Low Energy Demonstration Building of Tsinghua University

Picture

Fig.1 East façade of the building

Basic Information

Location:	East Campus of Tsinghua University, Beijing
Climate:	North China, Continental Monsoon
Project brief:	The project has the features in nearly 100 of the most energy-efficient technologies and products. It is used for demonstration, research, teaching, and exhibition of the most advanced building energy efficient (BEE) technologies. In addition, channels between academia, industry, and education in the field of BEE field have been formed as a result of the new facilities. It has four floors above ground and one floor under ground with total 3000 m^2 construction area.
Client:	Tsinghua University
Architect:	Design and Research institute of Tsinghua University
Timetable:	Start Project: January 2004

End date project: March 2005
Area: 3000 m^2
Cost: RMB 24 million

Design features

Bioclimatic features: By making use of the combination of thermal pressure and wind pressure, and also based on the building configuration, an atrium is designed between stair well and corridor, which responsible for ventilation of every floor. Glass stack is designed at top of the building to strengthen the ventilation effect by solar energy. Besides, windows at exterior façade are mounted at appropriate place, in order to urge the outdoor air drill through the building smoothly due to wind pressure.
Solar protection provided by horizontal and vertical sun shading blind.

Materials/ Construction: Double layer glass façade in east and south façade; Both west and north façade adopt lightweight insulation exterior wall, from exterior to interior are aluminum wall (50 mm polyurethane), insulation cotton (150 mm), gypsum bricklaying (80 mm).

Technical features:
Phase change and energy storage floor system
Natural ventilation system
Renewable energy system: PV walls, solar collector, solar lighting system
Horizontal and vertical sun shading devices
Dehumidification solution system
Ceiling capillary cold radiation system
Landscaping type marsh technology
Roof planting technology

U-values: Integral heat transfer coefficient for transparent parts is less than 1 W/(m^2K), and 0.3 W/(m^2K) for non-transparent parts.
Less than 0.3 W/(m^2K) for west and north façade, less than1.1 W/m^2K for west and north windows and outer doors
Less than 0.1 W/(m^2K) for roof

Project Details

Context and site: A preliminary demonstration building for the 2008 Olympic Games, which embody the themes of “High-Tech Olympics” and “Green Olympics.”
A key research project funded by the Beijing Science and Technology Committee. The building evolved from the “Green building key technology

research project," which is included in China's Tenth Five-Year Plan as one of the major technology projects.

Many of the latest technologies were used in the construction of the building, including BEE technologies from many countries, such as the U.S., Germany, Japan, Denmark, and Italy.

About 50 corporations donated their products for the building, ten of which were used in China for the first time.

The building has the characteristics that east and west façade are wider, south and north façade are shorter, due to reason that the location is adjacent to existing building. The west façade of the demonstration building is sheltered by the existing building.

Function & form: Multi-storey (four floors), office building and laboratories

Structural system: Steel frame for main body

Energy efficiency control:

Thermal insulation of building envelope: East facade has three types: double layer glass façade with wide bypass and exterior circulation, glass façade with horizontal sun shading or vertical sun shading devices (Fig.1). Integral heat transfer coefficient is 1 W/m^2K, and sun heat gain coefficient (SHGC) is 0.5.

Wind inlet and outlet are mounted at exterior wall of façade, interior wall is closed. There is a 600 mm gap between these two glass walls, which can be seen from Fig 2. Based on the temperature between inside and outside walls, the open extension of wind inlet and outlet can be adjusted electrically. For instance in summer, outside air is heated by hot glass and rise up to form the ventilation between the two walls, bringing the heat away from inside room. In winter, the wind inlet can be closed to prevent the infiltration of cold air. Mirror reflectors are mounted every 300 mm below wind inlet to offset the lack of lighting. The interior glass wall adopts the 4+9A+5+9A+4mm hollow Low-E glass.

