

URBAN CENTER USING SHIPPING CONTAINERS.

A THESIS

Submitted in partial fulfillment of the requirements for the award of
Master of Architecture degree in Sustainable Architecture

By

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**INSTITUTE OF SCIENCE AND TECHNOLOGY
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BONAFIDE CERTIFICATE

This is to certify that Thesis Report is the bonafide work of **VAISHNAVI J (42890008)** who carried out the Thesis entitled "**Urban Center Using Shipping Containers**" under our supervision from January 2024 to May 2024.

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I, **Vaishnavi J** hereby declare that the Thesis Report entitled “Urban Center using shipping containers” done by me under the guidance of **Ar. Esther Kiruba Jebakumar Clifford** (Internal Guide), **Ar. Catherine Selvaraj** (Internal Review Member) and **Ar. Krithikha Muthukrishnan** (External Guide) at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Master of Architecture degree in Sustainable Architecture.

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ABSTRACT

This thesis explores the use of shipping containers in urban centres, focusing on thermal comfort parameters. As urbanization demands affordable and sustainable housing, shipping containers offer a promising solution. This study analyses thermal performance, addressing challenges in temperature regulation, insulation, and ventilation.

Using simulations and empirical data, the research evaluates thermal comfort in container architecture. It explores passive and active design strategies to enhance comfort, including insulation, shading, and ventilation systems. Case studies of successful implementations are reviewed to identify best practices.

The findings highlight that while shipping containers have thermal challenges, appropriate design can significantly improve comfort. The thesis provides practical guidelines for optimizing thermal comfort in container-based projects, contributing to sustainable urban development.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

In India, the building industry is responsible for around 38% of all yearly CO₂ emissions. Energy-intensive building materials like Cement, brick, account for 80% of the CO₂ emissions. By reusing the building materials, this can be reduced. Both the energy consumption and the amount of waste materials can be decreased, depending on the building method used.

Prefabricated and modular components are currently becoming prevalent in architecture. The increase in popularity of container buildings is therefore being fueled by their modular architecture and their availability in huge quantities at inexpensive costs.

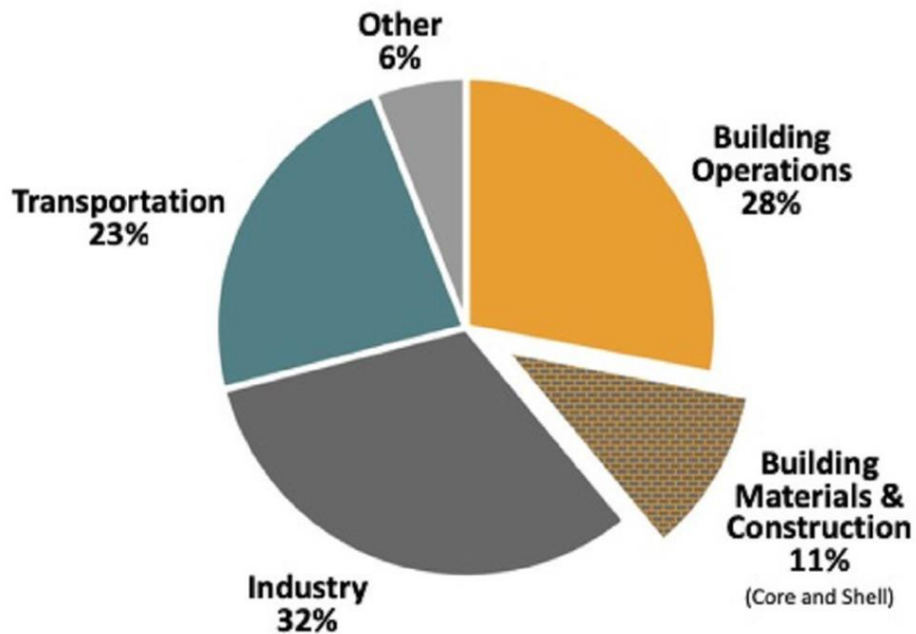


Fig 1.1 Global CO₂ emissions by sector, from the Global Alliance for Buildings and Construction

1.2 NEED FOR THE STUDY

Shipping containers have an active life of 8-10 years when used for shipping purposes. However, it has a lengthy technical life and if properly maintained, it has the potential to last another 15-20 years.

Container buildings have traditionally been used for emergency shelter and portable workplaces due to the advantages of having ease of construction and excellent strength to survive adverse weather conditions.

However, shipping container has many advantages like high strength and reduced cost and environmental impact, but the containers have not been designed to be lived in. Therefore, the first thing to be done when using containers in architecture is to ensure the minimum conditions of habitability inside.

Reuse

Refurbishing the existing containers reduces the need to extract and process new raw materials.

Fast construction and Modularity

The used containers are also kept out of the waste stream, thus making the construction sector, highly sustainable.

Saves energy

Reusing SCs for architecture also saves the energy, as the energy consumed in converting the container into a building is negligible compared to the energy consumed in converting it into scrap.

Reduced embodied energy

The shipping containers offer enormous potential as a habitable space including constructability, structural performance and building services. Stackable building components like shipping containers can cut down on construction time, expense, and waste.

Easy Stacking

The maximum stacking capacity of SCs ranges between 6 when fully loaded and 12 when empty. It has been inferred that stacking ranges from 1 to 9 stories.

1.4 AIM

The aim is to promote sustainable urban regeneration by creating an urban market space using shipping containers.

1.5 OBJECTIVES

- To examine and apply sustainable urban regeneration principles.
- To design a commercial space that engages physical and visual interaction with people with less environmental impact.
- To design space with optimal thermal comfort by upcycling shipping containers.
- To increase the socioeconomic value of the neighbourhood.

1.6 Scope

- Focuses on small independent traders.
- Transforming the quality of retail and leisure offers around the neighbourhood.
- To draw in customers and new business around the region.

2 LITERATURE REVIEW

2.1 What is Sustainable Urban Regeneration?

- Sustainable Urban regeneration is a term used to describe a set of initiatives aimed **at promoting social inclusivity and energy efficiency in cities.**
- **To bring back underutilized assets and redistribute opportunities, increasing urban prosperity and quality of life.**
- **seeks to resolve the social and economic problems** afflicting an urban area.
- Aimed at resolving the multi-faceted problems of deprived urban areas in order to improve their quality of life.

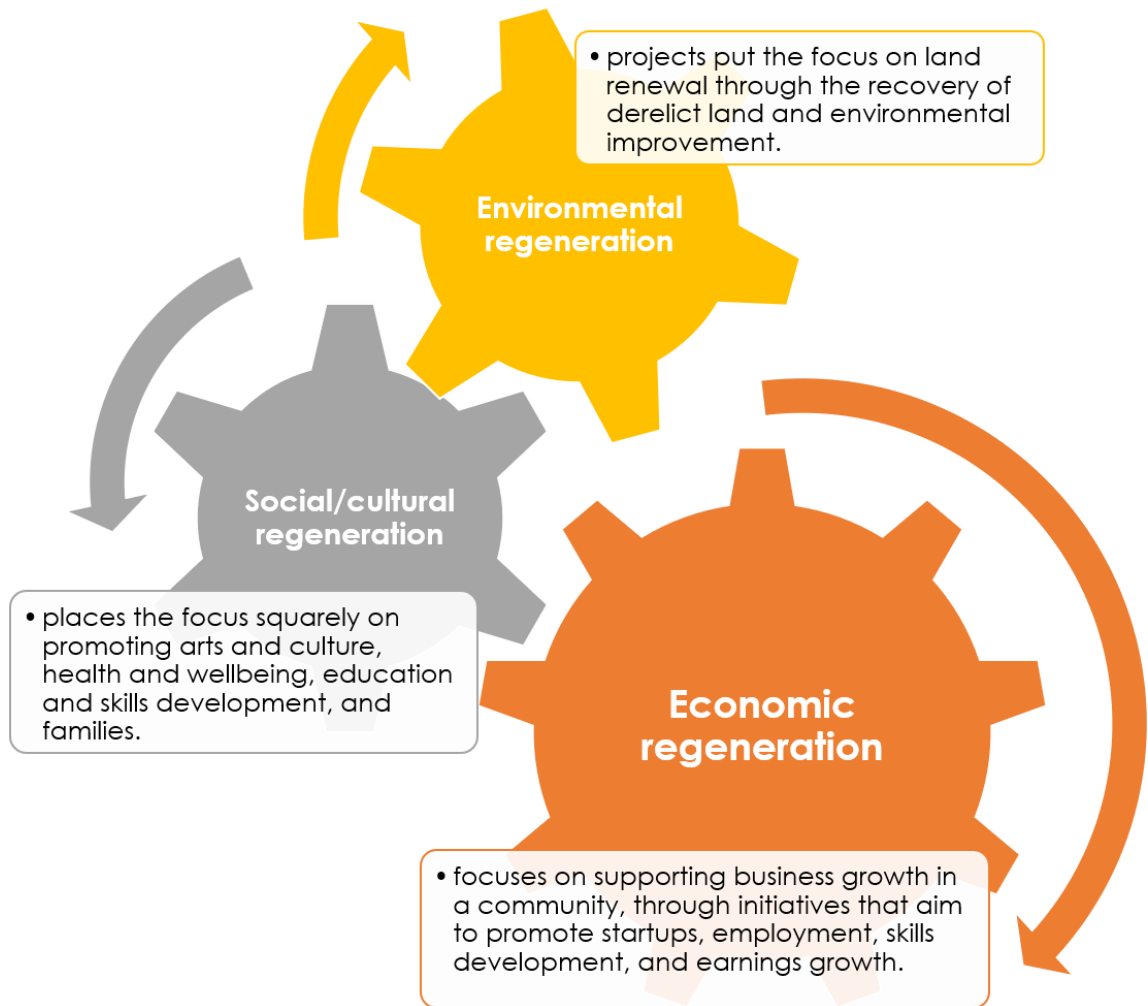


Fig 2.1 Sustainable Urban Regeneration

2.2 Container Specifications

ISO as 1AAA and 1CCC, also known as 20'HC and 40'HC are used prevalently in architecture.

The height of the containers (2.71 m) enables a minimum clear ceiling height of 2.40 m. This respects the minimum required by many national codes for the construction of housing buildings.

Model	Length (m)		Width (m)		Height (m)		Weight (kg)		
	Ext.	Int.	Ext.	Int.	Ext.	Int.	Payload	Tare	Rating
20'HC	6.0	5.9	2.4	2.35	2.89	2.70	28,180	2,300	30,480
40'HC	12.2	12.0	2.4	2.35	2.89	2.70	26,640	3,840	30,480

Fig 2.2 container specification

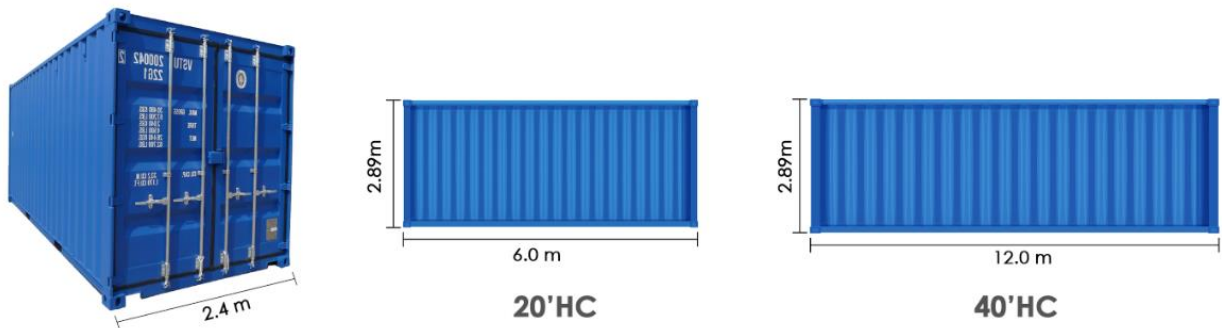


Fig 2.3 20' HC and 40' HC container

2.3 Structure and Apertures:

The thickness of the steel sheets for walls and ceiling is 2 mm.

The depth of the corrugated steel sheets ranges between 25, 30, and 50 mm, depending on the model.

Deep corrugation provides more rigidity.

The corners are designed as rigid elements to support the container and allow for connection between containers.

The standard flooring in an ISO SC is 28 mm thick marine-grade plywood.

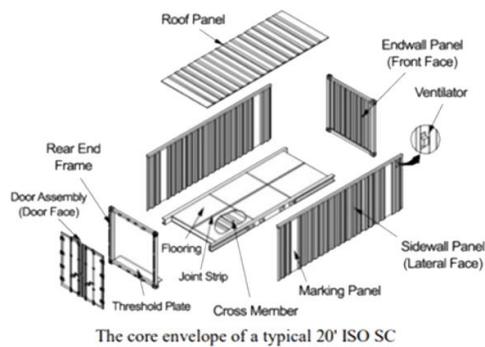
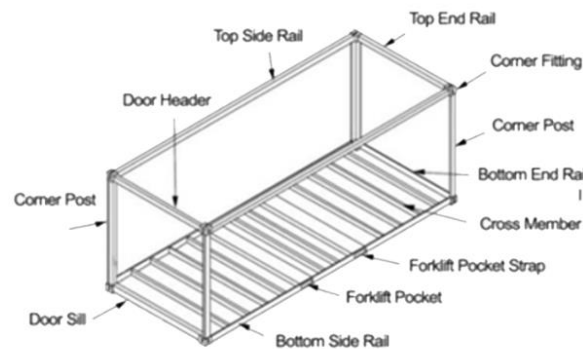


Fig 2.4 The core envelope of a typical 20' ISO SC



5; researchgate.net/publication/353835981

Fig 2.5 Primary structural components for a typical 20' ISO SC

2.4 Why market?

- Due to globalisation, things around us are constantly evolving and getting modernised, for instance, **'santhai'(open market space) has evolved as a supermarket.**
- Supermarkets provide shoppers with. **quick service but lack a sense of place and social interaction.**
- Markets should act as an **exchange medium between communities not only economically, but also socially.**
- Revitalizing urban areas is crucial for urban regeneration.
- Creating a market space is focused on **creating opportunities for growth and development, not just for businesses, but for the community as a whole.**



Fig 2.6 Indian market space

2.5 Why shipping containers?

Tactical urbanism is a low-cost, temporary change to the built environment, usually in cities, intended to improve local neighborhoods and city gathering places. It is fast, affordable, promotes changes.

- This concept relies on the beneficial properties of shipping containers, which provide a **cost-effective and efficient alternative to traditional construction materials**.
- **By optimizing the thermal performance** of these containers, the market can be designed to mitigate the negative effects of heat and humidity, creating a comfortable and enjoyable experience for the users.

3. Case Studies on container and urban Markets

3.1 Box park, UK

Architects:	BDP
Location	Croydon, UK.
Climate Type	Temperate
Area	2622 m ²
No. of Floors	3
Year	2016
Market Type	enclosed market hall
No. of shops	42 units of shops, restaurants and bars
No. of Entrance	2 (main Dingwall Street entrance and another on George Street).
No of containers used	96 NOS
Materials used	polycarbonate roof supported by a steel roof structure
Capacity	2000 people
Activity	Movie screenings, live music, workshops, exhibitions, indoor markets.

Tab 3.1 Box park details

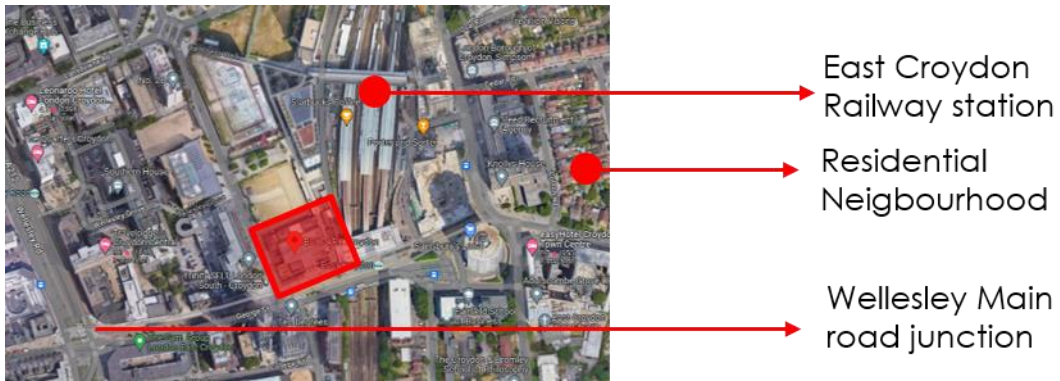


Fig 3.1 Location map

- The center was built with a £3 million budget and **intended to be a temporary structure** that would last for five years until homes and offices could be developed around the neighborhood.
 - The Box Park has direct pedestrian access to the adjacent East Croydon **Railway station**.
 - A footpath that will link into the new Ruskin Square (**commercial development**).
- The ground floor plan shows the relationship between the retail shop(containers) and the central atrium space which emphasizes interaction between the users and provokes a sense of community.

