Seeking Strategies in Searing Settings

Passively-cooled mid-rise housing

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Arab speaking cities

Typology of mid-rise

Methodology

Preliminary results

Cities in hot climates

Cairo, Egypt

Amman, Jordan

Casablanca, Morocco

Muscat, Oman

Sao Paolo, Brazil

Mumbai, India

Fuzhou, China

Research question

In such cities, common parameters include hot climates, population increase and urbanization. So what characterizes these built environments?

A – Mid rise buildings

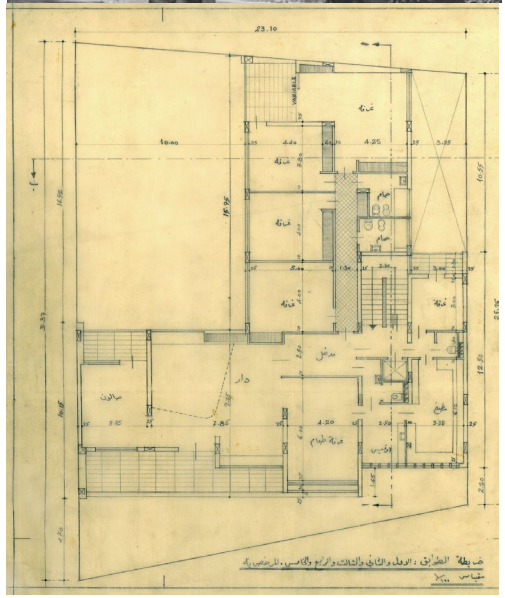
B – Housing / residential typology*

C – Construction materials are mainly cementitious

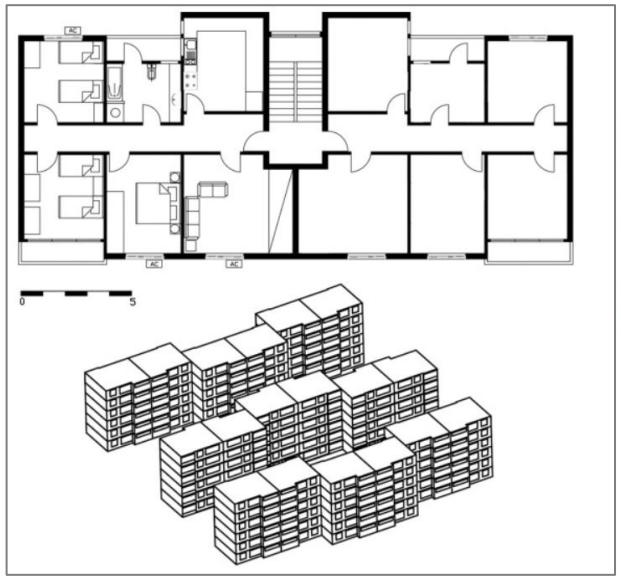
Consequently: in these built environments, what are the opportunities to integrate passive low energy architectural strategies?

*For example, in Cairo alone, 66% of buildings are in the residential sector, i.e. about 9.7 million buildings. (Ref Egypt GBC, BUILD ME Project – Phase II)

