagnia di San Paolo is the banking foundation mentioned above, one of the oldest and largest private foundations in Europe. The foundation pursues socially useful objectives in order to promote **cultural, civil and economic development** with the income from its assets. The foundation has been contributing a lot of projects in Turin and it is the major supporter of CUS Torino.

CUS Torino (Centro Universitario Sportivo Torino) is an association of social promotion of sports practice at the university level (in Turin), as part of the Italian Sports University Center (CUSI), recognised by the Italian National Olympic Committee.

The sports development plan has suggested to launch a pilot project starting from environmental sustainability. The city will give its total support in the project, as it is not just a new sports complex but urban renewal project, activating the city, activating the people.



2010
2012
2015
2019



Piazza Arbarello

Via Garibaldi

Corso Siccardi
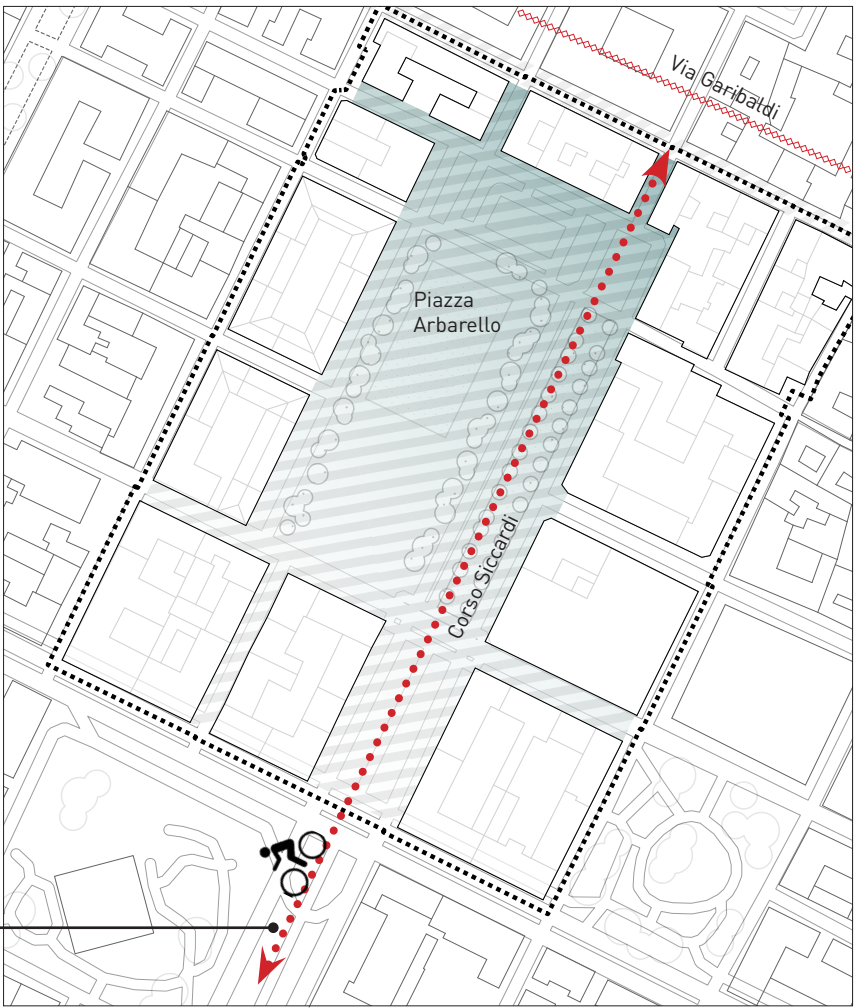


In 2016, the foundation started a five-year project for the improvement of the sports facilities of Turin City University
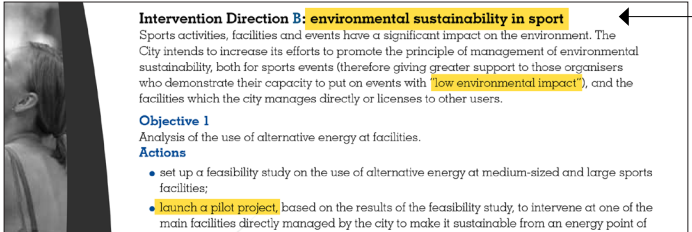


"...launch a pilot project...make it sustainable from an energy point of view"
- Turin's Sports Development Plan 2011-2016

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# Procurement

The selection of an appropriate procurement method is critical for the creation of a successful construction project; delivered on time, to a high standard and on budget.

Unfortunately in the real world all through are hard to attain.
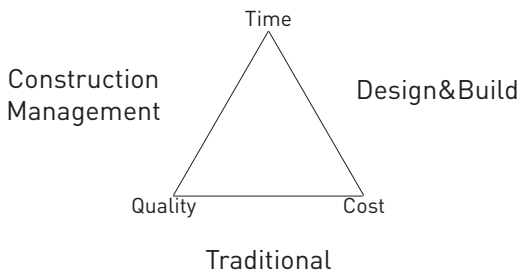


## Traditional Contract
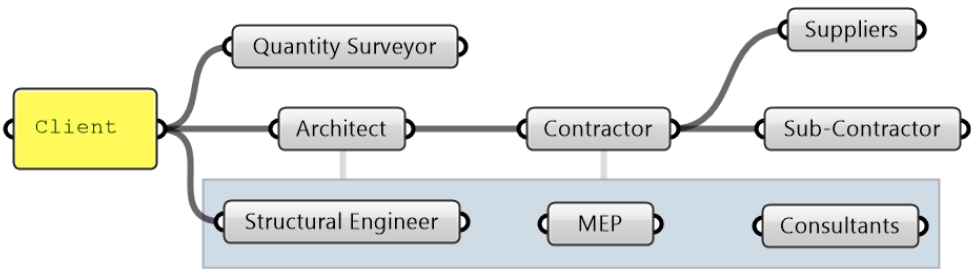


**Advantages:**

- project is lead by the design team. client and design team have constant communication.
- design process is seen through from beginning to end, typically resulting in cost-certainty before work begins on site.
- typically unforeseen risks and delays are reduced.
- considered to result in a higher quality finished project.

**Disadvantages:**

- potential for a long drawn out design process.
- construction process can be delayed by constant interruption by design team.
- contractors may price work to win the project rather than accurately price the work to be carried out.
- issues involving the design are often not picked up until too late.

## Design and Build Contract
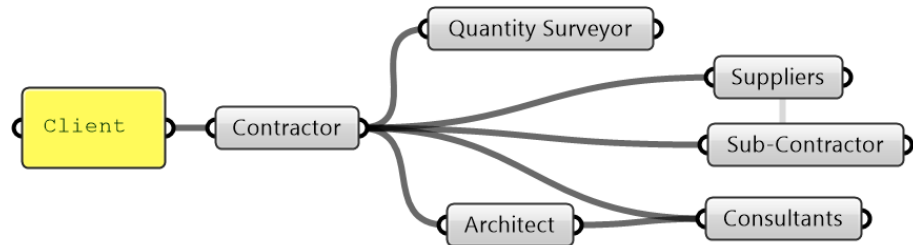


**Advantages:**

- responsibility resides entirely with the contractors.
- tendency to be an 'easier' process for clients.
- cost and time efficient. with set deadlines.
- work can start on site whilst later design stages are still being produced.

**Disadvantages:**

- rigid design process once on site.
- client control is reduced.
- reduced quality as incentives for contractor to rush jobs (without careful specification and quality-control).
- no benefits from a competitive tender.
- usually not suitable for complex or bespoke jobs (lack of design team involvement).

## Construction Management Contract



**Advantages:**

client maintains a high level of control over design and construction stages.
- design and construction are an integrated process.
- generally better communication between design team, contractors and client, resulting in a better building.
- client has greater flexibility and opportunity to make design changes.

**Disadvantages:**

- client is often fully involved and is not for the inexperienced.
- costs are difficult to predict.
- delays can occur with multiple levels of involvement.

---

## Construction Management

Construction Management is chosen as the procurement method in this project. The project is very complex, it involves a lot of moving elements, they are highly sophisticated therefore specialists are required.

Quality is the key. As a part of Torino regeneration project, the project's aim is to create a new pleasure garden, an urban playground at the heart of Torino, where people can celebrate the healthy and delightful life style.

This project is ambitious and complex on its own, and as an urban renewal work, it requires a series of organised coordination and preparation work. With mechanisms as a feature, tests and adjusts are expected to happen at a later construction period.

## Warranties

Written contracts/ appointment agreements are signed by relevant parties before any work is undertaken.

Collateral warranty is a contract under which a professional consultant (such as an architect) or a building contractor warrants to a third party (such as Compagnia di San Paolo) that it has complied with its professional appointment or building contract.

On large projects such as this, with many consultants and sub-contractors,there can be a great number of warranties involved to completing the sports complex.

Also the building is majorly mechanical and it is expecting large number of visitors, given its programme and site location, it is essential to keep them for future maintenance.

## Enabling Works

The upgrading work of the electrical substation on the south side of the site has been planned. A strategy for the existing underground carpark on the north has to be planned.

The project requires to demolish the whole of the existing carpark. It is required to provide them carparking during the construction period.

