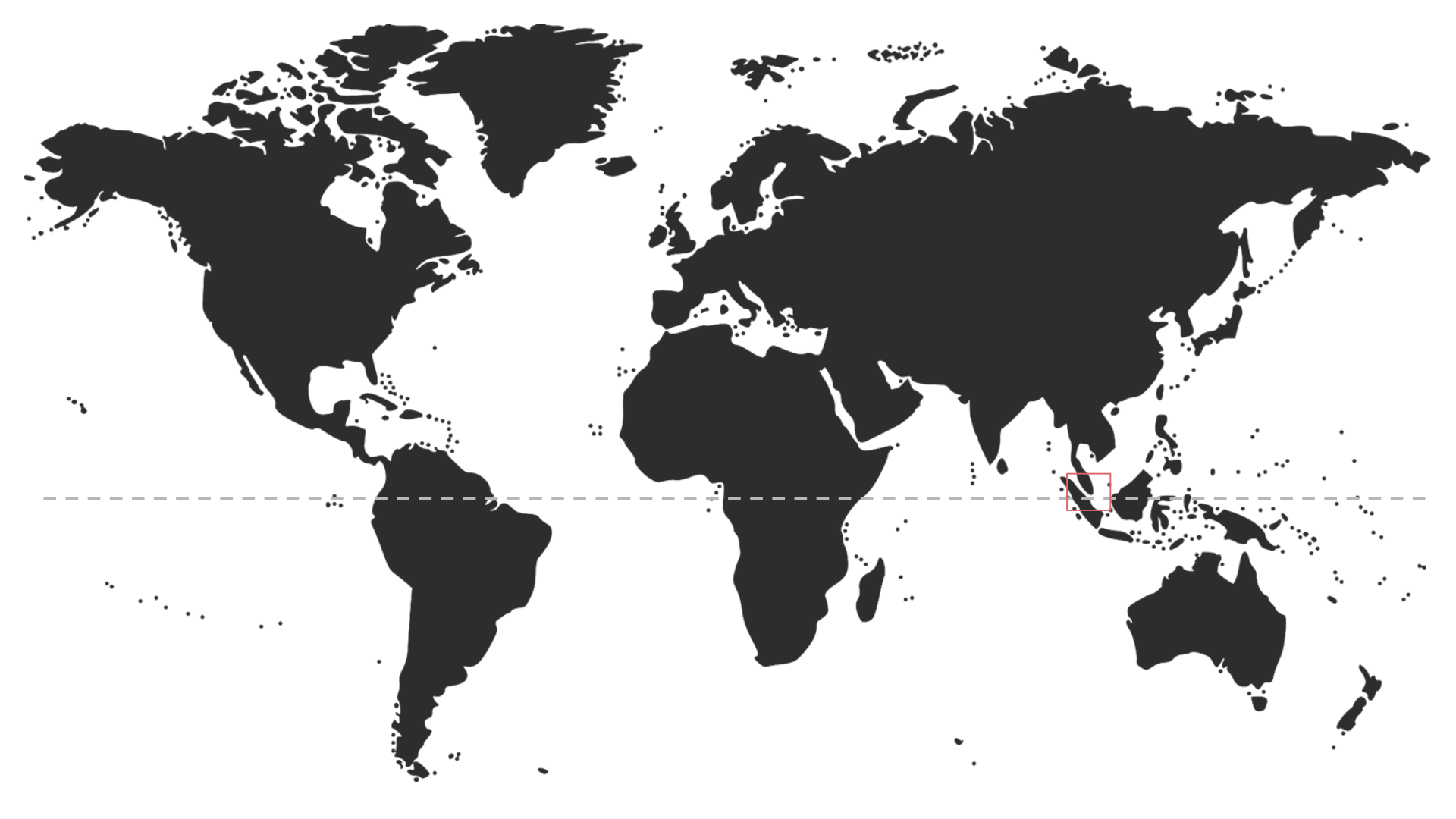
New Chautauqua Institute // Singapore

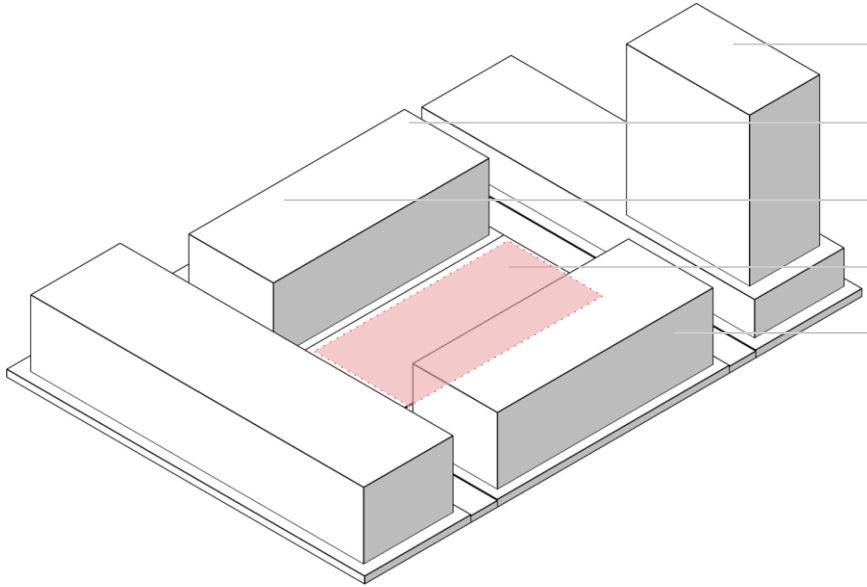
Arch_708-201 // Environmental Design Studio

Critics: Dr. W. Braham // Mostapha Sadeghipour

Team: José Barría, Bhakti Kothari, Neeharika Siram



Site & Context



Site and Context

Summary

Currently home to *“Electronic Parking System C013”*

Dense urban context, close to “denser” downtown
Surrounded by mixture of commercial and residential development
Context dictates mid-size (5-7 storeys)
Commonly walkable area
Slower wind speed due to context
“Trapped” humidity and heat due to context

Climate Profile

Season Overview

Latitude: 1.37°
Longitude: 103.98°
Köppen: AF- Tropical Rainforest

NE Monsoon Season:
(Wet Phase)
Monsoon Surges cause widespread continuous moderate to heavy rain, at times with 25-35 km/h winds in the first half of the season, usually from December to early January.
Rapid development of afternoon and early evening showers.
(Dry Phase)
Windy and relatively dry in the later part of the season, usually from late January to early March.

Inter-Monsoon Period:
Thunderstorms, at times severe, occur in the afternoon and early evening.Hot afternoons are common (maximum temperature above 32°C).

SW Monsoon Season:
Occasional “Sumatra Squalls” with wind gusts of 40-80 km/h occurring between the predawn hours and midday.Short duration showers/thunderstorms in the afternoon are common.

Inter-Monsoon Period:
Thunderstorms, at times severe, occur in the afternoon and early evening.Generally wetter than the Inter-monsoon Period earlier in the year.

NE Monsoon Season	Inter-Monsoon Period	SW Monsoon Season	Inter-Monsoon Period
Dec - Mar	Mar - May	Jun - Sep	Oct - Nov

Climate Profile

Temperature + Humidity

Temperature:
Max: 35ºC
Mean: 26ºC
Min: 20ºC

Comfort Metrics:
UTCI: **72% time Heat Stress**

Relative Humidity: 30-100%
Average: 80%

Annual rainfall: 2331.2mm
Average rainy days: 178

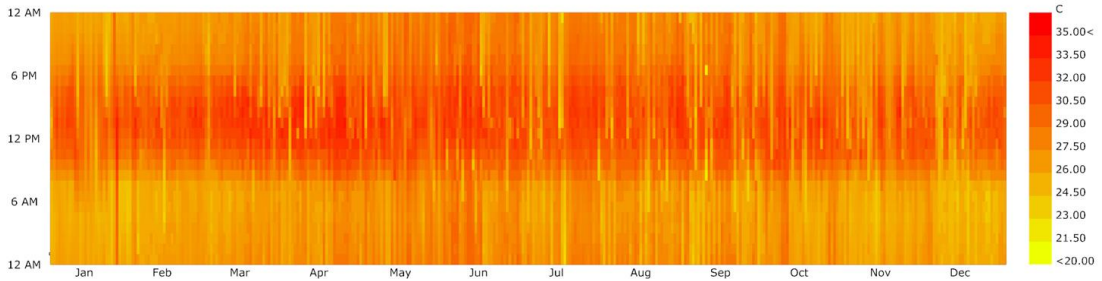
Heat stress is almost equally distributed throughout the year. There is little fluctuation in temperature, and clearly the objective is to cool indoor spaces.