Typology of mid-rise apartment buildings

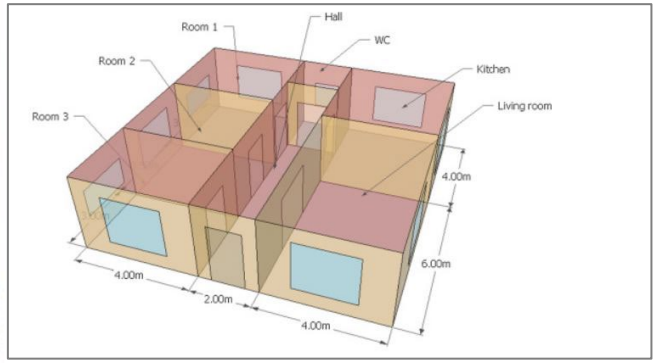


Beirut



Cairo

Tripoli



Morocco

Amman

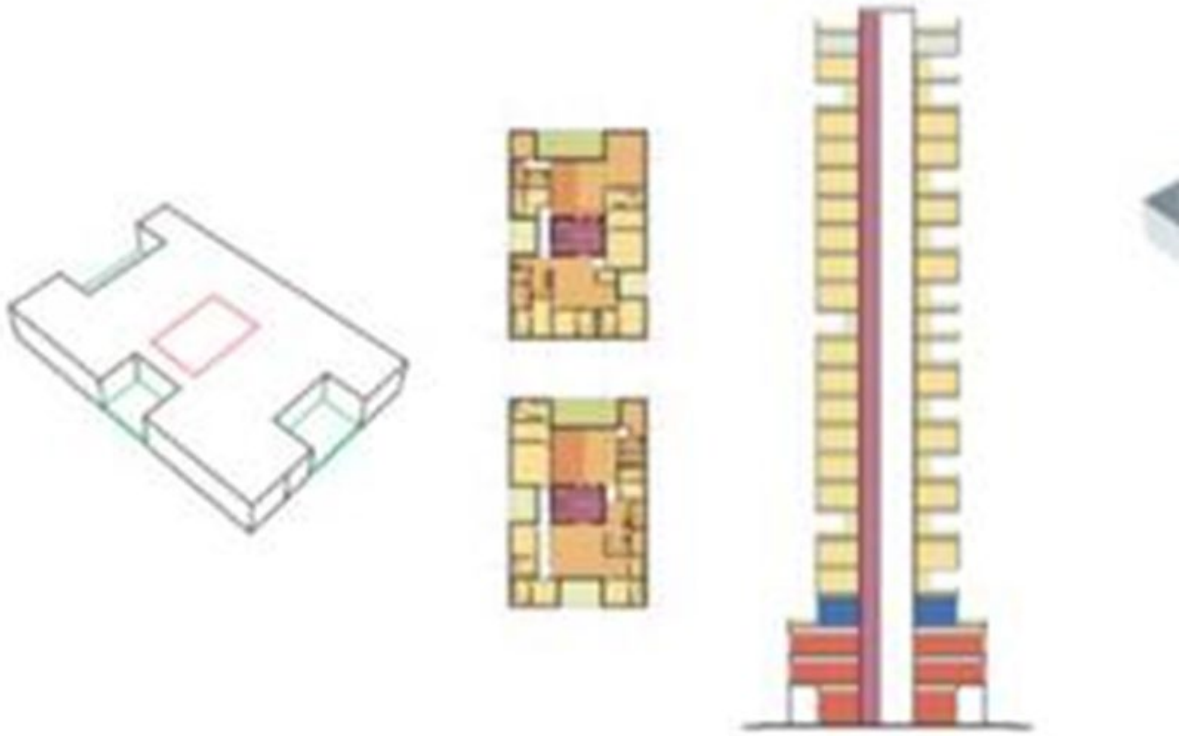
Morocco

Characteristics of the typologies

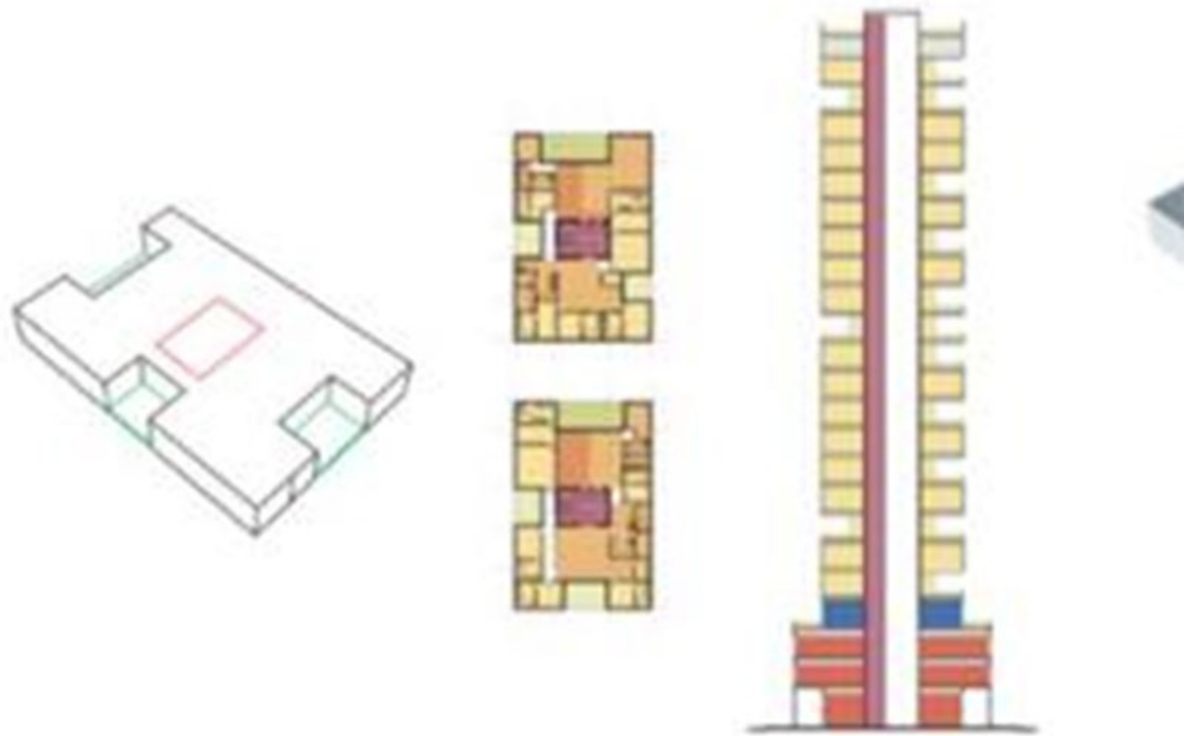
- Vertical circulation and service core
- 6 floors to 15 floors
- Reinforced concrete structure (columns, beams, shear walls, slabs)
- Balconies (terraces, loggias)
- More than one apartment per floor

Opportunities

- Vertical circulation and service core



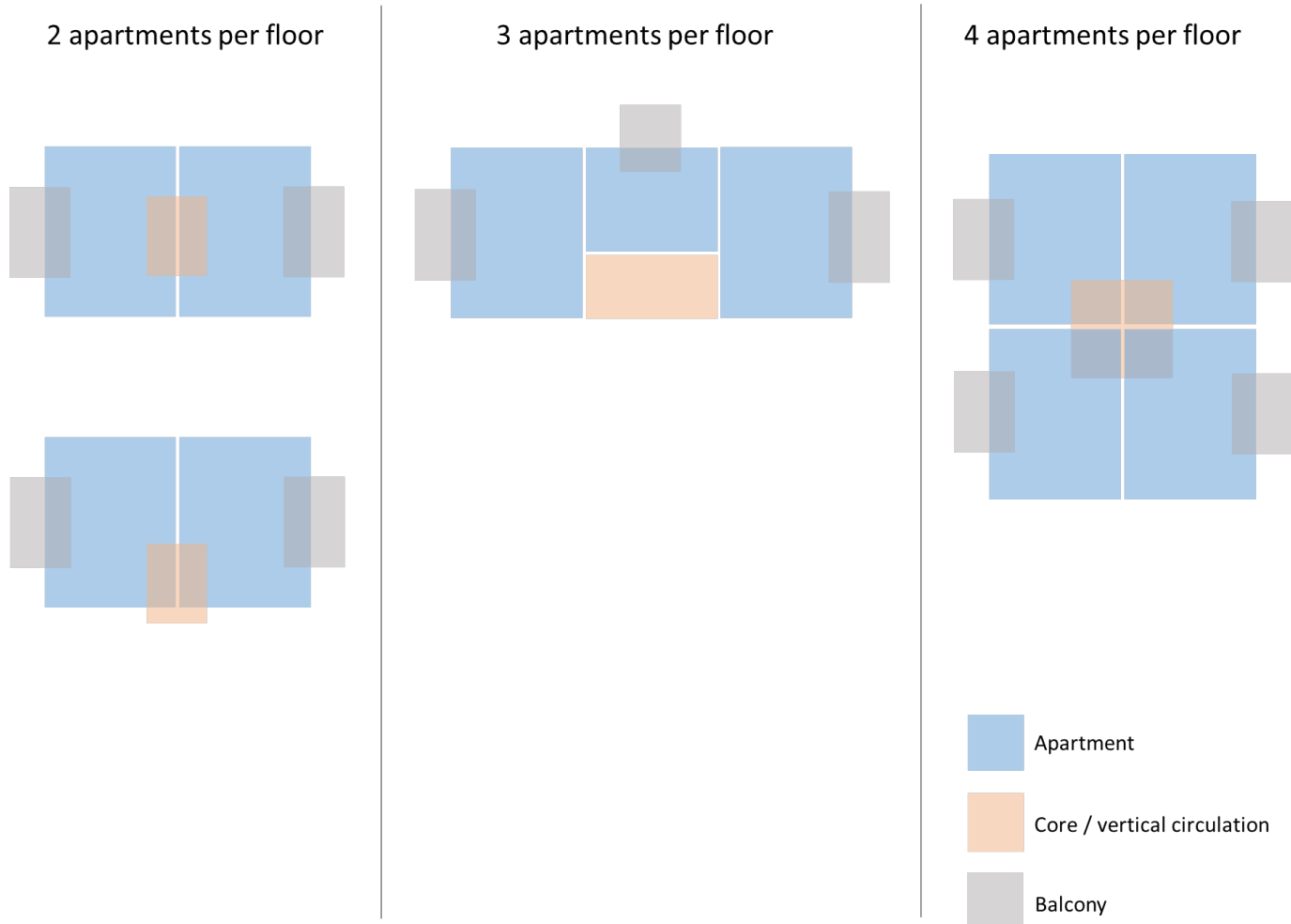
- 6 –15 floors



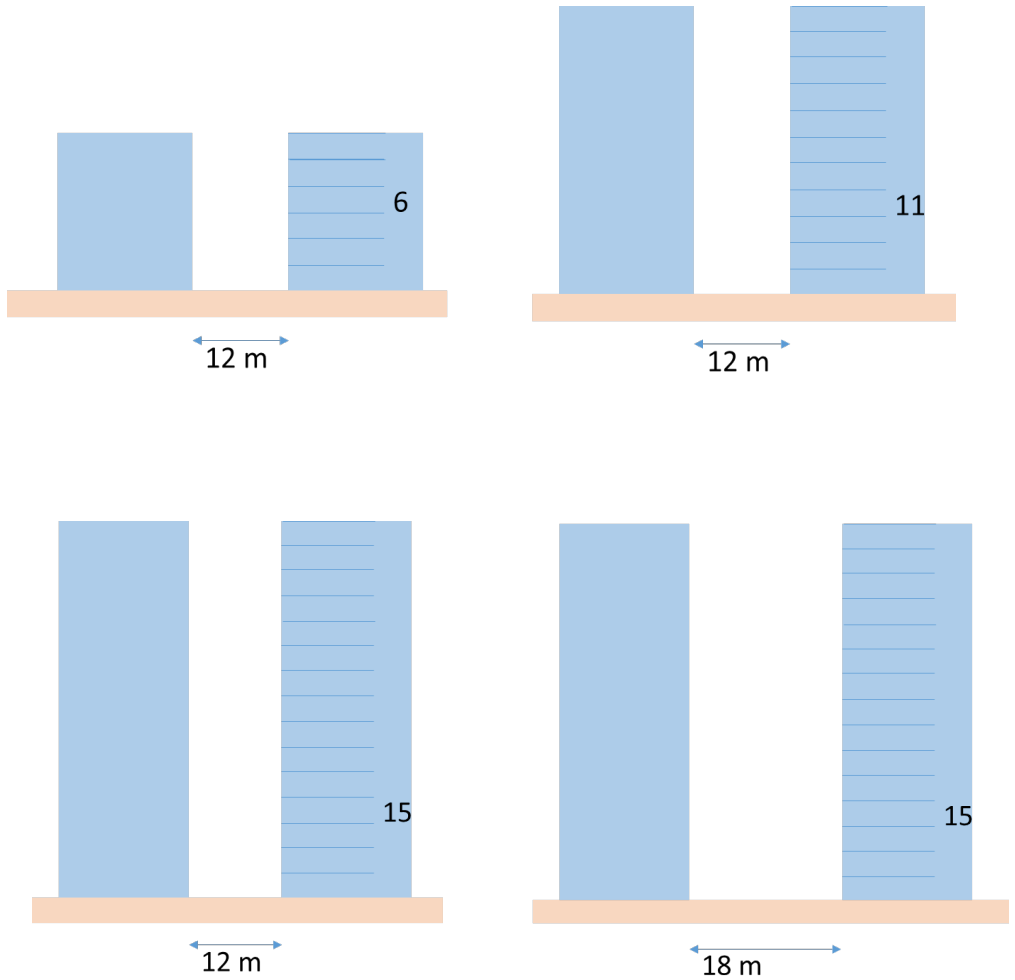
- Reinforced concrete structure

- Balconies (terraces, loggias)

