Integrated Building Environmental Design
Case Study: Beijing Parkview Green

The 7th International Energy Agency Annex 44 Forum
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Dr Raymond Yau
Director
Ove Arup & Partners Hong Kong Ltd.
Building Information

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
Design Objectives

- New paradigm of sustainable building in China
- Sustainable & environmentally-friendly occupied areas
- 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 °C
- Average Outdoor Temp. of the Hottest Month (July) 25.9 °C
- Average Outdoor Temp. of the Coldest Month (Jan) -4.8 °C
- When outdoor 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%

Weather Condition in Beijing

- Mean
- Min
- Max

Location: Beijing, China
Lat: 39.6° N
Long: 116.4° E (Local Time: 6:00 AM)
Sun Path:
- June 21
- March 21
- September 21
- December 21
- January 1

Relative Humidity (%)

Month

- Jan
- Feb
- Mar
- Apr
- May
- Jun
- Jul
- Aug
- Sep
- Oct
- Nov
- Dec

Annual Average Outdoor Temp. 11.7 °C
Beijing Climatic Data - Wind

Summer prevailing wind:  SW
Winter prevailing wind:  N, NNW

- Sandy and dusty weather originated in Inner Mongolia, Gansu and the Ningxia Hui Autonomous Region will affect the region in spring season.

<table>
<thead>
<tr>
<th></th>
<th>Outdoor Air Speed (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annual</td>
</tr>
<tr>
<td>Average Wind Speed</td>
<td>2.5</td>
</tr>
<tr>
<td>Frequency of Occurrence</td>
<td>-</td>
</tr>
</tbody>
</table>
Architectural Design

4 buildings enclosed by Microclimate Envelope

Atrium space amongst buildings

Block A

Block B

Block C

Block D

Hotel

Offices

Retail
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North

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Natural Vent Intake

Sunken Level 2 - Layout

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Fabric Construction of Microclimate Envelope

<table>
<thead>
<tr>
<th>Material</th>
<th>U-value</th>
<th>SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETFE roof</td>
<td>1.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Internal facade glaze</td>
<td>1.6</td>
<td>0.5</td>
</tr>
<tr>
<td>External facade glaze (-facing buildings)</td>
<td>1.6</td>
<td>0.85</td>
</tr>
<tr>
<td>External facade glaze (4 facades connecting to atrium)</td>
<td>1.6</td>
<td>0.3</td>
</tr>
<tr>
<td>L9 glazed roof</td>
<td>1.9</td>
<td>0.3</td>
</tr>
</tbody>
</table>
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.
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…….
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

- 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)

Spring & Autumn Seasons
Natural Ventilation – windy condition
Natural Ventilation – windless condition
Microclimatic Envelope Design

- Summer Season
  - Summer outdoor temp: 35°C

- Office Floors – Air-conditioning Operating
- Retail Floors – Air-conditioning Operating
- Atrium – Hybrid Ventilation Operating

- Exhaust Vent Opened

- Ground Floor Inlet Vent Opened

- 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)

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

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ARUP
Microclimatic Envelope Design

Additional Fabric Insulation → Heating energy consumption: 80%

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

Office Floors – Air-conditioning Operating
Retail Floors – Air-conditioning Operating
Atrium – Hybrid Ventilation Operating

Winter outdoor temp: -10°C

Winter Season

Ground Floor Inlet Vent Opened

Exhaust Vent Closed

Exhaust Vent Closed

Restrict freezing air infiltration and retain internal air temperature

Envelope Exhaust Vent Closed →
retain internal hot air

Envelope Inlet Vent Closed →
Restrict freezing air infiltration and retain internal air temperature
# Energy Saving for HVAC System

Function of microclimate envelope – reduce system energy consumption

<table>
<thead>
<tr>
<th>Season</th>
<th>System cooling / heating load (without microclimate envelope)</th>
<th>System cooling / heating load (with microclimate envelope)</th>
<th>Total AC energy saving</th>
</tr>
</thead>
</table>
| 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)
## Atrium Comfort Improvement

### Summer – SL2 Atrium Environment

<table>
<thead>
<tr>
<th>Optional thermal environment improvement system</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Exhaust air reuse</td>
<td>Utilize retail exhaust</td>
</tr>
<tr>
<td></td>
<td>Exhaust air flowrate 32 m³/s</td>
</tr>
<tr>
<td></td>
<td>SA temp 25.0°C</td>
</tr>
<tr>
<td>Atrium air supply system</td>
<td>Utilize office exhaust / atrium cooling unit</td>
</tr>
<tr>
<td></td>
<td>SA flowrate 70 m³/s</td>
</tr>
<tr>
<td></td>
<td>SA temp 25.0°C</td>
</tr>
<tr>
<td>Radiant cooling</td>
<td>Less effective than supply air system, require chilled water supply, pipeworks cannot be laid under EVA</td>
</tr>
<tr>
<td>Pool evaporative cooling</td>
<td>Less effective than supply air system, require large amount of make-up water, condensation at retail shop glass surface adjacent to the pool</td>
</tr>
</tbody>
</table>
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
Office Ventilation Design

Air Conditioning Mode

Legend:
- WINDOW IN OPEN POSITION
- WINDOW IN CLOSE POSITION
- EXHAUST / RETURN AIR DAMPER IN OPEN POSITION
- EXHAUST / RETURN AIR DAMPER IN CLOSE POSITION
- VOID FOR AIR INTAKE
- VOID FOR AIR EXHAUST
- FRESH AIR FLOW PATH
- VOID FOR AIR FLOW PATH
- AREA WITHOUT PARTITION WALL
Office Ventilation Design

Free Cooling Mode

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

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

- New paradigm of sustainable building in China
- Sustainable & environmentally-friendly occupied areas
- Making of microclimate and maximize use of hybrid ventilation
- Low natural resources consumption and energy efficient buildings
- Cost effective and low O&M cost green technologies
- Good indoor environmental quality
Thank You