Both natural ventilation and mechanical techniques should be accounted for. However, relative humidity and other wind factors must be taken care of before considering natural ventilation.

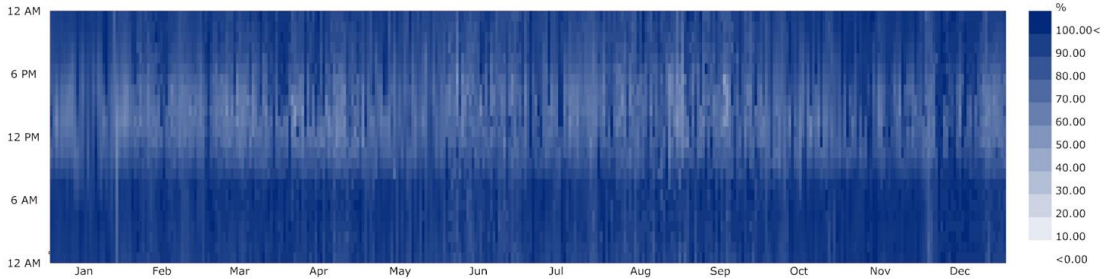
Shading **must** be considered for both opaque and translucent surfaces within the envelope, since exposure should be reduced to the minimum.

Relative humidity almost always lies within the uncomfortable range (above 60% RH more than 50% of the time). This presents problems for both building construction integrity and occupant thermal comfort. Also, dehumidification can account for anywhere from a quarter to a third of energy consumption for cooling loads.

Rainfall is plentiful throughout the year, so there is great potential for harvesting and reusing rainwater for other processes in the building.



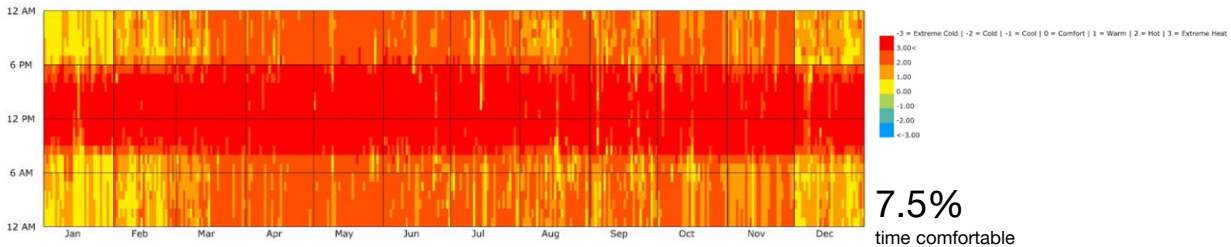
Dry bulb temperature



Relative Humidity

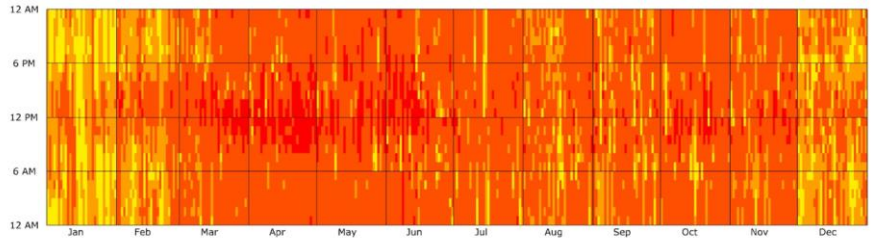
Climate Profile

Climate Challenges - Overview



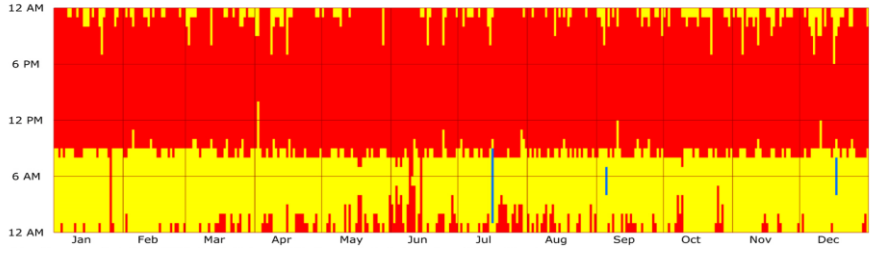
7.5%
time comfortable

Outdoors - Unshaded



8.43%
time comfortable

Outside - Shaded

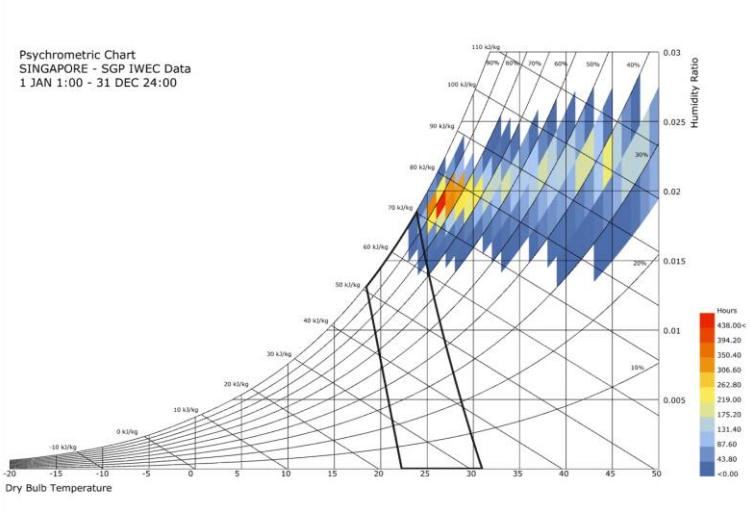


20%
time comfortable

Adaptive - Indoors

Major Reasons For Discomfort

i. Humidity
ii. Heat Stress



Climate Profile

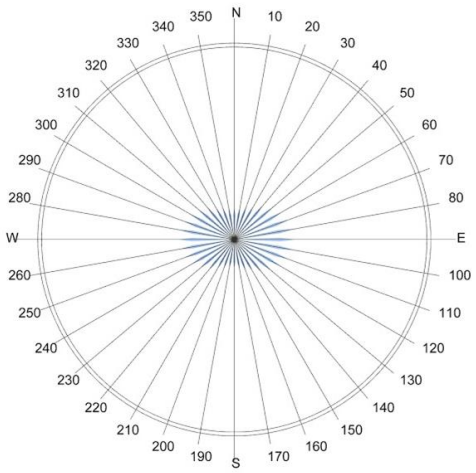
Skies + Light

Sky coverage:
85% of the time above 70% coverage

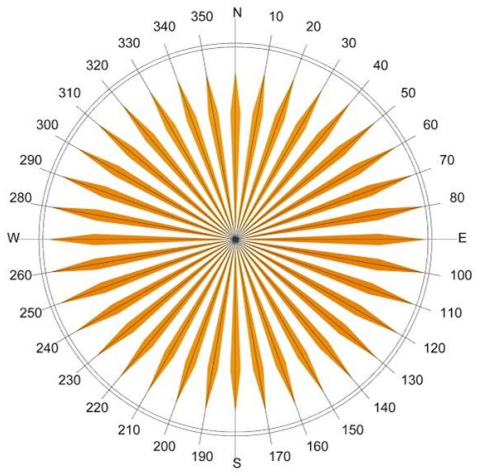
Daylight hours:
4-5 hrs (daily) during wet months
8-9 hrs (daily) during dry months

Proximity to the equator means that sunlight is distributed almost equally by north (Apr - Sep) and south (Oct - Mar). Since most of the radiation will be coming from above, rather than sideways, the roof must be meticulously cared for.