- Plan configurations



Different sectional configurations: building heights and street widths



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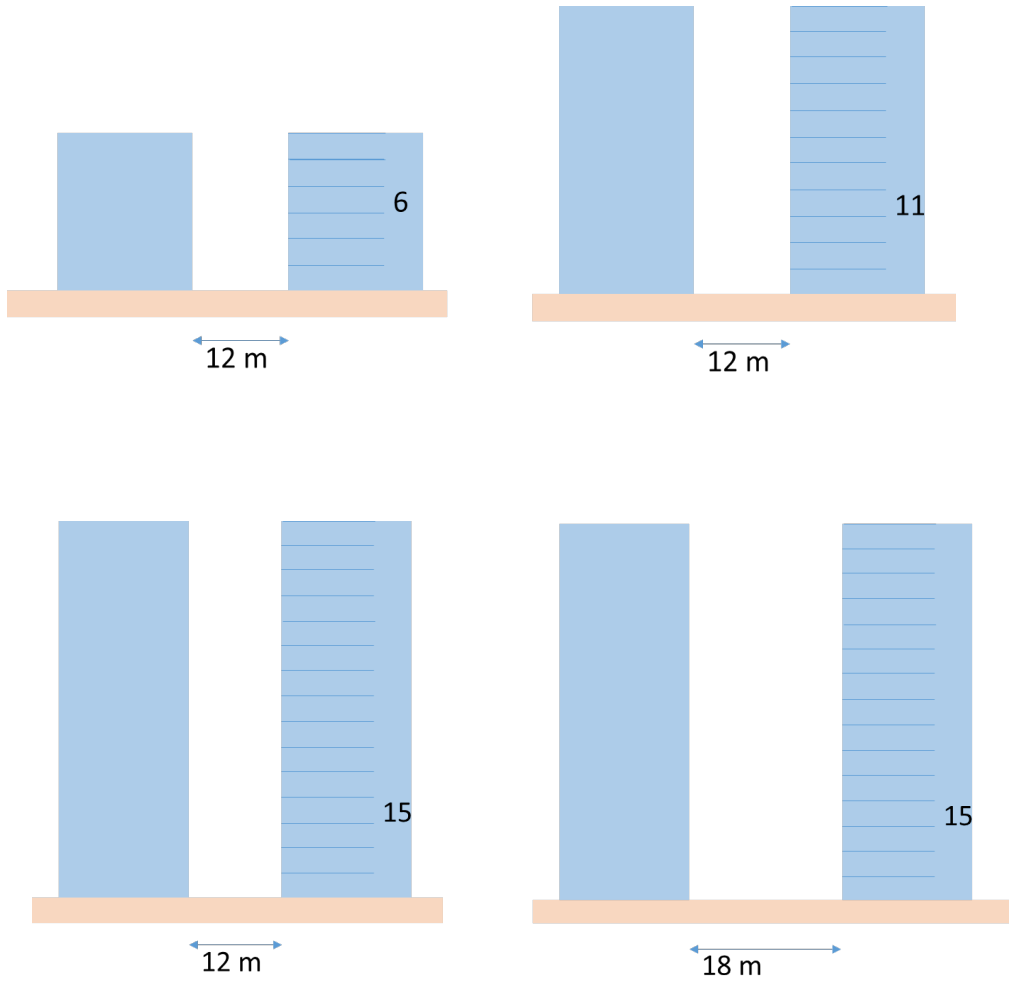
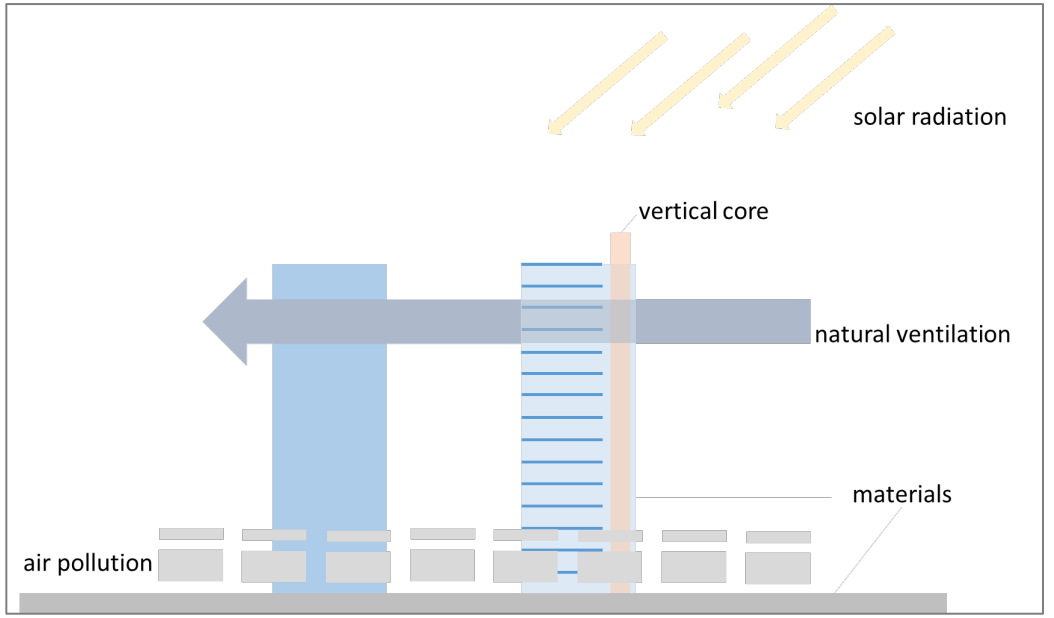
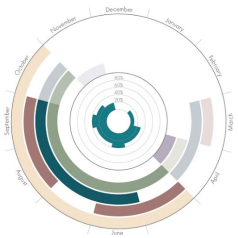




