The Braun headquarters, Kronberg, Germany

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Introduction

The principal ideas behind the environmental concepts for the new Braun HQ building in Kronberg, near Frankfurt, were developed by Arup together with the architects Schneider + Schumacher during the invited competition in 1996. This building represents a 'second generation' of the design philosophy of this particular team of architects and engineers, who worked closely together on a series of earlier projects. The building Schwedlerstrasse 6[1] in Frankfurt belongs to the first generation of this series, and the design principles established there were developed further, optimised, and combined with new approaches in this second generation. The team is currently working on a low energy office building in San Diego, California.

Competition

Design principles carried forward from the earlier Schwedlerstrasse project include exposed concrete slabs (thermal mass), displacement ventilation, raised floors, glass-enclosed space used as a thermal buffer, and thermal zoning. Due to the heavy traffic on the south west of the site, a double façade was provided here for sound insulation. A mixed mode ventilation concept was conceived, whereby the offices would be predominately naturally ventilated, the mechanical displacement ventilation system being used only in extreme weather. An unheated central atrium would act as a thermal buffer, in which trees, water features, and an air supply via an underground duct system improve the environmental conditions. For office planning, the client's brief called for a so-called 'combi-büro' concept with small cellular offices on the perimeter and a flexibly-used central 'combi-zone' inside. However, total flexibility, with the capacity to switch to traditional cellular offices with a central corridor or open plan, was also required. The external zone would have constant mechanical ventilation, and perimeter heating by trench heaters in the raised floor void.

Design development of environmental concepts

One characteristic of a double skin façade is that the outer surface appears smooth, though a semi-external shading system can still be provided.

To achieve this smooth appearance all round, it was decided early in the project to extend the double façade to all sides of the building. The resulting improvement in the façade's thermal performance then allowed the question to be posed as to whether the offices could be heated and cooled by a heated or chilled ceiling surface alone. This would allow the mechanical ventilation system in the external zone and the trench heaters to be eliminated, resulting in a large reduction in the building services' costs.

Using the ceiling as a heating surface is feasible, as long as the temperature difference between the surface of the ceiling and the room is no larger than about 5°K. It is also important that the temperature difference between the room and the internal surface of the façade does not lead to cold draughts, the design external temperature in Frankfurt being -12°C. Both conditions were met by the proposed façade design. The specific heat capacity of water is roughly four times greater than that of air, so the same energy content can be transported by much smaller systems. The decision to cool the building using chilled ceilings instead of the original air system enabled a significant reduction in space requirements for plantrooms and shafts. The resulting design comprised small bore plastic tubing embedded in a plaster layer on the underside of the concrete slabs, connected to pipework running in the void of the floor above. Access panels for the valves are in special elements cast into the slabs, which also contain the lights, sprinkler heads, and smoke detectors.

1 top:
The finished building at dusk.

'The client is very happy with the building's performance, and occupants have found that the thermal environment is very pleasant...'

Early in the project Arup carried out feasibility studies on the viability of these façade and HVAC services concepts, looking at the following aspects:

• thermal performance in winter

• thermal performance in summer

• acoustic performance

• condensation risk

• control stategies (ventilation, solar shading)

• effect on the heating load of the building

• effect on the cooling load of the building.

Two alternatives were compared - a single-glazed external skin plus a double-glazed internal skin; and a double-glazed external skin plus a single-glazed internal skin.

The former was chosen, mostly because of better acoustic performance and the lower internal surface temperature of the façade in summer.

The proposed HVAC system was also examined and compared with the conventional air-conditioning system preferred at first by the client, in particular the US parent company, Gillette. Extensive computer simulation showed that the proposed concept could deliver comfortable conditions in both warm and cold weather. The lower surface temperature of the ceiling slab in summer and the higher temperature in winter enables a higher air temperature in the room in summer and a lower air temperature in winter, leading to energy savings. Since the external offices are naturally ventilated, the cooling capacity of the system is compromised when external conditions are warm and humid, as the flow temperature of the chilled water has to be adjusted upwards to avoid condensation on the ceiling surface. The studies showed, however, that the desired internal conditions are not attained due to the above during only 50 hours per year (less than 3% of the working year).