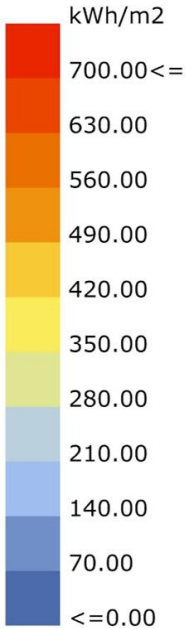
The sun path suggests the building should be oriented on an elongated north-south axis, avoiding high sun positions throughout the day. East and west facades should be built with high thermally resistant materials - especially with high thermal inertia, so heat will radiate outwards during the night.



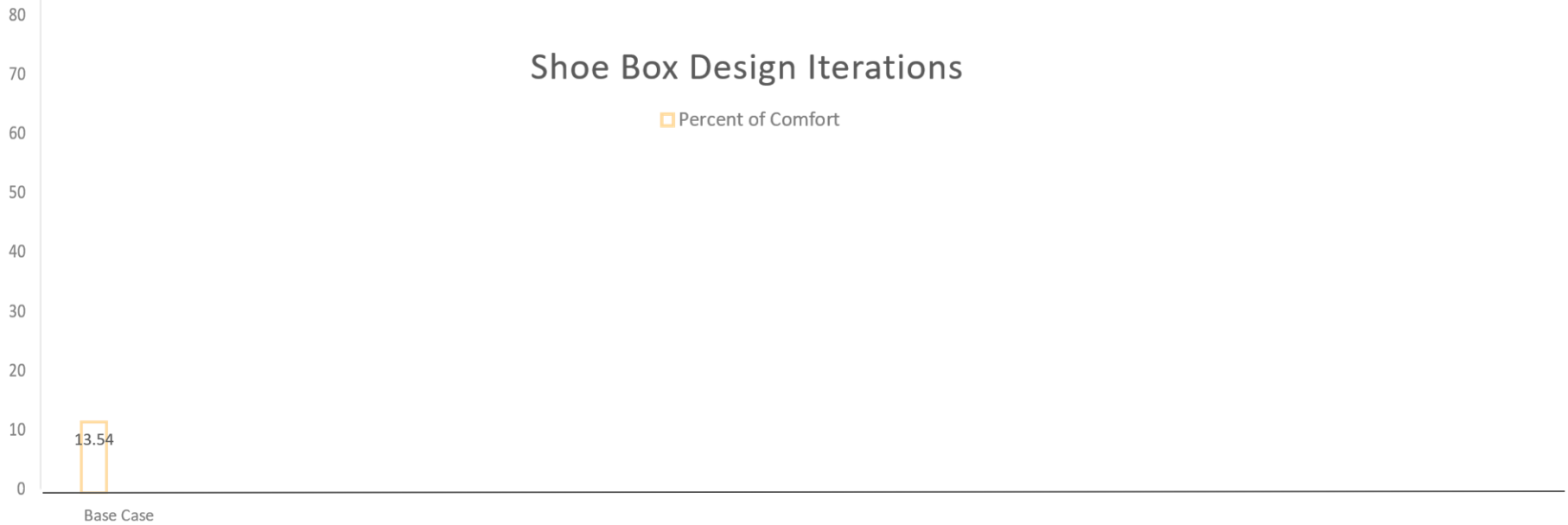
Direct Radiation(kWh/m2)
SINGAPORE_SGP
1 JAN 1:00 - 31 DEC 24:00

