Vocational training school in Biberach

EnBau

The Gebhard Müller School is a business school in the Kreis-Berufsschulzentrum Biberach (Biberach District Vocational School Centre). This new construction meant that the school was to have its own building, oriented towards the contractor's very ambitious requirements with regard to comfort, flexibility of the indoor areas, and energy consumption. The construction project includes an innovative energy concept with a low heating requirement, equivalent to that of a "3-litre house". For heating and cooling, the building primarily uses thermo-active building systems (TABS).

Daytime view of the vocational school in Biberach, as seen from Leipziger Strasse.
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Building summary

Project status	
Location	Leipzigstraße 25, 88400 Biberach, Baden-Württemberg
Completion	2004
Inauguration	2004
Building owner	Landkreis Biberach
Operator	Kreisschulverwaltung Biberach
Occupant	Gebhard-Müller-Schule
Heated net floor area	10.650 m^2
Gross volume	43.639 m^3
Usable floor area (according to EnEV)	5.542 m^2
A/V ratio	0,31 m^2/m^3
Key aspects	Heat insulation, Glazing + windows, Atrium, Daylight planning, Daylight systems, Optimised lighting, Ventilation + heat recovery, Thermo-active building element systems, Heat pump, Control technology, operational management, building automation, Optimisation of operations

Project description

School buildings comprise different areas (classrooms, corridors, atria, sport halls), some of which have different usage periods. High occupancy densities in the classrooms, which entail high internal thermal loads and strict air hygiene requirements, must be taken into account. Adequate lighting conditions, glare protection, sun protection, and indoor acoustics are also important for studying and working in comfort.
One area on which the Biberach project is focussed, is on optimising the operation of the complex system technology. The building was handed over in September 2004, and at the beginning of 2005, it was possible to start the two-and-a-half-year phase of optimisation of operations and measurement.
Before the construction work, the contractor (the District of Biberach) debated at length in district council meetings, and set itself the objective of realising an exemplary, innovative building concept. A Europe-wide invitation to tender attracted applications from numerous planning offices. According to a list of criteria, five offices were selected, and were asked to submit a plan. In conferences, a commission of architects and school staff facilitated the development of these plans. Thus, it was already possible to have a guiding influence during the planning process.

Building concept

The three-storey school building comprises one wing along the access road. Two cubic building structures, in which the classrooms are situated, join onto this wing. All building structures are interconnected by a central hall in the main wing. Running along the hall in the suspended ceiling, is the equipment channel, from which the supply channels branch off into the corridors and rooms.
The building has two atria. The large atrium is suitable for school events (approximately 500 seats) and for concerts, as it has very good acoustics. An underground car park is situated beneath the building, with a ceiling which has 18 cm of mineral wool insulation on the underside.

The building is a reinforced concrete structure, the main wing is designed as a solid construction with a perforated facade, and the cubic classroom buildings are constructed as skeleton structures with a mullion-and-transom curtain wall facade. The slabs are largely uncladded, and have an average thickness of 35 cm, so additional impact sound insulation and flooring is unnecessary. Despite spaciously laid-out traffic areas, a compact building with an average U-value of 0.43 W/m²K was the result.
Exterior blinds with a light-diverting function protect the classrooms and administration rooms from unwanted heat influx, and ensure a glare-free working environment. The atria have interior sun protection made of coated fabric. Solar protection glass (g-value 0.21) was installed to reduce heat influx in staircases, the cafeteria, and conference areas. The exterior blinds are controlled automatically, according to the position of the sun, and also partly according to room temperature, but can also be operated manually. The corridor areas are supplied with daylight via the atria, and supplement the natural lighting of the classrooms by means of skylights. The artificial lights are switched on by the user, and are switched off either completely, or row by row, depending on the available daylight.