The capital costs of the proposed system, about 300DM/m^2 (€150/m^2), were significantly lower than the cost of conventional air-conditioning. The estimated reduction in running costs was calculated as DM40 000 pa (€20 000 pa). As one complete system - the conventional perimeter heating - could be dispensed with, the financial viability of the double façade concept is greatly improved compared to other built projects of this type to date. On the basis of these studies the client was convinced to go ahead with the proposed concept. The aim was a completely transparent glass-faced building, which by virtue of the proposed ceiling system would have an internal climate approaching that of traditional heavyweight construction and with no visible HVAC services in the rooms.

Façade design

On the external faces the double-skinned façade is achieved by adding a second glass skin; on the atrium side the atrium roof provides the second skin. The following advantages result:

• improvement of sound insulation against external noise

• heating from the ceiling, which reduces capital costs as the ceiling system is provided for cooling in the summer anyway

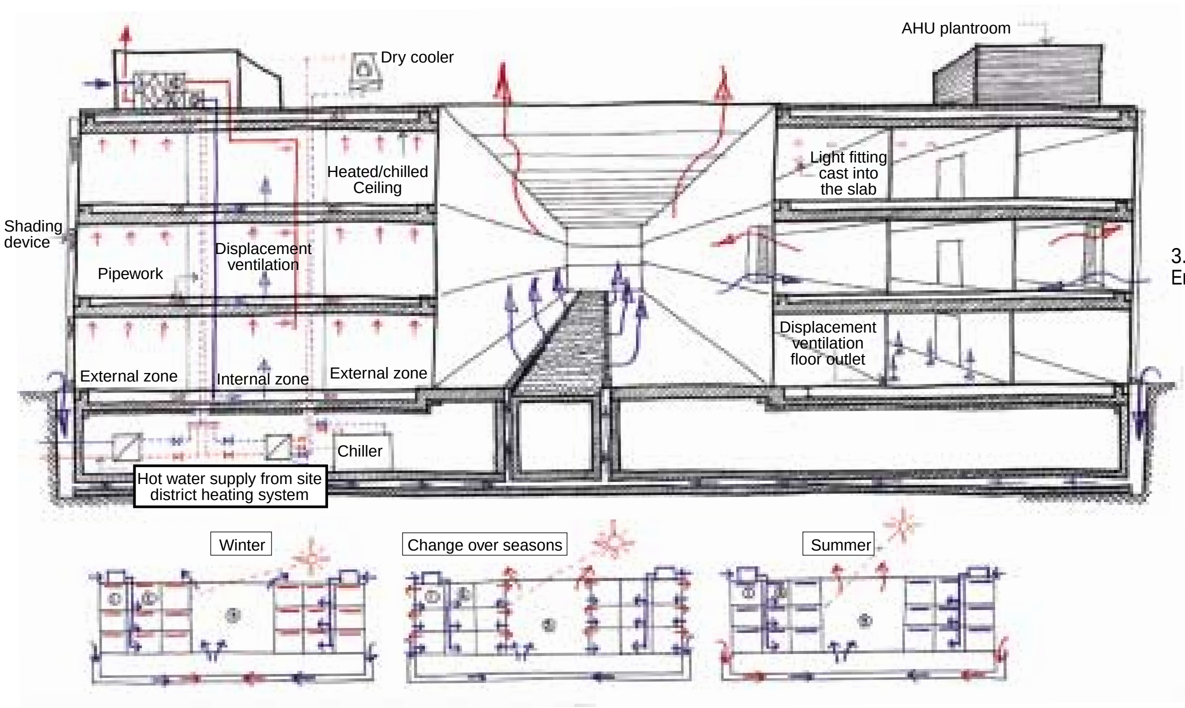
• reduction in running costs; heating, cooling, ventilation

• night-time ventilation in summer flushing the building and cooling the rooms, with protection against break-ins and adverse weather from the second skin