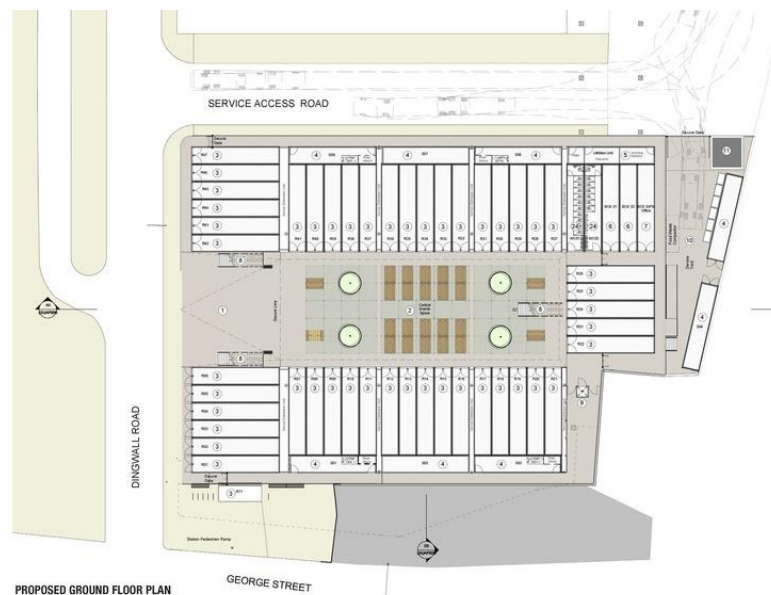
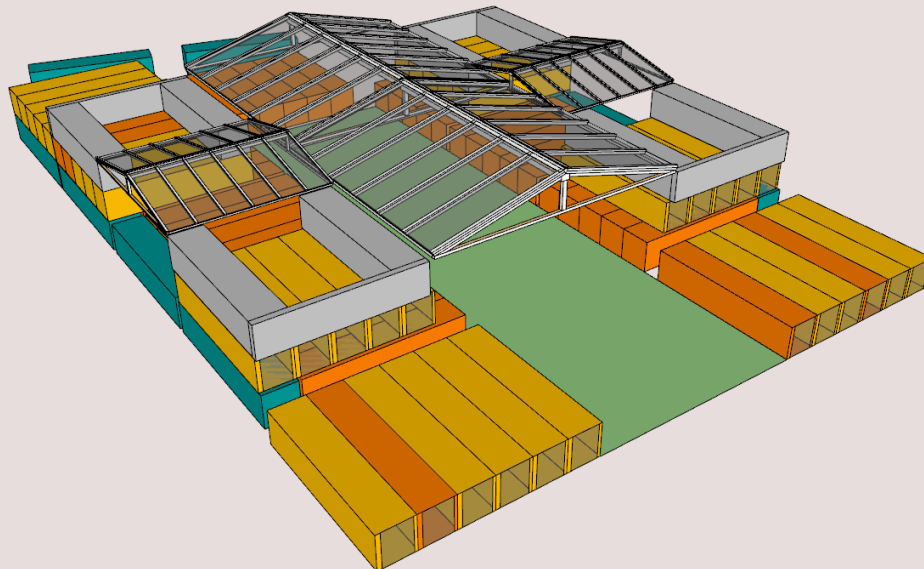
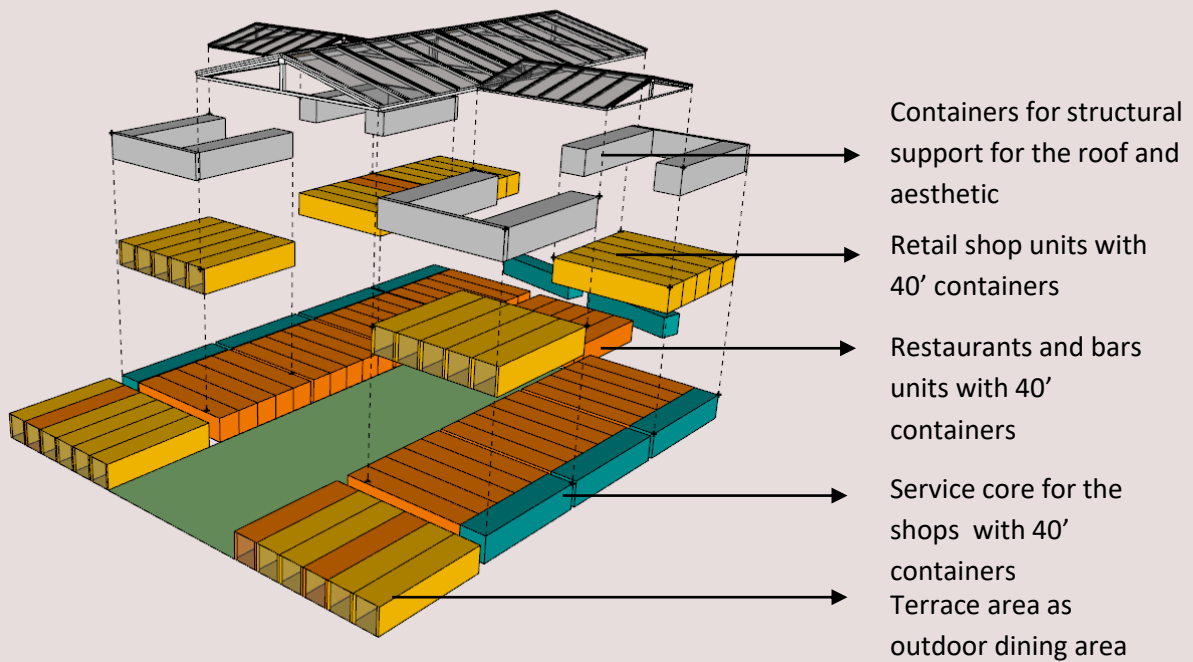


Fig 3.2 Plan



Fig 3.3 Interior images



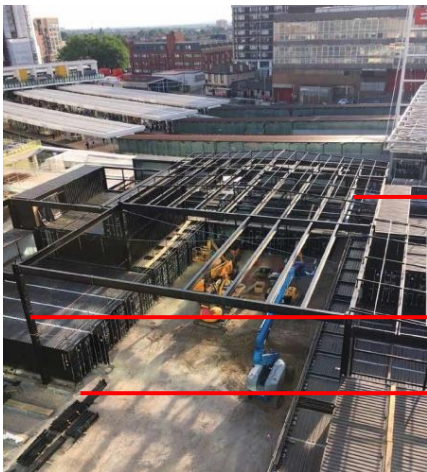
3.1.1 Design modifications

- The cutting out of entrances and side doors has been done offsite.
- combining of two to three containers to form bigger shop units was done on-site.
- Early site works included installing piles for the steel roof support columns and laying timber sleepers for the ground floor containers to sit on.
- In order to cover all three of the outdoor seating areas, the steel-framed roof canopy structure is cruciform-shaped.
- It is clad with polycarbonate roofing (20m x 20m) which allows natural light to penetrate the areas below.



Spray Polyurethane
Foam insulation

Modified container
structure



Cruciform steel
frame structure
for roofing

Steel column

40' prefabricated containers in
ground floor

Fig 3.5 Design modifications

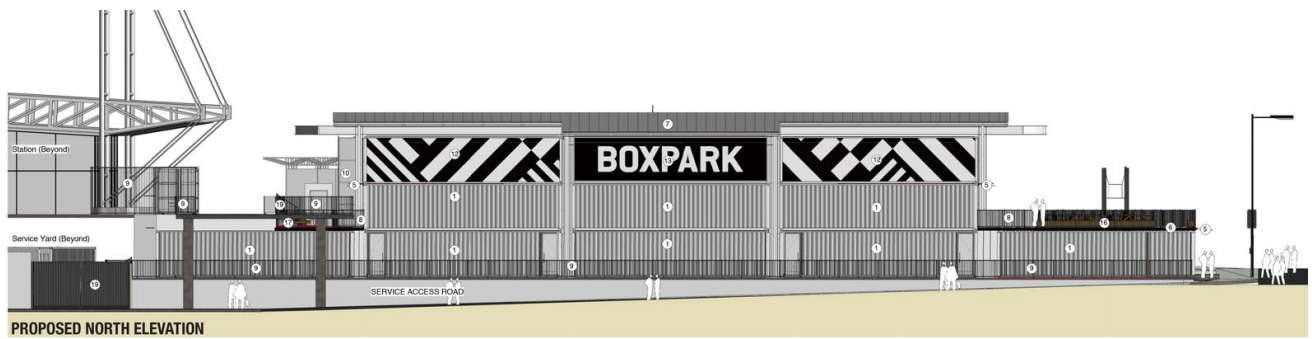


Fig 3.6 Section



Fig 3.7 Section

3.2 Box Park, Dubai

Architects:	Studio M , Meraas Developer
Location	Al Wasl Rd - Al Wasl - Dubai
Climate Type	Hot and arid
Area	15,000 sq.m
No. of Floors	2- 5
Year	2015
Market Type	City Walk outdoor mall

No. of shops	44
No. of Entrance	3
No of containers used	220
Materials used	shipping containers, Precast concrete, steel
Capacity	---
Activity	Restaurant, retail store, children play area, gym, salon.

Tab 3.2 Details



Fig 3.8 Location map

- Creates a unique experiences in Dubai's important high-street districts in Al Wasl and Jumeirah.
- a refreshing change from the towering skyscrapers.
- The project has had the effect of encouraging local startups and revitalizing the area.
- The residential district in which Box Park was built has been slowly transforming into a strong retail district.
- now becoming a Dubai landmark and attracting a younger, hipper client base.

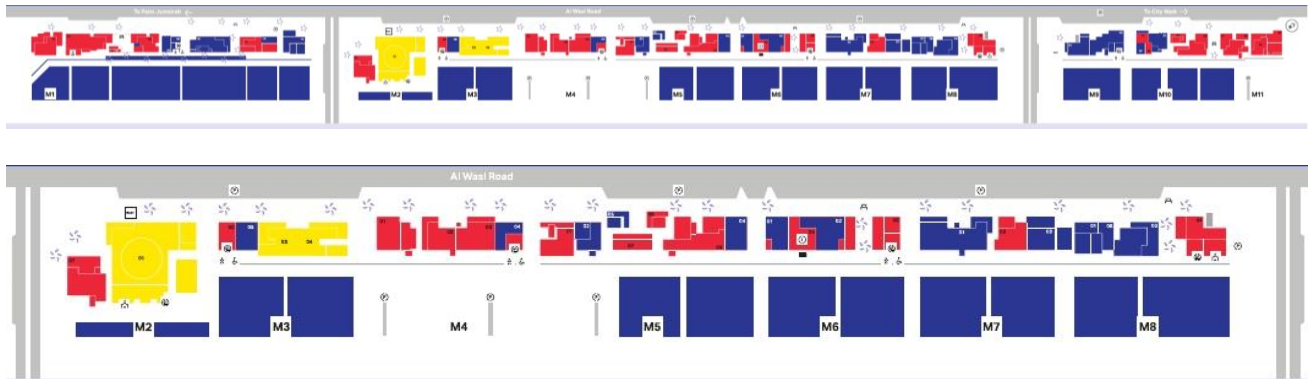


Fig 3.9 Plan

The **entire 1.5 km stretch is divided into 3 parts** where in every zone they have provided **prayer rooms, toilets, a baby changing station, and an info desk.**

- Each zone has its sets of restaurants, cafes, and retail shops with intermediate children's play areas.
- Shipping containers were stacked together to form the stores and restaurants, and in many cases **supplemented with concrete precast structures.**
- The blocks in larger sizes are made with precast concrete to accommodate high value retail stores.

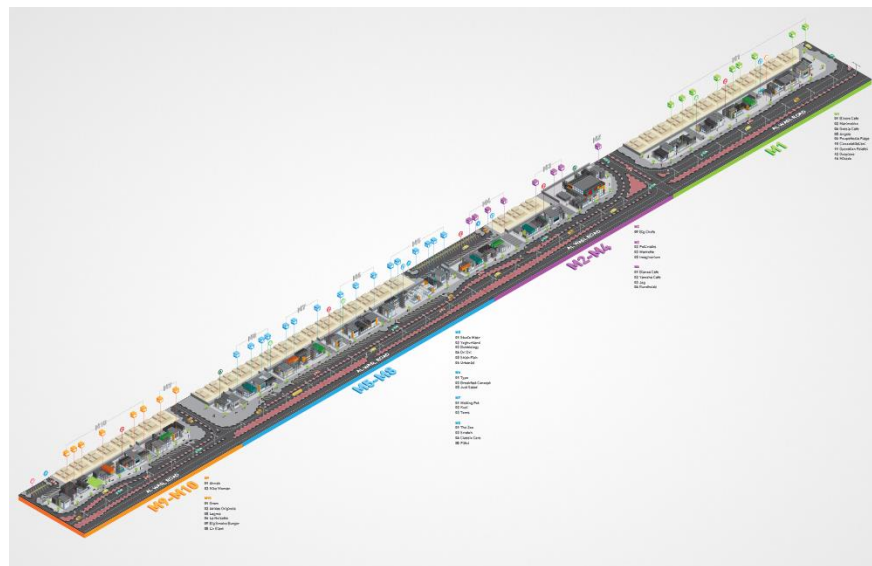


Fig 3.10 View

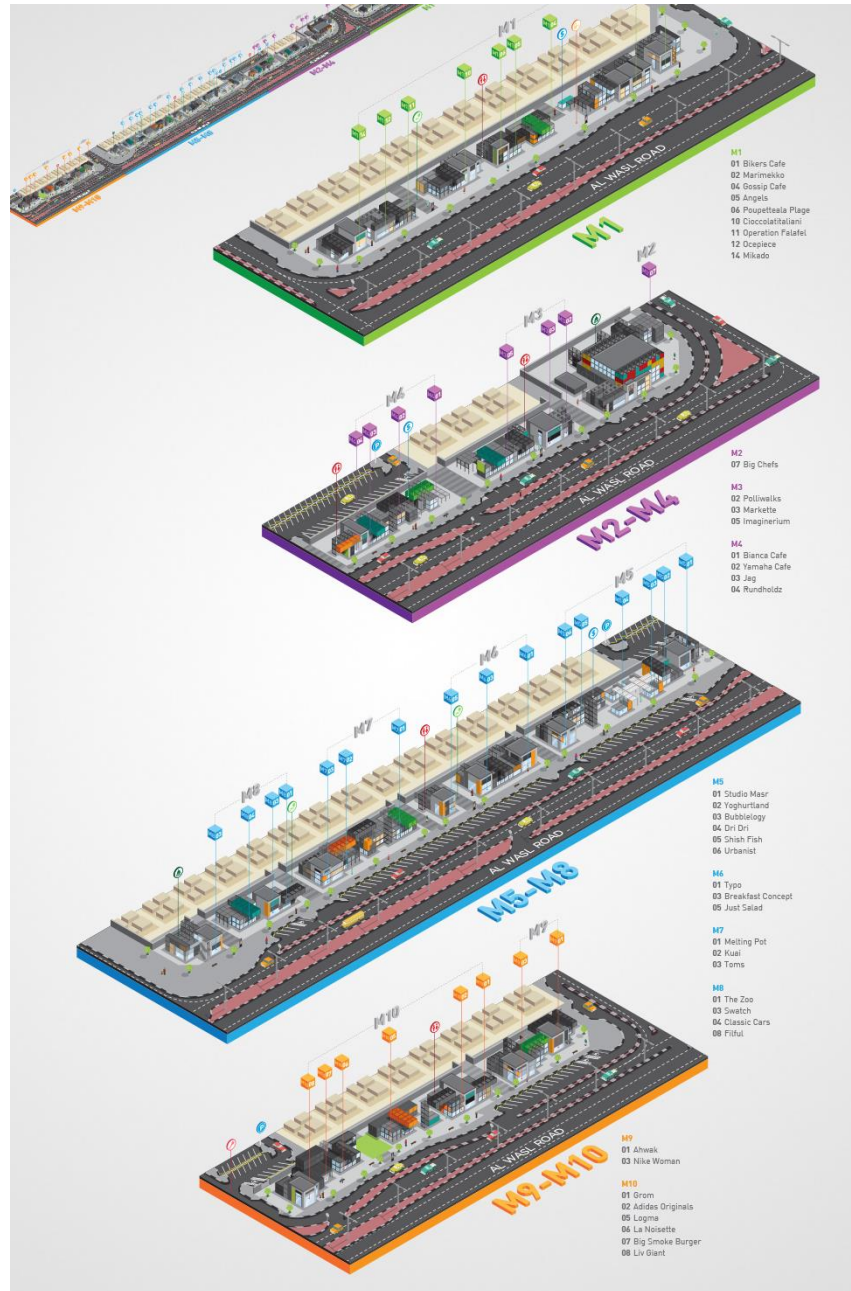


Fig 3.11 isometric view

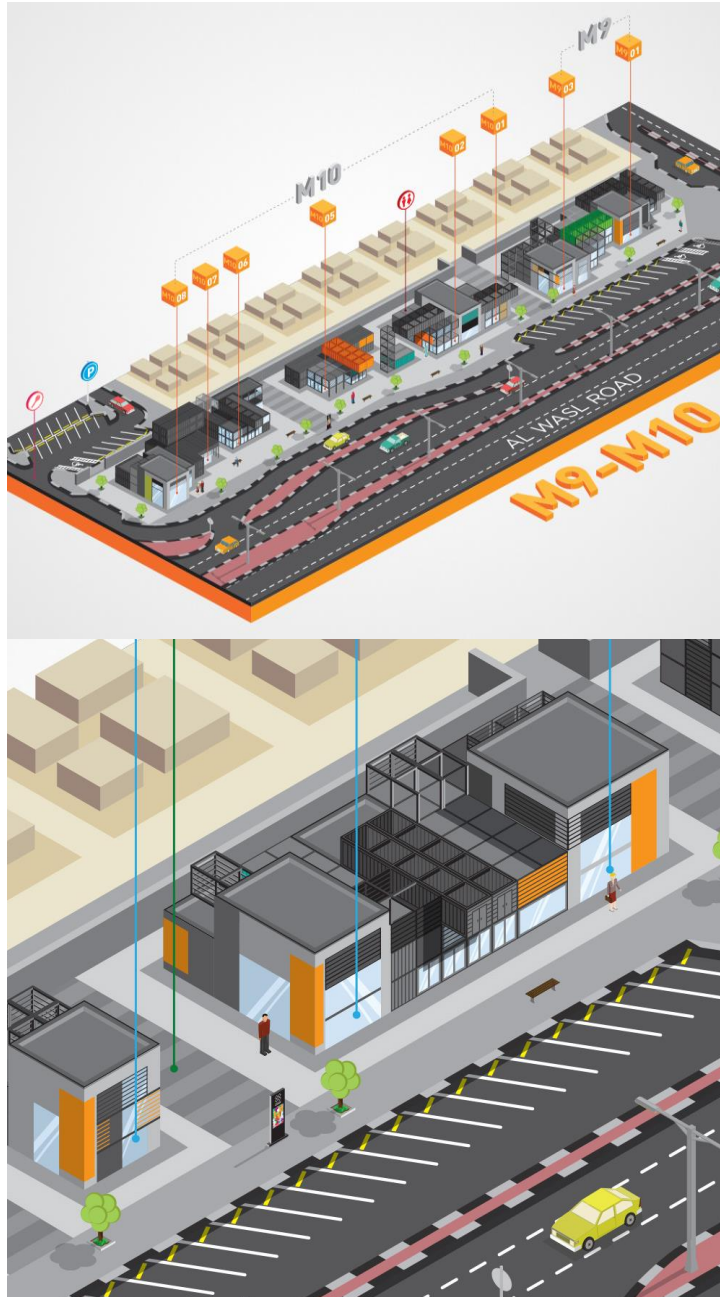


Fig 3.12 isometric view

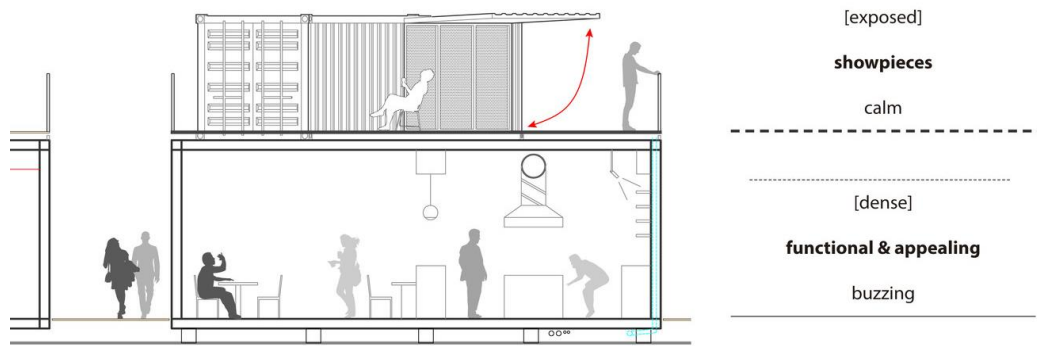


Fig 3.13 Section

- Since the longer axis of the plan faces east and west, the blocks have been provided with shading lovers with the use of container steel.
- A tensile rollable shading device has been provided for the ground-floor shops.
- Since the longer axis faces east wet vertical louvers with container panel is provided for the first floor and tensile shading device for ground floor shops.
- In every zone, a children's play area is provided which breaks the monotony and acts as a leisure space.
- Precast concrete blocks have been used in between the container blocks with steel panel
- Due to the placement of blocks close to each other it helps in self-shading within the blocks
- Screen wall with graffiti and green wall has been provided behind the box park to hide the residential neighborhood behind
- AC outdoor units and ventilation tunnel are covered with containers

3.3 Stackt Market, Canada

Architects:	LGA Architectural Partners
Location	Toronto, Canada
Climate Type	Cold – Humid
Area	2099 sq.m
No. of Floors	3
Year	2019
Market Type	semi-enclosed market hall
No. of shops	30
No. of Entrance	4 (3 Pedestrian entrances and 1 parking and truck entrance).
No of containers used	197 NOS
Materials used	Retrofired shipping containers and tensile roofing
Capacity	
Activity	retail shops, microbrewery, restaurants, and community programming.

