Integrated Building Environmental Design

Beijing Parkview Green

10 May 2008

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Developer : Beijing Chyau Fwu Properties Co., Ltd.
Architect : Integrated Design Associates
Engineering Consultant : Ove Arup & Partners Hong Kong Ltd.
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Building Information

Forbidden City

Development Site

Location:	Beijing, China
No. building:	4 buildings enclosed by a Microclimate Envelope
Building usage:	Class-A office, retail, hotel, restaurant and carpark
Floor area:	200,000 m²
Building height:	87m

No. of storey:

- 3-storey basement carpark
- 4-storey retail floor
- 7~10-storey office floor
- 6-story hotel

Latitude = 39.93N
Longitude = 116.28E
Elevation = 55m

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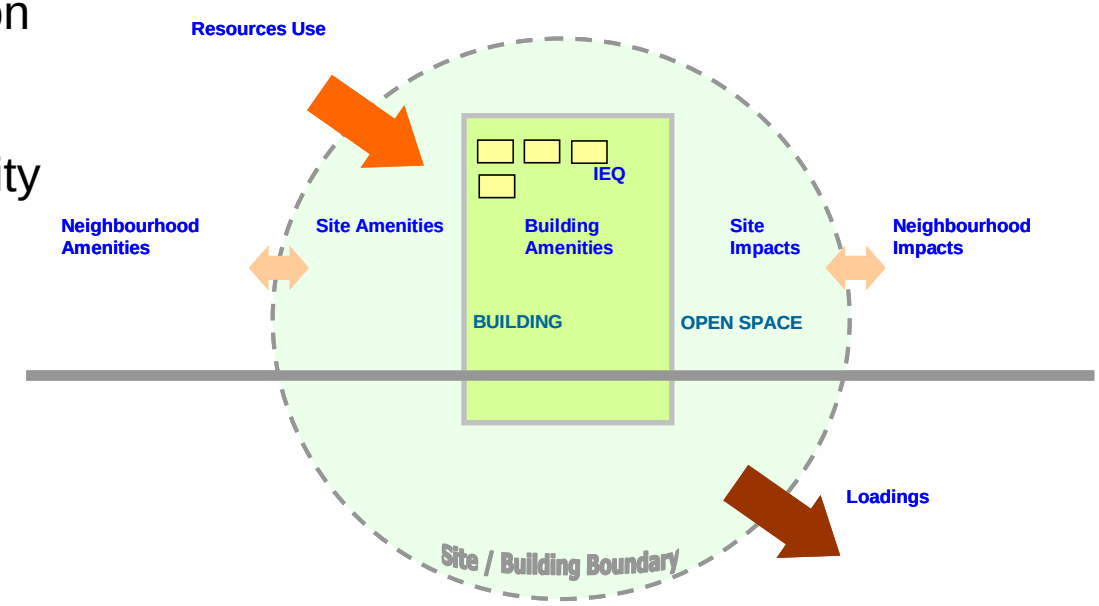
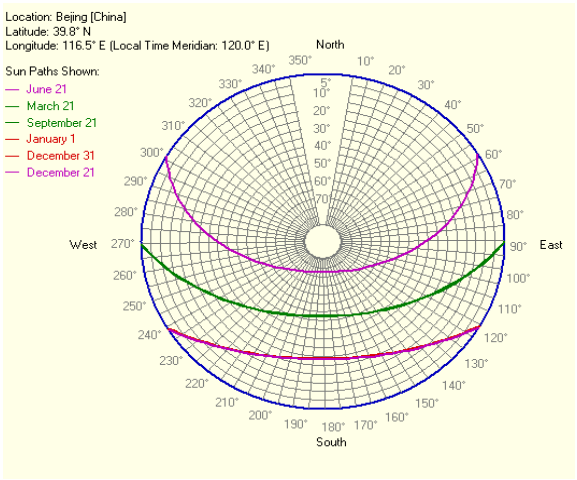
Design Objectives

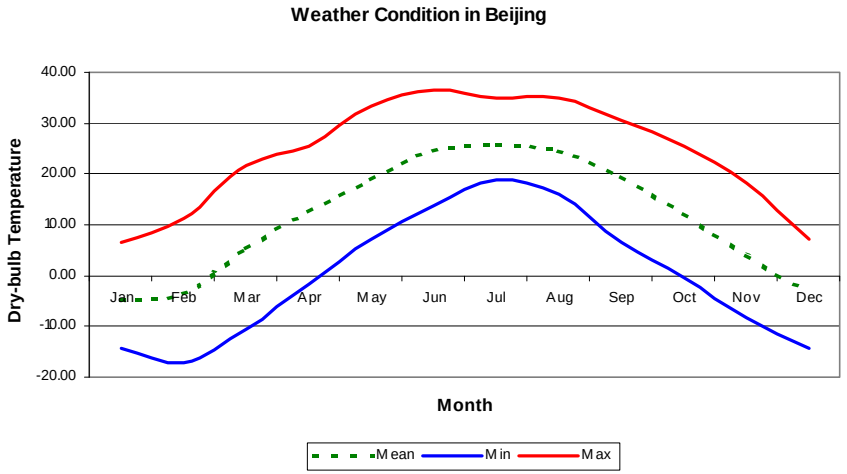
- New paradigm of sustainable building in China
- Sustainable & environmentally-friendly design to the neighbourhood, the covered common spaces and the occupied areas in buildings
- Low natural resources consumption and energy efficient buildings
- Minimal social and environmental impact to surrounding building occupants
- Cost effective and low O&M cost green technologies
- Maximize use of hybrid ventilation
- Low environmental impact
- Good indoor environmental quality
- Safe, healthy and liveable space

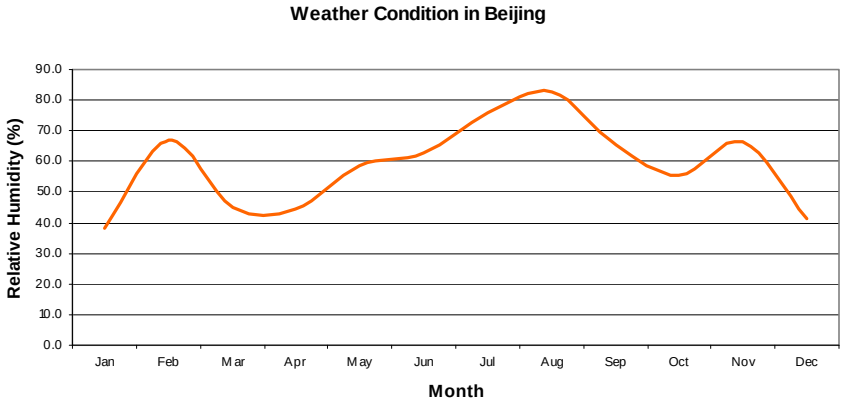


Beijing Climatic Data – Outdoor Temperature & Humidity

- Annual Average Outdoor Temp. 11.7 ºC
- Average Outdoor Temp. of the Hottest Month (July) 25.9 ºC
- Average Outdoor Temp. of the Coldest Month (Jan) -4.8 ºC
- When outside critical illuminance is 5,000 lx, available time of daylight is about 3,900 hours
- Maximum altitude in summer is 73.7°
- RH 40%-80%





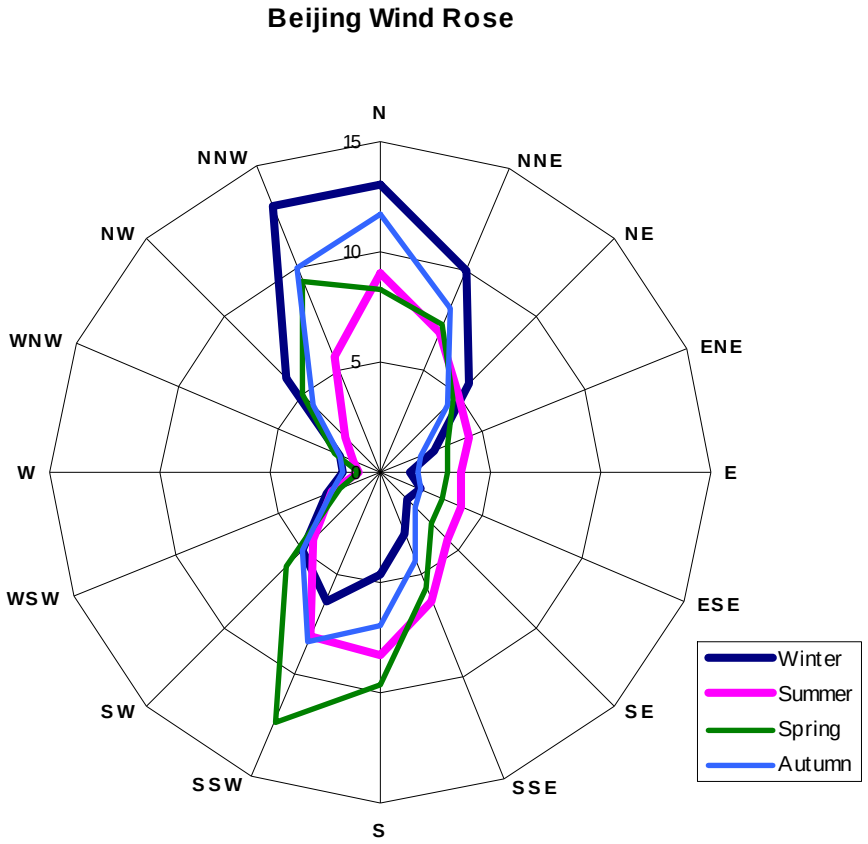


Beijing Climatic Data - Wind

Summer prevailing wind: SW

Winter prevailing wind: N, NNW

- Located on the fringe of the loess belt
- Sandy and dusty weather originated in Inner Mongolia, Gansu and the Ningxia Hui Autonomous Region will affect the region in spring season.



	Outdoor Air Speed (m/s)		
	Annual	Winter	Summer
Average Wind Speed	2.5	2.8	1.9
Frequency of Occurrence	-	NNW (13%) N (13%)	SW (10%)

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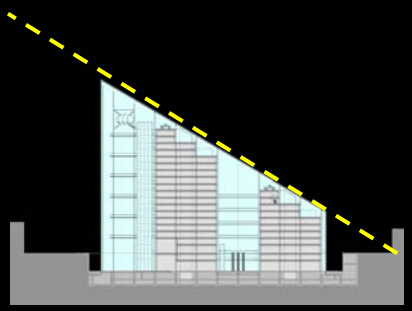
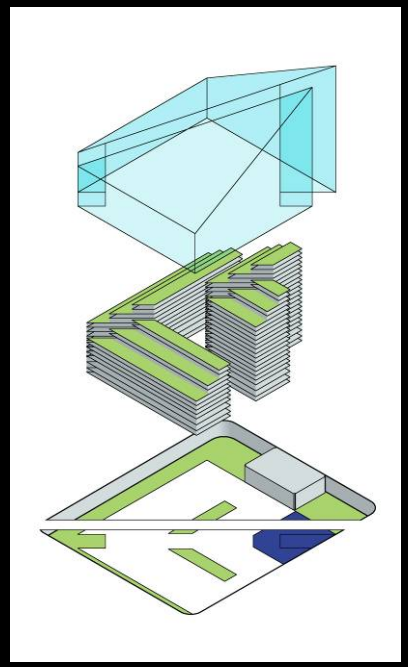
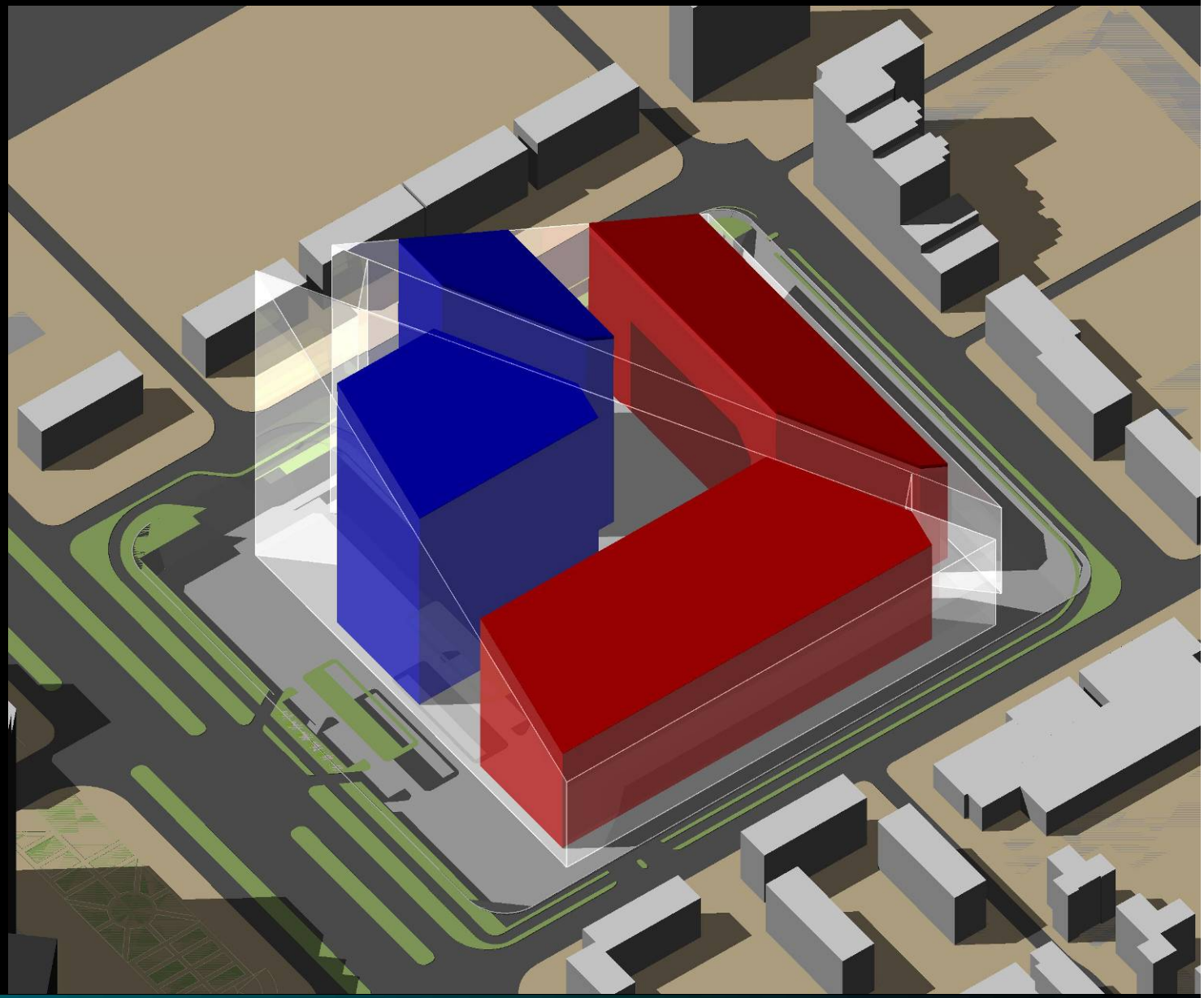
Massing







