BOB – Balanced Office Building

EnBau

Striking image: Night-time view of the BOB – Balanced Office Building.

A particular feature of the "Balanced Office Building" is that the designers are also the developers and users of the building. That enabled the building to be optimised in all details and in an interdisciplinary manner. In addition, it was intended right from the beginning to develop the individual building into a marketable serial product. The building was therefore intended to be particularly economical to create and operate. The concept of a solar housing estate encouraged its designers to fulfil the same energy requirements with their own new neighbouring office building. The building was assessed and optimised in terms of its cost effectiveness. The spacious floor plan without load-bearing interior walls enables the building to be flexibly sub-divided into different units and various office configurations. Another remarkable feature is that the building only has one electricity connection and relies on concrete core temperature control fed by borehole heat exchangers in combination with a heat pump.

Building summary

Project status	
Location	52075 Aachen, Nordrhein-Westfalen
Completion	2002
Inauguration	2002
Building owner	Bauherrengemeinschaft Schurzelterstrasse
Gross floor area	2.379 m^2
Heated net floor area	2.151 m^2
Gross volume	7.675 m^3
Work places	90
Usable floor area (according to EnEV)	2.153 m^2
A/V ratio	0,37 m^2/m^3
Key aspects	Heat insulation, Glazing + windows, Daylight planning, Daylight systems, Optimised lighting, Ventilation + heat recovery, Regenerative + passive cooling, Thermo-active building element systems, Heat pump, Control technology, operational management, building automation, Optimisation of operations

Project description

From the very beginning, the office building in Aachen was meant to be more than just a one-off experiment. It is planned to convert the concept into a "product series" in order to reduce planning costs and to benefit from the previously gained experience. The developers are also the investors, users and planning team.
The "Balanced Office Building" has won an award from the BDA Aachen (German Association of Architects) and was commended by the BDA NRW in its “Awards for new buildings 2003”.

Building concept

The compact, four-storey office building without basement has a north-south orientation. The staircase protrudes on the north side of the building. This is where the sanitary facilities are accommodated on each floor. The extensive floor plates without load-bearing interior walls allow flexible subdivision. The integration of the building services equipment into the ceiling and floors also helps the interior space to be used flexibly. The building depth of 16 m makes it possible for ancillary spaces to be accommodated in the central zone. Five tenants currently use the building with around 100 workplaces in total. It is possible to have up to eight units per floor.
The building was built using a massive type of construction with a high degree of prefabrication. The reinforced concrete framework structure with load-bearing, precast concrete facade panels and internal columns enabled an extremely short construction period of only nine months. The high standard of insulation is in line with the construction method of passive houses, but only achieves an average U-value of 0.48 W/m²K. The exterior

walls are covered with a rainscreen cladding system comprising ventilated terracotta tiles. The concrete walls are covered with a 20 cm-layer of mineral wool insulation. The perforated facades have triple-glazed windows with thermally separated aluminium frames. Because of the glazing's comparatively low g-value of approx. 50% and cooling using concrete core temperature control, exterior shading was not installed. Louvres are used for internal glare protection. The lower section of the louvres provides glare protection; the upper section directs the daylight far into the room via the partly white-plastered ceiling. A ceiling-mounted lighting system contains uplights that provide indirect illumination and downlights in the form of specular louvres, which provide direct light. The daylight-dependent control with a central sensor on the roof of the building can be adjusted decentrally by the occupants.

Energy concept

The construction of the main areas of the building was based on the method utilised in passive houses. The building has a compact structure and achieves an A/V ratio of 0.37. With 39.7 kWh/m²a, the calculated annual heating requirement undercuts the 1995 German Heat Insulation Ordinance (WschVO ´95), which was at that time applicable, by almost 40 per cent. For generating heat and cold, 28 borehole heat exchangers are used that extend to a depth of 45 metres. Here the required heat is extracted from the ground and, during winter operation, raised to the usage temperature by means of a compression heat pump. The heat pump supplies a 1000-litre buffer storage tank and raises the heating water up to the required supply temperature of 26 °C. The heat pump and buffer storage tank are contained within the thermal envelope. A concrete core temperature control system is used for heat dissipation. The pipes for CCTC and ventilation were cast into the concrete floor slabs together with the steel reinforcement mesh. The CCTC and the air comprise the sole system for heat dissipation. There are no additional radiators. In summer, the building is cooled geothermally via the borehole heat exchangers without relying on the heat pump. The CCTC is also used for cooling. The air intake and exhaust system operates with heat recovery (heat recovery level 75%) on a storey-by-storey basis. The borehole heat exchangers' water circuit is also used via the water storage tank for cooling and heating the supply air by means of an additional air/water heat exchanger. Domestic water is heated on each floor using decentralised, electric continuous-flow heaters. The rain water is collected and used for flushing toilets and watering landscaped areas.

