11.3 Wenyuang Building, College of Architecture and Urban Planning, Tongji University, Shanghai, China

Introduction
The Wenyuan Building on the campus of Tongji University in Shanghai was built in 1953 in the prevalent style of classic modernism of the 1920s. The designers were Xiongweng Ha and Yuling Huang, two former students of the prominent German Bauhaus architect Walter Gropius. Until late 2005, the building was used by the Department for Building Engineering, and it is designated to be refurbished for use by the College of Architecture and Urban Planning (CAUP) by the summer 2007. The premises will then be utilized by the school’s Department for Sustainable Building Design.

The project is considered a national pilot project for sustainable reutilization. In addition to other considerations, the brief for the refurbishment called for an integral approach of energy saving and improvement of human comfort, as well as respect for the historical nature of the building, which is a registered historical building landmark. This condition allows only sensitive interventions into the building substance during restoration.

The concept will therefore fully respect the historic character of the project yet will introduce building technologies that will serve as a model for advanced system design. High-tech building systems will be employed mainly in auditoriums, classrooms, and offices, and over the course of the building’s operation these systems will be evaluated.

Up to the beginning of the world exposition “Better City – Better life”, which will take place in Shanghai in 2010, data on building performance and user comfort will be recorded, and the results will be presented to an international audience during the Expo 2010.
Climate
Shanghai has a subtropical and maritime monsoon climate with four distinct seasons. Spring and fall periods are comparatively short. Winter temperatures range between 1 °C below freezing to 8 °C, and freezing occurs occasionally. During the hot summer months, average temperatures range from 28 °C – 35 °C. Cool air from the north reaches the area in October. The annual rainfall amounts to 1,135 mm, 50 percent of which falls between mid-May and mid-September. An average of 110 days of precipitation is typically recorded annually.

Building organization
The Wenyuan Building has a net floor area (NFA) of 4,200 m². Similar to its precursor, the historic Bauhaus in Dessau, Germany, designed by Walter Gropius, two east-west oriented wings crossed by hallways and offices house the functions of the department. The taller staircase to the east marks the main entrance to the building, and a transverse building wing connects the lecture halls to the west (Figure 11.28). Located between both staircases is a three-story office wing. The auditorium in the eastern wing of the building is a tall, single-storey space. The main façade orientations are facing north and south, respectively (Figures 11.29, 11.30/31).

Figure 11.30
South view

Figure 11.31
Ground floor plan
1 Lecture hall
2 Office
3 Exhibition
4 Staircase
5 Great lecture hall
6 Main entrance
Building structure

The structure of the building consists of a reinforced concrete post-and-beam system. Between the concrete columns, brick infill provides the outside enclosure for the building, which is not insulated. The roof and first-floor slab consist of concrete ribs that today also lack insulation. Interior partitions are of lightweight construction, and suspended ceilings reduce the clear height of the floors from 3.90 m to 3.25 m. The clear height of the auditorium varies between 5.25 and 8.60 m.

The interior is dominated by whitewashed walls and terrazzo floor tiles. During its use over the past decades, hardly any changes or additions to the building's substance were made, except for improvements in the auditorium, which received a new lighting system and new seating.

Windows consist of steel frames and are single glazed; they can be opened for natural ventilation. As a sign of the time of its original construction, no thermal insulating glass or thermal breaks in the frame construction can be found (Figures 11.32, 11.34). The window area in relation to the total surface of the façade is approximately 45 – 55 percent. As part of the original building design, solar shading does not exist. The wooden entrance doors are swing-doors consisting of two swinging wings each and a transom window with fixed glazing. Due to their construction, neither doors nor windows provide an airtight building envelope.

Apart from electric conduit and lighting, no further technical equipment was originally installed in the building. It remained unheated in winter, and in hot weather some office and educational areas were – insufficiently – cooled split units attached to the outside of the façade. Both in summer and winter the interior thermal comfort can be described as unsatisfactory.

There is no visible damage to the building’s structure or foundation except for minor rainwater impact affecting outside walls due to a lack of proper drainage.
Restoration concept

Building envelope
To increase interior thermal comfort, all perimeter building components such as the walls, the roof, and the floor slab will receive proper insulation. Because of the requirement to protect the historic appearance of the building’s outside, brick walls can be insulated only on their inside. In some areas, the original ground floor slab will be replaced by an insulated lightweight construction. The restoration of the roof will consist of a reversed insulation system providing the basis for a future green roof.

