Dynamic and exciting structure with twisted towers connected by diagonals

The European Central Bank

The new building for the European Central Bank (ECB) (fig. 1) consists of two peculiar towers connected by diagonals. It is located in the east of Frankfurt, between the historic wholesale market, the Großmarkthalle and the Main River. The Großmarkthalle, an impressive brick building and monument from 1928 designed by Martin Elsaesser, was restored as part of its integration within the construction of the new ECB towers. Due to the twist of the towers, also torsion effects had to be considered. The locations of the diagonal elements were generated parametrically in an evolutional process.

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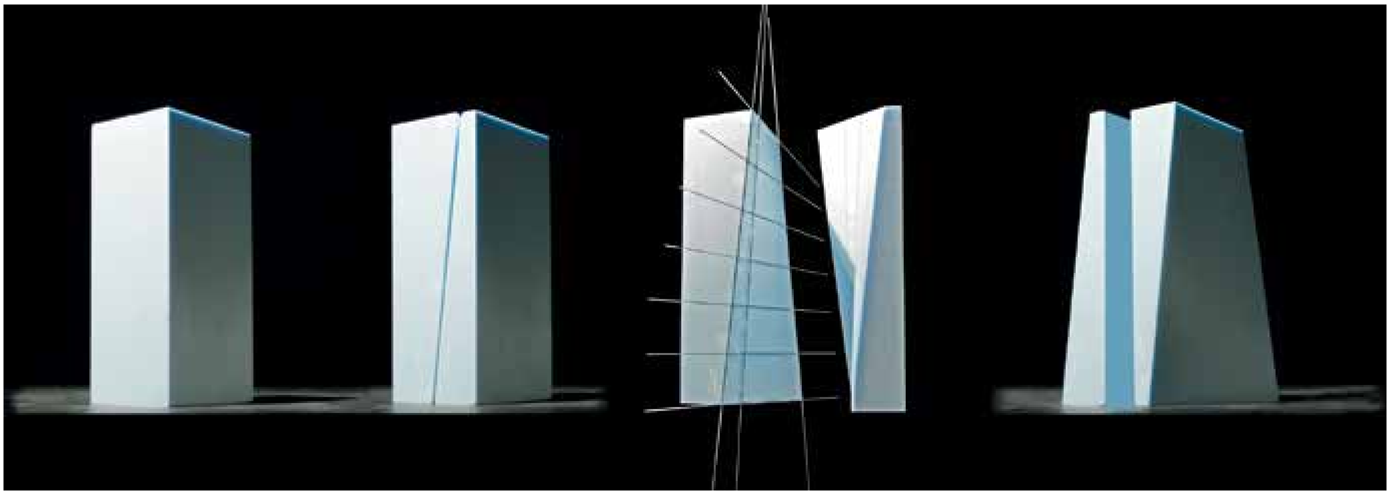
1 The Großmarkthalle and the ECB towers
credits: Paul Raftery
2 Design of the towers
credits: Coop Himmelb(l)au
3 Element of the structural system: the cores
credits fig. 3 t.m. 10: Bollinger + Grohmann
4 Horizontal platforms and bridges and diagonal struts



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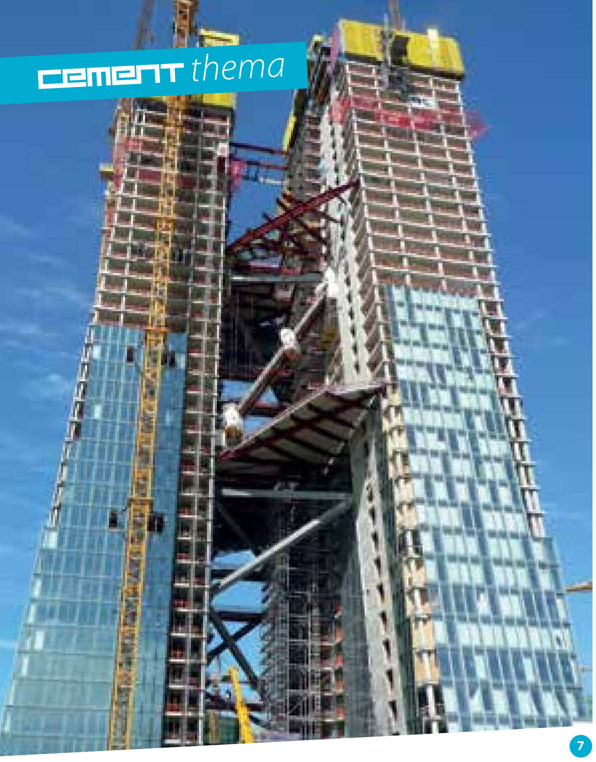
The architectural design process

The design of the new building for the European Central Bank was developed during a competition in 2002. The geometry of the striking 180 m high double towers follow the 'deconstructivistic' idea of the architects Coop Himmelb(l)au to divide a block diagonally, then turn the inner faces outside and the bottom to the top (fig. 2). The two parts are combined into one unit by a full height glass atrium.