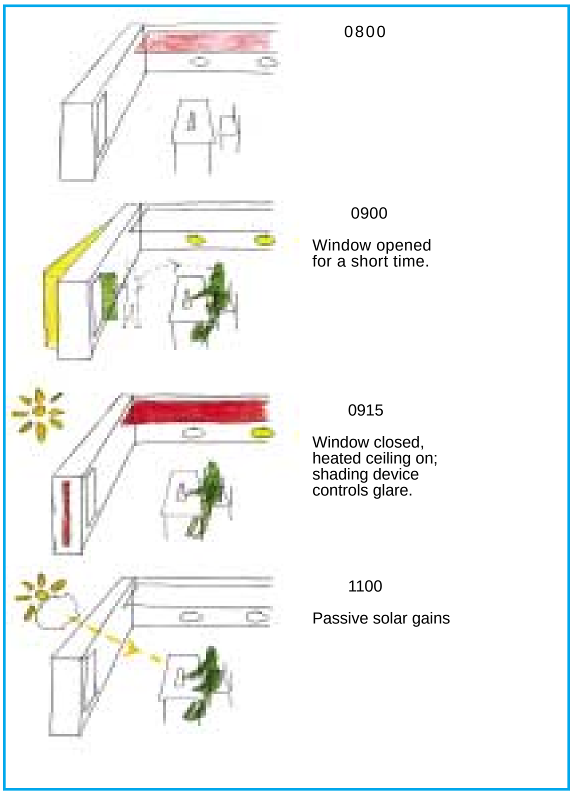
• more comfortable internal conditions in the perimeter zone

• installation of a semi-external solar shading device (external façade appearance is smooth; solar shading device is protected from the wind and bad weather).

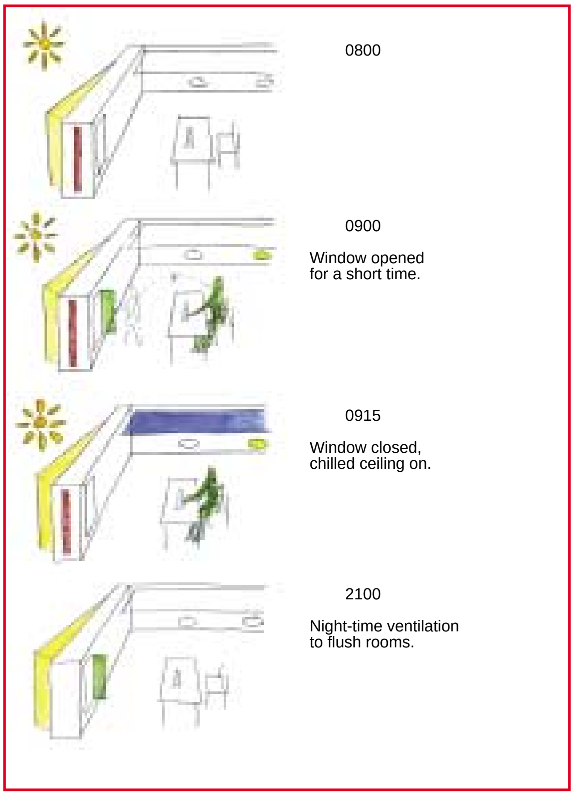
2.
The façade, the atrium, and the PTFE roof (open).



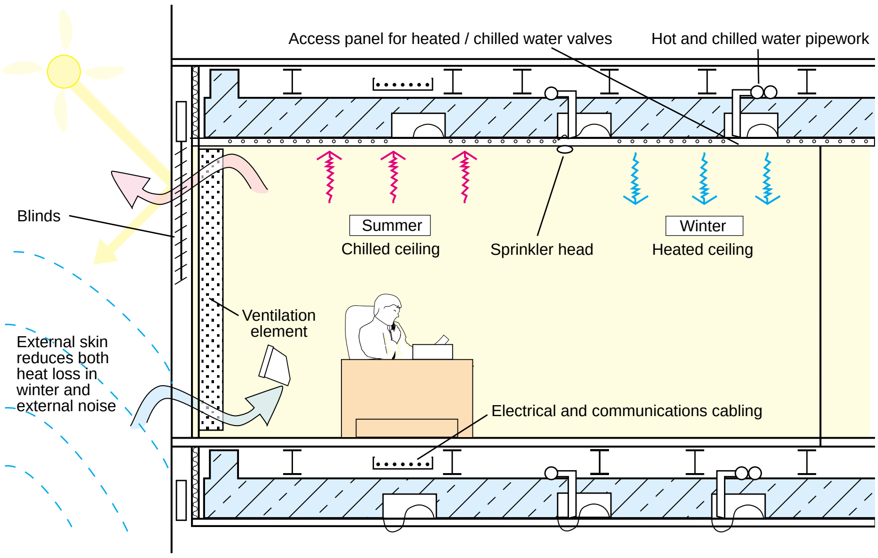
3.
Environmental concept.