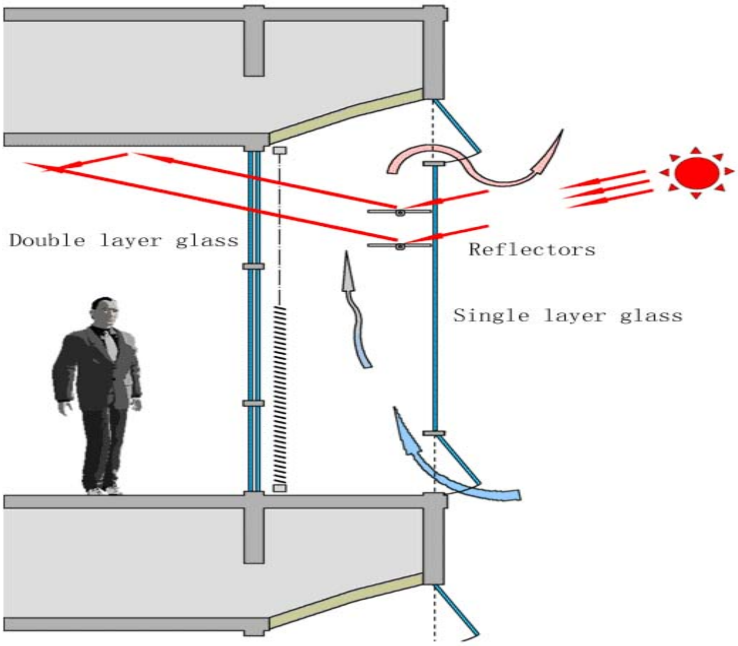


Fig.2 Sketch map of double layer glass facade with wide bypass and exterior circulation

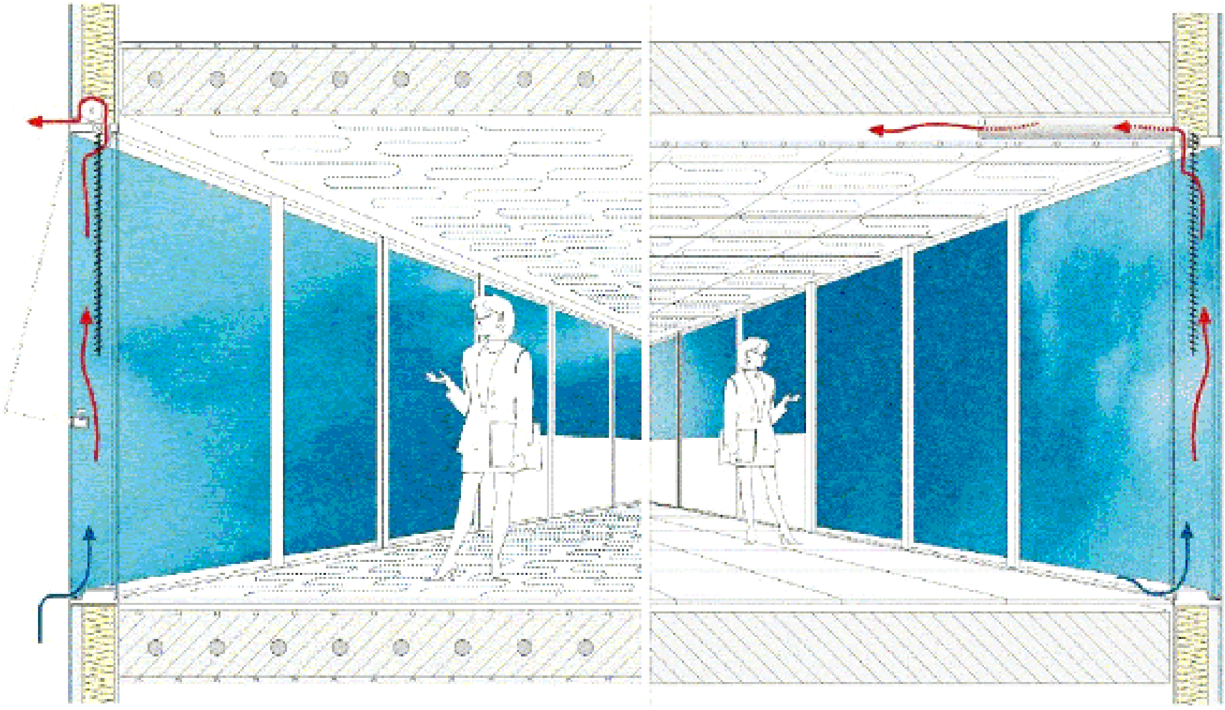
South façade has three types, one is similar with east façade, e.g. glass façade with horizontal sun shading devices. Another two types are different from east façade in terms of installation manner and width of bypass between two walls.