Tab 3.3 Details

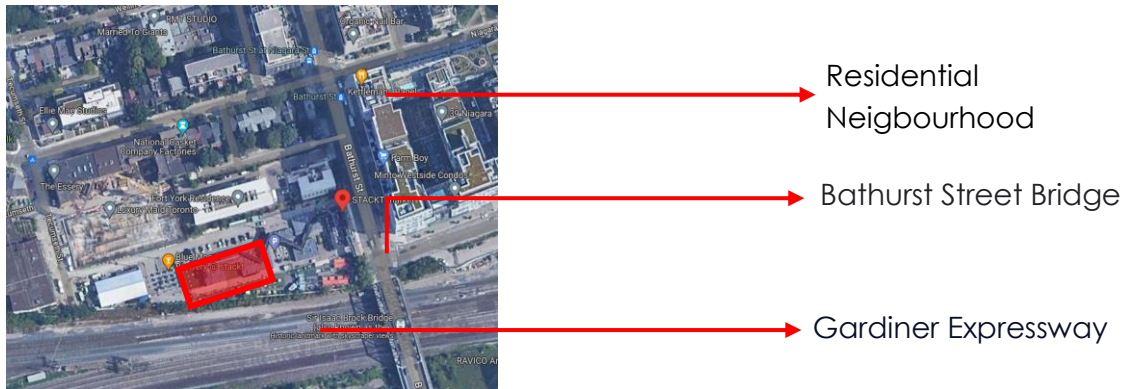


Fig 3.14 Location map

- A brownfield land had an industrial purpose as the site of a smelting plant and coal storage facility.
- Over time, the city of Toronto came to own it, and turned the space into a park.
- The developers proposed a shipping container marketplace as a temporary use of the empty lots until the city moves forward with the permanent park.
- It supports local art, music, social enterprise, and cultural communities.

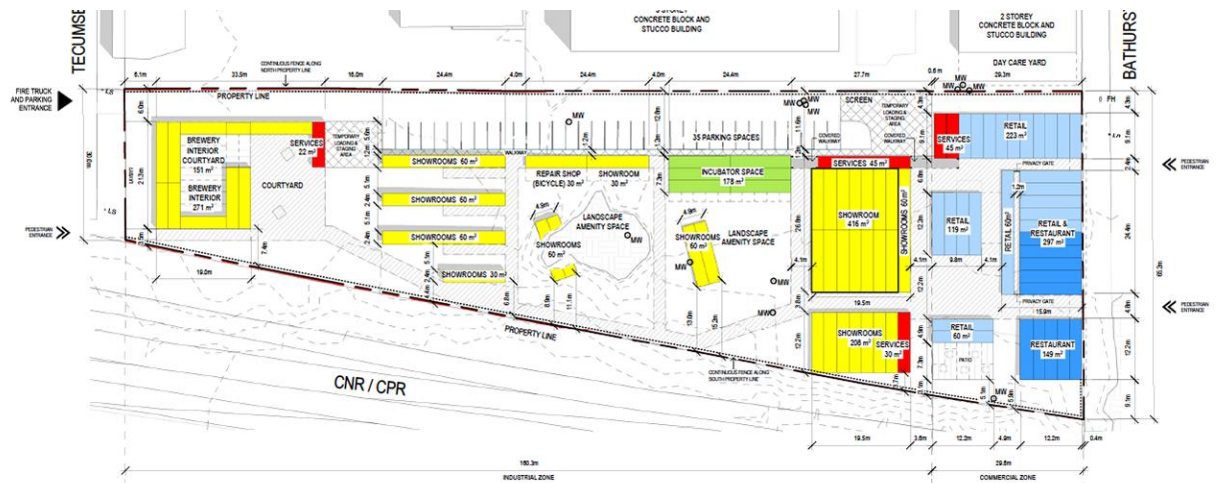


Fig 3.14 Plan

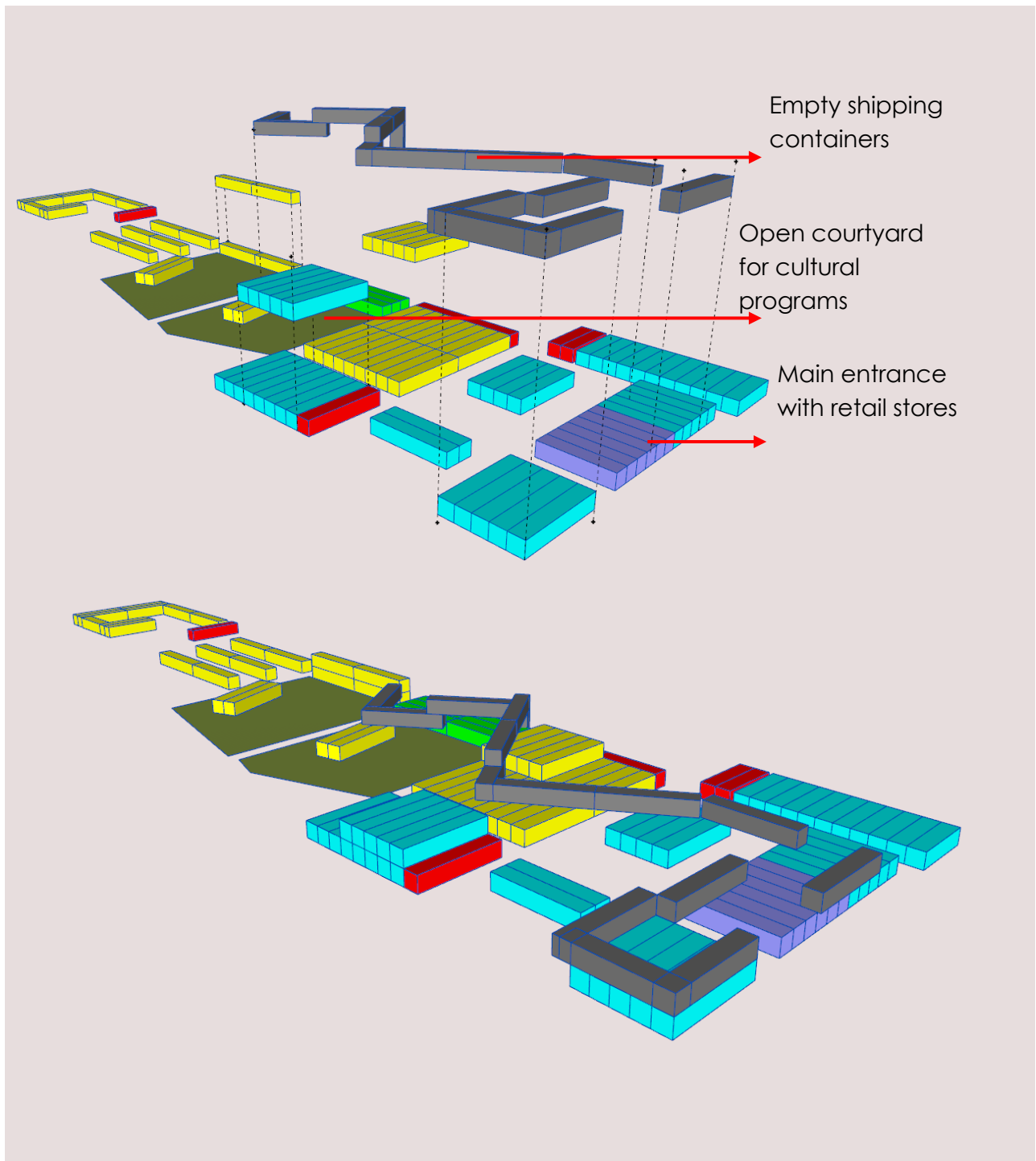


Fig 3.15 Exploded view

- The storefronts are deliberately uniform to reduce visual clutter.
- On the ground-level network of detached buildings with single and double-height interiors.
- The containers' arrangement creates side **streets that enhance the pedestrian experience, and courtyards ideal for cultural programming.**
- Containers on **the elevated levels are empty and serve only to fill out the design as a canvas for the numerous murals.**
- **providing some dynamism and presence from outside.**
- The cutting out of entrances and side doors has been done offsite.
- combing of two to three containers to form bigger shop units was done off-site.
-
- On the ground level the new containers thread in and out to create a network of detached buildings with single and double-height interiors.
- Insulation has been provided for thermal comfort inside the spaces



Fig 3.16 Interior views

3.4 Salt lake city center, kolkata

Architects:	Charles Correa
Location	Kolkata, West Bengal, India
Climate Type	Warm and Humid
Site Area	10,700 m²
Built up area	50,400 m²
Year	2004
Market Type	Mixed use building
No. of shops	297 shops, 16 kiosk
No. of Entrance	12 gates, 10 – entry and 2 exit
Parking	800 Cars

Tab 3.4 Details

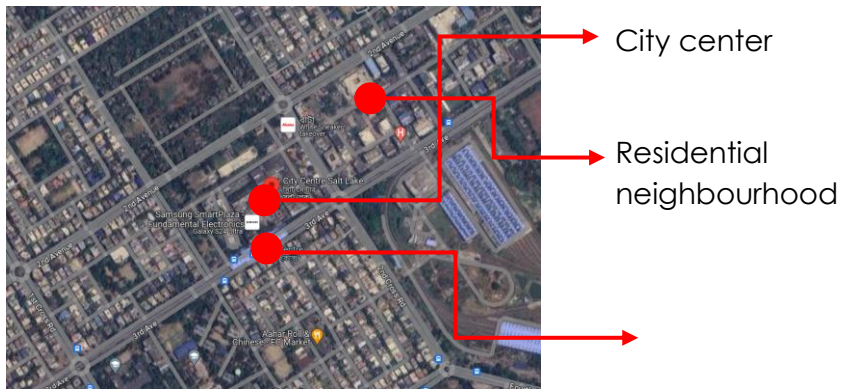


Fig 3.17 Location map

- Salt Lake City Centre is a fusion of typical Indian markets and up-scale shopping malls.
- inviting to all classes of society due to its range of retail spaces and open public spaces where people could rest and enjoy the chaos.
- Mixed-use design that constitutes a variety of space-high-end shops, local brands, restaurants, café, banquet hall, Multiplex cinema, spa and salon. Offices, hospital and residence.
- It is designed in clusters with free flowing seamless spaces from open to close and from air-conditioned to non-air conditioned spaces.

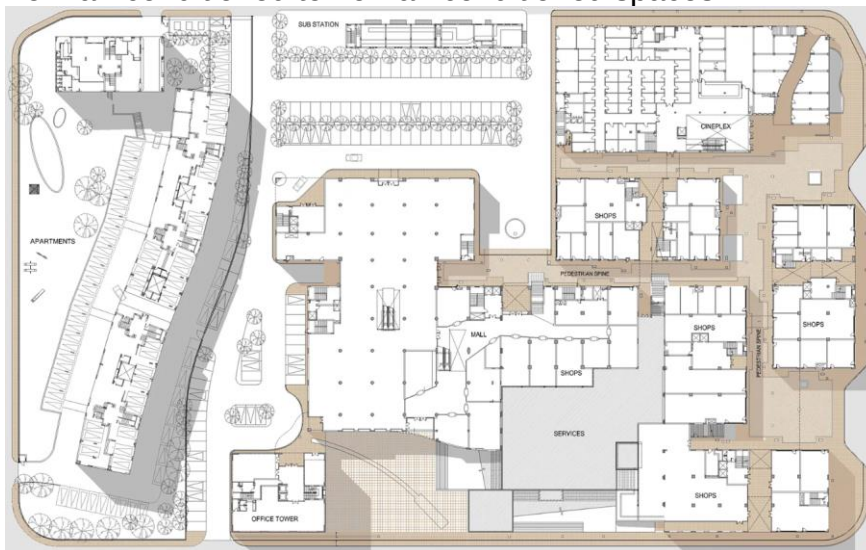


Fig 3.18 Plan



Fig 3.19 Interior Views

The edge of the site does not have any boundary walls and the mall can be entered from any side of the site which gives a welcoming sense to the city centre. It has a total of 12 gates- 10 for entry and 2 for exit.

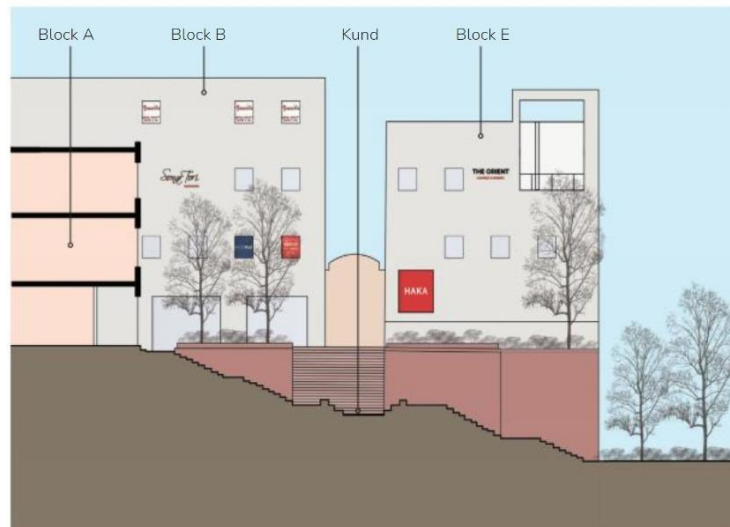
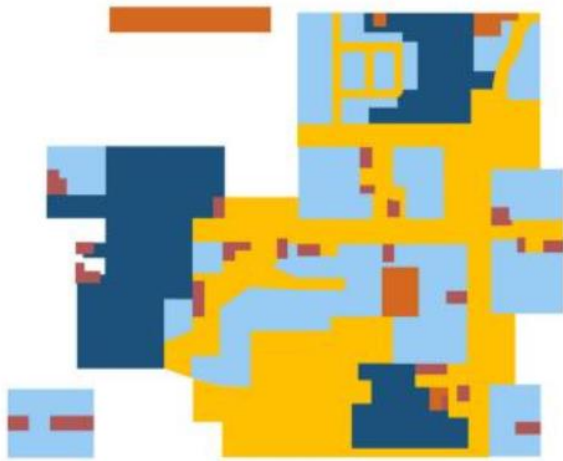
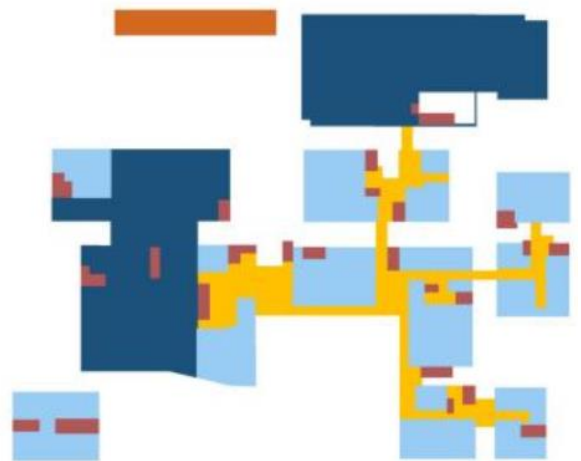


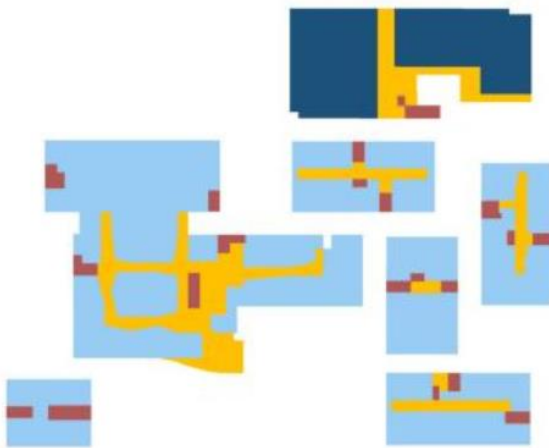
Fig 3.20 Section



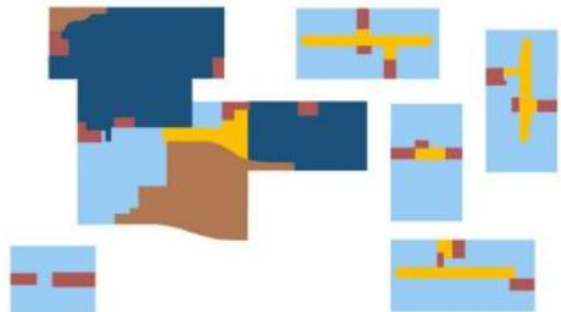
Ground floor plan



First floor plan



Second floor plan



Third floor plan

Fig 3.21 Spatial zoning

The major area (48%) of the Salt Lake City Centre comprises the retail spaces while the other 48% comprises other functions such as offices, food court, entertainment and banquet.

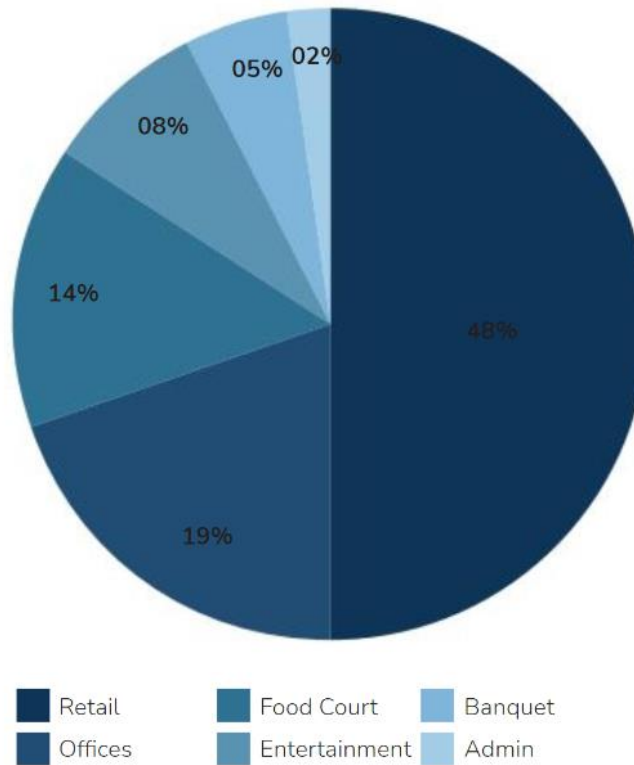


Fig 3.22 Pie chart

3.4.2 Horizontal distribution:

All the clusters are connected through passages, thus connecting all the indoor and outdoor spaces throughout the site.

The ends of these passages are secured with anchor stores- anchor store in the mall within mall, small anchor store at front and a multiplex cinema at the rear end of the site.



Fig 3.23 Horizontal distribution

3.4.3 Vertical distribution:

The front areas are designed to be public space while the rear areas are designed to Anchor stores.

An open Public space is given at the entry which is directly on first floor with a kund in the middle.

Others is given integrated with open cafes and restaurants on the 3rd floor.

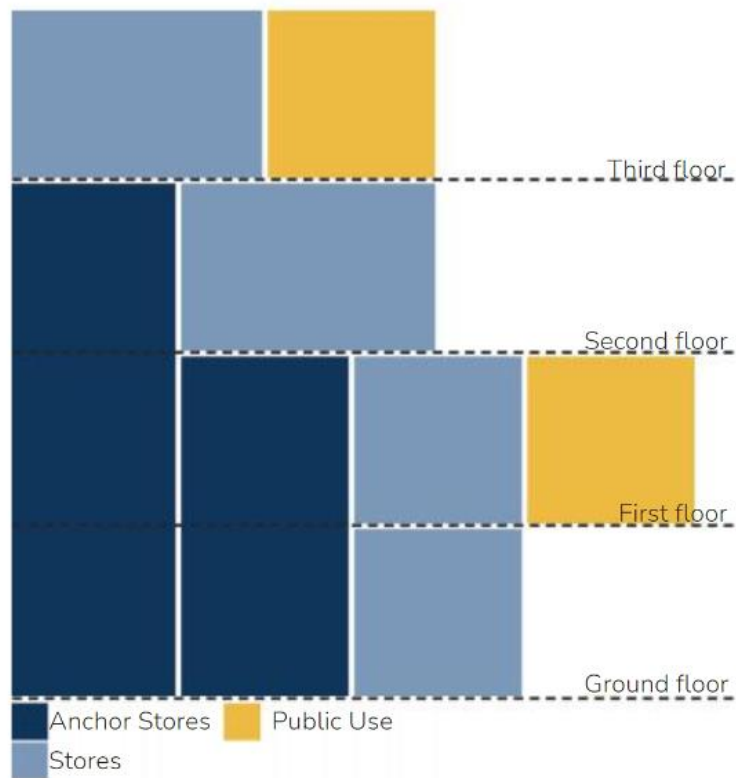


Fig 3.24 Vertical distribution

- Air gets deflected within the Kund region from the tall built forms.
- The kund highly contributes to the wind movement inside the spaces.
- Since it is located in the southeast direction, the surrounding spaces get constant air movement.
- The play with light and Shadow is entertained by people are different times at different sense of place.
- The corridors are covered with pergola with polycarbonate sheets to provide diffused sunlight inside the spaces.