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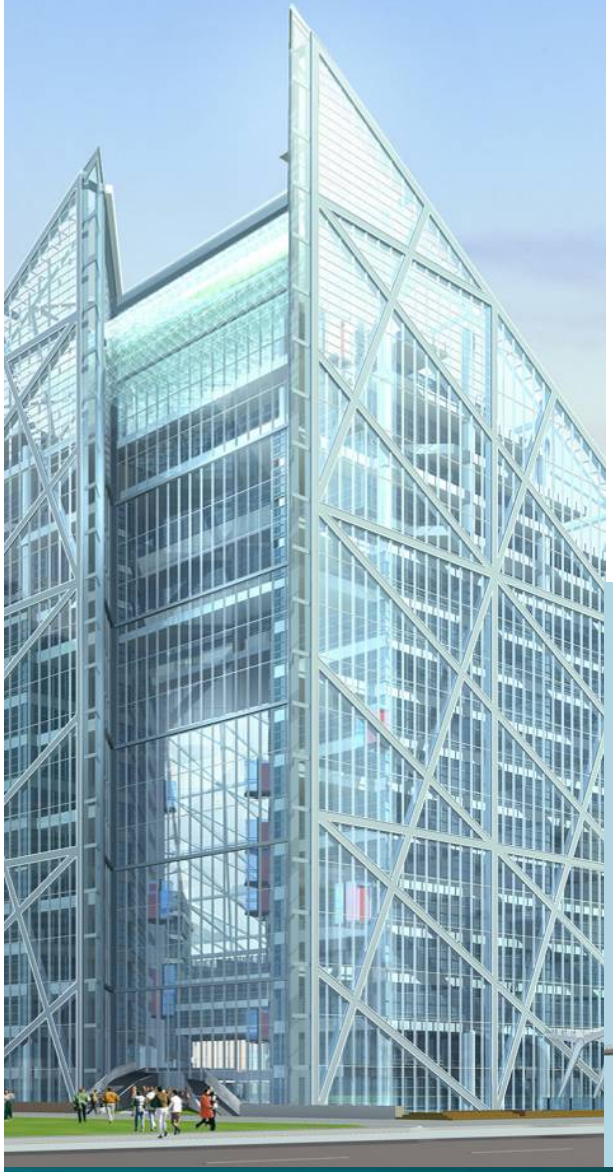
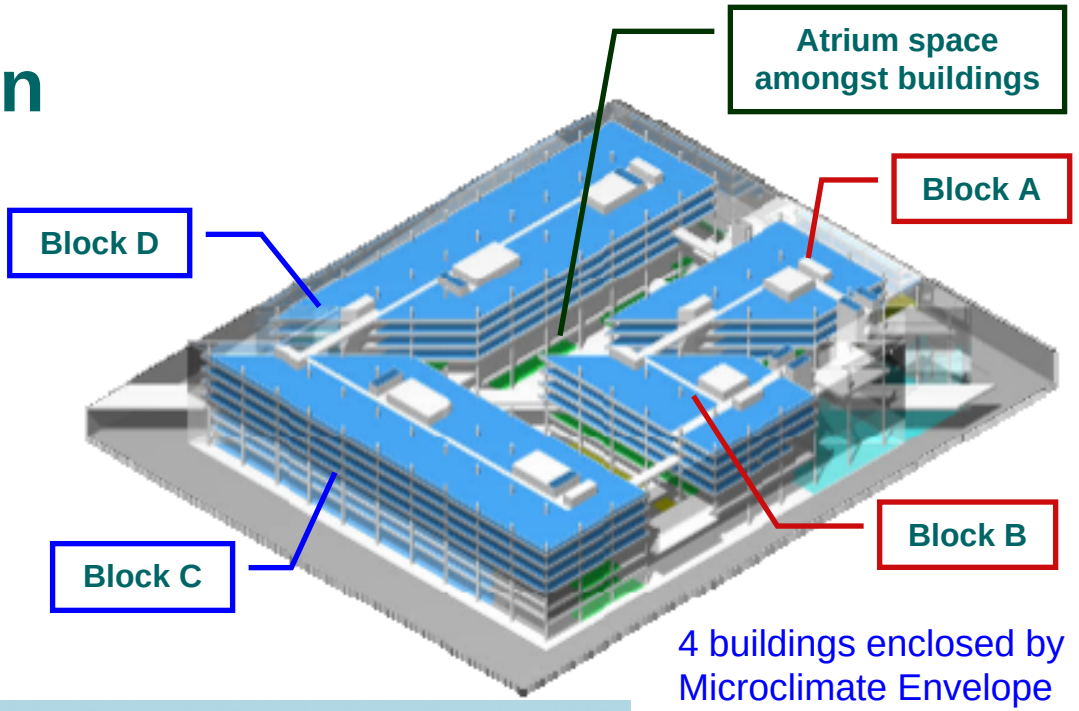
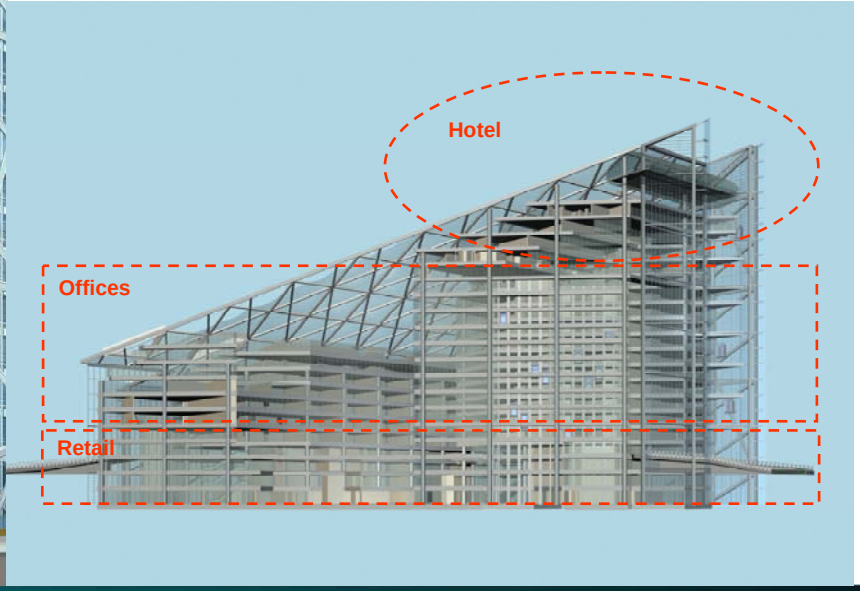
Architectural Design





4 buildings enclosed by Microclimate Envelope



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11
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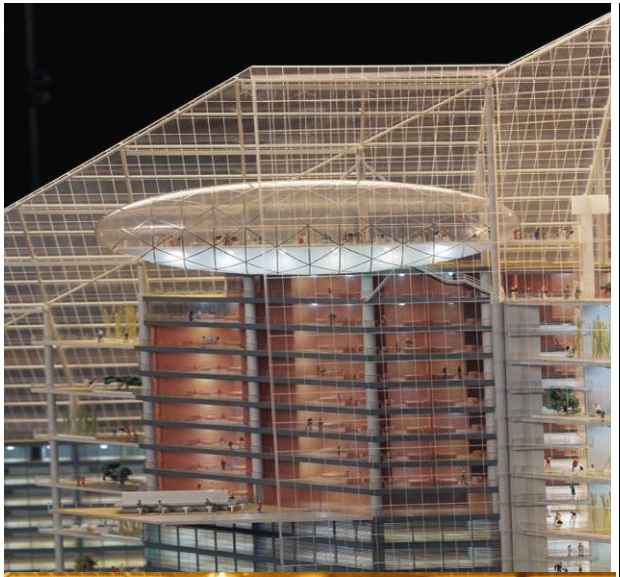

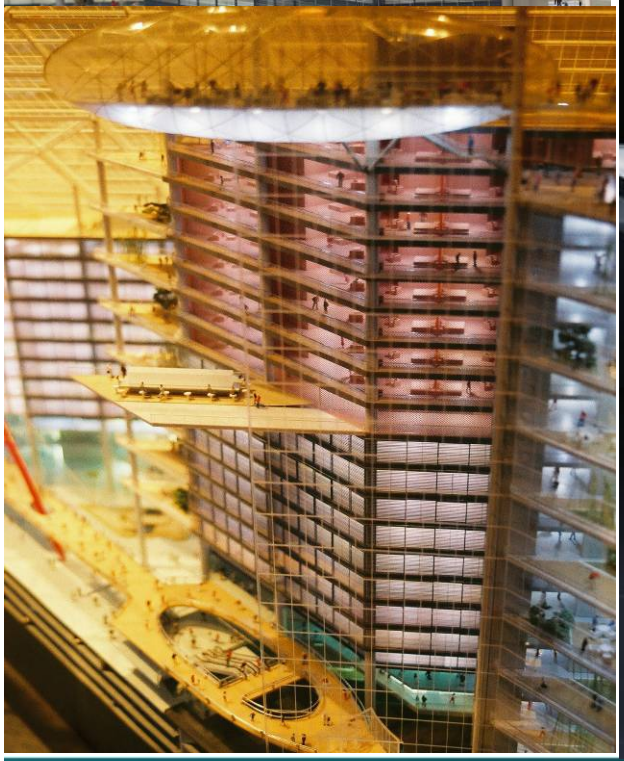

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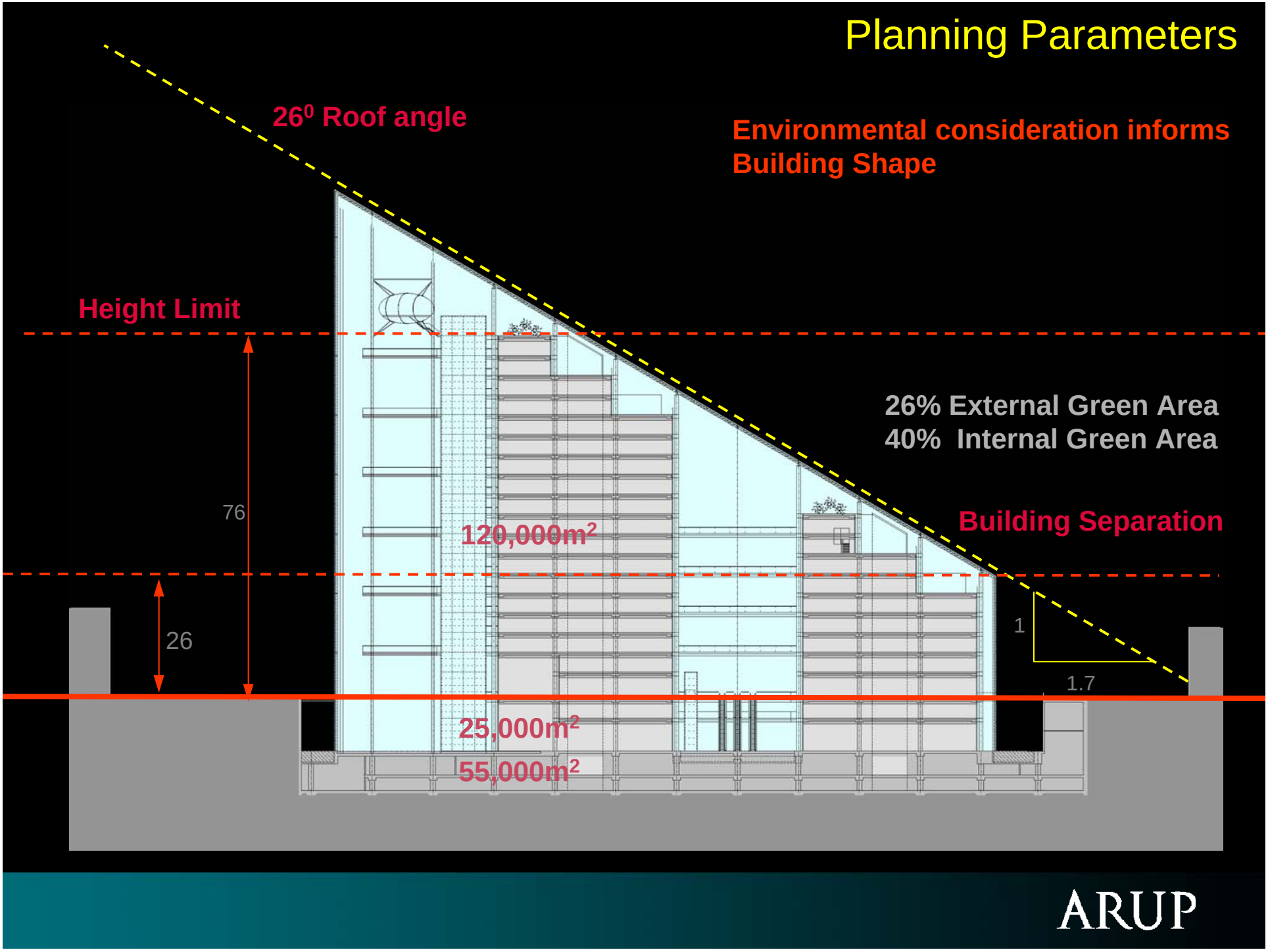
Planning Parameters



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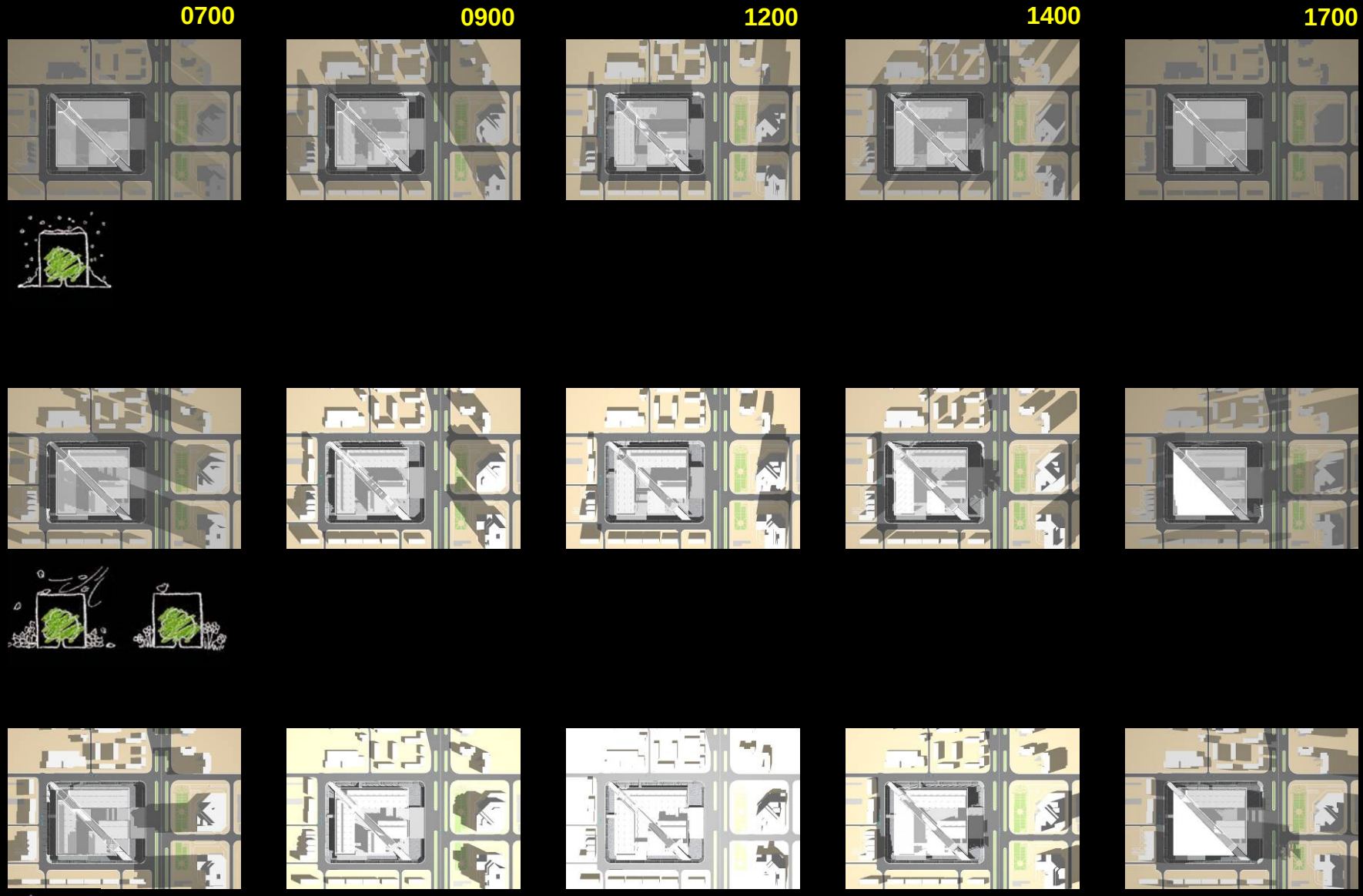