4.
Winter day environmental control.



5.
Summer day environmental control.



The internal skin of the double façade is double glazing while the external skin is single glazing. Blinds in the cavity provide shading; they are controlled centrally by the building management system but can be adjusted via an override switch by individual users. To prevent condensation on the glass surfaces, there are openings in the external skin. The façade grid is 1.45m; each segment has an openable window in the external skin and a 200mm wide opaque insulated openable ventilation element in the internal skin.

6.
Section showing HVAC concept.

7:
Atrium roof in the open position.

8.
Typical office space, before occupation.

10:
Typical cellular office.

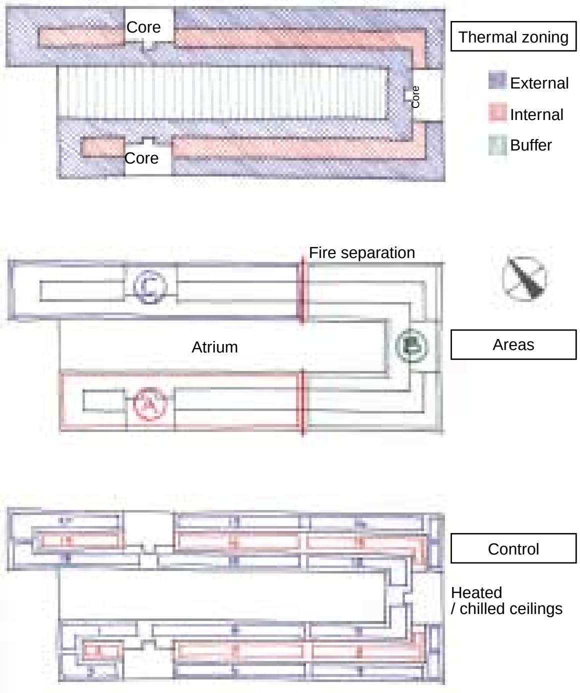
The remainder of the internal skin is transparent glazing and can only be opened for cleaning. The façade cavity has horizontal breaks at each floor level and vertical separation at each gridline. The U-value is approximately 1W/m²°K: in warm weather, under certain external conditions, the outside windows are automatically opened to remove the excess heat. In cold weather the outside windows remain closed unless an inside window is opened; then the associated external window opens automatically to ensure fresh air supply to the room concerned. After a preset time of about five minutes, the external window closes again automatically to reduce unnecessary heat loss. The external windows are automatically closed in the event of wind or rain. The façade facing the atrium consists of neutrally coloured solar control glazing with an internal shading device.

Thermal zoning

The building is divided into five thermal zones:

- *External zone:*
  up to 4.25m from the façade,
  natural ventilation,
  heated / chilled ceiling,
  room temperature in winter = 20°C,
  maximum room temperature in summer = *c*28°C.
- *Internal zone:*
  further than 4.25m from the façade,
  displacement ventilation,
  heated/ chilled ceiling,
  room temperature in winter = 22°C,
  maximum room temperature in summer = *c*26°C.
- *Cores:*
  staircases, toilets.
- *Atrium:*
  unheated buffer zone.
- *Basement:*
  parking, computer rooms, plantrooms.

In line with the client's wish for a high degree of flexibility, cellular office layouts with a central corridor, open plan, or so-called 'combi' layouts are possible. The building services design caters for this.



