Title:	**Lotte World Tower: Seoul's First Supertall**
Author:	James von Klemperer, President, Kohn Pedersen Fox Associates
Subject:	Building Case Study
Keyword:	Supertall
Publication Date:	2018
Original Publication:	CTBUH Journal 2018 Issue I
Paper Type:	1. Book chapter/Part chapter 2. **Journal paper** 3. Conference proceeding 4. Unpublished conference paper 5. Magazine article 6. Unpublished

Lotte World Tower: Seoul's First Supertall

James von Klemperer

Author

James von Klemperer, President
Kohn Pedersen Fox Associates
11 West 42nd Street
New York NY 10036
United States
t: +1 212 237 3466
f: +1 212 956 2526
e: jvonklemperer@kpf.com
www.kpf.com

James von Klemperer is President and Design Principal at Kohn Pedersen Fox Associates, where he began as a young architect in 1983. His work ranges in scale from a house to a city, and he contributes closely to these efforts from conception to completion. In addition to focusing on his own projects, he leads the community of designers within the firm in exploring shared architectural agendas and goals. As President of the firm, he leads a staff of 550 people in six offices around the world. Von Klemperer received a Bachelor of Arts from Harvard University in 1979 and his Master of Architecture from Princeton University in 1983.

Abstract

The Lotte World Tower became the world's fifth-tallest building upon completion in 2017, and is currently the only supertall building (300 meters or higher) in Seoul. As it is located a fair distance from other tall buildings, the project's designers bore substantial responsibility to not only create an enduring skyline icon, but also to provide a culturally relevant and well-integrated project within the urban grain. Beyond the spectacle of its sleek design and great height, the tower is part of a mixed-use complex that has provided additional public amenities. With its diverse program, it is hoped the project will become a beloved destination in Seoul.

Keywords: Supertall, Seoul, Mixed-Use

Introduction

The design of Lotte World Tower is both the product and an instigator of an urban paradigm shift – a restructuring of the commonly held beliefs that surround the nature of the urban environment. It is inevitable that globalization and urbanization will persist, raising issues regarding population growth and urban density. The supertall towers and "vertical cities" created in response to these conditions present a solution. Opportunities abound to enhance vertical construction so that it can offer the diversity and experiential qualities typically found in linear, horizontal urban centers.

Major achievements in building technologies, including vertical transportation and structural systems, have accelerated the development of supertall towers around the world, but their social acceptance remains critical to their continued success. The newly completed Lotte World Tower in Seoul is removing

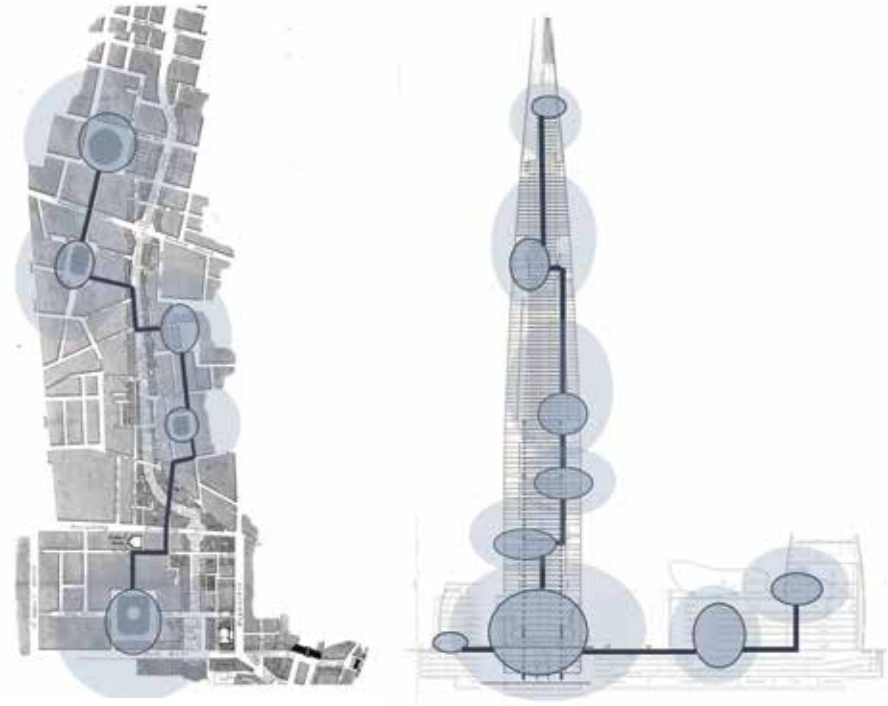

Figure 1. For skyscrapers to succeed as "vertical cities," they must carefully adopt the functions and spaces associated with dense urban centers, normally experienced linearly.

