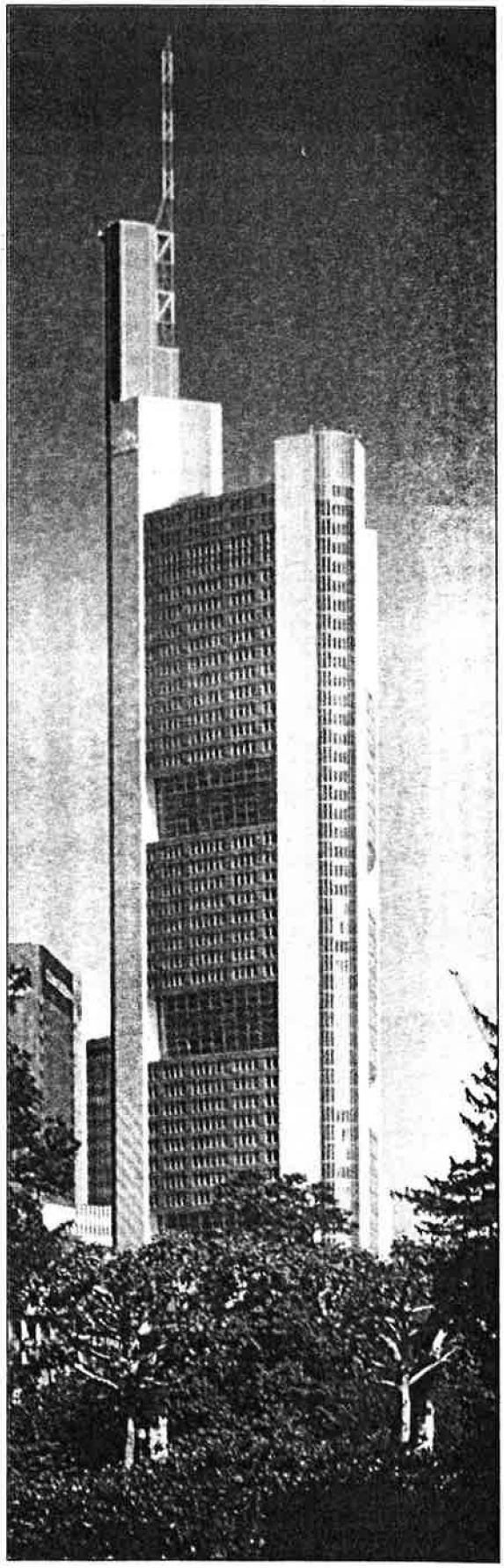
The new headquarters of the Commerzbank in Frankfurt - the tallest office building in Europe - has proved one thing conclusively: it is possible to build a vast high-rise in the middle of a busy city and use passive techniques to control its internal environment



The Big Friendly Giant

UNUSUALLY for a high-rise building, environmental friendliness was the fundamental design criterion in the new headquarters of Commerzbank, one of Germany's leading banks, and the structural and environmental engineering systems were major factors in the evolution of the overall design.

In Frankfurt, the Green Party has power; Commerzbank was encouraged by the politicians to make its new HQ a demonstrably 'green' building, and the brief for its international design competition stated that 'the environmental friendliness of the design shall be as important as functional worth'.

The team of Sir Norman Foster & Partners, with Ove Arup & Partners (structure and geotechnics) and HL Technik (environmental services) won: Roger Preston & Partners was subsequently appointed as lead environmental engineers.

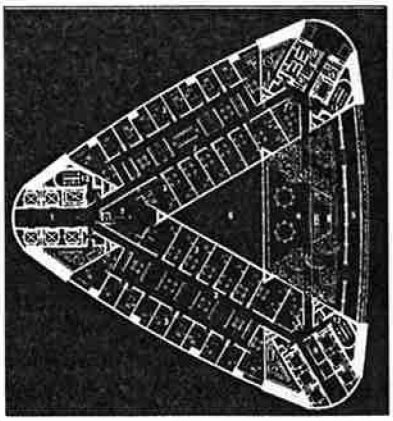
Commerzbank was designed 'in the real world', within existing urban guidelines. Whilst design teams often challenge clients' briefs, neither sites nor business circumstances can usually be changed, no matter how morally persuasive the case. The design team fully supported the need for environmentally aware urban planning, and tried to influence this positively where it could, particularly through the way the new HQ opens itself to the city to allow street level access and interaction.