Daylight Analysis

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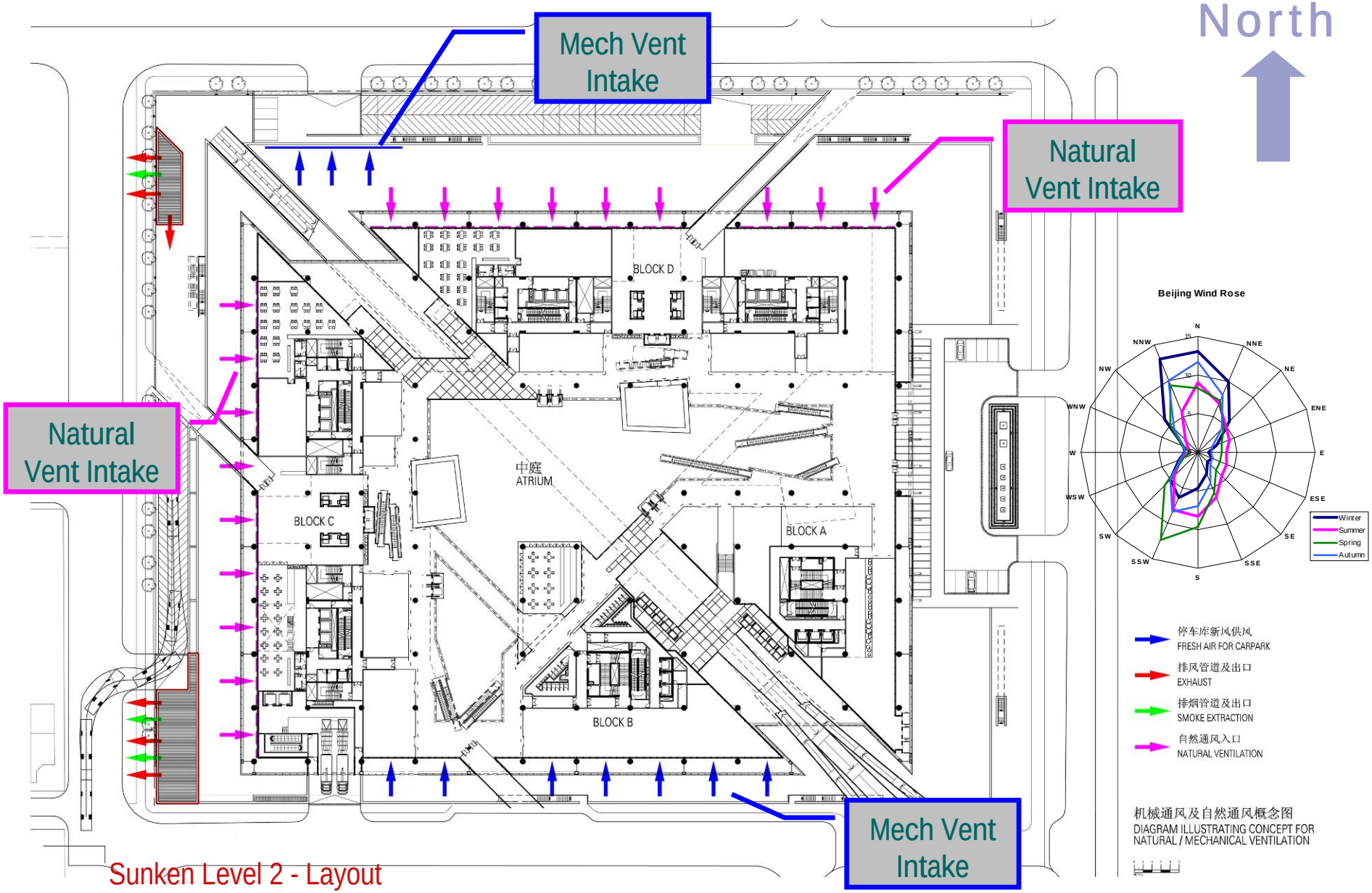

Sunken Level 2 - Layout

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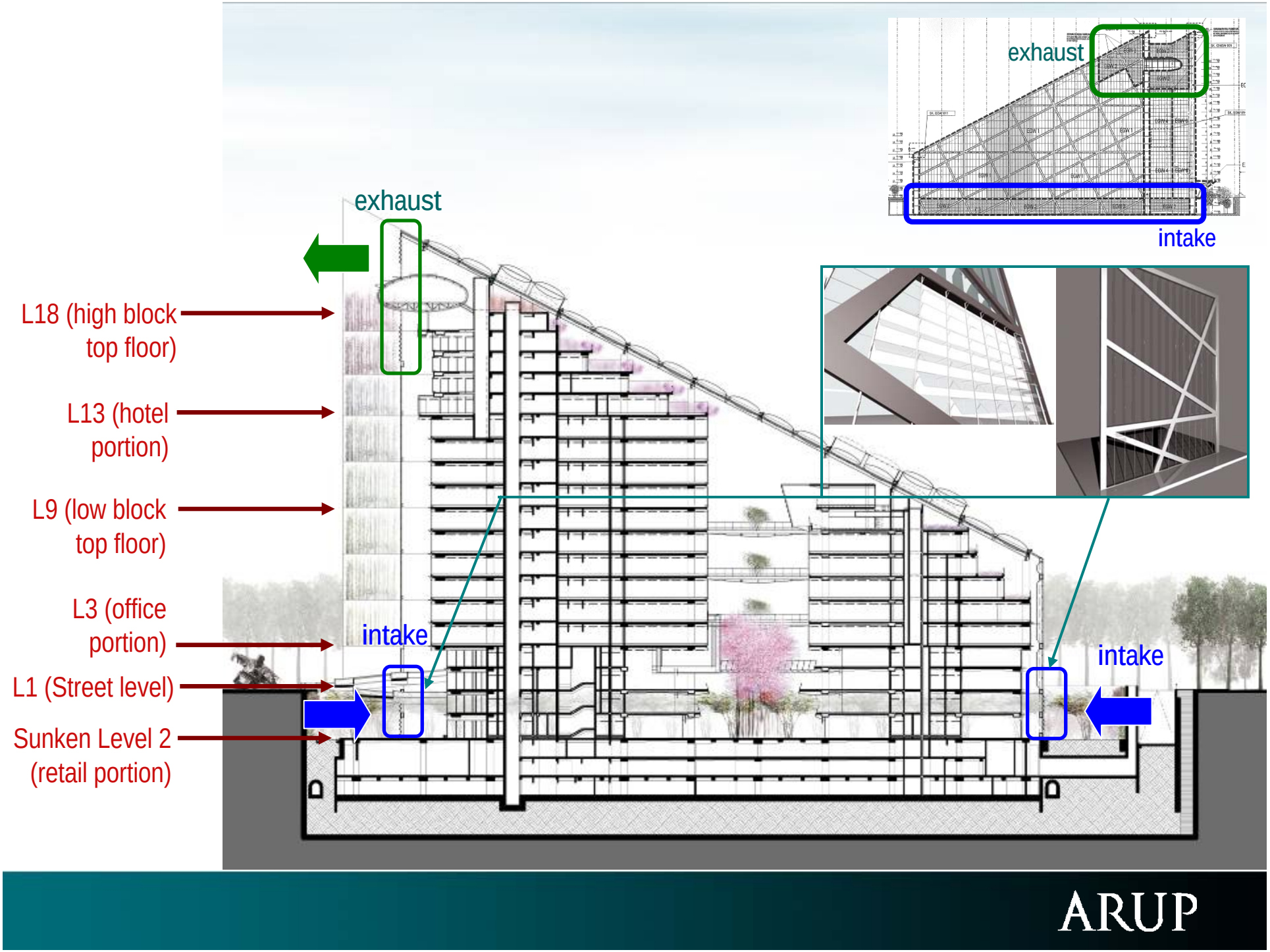
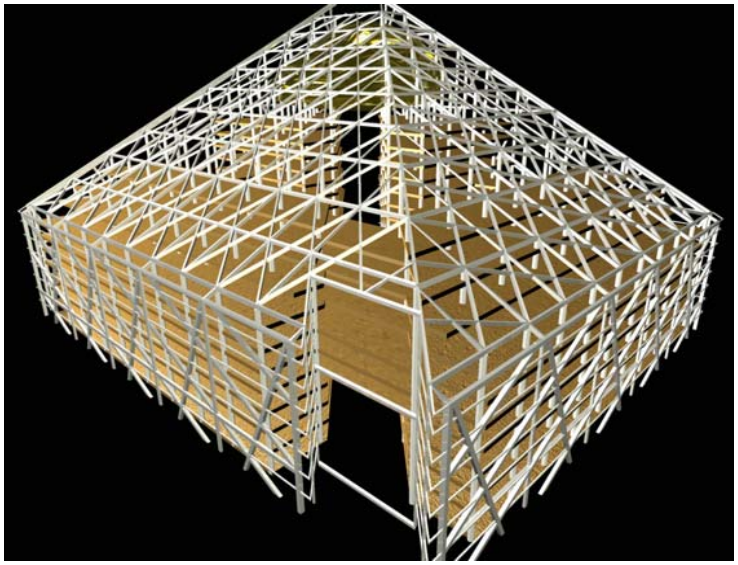

exhaust
intake
exhaust
L18 (high block top floor)
L13 (hotel portion)
L9 (low block top floor)
L3 (office portion)
L1 (Street level)
Sunken Level 2 (retail portion)
intake
intake

Fabric Construction of Microclimate Envelope

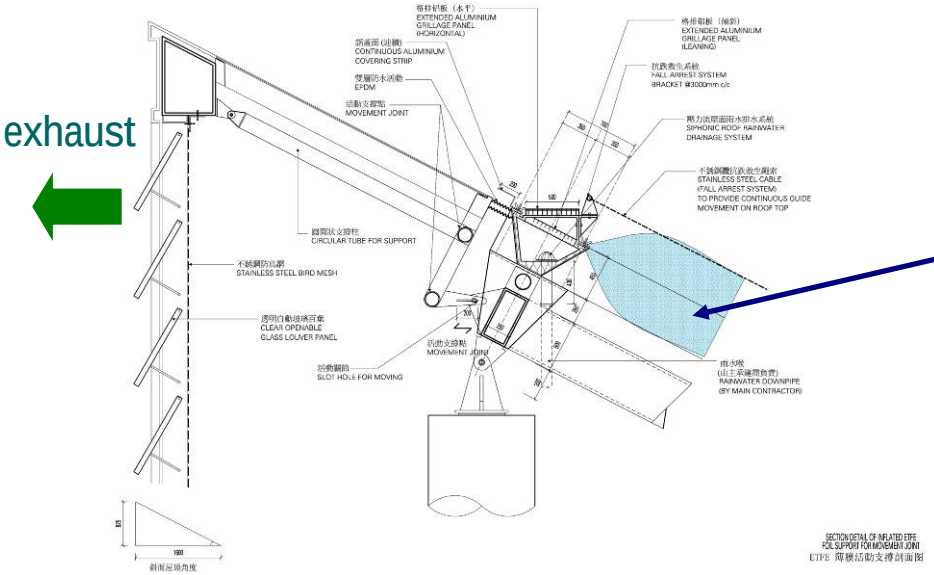
ETFE roof	overall U-value = 1.6, SC=0.4
Internal facade glaze	U-value = 1.6, SC=0.5
External facade glaze (facing buildings)	U-value = 1.6, SC=0.85
External facade glaze (4 facades connecting to atrium)	U-value = 1.6, SC=0.3
L9 glazed roof	U-value = 1.9, SC=0.3



ETFE Roof – Construction & Configuration

- All cushions are constructed from 2 or more layers of ETFE foil.
- Each foil layer is 100~250 microns thick.
- ETFE foils are highly elastic materials. Elongation at break point is approx. 400%.
- ETFE has a long-term memory, i.e. long-term elasticity.
- The cushion rise / dip for 15%~20% of span is allowed.
- Nominal inflation pressure 200Pa. (same as National Swimming Centre)
- Cushion foil and structure able to handle both wind up-lift and wind pressure.
- Cushion internal pressure to be controlled by air pump.

exhaust



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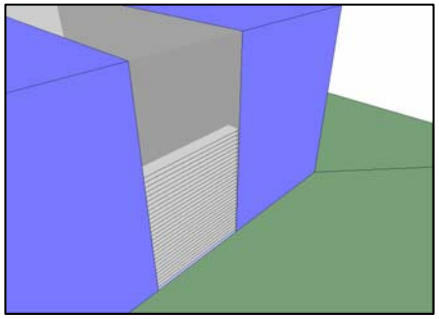
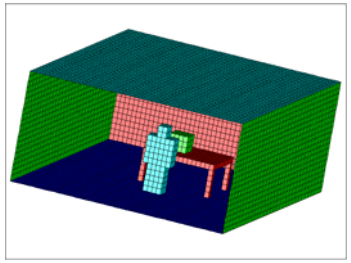
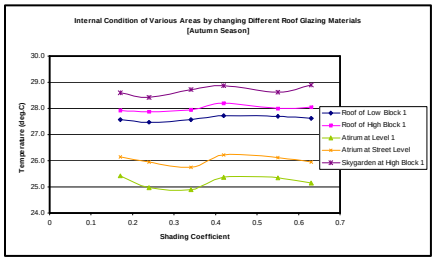
Overview of Green Features

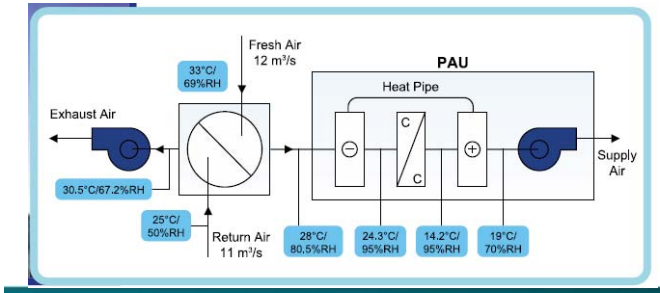
Green Features

- Hybrid ventilation and Night cooling in office
- Free cooling for air-side systems
- Skygraden
- Thermal break on facade interior (double skin facade)
- Daylighting
- Rainwater recycling
- AC condensate resued for cooling tower
- Evaporative cooling
- Heat Pipe
- Earth cooling in basement (fresh air pre-cool)
- Variable speed pump and ventilation fans
- Evaporative type water cooled air-conditioning









Technical Studies

- Hybrid ventilation
- Ventilated facade
- Ground source heat pump
- Photovoltaic system
- Heat pipe application
- Radiant cooling / heating
- Heat recovery chillers
- Building thermal and pressure distribution
- Building solar and daylight access
- Building energy simulation
- Ecological enclosure thermal and ventilation study
- Energy efficient air distribution system
- Air-side and water-side free cooling
- Outdoor and indoor cooling tower schemes
- Chiller plant heat rejection study
- And……..

