PEARL RIVER TOWER
GUANGZHOU, CHINA

BY
LUKE LEUNG

OF
SKIDMORE, OWINGS & MERRILL
1. Category (Check one and indicate New or Existing, if applicable)
   - Commercial Buildings
     - ☑ New or ☐ Existing
   - Institutional Buildings:
     - ☐ Educational Facilities
       - ☐ New or ☐ Existing
     - ☐ Other Institutional
       - ☐ New or ☐ Existing
     - ☐ Health Care Facilities
       - ☐ New or ☐ Existing
     - ☐ Industrial Facilities or Processes
       - ☐ New or ☐ Existing
     - ☐ Public Assembly
       - ☐ New or ☐ Existing
     - ☐ Residential (Single and Multi-Family)
       - ☐ New or ☐ Existing

2. Name of building or project: Pearl River Tower
   City/State: Guangzhou, China

3. Project Description: 309 m Corporate Tower
   Project Study/Design Period: 2006 (design start) to 2012
   Begin date (mm/yyyy) to End date (mm/yyyy)
   Percent Occupancy at time of submission:

4. Entrant (ASHRAE member with significant role in project):
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     ▬ Chapter: Illinois (049)
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   e. Member's Role in Project: Lead MEP Engineer
   f. Member's Signature: [Signature]

5. Engineer of Record: Guangzhou Design Institute

By affixing my signature above, I certify that the information contained in this application is accurate to the best of my knowledge. In addition, I certify that I have discussed this entry with the owner and have received permission from the owner to submit this project to the ASHRAE Technology Awards Competition.
PEARL RIVER TOWER

SUBMISSION FOR THE 2012 ASHRAE TECHNOLOGY AWARDS, ILLINOIS CHAPTER

The 2.3 million square-foot Pearl River Tower redefines what is possible in sustainable design by incorporating the latest green technology and engineering advances. The 809-meter tower's sculpted body directs wind to 49 pairs of openings at its mechanical floors, where traveling vortex pulsar turbines which generate energy for the building.

The design for the tower incorporates a series of other integrated sustainable and engineering elements including solar panels, double skin curtain wall, chilled ceiling system, under floor ventilation and natural daylight harvesting, all of which contribute to the building's energy efficiency.
Pearl River Tower

The Pearl River project, located in Guangzhou, China, weaves together highly innovative, yet proven, technologies that work together to significantly reduce the amount of energy required to operate the building's infrastructure. These systems also provide a level of human comfort and indoor air quality beyond what conventional "state-of-the-art" systems are capable of providing.

1. Energy Efficiency

Pearl River Tower uses an internally ventilated, high performance double wall on both the North and South façades, while the East and West façades are low-E frit insulated glass unit and feature fixed external shades with integrated PVs. The integrated façade assembly provides a very good thermal performance as well as high visual transmittance by increasing natural daylight to the space. The building's ventilation/dehumidification system uses heat collected from the double-wall façade as an energy source.

A wide scale photovoltaic system is integrated into Pearl River Tower's external solar shading system and glass outer skin, while a low energy high-efficient lighting system uses radiant panel geometry to assist in the distribution of light. The radiant cooling system provides improved human thermal comfort, efficient heat exchange and improved office acoustics. Additionally, daylight harvesting uses daylight responsive controls integrated with the automated blinds. These measures have yielded a large decrease in the building's MEP and lighting electrical consumption (45% reduction) as compared to the National Chinese Energy Code.

High Performance Exterior Facade

The south and north walls are design as a 300mm unitized system with an approximate 240mm cavity in between two layers of glazing. A low-e coated, insulating glass unit forms the exterior, with a single monolithic glazed panel adjacent to the interior occupied space. Motorized blinds/sunshade devices are provided within cavity for solar shading and glare control, and are controlled automatically in response to photocells that track the sun position relative to the elevation. Building Management Systems controls the tilt angle of the blinds automatically in response to solar intensity, solar altitude angle and solar azimuth angle.

The east and west façades are comprised of a low-e frit insulated glass unit wall with fixed 750 mm fixed exterior sunshades and automatically controlled motorized blinds within cavity, providing solar shading and glare control.

The cavity wall is mechanically ventilated from the occupied space via low level inlets in the monolithic glass. A ducted return air connection at the top of the cavity for each 3 meter section pulls warmed air through the cavity and returns it to the air handling units located on the mechanical floors. The movement of room air through the ventilated cavity
is critical to removing solar gain, especially on the south elevation, before it becomes a heat gain to the room. Volume control and smoke dampers are provided in the return ductwork for air volume balancing, and to close this return air path when the office floor is in fire/smoke exhaust mode. Once the hot return air is delivered back to the air handling system, the Building Automation System (BAS) control sequences decide whether to exhaust all of this air or use some of this return air to mix with the ventilation air. This return air will typically be much drier than the outdoor ventilation air, thus lowering the moisture content of the air being cooled by the system.