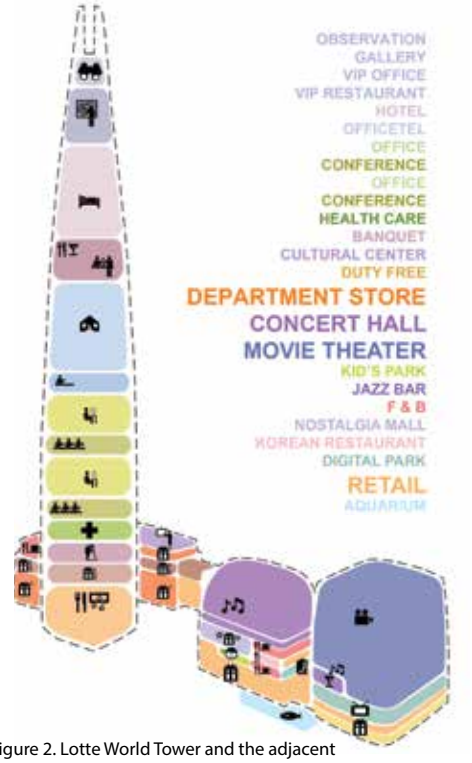

Figure 2. Lotte World Tower and the adjacent podium incorporate a tremendous density and diversity of programming.

barriers – both physically and psychologically – as it breaks the boundaries of vertical construction.

As the fifth-tallest building in the world, Lotte World Tower has a responsibility to its occupants and neighbors. Rising to 555 meters, the tower's design takes the horizontality of the city and transforms it vertically, offering a range of programming while remaining thoroughly attentive to individual experience. The tower focuses on a vertical programming strategy that supports efficient circulation, structural safety, and comfort. It offers a confluence of supportive systems that creates an experience reflective of its height and stature.

Lotte World Tower takes the horizontal life of a city and flips it on end (see Figures 1 and 2). But this is not just an act of replication. The inversion delivers a new experience to the urban dweller, one that is expressed and felt vertically. The tower boasts 123 floors of mixed-use programming, designed with specific attention to the lives of the people within its walls. Retail, entertainment, and cultural programming provide a base for state-of-the-art offices, residences, and a luxury hotel, all topped with one of the most impressive observatories in the world (see Figure 3).

Vertical Program

The programming strategy for Lotte World Tower is meant to be immersive and holistic. Public space is located throughout the tower, rather than being segregated on the ground floor, encouraging people to explore upper-floor destinations, including restaurants, lounges, viewing facilities, and other amenities. The design's intent was to provide flexible and convenient places for the day-to-day necessities of residents and office workers. While this story begins in the lobby, the pull of the sculpted interior ceiling panels and the multi-story, curving glass curtain wall (see Figure 4) invite further exploration.

Vertical stacking increases the efficiency of the supertall's programming, as well as its elevator

Figure 3. Overview of Lotte World Tower (left), with retail mall (behind the tower), concert hall (center) and movie theater (right). © Lotte Property & Development

layout. The podium provides a variety of retail, entertainment and cultural offerings, in addition to the public space found on floors above. Office space and amenities, including two floors dedicated to conference and event space, meeting and training areas, and cafeteria, are located on floors 11 to 39, while office-tel (home office) residences reach up to floor 75. Floors 76 to 107 provide space for a luxury hotel with a landmark design and amenities for Seoul's guests (see Figure 5). A publicly accessible, seven-story observatory caps the top of the tower, providing incredible views of Seoul.

Efficiency in Movement

Circulation throughout a supertall tower is as complex as in a dense horizontal urban environment, if not more so. Because experience is the number-one design priority, efficient circulation strategies are of the utmost importance. Thorough analysis was required to offer the occupants of Lotte World Tower a premier experience. The goal was to fully eliminate any sense of artificiality that can be associated with ascending hundreds of meters within the confines of an elevator cab.

To support the tower's mixed-use program, a behavioral study was required to establish effective circulation patterns. Movement through an office is drastically different compared to that which occurs in a residential or hotel space, dictating a multi-dimensional approach to elevator planning. It was determined that the tower's office spaces would see more up-peak traffic, with many occupants arriving within the same general time frame, while the hotel and residences would have more two-way traffic, which means equal "up" and "down" vertical demand for elevators.

Figure 4. The scalloped ceiling panels of the lobby entice the eye upwards. © Lotte Property & Development