The vehicles have to move to the newly built carpark in Corso Galileo Ferraris, that is 500 metres down the road, was also part of the urban renewal scheme.
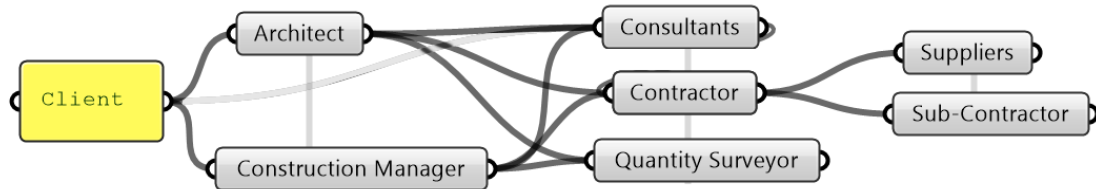


New at-grade park and carpark opened on
23rd November 2017.

footer: 45

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# Professional Roles

## The Client
Città di Torino (City of Turin)
Compagnia di San Paolo

### Other characters and influences
Sport e tempo libero
(Department for Sport and Leisure)
Centro Universitario Sportivo Torino
(CUS Torino)



**Stefano Gallo**     **Piero Fassino**

Councillor for Sport & Leisure    Mayor of Turin

The project's budget is estimated to be 30million. It is jointly financed between the city (20%) and Compagnia di San Paolo (80%). Any budget overrun will be contributed by the later.

The building itself will be managed by CUS Torino, as they have got the experience running Torino's sporting facilities.

## Construction Manager

- hired by the City Council

- responsible for managing and overseeing the costs, quality and performance of the design

- help to coordinate the delivery of the project during the construction phases.

- Unforeseen risks and delays will have to be closely watched.

## Design Team

Chief Architect
Renzo Piano

Project Architect
Lester Cheung

Local Collaborating Architect
Iotti + Pavarani Architetti

Structural Engineer
Arup, Eckersley O'Callaghan

M&E Engineer
SWECO

Landscape Architect
Field Operations

## The Architect

- Feasibility studies: Understanding the potential of the site and how it meets need of the public in Torino

- Advising and consulting on its new use

- Study the urban condition, future traffic implication and pedestrianisation of the area

- Concept design

- Preparing drawings and specifications of this project

- Coordinating with engineers, consultants contractors, and clients.

- Prepare planning documents

- Providing clients with visual materials for public relations

- Providing PPP (Public Private Partnership) contractor with construction drawings and specifications.

- Public Consultations

- Reviews with City Council, and various design teams

## Specialists

- Mechanical Engineer
hired to help advise on moving elements in the project

- Structural Engineer
hired to work with mech-engineers for a structurally sound building with mechanical parts

- Software Engineer
hired to help advise the designing and programming of the system

- Electrical Engineer
hired to work with mech-engineers to ensure every mechanical parts to work

## The Consultants

- Meteorologist
hired in the early stages of the design project for the collection of the weather data, understanding behaviour of the local weather

- Environmental Consultant
hired to give advice on environmental strategy and the building's adaptive system

## Planning Process

- Check local architectural, public space regulations;

- Check planting requirements regarding to the arrangement of it in the overall plan;

- Hold Public Consultation on site;

- Prepare Planning Application as part of Torino's Regeneration masterplan.

- Submit Planning Application

- Revise According Planning Application

---

## Health and Safety

Due to the project being an urban playground and sports complex, the users will all be physically active in the site, just that is enough to cause serious injuries. On top of that, the building consists large mechanical elements, which makes participating inside more dangerous, as well as during the construction.

At the same time, the project is designed for all generations, from toddlers to elderly, therefore considerations for all are required, such as, how to balance between risk and fun when designing a playground for kids.

### Risk Considerations in Construction

| Risk | Precautions Taken |
| --- | --- |
| - Being hit by moving elements while testing | - Safety harnesses and clothes used, e.g. hi-vis jackets |
| - Chemical burns from concrete pouring | - Concrete specialists should be employed for this work |
| - Damage to ears from noise from machinery | - Protections should be worn |
| - Crane accidents from lifting roof panels | - Training is given for any crane operator |
| - Falling/ tripping on slanted ground | - Hard hats and sturdy boots are worn at all times |

### Risk Considerations in Use

| Risk | Precautions Taken |
| --- | --- |
| - Danger of drowning in pool | - Life guards will be on duty throughout the day |
| - Being hit by the moving elements | - Siren will be played when the pieces are in fast motion |
| - Growth of bacteria/moulds in pool water | - Small amount of chlorine added to kill bacteria |

## Specialist Studies

A Meteorologist is hired in the early stages of the design project for the collection of the weather data. It is critical to have the **site specific** data for the building to work reliably. The existing data is collected from Caselle Weather Station in Torino airport (45°13'12.0''N 7°39'00.0''E), a wide open location, is be very different from the site in the middle of the city.

A small scale 'weather station' will be set up on site to collect the weather data during construction. When the project is completed, the equipment will then be moved to the building. Using the building as the in-city monitoring station, the data collected will also be contributing to Torino's Meteorological Department.