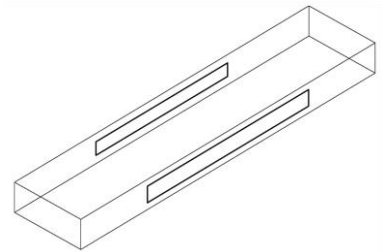


Diffuse Radiation(kWh/m2)
SINGAPORE_SGP
1 JAN 1:00 - 31 DEC 24:00

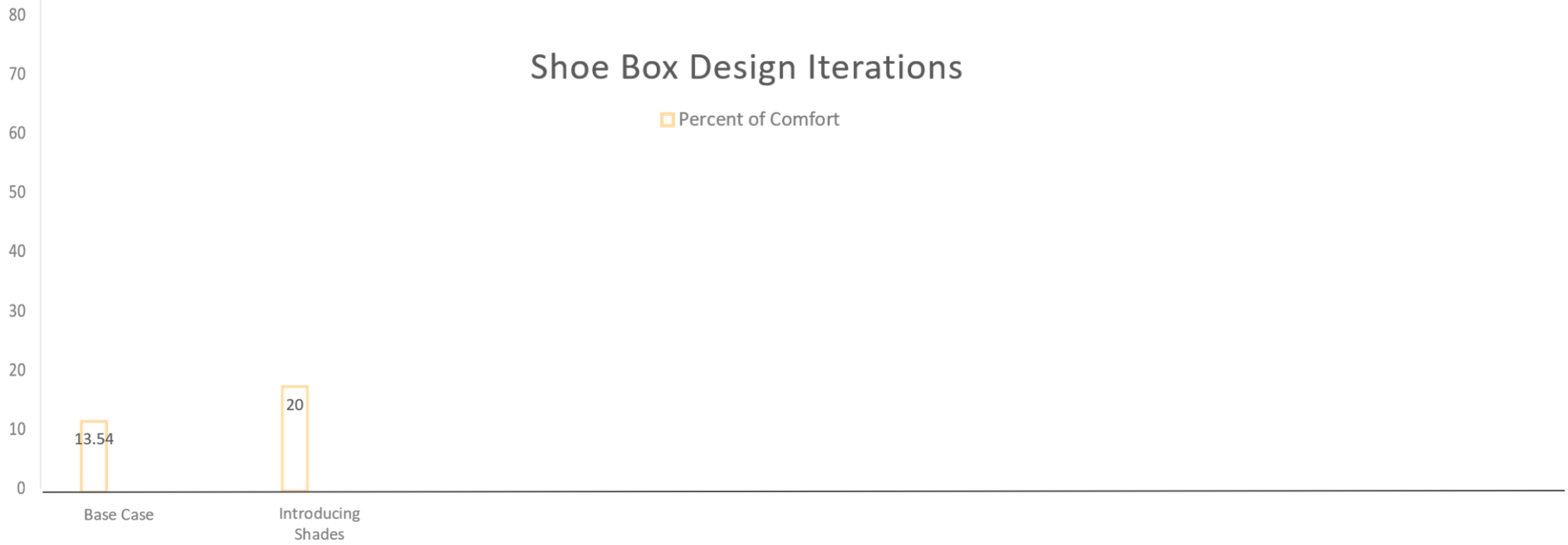


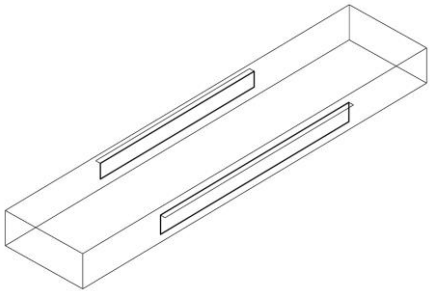
Radiation Rose



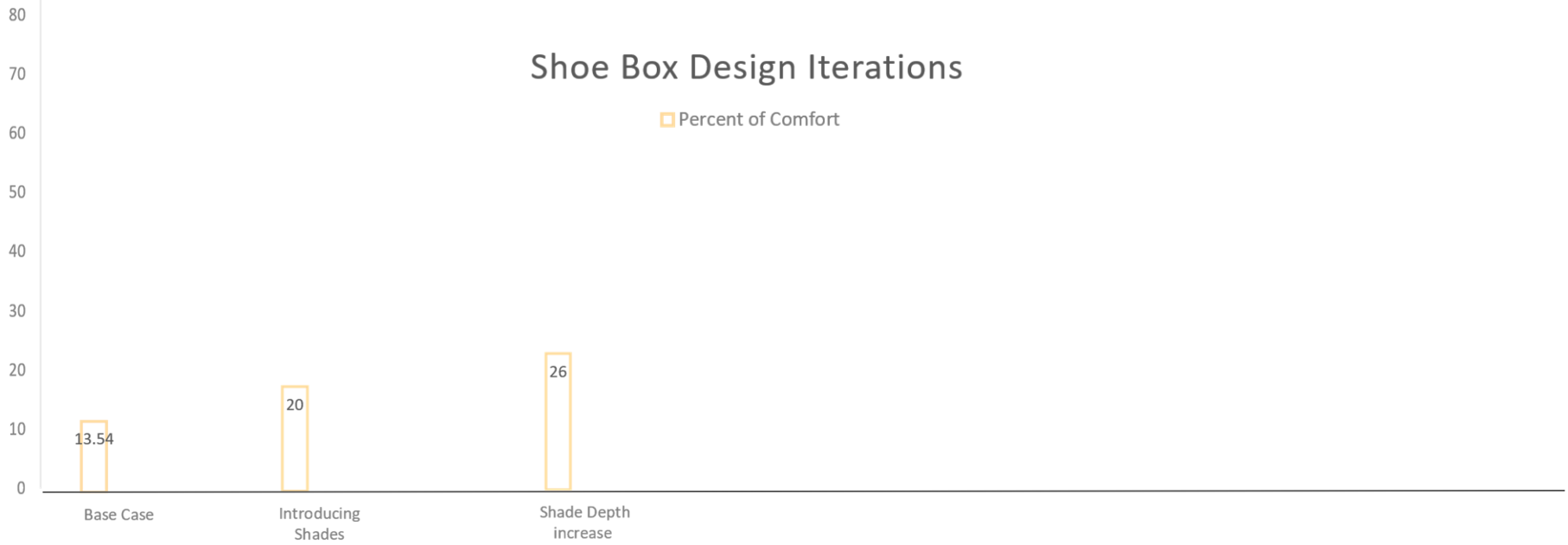


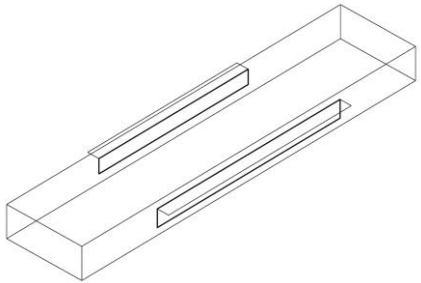
Dimensions - 46 * 10 * 4
Glazing - 20% North
30% South



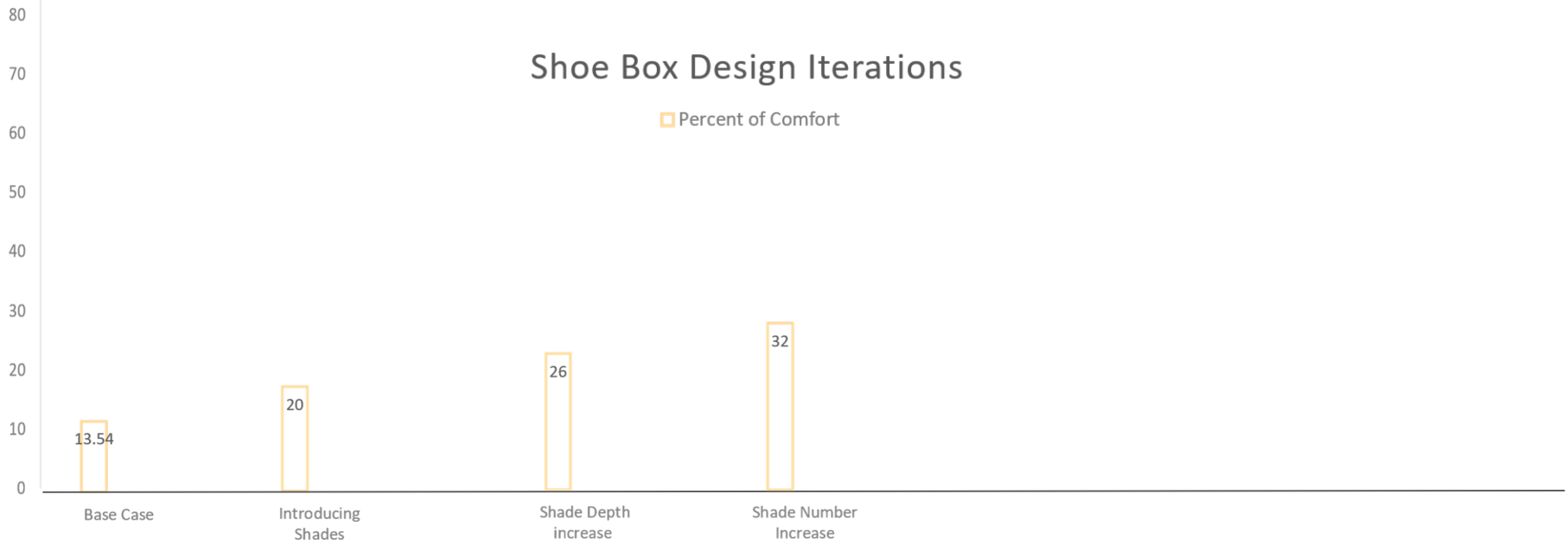


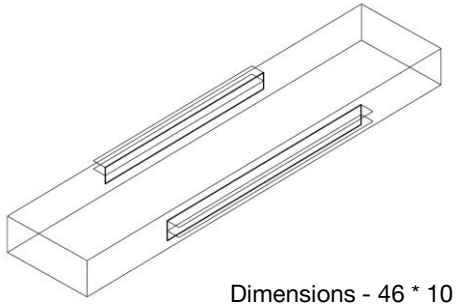
Dimensions - 46 * 10 * 4
Glazing - 20% North
30% South
Shades - 0.6 m depth x 2



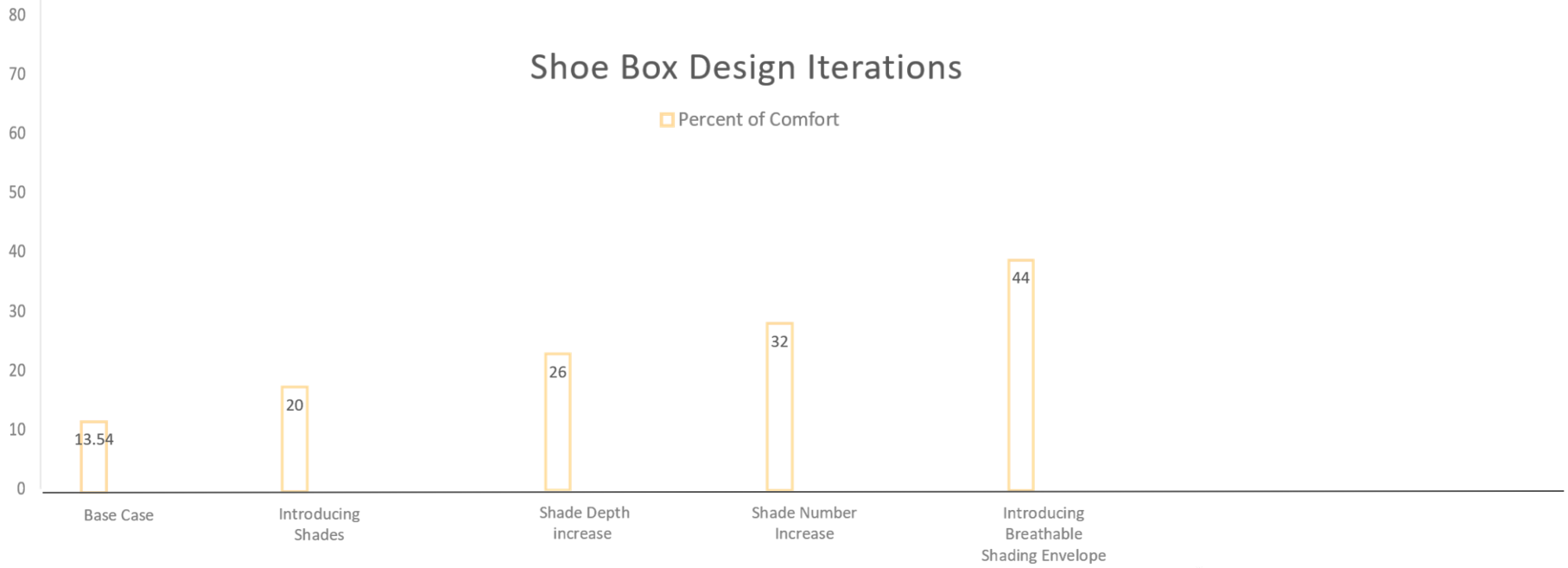


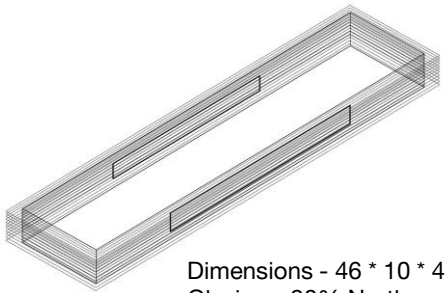
Dimensions - 46 * 10 * 4
Glazing - 20% North
30% South
Shades - 1 m depth x 2



