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SUPERENGINEERING

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Shanghai Tower

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Owner: Shanghai Tower Construction & Development Co., Ltd.

Contractor: Shanghai Construction Group Co., Ltd.

Architectural Designer: Gensler, USA

Structural engineer: Thornton Tomasetti, USA

Construction Drawing Designer: Tongji Architectural Design (Group) Co., Ltd.

With a height of 632 m, the Shanghai Tower stands as the tallest building in China and the second-tallest building in the world and is located in the financial center of Lujiazui. It was completed in 2015. It is a skyscraper catering to commercial, office, accommodation, and sightseeing purposes. The overall floorage of the Shanghai Tower is 580,000 m^2, including 5 levels under and 124 levels over the ground. During construction, a super-long bored pile was adopted in the pile foundation. The structure is a steel-concrete system, in which the vertical structure includes a steel-concrete core tube and a huge-scale column; the horizontal structure contains steel beams, floor truss, belt truss, outrigger truss, and composite floors. A crown roof is set up on the top of the tower. The project was titled the Best Tall Building Worldwide in 2016 by the Council on Tall Buildings and Urban Habitat and the LEED Platinum Certified Building. It also won the Emporis Skyscraper Award in 2015, the Outstanding Structure Award 2016 conferred by the International Association of Bridge and Structure Engineering, "People's Choice Award" of MIPIM Awards 2016 (MIPIM is the world's leading property market) in France, and "Design of the Year" award by the American Architecture Prize 2016. It has been reported as "one of the 125 most important buildings in the past 125 years" in 2016 by *Architectural Record*.

The Shanghai Tower, like a dragon, is characterized by its spirally rising surface. The external double-glass curtain wall with a rotating surface is supported by a flexible suspension steel structure. Meanwhile, the exterior design of 120° rotating tucked-up points of shape greatly reduces the wind load on the building. Moreover, the two layers of the glass curtain wall guarantee energy conservation and environmental protection. The upper-air atrium among the glass curtain wall facade forms an independent biological climate zone, which improves the air quality of the building. As a model of green super-high-rise buildings, based on the design concept of global sustainable development, the tower was constructed by applying numerous green building technologies—turbo-type wind power generation, rainwater re-utilization, ground-source heat pump, distributed energy, thermal recycling, and variable air volume air conditioning—making the Shanghai Tower the first green super-high-rise building exceeding 400 m in height in the world.

The Shanghai Tower is a masterpiece among super-high-rise buildings with advanced construction technologies. Initially, to solve construction difficulties caused by soft soil foundation, large-diameter, super-long bored grouting piles were driven, and the bearing capacity of the pile end was greatly increased by pile end grouting after piling. In fact, the designed bearing capacity is as high as 1000 t. Next, to deal with difficulties in foundation pit construction with an area of 30,000 $m^2$and a depth of 33 m, high-efficiency partition construction technologies were employed to achieve normal construction of the circular diaphragm wall (inner diameter: 121 m) foundation pit in the main building and top-down construction of the surrounding podium area. This helped achieve the optimal goal of the shortest construction period for the main building, minimum investment of temporary support, and better environmental protection. Later, for tackling control difficulties related to mass concrete casting of the foundation slab of the main building, concrete preparation technologies with low hydration heat and low shrinkage were adopted, creating a new world record of one-time

