INTEGRATED SUSTAINABLE BUILDING DESIGN
CONCEPTUAL SOLUTION
OF A MUNICIPAL GOVERNMENT BUILDING IN BEIJING

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This is about:

- Realising the importance of applying systems that monitor and lower energy consumption in building design and their impact on the environment.
- Testing and applying systems for monitoring and minimizing energy consumption
- Benefits of using these systems
- Preservation of the environment
### Project goals, techniques and standards

**GOALS:**
- Sustainable and highly efficient municipal building with a low environmental impact through integrated building design
- Tendency to approach “Net Zero Energy” reduction of CO₂ emission
- High level of comfort required in a modern building

**TECHNIQUES:**
- High performance Envelope design
- HVAC system
- Luminance level controlled lighting
- Use of Photovoltaic panels
- Use of PCM (Phase change materials) in envelopes

**STANDARDS:**
- ASHRAE Standard 189.1 2014
- ASHRAE Standard 90.1-2013 (I-P)
- ASHRAE Standard 62.1-2013
- ASHRAE Standard 55
- ASHRAE Handbook HVAC Applications 2011
- LEED v4
Architectural report
Beijing, the capital of People’s Republic of China, one of the largest cities in the world, a place where tradition meets modern day culture. This complex and beautiful environment was the setting for our project.
Site and Accessibility:

- The building is located in the northern part of the city, named Huayuan Road District
- Jian’an Road, large ring road, high frequency location
- Numerous subway stations and bus lines surrounding the building location
- Cycling lanes
Concept and design:

The idea was to design an inviting structure, housing an important city attribute, a Municipal Government Building

- The design was guided by the location itself
- Long axis N-S, short axis E-W, following the city street grid
- Benefits of the Sun's energy and the beauty of daylight (large transparent surfaces on the facade)
- Southern and part of the Eastern facade tilted towards the ground forming 71° angle
- Large area covered with grass and vegetation
- Parking spaces (8) covered with PV panels
The architectural aspect of the building was simple. Providing the municipal government building with all of the required rooms and spaces, but also adding some features, like the skylight atrium for the office space and large glass facades for the common grounds, which contribute to the work environment comfort.
Mechanical Systems Design

Envelope:

- Steel framed walls which are easy to install
- Triple pane glass with low E-coating
- Insulating materials 90% produced out of recyclable materials

Benefits

- Low energy consumption
- High quality recyclable materials
- Achieved 17% lower sensible loads than prescribed in ASHRAE 90.1 2013
Mechanical Systems Design

Lighting:

- Window/Wall = 65%
- High amount of interior sunlight
- Lowering artificial light energy consumption

■ Dimmable LED panels 300x300mm
■ Dimmable LED panels 600x600mm

Lighting plan based on level of luminosity

■ 53% less installed power than when using Building Area Method from ASHRAE 90.1 2013 for lighting planning

Lighting control: Luminosity sensors and dimmers
Indoor environment quality (IEQ)

- Underfloor air distribution for high thermal comfort with an air distribution effectiveness of 1.0
- Treated air volume reduced to the occupied zone
- Lower necessary airflow and energy consumption
- Swirl diffusers enable the occupant to regulate the airflow
Mechanical Systems Design

CFD analysis:

- The average planned temperature of 23°C (cooling season) is achieved with inlet air temperature of 19°C.
- Temperature difference between the floor and the high of 1.80m, does not exceed 3.5°C.

CFD: Small office

- 50% lower flow rate than calculated by ASHRAE 62.1.
Mechanical Systems Design

CFD analysis:

- The average planned temperature of 23° C (cooling season) is achieved with inlet air temperature of 19° C.
- Temperature difference between the floor and the high of 1.80m, does not exceed 3.5° C.

Only 6% increase in flow rate, relative to the small office space.
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HVAC system:

- Dedicated Outdoor Air System with heat recovery equipment constantly provides 100% freshly treated outdoor air to the occupants
- Minimizing the amount of fresh air usage is lowering the cost of heating and cooling systems
- Airflow of 14.5 m3/sec
- Infloor active chilled beams cover additional solar heat gains
- Sensible heat from the return air is recovered with heat recovery wheel
Ground source heat pumps:

- 4 identical heat pumps (heating/cooling capacity of 40kW each)
- 42 holes (diameter: Ø150mm, depth: 100m)
- Layout: 10m×10m, on the northern side of the site

The Ground Source Heat Pump system and HVAC system are situated in the basement. All the pumps are steered by a CPU cascade control system, so only one heat pump works on low demand and all of them work on peak demand.
Mechanical Systems Design

Arguments in favor of selecting Ground Source Heat Pump system:

- Building Site is suitable for both ground- and groundwater source heat pumps systems
- Several Ground Source Heat Pump with total nominal power of approximately 150 kW would cover both heating and cooling peak loads, and serve as spare service water heater
- Conditions in most thermal zones are similar, this means all zones can by treated by the same HVAC system
- If combined with PV panels, the CO2 emission would be reduced to a considerable extent, giving possibility for Greenhouse Gases reduction incomes in following years of system utilization
Photovoltaic System:

- Total number of 153 PV panels (230W each)
- Total nominal power of 35.2kW
- Shading losses are estimated to be up to 0.35%
- Estimated annual electricity production is 51 MWh (over 23% of annual electricity consumption)
Phase-change materials (PCM):

- PCM panels are installed in floor surfaces
- Activation temperature range: 22-24°C
- Approximate heat absorption capacity: 155 kJ per panel

<table>
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<th>Location</th>
<th>Peak hours window transmitted beam solar radiation energy (kJ)</th>
<th>Length (m)</th>
<th>Number of tiles</th>
<th>Capacity (kJ)</th>
<th>% absorbed</th>
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Table shows solar beam radiation energy transmitted through windows (for 21st July) and total heat capacity of PCM floor panels if they were arrayed alongside the curtain walls in 3 or 4 rows stretching to 1.8m or 2.4m inside the space area. Depending on the area covered by PCM panels, heat capacity of the floors range from 15% to 49% of the direct solar radiation energy transmitted through fenestration.
Mechanical Systems Design

PCM panels installed in the floor of the building interior
Conclusion

Integrated design contributed to the creation of a modern, energy efficient and LEED certified (Platinum Rating) administrative building with:

- Annual (electrical) energy consumption of 83.5 kWh/m²
- 17% decrease of thermal loads achieved with high performance building envelope
- 23% electricity needs covered by PV panels
- Lighting power needs reduced by 53% through lights selection based on illumination level
- Acceptable thermal comfort and air quality using adequate air filters and underfloor air distribution
Thank you

Presented by:

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