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Hybrid Ventilation Design in Atrium Area

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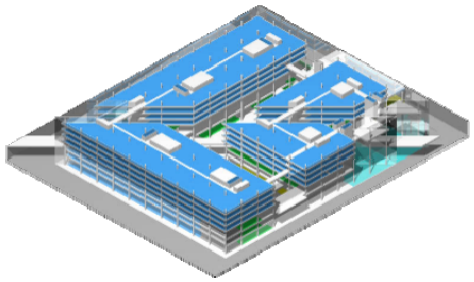
Microclimatic Envelope Design

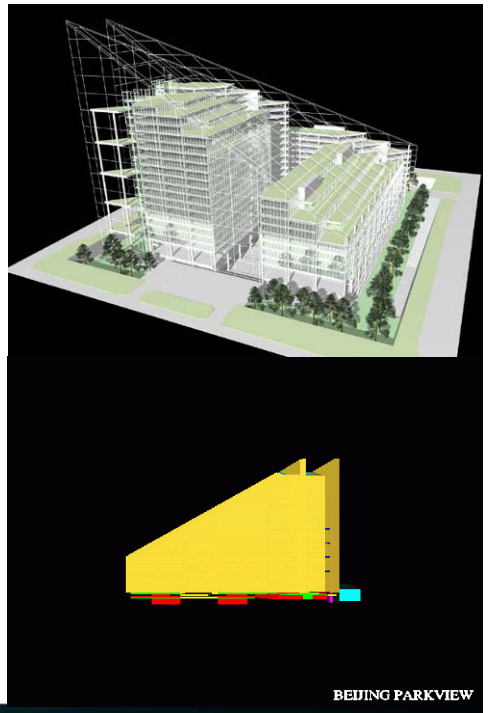
Function of Microclimatic Envelope



- **Spring & Autumn Seasons**
  - Introduce natural ventilation – enhance thermal comfort in Atrium and Sky-gardens
  - Introduce natural ventilation – reduce energy consumption for Office air-conditioning systems
  - Reduce energy consumption of air-conditioning system for other areas, I.e. Hotel and Retail by reduction of solar heat gain

- **Summer Season**
  - Reduce energy consumption of air-conditioning system for all areas, I.e. Office, Hotel and Retail by reduction of solar heat gain
  - Introduce natural ventilation – Increase the air movement inside the atrium and thermal comfort

- **Winter Season**
  - Isolation from freezing environment – Increase Atrium air temperature and thermal comfort
  - Reduce energy consumption of heating system by reduction of fabric heat loss



Microclimatic Envelope Design

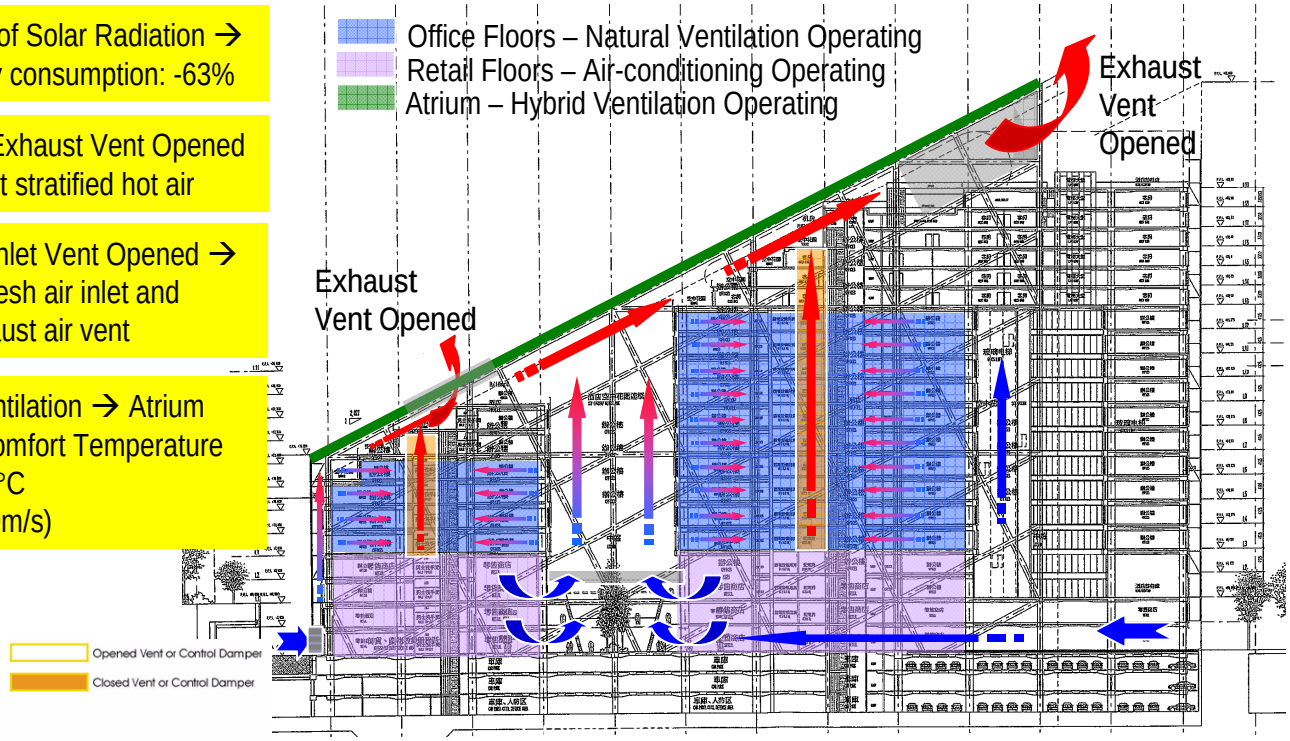
Spring & Autumn Seasons

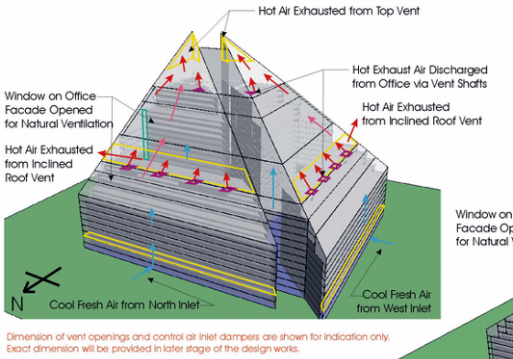
Reduction of Solar Radiation → A/C energy consumption: -63%

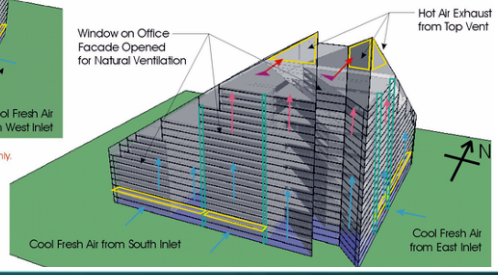
Envelope Exhaust Vent Opened → Vent out stratified hot air

Envelope Inlet Vent Opened → Increase fresh air inlet and assist exhaust air vent

Natural Ventilation → Atrium Thermal Comfort Temperature 29° C- 31°C (0.5m/s-1.0m/s)







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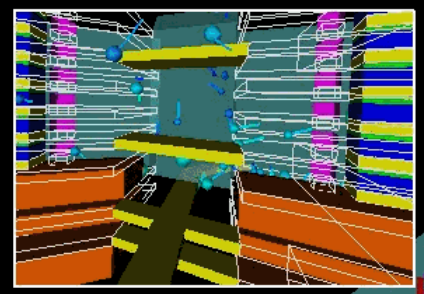
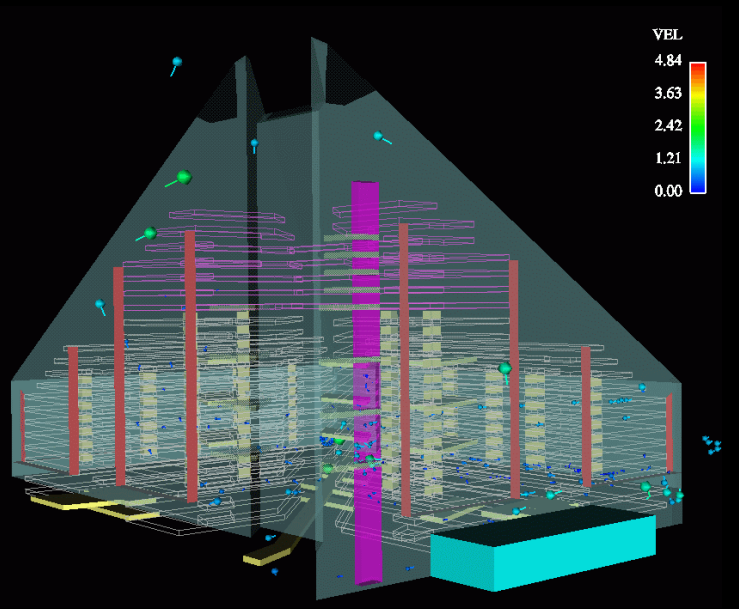
Natural Ventilation – windy condition





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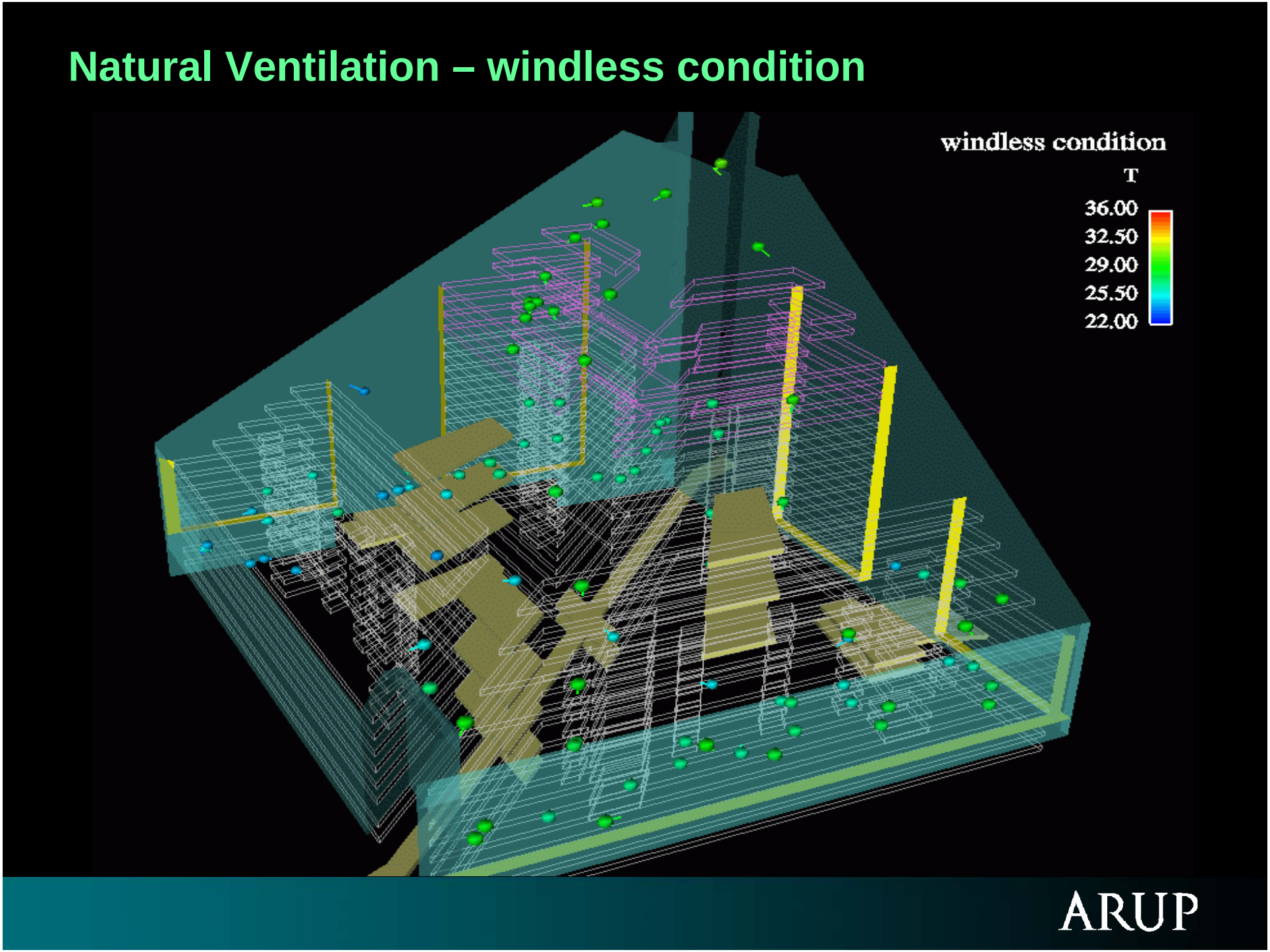
Natural Ventilation – windless condition



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Microclimatic Envelope Design

Summer Season

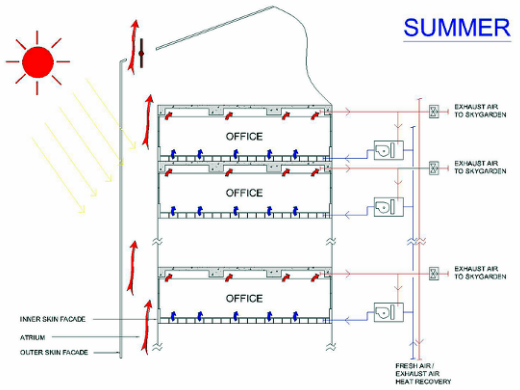
Reduction of Solar Radiation → A/C energy consumption: -13%