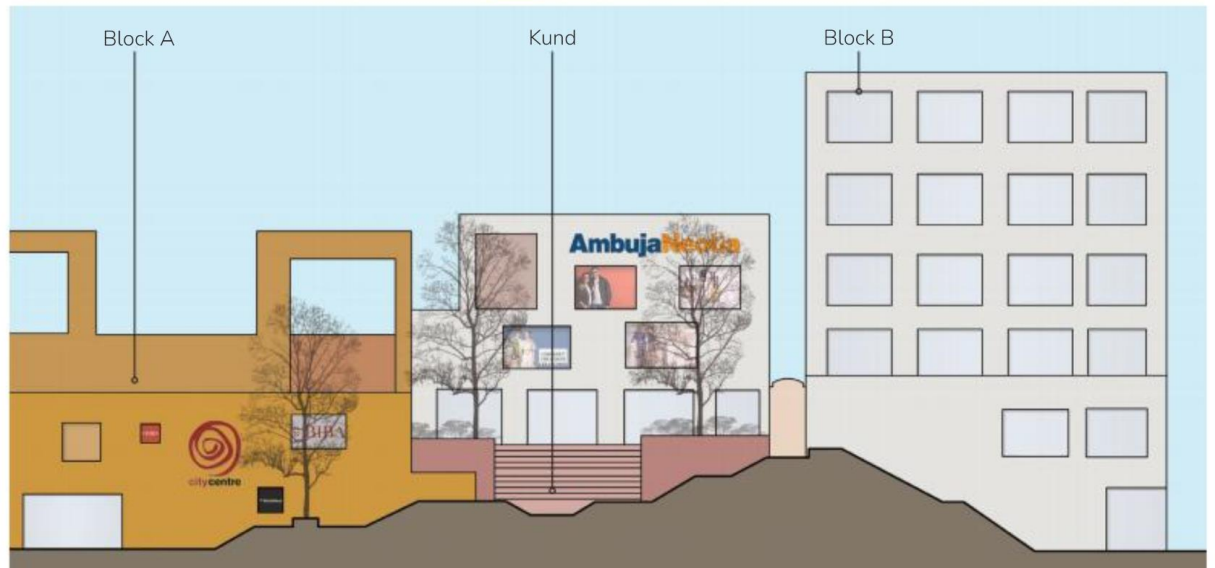


Fig 3.25 Section

3.5 SRP, food court, Chennai.

Architects:	-
Location	Vanagaram, Chennai.
Climate Type	Warm and humid
Site Area	1,028.14 m²
No. of Floors	2
Year	2019
Market Type	Semi-open food court
No. of shops	15 shops including 1 clothing center
No. of Entrance	1

No of containers used	8- 12m container
Materials used	Half truss roof with Corrugated roofing and 3"x3" steel column, 9" concrete column vitrified tile,
Capacity	-
Activity	Movie screenings, food court, kids play area

Tab 3.5 Details

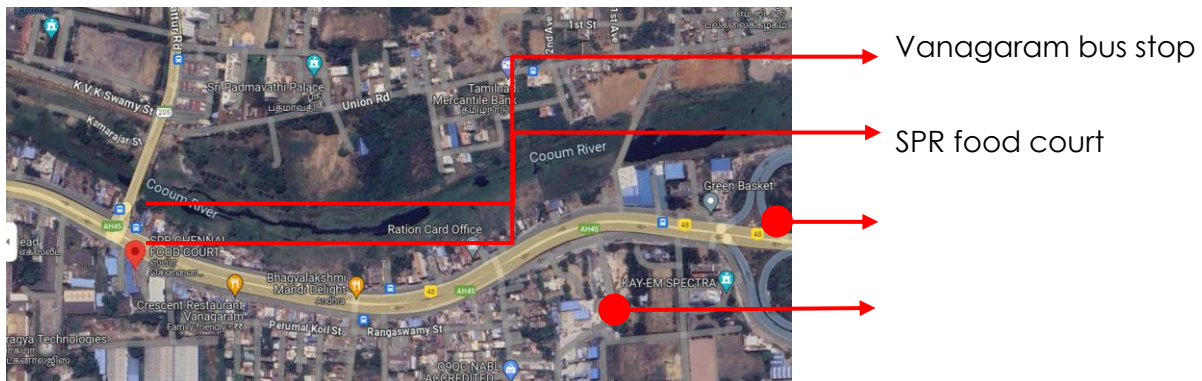
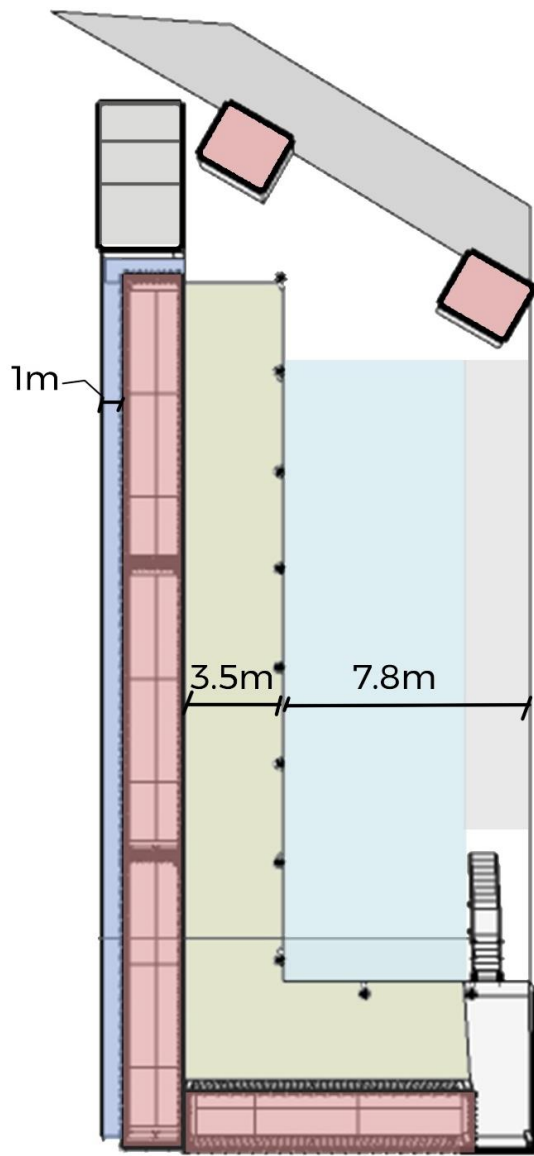
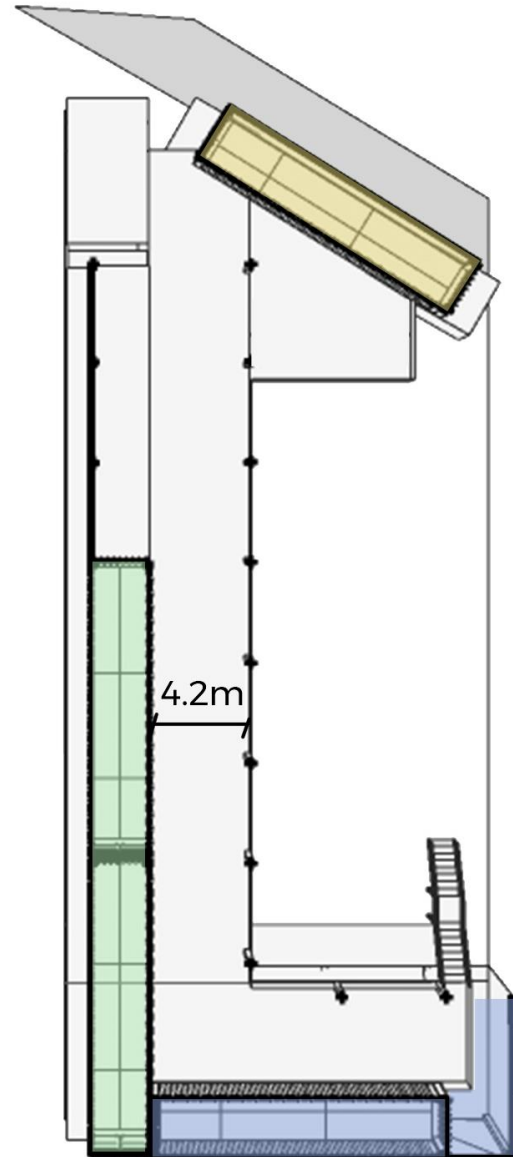


Fig 3.26 Location map

- The food court consists of 15 shops each 28 sq.m area
- 1- 12.m HC container is divided into 2 – 3 shops depending upon the need.
- The walls are unmodified and the roof is covered with half truss roof with corrugated sheet with a gap of 0.5m which allows air circulation above the container roof.



Ground floor plan



First floor plan

Fig 3.27 Floor plan



Fig 3.28 Site photos



Fig 3.29 Section

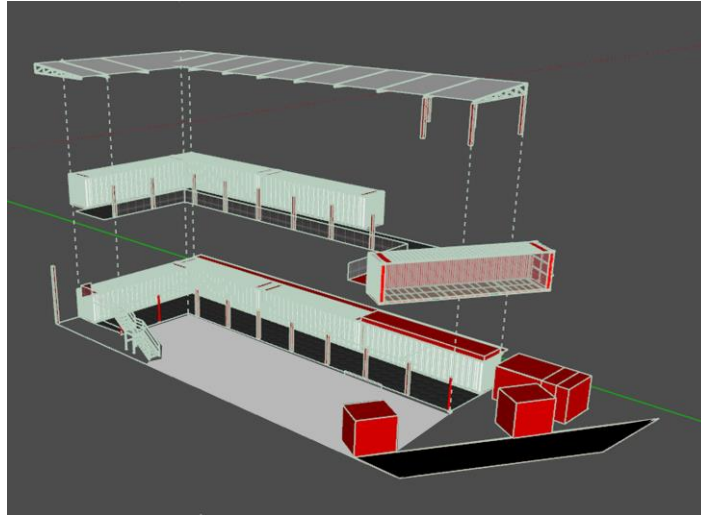


Fig 3.30 Exploded view

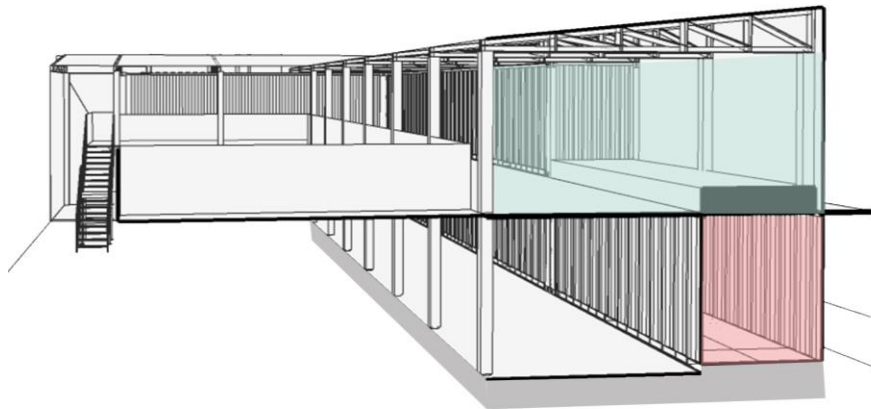
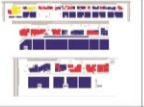
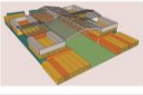
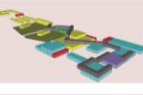
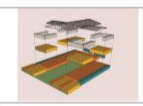
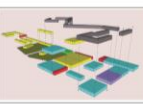
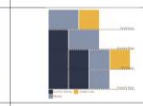
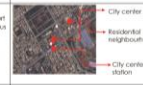
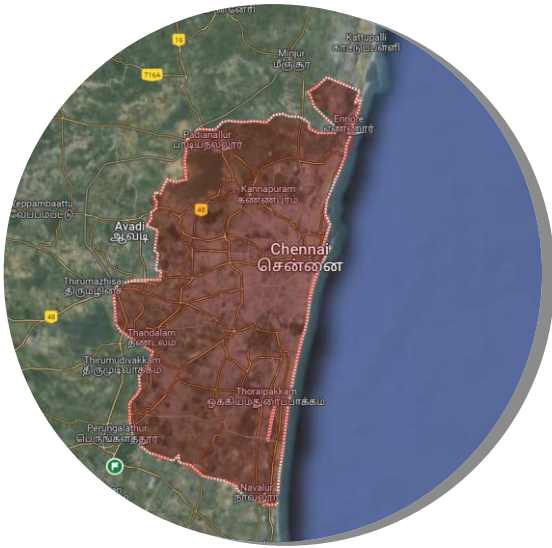


Fig 3.31 Section

Parameters in terms of Design						
	Box Park	Box park	Stack Market	SPR food street	Salt lake city centre	Inference
Location	Craydon, UK.	Al Wasi - Dubai	Toronto, Canada	Chennai	Kolkata	
Climate Type	Temperate	Hot and arid	Cold - Humid	Warm and humid	Warm and humid	
Year of construction	2016	2015	2019	2019	2004	
Planning						All the case studies have provided open spaces equally to the retail spaces which makes the planning more interesting
Builtup area	3907 sq.m	15,000 sq.m	2144 sq.m	1200 sq.m	50,000 sq.m	Ideal built up area for a neighbourhood center can be around 5000- 1000 sq.m
No. of Floor	3	2 - 5	3	2	5	
No. of shops	36	44	30	15 food stall 28 sq.m area , 1 shop	297 shops, 16 kiosk, 4 screens	
Type of container used	12m	6 & 12m	6 & 12m	12m		
No. of containers used	96	220	197	8		
						In all the case studies 12m HC containers has been used, which is ideal for retail spaces and food stalls can be made of 6m HC containers
No. of Entrance	2	3	4	1	12	Multiple entrance should be provided for more easy access
Parking	no on-site parking - off site parking 500	2000-3000	35		800	
Average daily foot			3000- 4000	500 - 1500	18000 - 35000	
Type of activity	Food and beverage, retail store, cultural program, movie, sports matches screening.	Restaurant, retail store, children play area, gym, salon.	Restaurant, retail store, children play area, gym, salon.	Food court, Retail store, movie screening space, gaming zone, party hall	High end retail, street shopping, open spaces, multiplex, food court, restaurants	Variety of spaces should be provided to attract various user group
Design Modifications to the container	Doors and windows cutting and glass doors are added, two - three containers are joined together to form larger spaces.	Doors and windows are cut and welded, shading panels are added and all walls roofs are removed to create pavilions.	Doors and windows cutting and glass doors are added, Two - three containers are joined together to form larger spaces.	Doors and counter cutted and welded, one 12m container in covered into two stalls.		Containers can be cutted and welded to make larger stores, ideally 12m blocks
						
Energy- Efficient Features	central atrium with polycarbonate roofing provides daylight, and SPF Insulation is provided.	shading device provided on all sides,	Permeable pavers, Insulation proved for selected spaces.		Natural daylighting in corridors and wind movement and cross ventilation in non airconditioned spaces	Provision of natural daylight and proper wind movement must be given importance in all the spaces and OSPP insulation has been used prominently
						
Basic arrangement of the blocks	End to end placement of container	shipping containers, Precast concrete, steel	Retrofired shipping containers and tensile roofing	The walls are unmodified and the roof is covered with half truss roof with corrugated sheet with a gap of 0.5m which allows air circulation above the container roof.		The structure can be combined with other efficient material according to the need
						
Materials used	Reused Containers, Polycarbonate roofing.	Vertical staggering with different combination	Vertical staggering with zig-zag pattern with empty containers for aesthetic	Half truss roof with Corrugated roofing and 3"x3" steel column, 9" concrete column vitrified tile,		End to end vertical staggering is ideal for structural strenght and empty containers can be used for aesthetic.
Parameters in terms of Function						
Type of market	Semi open market	Outdoor mall	Semi enclosed market	Semi-open food court	Semi enclosed mall	
Accessibility	Connectivity from railway station within 10m, pedestrian pathway from main road, 3 residential neighbour hood	5 minutes drive from jumeirah metro station and 100m from residential neighbourhood, in center of tourist attractions	200m from residenetial neighbourhood, near expreshighway, connected with other part of the city	100m from Vanagram bus stop , 300m from residential neighbourhood.	special metro station at the entrance, 100m from the residential apartments	
						The site should be ideally located near residential area and should be well connected through public transportation.
Type of amenities	Retail store, outdoor and indoor areas, toilet, changing statin, popup shops.	children's playa area, changing station, toilet, security, info desk, charging points, parking	Parking, toilet, open area, outdoor dining	Parking, toilet, open area, dining area	Retail store, outdoor and indoor areas, toilet, changing statin, popup shops.	Provision of additional facilities like childrens play area, toilets, charging points can be added advantage

3 SITE ANALYSIS



Chennai in Tamil Nadu



Injambakkam in Chennai



Site location in Injambakkam

Fig 4.1 Location

PARAMETERS	SITE – INJAMBAKKAM 12.9198° N; 80.2511°
Site area	36,750.71 m² (9 acres)
Land use	Aquifer recharge area
Landmarks	VGP Universal Kingdom (100 m) The Vijay Park Multiplex (100 m) Sea shells beach (700 m)
Access road	ECR -SH 49 (18.4 m road)
Distance – Nearest bus stop	V.G.P. Golden Beach stop (20m)
Issues	semi-enclosed market hall

Tab 4.1 Location Parameters

4.2 SITE LOCATION - UNDERSTANDING THE CONTEXT

- Located in the southern region of Chennai, Injambakkam is predominantly a residential area with a mix of permanent residents and vacation homes.
- The presence of VGP Universal Kingdom also contributes to the local economy by attracting tourists and providing employment opportunities.
- The East Coast Road provides easy access to Injambakkam from Chennai and other nearby cities.
- The road offers scenic views of the coastline, making it a popular route for weekend getaways and road trips.
- Overall, Injambakkam offers a blend of natural beauty, recreational opportunities.