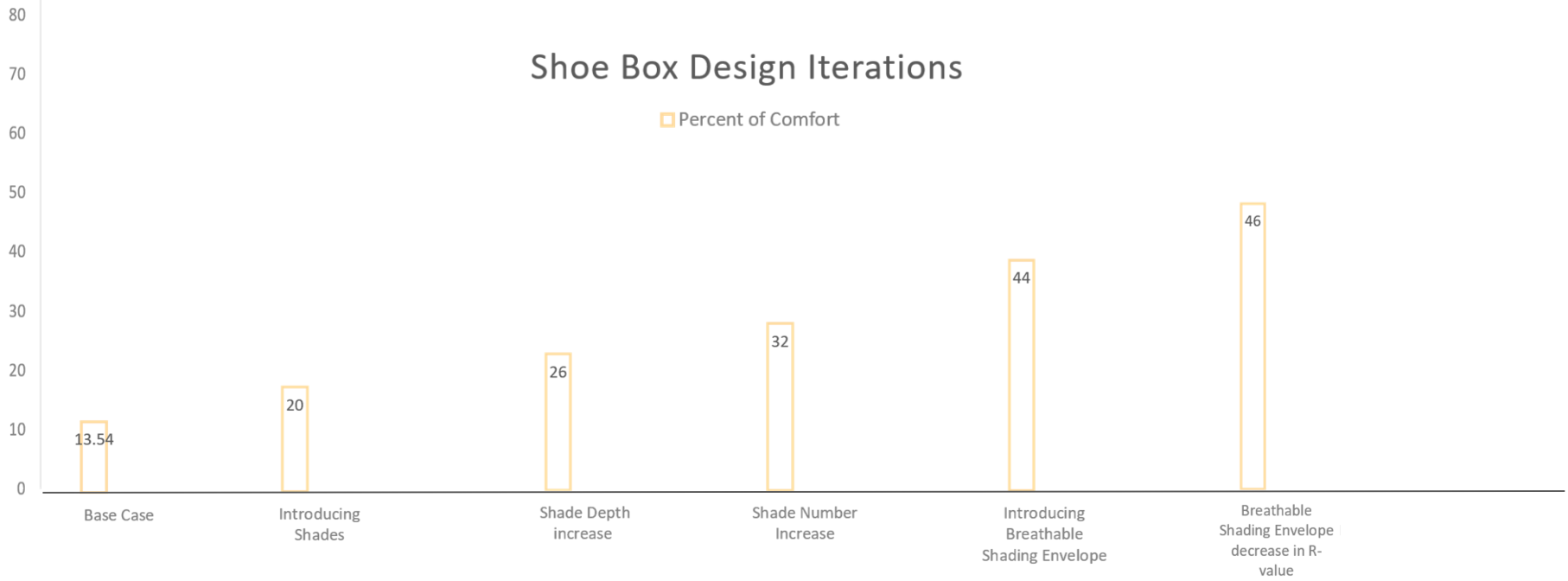


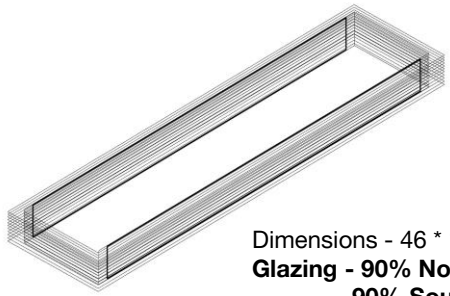
Dimensions - 46 * 10 * 4
Glazing - 20% North
30% South
Shades - 1 m depth x 4



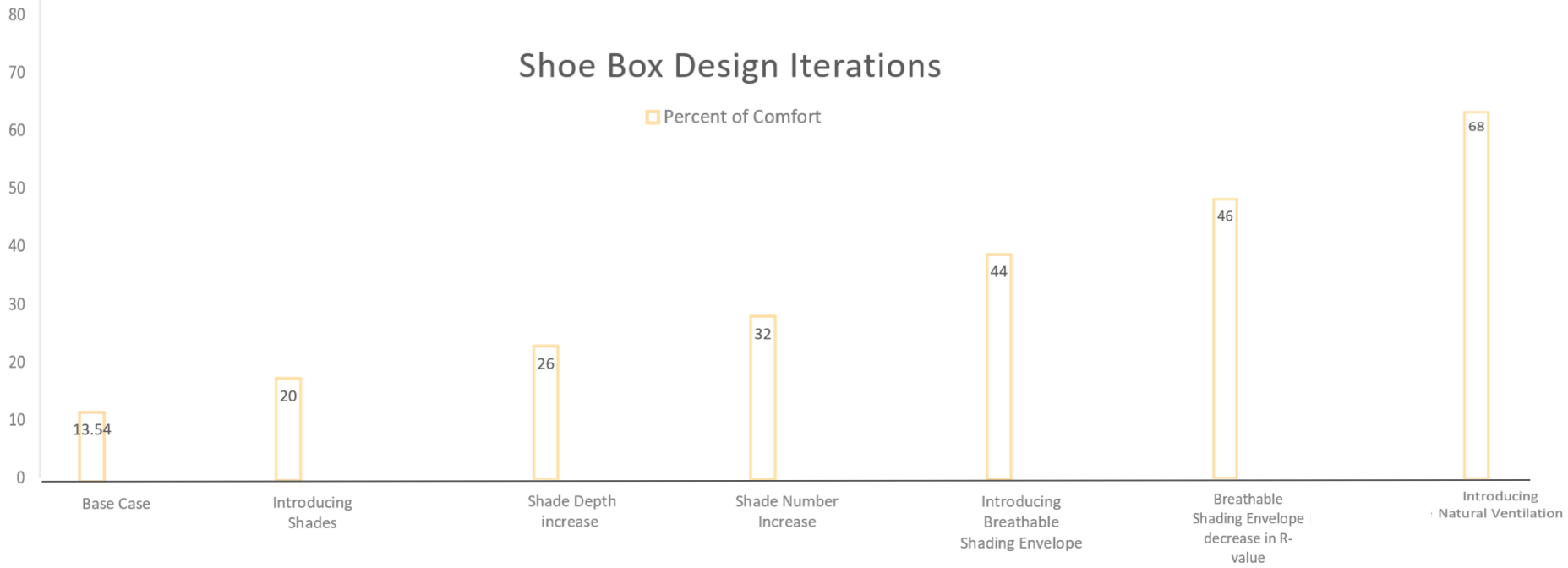


Dimensions - 46 * 10 * 4
Glazing - 20% North
30% South
Envelope - 1 m distance x 10





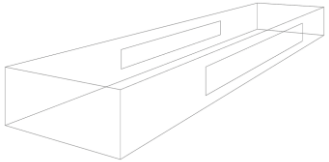
Dimensions - 46 * 10 * 4
Glazing - 90% North
90% South
Envelope - 1 m distance x 10