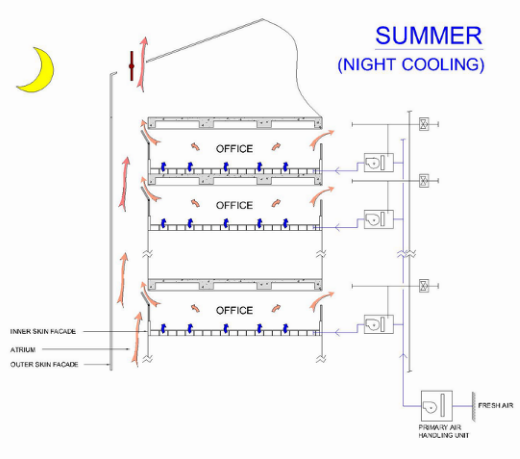
Envelope Exhaust Vent Opened → Vent out stratified hot air

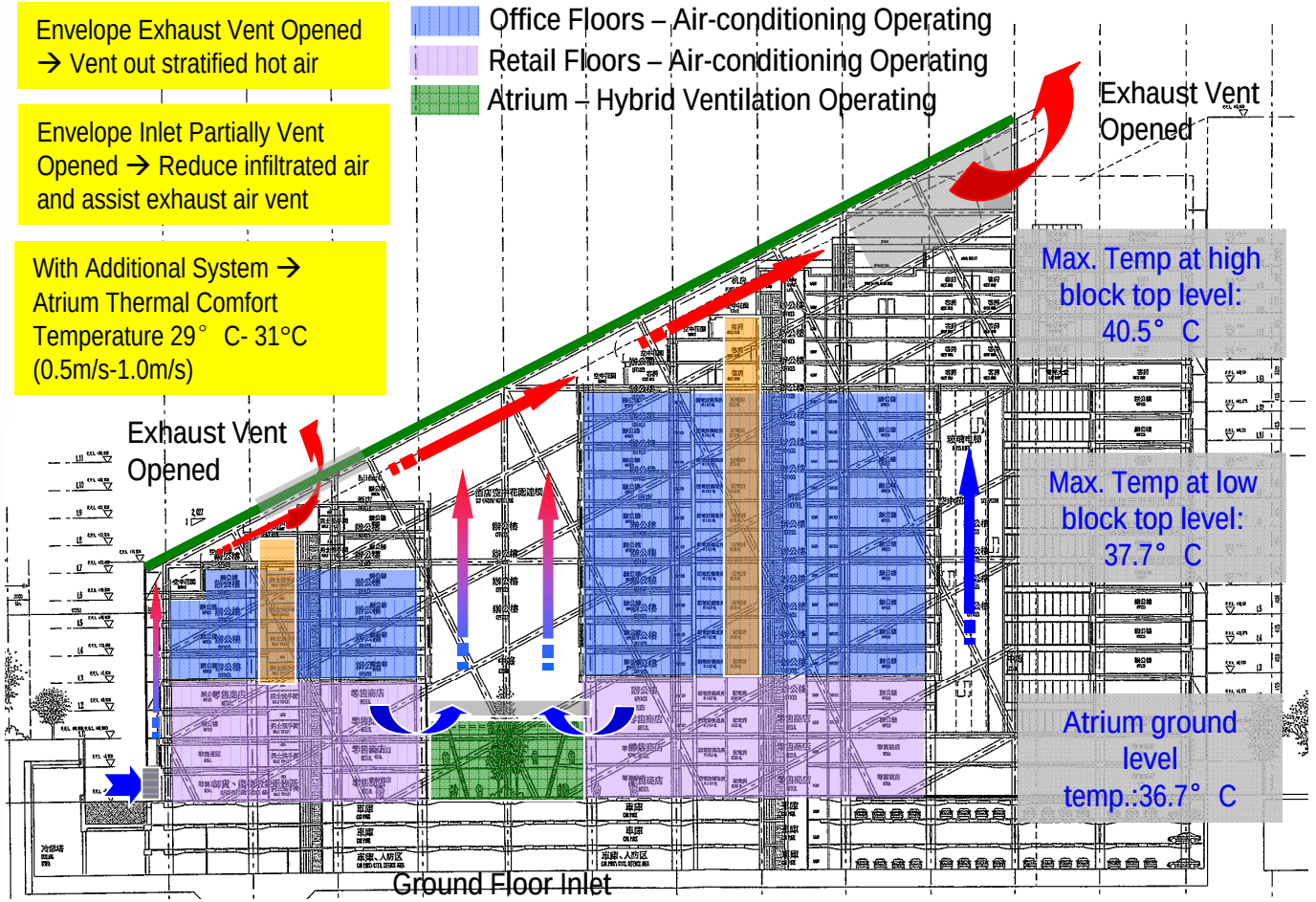
Envelope Inlet Partially Vent Opened → Reduce infiltrated air and assist exhaust air vent

With Additional System → Atrium Thermal Comfort Temperature 29° C- 31°C (0.5m/s-1.0m/s)

Summer outdoor temp: 35° C







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Microclimatic Envelope Design

Winter Season

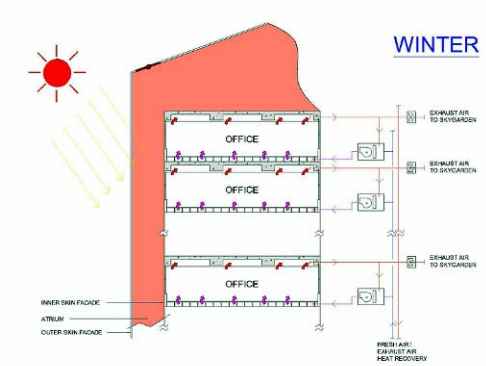
Additional Fabric Insulation → Heating energy consumption: 80%

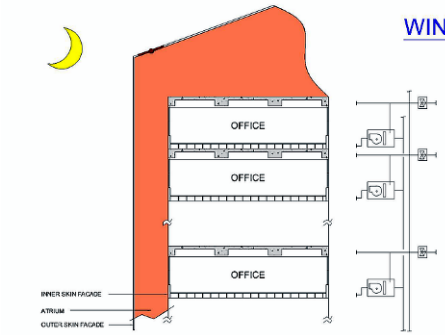
Envelope Exhaust Vent Closed → retain internal hot air

Envelope Inlet Vent Closed → Restrict freezing air infiltration and retain internal air temperature

With Additional System → Atrium Thermal Comfort Temperature 3° C - 10°C (< 0.5m/s)

Winter outdoor temp: -10° C





Office Floors – Air-conditioning Operating

Retail Floors – Air-conditioning Operating

Atrium – Hybrid Ventilation Operating

Exhaust Vent Closed

Max. Temp at high block top level: 7° C

Exhaust Vent Closed

Max. Temp at low block top level: 7° C

Atrium ground level temp.: 0° C

Ground Floor Inlet Vent Opened

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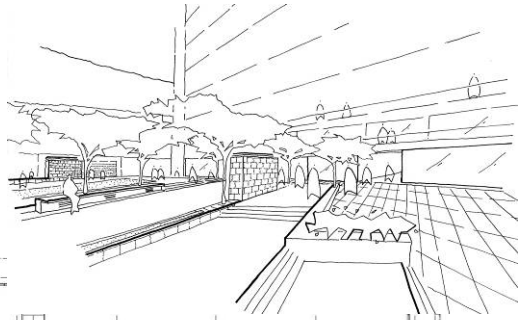
Energy Saving for HVAC System

Function of microclimate envelope – reduce system energy consumption

	System cooling / heating load (without microclimate envelope)	System cooling / heating load (with microclimate envelope)	Total AC energy saving
Spring & Autumn	Office = 10300 MWh Hotel = 530 MWh Retail = 4100 MWh	Office = 1700 MWh Hotel = 470 MWh Retail = 3300 MWh	**63% (cooling)**
Summer	Office = 9100 MWh Hotel = 540 MWh Retail = 3300 MWh	Office = 8000 MWh Hotel = 470 MWh Retail = 2700 MWh	**13% (cooling/ heating)**
Winter	Office = 4000 MWh Hotel = 340 MWh Retail = 1400 MWh	Office = 800 MWh Hotel = 70 MWh Retail = 280 MWh	**80% (heating)**

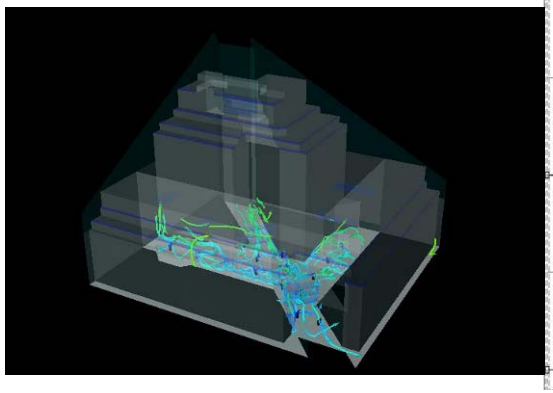
Atrium Comfort Improvement

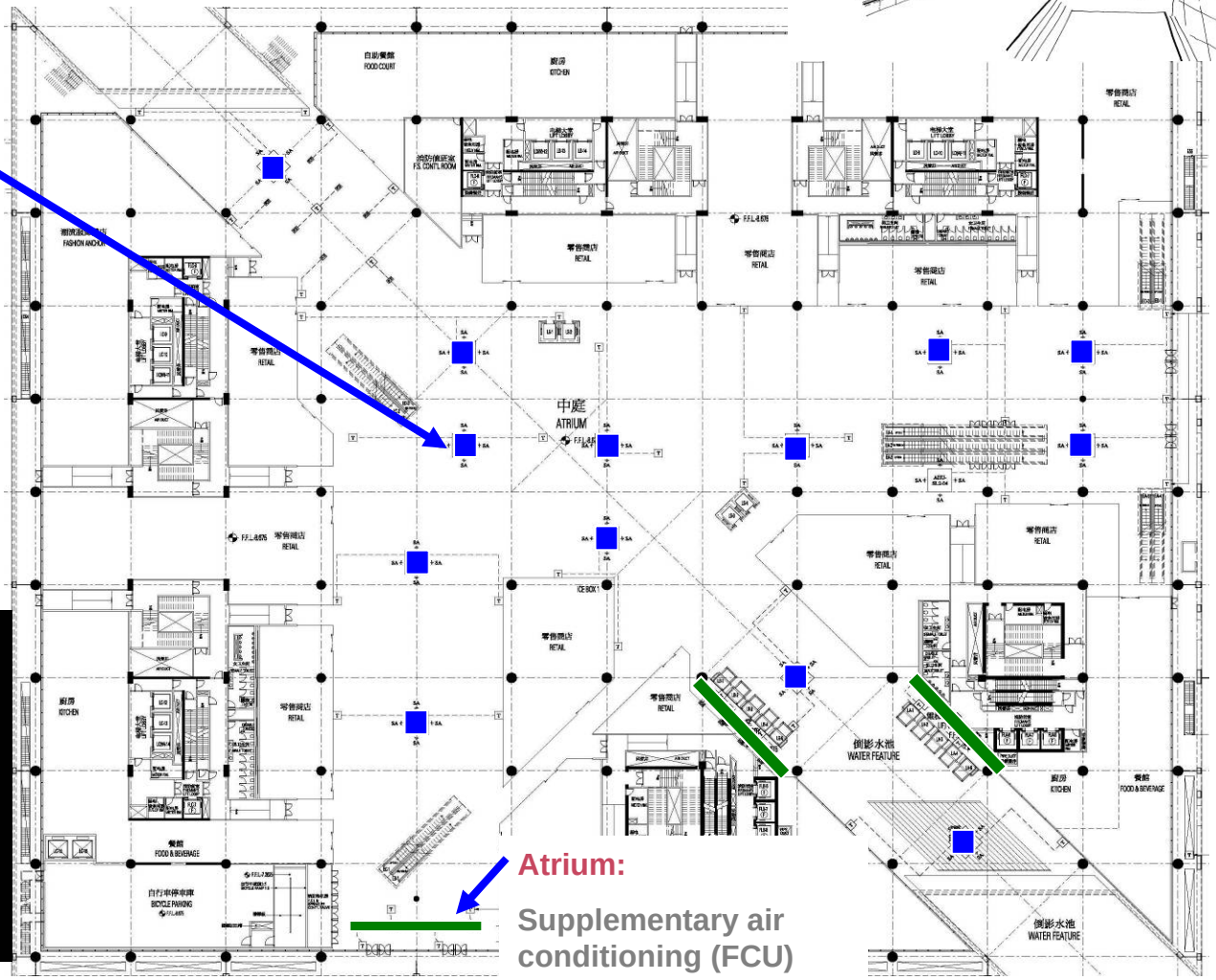
AC System Layout Plan at SL2 Atrium



Atrium:

Supplementary air conditioning (AHU)





Atrium:

Supplementary air conditioning (FCU)

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Atrium Comfort Improvement

Summer – SL2 Atrium Environment

Optional thermal environment improvement system	
Exhaust air reuse	Utilize retail exhaust Exhaust air flowrate 32 m^3/s SA temp 25.0°C
Atrium air supply system	Utilize office exhaust / atrium cooling unit SA flowrate 70 m^3/s SA temp 25.0°C
Radiant cooling	Less effective than supply air system, require chilled water supply, pipeworks cannot be laid under EVA
Pool evaporative cooling	Less effective than supply air system, require large amount of make-up water, condensation at retail shop glass surface adjacent to the pool