4.3 SURROUNDING AND INFRASTRUCTURE - CONTEXT AND CONNECTIVITY (1km radius)

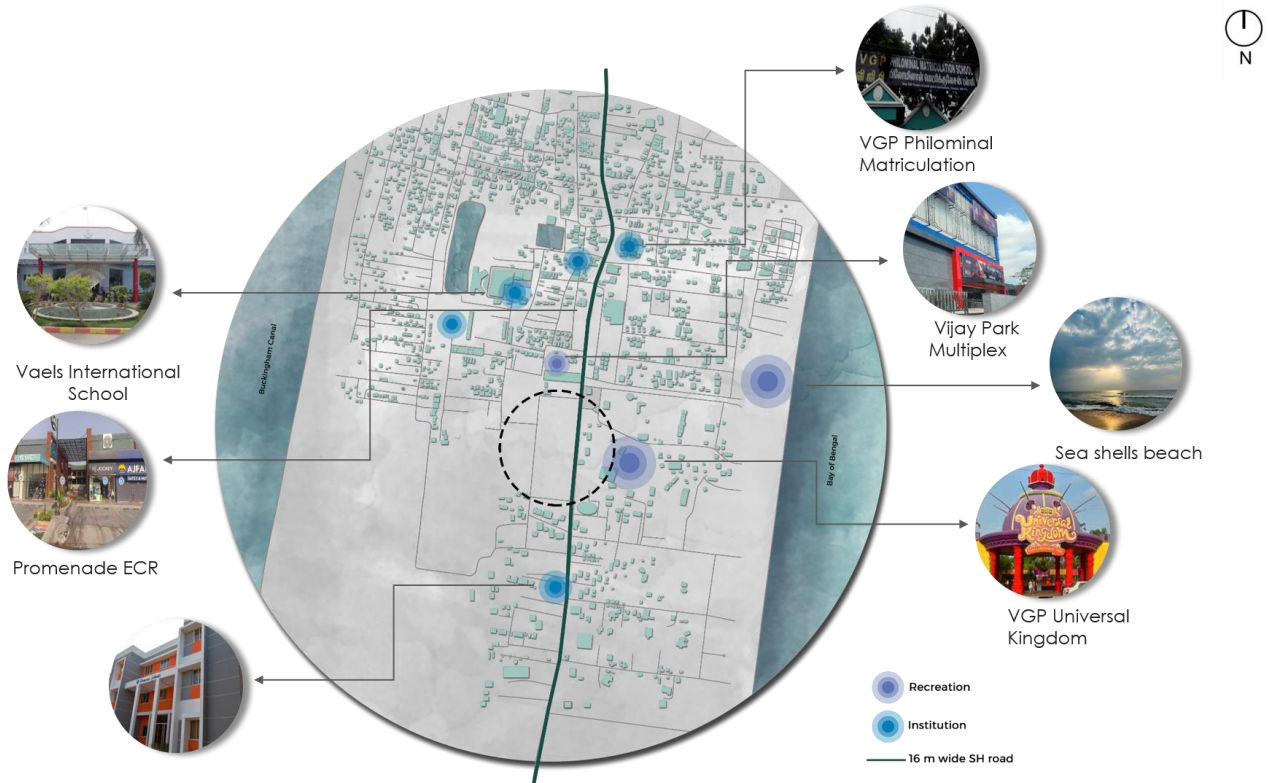


Fig 4.2 1km Map

4.4 LAND-USE & SOIL PATTERN - NEIGHBOURHOOD LEVEL

According to TNCDBR - All commercial and business uses including all shops, stores, markets, shopping centres and uses connected with the display and retail sale of merchandise come under commercial use. In areas designated for Aquifer Recharge Area

recreational activities, daily or weekly markets and other commercial activities shall be regulated with reference to planning parameters of non-high rise buildings, subject to a maximum FSI of 0.80 and maximum plot coverage of 40%.

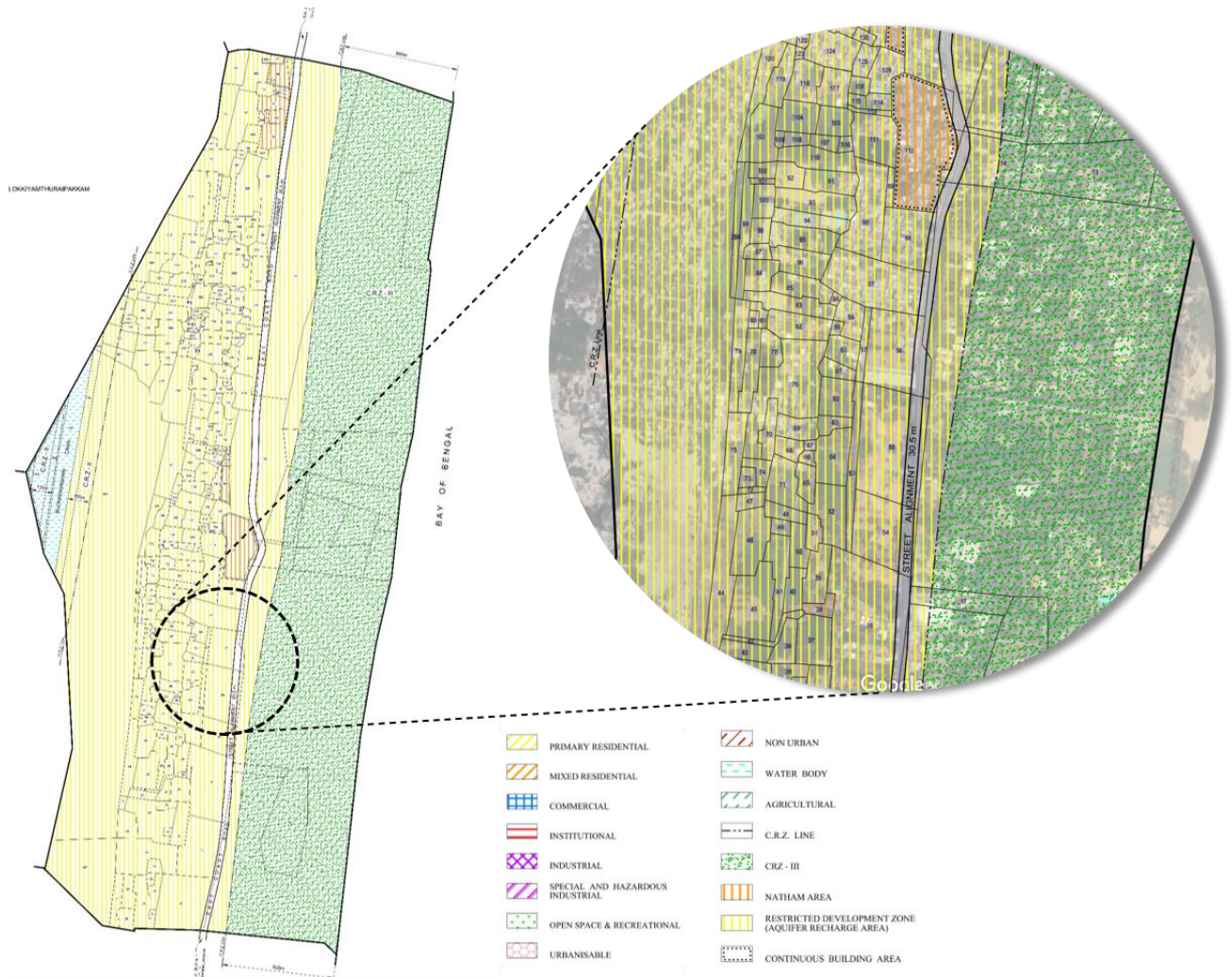


Fig 4.3 Land Use Map

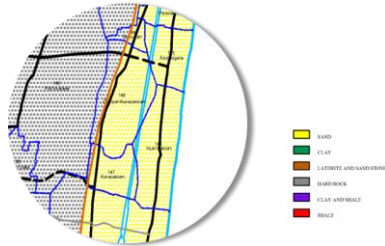


Fig 4.4 Soil Map

4.5 DEVELOPMENT CONTROL RULES - SITE DATA AND BYE-LAWS

Road width	18.4 m
Maximum building height allowed	18.30m
Permissible FSI	0.8
Site area	36,750.71 m²
Plot coverage	40%
Allowable built up area	29400.5 m²
Allowable ground coverage	14700.284
Front set back	4.5 m
Side and Rear set back	3.0m
Distance between buildings	3.0m
Vehicular access	
OSR	3675.07 m² (10%)

Tab 4.2 Guidelines

Source: TNCDBR - Planning Parameters for Non High Rise Buildings. upto 18.30m height and exceeding 16 dwelling units and exceeding 300 square meters of commercial building (pg: 42);

Regulation for developments in the Aquifer Recharge Area (pg :180)

4.6 SITE ANALYSIS – SUN & WIND PATH

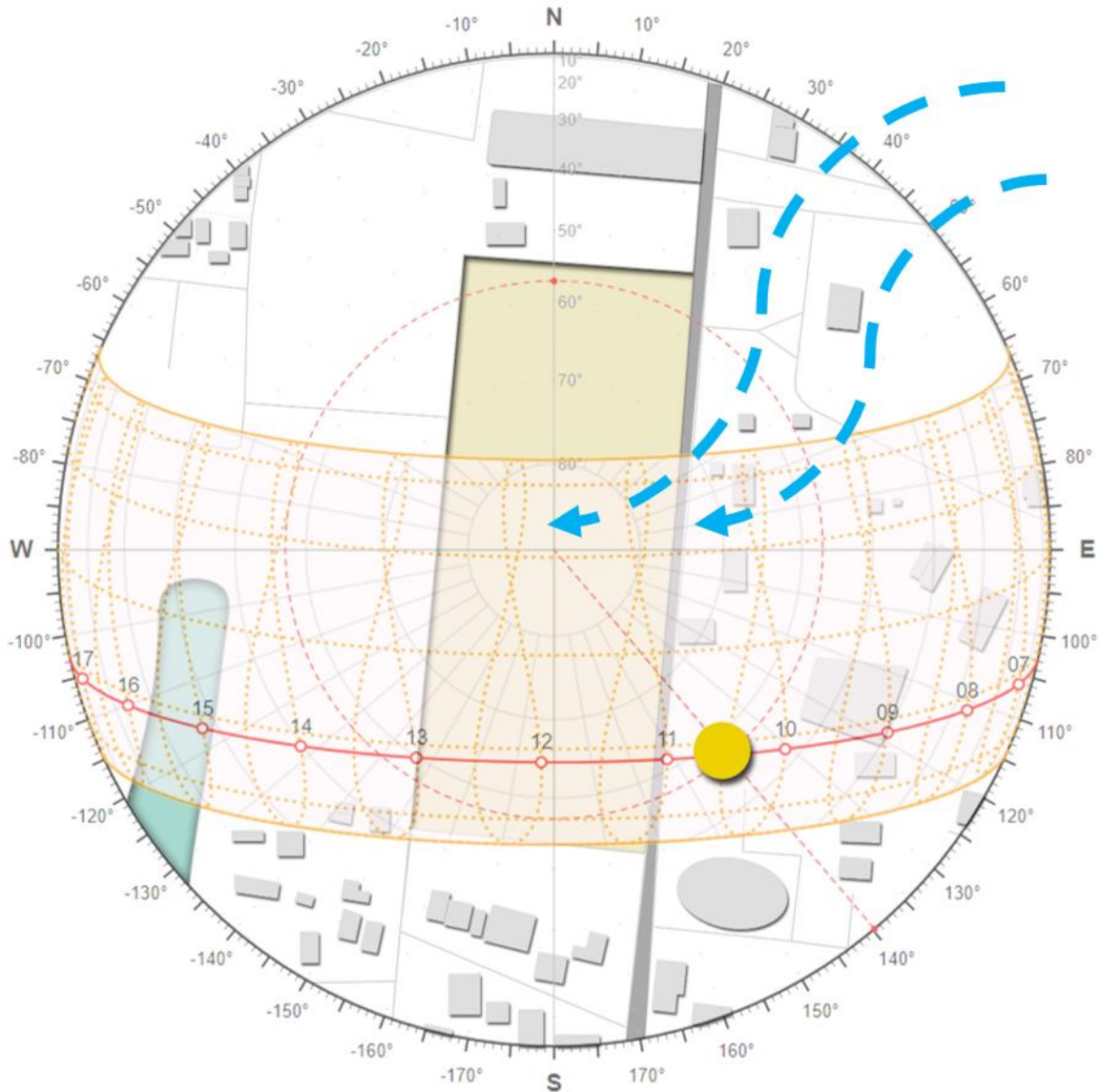
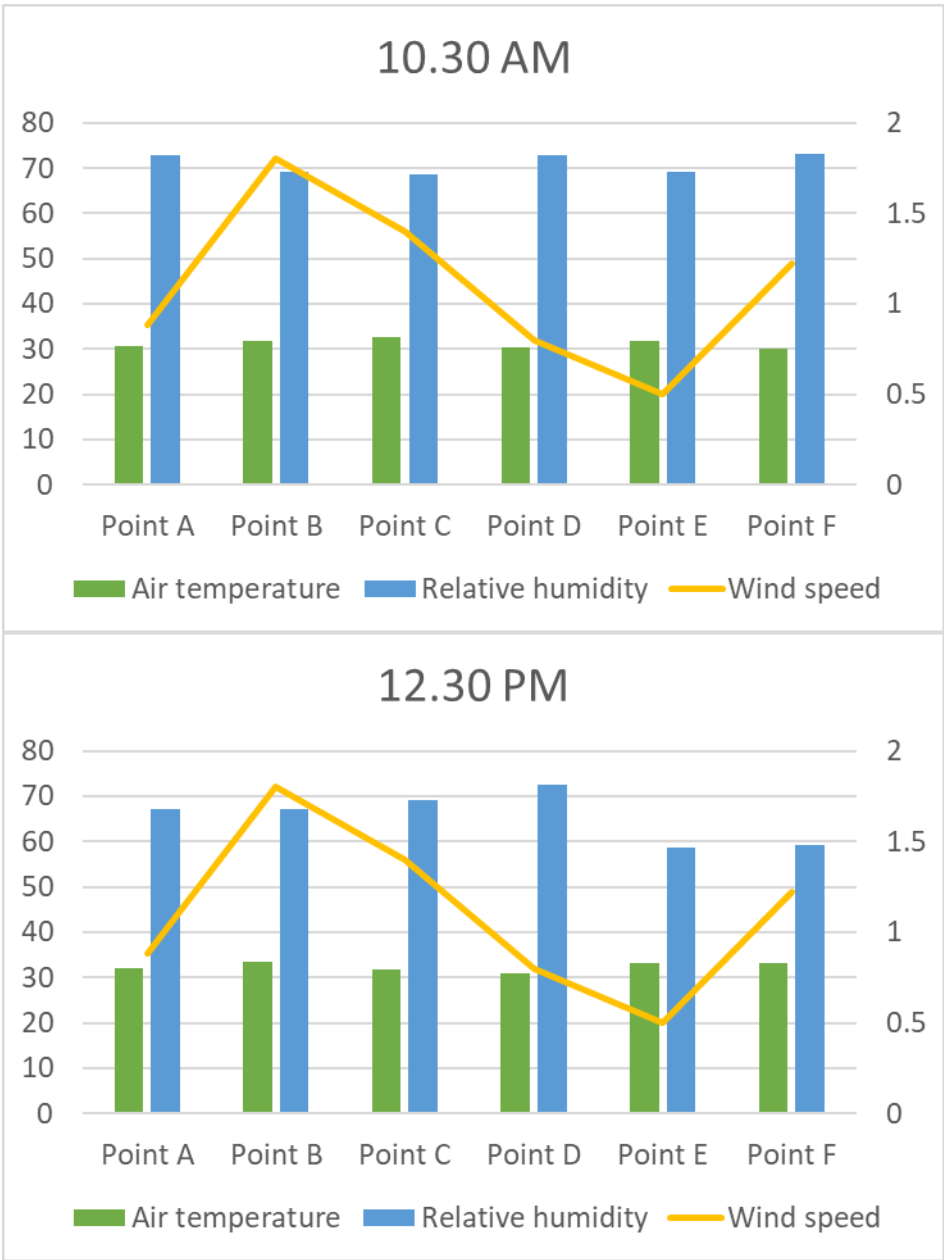


Fig 4.5 Sun Path

4.7 Site Reading (Air Temperature, Wind, Humidity)



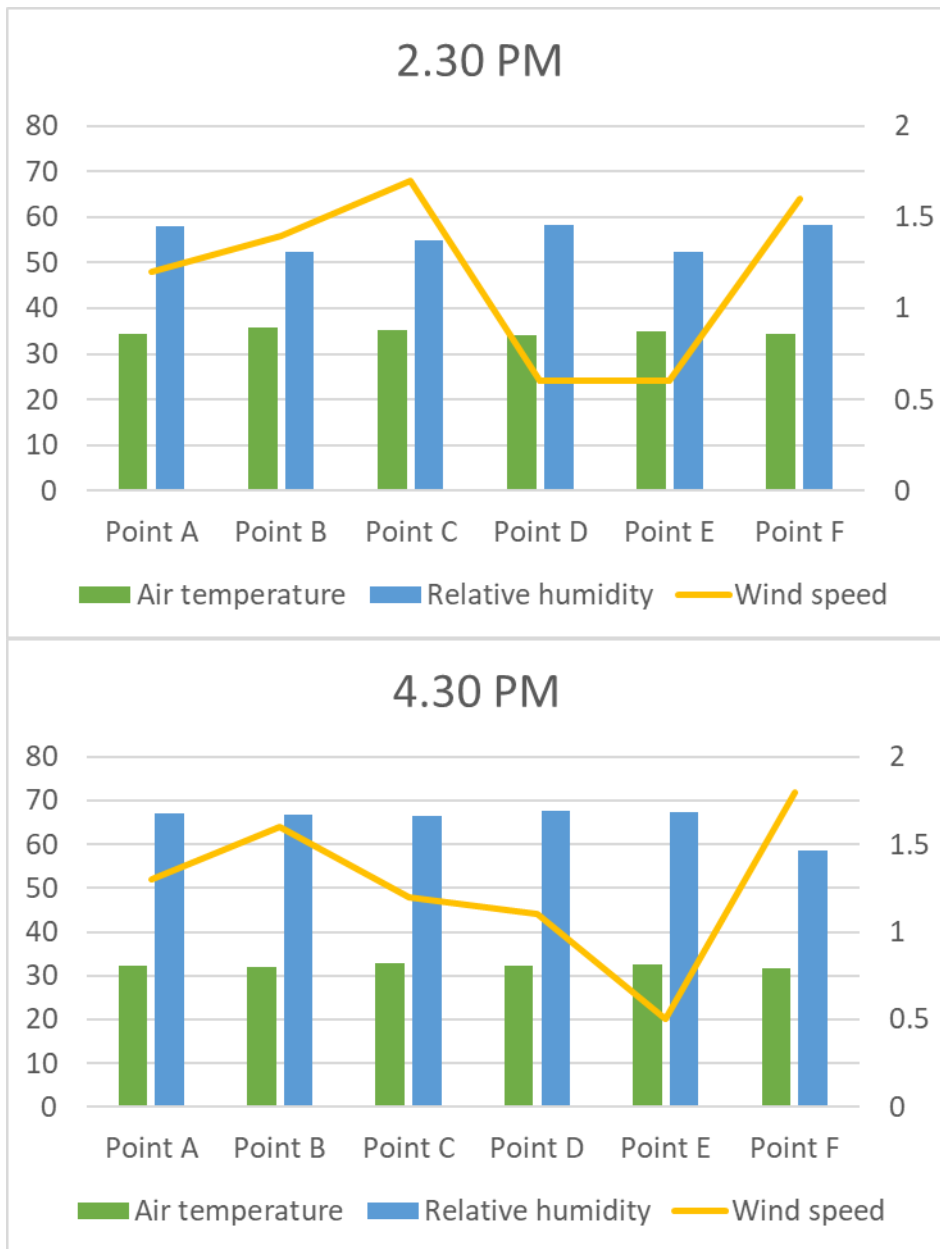
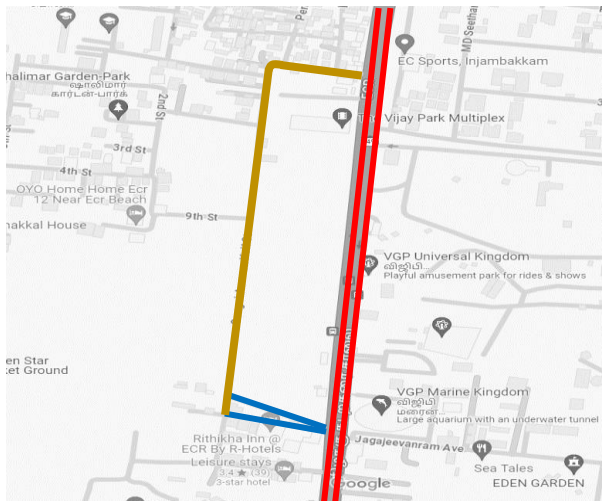