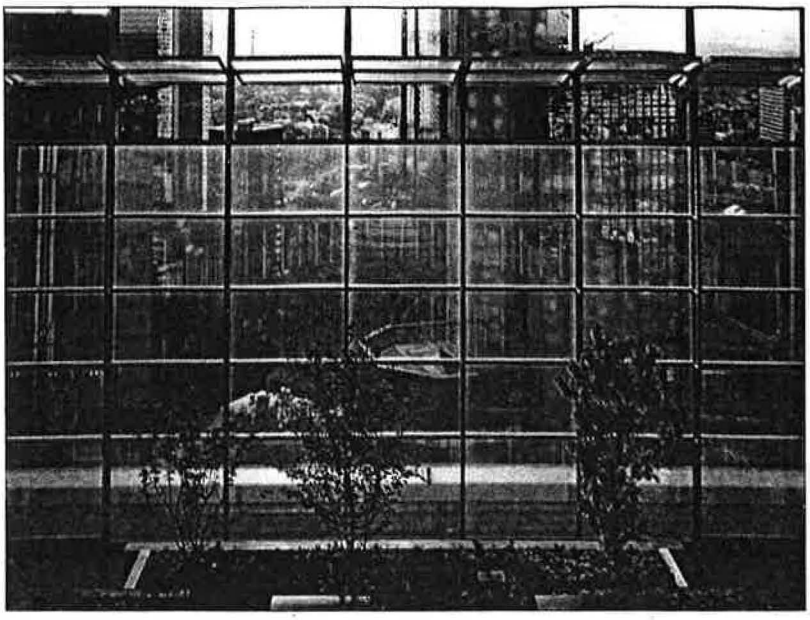
The project's overall financial viability was improved by its approach to green issues. The capital cost was more than offset when the city granted planning permission for Europe's tallest building with a greater plot-ration than originally expected. The extra built area meant the client need not buy another expensive site in Frankfurt's financial district, and could house all 34 head office departments on a single site.

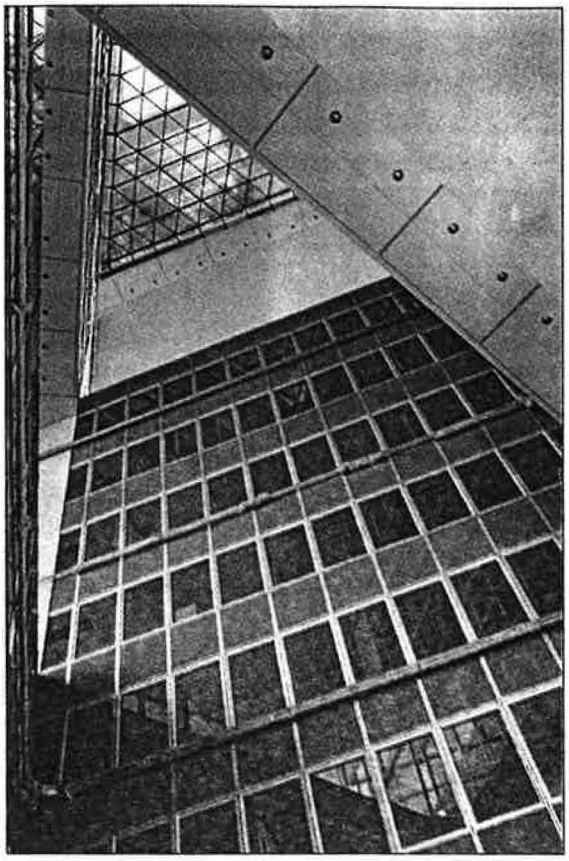
Commerzbank comprises a 56-storey office tower, 299m from street level to the tip of the mast; a three-storey basement; a six-storey building east of the tower, containing apartments, offices, retail, and car parking; an auditorium; a partially enclosed public plaza; and refurbishment of existing adjacent historic buildings. The design radically departs from traditional high-rise planning, working practices, and constructional thinking, and needed new engineering solutions. The aim was a structure fully integrated with the architectural and environmental concepts, elegant, and fast and economical to construct.

