

# A skyscraper

**With its 300 metre height, the distinctive feature of the new Commerzbank high-rise office block in Frankfurt, which towers over all other buildings in this world famous banking city, is not just its imposing height. The London firm of architects, Sir Norman Foster and Partner, chose for the giant building, a triangular form, each side of which has a length of 60 metres.**

More than 2300 members of staff moved into the Commerzbank Tower in mid 1997 and they feel comfortable in their "glass office". The triangular form provides, amongst other things, good light and visibility and creates little air turbulence. The "Gardens of Heaven" contribute substantially to the pleasant working conditions and room climate. A total of nine large window fronts, offset around the building at different heights, break up the office storeys. They have been laid out as gardens and are suitable as areas of relaxation and meetings. These four-storey high green zones are a part of the concept which distinguishes a new type of ecological high-rise building. The energy bills should be considerably lower (up to 40%) than with traditional high-rise buildings. There is no typical air conditioning system. The front of the building has been conceived as a climatic facade which allows the air to circulate. The architects let the core of the building remain free to form an

enormous atrium with a height of more than 160 metres, which for safety reasons (fire prevention) is covered with a glass roof every twelve storeys.

The modern building is a pure steel construction down to the beams of re-inforced concrete at the corners. A framework of about 18,000 tons in weight comprised of around 9,000 large girders, supporting and connecting elements, are held together by hundreds of thousands of special screws. Thanks to its steel construction, the Commerzbank office tower weighing around 200,000 tons has considerably lower weight than a concrete re-inforced steel building of comparable size. The tower not only rises upwards; it penetrates downwards as well. It stands on 111 foundation stilts which are securely anchored in the rocky subsoil. The largest of the 1.80 metre thick stilts are up to 50 metres high.

## High tolerance standards

The firm of surveyors, Grandjean in Frankfurt were responsible for surveying the complete building project. During the steel structure erection exacting problems had to be solved. To maintain and secure the high tolerance standards, a comprehensive measuring program was worked out to accompany the building work. From a measuring platform, which was fixed to the highest mounted steel element in the atrium, about 50 marks were

## A few statistics

Start of construction	May 1994
Completion	July 1997
Height with antennae	300.01 m
Height without antennae	258.70 m
Number of storeys	63
Number of basement floors	2
Useable floor area	52,700 m <sup>2</sup>
Total weight	200,000 t (approx.)
Weight of steel	18,000 t (approx.)
Weight of steel construction per floor	300 t (approx.)

measured. This measuring platform was positioned relative to three highly accurate measured fixed points located in the corners of the atrium. As a result the surveyors were always a few metres ahead of the steel constructors.

Part of the daily work had to be completed before dawn prior to steel constructors arriving at 6 o'clock for their first shift. Surveyor Markus Grandjean said: "Physical influences such as sun, wind and temperature fluctuations cause the steel construction to distort. The resulting movement from the perpendicular line of gravity made by the steel girder construction was increased by the building work itself, in particular by crane loads.

A behavioural model of the steel construction was developed by taking distortion measurements during the building process. Even after selecting and calibrating suitable precision surveying instruments, measurements were corrected by the distortion of the behavioural model. The result was an iterative process of calibrating,



measuring and then correcting measured values. For erecting the steel supports, the results of measuring had to be available immediately. This was guaranteed by easy data exchange between measuring instruments, computers and printers (partly on-line, partly via a PCMCIA card) and calculation procedures which enabled up-to-date evaluation of the measurement values with numeric and graphic display of results on a vector plan."

## Surveying instruments

Surveying was made with instruments from Leica. Two instruments of the same model were used simultaneously to ensure the quality of the measuring, and to organise surveying reliably into the logistics of the progress of

# with a garden

*This demanding project in the centre of Frankfurt was finalised within de planned timeframe of 3 years.*

*Photos: Commerzbank Press Office (1), Mätzler (2)*



the building work under building site conditions. Extremely different temperatures, in rain, in cloud and in fog, added to the complications. The surveying was carried out with

- TCM1800 total stations
- Nadir plummets
- Leica Nivel 20 inclination sensors for measuring movements
- NA3000 digital levels (levelling on and under the ground level)
- GPS System 300 (for independent control of the high plumbing and position fixing in conditions of poor visibility).

## Surveying

In connection with the construction of the Commerzbank office tower in Frankfurt, the Grandjean

survey office had to carry out the following survey work:

### Outline survey

- Layout of a geodetic fixed point network of extreme accuracy for position and height measurements for:
  - the outline
  - the construction work
  - control of the construction work (building tolerances)

- preservation of evidence (measuring distortions to neighbouring buildings and obstructions)
- tracing and resetting the boundaries of the construction site
- planning relevant points of the old building work in position and height
- examining the building regulations, and the position and height of the project in the neighbourhood
- finding the clearance surfaces according to local building regulations
- creating a digital height model of the neighbouring area as a basis for radar, lumination and shading assessments
- creating the "Site plan for building application" to accompany registration of the project for a decision on the building regulations and planning guidelines

- checking the steel supports following fixing
- subsidence and distortion measurements on neighbouring buildings and on the building under construction.

### Measuring the building

- measuring the building after completion
- supplying the results of measurements to the land registry according to the local surveying laws so that the official land register maps and books are current.

**Erich Mätzler**

### Staking out and measuring during building progress

- staking out the outer limits of the building work or the main axis according to local building regulations
- directing the control measurements for the steel supports during building progress with up-to-date numeric and graphic display of results

*Dr.-Ing Hans-Erich Grandjean - his surveying company has long experience in this field especially with large construction sites. For the project of Commerzbank Tower his son Markus was in charge.*