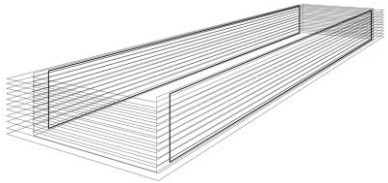


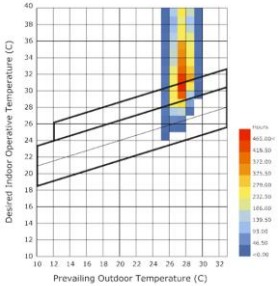
Dimensions - 46 * 10 * 4
Glazing - 90% North
90% South
Envelope - 1 m distance x 10
Natural Ventilation type - Wind Driven

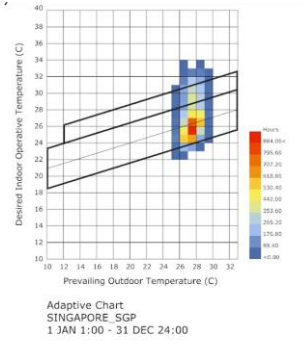
Shoebox Design Iterations

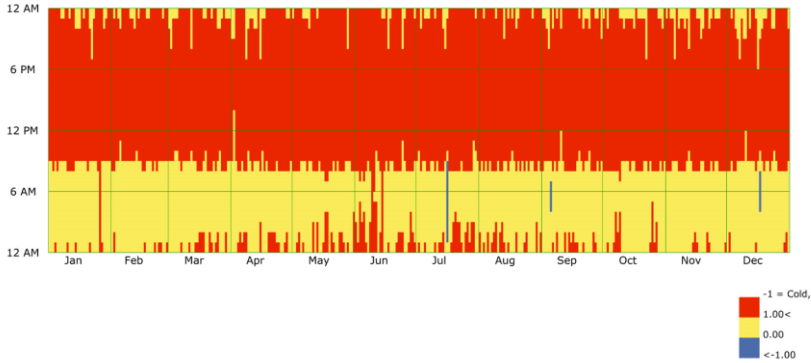
Base Case Vs Final Case

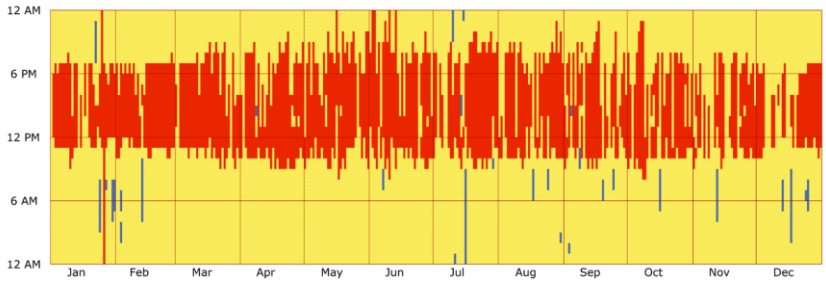












Design Strategies Identified

Macro-climate

Breathable Shaded Envelope

An offset envelope creates a “breathable” buffer zone, increasing overall thermal resistance.

Ventilation

Stack Ventilation

Hot air tends to rise, and having a constantly heated surface on top will “suck” air upwards, improving wind speed.

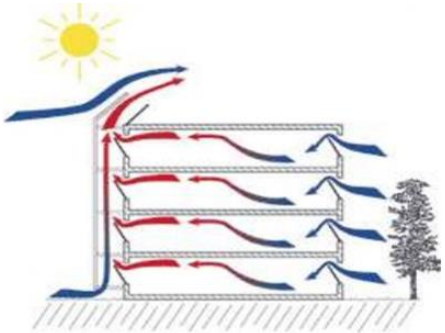
Dehumidification

Green Envelope

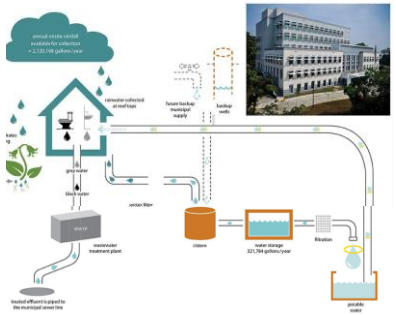
Tropical plants called epiphytes such as English Ivy, Peace Lily, Reed Palm, Boston ferns and Tillandsia . These plants that get all their water from the air instead through roots..

Water Harvesting

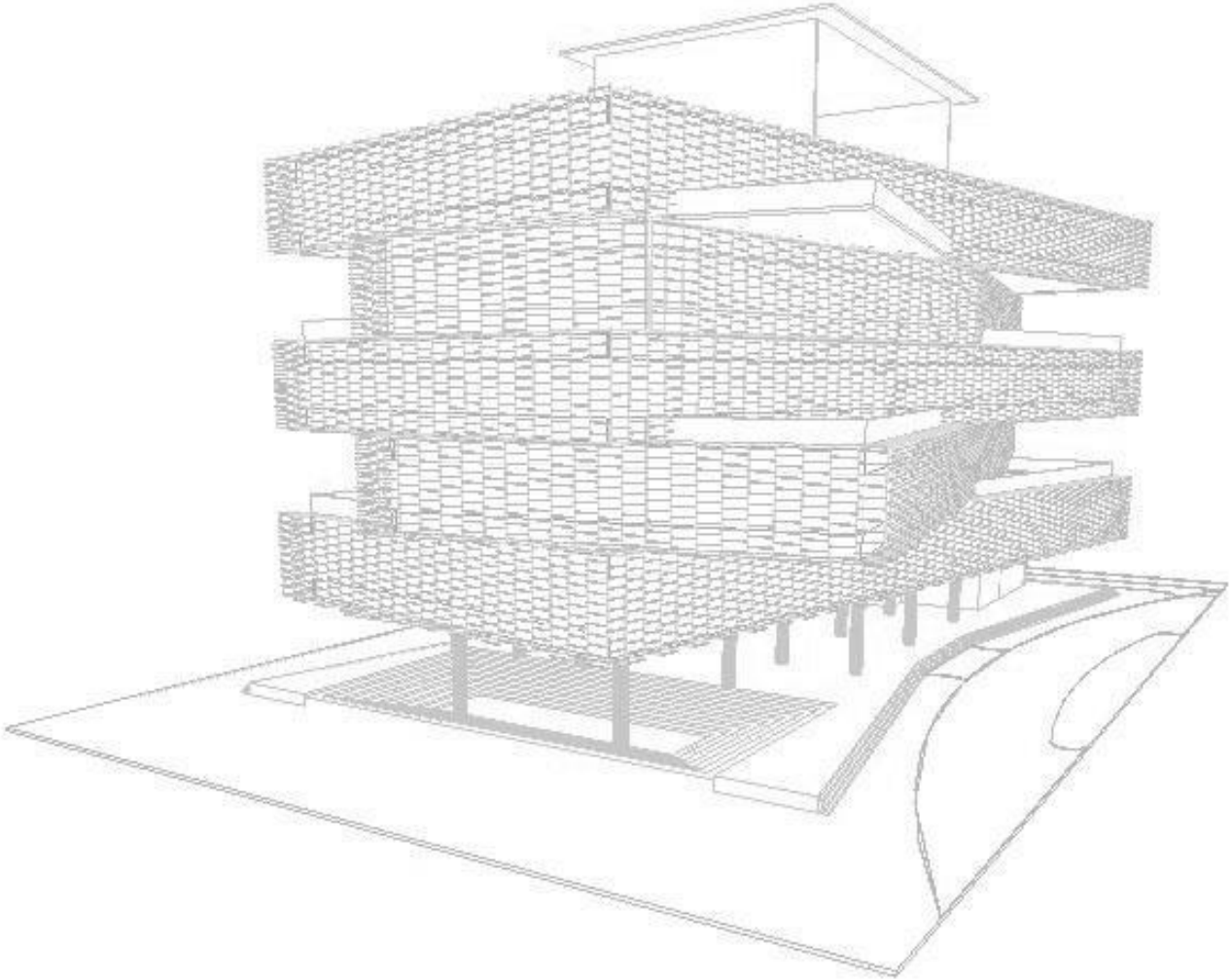
Singapore relies on desalinization plants, and there is much usable stormwater to offset demands (flushing toilets and maybe process water)