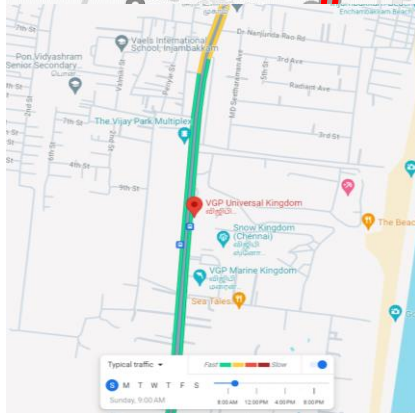
Fig 4.6 Live Reading Graph



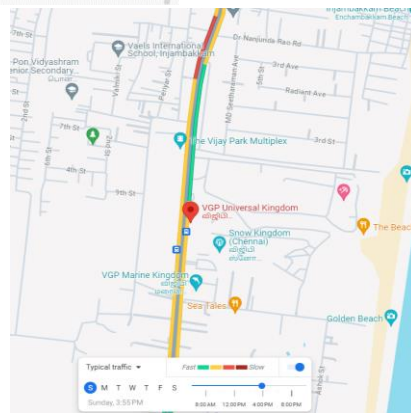
Fig 4.7 Site photos



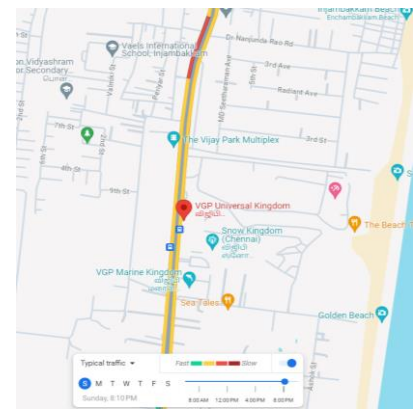
- Primary road (18.4 m)
- Secondary road (6 m)
- Tertiary road (3.5 m)



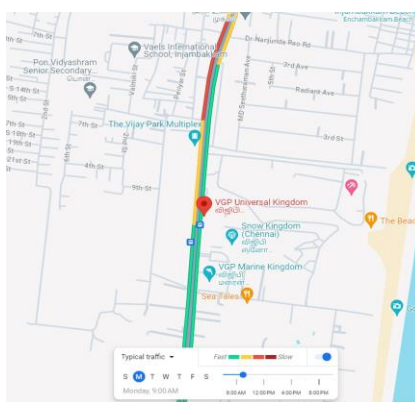
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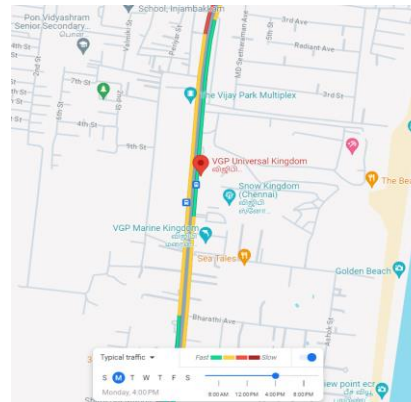
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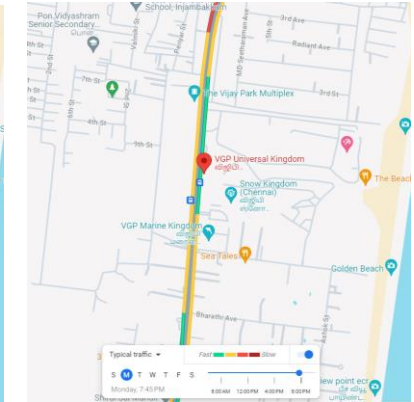
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Weekday 10.00AM



4.00 PM



8.00 PM

Fig 4.8 Traffic Analysis

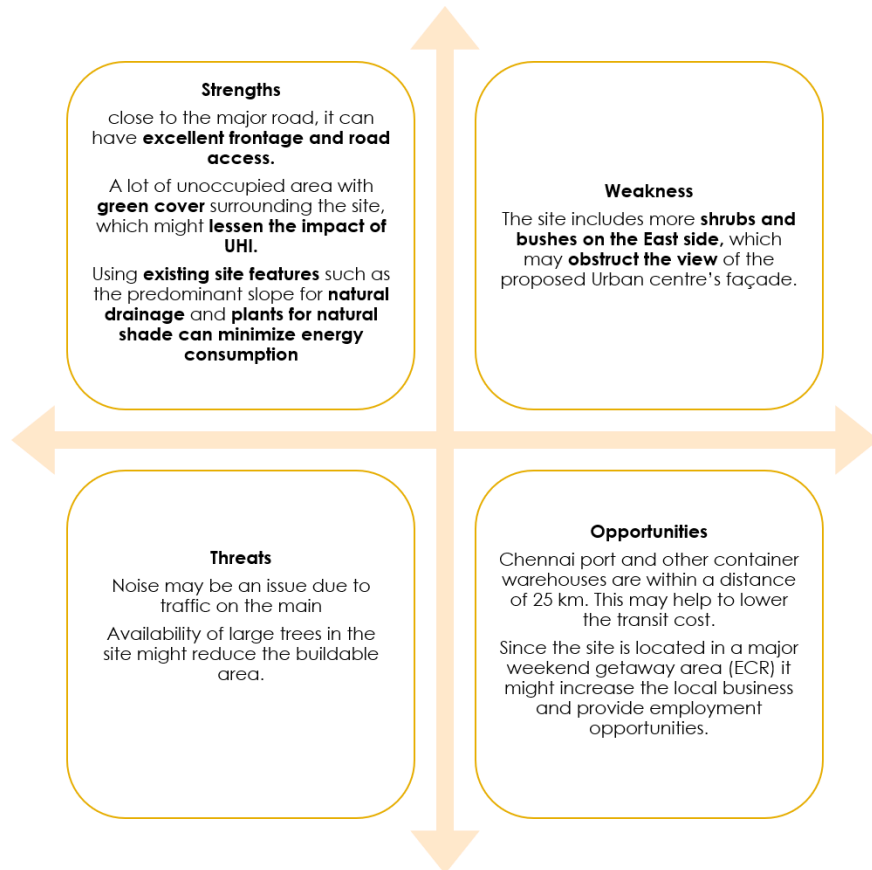


Fig 4.9 Swot Analysis

Neighbourhood planning unit (large scale settlement)	Local shopping centre
Population	15,000
Minimum Land area requirement	4,600 sq.m
Area per 1000 persons	300 sq.m
Number of shops	75 nos (1 shop / 200 person)

Tab 4.3 Standards

<i>Occupancy</i>	<i>Area required</i>
<i>General design purposes</i>	<i>0.8 sq.m</i>
<i>People moving at good walking space</i>	<i>3.7 sq.m</i>
<i>People moving at a shuffle</i>	<i>0.27 – 0.37 sq.m</i>
<i>People standstill</i>	<i>0.2 sq.m</i>

Tab 4.4 Standards

<i>Space</i>	<i>Area required</i>
<i>Shops</i>	<i>30-60 sq.m</i>
<i>Urinals</i>	<i>1/ 100 persons</i>
<i>Retail shops</i>	<i>4.6 to 7 sq.m/person</i>
<i>Restaurants</i>	<i>0.9 to 1.1 sq.m /person</i>
<i>Department stores</i>	<i>0.9 sq.m/person</i>
<i>Kiosk/ small retail</i>	<i>0.46 sq.m/person</i>
<i>Offices</i>	<i>9.3 sq.m/person</i>

Tab 4.5 Standards

Area statement			Acessibility		
Spaces	No.of units	Total area range (sq.m)			
Retail					
Anchor stores	2	2000-3000	Vehicular Entry/ Exit		
Billing counter			Pedestrain Entry/ Exit		
Trail rooms			Bicycle Track		
Baggage counter			Car Parking	1- 50 sq.m	
Storage area			Two wheeler Parking	1- 50 sq.m	
Shopping Area			Connectivity from the Nearest Public Transportaion		
Unloading area					
Displya Area					
Escalators/ staircase					
		2400	Foot Bridge / Pedestrain walkway		
Retail outlets	30-50	50- 150			
Billing counter			Services		
Trail Rooms			Mechanical/ Electrical room	1	
Storage Area			Storage Area		
Displya Area			CCTV room	1	
Shopping Area			Fire sevicees	1	
Unloading area			HVAC	1	
Displya Area			Water supply		
Escalators/ staircase			STP	1	
		3000	Total builtup area		9839
Kiosks	15	10- 29sq.m			
		300			

Tab 4.6 Area Programme

4 Zoinning

5.1 Iteration 1

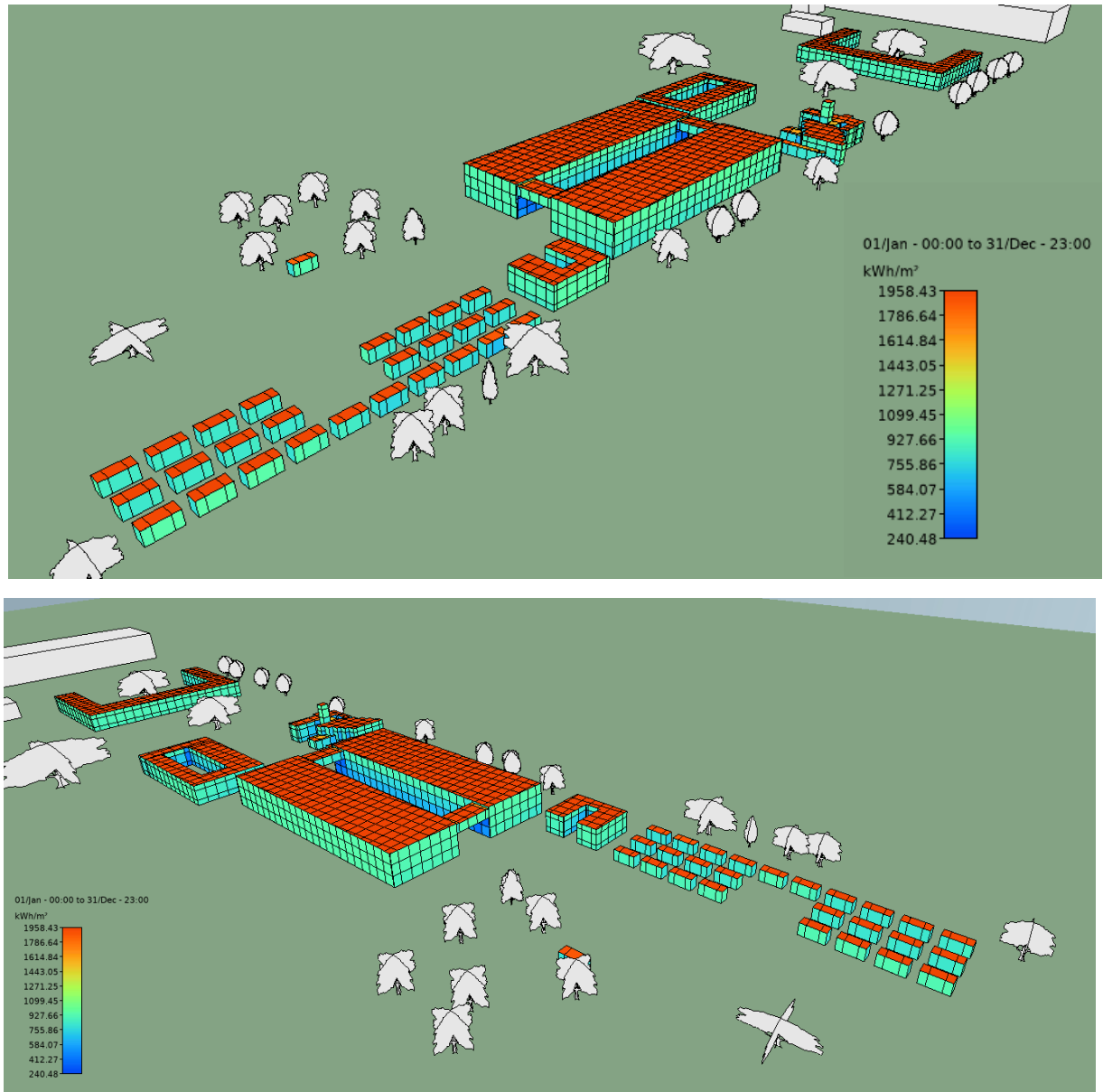


Fig 5.1 Solar Radiation -1

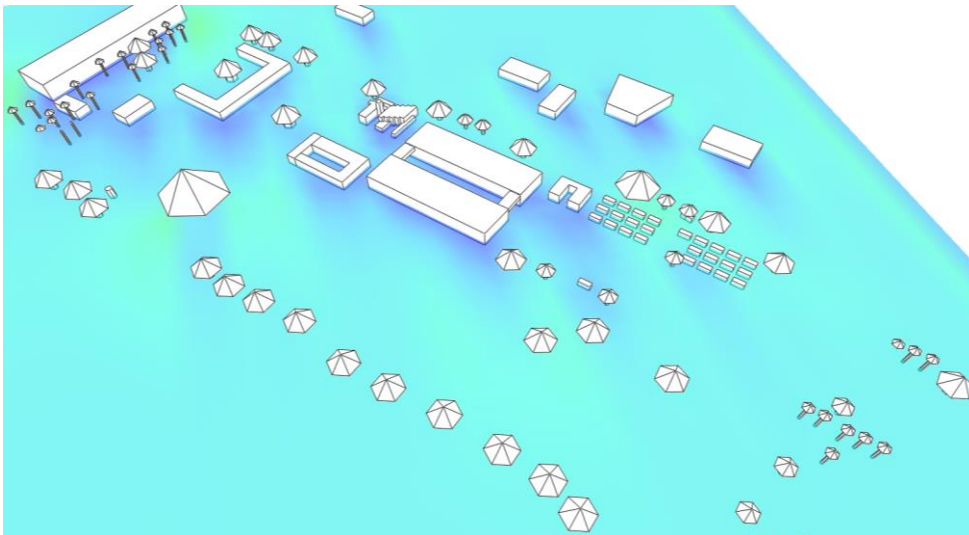
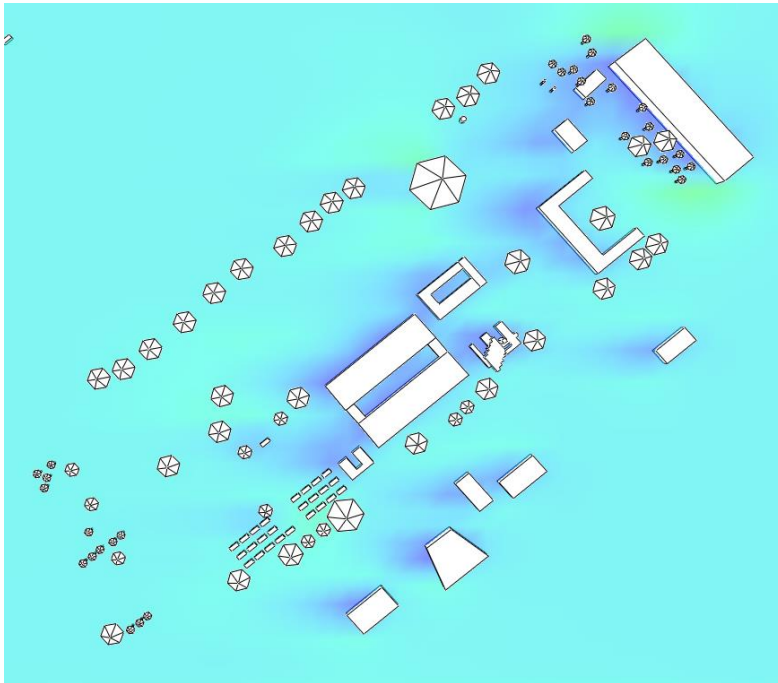


Fig 5.2 CFD -

5.2 Iteration 2

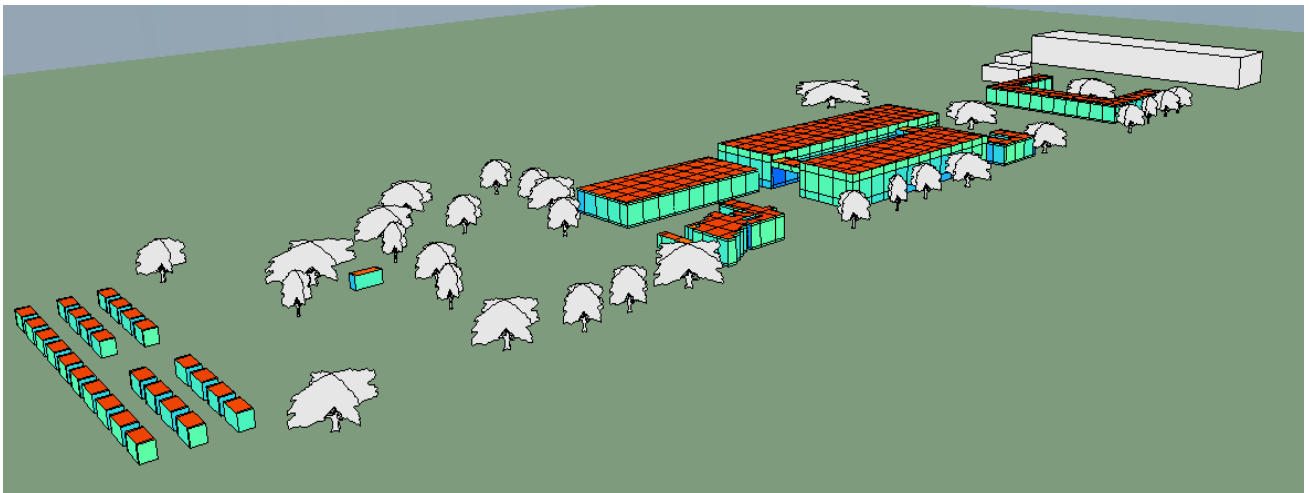
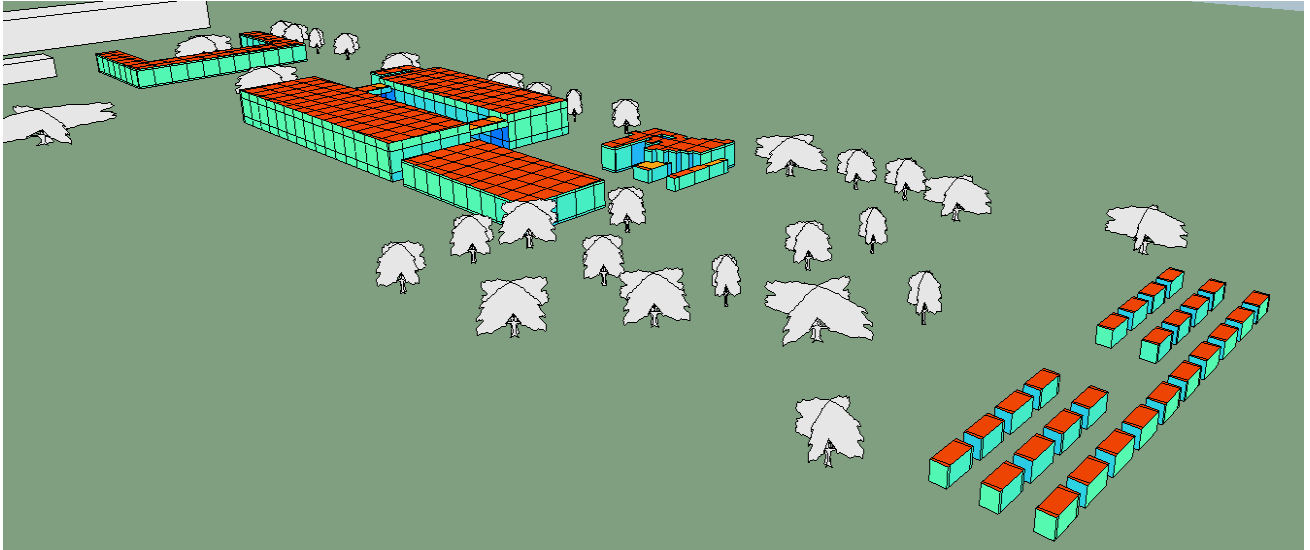