Methodology

1

Project / program identification



2

On site wind availability

Wind at different heights

3

Strategy identification

Cross ventilation

Wind catcher

4

Stack ventilation

Evaporative cooling

Nighttime cooling

Ground cooling

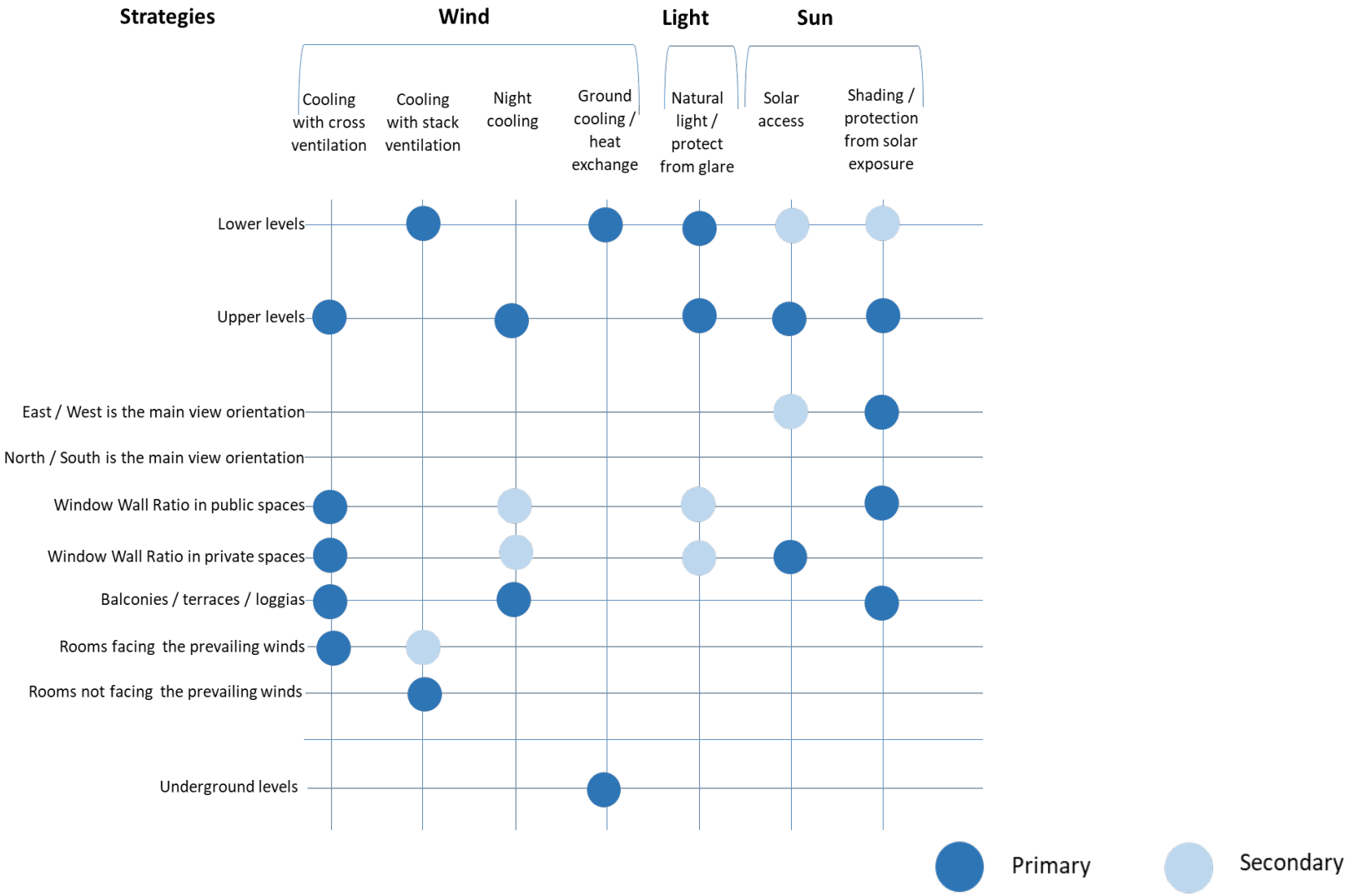
5

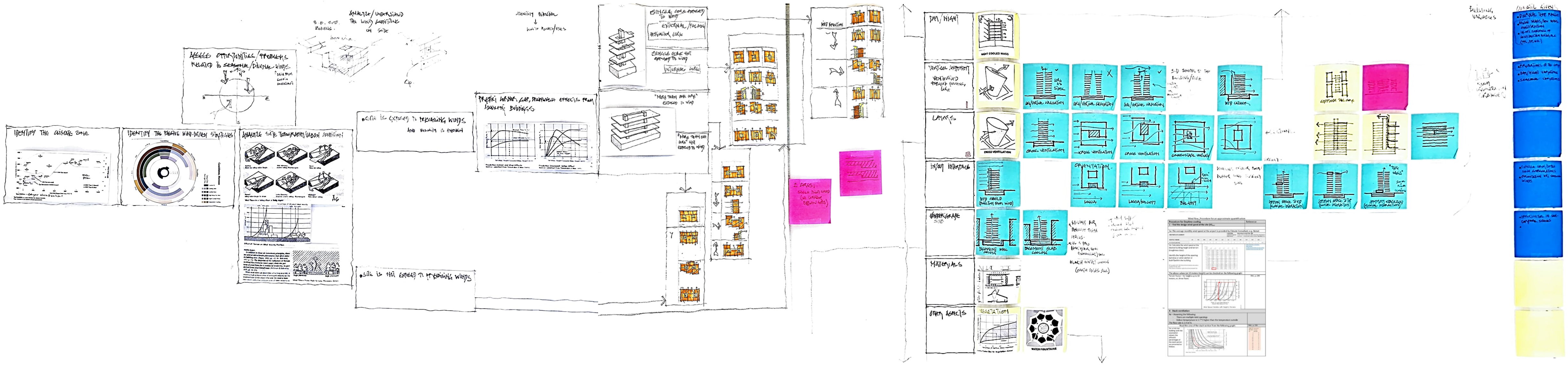
Integration options and synergies

Early design stage assessment

Mid-rise Residential

Project parameters



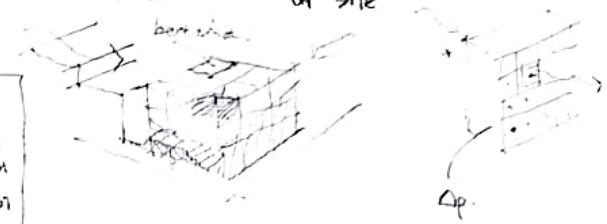


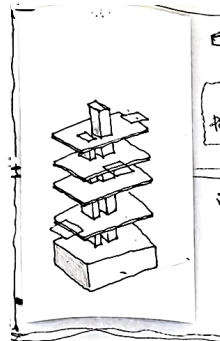
IDENTIFY THE CLIMATE ZONE
SITE IS EXPOSED TO PREVAILING WINDS AND VELOCITY IS ENOUGH
SITE IS NOT EXPOSED TO PREVAILING WINDS
DAY/NIGHT
NIGHT COOLED MASS
LAYERS
CROSS VENTILATION
IN/OUT INTERFACE
MATERIALS
OTHER ASPECTS
VEGETATION
WATER FOUNTAINS

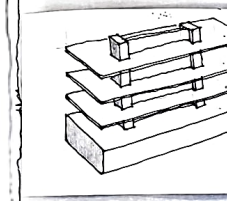
3.D. SITE ZONING.

ANALYZE/UNDERSTAND THE WIND CONDITIONS ON SITE

IDENTIFY POTENTIAL → LOCATE ROOMS/USES

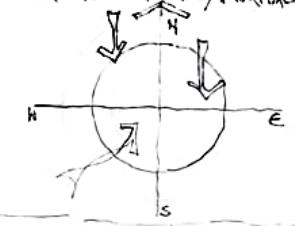






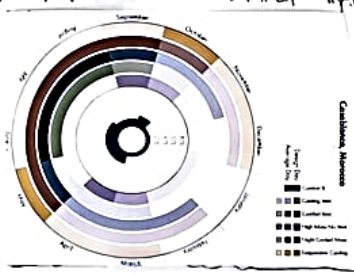
ASSESS OPPORTUNITIES/PROBLEMS RELATED TO SEASONAL/DIURNAL WINDS

↑ DATA FROM CLIMATE CONSULTANT

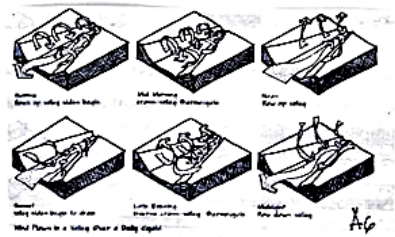


IDENTIFY THE CLIMATIC ZONE

IDENTIFY THE PASSIVE WIND-DRIVEN STRATEGIES



ANALYZE SITE TOPOGRAPHY/URBAN CONDITION



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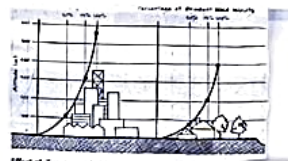


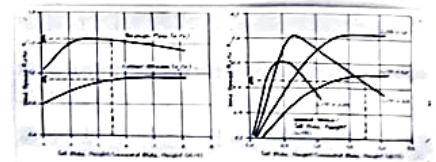
Effect of Terrain on Wind Velocity Profiles

Wind Flows From High to Low Pressure Zones

- SITE IS EXPOSED TO PREVAILING WINDS AND VELOCITY IS ENOUGH

- SITE IS NOT EXPOSED TO PREVAILING WINDS

PASSING CORNER, GAP, DOWNWASH EFFECTS FROM ADJACENT BUILDINGS



identify potential

↓

locate rooms/uses

SINGLE CORE EXPOSED TO WIND

EXTERNAL / FACADE

PERIMETER CORE

SINGLE CORE NOT EXPOSED TO WIND

INTERNAL CORE

"MORE THAN ONE CORE" EXPOSED TO WIND

"MORE THAN ONE CORE" NOT EXPOSED TO WIND

WIND DIRECTION

2 CORES;
SINGLE POINT LOADS
(NO LATERAL FORCES BETWEEN CORES)

DAY / NIGHT

NIGHT COOLED MASS

VERTICAL COMPONENT

VENTILATED FACADE, CORE

CORE AS SINK

CORE/VERTICAL INSULATION

CORE/VERTICAL CIRCULATION

MASS

CROSS VENTILATION

CROSS VENTILATION

CROSS VENTILATION

IN/OUT INTERFACE

WIND SHIELD (PROTECTION FROM WIND)