Buoyancy Driven



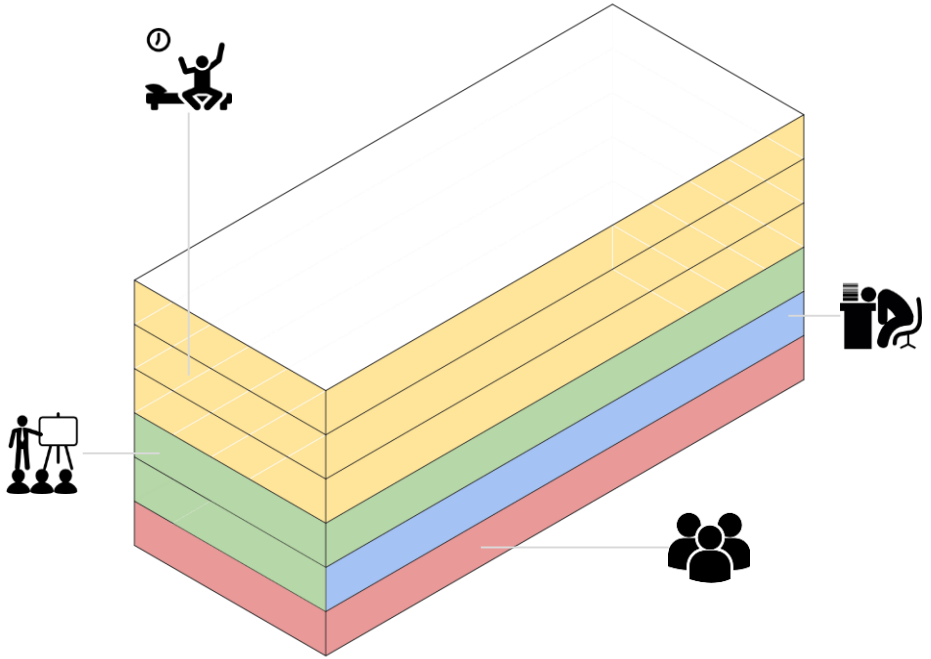
Design Process



Design Process

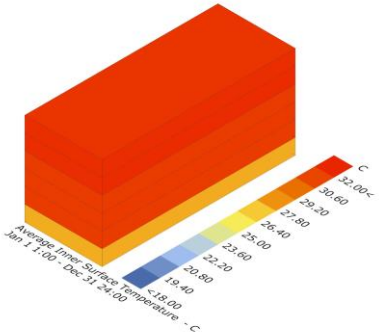
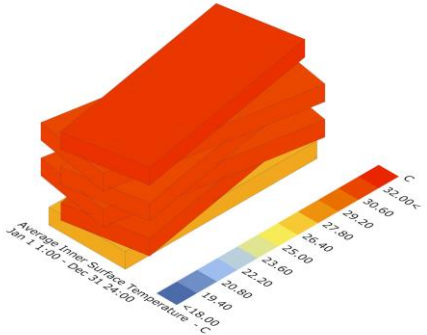
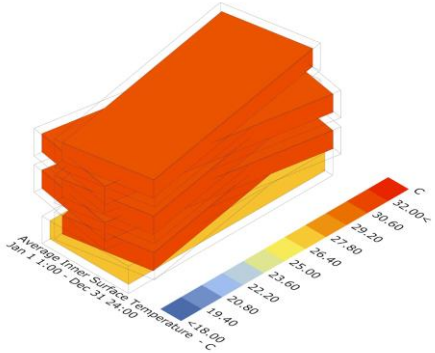
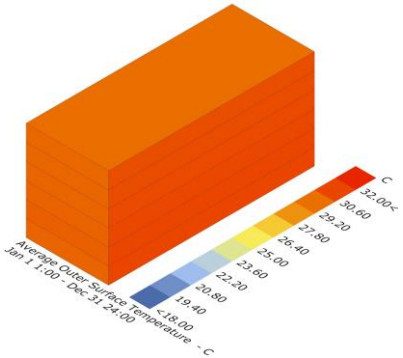
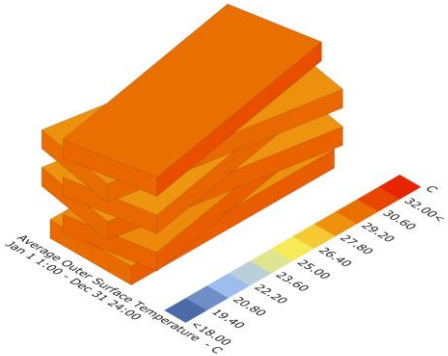
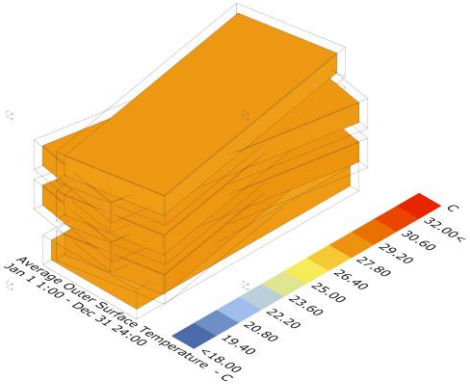
Program Allocation

	#	SF#	SF Total	12500	D	V	O	F
Public, Common								
Lobby	1		700	700				
Retail	1		5000	5000				
Toilets	6		250	1500				
Circulation				2500				
Mechanical				2000				
Trash	1		400	400				
Bicycle Storage, Shower	1		400	400				
Administration & Development				5000				
Director, staff	1		800	800				
Team office	8		75	600				
Conference room	2		500	1000				
Small office	6		100	600				
Large office	4		250	1000				
Files, servers, copiers, kitchen	1		1000	1000				
Research & Education				12800				
Research director, staff	1		2500	2500				
Research offices	12		200	2400				
Small classroom (30)	6		650	3900				
Auditorium, large (250)	1		3000	3000				
Conference, workroom	1		1000	1000				
Residential				25000				
Apartments, hotel, or dorm								
			Total	***55300***				



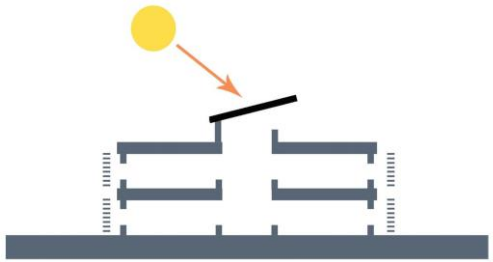
Design Process

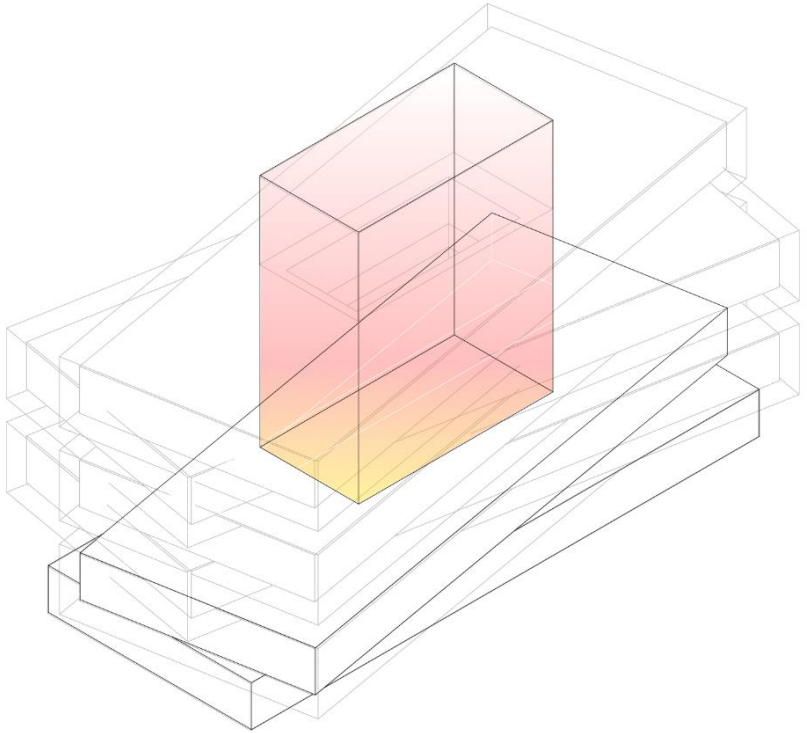
Surface Temperature Analysis

	Simple Massing	Massing Rotation	Secondary Envelope
Interior Surfaces			
Outdoor Surfaces			