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# Plan of Work

## Stages

| | 0 Strategic Definition | 1 Preparation and Brief | 2 Concept Design | 3 Developed Design | 4 Technical Design | 5 Construction | 6 Handover and Close Out | 7 In Use |
|---|---|---|---|---|---|---|---|---|
| **Duration** | 2 months | 3 months | 4 months | 5 months | 8 months | 5 months | 3 months | — |
| **Dates** | October to December 2017 | December 2017 to March 2018 | March to July 2018 | July 2017 to December 2018 | December 2018 to August 2019 | August 2019 to Jan 2020 | Jan 2020 to April 2020 | 10 years of use before Torino Council need to decide is they want to make modifications. |
| **Core Objectives** | Torino City Council invites architects to participate in a design competition for Piazza Arbarello. A design is chosen out of entries which shows the most innovative working method and potential. Design parameters are set out. | City Council as client, identifies the main objectives of this project. Site information is examined, extra surveys are organised. Clients set initial brief. Additional design competition for Piazza Arbarello is advertised. | Outline proposal for Piazza Arbarello public space, structural and services strategy are prepared. Environmental, sustainability and access strategies set out. Planning consultant is appointed. Project brief is finalised and issued. | Prepare developed design drawings; draw up specifications and structure + services strategy, based on discussions with Structure Engineer and M&E Engineer. Construction and Health & Safety strategies are reviewed. Consider BREEAM assessment. Planning application is submitted by the end of this section. | Planning application is granted by the end of this section. Technical design information prepared by Design Team and checked by architect and signed off by City Council. Prepare detailed specifications and review construction schedule. Building Regulations Submission prepared. | The construction manager takes control of the site and program and carries out the oversees construction work. As each trade contract is completed, individual certificates of practical completion must be issued, and then a certificate of project completion issued once all trade contracts are complete. | The construction manager no longer has possession of the site, clients and the architects visit the site and point out any amendments to be made. Any defects are rectified and the final certificate is issued signifying that the construction works have been fully completed. Final statements issued, the construction manager co-ordinates preparation of the final report and issues the final certificate for the project. | Trained staff of CUS Torino deal with the day to day running of the sports complex. Post occupancy evaluations carried out by the consultant team. |
| **Procurement** | Stefano Gallo, Councillor of Department for Sport and Leisure contacts Piero Fassino, Mayor of the City. Dept. for Sport speaks to Compagnia di San Paolo board members and together, they draw up a plan for funding the project. | City of Torino needs to (1) set out procurement strategy, (2) arrange surveyors, (3) prepare appointment documents and (4) hold design competition on river front public space, judged by the City Council and the public. Architect of winning proposal is appointed. | Structural Engineer, Mechanical Engineer and Environmental Engineer are appointed by City Council. | Main contractor is appointed by City Council. Concrete contractor is also appointed. | Specialist and sub-contractors to produce mock-ups at 1:1 scale to test out moving architectural elements. | Trade contractors deliver their packages at their own premises if possible, as many components are prefabricated off site. They are then all brought together and assembled on site relatively quickly. This is managed by the project manager. Pieces do not fit need to be remade. | The trade contractors have finished their work on site and begin clearing/cleaning up. They have gone over the original budget due to the testing and remaking the pieces, but they finally work! The PR team step in to start planning press material for opening. Photoshoot is done. | Building is in operation. |
| **Programme** | Feasibility studies undertaken to establish key consultants and possible trade contractors. Site survey performed. Meteorologist contacted to understand the site climate in the area. | City Council refines the programme with site boundaries and restriction, as well as specific function and area requirements. Compagnia di San Paolo set out the estimated duration and cost for this public space development. | Public's opinions are taken into consideration and reflected on design amends. Payment from concept phase onwards is made to contractors and architects. | Regular meetings with consultants and mechanical engineers on design. Other consultants for concrete and glass material also give suggestions and revise the design. CG visualisations and physical models are made for communicational purposes, which make sure the different parties in this process are on the same page. | The information need to be passed on to construction contractors to commence work and get prepared. Site is cleared and structural engineer supervises the demolition of the existing underground carpark. Off site manufacturing of pre-fabricated pieces. | The architect co-ordinates the preparation of any additional information required by the trade contractors for construction. Whilst construction is in progress, the careful co-ordination of suppliers, deliveries and contractors is achieved by the project managing team. Components transported to site in batches. | Once press photos are taken, Francesco Profumo, chairman of Compagnia di San Paolo started to fiddle with the switches on the control panel, trying to move the roof panels. He also went to have a shower in the 'rain room'! | Building is in operation. |
| **Planning** | Stefano Gallo contacted Francesco Profumo, chairman of the foundation to get them on board. | Pre-applications are discussed with Compagnia di San Paolo, Department for Sport and Torino City Council. | Outline Planning application is drafted and reviewed by Compagnia di San Paolo and Department for Sport and Leisure. | Planning authorisation is submitted to the mayor's office, where the 10 councillors authorise the scheme. | Compagnia di San Paolo asks the architects to co-ordinate the preparation of a detailed design report. This is reviewed by their chairman and councillor of Dept. for Sport. They assess the need for changes to the design or for a value management exercise. | Planning officers at the council check that the project is being constructed according to planning proposal drawings using 3D scanning, given the complexities of components and forms. | Planning officers take one last visit to the site and perform final checks against the 3D model. The mechanical elements are well in operation. The building can move! | Torino City Councillors discuss success of the scheme, may apply the same technology when improving existing sports halls or other buildings! |
| **Key Support Tasks** | Review feedback collected from existing public and CUS Torino sports halls. Draw up plans for enabling works of Piazza Arbarello. | Review the public comments on the overall regeneration plans and hold public consultation if necessary, since Piazza Arbarello has a historical value for Torino. | Public protest is unavoidable, therefore, it is essential to keep communication frequently and smoothly through public consultation, which not only helps the design team to fulfil the request of the local residents, but also helps the local to understand what the new public space would offer them with. Though it is unlikely to completely alter the objections of some, attitude and actions matter. | 1:1 component pieces start being assembled and tested. These will test some of the connection and joints through the project, tolerances of mechanical gears. Handovers are prepared, risk assessments are completed. | Building regulations submission is prepared. the foundation considers advice from the consultant team and construction manager on the need to appoint specialist trade contractors to assist in preparation of the technical design. The construction manager issues tender documentation to prospective tenderers. | Excavation, foundation and concreting works are carried out. CUS Torino begins preparations for occupation of the development, including the preparation of an operational policy and migration strategy setting out how they will manage the transition into and the operation of the new facility. | Software engineers on site to debug and clear the system cache. Environmental specialists decide to do a study on the sports complex regarding operable building envelopes in cold climates. Building regulations submission is prepared. | Building is in operation. |
| **Publicity Control** | Information about building a new sports hall is leaked to CUS Torino athletes. They talked about it in the changing rooms in university sports halls. | Publishing on websites such as local Torino website, Sportorino and CUS Torino. Keep the public informed on the latest decisions, progress and changes. Using existing social media such as Instagram (@custorinofficial,@sportorino), Twitter, and YouTube to build a closer connection with the public. | Hold regular public consultation and actively engage them with the design developments. Set up votes and discussion panels with the local on making several design decisions, if necessary. The aim is to make it clear that we, as design teams, share the same value with the local residents, and the actual designer of this public space is always 'the public'. | Leaflets on the project can be picked up in the area from local shops and other sports halls to help people understand the undergoing changes and encourage them to participate in the design votes and share their opinions. Websites and social media accounts should be managed and updated regularly to keep the information correct and open to the public. | A formal publicity launch is necessary at this stage to announce the new stage of this project. Keep updating relevant information about the project. | An overall construction process can be recorded in timelapse and published on council website weekly, which helps the public to monitor this process and witness the change happening. | A soft Launch will be hold during the day for City Council and the building will be tested out by the CUS Torino athletes. | The Major of Torino will formally launched the urban playground project, as a part of Torino's regeneration plan. All citizens are welcomed to come to the site for an official opening. Players from Juventus and Torino F.C. will perform a friendly 5-a-side match in the building! ⚽⚽⚽ |
| **Information Exchanges** | Building form is established and 3D models/ drawings are made for the foundation to take to board meetings with Torino Council to explain the scheme. Strategy brief is concluded. | The project brief is issued to user panels, champions and other stakeholders, such as Torino City Council, who want to have further involvement in its development. Climate model of the site is built by the meteorologists. | The frozen project brief is issued to user panels, champions and other stakeholders. Compagnia di San Paolo arranges a meeting for them to get together and discuss the progression of the design. Programming of the sensing/ control system drafted by the software engineers. | Co-ordinated architectural, structural and building services design and Cost Information are updated. The building's microclimate model is built by the environmental consultant. | Concept design package, project strategies and final project brief are handed to Torino City Council. | Updates of additional information to trade contractors when the need arises. | Completion of the construction phase signed off. | Chairman of Compagnia di San Paolo signs off on the completion of the sports complex. Software API and SDK released to public for their contribution to improve the system. |
| **Parties Involved** | Client (Torino City Council); Compagnia di San Paolo; Department for Sport and Leisure; Surveyor; Meteorologist | Client (Torino City Council); Compagnia di San Paolo; Surveyor; Quality Service; Competing Architects; Local Authorities; Meteorologist; Environmental Consultant | Client (Torino City Council); Compagnia di San Paolo; Surveyor; Quality Service; Architect; Local Authorities; Mechanical Engineer; Structural Engineer; Electrical Engineer; Software Engineer; Planning Consultant; Environmental Consultant; Programming Specialist | Client (Torino City Council); Compagnia di San Paolo; Quality Service; Architect; Local Authorities; Mechanical Engineer; Structural Engineer; Electrical Engineer; Software Engineer; Planning Consultant; Planning Authority; Environmental Consultant; Main Contractor; BREEAM Assessor | Client (Torino City Council); Compagnia di San Paolo; Quality Service; Architect; Landscape Architect; Mechanical Engineer; Structural Engineer; Electrical Engineer; Software Engineer; Main Contractor; Sub-contractors; Concrete Specialist; Programming Specialist | Client (Torino City Council); Compagnia di San Paolo; Quality Service; Architect; Mechanical Engineer; Structural Engineer; Electrical Engineer; Software Engineer; Main Contractor; Sub-contractors; Site Manager; Building Apprentices; Concrete Specialist | Client (Torino City Council); Compagnia di San Paolo; Department for Sport and Leisure; Quality Service; Architect; Software Engineer; Main Contractor; Site Manager | Client (Torino City Council); Compagnia di San Paolo; Department for Sport and Leisure; Quality Service; Architect; Main Contractor; Site Manager; Local Torinese |

## Decision-making Process of the System

Every single hour, the programme will decide the building's openness.
The decision will be made automatically, not based on historical weather data but the real-time one.

What is the outdoor dry-bulb temperature now? (Computer talking to himself)

- **A** Lower than 12°C
- **B** Between 12-16°C
- **C** Higher 16°C

By default, the programme choose one with the lowest energy consumption. Therefore, the decisions for each will be as follow.

- **A** 100% enclosure
- **B** Random%
- **C** 100% open

The question is more or less tailored for the main sports hall, due to its significance (size and purpose) within the building and its optimum temperature is 12-16°C. This is done in order to show clearly the principle of the logic behind the decisions.

So, in the simplest sense, the most straightforward way is to 100% close up the building when the weather is cold, and 100% open up when it's hot. However, it becomes uninteresting when the building has only got two states (either open or closed). The design and the programming is so much more capable than that.

In **B**, the decision is a random percentage of openness. It can be 45% or 2%, it does not matter, as the outdoor temperature is in the 12-16 optimum range, neither heating or cooling system is turned on, therefore no energy will be lost.

The next question the computer asks itself will be:
Is it raining? Do we want to close the roof?

*There will be dozens of questions that the system run through, and the answers are never just Yes or No. The flow chart on the right is just showing one simple example. The complexity starts below.*