9.
Building zoning.

Offices

The external zone is heated and cooled via the ceiling system and naturally ventilated by windows, which in extreme weather are opened for short periods to give the required outside air quantity. In the change-over seasons, natural ventilation is used to achieve the desired internal conditions. On summer nights, users can leave the windows open to flush the building and cool the exposed thermal mass in the rooms, while the outer skin provides protection against break-ins and adverse weather. The heated / chilled ceilings consist, as designed, of microbore plastic tubing attached beneath the concrete slabs and covered with 20mm of plaster. The main flow and return pipework is in the floor void of the floor above.

11.
The central artium, showing the air supply grilles from the underground ducts beside the water feature.

Elements are cast into the concrete slabs to accommodate the light fittings, sprinkler heads, smoke detectors, and the access panels to the isolating valves for the heated / chilled ceiling. A two-pipe change-over system with a dead band control zone between heating and cooling is provided. Within the dead band the building does not need to be mechanically heated or cooled; free cooling can be provided by window ventilation.

Conventional individual room temperature control is not provided, due to the high thermal inertia of the system and the prohibitive costs of individual control in each possible room, given the high degree of flexibility required from the client. 20 zones are provided on each floor level.

Individual control for each zone is achieved by the use of two port control valves; occupants operate the windows and shading to achieve the desired internal conditions. The internal zone is provided with a mechanical displacement ventilation system (two air changes per hour) via floor outlets. Extract grilles over the doors to the central core area collect the return air at high level. Motor-controlled dampers in each zone allow users to dis-enable the ventilation if necessary, but variable speed fans operating in conjunction with pressure sensors in the ductwork systems ensure that turning off the supply to some areas does not lead to undesired effects elsewhere. A heated / chilled ceiling is also provided in the internal zone.

Atrium

The atrium is an unheated buffer zone incorporating a water feature and a tree to improve the microclimate. Its roof is a transparent openable membrane construction (PTFE air cushions) with a U-value of approximately $2W/m^2°K$. The atrium is heated by passive solar gains and heat gains from the adjoining office areas, and is naturally ventilated by air drawn in through shafts next to the external faces of the building and tempered via its passage through underground ducts before entering the atrium through grilles beside the water feature. In the winter, used air escapes through ventilation openings on the sides of the roof, which can be closed when it is very cold outside.

The offices facing the atrium receive fresh air from it via operable windows, whilst in summer the whole roof can be opened up to allow warm air to escape. The make-up air is pre-cooled via the underground ducts, which are laid with a fall to sump pump units, so that condensation is drained away. CO_2 and temperature levels in the atrium are used to control the ventilation openings in the roof.

Energy supply

The building is connected to the local district heating system supplied by a boiler house on the site. Chilled water is supplied by a central water cooled chiller in the basement, whilst dry coolers are on the roof. The building's electrical supply is from the site's existing 20kV ring main. The step down transformer is in the basement.

Electrical and public health services

Electricity circulates via distribution boards in the core areas of each floor. The horizontal distribution is in the raised floor void. In the office areas floor outlets are provided with electrical and IT-sockets. Basic lighting in the offices is from downlights integrated into special elements cast into the concrete slabs, which also contain the sprinkler heads, smoke detectors, and access panels to the heating/ cooling valves. Daylight control of the office lighting is provided. Rainwater is used to flush toilets and irrigate the green areas.

Conclusion

The building has been in operation since January 2000 and the client is very happy with its performance. Summer and winter temperatures were within the predicted levels and many occupants have remarked that the subjective thermal environment is very pleasant, probably attributable to the radiation from the ceiling.

The same team of architects and engineers is now working on a low energy office building in San Diego, California...

Reference

(1) CODY, B, LEWIS, D, *and* VAN AERSCHOT, C. Schwedlerstrasse, Frankfurt am Main, Germany. *The Arup Journal, 31*(2), pp14-16, 2/1996.

Credits:

Client:
Braun AG

Architect:
Schneider + Schumacher Architekten

Building services engineers:
Arup GmbH
Brian Cody, Marcus Ebeling, Susanne Flis, Karl Pudwitz

Structural engineer:
Bollinger + Grohmann

Landscape architect:
Ulla Schuch

General contractor:
Hochtief

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