ORIENTATION

LOGGIA

UNDERGROUND SUB

BASEMENT WALL COOLING

BASEMENT SLAB COOLING

MATERIALS

OTHER ASPECTS

VEGETATION

WATER FOUNDATIONS

IDENTIFY POTENTIAL
↓
LOCATE ROOMS/USES

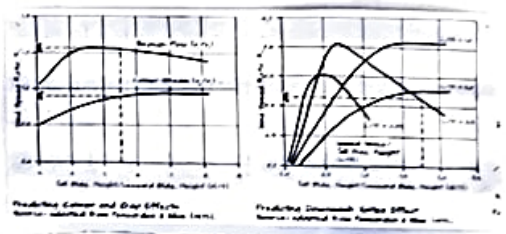
SINGLE CORE EXPOSED TO WIND
EXTERNAL / FACADE
PERIMETER CORE

SINGLE CORE NOT EXPOSED TO WIND
INTERNAL CORE

"MORE THAN ONE CORE" EXPOSED TO WIND

"MORE THAN ONE CORE" NOT EXPOSED TO WIND

PREDICT CORNER, GAP, DOWNWASH EFFECTS FROM SURROUNDING BUILDINGS



WIND DIRECTION

2 CORES:
SINGLE POINT LOADS
(NO OVERHANG BETWEEN CORES)

DAY / NIGHT

VERTICAL COMPONENT
VENTILATED THERMAL COOLING, LOAD

LAMELLAS

IN/OUT INTERFACE

UNDERGRADE
SUB

MATERIALS

) TO PREVAILING WINDS
AND VELOCITY IS ENOUGH

OSED TO PREVAILING WINDS

DAY/NIGHT

NIGHT COOLED MASS

VERTICAL COMPONENT

VENTILATED FACADE COOLING, LIKE

CORE AS SINK

CORE/VERTICAL INSULATION

CORE/VERTICAL ORIENTATION

CORE/VERTICAL ORIENTATION

SUB ZONING OF THE BUILDING/CORE

WIND CATCHER

LAYERS

CROSS VENTILATION

CROSS VENTILATION

CROSS VENTILATION

CROSS VENTILATION

CROSS VENTILATION

IN/OUT INTERFACE

WIND SHIELD (PROTECTION FROM WIND)

ORIENTATION

LOGGIA

LOGGIA/BALCONY

BALCONY

ROOM

UNDERGRADE SUB

BASEMENT WALL COOLING

BASEMENT SLAB COOLING

BUILDING AIR PASSING THROUGH SPACES

MATERIALS

OTHER ASPECTS

VEGETATION

WATER FOUNTAINS

Wind flow_Procedure for an approximate quantification

Procedure for Daytime cooling	Reference
1 – Find the design wind speed at the site ($V1_{des}$)	
1a: The average monthly wind speed at the airport is provided by Climate Consultant, e.g. Beirut:	
1b: Calculate the wind speed at the desired building height and terrain (roughness class): Identify the height of the opening (window or wind catcher or both?)within the building	
The above values (at 10 meters height) can be checked on the following graph:	
Terrain Factor – for heights up to 10 meters, or, three floors	SWL, p. 290
4 - Stack ventilation	
4a – Assuming the following: - There are multiple inlet openings - Indoor temperature is 1.7 °C higher than the temperature outside The flow rate is 2.4 m³/s	
Read the area of the stack section from the following graph:	SWL, p. 230
For a mid-rise building (with the assumption above), the different percentages of the stack section are presented as follows:	

BUILDING VARIABLES

CLIMATIC GIVENS

- DIURNAL TEMP. RANGE
- HIGH MASS/LOW MASS CONSTRUCTION
- IN-DEPTH KNOWLEDGE OF CONSTRUCTION MATERIALS (TM, DP, GR)

- FLUCTUATIONS OF THE CORE
- DAY/NIGHT VARIATIONS
- SEASONAL VARIATIONS

- SINGLE SKIN/DOUBLE SKIN CONFIGURATIONS
- ORIENTATION W.R.T. SEASONAL WINDS

- OBSTRUCTIONS IN SURROUNDING SPACES

Wind flow_Procedure for an approximate quantification

Procedure for Daytime cooling	Reference
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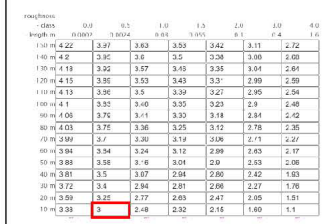
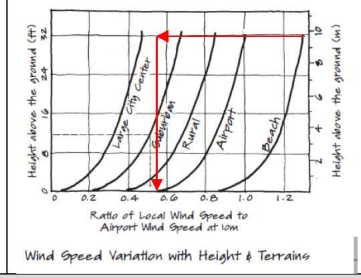
WEATHER DATA SUMMARY

LOCATION: Beirut Hariri Intl AP, BA, LBN
Latitude/Longitude: 33.821° North, 35.488° East, **Time Zone from Greenwich** 2
Data Source: ISD-TMYx 401000 WMO Station Number, **Elevation** 26 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Wind Speed (Avg Monthly)	3	2	2	2	2	2	2	2	3	3	2	2	m/s

1b: Calculate the wind speed at the desired building height and terrain (roughness class): Identify the height of the opening (window or wind catcher or both?)within the building © Copyright 1997-2003 Danish Wind Industry Association Updated 18 May 2003 http://www.windpower.org/en/tour/wres/calculat.htm		http://www.xn--drmstrre-64ad.dk/wp-content/wind/miller/windpower%20web/en/tour/wres/calculat.htm

roughness class	0.0	0.5	1.0	1.5	2.0	3.0	4.0
length m	0.0002	0.0024	0.03	0.055	0.1	0.4	1.6
150 m	4.22	3.97	3.63	3.53	3.42	3.11	2.72
140 m	4.2	3.95	3.6	3.5	3.38	3.08	2.68
130 m	4.18	3.92	3.57	3.46	3.35	3.04	2.64
120 m	4.15	3.88	3.53	3.43	3.32	2.99	2.59
110 m	4.13	3.86	3.5	3.39	3.27	2.95	2.54
100 m	4.1	3.83	3.46	3.35	3.23	2.9	2.48
90 m	4.06	3.79	3.41	3.33	3.18	2.84	2.42
80 m	4.03	3.75	3.36	3.25	3.12	2.78	2.35
70 m	3.99	3.7	3.30	3.19	3.06	2.71	2.27
60 m	3.94	3.64	3.24	3.12	2.99	2.63	2.17
50 m	3.88	3.58	3.16	3.04	2.9	2.53	2.06
40 m	3.81	3.5	3.07	2.94	2.80	2.42	1.93
30 m	3.72	3.4	2.94	2.81	2.66	2.27	1.78
20 m	3.59	3.25	2.77	2.63	2.47	2.05	1.51
10 m	3.33	3	2.48	2.32	2.15	1.60	1.1

The above values (at 10 meters height) can be checked on the following graph:		
Terrain Factor – for heights up to 10 meters, or, three floors		SWL_e p. 290