The installation manner is by using unit façade but not component façade. All components in unit façade are prefabricated in factory, glue is not needed due to dry seal, thus the installation speed is very fast. Only one day was consumed for the spot installation of totally 16 units in the demonstration building.

South façade adopt double layer glass façade with narrow bypass, the gap between the two walls is 100~200 mm. It can save some space compare with wide bypass, but circulation effect is worse, therefore, small type fan is mounted to assist air circulation. The circulation mode in first and second floor is interior circulation, and exterior circulation for third and fourth floor, which can be seen from Fig.3.

For the interior circulation mode, outside room is 8 mm Low-e+12A+10mm hollow glass, inside room is 8 mm transparent toughened glass, interlayer has 200 mm. The ventilation system for glass façade is linked with air conditioning ventilation system. The cold air from air conditioning system will pass the channel between two walls and then discharged, thus the cold in the air can be used in summer and the heat can be used in winter, achieving energy saving. The electric driven interior sun shading blind is mounted between the two walls, width of window blind is 50 mm, and angle can be adjusted. The inside glass can be open to clean the interlayer and wind blind.

The bypass for exterior circulation is narrow, with only 110 mm, air circulation is $40m^3/h$ along façade for every meter. The small type fan is mounted on the top of interlayer, aperture area in exterior facade is very small, thus it is not influence artistic effect of the building.



(a) Double layer glass facade with narrow bypass and exterior circulation

(b)Double layer glass façade with narrow bypass and interior circulation

Fig.3 Section sketch map of double layer glass façade with narrow bypass

Both west and north façade adopt lightweight insulation exterior wall, from exterior to interior are aluminum wall (50 mm polyurethane), insulation cotton (150 mm), gypsum bricklaying (80 mm). Heat transfer coefficient for exterior wall is less than 0.35 W/m^2K, and less than 1.1 W/m^2K for windows and doors. The gypsum bricklaying is the byproduct generated from glue gas desulfurized process in power plant, which is also can be recycled after being smashed. One of the raw materials of polyurethane is waste plastic bottles and CDs, which shows the environmental friendly concept during material selecting process.

Sun shading devices

The width of horizontal and vertical sun shading blind is 600 mm, every blind can be individually and electrically controlled based on the need of lighting, visual field and solar collection, in order to realize the maximum utilization of solar energy in winter and optimal utilization between lighting and sun shading function in summer. For instance, in winter, the window blind is parallel to solar altitude, in order to absorb as much as solar energy, however during the night, the window blind is closed to decrease the heat loss due to the radiation. In summer is the reverse condition.

The window blind between the double layer glass façade is fixed at bottom of façade, thus it will ascend when it is used, which guarantee the sun shading function but not affect indoor lighting, the light can shine into the room from upper part of the window.

Space heating cooling, ventilation, air conditioning:

Floor system

To increase the thermal inertia of the building and stability of the indoor thermal environment, the building adopts phase change material (PCM) type floor. The detail means is by putting the shapely PCM (Fig.4) with 20～22℃ phase change temperature, into the traditional moving floor, to be the filling stuff. Thus the heat storage floor can store the solar radiation energy coming from glass façade in winter, and emit heat at night, bringing the fluctuation of indoor temperature not beyond 6℃.