**Radiant Cooling System couple with Underfloor air Ventilation**

The radiant ceiling cooling system delivers sensible cooling directly to the space, which de-couples the sensible cooling load from the latent-cooling load. Radiant cooling panel systems in combination with direct outdoor air systems (DOAS) and under floor air delivery allows for exceptional environmental comfort addressing ventilation issues.

2. Indoor Air Quality

Pearl River Tower’s “de-coupled” ventilation system is delivered via a raised access floor, providing improved indoor air quality and air change effectiveness. Given the tower’s enhanced thermal comfort, natural lighting, ventilation and acoustics, improved human performance and increased human productivity are expected within the corporate office space.

3. Innovations

A building-wide “chilled” radiant ceiling system is employed for human comfort control, while integrated vertical axis wind turbines are designed to use the building’s geometry to significantly enhance turbine performance. The tower’s mechanical design approach allowed architects to reduce the building’s “floor-to-floor” height from 4.2 meters to 3.9 meters, allowing for an additional five constructed stories within the same square footage of exterior envelope. It should also be noted that the double wall façade allows greater flexibility to the layout of office space. Improved thermal conditions at the perimeter zones allow occupants to be comfortably positioned close to perimeter walls. Due to the absence of fan coils, VAV boxes, filters, ductwork, insulation and other items typically requiring tenant-specific alterations throughout most of the floor plate, there is also a reduced cost for tenant fit-out and future retrofits.

Consistent with the high performance approach to building design, the use of wind turbines on the Pearl River Tower is significantly enhanced by the aerodynamic properties resulting from the building architecture. The Pearl River tower integrates two sets of vertical axis wind turbines at each mechanical floor, which are capable of harnessing winds from prevailing wind directions with minor efficiency loss. The building design optimizes the pressure difference between the windward and leeward side of the building initiating air flow through the four tunnels located at the mechanical floors...
within the building. These turbines serve to generate power that can be directly fed to the mechanical equipment with minimal loses. By adding curvature to the double wall façade the entire building serves as an air intake to turbine location, maximizing the velocity and thus the potential energy rendered from the system.

4. Operations and Maintenance

Pearl River Tower’s chilled ceiling system and de-coupled ventilation has low maintenance and replacement needs and is more flexible for operation compared to traditional fan coil or VAV systems, especially during the tenant re-fit out phase. Tenants will not have to alter duct work and vent location can be easily relocated. Additionally, the blinds in the tower’s double wall cavity are automatically controlled, thereby reducing the building management’s operational requirement for maintenance, cleaning and adjustment.

5. Cost Effectiveness

Pearl River Tower’s design offers the client increased revenue potential due to a large increase in the building’s “net-to-gross” ratio, resulting from the elimination of fan rooms and the reduction of air shaft sizes. Improved floor efficiency coupled with an additional five floors of leasable space provides a 5 year payback offsetting the increased premium of the double wall and innovative mechanical systems in a term that met the clients economic expectations.

6. Environmental Impact

Pearl River Tower’s innovative and integrated design approach results in a substantial decrease in the amount of electrical power required to operate the building’s cooling, heating, dehumidification, ventilation and lighting systems. Energy efficiency coupled with onsite renewable energy generation reduces source energy consumption from the fossil fuel power plants thereby lowering the overall green house gas emissions that result from the energy production process. This statement is quantified in the following statistic: During July (the month of highest energy usage), the implementation of Pearl River Tower’s sustainable strategies will result in an overall energy savings of approximately 50% as compared to baseline building, if it had been designed to meet the Chinese energy code and associated conventional design guidelines.
PUTTING WIND TO WORK

PV Crown
PV at Mechanical Floors
PV integrated on Shading
Vertical Axis Turbine
Internally Ventilated Facade
Installed Turbine
Well Daylit Lobby
Chilled Ceiling

+ 5 Floors (100,000 SF)

8% more floor space

pressure

South wind 6 m/s; throat 7 to 9 m/s

speed

North wind 6 m/s; throat 7 to 9 m/s
**PREDICTED ANNUAL ENERGY CONSUMPTION**

- Space Heating
- Pumps and Aux
- Ventilation Fans
- Heat Reject
- Space Cooling
- Lighting

*Based on preliminary Energy Simulations to be verified with measured data

**DOUBLE SKIN FACADE CAVITY VENTILATION RATE**

Room, Cavity and Total System Loads vs Cavity Flow Rate (May)

**TEMPERATURE**

Aug 8 - 40 m³/hr/m
\[ T_{\text{in}} = 32°C \]

Nov 11 - 120 m³/hr/m
\[ T_{\text{in}} = 31°C \]

Nov 11 - 40 m³/hr/m
\[ T_{\text{in}} = 39°C \]

**3D SIMULATIONS RADIANT CEILING & UFAD**

South Facade Peak Conditions

Perimeter Office Geometry

Air Temperature

Operative Temperature

Age of Air plot demonstrating good air dispersion