Mentioned in section 3, it is possible to manipulate the internal air velocity by just open/closing the windows. There will be a 'badminton button' that can override the default settings. For example, if some group of people booked the court for badminton, the 'button' will be activated, and the windows will close (to a certain degree).
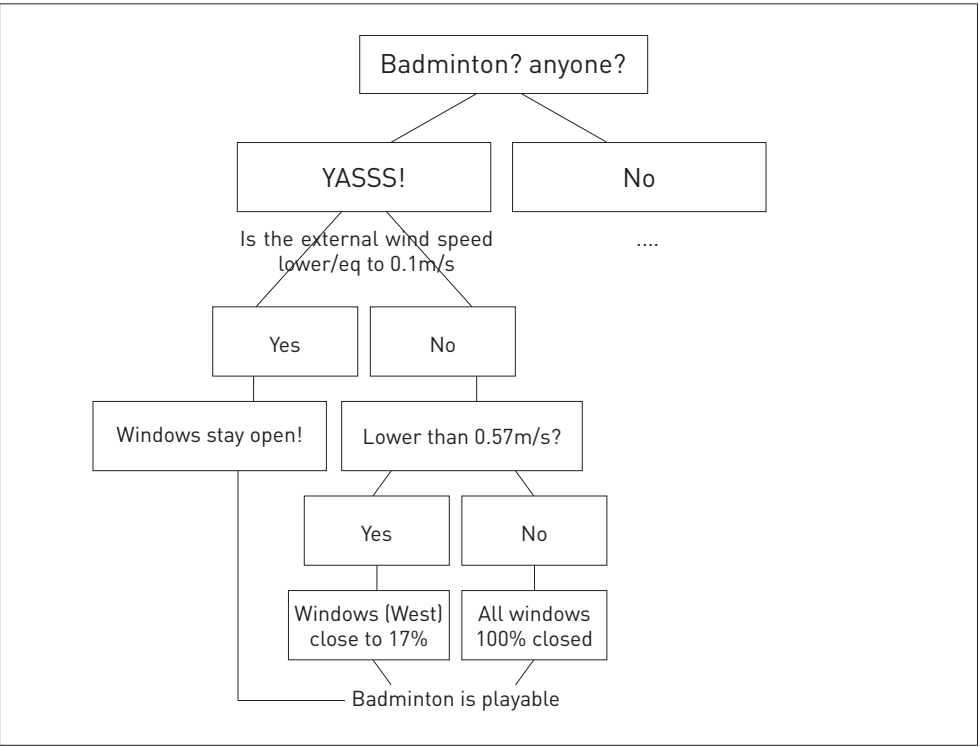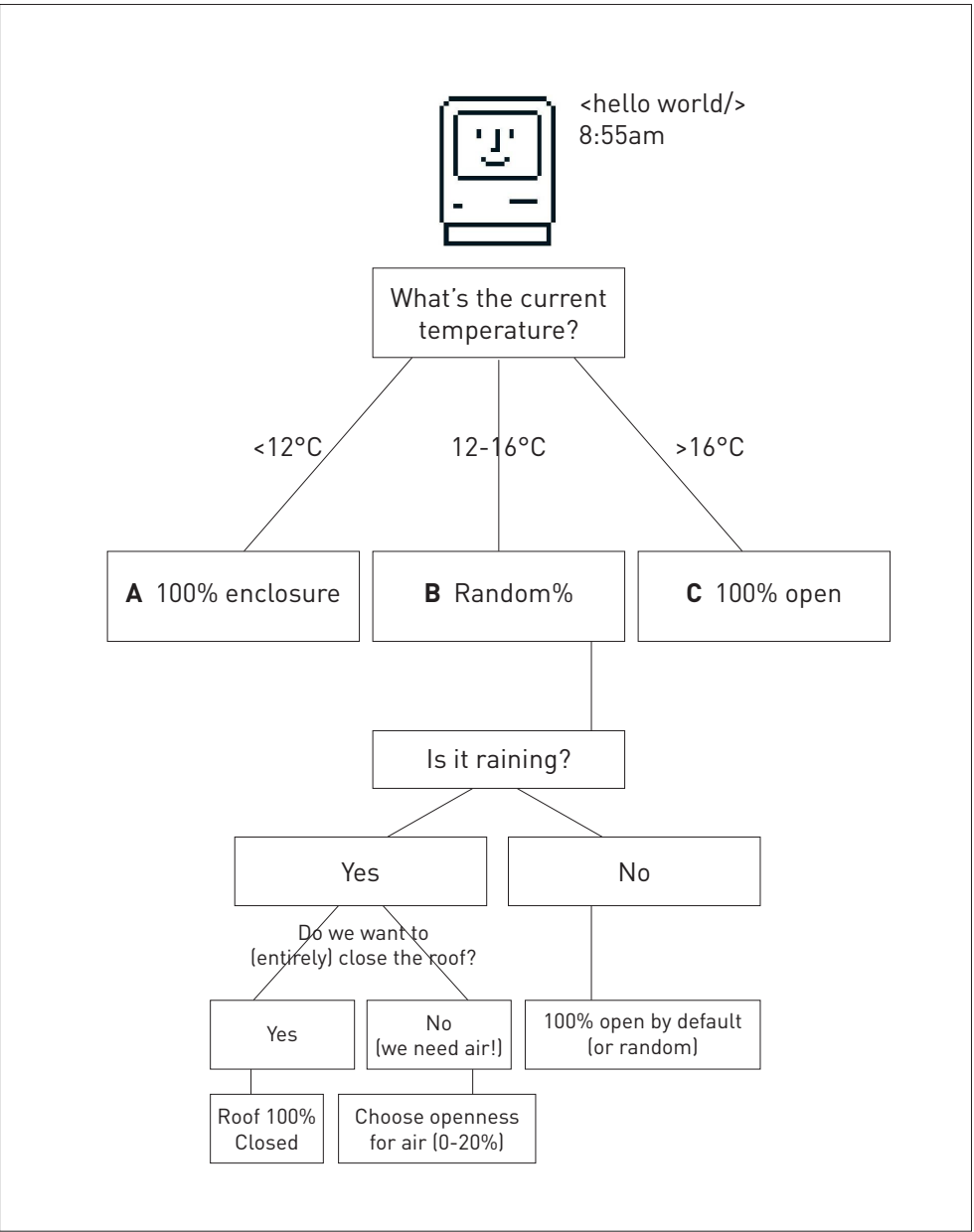
Configurations can also change internal air flow. There will be a better cross ventilation if we close up the East elevation to 60%, than opened to 100%.

There are many factors that can affect final result, the system is able to learn along. The basic principle is shown in the logic diagram.

Once the system has been tested working, it can then hook up to the internet booking system. So the building can adjust itself before the badminton players arrive the court.

Thermal imaging camera will be installed to monitor and analysis the occupants and internal environment, the data can then be used for adjustments.

The latest technologies can also be implemented. Facial recognition can be used, where the system can process the proportion of occupants from different age groups, then calculate the optimum temperature for all.
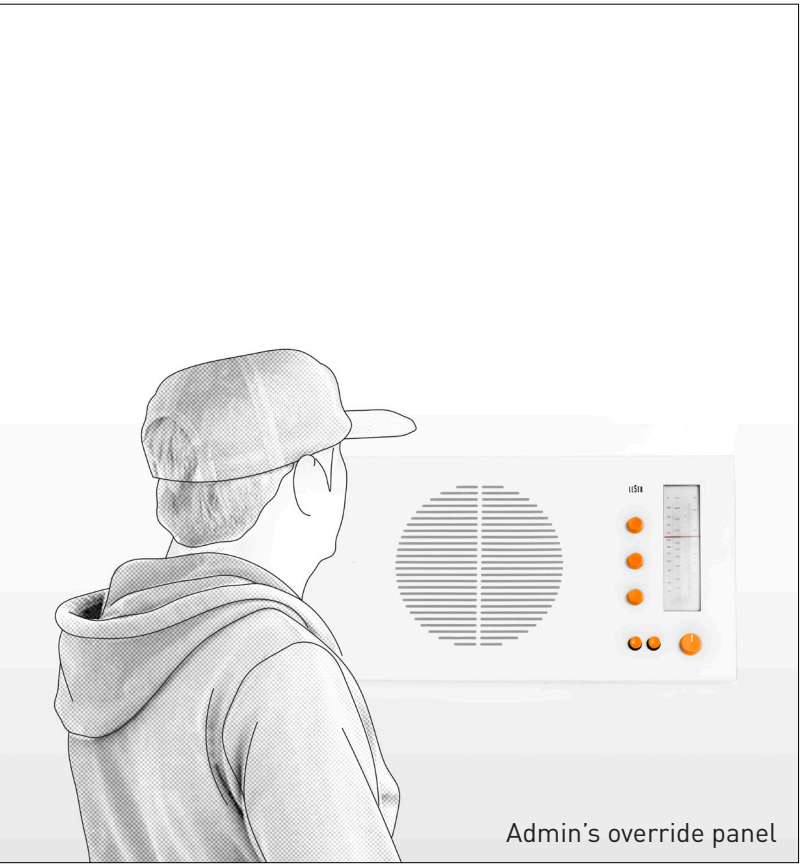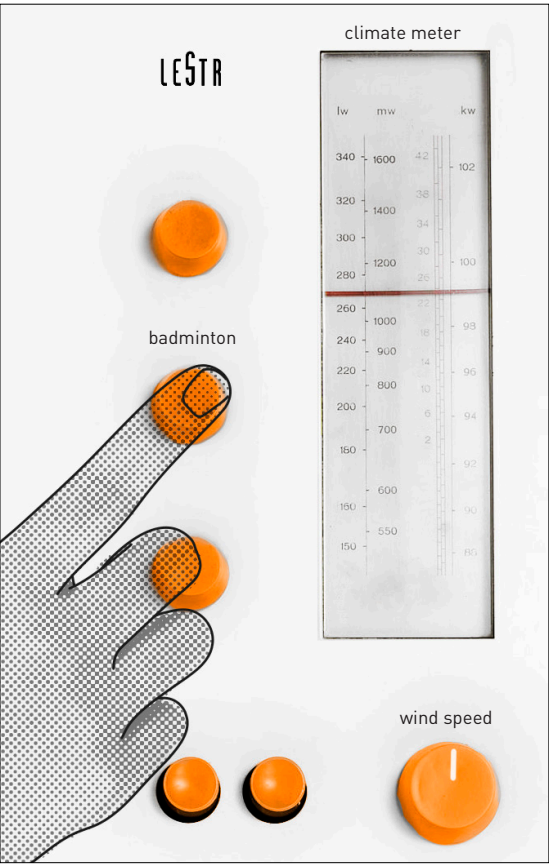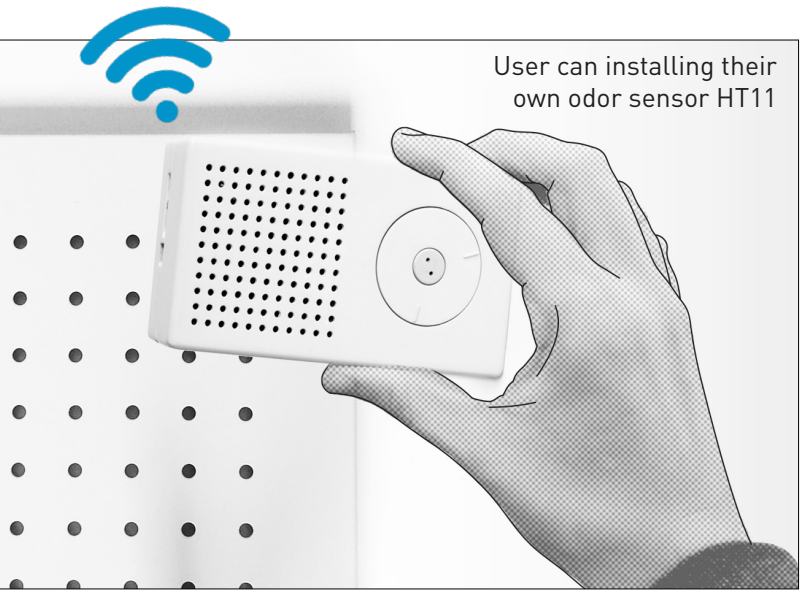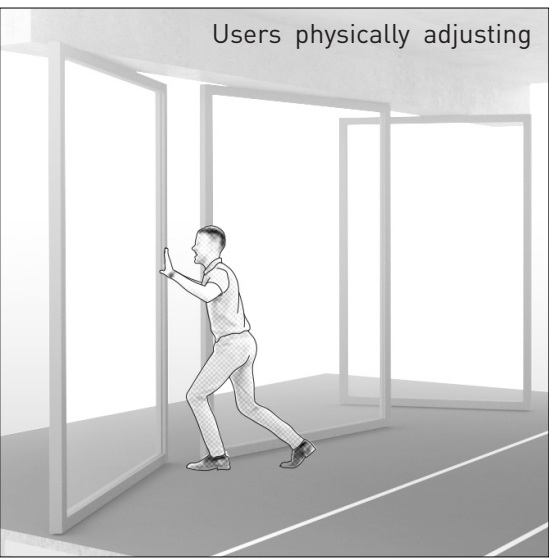
8:55am

What's the current temperature?