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4a – Assuming the following: - There are multiple inlet openings - Indoor temperature is 1.7 °C higher than the temperature outside The flow rate is 2.4 m^3/s	
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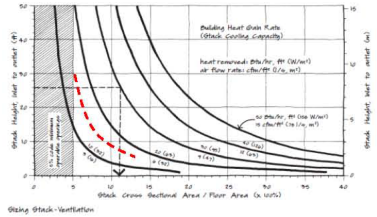
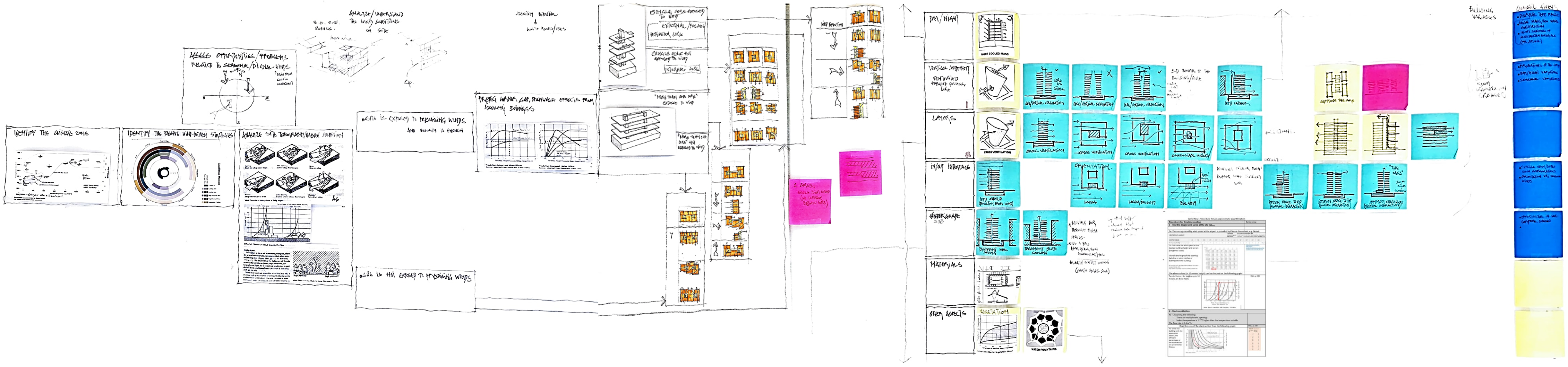
For a mid-rise building (with the assumption above), the different percentages of the stack section are presented as follows:		

Height of the stack (m)	Percent of the plan area (%)
3	9
6	6
9	5
12	5
15	4
18	4
21	3
24	3
27	3
30	3
33	3
36	3


IDENTIFY THE CLIMATE ZONE
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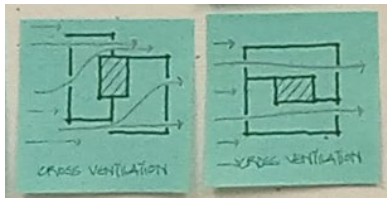
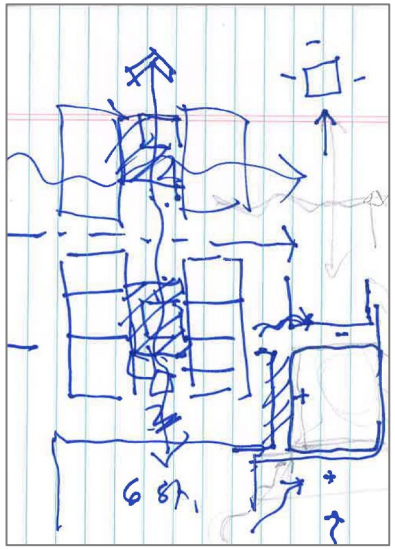
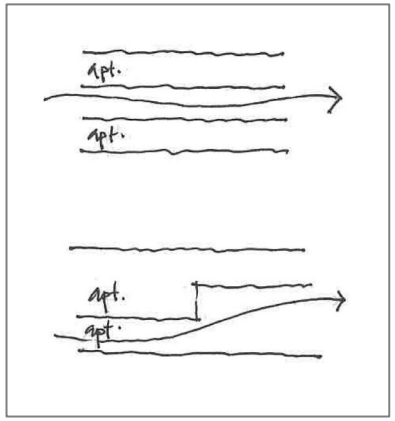
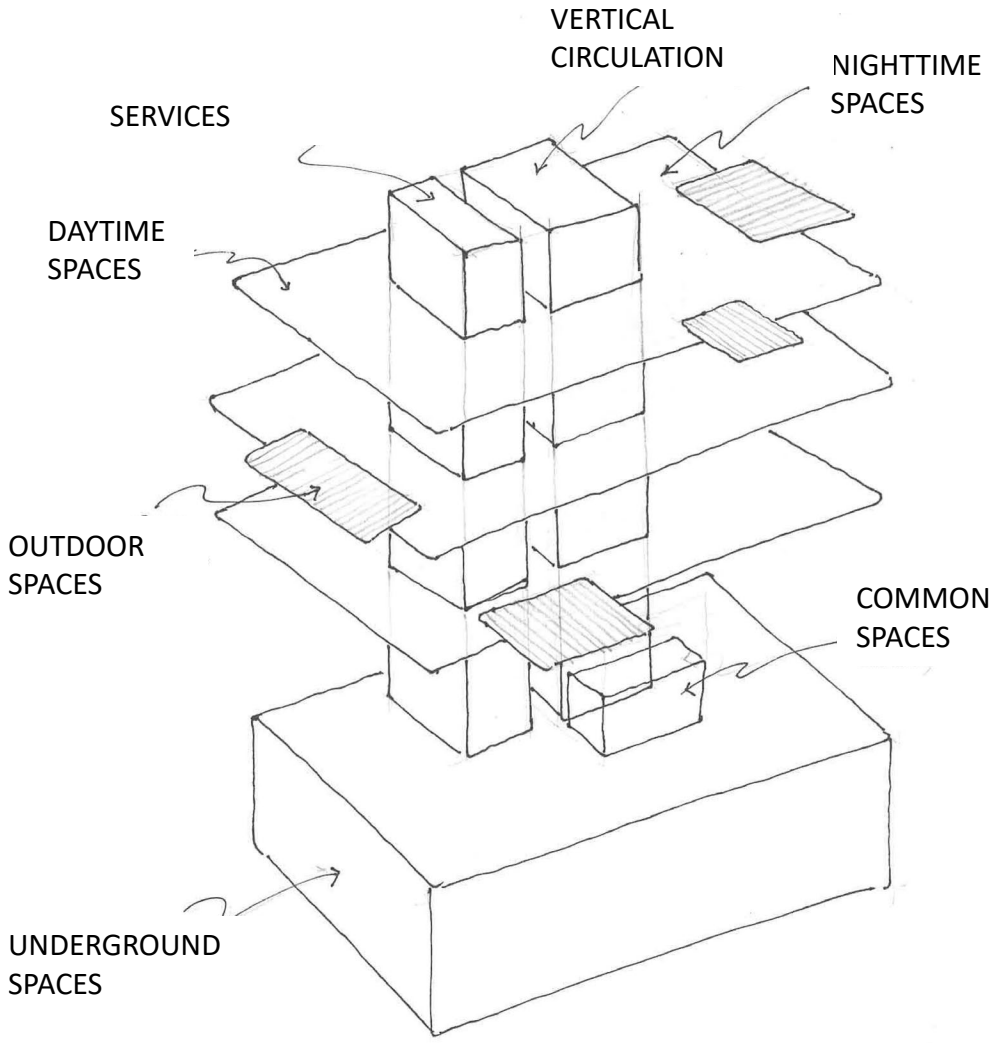
Indoor spaces