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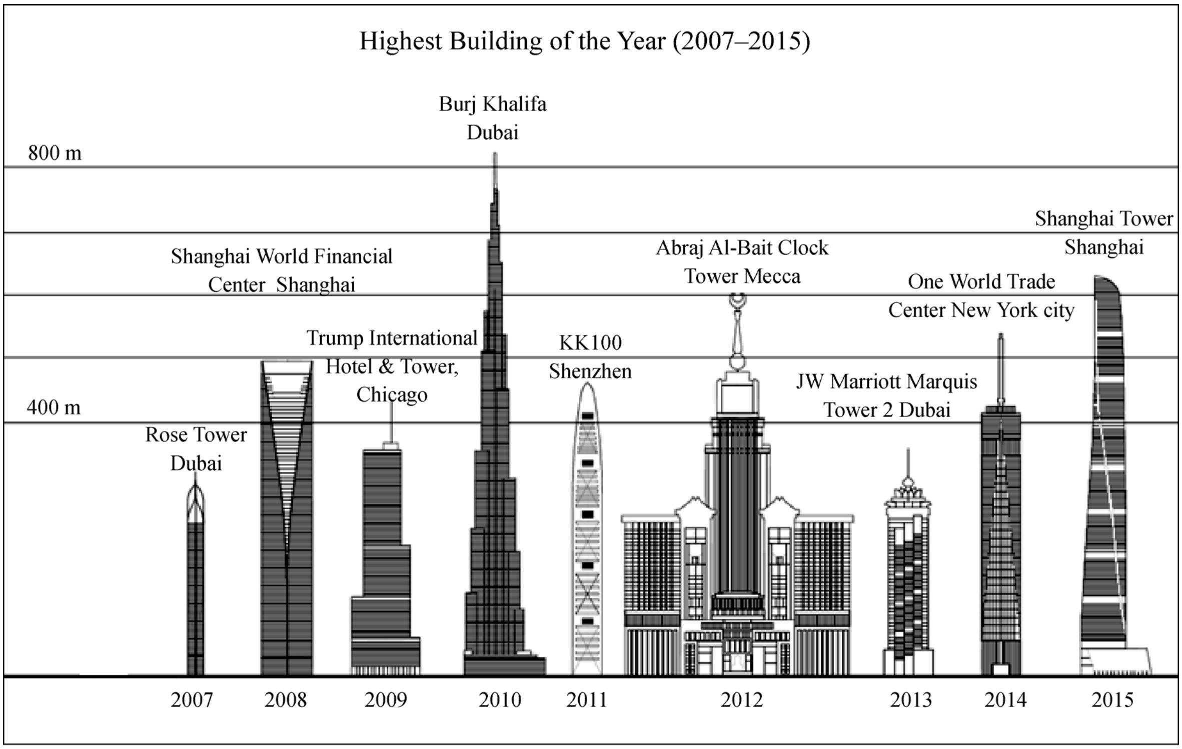
continuous large-volume concrete casting with a strength grade of C50, length of 121 m, thickness of 6 m, and volume of 60,000 m^3. Then, the cooperative control of an integrated performance index was adopted to solve the difficulty of pumping concrete for the super-high building. One-time C60 concrete pumping height reached 582 m, for C45—606 m, C35—610 m, and for 120-MPa ultrahigh concrete—620 m, setting a new world record for the largest one-time concrete pumping height. With regard to technological difficulties for safe construction equipment with super-high altitude and high efficiency, a new integral steel platform formwork system based on a steel platform, scaffolding, formwork, supporting, and climbing systems was invented to realize modularized standard component integration and intelligent control, greatly improving work efficiency and reducing labor intensity. Finally, to solve installation difficulties related to the glass curtain wall with a rotating surface, a self-adaptive sliding bearing of glass curtain wall deformation compatibility was introduced along with a novel construction method called the flexible suspension structure installation of a downward intelligence platform system in order to complete the installation of more than 20,000 glass pieces of different sizes in the curved glass curtain wall.

To tackle the great construction difficulties and high technical requirements, many new methods were adopted



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in the engineering management of this project, reflecting a new mode of digitalized management. Digital construction technologies were widely applied to construction site planning, including pile positioning using the reverse construction method; studies related to environmental impact of confined water, environmental impact of foundation pit construction and visualized monitoring; crack monitoring of mass concrete; steel structure processing and use of the welding robot; mechanical and electrical installation and component processing; design and processing of the glass curtain wall; modular design of the formwork equipment and visual control; material purchasing management and logistics tracking; collaborative project management and so on. The digital project management methods improved work efficiency, solved the difficulties encountered, and enriched the connotation of modern project management, providing a model of the initiation of digital construction.