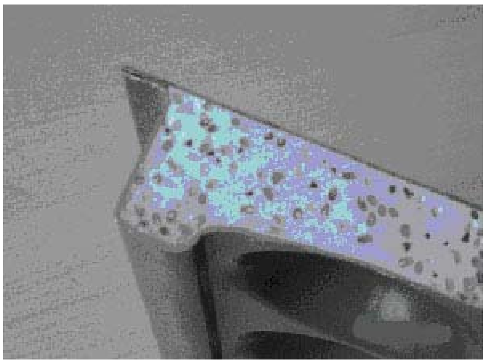


Fig.4 Phase change material used in the building

The building adopts overhead moving floors (Fig.5), height of overhead is 1.2 m, which is much higher than normal project. The high floor offer the advantage of orderly laying diverse wind pipes, water pipes, cable, etc, to avoid conflict of each type of pipes.

Fig.5 Overhead moving floor used in the building

Roof system

In order to improve the insulation performance of roof system and ecological & environmental quality, roof planting technology is adopted. Combined with water proof and weight bearing requirements, the low shrub and turf with light-like, dryness bearing, shallow root are selected, which also adapt the climate characteristics of Beijing.

The roof insulation adapts polyurethane with130 mm thickness and 40～50kg/m³ density, combined with concrete layer and roof planting layer, integral heat transfer coefficient is less than 0.1W/(m²·K). Considering the transpiration effect from plant, zero heat resistance can be achieved some times, even negative heat resistance.

Natural ventilation

By making use of the combination of thermal pressure and wind pressure, and also based on the building configuration, an atrium is designed between stair well and corridor, which responsible for ventilation of every floor. Glass stack is designed at top of the building to strengthen the ventilation effect by solar energy. Besides, windows at exterior façade are mounted at appropriate place, in order to urge the outdoor air drill through the building smoothly due to wind pressure.

Fresh air treatment

The traditional method to dehumidify the indoor air is by refrigeration, but it brings high energy consumption due to the counteract of cooling and heating. By using dehumidification solution system (Fig.6), the dehumidification process becomes independent, which use low quality energy to realize dehumidification, as a result the energy consumption of air conditioning system is decreased.

Fig.6 Dehumidification solution system

The building has four fresh air treatment units, with 4000 m3/h air volume. Meanwhile, to satisfy the fresh air requirement, and decrease the energy consumption by air conditioning system, heat recovery system with 80% efficiency is also integrated with the fresh air treatment units.

Terminal regulating equipment

Dehumidification solution system can bring the humid load away, terminal equipment only responsible for sensible heat, thus in the environment with dryness, dew condition could not happen. Consequently, mildew will not grow to deteriorate air quality.

Based on actual usage function of every rooms, ceiling capillary cold radiation system (Fig.7) is installed to remove indoor sensible heat load. For the special room, such like reporting room and meeting room, which has concentrated and unstable heat load, fan coil units with dynamic wind are adopted to lower the peak load.

Fig.7 Ceiling capillary cold radiation system

BCHP system

The building adopts solid fuel cells and gas engine for heat and power co-generation system, overall efficiency is 85%, electricity generation efficiency is 43%. Extra heat generated from co-generation system can be used for heating space in winter, and to be the regeneration heat for humidification solution system in summer.

Lighting: The light introductory system is mounted at top of roof (Fig.8), and makes use of daylight to light basement, decreasing electricity consumption.

Fig.8 Light introductory system

Renewable Energy use:

30 m^2 PV panels are laid at south part of the building, power which generated from PV system (5 kW) is used for driving the glass façade and window blinds. Solar air heater (Fig.9) is mounted at top of the building, and produced hot air is used for regeneration of the dehumidification solution system. .

Fig.9 Solar air heater

Solar high temperature thermal electricity generated device with 3 kW power is setup on top of building, tracking the sun at daytime.