555m Tall Lotte Super Tower, Seoul, Korea

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Summary

Located in Seoul, Korea, the Lotte Super Tower is a unique form that transforms from a square, 70-meter square footprint to a 39-meter circle at 555 meters above ground. The shape of the building has been refined to reduce wind forces and accelerations. A dual system comprised of an exterior steel diagrid and an interior reinforced concrete core is utilized for lateral resistance to wind and seismic effects. Each of the components of the structural system have been optimized to provide material efficiency, and geometrically rationalized to increase constructability. When completed, the Lotte Super Tower will be the second tallest building in the world.

1. Introduction

The Lotte Super Tower is sited in southeastern Seoul, defined by the Han River and the nearby granite mountains. Striving to create a landmark within this context, the Tower's form and geometry are highly influenced by an existing icon from Korean culture: Chum-Sung-Dae. The historic Chum-Sung-Dae observation tower in Kyongju, South Korea is a register of the rich cultural and scientific heritage of Korean society in the 7th century. This new iteration will be a national icon and a testament to the progress of technology in Korea today.

The Tower is comprised of 112 above-grade stories, containing mixed-use space for office, hotel, retail and building services. There are also four (4) below-grade levels which connect with a large podium structure. A perimeter structural diagrid defines the form throughout the building height. The tapering profile of the building in combination with the modeled surface at higher elevations creates a highly efficient structural form. A ductile interior concrete core tube allows clear spans and improves wind and seismic resistance. The composite system established by the steel diagrid and concrete core, enhanced by the tapered and faceted profile, creates an extremely efficient high rise structure.

2. Structural System

The lateral load-resisting system of the Lotte Super Tower is comprised of a highly efficient perimeter structural steel "trussed-tube" diagrid combined with a central, ductile, reinforced-concrete core wall system.

The lateral loads in the perimeter steel diagrid are resisted by a network of diagonals and horizontals, in which the angles have been optimized so as to limit wind deformation and overall shear forces. The diagonals carry both wind and gravity loads to the base of the structure. Because

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the diagonals utilize their entire cross sections to resist the loads, as well as resisting the loads in direct compression without bending, they are very efficient. Additionally, long-span floor framing is used to increase the gravity load on the perimeter. As a result, there is sufficient gravity load on the perimeter to limit tension in the diagrid columns under combined wind and gravity loading. The diagonals are rigidly connected to major horizontal spandrel beams on multi-floor modules (diagrid nodal floors) occurring at the intersection of adjacent diagonals.

An interior reinforced concrete core wall system is utilized to compliment the structural steel diagrid, from foundation through level 112. These walls are configured to optimize material, eliminate transfer zones, and provide easy transiting of the tapering floor plates. In addition, the core wall system provides excellent damping in the overall system to limit wind-induced motions and accelerations. The floor framing system for a typical level consists of a composite metal deck slab with normal-weight concrete topping. The slab is supported by structural steel floor framing spanning between the concrete core wall and the perimeter diagrid. Within the core one-way concrete slabs span between reinforced concrete beams and girders. Foundations consist of a 4.0 meter thick reinforced concrete mat under the entire footprint bearing directly on the underlying rock. The mat is used to distribute loads and minimize both total and differential settlements.

3. Wind Engineering of Overall Structural Form

The form of the Tower was not only influenced by the rich cultural past of Korean society but by the intensive collaboration of both architects and structural engineers to provide an efficient form to resist both wind and seismic forces. For any super tall building, the effects of wind always have a huge impact upon the design of the structural lateral system. Wind induced vortex shedding or crosswind building movements can cause high building accelerations that can make building occupants uncomfortable. However, by choosing an efficient form that tapers over the entire height, and by utilizing an open lattice structure at the top of the building, the Tower's accelerations are kept within an acceptable range.

4. Optimization of Structural Diagrid System

In its most simplistic form, a tall building is essentially a cantilever. When the trajectories of the principle stresses in a solid cantilever under wind loads are broken down, one can see that the forces at the base are primarily axial loads, and thus want to be more vertical, while the stresses at the top of the building are controlled by shear, and thus want to be more horizontal. Applying this simple concept to the Lotte Super Tower, the optimum angles for the primary structural columns were calculated. Since the diagrid runs through several floors before changing angle at a node, the theoretical angles had to be rationalized and grouped. This led to a diagrid solution in which the angles vary over the height of the structure. When coupled with a reinforced concrete core wall system to provide building mass and additional stiffness, the structural steel diagrid completes a balanced structural system to resist the lateral loads in a very efficient manner.

5. Conclusion

When completed the Lotte Super Tower will be the second tallest building in the world. Its distinctively engineered form will be a national icon for Korea, and serve as a testament to the progress of technology in Korea today. The Tower's dual system of an exterior steel diagrid and an interior reinforced concrete core provides an efficient and effective use of systems and materials, so as to create a visually stunning tower, and also to satisfy all of the structural performance requirements of a supertall building.