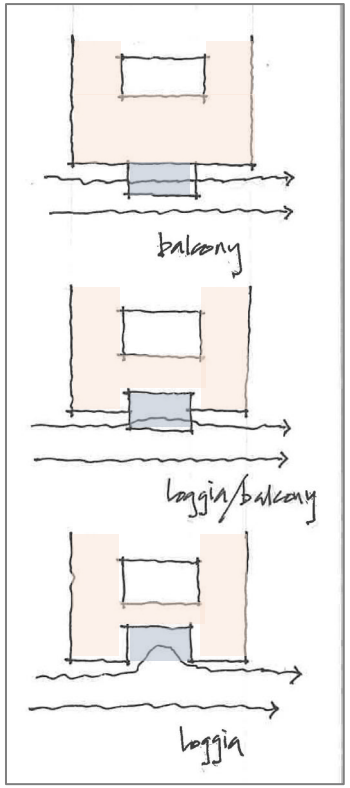


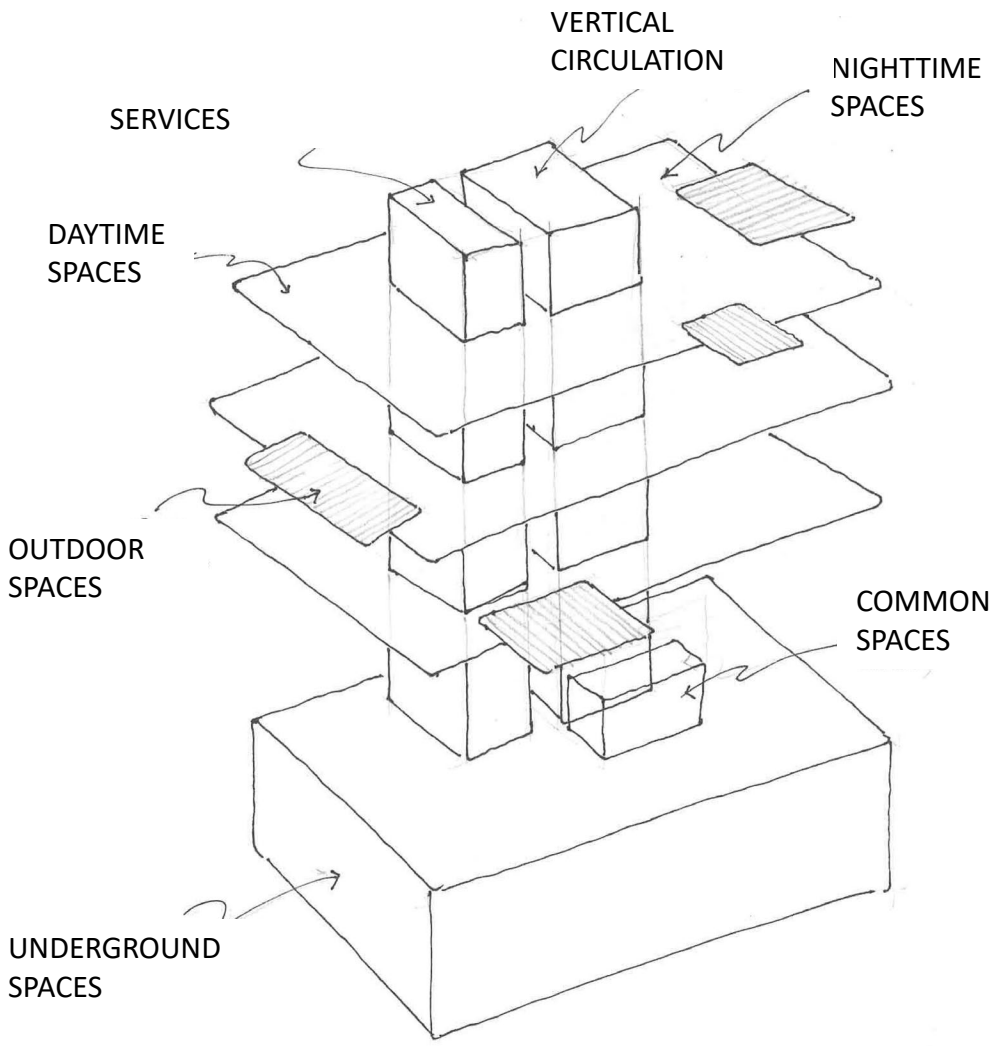




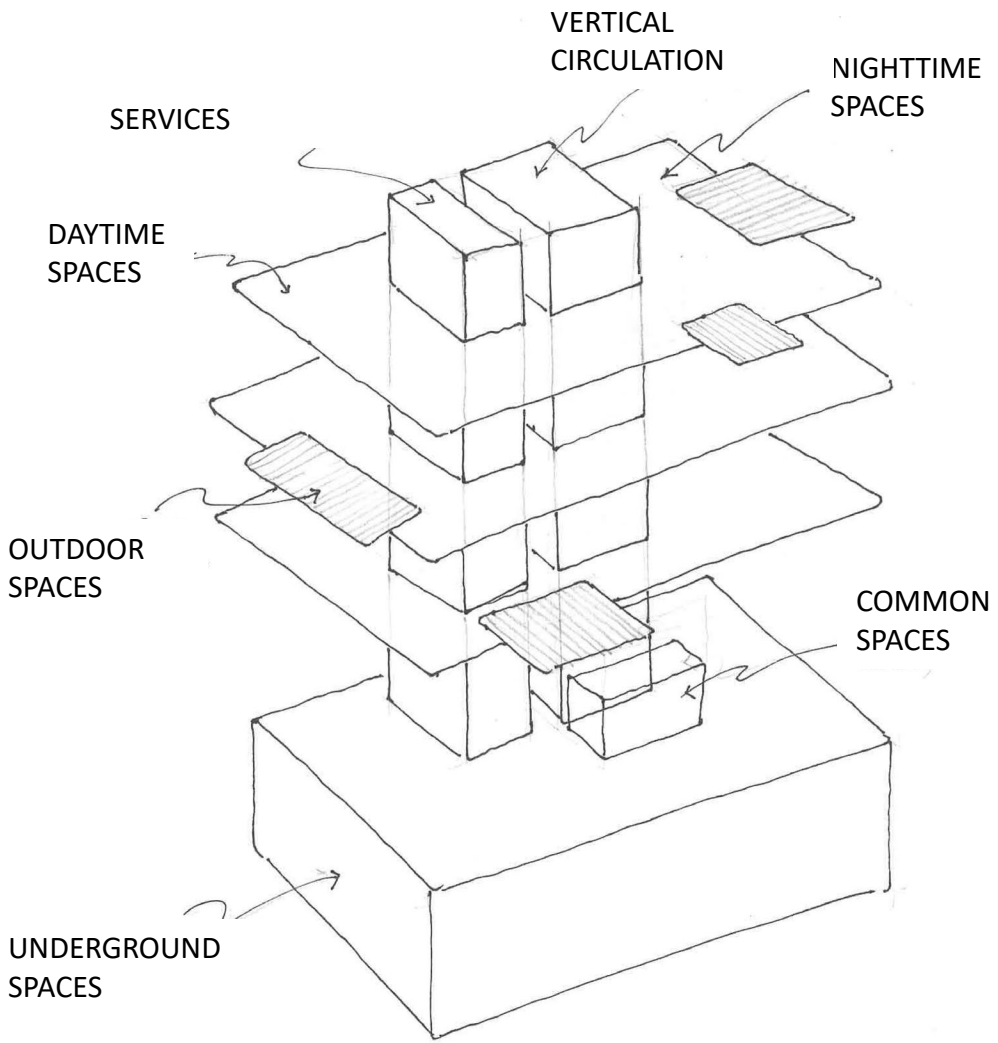


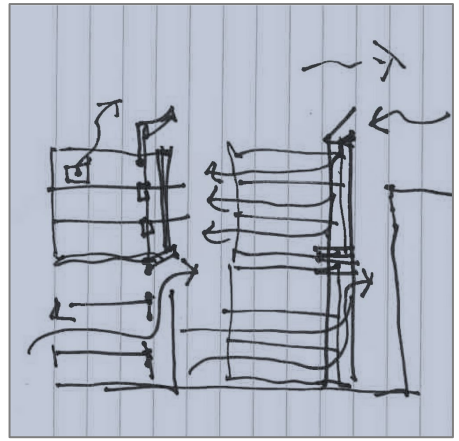
Outdoor spaces

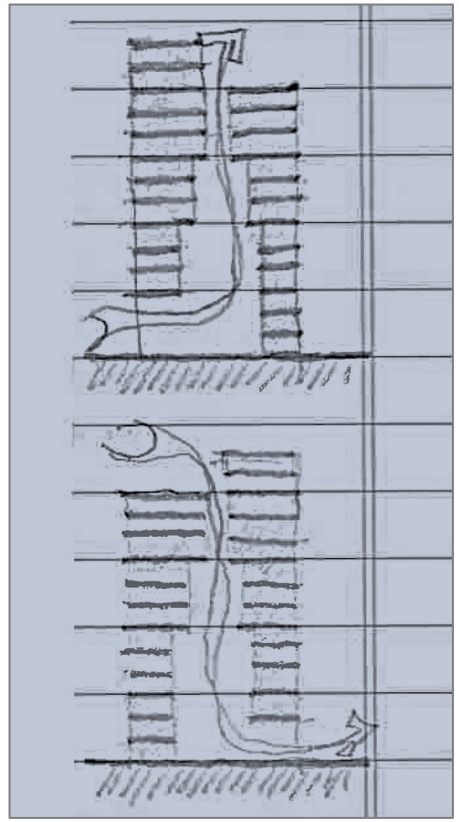




Core / vertical circulation







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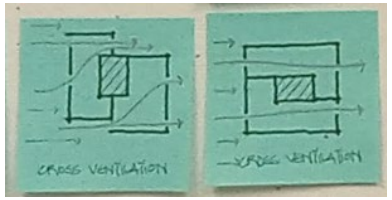