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Innovative HVAC Design

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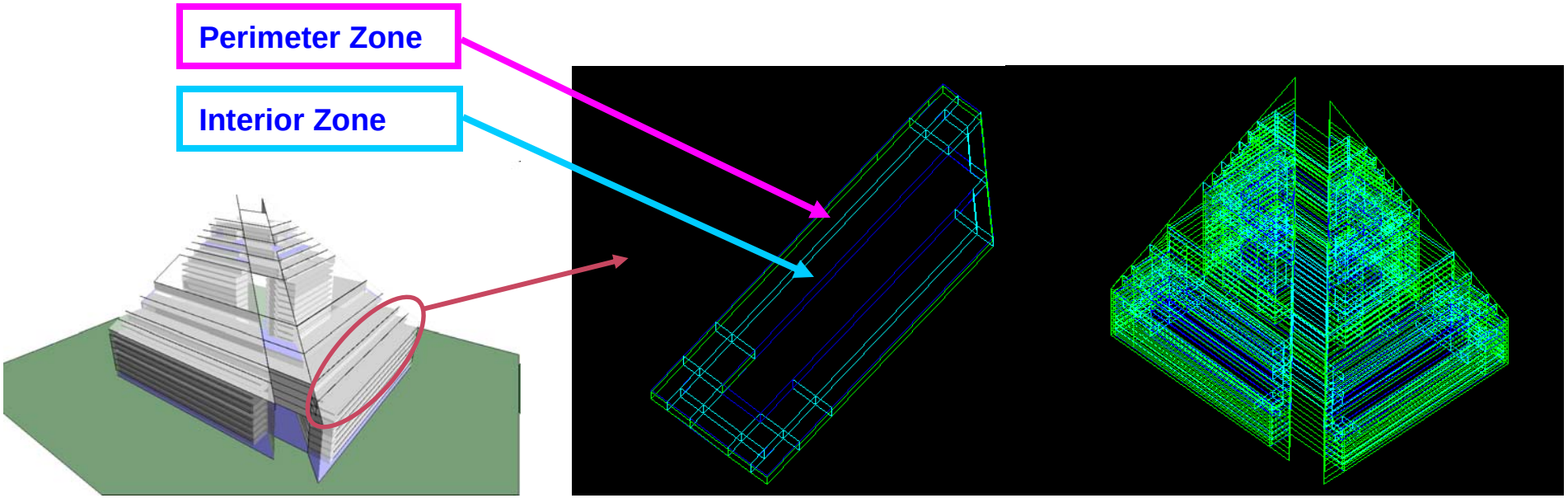
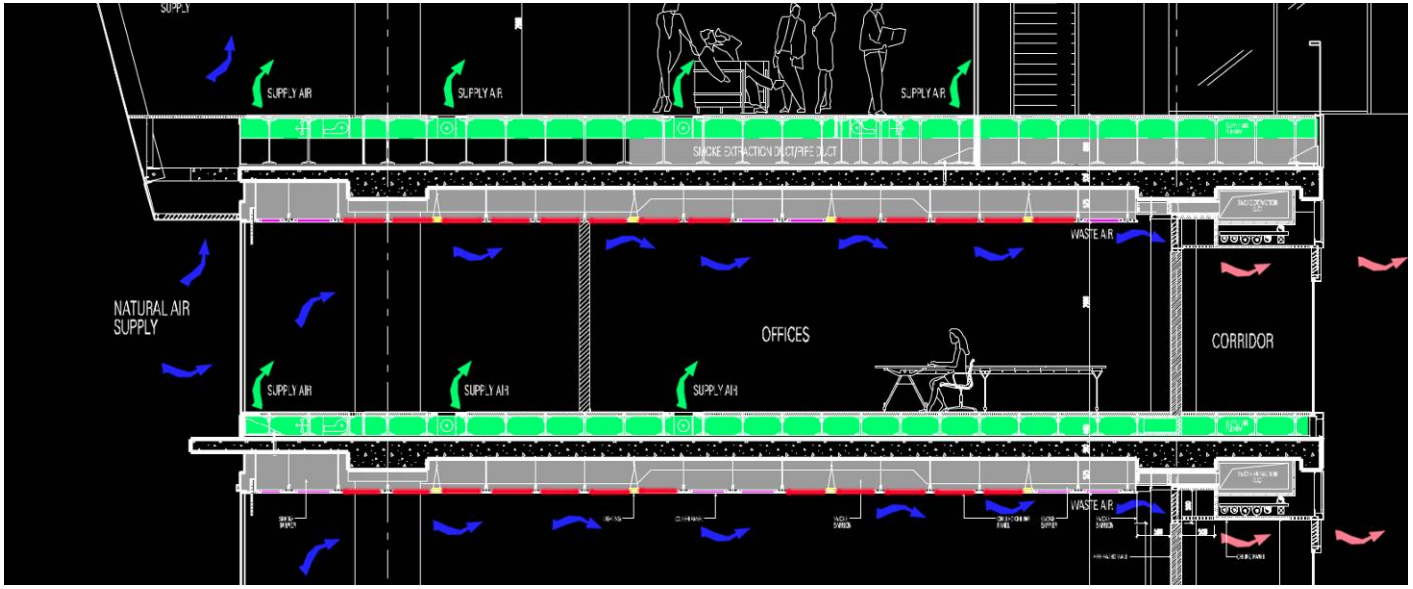
Load Estimation

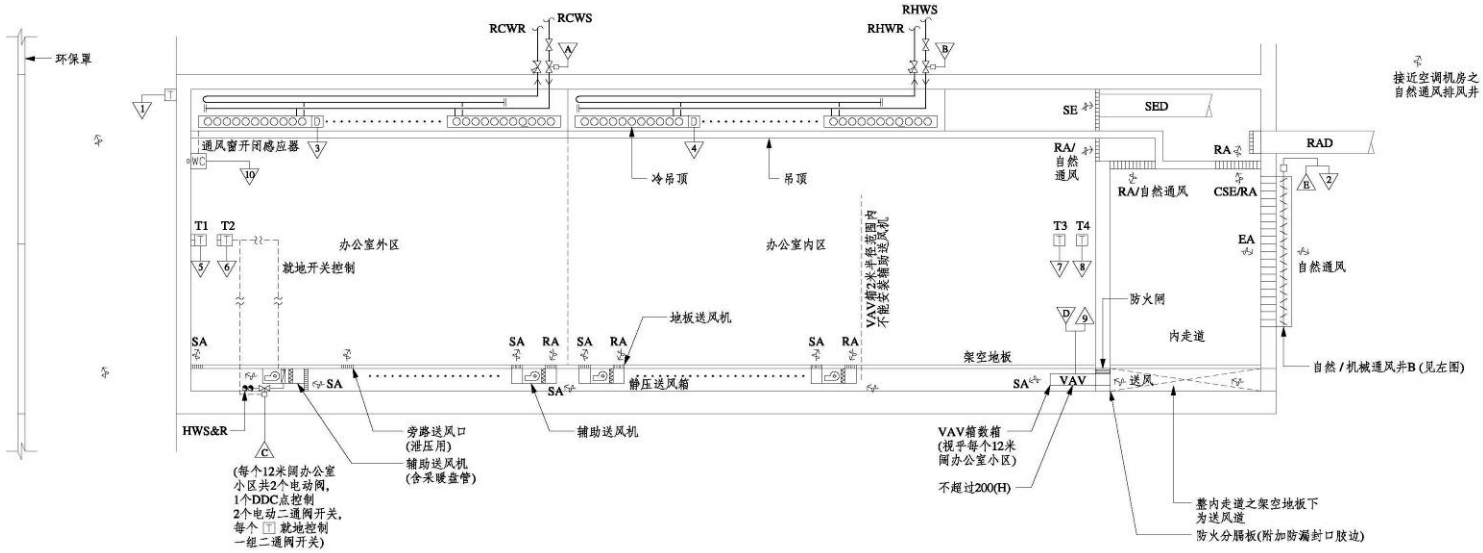
- Dynamic thermal analysis
- 3D model separated in different zones
- Heat transfer between building and the surroundings
- Consider solar heat gain, fabric gain, convective heat gain, internal load



Hybrid Ventilation System in Office



Chilled Ceiling & Underfloor Air Supply System in Office



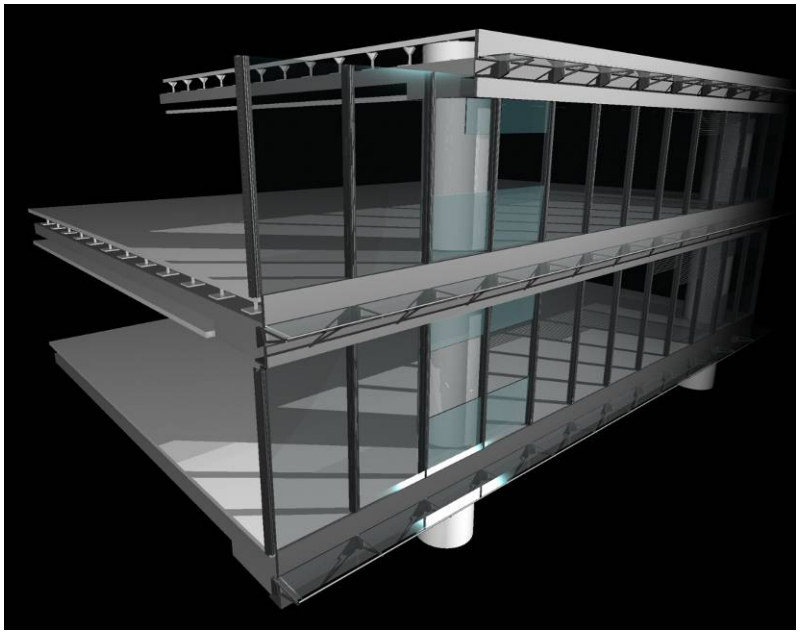
Control point for office AC system

Hybrid Ventilation Modes

Hybrid ventilation system will be adopted on office floors. Hybrid ventilation system consists of 3 individual operating modes:

- **Air Conditioning Mode**
- **Natural Ventilation Mode**
- **Free Cooling Mode**

- Provide pleasant internal temperature level
- Protect against summer overheating, reflection effects and draughts
- Eliminating “cold wall” effects and ingress of cold breeze in winter
- Reduce energy use for heating and cooling
- Encourage use of semi-outdoor space



Key Issues in Hybrid Ventilation

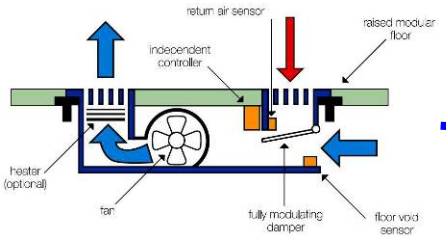
- Operational strategy for the microclimate envelope and all buildings in different seasons
- Air circulation and temperature distribution within the microclimate envelope
- Air circulation for hybrid ventilated space – office and circulation area
- Materials selection for the included roof of microclimate envelope
- Materials selection for different elevation of microclimate envelope and buildings
- Vent (intake & exhaust) openings design on microclimate envelope
- Air intake locations (orientation & level) and adjacent usages
- Control interface with HVAC systems
- Performance monitoring

Office Floors 办公室

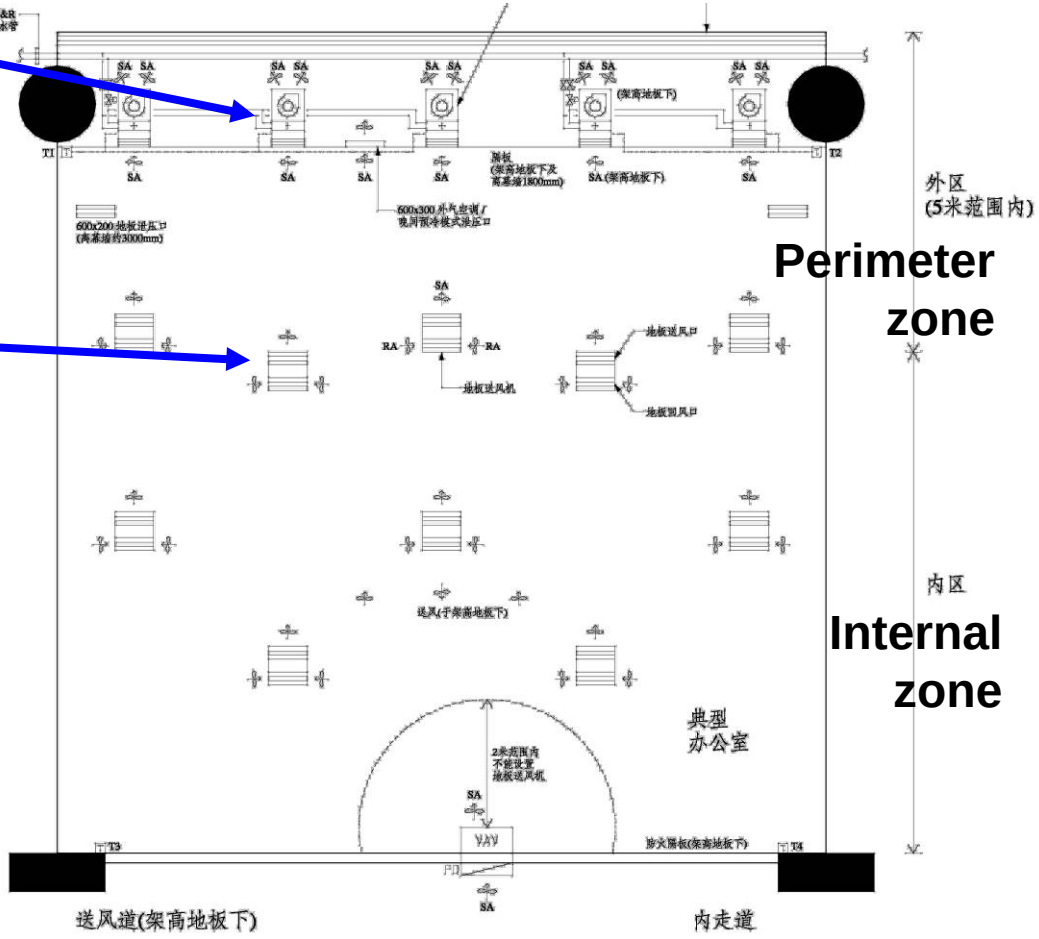
Underfloor AC system

Typical office (High block & Low block L3-7)