Sense of place

- *innovative planning and working arrangements: office areas in elevated 'villages' sharing communal 'sky-gardens'*
- *an internal planning strategy encouraging interaction between people and departments, and giving sense of orientation - unlike a conventional central-core tower where everyone looks outward, but has limited visual or physical contact with anyone else*
- *column-free, open-plan floors around the sky-gardens and a central atrium extending the building's full height to give natural light and cross-ventilation, and views from all directions*







- *an open entrance level blending with Frankfurt's urban fabric, creating a new public plaza for city-dwellers and Commerzbank staff alike*
- *a rational lift strategy minimising travel distances and encouraging short journeys during the working day.*

Transparency

- *The spiralling sky-gardens visibly express the building's green ambitions for natural lighting and natural ventilation.*
- *You can see right through the building from street level.*

Very low energy demand

- *It is the first naturally-ventilated tall office building - using local and global natural ventilation systems.*
- *High daylight levels minimise the need for artificial lighting*
- *The internal environment integrates with an openable glazed facade controlled by the Building Management System (BMS), driven by the building's own weather station.*
- *Full use of passive and low-energy techniques gives very low energy consumption.*
- *High-quality working environment can be individually controlled adjusted by Bank staff from their desks.*
- *Simple servicing strategy minimises horizontal services runs, giving minimum storey heights.*

German workplace regulations require occupants to be within 7.5m of a conventional external wall to receive enough natural light.

Every fourth level, the plan rotates 120°, so that gardens on all three sides bring air and light to the office areas from every direction. The tower sub-divides into 12-storey 'villages' of about 650 people sharing three sky-gardens. Each village forms one environmental entity between glass floors across the atrium that provide fire separation and define internal ventilation and smoke control zones. In the original design, the atrium was completely open for 56 floors, but studies by Roger Preston & Partners showed this would generate violet vertical air currents, and a surfeit of hot air in the boardrooms at the top.

The garden spaces enhance the work environment by giving easily accessible recreational facilities inside the building, each landscaped to a different theme to help orientation and 'village identity'. The windows on each four-storey glass wall are essential to the whole building environment and so are opened and closed centrally by the BMS.

" The tower was designed within existing urban guidelines "

Natural ventilation

- This was the key to the environmentally friendly design: to succeed in a high-rise building subject to high winds and significant stack effects was a significant technical challenge. All the offices can be naturally ventilated during temperate weather by openable windows in the external facade, in the atrium, and in the garden walls. Gardens and offices are lined via the atrium which provides the stack effect to drive cross-ventilation within each 12-storey village.

Natural ventilation is likely to be used up to 60% of the time, with target office temperatures of 20°C minimum in winter and 27°C maximum in summer. In extreme

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" Natural ventilation can be used up to 60% of the time "

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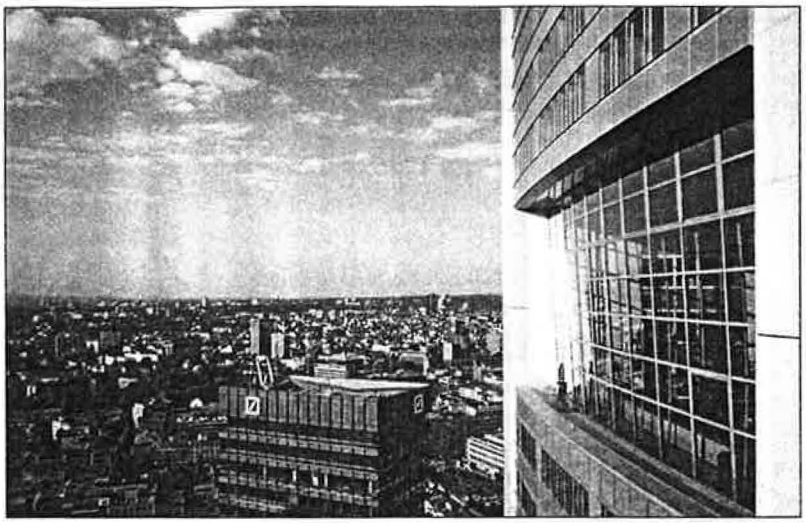
weather, it will not provide good enough comfort conditions, so a complementary mechanical air-conditioning system has been installed. Each village has its own AHUs, comprising VAV supply and extract fans, thermal wheels, filters, cooling coil, a humidifier, and fresh air/recirculation dampers.