Energy concept

At approximately 30 kWh/m² p.a., the calculated annual heating requirement of this compact and well-insulated building is very low. For heating and cooling, the building primarily uses thermo-active building systems (TABS). In winter, the temperature level of the TABS heating water is increased to temperatures of up to 28 °C overnight. The supply temperature is controlled centrally in four separate zones, but cannot be altered for individual rooms. Two heat pumps cover the base heating load. Ground water serves as a heat source for the heat pumps, as the ground water streams which are present at the site meet the prerequisites very well. The ground water is made accessible by means of a 16 m-deep supply well and two injection wells. In summer, the ground water serves as the sole cold source for direct cooling by means of a heat exchanger.
The entire school building is mechanically ventilated all year round by means of three centralised ventilation systems with heat recovery. Air is heated solely via the heat pumps when outdoor temperatures are approximately -5 °C or above. Only when outdoor temperatures drop lower, are backup heat exchangers activated, provided with higher supply temperatures by means of a wood pellet boiler. In summer, temperature control of the supply air occurs via the ground water heat exchanger and cold exchanger. Mixed gas sensors control the supply air volume. One window can be opened per room module. Window contacts cause the ventilation system to be deactivated in the respective room as soon as the window is opened.

Performance

The results from 2005 confirm the predicted high thermal comfort with good air quality, both in winter and in summer. To date, the energy consumption values still show deviations from the planned values. For instance, the heating consumption of 37 kWh/m² p.a. in 2005 is somewhat higher than the calculated value of 30 kWh/m² p.a. The low maximum heat pump supply temperature of 28 °C which was planned, was greatly exceeded in 2005 (up to 48 °C) due to control-related reasons. This deviation and a number of other problems (e.g. pumps' running times and cycle times) were successfully corrected by optimisation of operations.
In the summers of 2005 and 2006, due to the high performance of TABS, the building was cooled more than was required. Thus, optimisation measures are being implemented now, and in the future, for adjustment purposes, i.e. for reduction of cooling, in order to lower the pumps' energy consumption in summer. Overall, the support initiative's energy objective, a primary energy characteristic value for heating, ventilation, cooling and lighting of 100 kWh/m² p.a., was not yet fully achieved in 2005, with 116 kWh/m² p.a. However, it can be expected that this target will be reached in the future, due to the measures which have already been taken, especially regarding the control technology.
Since September 2004, the school building has been used full-time by approximately 1,700 students and around 91 teachers , who are very satisfied with "their" school. The interior climate is explicitly praised. A survey indicated that the air quality and the temperature in the classrooms are considered to be very good to excellent.

Optimisation measures and possibilities

The air-tightness measurement (n_{50} = 0.34) showed that while the entire building met the requirements, the technical centre indicated significant leaks. Here, subsequent improvements were necessary, most of which are now complete.
As the building's heating energy consumption, at approximately 37 kWh/m² p.a., turned out to be somewhat higher than calculated, there are currently efforts being made to achieve the ambitious planned value of 30 kWh/m² p.a. by means of optimising operations. The same applies to the heat pumps, for which the supply temperature is to be reduced further. The optimisation of overall systems operation during the first phase of occupancy was successful in lowering the 2006 electricity consumption for distribution of air and water. Further savings are by all means still possible, and are currently being investigated. A final analysis of the measurement phase will occur in 2007.

Construction costs and profitability
Despite a strict energy standard and sophisticated system technology, it was possible to construct the building in a relatively inexpensive manner (see key cost data).

Key energy data

Energy indices according to German regulation EnEV (in kWh/m²a)	
Heating energy demand (according to net floor area (without underground car park))	30,00
Measured energy consumption data (in kWh/m²a)	
Thermal heat consumption (in 2005 according to net floor area (without underground car park))	37,00
Total source energy (in 2005 according to net floor area (without underground car park))	116,00
Ventilation	11,20
Heat pump	10,60
Auxiliary power	10,00
Lighting	6,70

Implementation costs

Costs of implementation in €/m²	
Construction (KG 300)	850
Technical system (KG 400)	415

These figures represent cost quotations
Net construction costs (according to German DIN 276) relating to gross floor area (BGF, according to German DIN 277)

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