Underfloor fan box c/w hot water supply

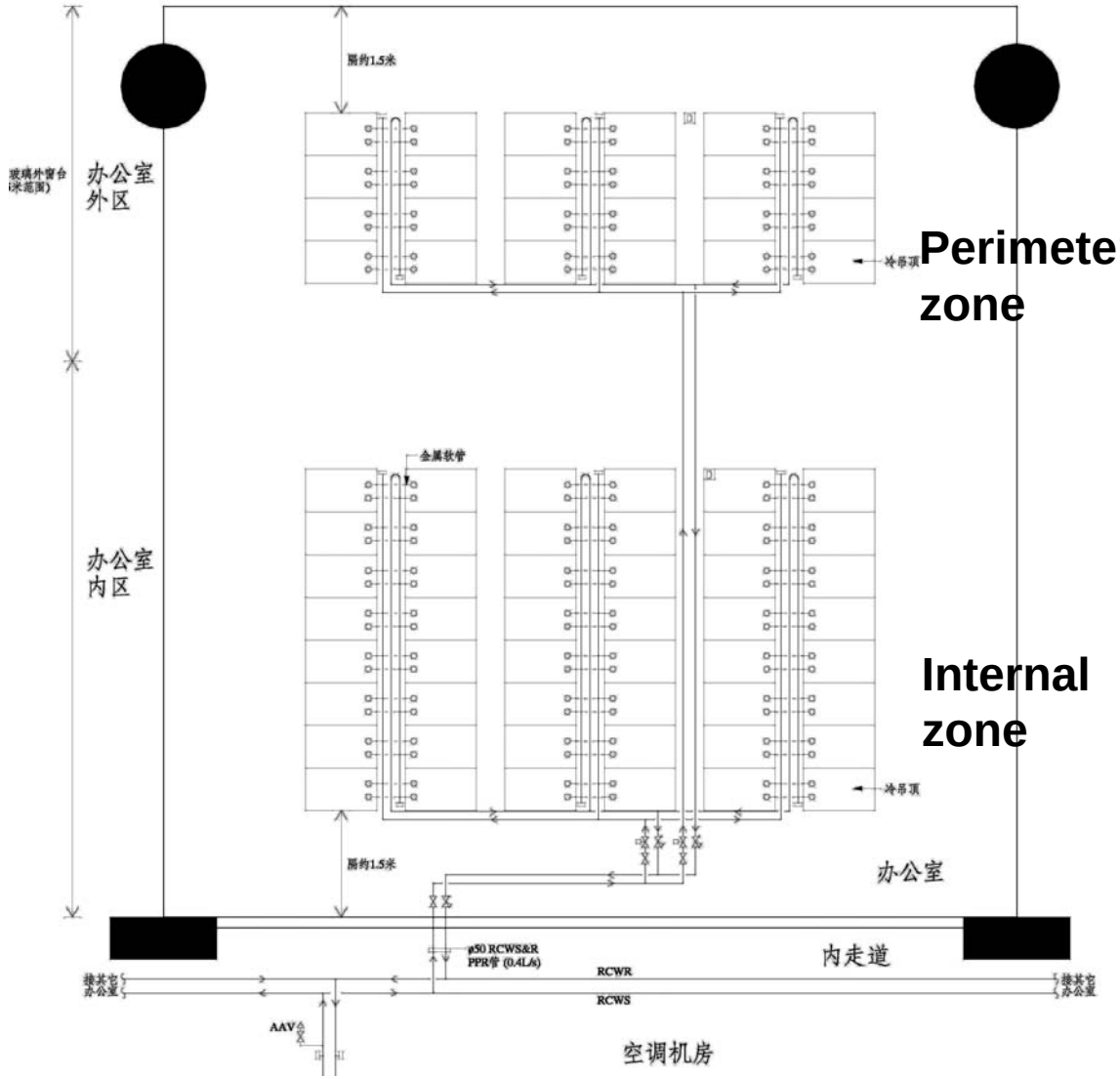


Underfloor fan box size 600x600



Office Floors 办公室

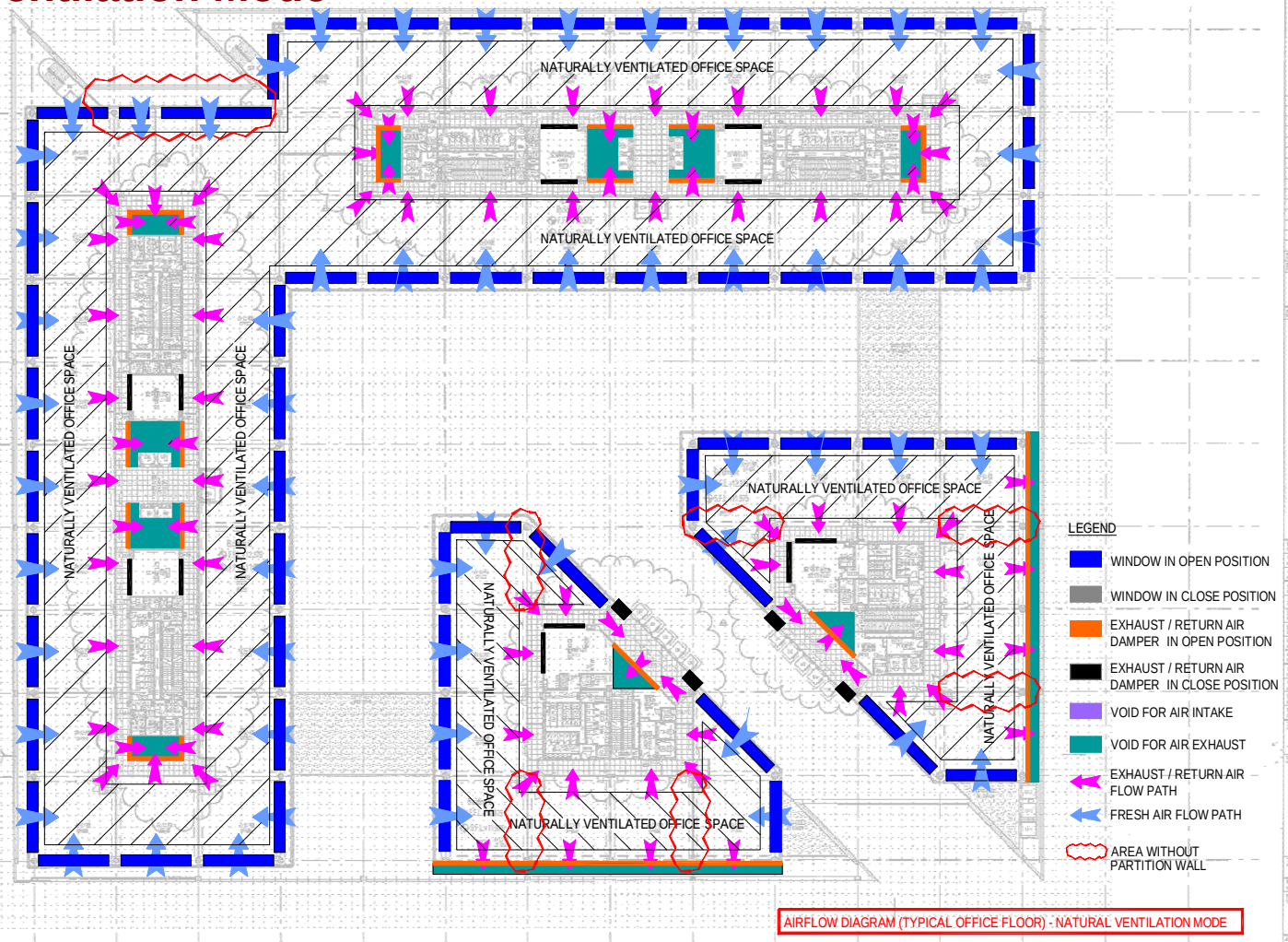
Chilled ceiling system



Typical office (12x12m2)