Fig 5.3 Solar Radiation -2

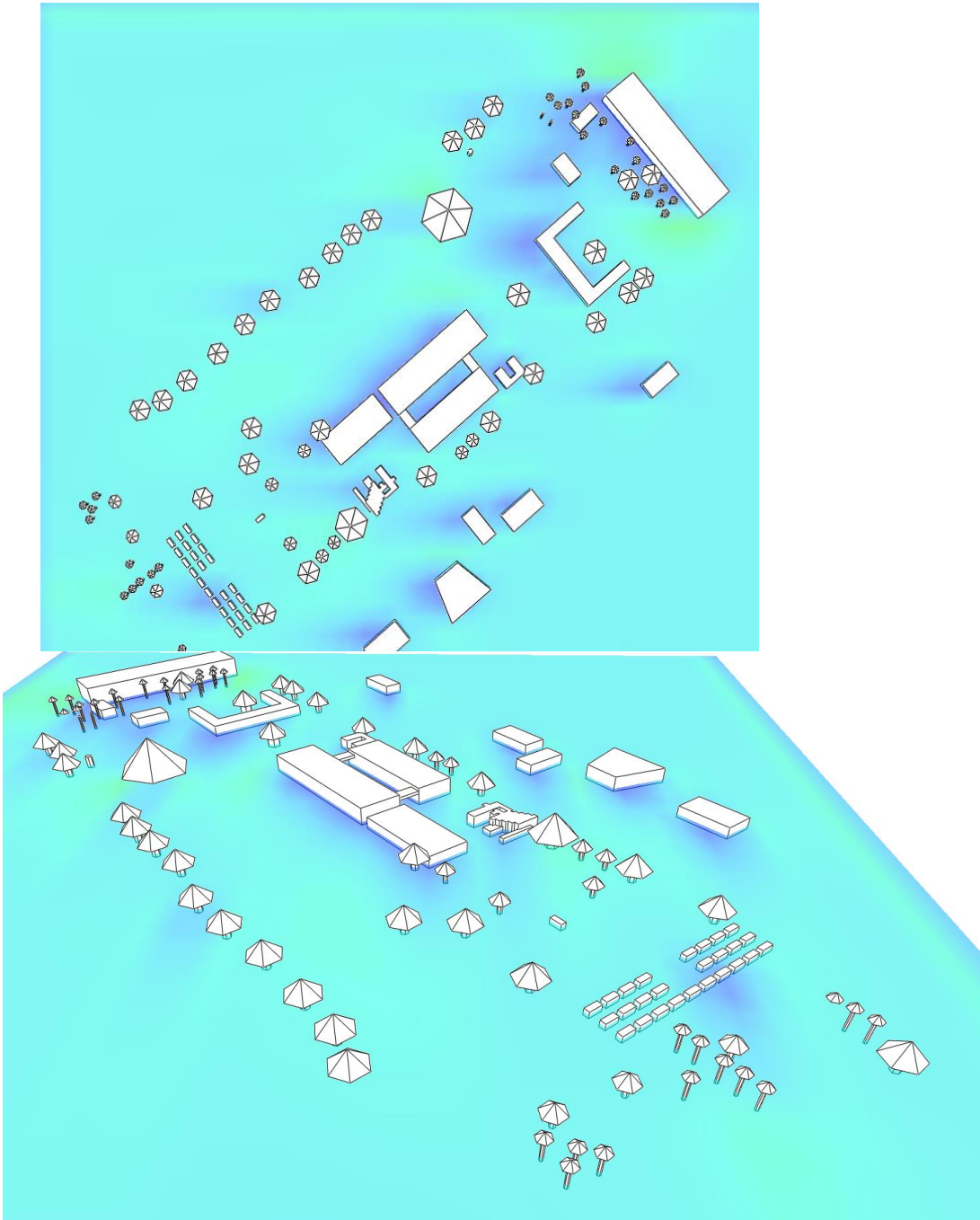


Fig 5.4 CFD -2

5.3 Iteration 3

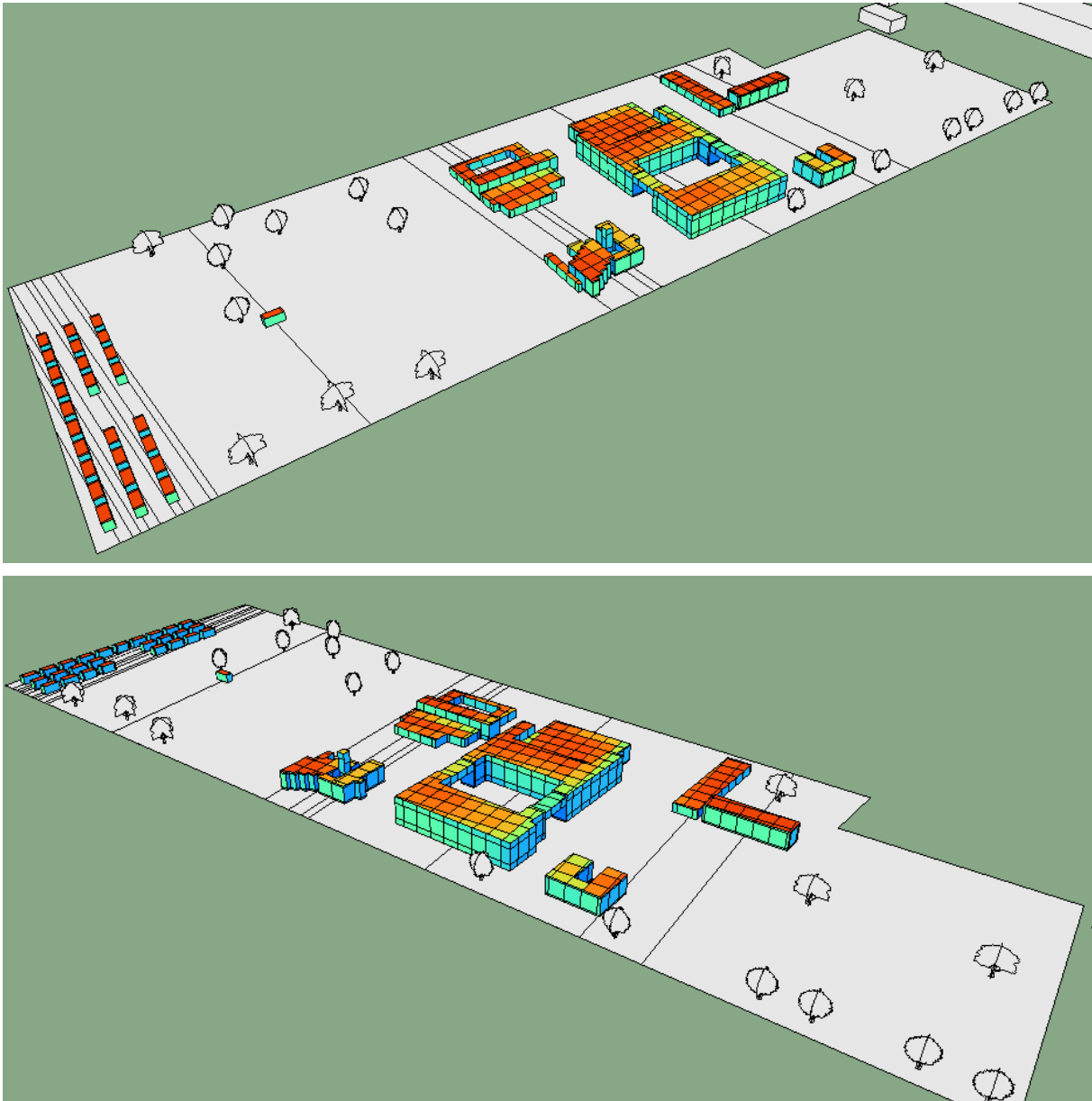


Fig 5.5 Solar Radiation -3

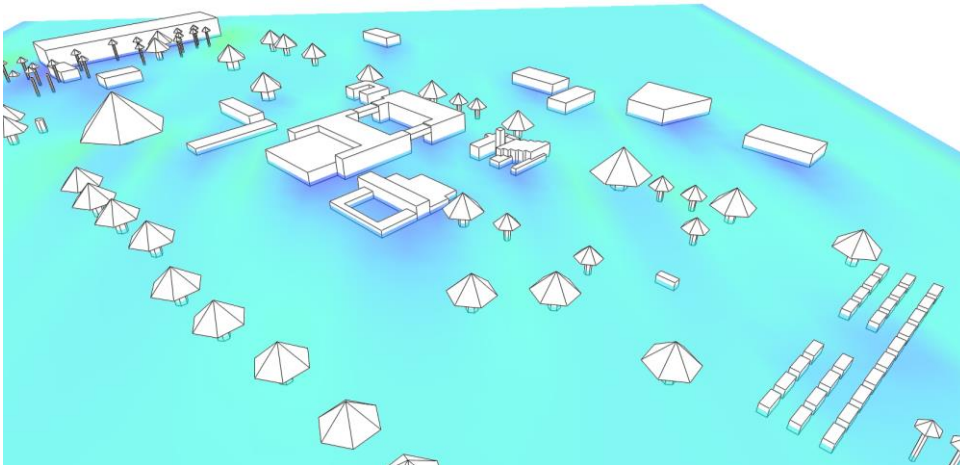
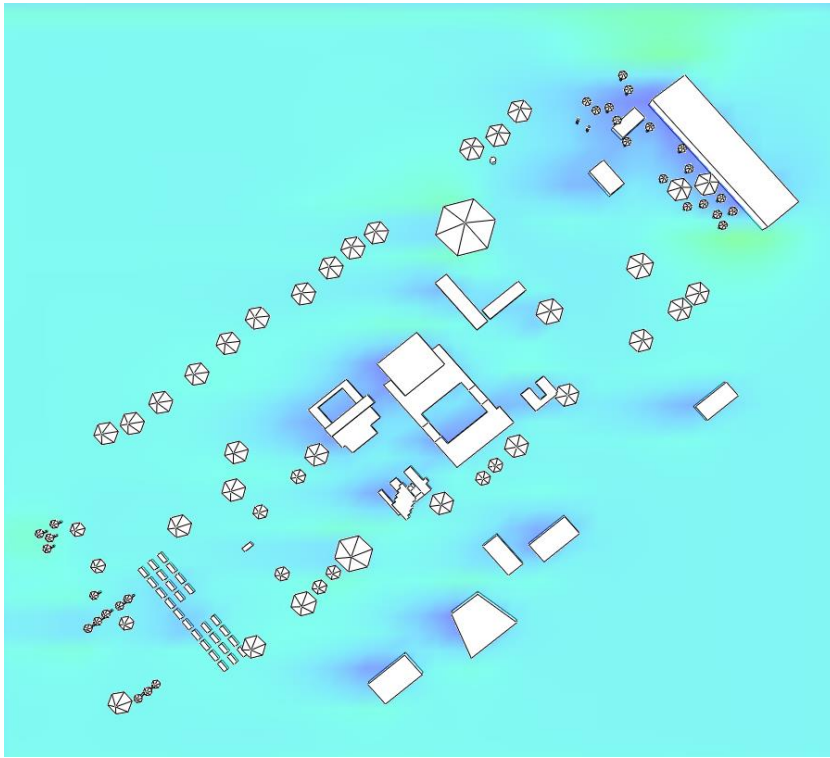


Fig 5.6 CFD

5.4 Iteration 4

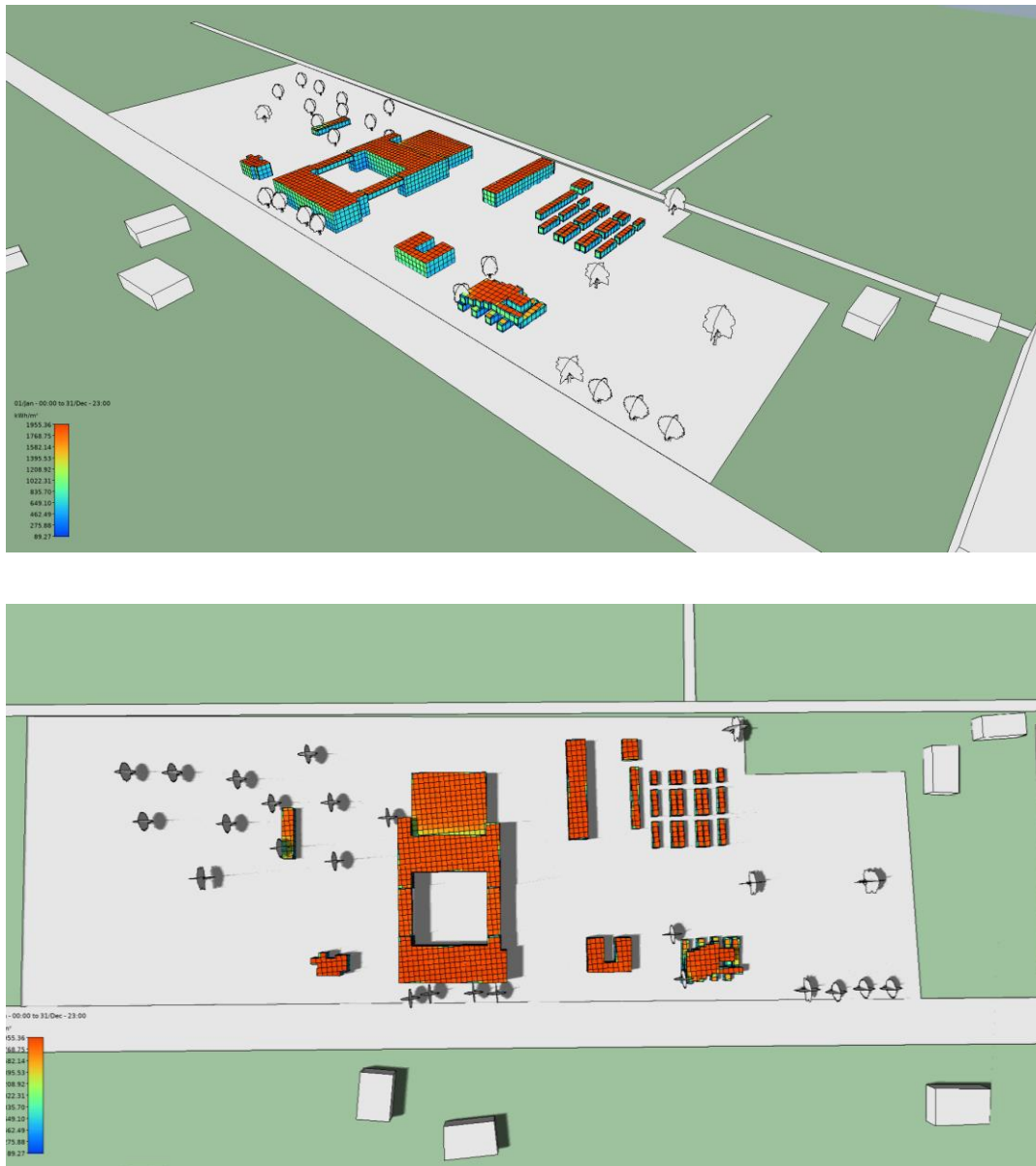


Fig 5.7 Solar Radiation -4

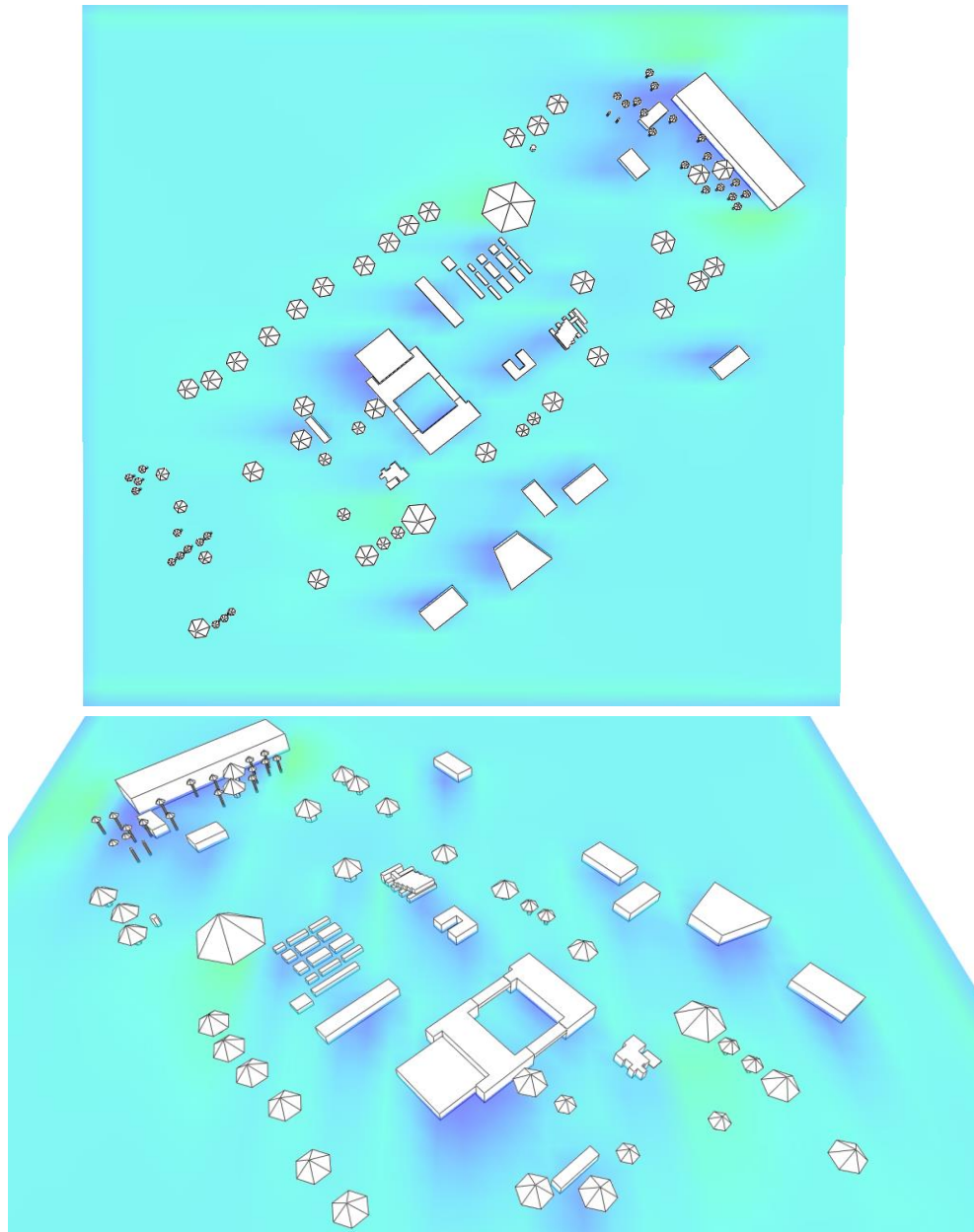
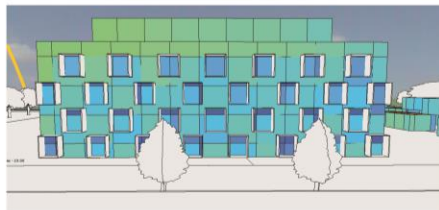
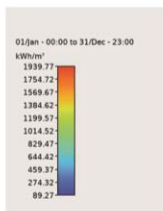
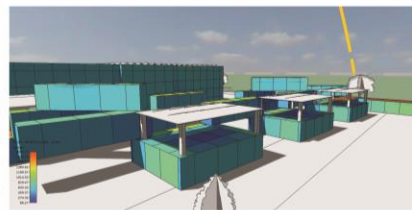