<12°C — 12-16°C — >16°C

**A** 100% enclosure | **B** Random% | **C** 100% open

Is it raining?

Yes — No

Do we want to (entirely) close the roof?

Yes | No (we need air!) | 100% open by default (or random)

Roof 100% Closed | Choose openness for air (0-20%)

Badminton? anyone?

YASSS! — No

Is the external wind speed lower/eq to 0.1m/s ....

Yes — No

Windows stay open! | Lower than 0.57m/s?

Yes — No

Windows (West) close to 17% | All windows 100% closed

Badminton is playable

Member: Lester C.
Gender: Male
Age Group: 20-25
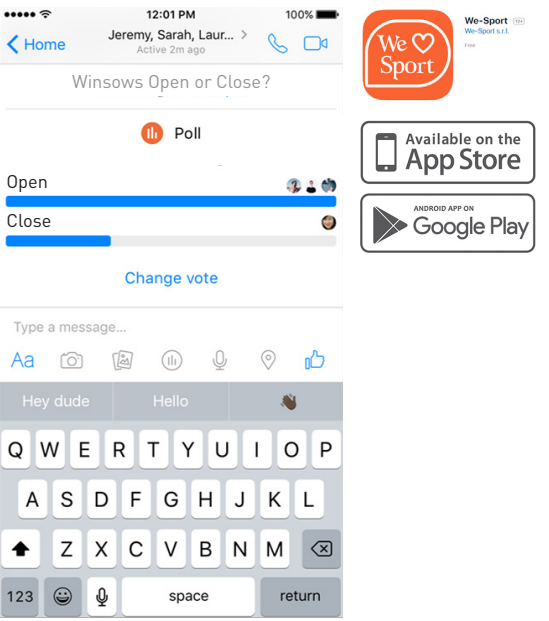Preferred Temp.: 16-22°C
Sports pref.: Soccer and Badminton

## Users Controllability

Users can 'take over' the building microclimate. The simplest way to do is just to manually move open a window. Apart from that, users are allowed to 'hack' the building. They are welcome to install more sensors to the building, contributing their data to the system, where the building (programme) can then have more options for its behaviour. It can only get more sophisticated.

There are dedicated walls space that allows 3rd party (occupants') devices to be installed. That part of the wall is magnetic and has the ability for wireless charging, so the users' sensors will not run out of power. Third party devices are required to have wifi connection, as the data has to be sent to the main system.

There will also be digital voting system that occupants can make a poll whether or not to open the windows, using the WeSport app (a product of Torino Capital of Sports 2015).



Users physically adjusting

User can installing their own odor sensor HT11

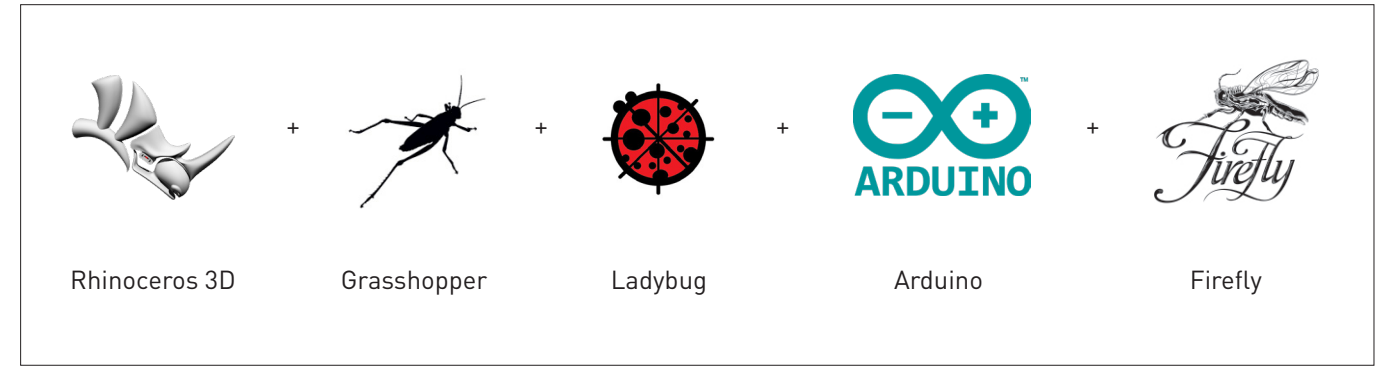Admin's override panel

## Active Participation and Future

This project will collaborate with Università degli Studi di Torino (University of Turin) and Politecnico di Torino (Polytechnic University of Turin), allowing students to contribute. Compagnia di San Paolo will be in support of this.

Interested parties are welcome to participate in the development of environmentally-friendly architecture, by experimenting with this pilot project. The programme for the system is open-sourced. They will be provided with the softwares SDK and API for the maximum freedom of exploration. The following softwares and plugins were used by the architects during the concept design stage. It is recommended for the participants to know them all.

With contribution from the public, the system can only get better and better. The building will be a successful pilot project in the built environment industry, the system will then be patented for future applications in the field.



UNIVERSITA DEGLI STUDI DI TORINO

POLITECNICO DI TORINO
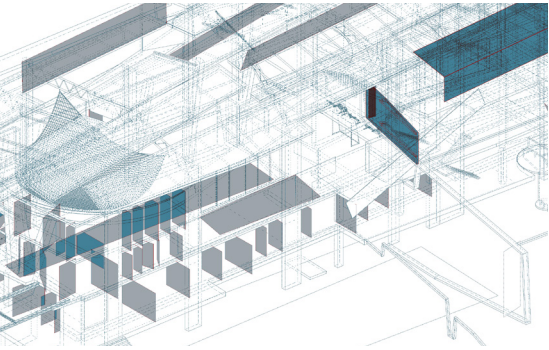
Programming workshops held between software developers.

Rhinoceros 3D + Grasshopper + Ladybug + Arduino + Firefly

Time-based simulations were generated using Rhinoceros, a 3D modelling software, together with Grasshopper, an algorithms plug-in for Rhino.

Ladybug is a Grasshopper component for environmental design and extracts weather data.

The initial design was entirely based on weather data provided by International Weather for Energy Calculations (IWEC).

Arduino is open-source electronic prototyping platform enabling users to create interactive electronic objects.

Moving elements in the early design stage were programmed based on it. The platform is able to take data from all kinds of sensors, therefore it is very useful.

Firefly is a Grasshopper component to connect Arduino boards and sensors to Rhino 3D.

Real time sensing can provide real time 3D simulations.

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Climate Curtains
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How air curtains works
https://www.youtube.com/watch?v=BprPV9hWR7k

Grasshopper 3D
http://www.grasshopper3d.com/

# Appendix

## GA Drawings

GF 1:200

Key

01 Reception
02 Resting Space/ Area for Elderly
03 Kids Playzone
04 Changing Rooms
05 Main Hall
06 Spectactors Seatings
07 Outdoor Rockclimbing Wall
08 3m Diving Board
09 Net Playscape
10 Rotating Slide
11 Small Outdoor Theatre
12 Outdoor Pitch
13 Outdoor Pool
14 Outdoor Pool (Shallow)