Office Ventilation Design

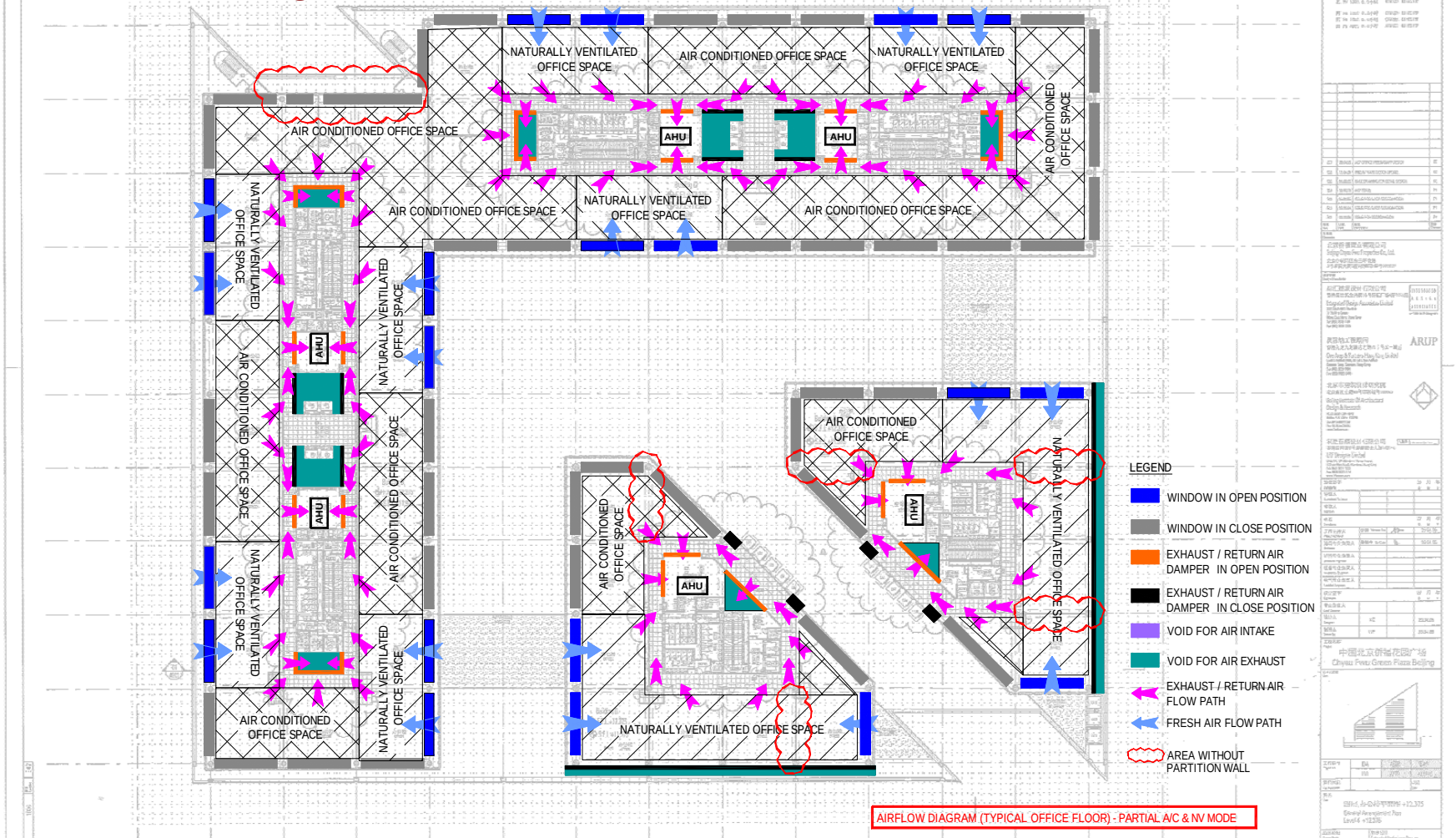
Natural Ventilation Mode



AIRFLOW DIAGRAM (TYPICAL OFFICE FLOOR) - NATURAL VENTILATION MODE

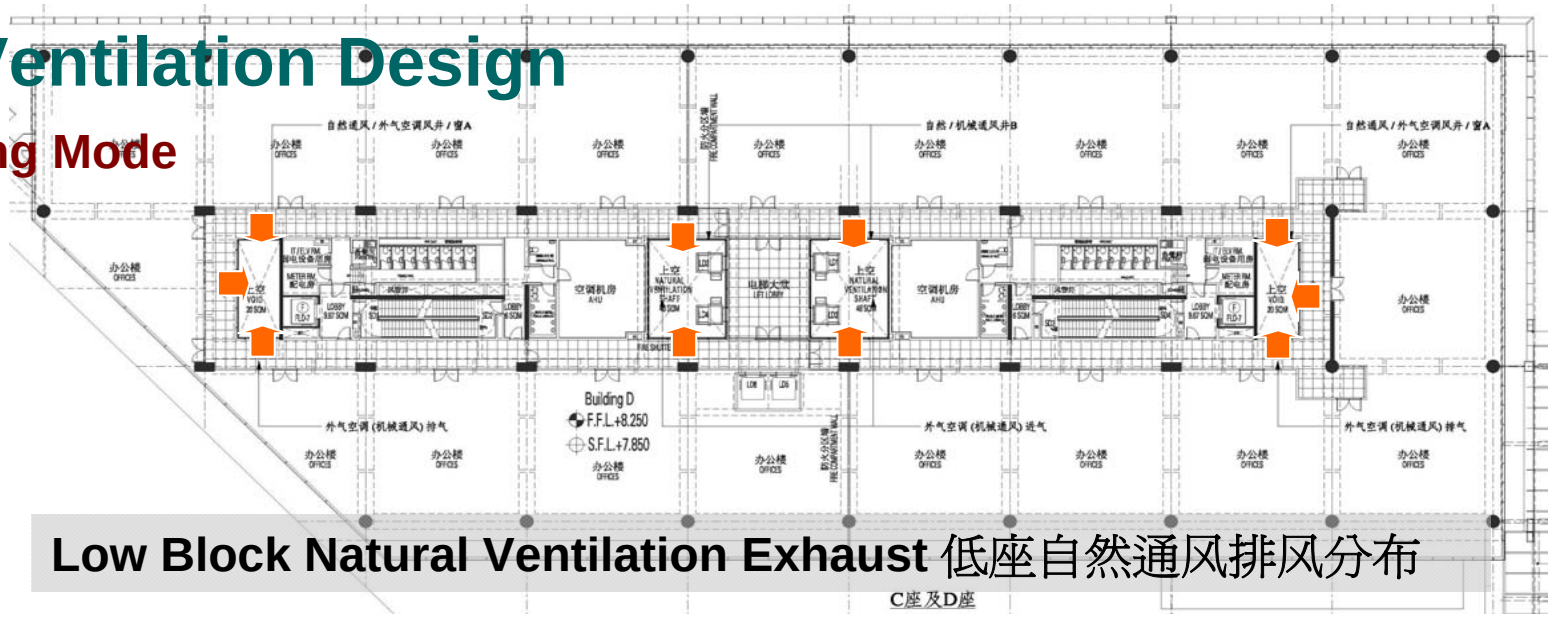
Office Ventilation Design

Air Conditioning Mode



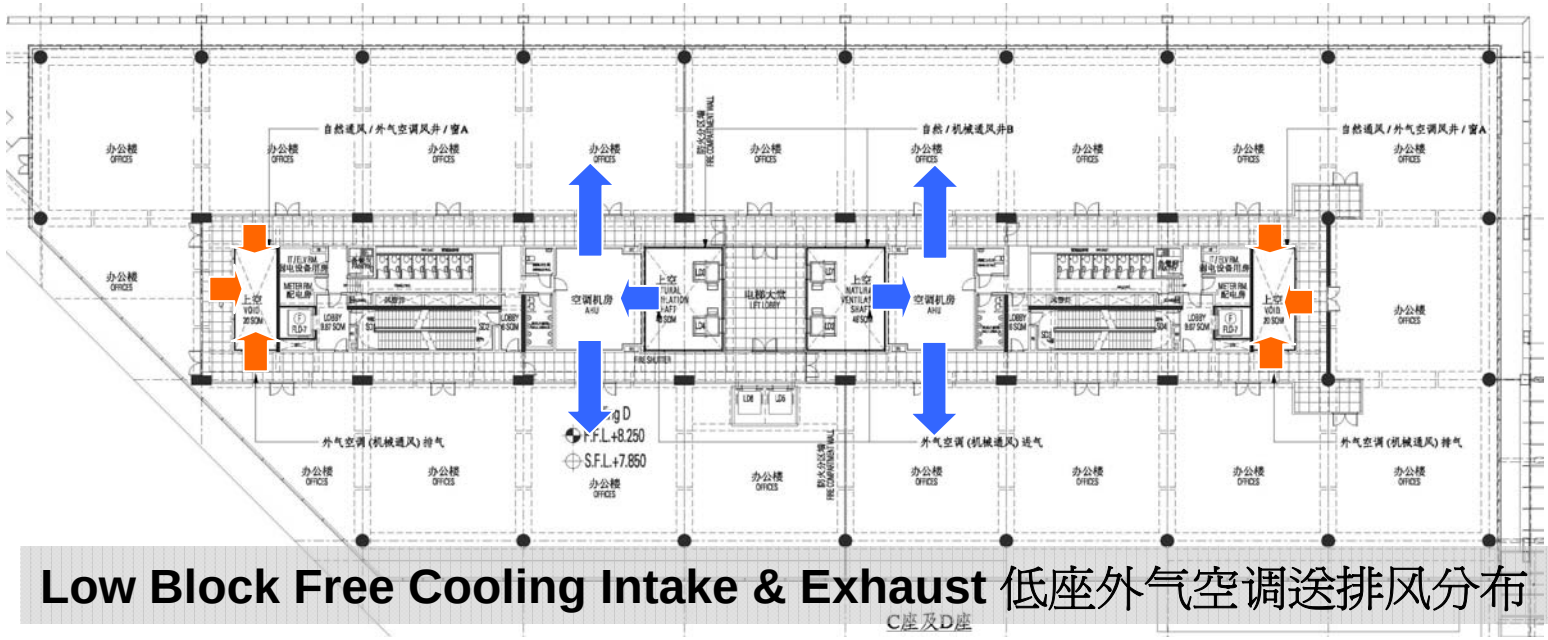
Office Ventilation Design

Free Cooling Mode



Low Block Natural Ventilation Exhaust 低座自然通风排风分布

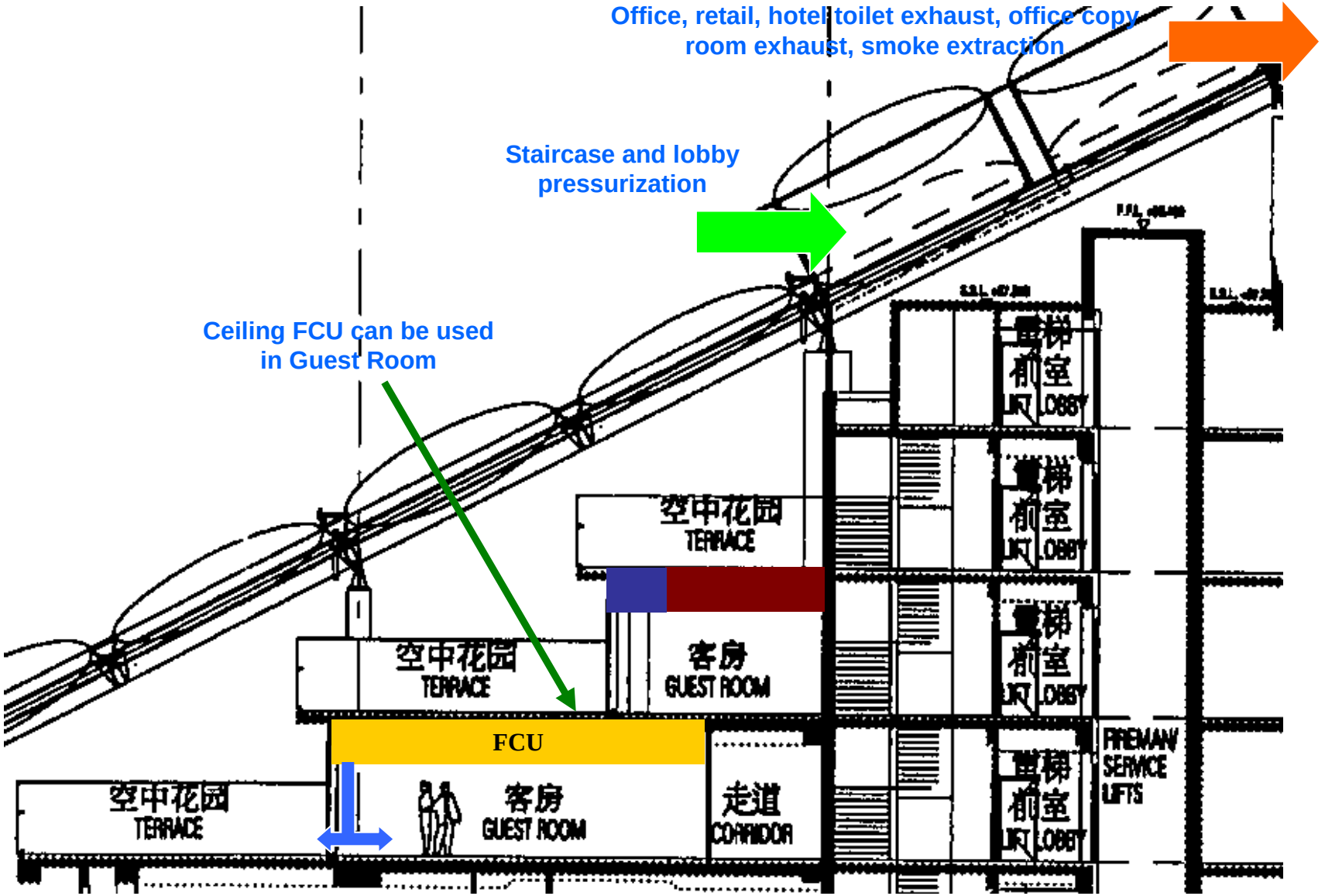
C座及D座



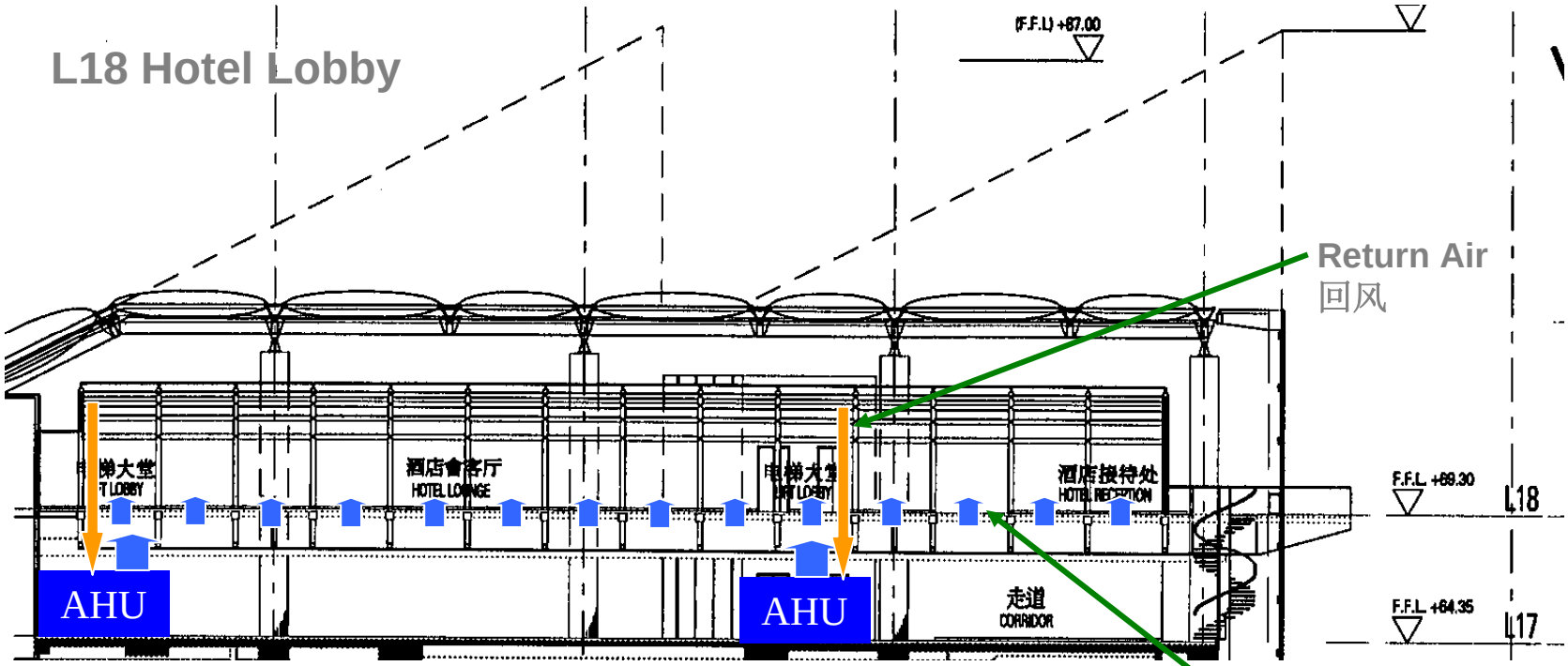
Low Block Free Cooling Intake & Exhaust 低座外气空调送排风分布

C座及D座

Hotel – HVAC Provision



Hotel Lobby – Underfloor AC System



6

Other Building Services Design Considerations

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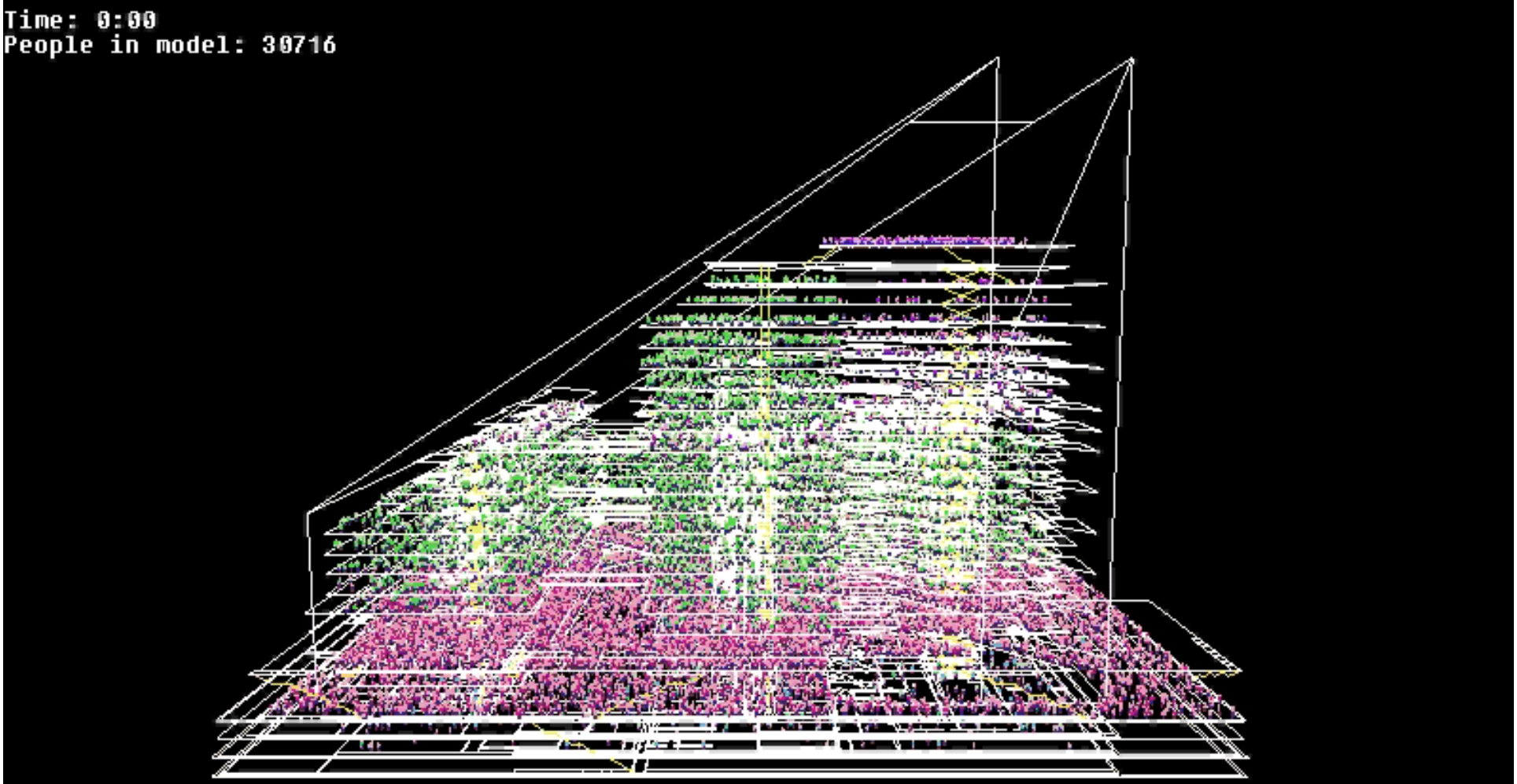
Fire Engineering – Evacuation Modelling



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7

Construction Progress

Site Construction Progress

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Construction of Microclimate Envelope

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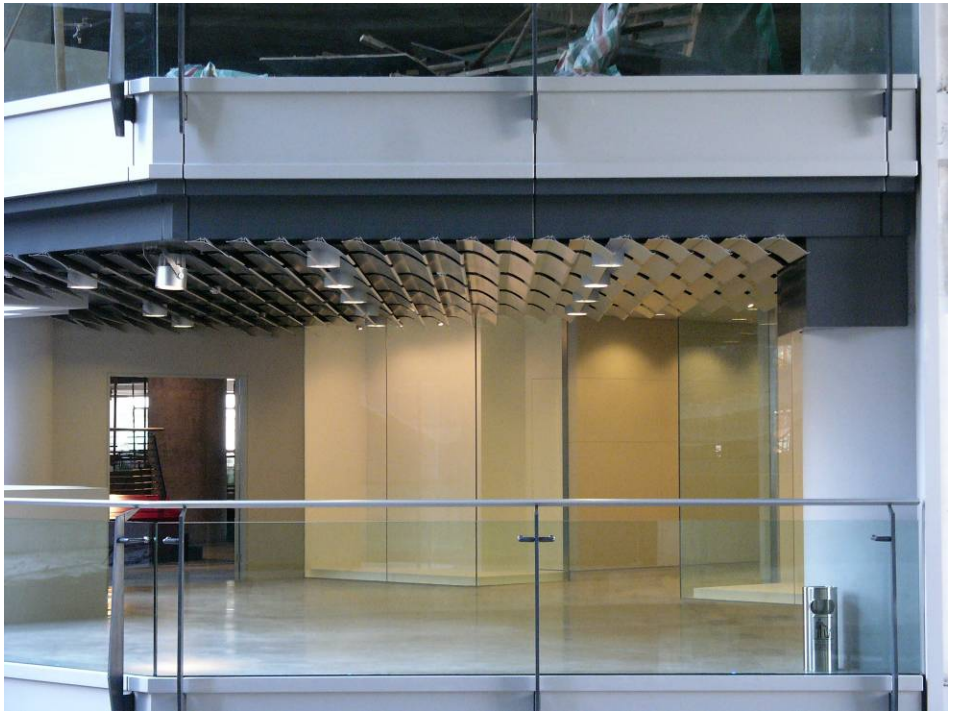

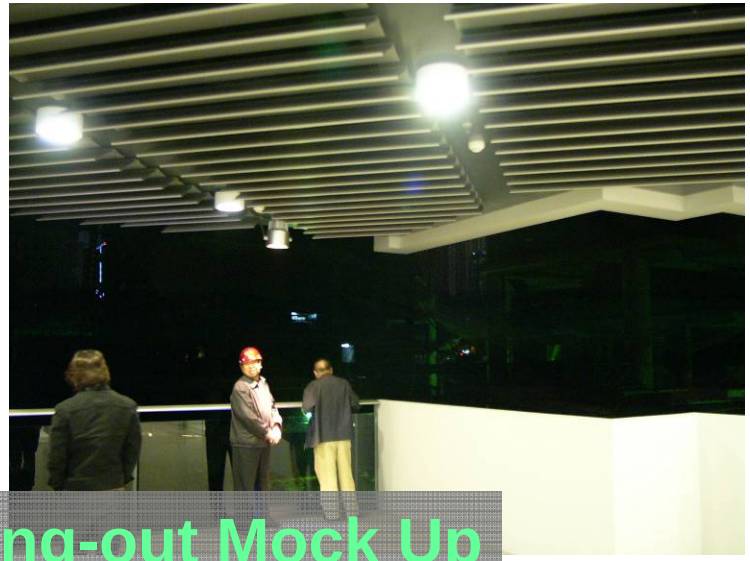

Interior Fitting-out Mock Up

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Thank You