The openings and proportions of the windows of the Wenyuan Building are, in detail, designed according to their Dessau model, which raises complex questions concerning their restoration. Although the appearance of the building will be preserved, the provision of an air-tight envelope is essential for correct, updated building physics. To achieve windows that are as true as possible to their originals, new window profiles with thin frames that include the necessary thermal breaks have been developed. In addition, the façade will receive modern insulated glazing and solar shading (Figures 11.35 – 11.37).

Building systems
The sustainable energy concept involves providing cooling and heating of the building using natural resources. Bore-hole heat exchangers (BHE), which are part of the technology concept of the Pujiang building (see pages and Figures in chapter 11.2.3), will provide the energy for heating and cooling in this building as well. Preliminary estimates call for approximately 80 piles with a length of 100 m each, which is a shallow geothermal application. A final decision regarding pile numbers and necessary depth will be based on the results of a hydrological exploration of the local soil conditions, the so-called Thermal Response Test (TRT).

Spaces in the center wing of the building will be statically heated and cooled, windows will be used for natural ventilation for most of the year. Capillary pipe mats containing circulating cooling water will be attached to the underside of the structural ceiling to supply the base load for cooling. During hot summer months, exhibition areas as well as the classrooms and offices will also be mechanically pre-cooled and dehumidified (Figures 11.38, 11.39).
The concept for the classrooms suggests the introduction of a flexible system that is capable of adapting to changing space occupancies and weather conditions. These rooms will be mechanically ventilated with air-handlers outfitted with cooling coils, and they will be dehumidified.

In addition to cooling chillers operated by waste heat, sorptive dehumidification and adiabatic cooling (SGK) will be installed. The necessary heat for the process will be gained from vacuum heat pipe collectors. Temperatures within the offices and lecture halls will be cooled in summer to a limit of 26 °C.

During the winter, all rooms will be heated to at least 18 – 20 °C. Lecture halls will be systematically supplied from their rear, which ensures short duct and pipe lengths and easy access for maintenance. Both building wings on the north and south will be supplied via short distance by a mechanical equipment room in the basement placed between the wings. The staircases will be heated at low temperatures, and a minimum temperature of 15 °C will prevent condensation on floors and ensure better indoor comfort.
Building management system (BMS)
All technical equipment related to indoor comfort, such as cooling, dehumidification, ceiling cooling components, solar shading, and daylight-coupled electrical light switching, will be centrally controlled by a building management system. Temperature and humidity sensors will relay continuous information about current conditions inside the rooms.

Solar shading is controlled by level daylight sensors on the roof, whereas an interior motion sensor will switch the artificial light according to the occupancy of the respective space. Lighting units will be activated depending on their distance to the façade and the luminosity within the rooms.

Contacts installed inside the window frames inform the BMS of operating conditions. During summer, ventilation and cooling will be deactivated once the sensors detect an open window (see: pages for important notes concerning static building cooling in hot-humid climates). Similarly, during winter the heating will be turned off when windows are opened for longer intervals of natural ventilation.

Post-occupancy evaluation
Monitoring and commissioning
After the completion of the described refurbishment, the success and the efficiency of the selected innovative technologies will be monitored and evaluated on a long-term basis. Indoor comfort will be recorded, and the settings for all installed mechanical and electrical equipment will be constantly adjusted to secure low-energy usage. Results will be available during the “Better City – Better Life” exposition in 2010.

Data
NGF 4,209 qm
Height 3 floors
Costs approximately 5 Mio. Euro (estimated)

Alteration planning
Zhigang Wu, College of Architecture and Urban Planning (CAUP), Tongji University, Shanghai
Technical concept
Institut für Gebäude- und Solartechnik (IGS), Manfred N. Fisch, Thomas Wilken, Technical University, Braunschweig, Germany

Figure 11.42
Cross section shows an office

Figure 11.43
Cross section of great lecture hall with underfloor air supply
1 Storage
2 Cooling machine
3 Gas backup boiler