The Tianjin Jinta Tower: 74-Story Steel Plate Shear Wall Tower

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Summary

The 329.6 meter tall 74-story Jinta Tower in Tianjin, China, is expected, when complete, to be the tallest building in the world with slender steel plate shear walls used as the primary lateral load resisting system. With an overall aspect ratio close to 1:8, the design challenge for this tall building was to develop an efficient lateral system capable of resisting significant wind and seismic lateral loads, while simultaneously keeping wind induced oscillations under acceptable perception limits. The paper will describe the genesis of the structural system selection considering various available options and significant aspects of the analysis, design, testing and proposed construction. US and Chinese codes and standards, current on-going research and development, and project specific testing were integrated to develop the analysis and design procedures used.

Keywords: Steel plate shear wall; SPSW; tension field action; boundary elements.

1. Introduction

The 329.6 meter tall 74-story Jinta Tower (Tower) in Tianjin, China, is expected, when complete, to be the tallest building in the world with slender steel plate shear walls (SPSW) used as the primary lateral load resisting system. The Tower has four stories of parking space below existing grade and 74 stories of office space above grade (Fig. 1). It has an elliptical footprint approximately 42m by 81m at the base which changes with height to create an “entasis” effect. The total framed area of the tower is approximately 205,000 sq. m. The building is intended for office use.

Because of the tower’s slender form, it has an overall aspect ratio close to 1:8, a key design challenge was to develop an efficient lateral system capable of resisting significant wind and seismic lateral loads while simultaneously keeping wind-induced oscillations under acceptable perception limits. A wind tunnel analysis was performed for the tower.

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Fig. 1: Architectural Rendering of Tower

Several structural system options were considered in the concept and early schematic design phases including a concrete dual system with perimeter special moment resisting frames and core shear walls; composite systems with perimeter steel special moment resisting frames, steel floor framing and composite metal deck slabs, and composite concrete and steel plate shear walls; and steel systems with perimeter special moment resisting frames and braced or SPSW cores. The steel and composite systems utilized concrete filled circular tubes (CFT) columns to minimize their dimensions. Concrete systems were eliminated primarily on account of the large sizes of the members required that had a significant impact on rentable area. Two types of composite shearwalls were considered; a double steel plate "hull" system with concrete infill and a more conventional system with a single steel plate embedded in the middle of a concrete wall. Both alternatives were eliminated after detailed investigation showed that there was insufficient precedent and research / testing data available (considering the specific features of the project such as the CFT columns) to convincingly demonstrate the feasibility of these systems to the authorities without very significant research, testing, cost and, most significantly, time. Steel dual systems with braced cores were found to require as much as 20 - 25% more steel to satisfy structural performance requirements than SPSWs. This fact, taken together with the minimal dimensions of the steel plates, the availability of substantial code provisions and design guides, research and testing data that highlighted the superior ductility of SPSWs, and excellent predicted structural performance resulted in a decision to use SPSWs over braces in the tower core.

Because of the relative newness of the structural system as well as its significant height that exceeded the code, at the end of the Design Development Phase the project was subjected to review by panels of seismic and wind experts in accordance with the regulations in China. The experts reviewed the seismic and wind performance of the proposed structure and imposed additional requirements to address the unique nature of the project and ensure its safety.

2. Conclusions

Steel plate shear walls acting in tandem with ductile moment resisting frames were determined to be the optimal solution to structuring the 329.6m tall Tianjin Jinta Tower with an aspect ratio of 1:8. The design solution was subjected to rigorous review by panels of seismic and wind experts in China at the end of the "Design Development" Phase. This review resulted in the adoption of enhanced analysis and design procedures and performance goals; and testing. The project is nearing completion of the "Construction Documents" Phase. Excavation of the site is complete and construction of the foundations is under way.

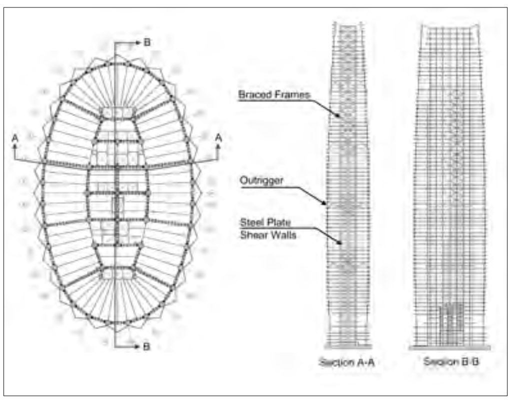

Fig. 2: Typ. Structural Plan, Sections