Fig 5.8 CFD -4

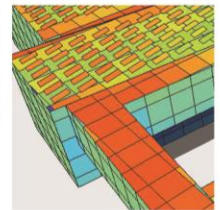
Zoning	Radiation Analysis	CFD (External wind Movement)	Area of Exposure	Inference												
Iteration 1			<table><tr><th>Orientation</th><th>Above-grade wall area (m²)</th></tr><tr><td>North</td><td>1554.1</td></tr><tr><td>East</td><td>2763.5</td></tr><tr><td>South</td><td>1556.8</td></tr><tr><td>West</td><td>2752.0</td></tr><tr><td>Horizontal</td><td>5200.4</td></tr></table>	Orientation	Above-grade wall area (m²)	North	1554.1	East	2763.5	South	1556.8	West	2752.0	Horizontal	5200.4	The amount of area exposed to the east and west is comparatively higher (2700 sq.m) than the north and south orientation. The flow in the courtyard spaces and Leeward area has a low velocity and negative pressure is created.
Orientation	Above-grade wall area (m²)															
North	1554.1															
East	2763.5															
South	1556.8															
West	2752.0															
Horizontal	5200.4															
Iteration 2			<table><tr><th>Orientation</th><th>Above-grade wall area (m²)</th></tr><tr><td>North</td><td>1731.7</td></tr><tr><td>East</td><td>2355.6</td></tr><tr><td>South</td><td>1734.2</td></tr><tr><td>West</td><td>2355.9</td></tr><tr><td>Horizontal</td><td>5702.5</td></tr></table>	Orientation	Above-grade wall area (m²)	North	1731.7	East	2355.6	South	1734.2	West	2355.9	Horizontal	5702.5	The amount of area exposed to the east and west has been reduced. And the wind movement is increased in the leeward spaces.
Orientation	Above-grade wall area (m²)															
North	1731.7															
East	2355.6															
South	1734.2															
West	2355.9															
Horizontal	5702.5															
Iteration 3			<table><tr><th>Orientation</th><th>Above-grade wall area (m²)</th></tr><tr><td>North</td><td>1954.6</td></tr><tr><td>East</td><td>1613.9</td></tr><tr><td>South</td><td>1956.3</td></tr><tr><td>West</td><td>1618.0</td></tr><tr><td>Horizontal</td><td>4344.8</td></tr></table>	Orientation	Above-grade wall area (m²)	North	1954.6	East	1613.9	South	1956.3	West	1618.0	Horizontal	4344.8	The area exposed to the east and west has been reduced to 1600 sq.m and the north-south 1900 sq.m the increased length of the courtyard spaces is increased (12m) the wind movement in the leeward spaces.
Orientation	Above-grade wall area (m²)															
North	1954.6															
East	1613.9															
South	1956.3															
West	1618.0															
Horizontal	4344.8															
Iteration 4			<table><tr><th>Orientation</th><th>Above-grade wall area (m²)</th></tr><tr><td>North</td><td>1882.0</td></tr><tr><td>East</td><td>2026.2</td></tr><tr><td>South</td><td>1884.3</td></tr><tr><td>West</td><td>2026.0</td></tr><tr><td>Horizontal</td><td>3943.5</td></tr></table>	Orientation	Above-grade wall area (m²)	North	1882.0	East	2026.2	South	1884.3	West	2026.0	Horizontal	3943.5	The area exposed to the east and west has been reduced to 1600 sq.m and the north-south 1900 sq.m the increased length of the courtyard spaces is increased (12m) the wind movement in the leeward spaces.
Orientation	Above-grade wall area (m²)															
North	1882.0															
East	2026.2															
South	1884.3															
West	2026.0															
Horizontal	3943.5															
Iteration 5			<table><tr><th>Orientation</th><th>Above-grade wall area (m²)</th></tr><tr><td>North</td><td>2084.9</td></tr><tr><td>East</td><td>1393.6</td></tr><tr><td>South</td><td>2083.9</td></tr><tr><td>West</td><td>1393.8</td></tr><tr><td>Horizontal</td><td>3645.1</td></tr></table>	Orientation	Above-grade wall area (m²)	North	2084.9	East	1393.6	South	2083.9	West	1393.8	Horizontal	3645.1	The area exposed to the east and west has been reduced to 1300 sq.m and the north-south 2000 sq.m and the carparking is moved to the leeward side.
Orientation	Above-grade wall area (m²)															
North	2084.9															
East	1393.6															
South	2083.9															
West	1393.8															
Horizontal	3645.1															
Iteration 6				To increase the wind movement in the food court area single module is rotated 45 degrees (along the wind direction), rather it increases the negative pressure in the dining area.												
Iteration 7				There is no improvement in the wind movement in rotating all the modules to 20 degrees.												



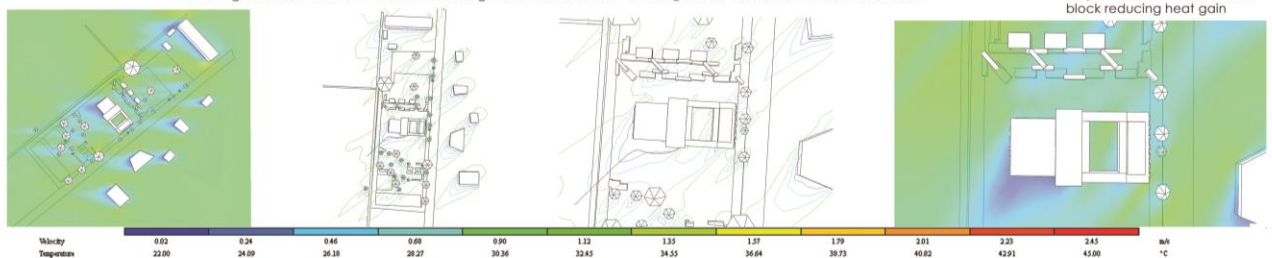
Shading Device on East and west facade using the container doors



Shading Device for the roof in food court area



PV panels on the roof of retail block reducing heat gain



5.5 Conceptual Design

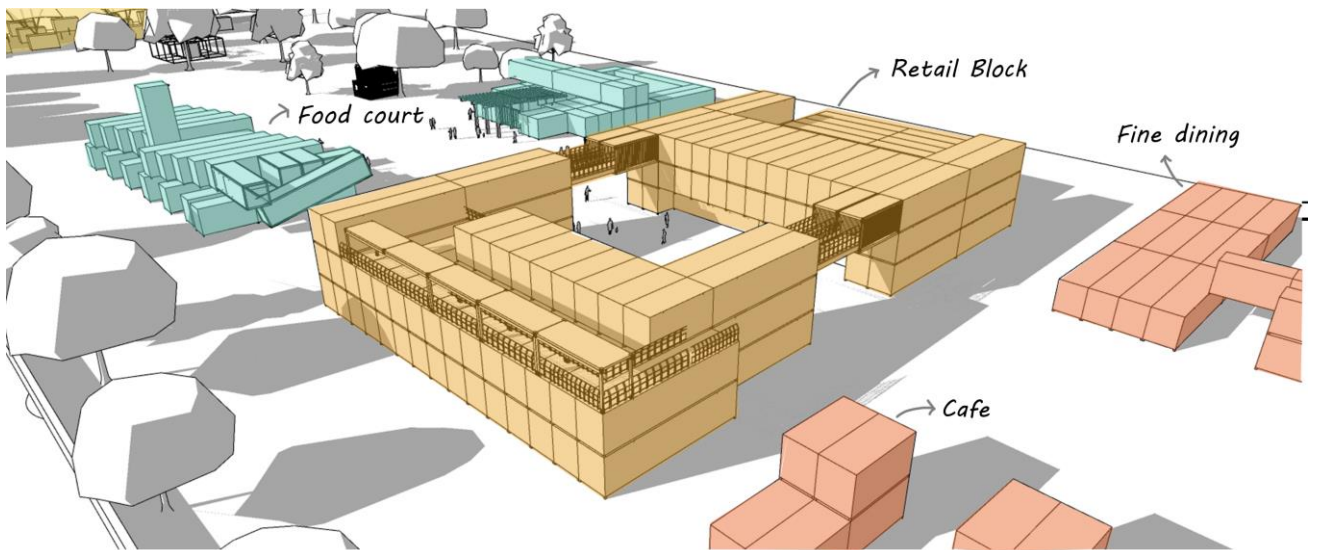


Fig 5.9 Retail block

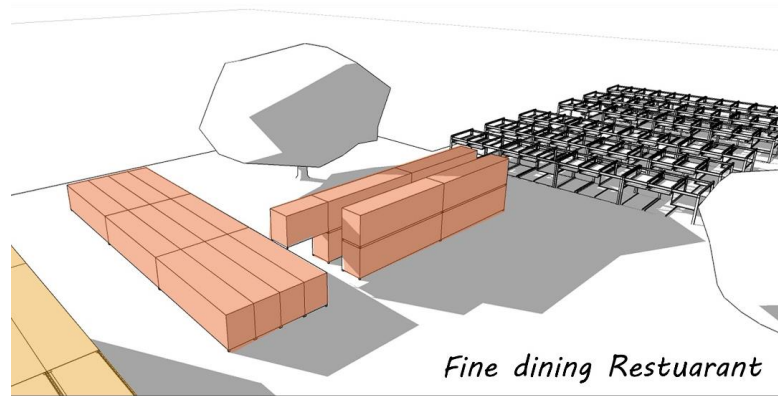


Fig 5.10 Fine Dinning

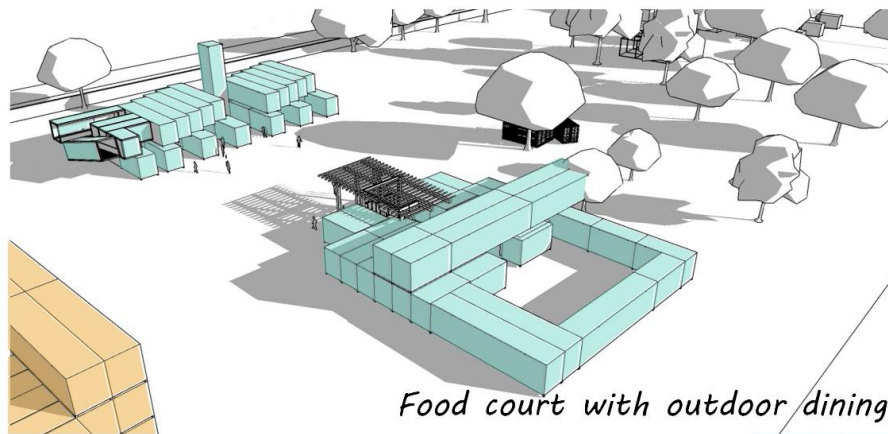


Fig 5.10 Fine Dinning

5.6 Thermal comfort

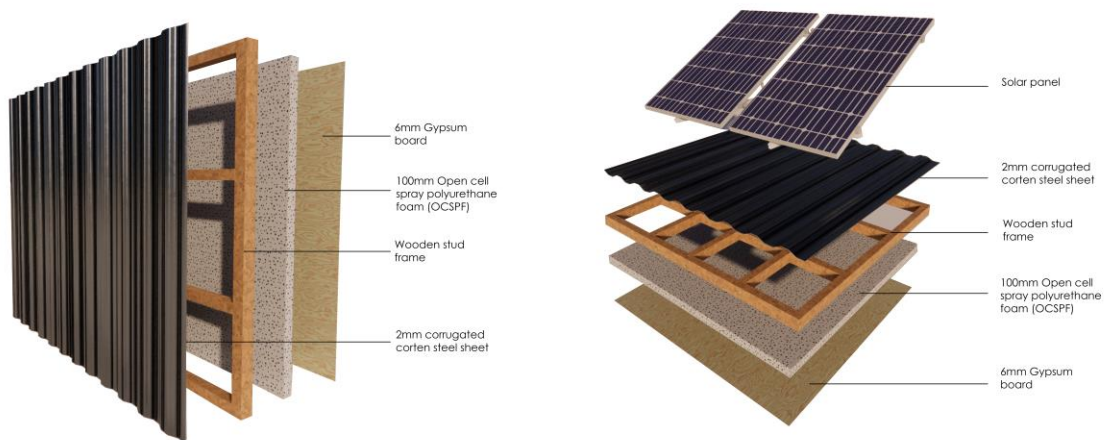
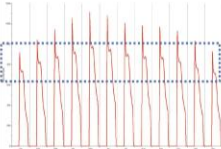
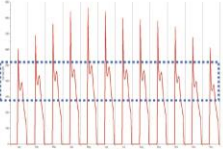
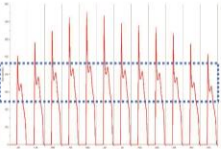
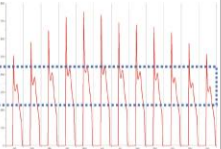
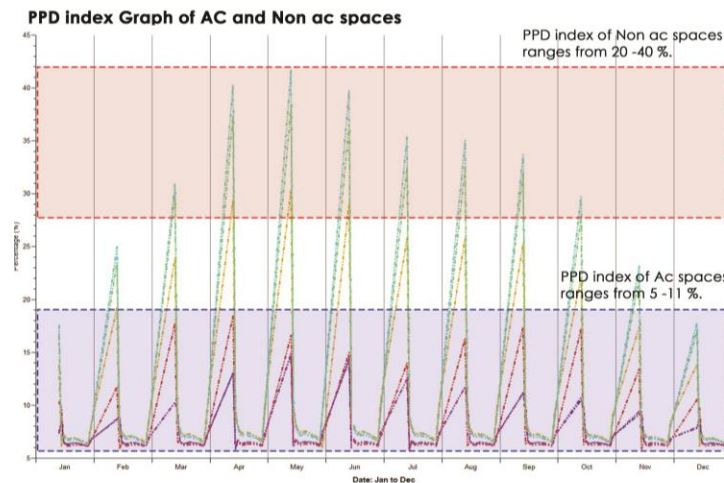


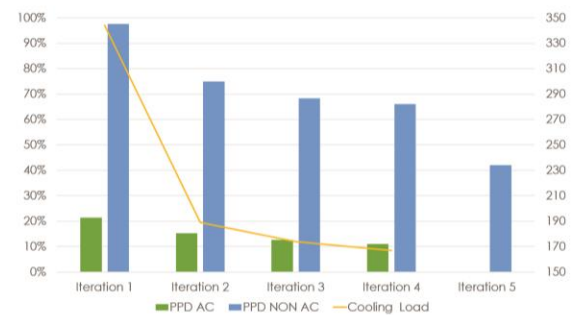
Fig 5.11 Material Configuration

Model description	Iteration -1	Iteration -2	Iteration -3	Iteration -4	Iteration -5 (Non AC)
Wall	2mm corrugated corten steel sheet	2mm corrugated corten steel sheet + 100mm OCSPF insulation +6mm Gypsum board + clear Glass	2mm corrugated corten steel sheet + 100mm OCSPF insulation +6mm Gypsum board + Low E window (0.3 VLT)	2mm corrugated corten steel sheet + 100mm OCSPF insulation +6mm Gypsum board + Low E window (0.3 VLT) + shading device	2mm corrugated corten steel sheet + 100mm OCSPF insulation +6mm Gypsum board + shading device +Louvers
U- value	6.24 W/m ² ·K	0.3178 W/m ² ·K			
Roof	2mm corrugated corten steel sheet	Roofing tile +100mm OCSPF insulation+2mm corrugated corten steel sheet +6mm Gypsum board	Roofing tile +100mm OCSPF insulation+2mm corrugated corten steel sheet +6mm Gypsum board	Roofing tile +100mm OCSPF insulation+2mm corrugated corten steel sheet +6mm Gypsum board +pv panel	Roofing tile +100mm OCSPF insulation+2mm corrugated corten steel sheet +6mm Gypsum board +pv panel
U- value	7.14 W/m ² ·K	0.3233 W/m ² ·K			
Cooling load (Mean)	344.7 kwh	189.3 kwh	174.8 kwh	167.1kwh	
					
PPD level FOR AC Mean	21%	15%	13%	11%	
PPD level FOR NON AC	98%	75%	68%	66%	42%

PPD index(Predicted percentage of dissatisfied index)provids an estimate of how many occupants in aspace would fell dissatisfied by the thermal conditions. All occupied areas in a spcae should be kept below 20% PPD in order to ensure thermal comfort according to the known standars [ASHRAE 55 and ISO 7730]

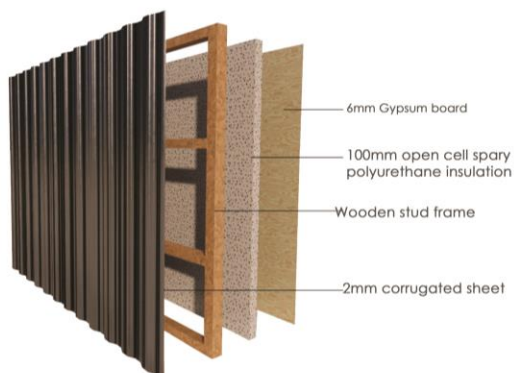


Thermal comfort and cooling load comparison



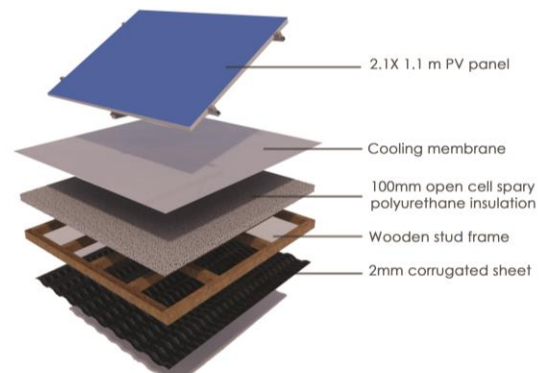
11 % of PPD level has been achived with the help of reduced U-value, shaing device and Cooling load of 182 kwh/ sq.m/ year.

Material Configuration



Wall Configuration

2mm corrugated sheet	42 W/(m·K)
100mm open cell spary polyurethane	0.035 W/(m·K)
6mm Gypsum board	0.16 W/(m·K)
U- value	0.3178 W/sqm·k



Roof Configuration

Cool roof membrane	0.16 W/(m·K)
100mm OCSPF insulation	0.035 W/(m·K)
2mm corrugated cor-ten steel sheet	42 W/(m·K)
U-value	k

5 Planning



Fig 6.1 Site plan



Fig 6.3 Rendered images



Fig 6.4 Rendered images



Fig 6.5 Rendered images

References

1. Source: <https://doi.org/10.1016/j.buildenv.2019.106332>
2. Assessing the thermal performance of upcycled shipping container as a sustainable building material in a Warm humid climate – IOPscience
3. Life cycle assessment of shipping container home: A sustainable construction | Request PDF (researchgate.net)
4. <https://www.researchgate.net/publication/319403965>
|
6. Evaluation, modeling, and analysis of shipping container building structures - ScienceDirect
7. <https://www.sciencedirect.com/science/article/abs/pii/S0360132319305426?via%3Dihub>
8. <http://dx.doi.org/10.1080/13549830903575596>
9. A study of Shipping Containers as a Living Space in Context of Sustainability | Semantic Scholar
10. https://www.researchgate.net/publication/319403965_Thermal_Performance_Assessment_of_Shipping_Container_Architecture_in_Hot_and_Humid_Climates
11. (PDF) Exploring the Potential of Climate-Adaptive Container Building Design under Future Climates Scenarios in Three Different Climate Zones (researchgate.net)
12. Thermal performance of reused shipping containers as building components - IOPscience
13. (PDF) Structural and Thermal Performance Assessment of Shipping Container as Post-Disaster Housing in Tropical Climates (researchgate.net)
14. <https://www.architecturelist.com/sustainable-architecture-containers-by-luis-de-garrido>
15. [https://www.researchgate.net/publication/291366234 Containers Architecture Reusing Shipping Containers in making creative Architectural Spaces](https://www.researchgate.net/publication/291366234_Containers_Architecture_Reusing_Shipping_Containers_in_making_creative_Architectural_Spaces)