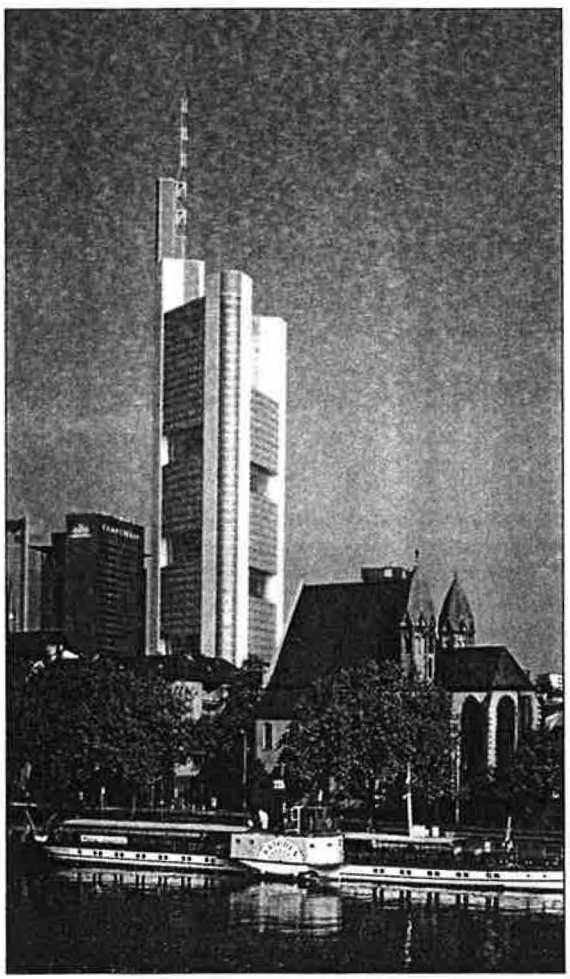
The concrete floor deck's thermal mass averages out peak cooling demands by being a thermal buffer.

Chilled ceilings

■ At night, the concrete cools as the building is unoccupied. For the first part of the day, the cool concrete helps minimise air temperatures in the occupied spaces, removing the need for active cooling.

The mechanical ventilation works in conjunction with chilled ceilings or perimeter heating. The former have both a convective and radiant cooling effect, which enables comfort conditions to be achieved with a higher air temperature than a conventional all-air system.





The large garden and atrium volumes raise light levels at work-stations round the atrium to that approaching an exterior daylit space. This gives significant energy economies as artificial lighting is a major energy user and heat generator.

The facade

■ This mediates between the surrounding environment and the workplace as a climate modifier to smooth the fluctuations of nature. After many design and cost iterations, the completed facade has a 200mm ventilated cavity with an opening double-glazed inner skin, hinged at floor level and motorised to allow the window to tilt in at the top. The outer skin, of single-glazed 8mm laminated safety glass, forms a screen to reduce air pressure fluctuations. The cavity is ventilated by continuous slots 125mm wide at the top and bottom of each floor, air flow being driven by the stack effect over a single storey. The ventilated cavity contains motorised blinds for solar shading, operable by the occupants. The internal panels are side-hinged for cleaning access to the blinds, and to the outer skin.

Early design concepts had summer air extracted via the cavity to remove solar gains, and warm air in winter supplied to the cavity, warming the glass surface and counteracting downdraughts from the open window. The final design, however, is essentially passive: more heat can build up in the cavity during summer, but the screened tilting window gives greater protection against rain and wind. Occupants can normally choose to open or close windows. In severe external conditions (wind, pollution, high or low temperature) they are closed automatically by the BMS, which constantly gathers data from the building's own weather station and seals the facade in zones.

All environmental systems are controlled by the BMS, zoned into the 12-storey village units and informed by weather stations at four levels. The BMS also monitors internal garden temperatures and initiates underfloor heating in bad weather. ■

Energy advantages

The advantages of choosing natural ventilation maximum daylighting, and a ventilated facade are estimated as:

cooling energy: .....65% saving
energy cost: .....50% saving
installed cooling capacity ..about 10% lower

This is an extract from an article that first appeared in the Arup Journal, co-authored by Peter Bailey, Harry Bridges, Paul Cross, Gabriele Del Mese, Chris Smith, Sean Walsh, and Chris Wise.