The global structure design process

The stability system is based on the core walls of each tower. In longitudinal direction the stiffness of these cores (fig. 3) was sufficient to resist lateral loads. In cross direction the core width is only 6 m. Thus the structural systems of each tower had to be extended from two single cores to a global system consisting of the two cores and a spatial truss system which connects the cores via the atrium (fig. 4). The cores act as

[1]) *Deconstructivism is a movement of postmodern architecture which appeared in the 1980s. It gives the impression of the fragmentation of the constructed building and is characterized by an absence of harmony, continuity, or symmetry (Wikipedia).*



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5 Slab geometry
6 Parametric design of the truss system
7 Construction stage: while the cores are nearly finished, the truss system follows up from approx. 60 m below
8 Installation of the trusses
9 Reinforcement of the foundation slab
10 Bracing, bridges and platform above
11 The finished structure inside the Atrium

credits: Paul Raftery

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upper and lower chord of a global truss system. While the location of the platforms, elevators and bridges in the atrium were geometrically fixed, all diagonal elements were generated in a parametric and evolutional process. The first models show certain design steps of the process, the last one is the final one (fig. 6). The governing criteria in this process were the eigenfrequency and the stiffness.

Torsional effects

Due to the inclined façade torsional effects have an impact on the towers. As both towers twist in the same direction, the global structural system, apart from wind loads, has also to resist these loads.

Slabs and columns

Due to the twist, all slabs have a different geometry and different span (fig. 5). The columns near to the façade follow the incline, while inner columns are vertical and straight.

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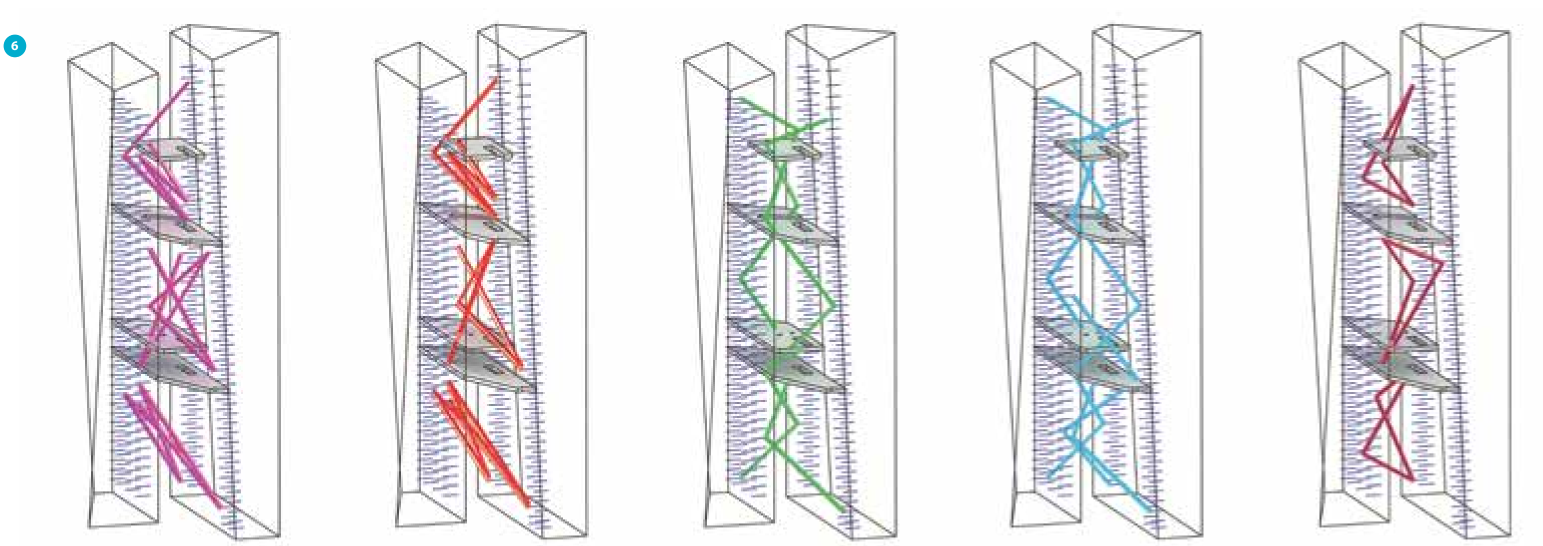

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Deformations and Pre-camber

The vertical and horizontal deformations of each column and slab were calculated considering the construction process as well as time-dependent factors like creep and shrinkage. These deformations were considered during the construction process by pre-cambering of these elements.

Construction process

During construction the structural system changed from pure core systems to partially finished truss systems (fig. 7, 8 and 10). For each construction stage the resistance of the structure had to be proved.

The foundation

All the loads of the towers are transferred into the ground by a combined pile-raft foundation (fig. 9).

Conclusion

With the construction of the new European Central Bank in Frankfurt a highly dynamic and exciting structure was realized. The design of the architects Coop Himmelb(l)au has been accompanied by the B+G structural engineers from the very beginning, i.e. already during the competition. Thereby, an optimized structure for this building has been developed. Through its expressiveness, it emphasizes and makes the seat of ECB architecturally appealing and standing out from afar (photo 1). ☒

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