Performance

After various optimisation measures, the building achieved a very good primary energy input of approx. 84 kWh/m²a. Despite the sole reliance on interior shading without solar protection glass, the occupants claim that the indoor environment was also satisfactory during the extremely hot summer of 2003. Effective cooling by the CCTC without any doubt contributed to this. Measurements in south-facing offices established that, in 2006, there were up to 128 hours of overheating, which means that air temperatures were above 26°C during working hours.

There is a very high user acceptance of the heating and cooling system using CCTC. Particularly the radiant cooling effect was found to be very comfortable by users. The low air change rate of 20m³/h (taking into consideration the simultaneous use of the offices) proved to be practicable. The nominal air change rate, which also provides fresh air in the morning and after the weekend, and the fact that staff can also open the windows, was found to be pleasant. Longer window ventilation proved to be relatively uncritical in terms of the thermal comfort, even with very low or high outdoor temperatures.

Occupants can individually adjust the shading effect and daylight control provided by the louvres. Via the building control technology and the internet-based energy management system, it is possible to optimise the ongoing operation of the building. According to users, the building does not require any expert knowledge in using the systems.

Optimisation measures and possibilities

Long-term monitoring enabled energy consumption and its influencing factors to be observed in detail and also allowed to highlight control deficiencies. For example, unnoticed by staff, the ventilation devices initially ran with supply temperatures that were too high.

The temperature regulation of the heat pump via reference rooms led to uneven temperature distribution and unnecessary pump running times as a result of unexpected staff absences or larger numbers of people working in the reference rooms. At the end of 2004, the system was switched over to demand-oriented control. At the same time, the supply temperature was lowered. Now, the pump is turned on and off depending on ΔT between supply and return temperature. The energy requirement control system developed especially for this building was difficult to adjust, especially in the beginning. The best time periods for measuring had to be determined empirically. Today, the control system is mature and there is a relatively large time period when no heating or cooling is demanded, i.e. when the heat pump is switched off. The supply temperatures were also reduced further. The annual coefficient of performance thus improved from 3.1 (2003) to 4.3 (2007).

The decision concerning the ventilation to only let in a low amount of fresh air has proved to be practicable. Measurements showed that the CO_2 concentration remains considerably below the maximum amount recommended for the workplace. Even with very low or high outside temperatures, longer window ventilation also had little impact on thermal comfort. Since the air ducts are not insulated and run partly within the temperature controlled floor slabs, the supply air also adopts the temperature of the room or floor slab. Therefore the additional temperature control function of the supply air with the borehole heat exchangers was shut down. The specific electricity consumption for the ventilation increased steadily for all floors, but by different amounts. On the one hand, due to high numbers of staff present at the same time and frequent occupancy in some offices the amounts of air required are larger than expected. On the other hand, the ventilation is often adjusted “by hand” and not changed back later.

Construction costs and profitability

As the developers and future occupants, the designers wanted to make the building particularly cost effective to build and operate. Therefore, during the concept phase, every minor aspect concerning construction and running costs was assessed and optimised. Still, high quality, durable materials were used for the building. Investment costs are below the average costs according to the building costs index (BKI), with a net figure of 1,017 €/m2 GFA (cost groups 300 & 400). This was attained because additional costs, such as those arising from the use of borehole heat exchangers, were balanced out by savings in other areas such as exterior sun protection. The running costs are also low: the energy costs for heating, cooling, air conveyance, lighting, water heating and the lifts amount to around 2.5 €/m²a, which is considerably less than the usual range between 10 and 18 €/m²a.

In Mönchengladbach, another building is currently being developed in accordance with the BOB concept. A gross floor area of 7,000 m² is being developed based on a tenant and part-ownership model. Because the designers are convinced of the economic viability of the building concept, they are taking over the energy costs for heating, ventilation, cooling and lighting for a period of five years.

Key energy data

Energy indices according to German regulation EnEV (in kWh/m²a)	
Heating energy demand (according to DIN 18599)	31,60
Overall primary energy requirement (according to DIN 18599)	76,20
Measured energy consumption data (in kWh/m²a)	
Site energy for heating and domestic hot water (dhw)	26,30
Source energy for heating and domestic hot water (dhw)	19,80
Total source energy	83,70
Final energy heat	10,80
Primary energy heat	4,30
Final energy lighting the offices	3,50
Final energy ventilation	2,40

Implementation costs

Costs of implementation in €/m²	
Construction (KG 300)	696
Technical system (KG 400)	321

These figures represent calculated costs

Net construction costs (according to German DIN 276) relating to gross floor area (BGF, according to German DIN 277)

Operating costs

Costs of operation in €/m²a	
Total energy costs	2,47
Heating and domestic hot water	0,67
Heating	0,64

Domestic hot water	0,03
Total electricity consumption	2,47
Lighting	0,91
Infiltration/ventilation/cooling	0,85

- **Building and concept: BOB online (site in german)**
- **Website of the Energieagentur NRW according to the project "50 solar energy housing estates"**
- **Projektinfo by BINE Information Service**