GF 1:200

Key
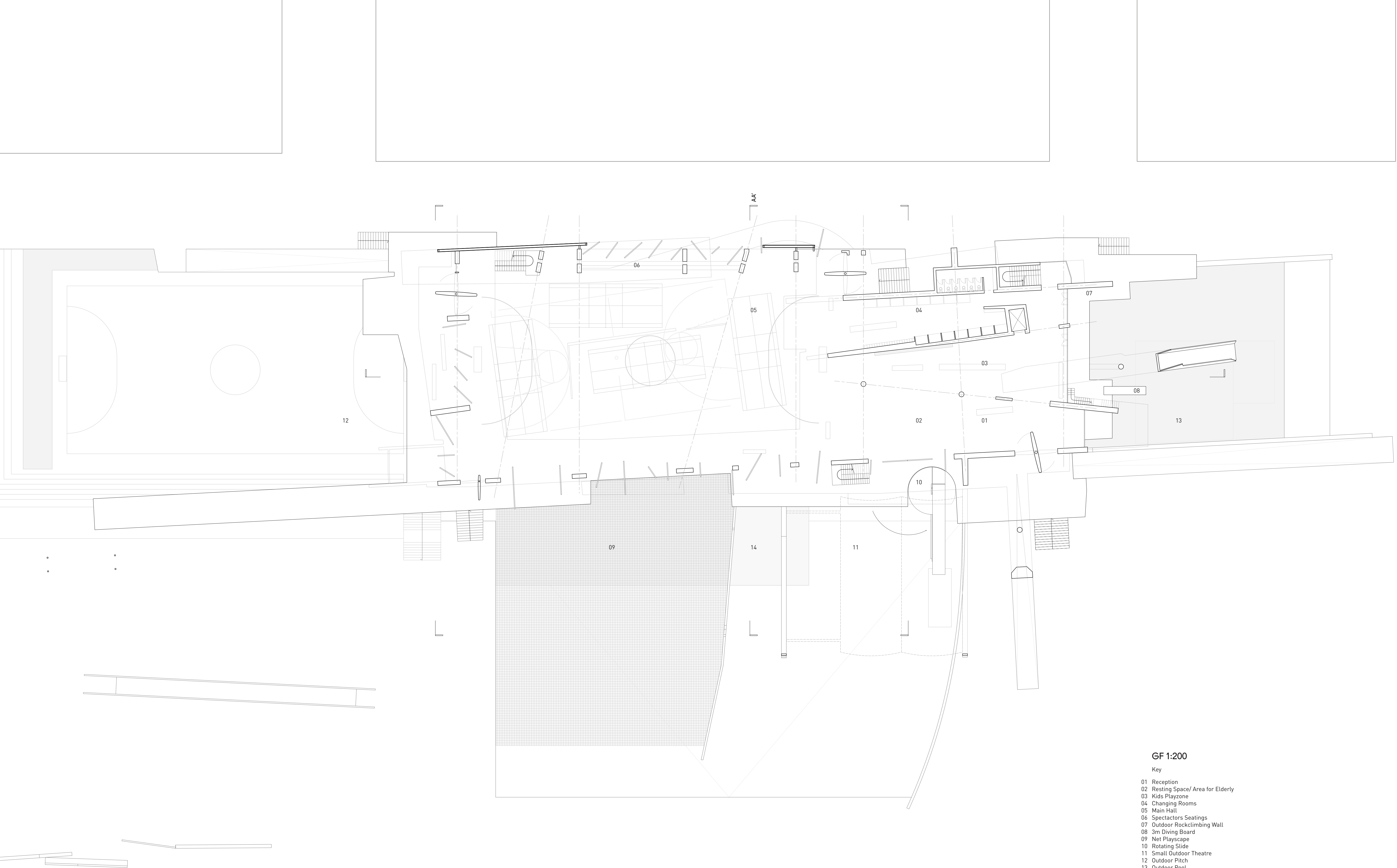
01  Reception
02  Resting Space/ Area for Elderly
03  Kids Playzone
04  Changing Rooms
05  Main Hall
06  Spectactors Seatings
07  Outdoor Rockclimbing Wall
08  3m Diving Board
09  Net Playscape
10  Rotating Slide
11  Small Outdoor Theatre
12  Outdoor Pitch
13  Outdoor Pool
14  Outdoor Pool (Shallow)
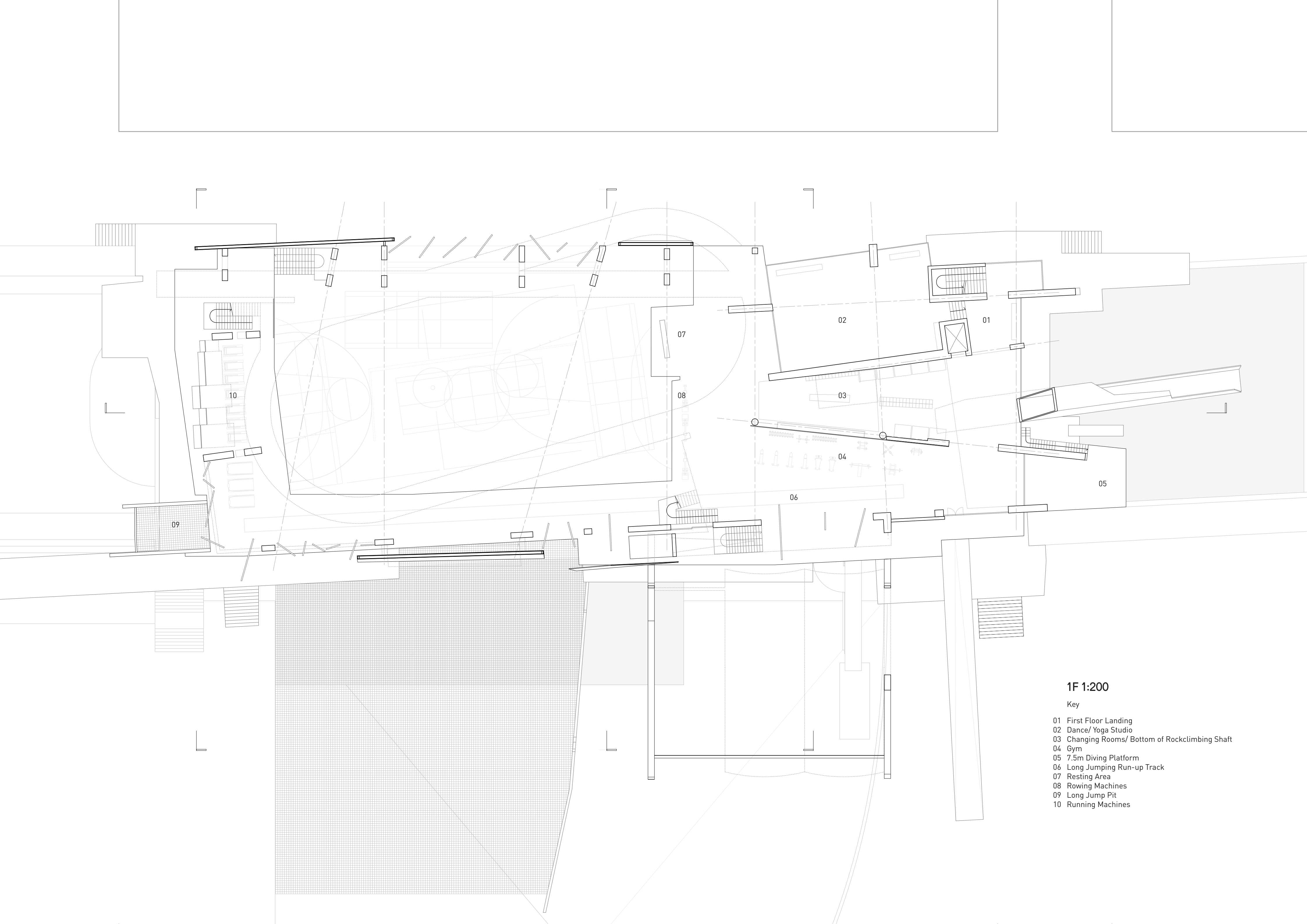
1F 1:200

Key

01  First Floor Landing
02  Dance/ Yoga Studio
03  Changing Rooms/ Bottom of Rockclimbing Shaft
04  Gym
05  7.5m Diving Platform
06  Long Jumping Run-up Track
07  Resting Area
08  Rowing Machines
09  Long Jump Pit
10  Running Machines