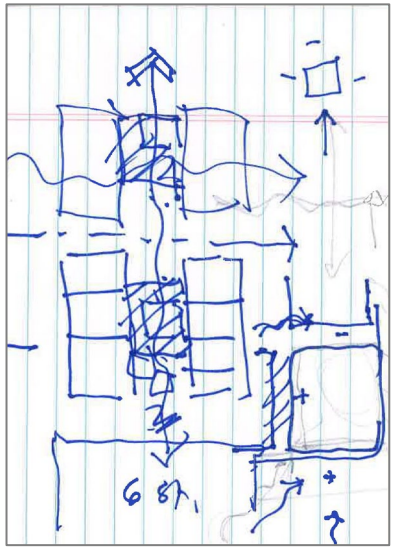

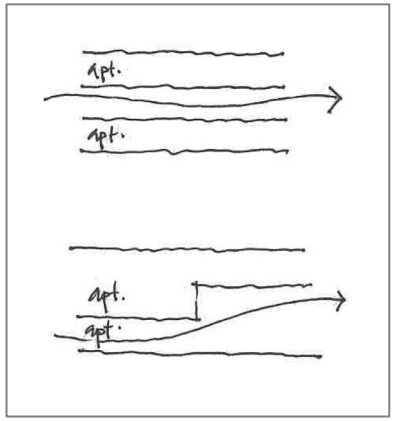

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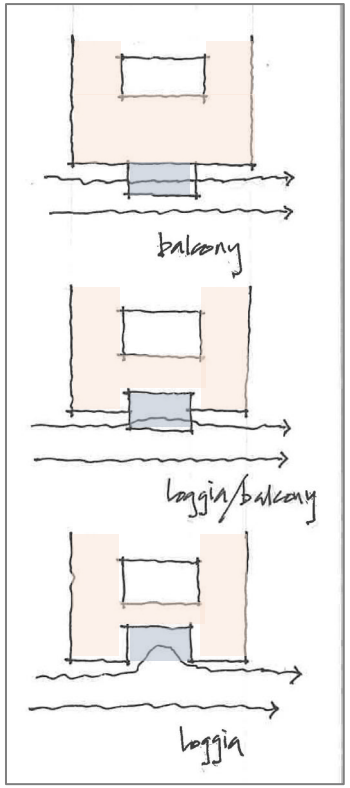
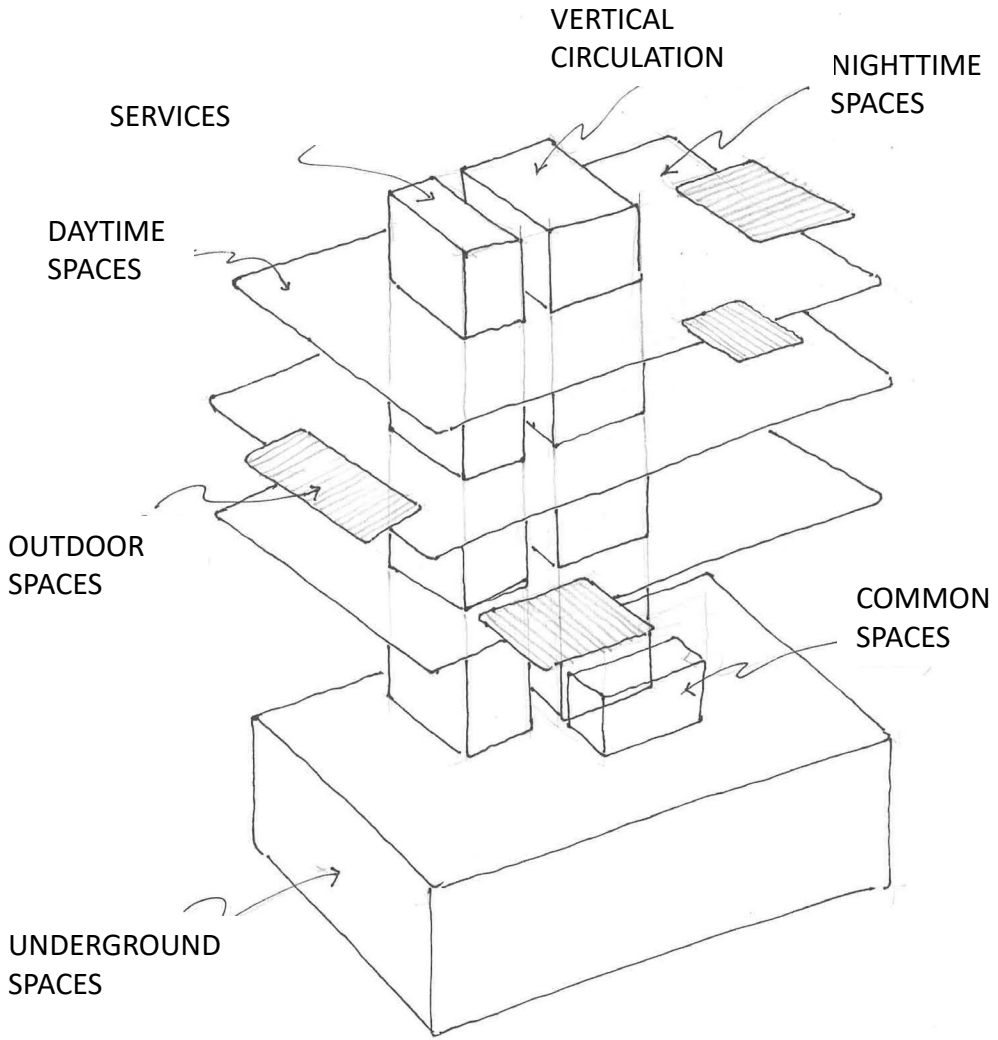
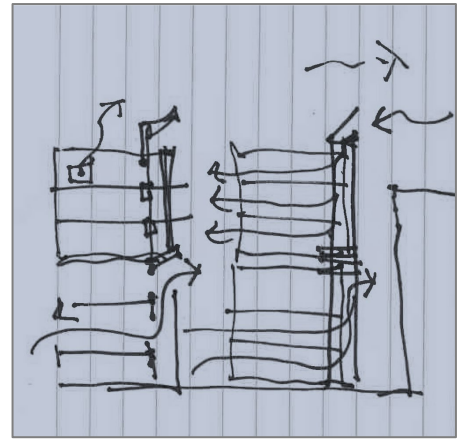
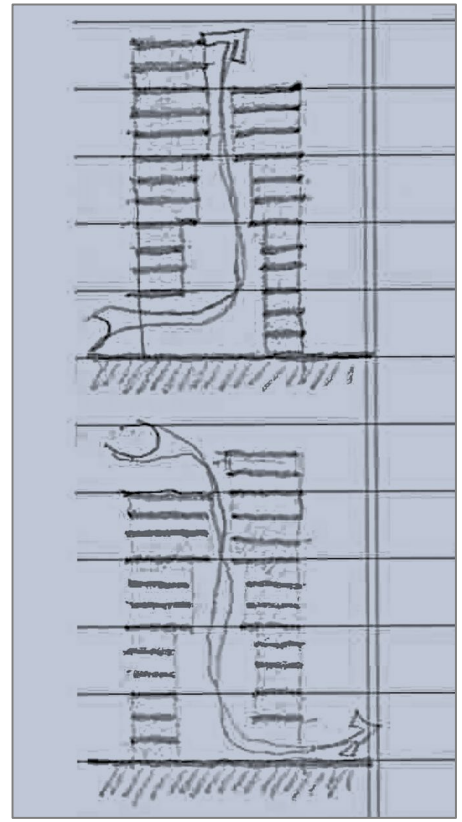




Core / vertical circulation





Conclusion

- The mid-rise housing typology presents numerous opportunities allowing the integration of climate responsive passive cooling strategies.
- The commonly used construction materials can be used to increase the efficiency of the strategies.
- The flow chart presents a process to integrate the appropriate passive cooling strategies.

Next steps

- Fine tune the strategies and create more reliable early design stage assessment methods for the strategies
- Study different strategies
- Address different building typologies (office, commercial, academic…)
- Study potential benefits of having underground levels.

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