Design Process

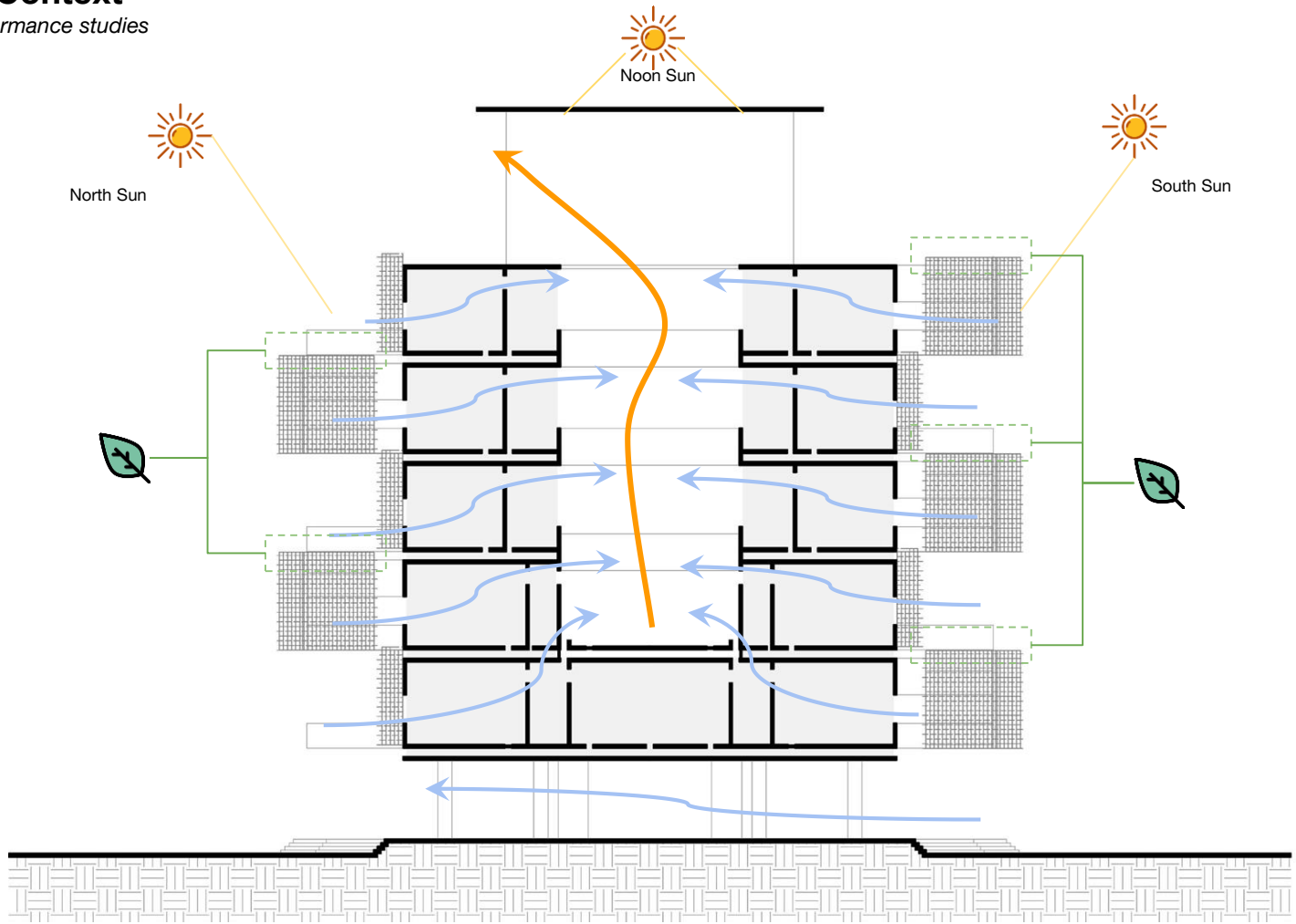
Atrium + Solar Chimney





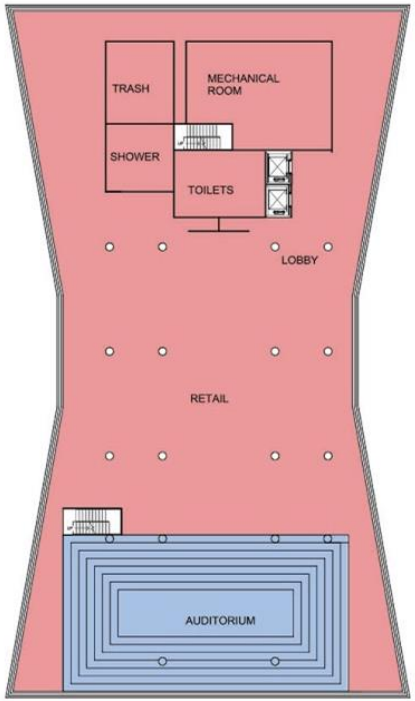
Site and Context

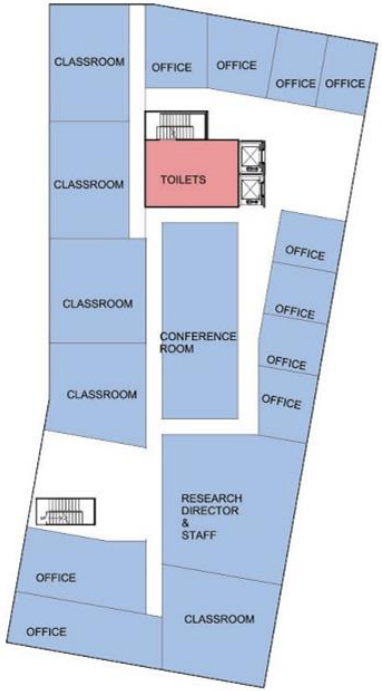
Envelope performance studies

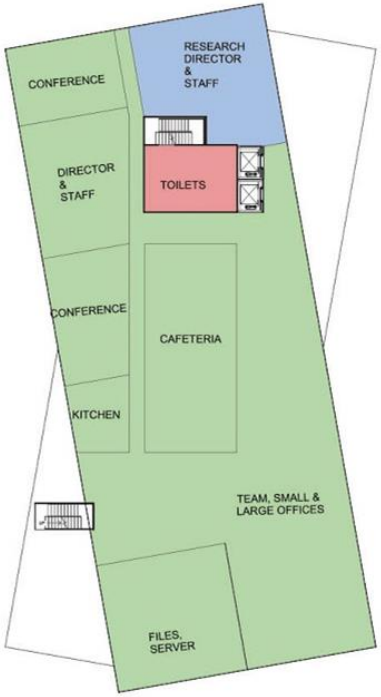


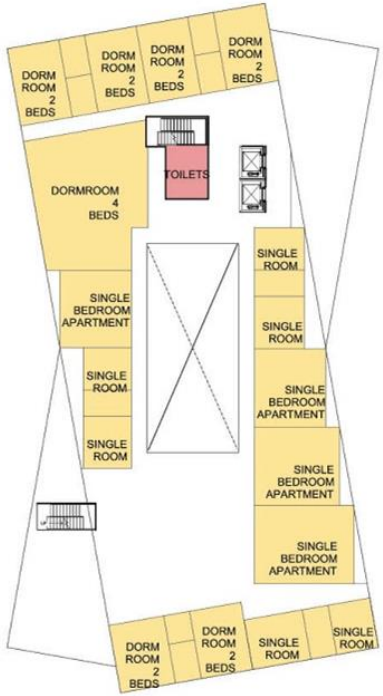
Design Process

Zoning & Planning









Design Process

Final result