01
02
03
04
05
06
07
08
09
10
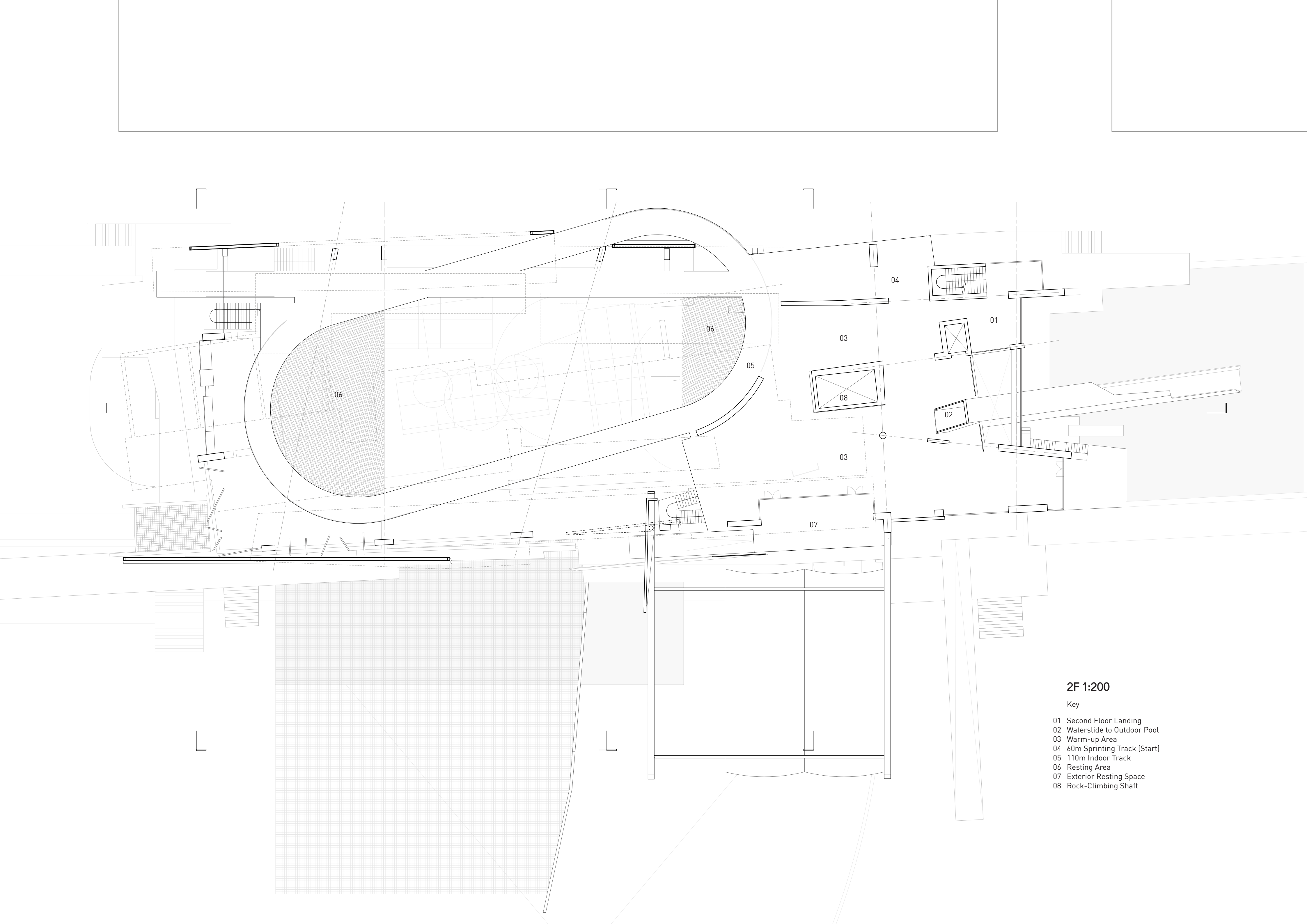
2F 1:200

Key

01  Second Floor Landing
02  Waterslide to Outdoor Pool
03  Warm-up Area
04  60m Sprinting Track (Start)
05  110m Indoor Track
06  Resting Area
07  Exterior Resting Space
08  Rock-Climbing Shaft

09

08

05

13

13

04

03

02

12

10

07

06

01

11

13

13

10
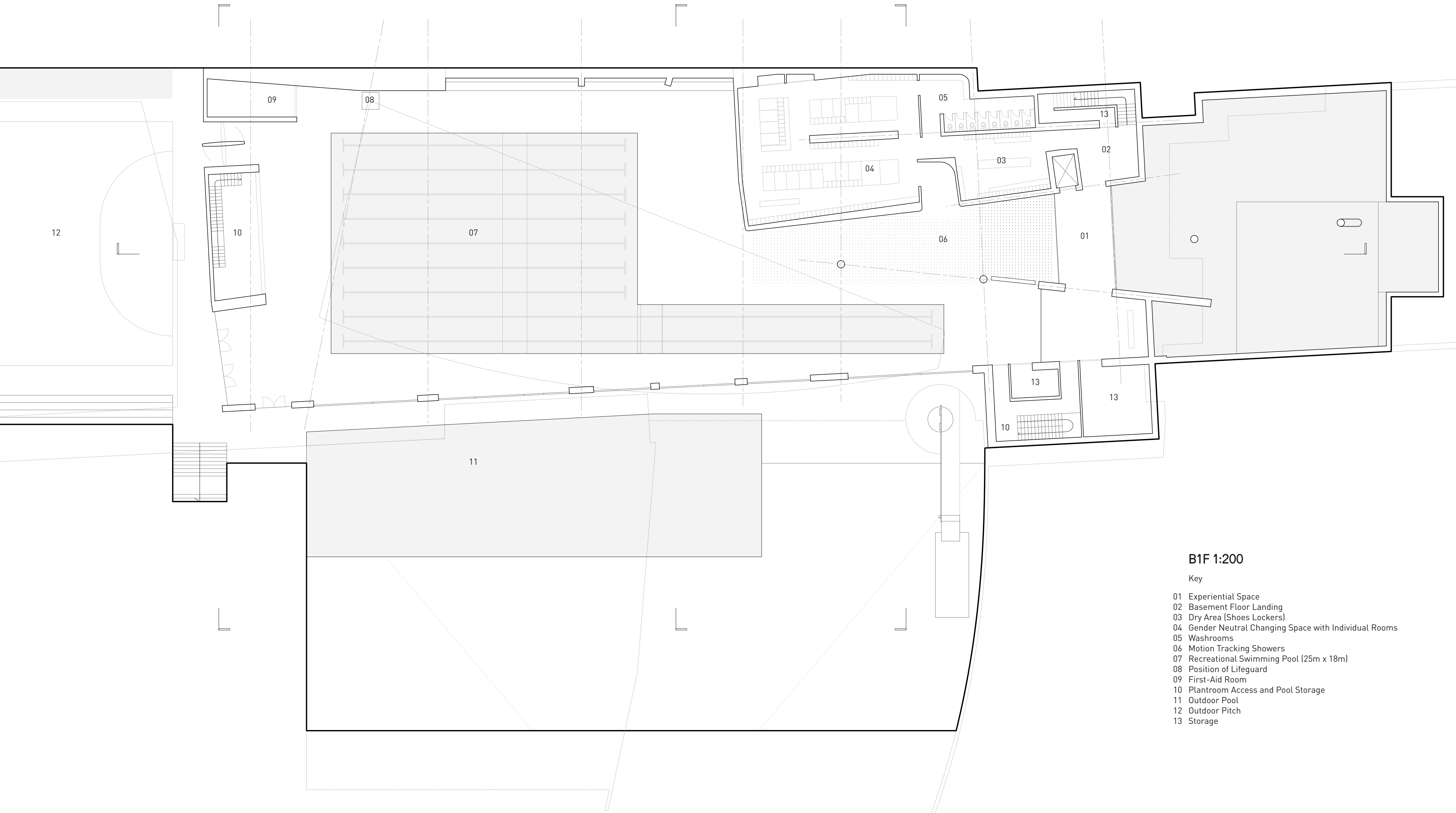
B1F 1:200

Key

01  Experiential Space
02  Basement Floor Landing
03  Dry Area (Shoes Lockers)
04  Gender Neutral Changing Space with Individual Rooms
05  Washrooms
06  Motion Tracking Showers
07  Recreational Swimming Pool (25m x 18m)
08  Position of Lifeguard
09  First-Aid Room
10  Plantroom Access and Pool Storage
11  Outdoor Pool
12  Outdoor Pitch
13  Storage

02

01

03

04

05

08

06

10

09

07

08

11

BB'

AA'
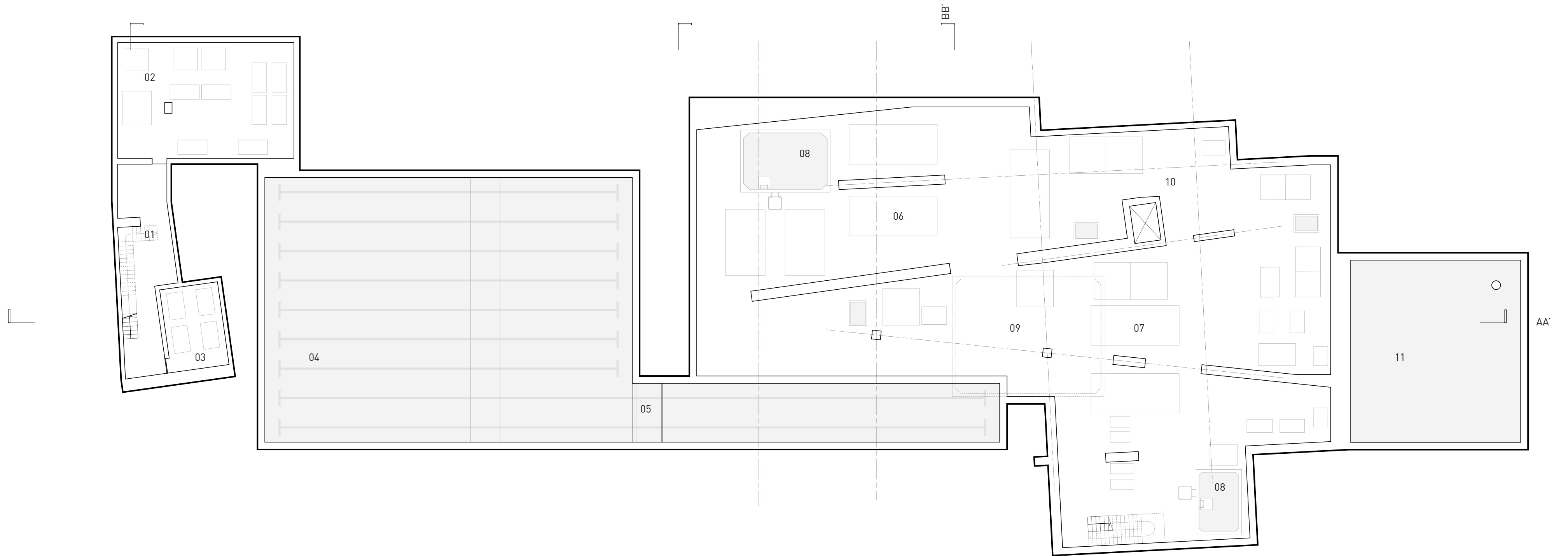
B2F 1:200

Key

01  Access from Pool Storage
02  Ozone Generator Room
03  Compressor Room
04  Multipurpose Indoor Pool
05  Pool Divider
06  Filtration Plant for Indoor Pool
07  Filtration Plant for Outdoor Pool
08  Makeup Water Tank
09  Backwash Holding Tank (Underneath)
10  Elevator Pit
11  Outdoor Pool
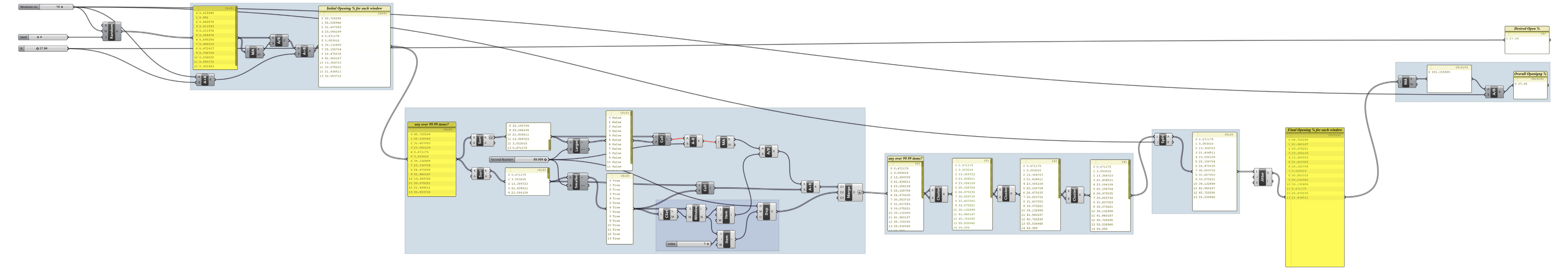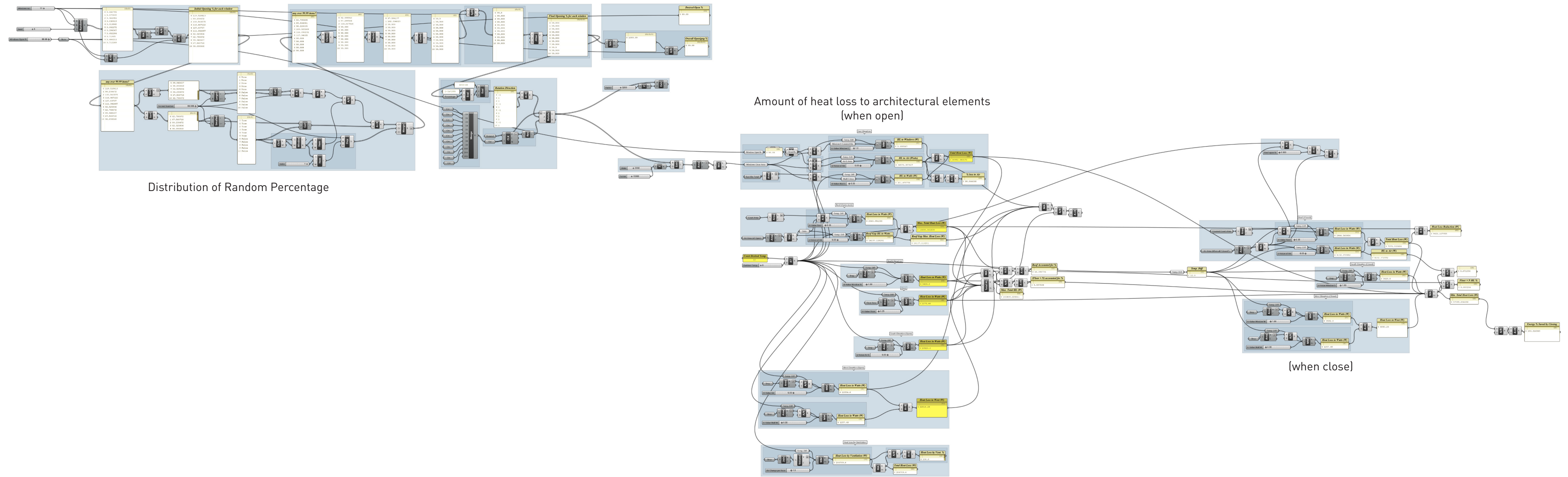
Torino bull
wind vane

Drain channel to minimise
rainwater falling in

University student installing a new indoor
sensor for testing

Indoor thermometer install on
the eye of the flamingo float

Staff moving the climate
meter to check the average

Stranger looking into the pool

Helical Wall Anchor

**Section AA' 1:100**

Key

01  Outdoor Pool (Shallow)
02  Pivoted Windows
03  Indoor Pool (50m Lane)
04  Motion Tracking Showers (back)
05  Pool Indoor Climate Meter
06  Pool Air Vent
07  Slide for kids from outside (opens in summer)
08  First Aid Cabinet
09  Pool Storage and Seatings
10  Main Hall
11  Fencing Area
12  Changing Rooms (back)
13  Spectators Seatings
14  First Floor Resting Area
15  Rowing Machines
16  Gym (back)
17  Long Jump Run-up Track
18  Indoor Running Track (100m)
19  Second Floor Resting Area
20  Sprinting Track (60m)
21  Rockclimbing Shaft
22  Second Floor Temperature Sensor
23  Pivoted Insulation Panel
24  Canopy for Outdoor Theatre

# Grasshopper Script
## Heatloss Calculation

Amount of heat loss to architectural elements
(when open)

Distribution of Random Percentage

(when close)

Initial Opening % for each window

Desired Open %

Overall Opening %

any over 99.99 items?

any over 99.99 items?

Final Opening % for each window

Grasshopper Script
Heatloss Calculation with Weather Data

Heat generated by human

Ladybug Component

Temperature

Analysis

Weather Data

Wind Speed
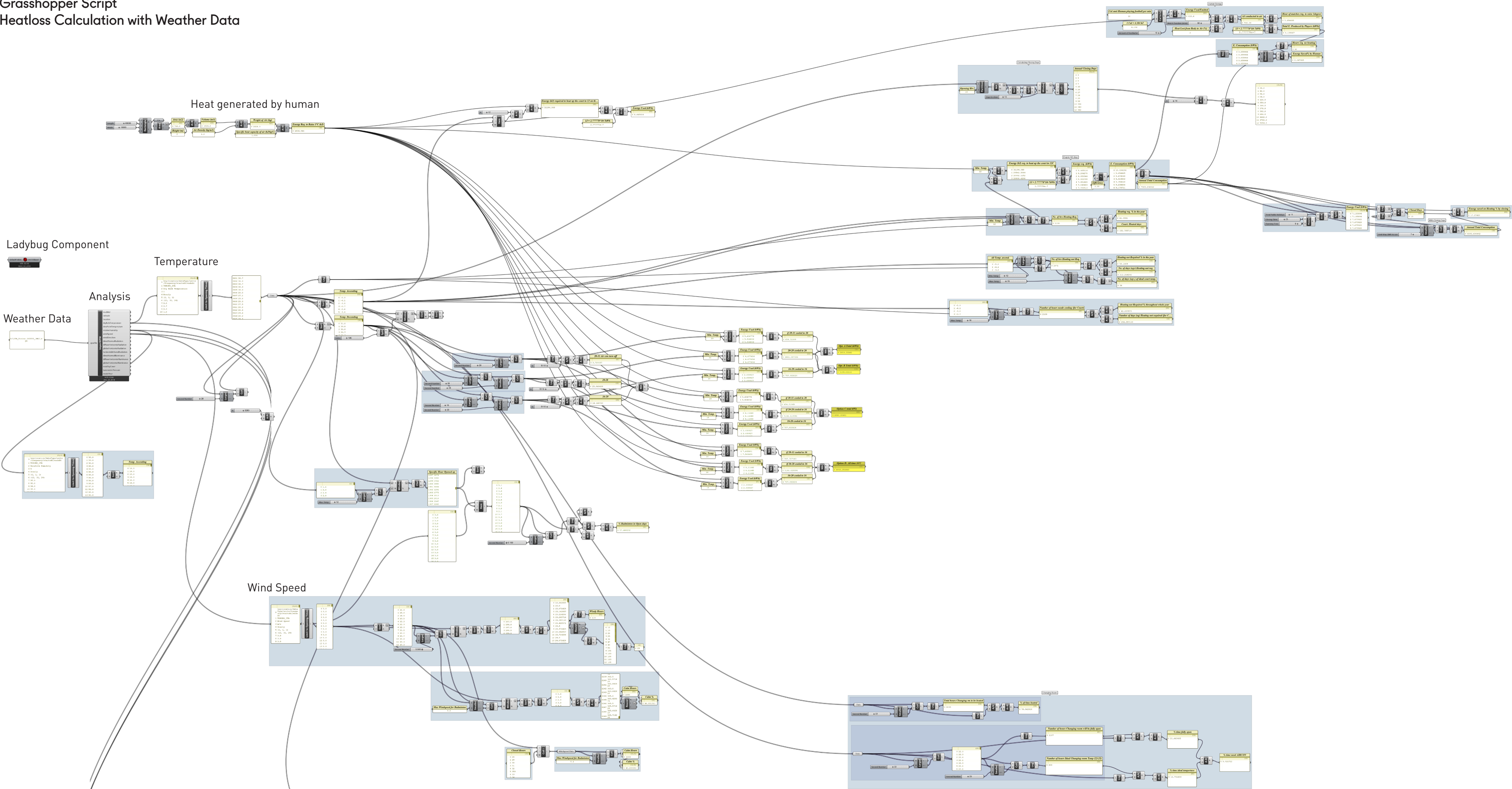
# Grasshopper Script
## Whole System

Redistributing   numbers
for every single window

Random Numbers

Choose data