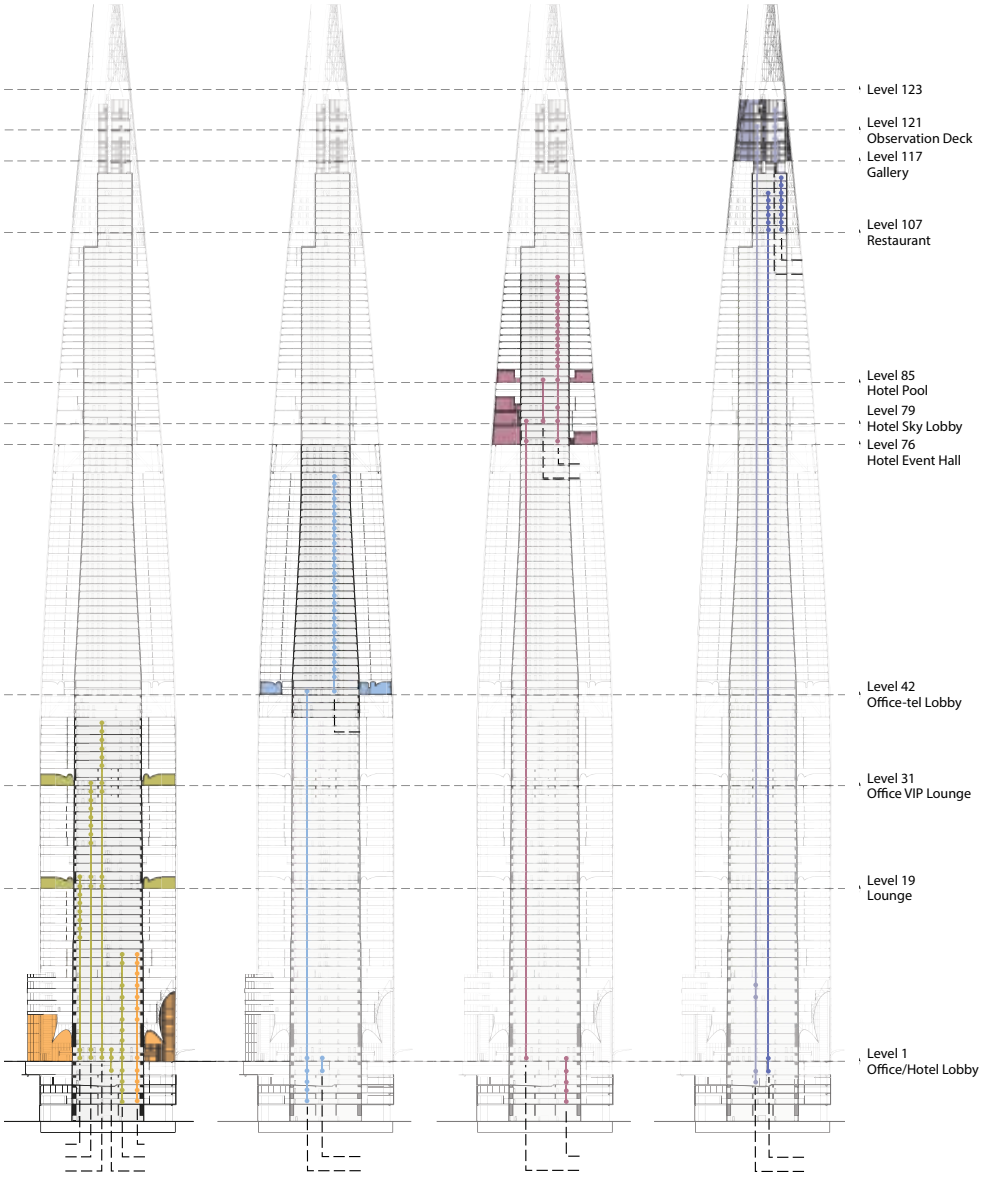

Figure 5. Stacking diagram showing the four elevator zones in the tower.
From left to right, office zone; office-tel zone; hotel zone; observation/restaurant zone.

Deeper behavioral characteristics were also evaluated to achieve the best possible vertical transportation system for the tower. Some issues studied include variations related to arrival time fluctuations, changing work schedules, and identifying industries that prefer a more collaborative environment and therefore require inter-floor traffic. People's inhabitation of amenities, public space and destination zones was considered according to vertical transportation needs.

Lotte World Tower's design alleviates potential circulation issues resulting from the tower's extraordinary height in several ways. In addition to grouping elevators based on building program, the design avoids extraneous elevator stops, which significantly enhances elevator speed and functionality. Two sky lobbies accommodate shuttle elevators and reduce core footprint, while presenting entire floors dedicated to amenities and public space (see Figure 5). The sky lobbies elevate the experience of the tower, especially when transitioning between local and express elevators. The hotel sky lobby on level 79, for example, combines extraordinary design with impressive views of Seoul to ensure that guests remain blissfully untroubled by the necessity of switching elevators to reach their rooms (see Figure 6).

Structural Strategy

Advanced capabilities in structural design push the limits of how tall we can build. Lotte World Tower was designed to withstand forces of nature that include hurricane-strength winds and earthquakes of a 9.0 magnitude on the Richter scale. Just as importantly, the tower's design reinforces a sense of comfort and safety to building occupants, even as they are enjoying the sights at the highest levels of the tower.

Lotte World Tower's structural strength begins deep within the ground. An immense foundation, reaching 30 meters below grade, applies 4,200 metric tons of large-caliber steel reinforcement and 80,000 metric tons of high-strength concrete to support the tower. The sheer weight of the concrete alone is almost seven times the weight of the entire Eiffel Tower.

The tower's main structural components are its core, configuration of eight megacolumns, and system of outrigger and belt trusses (see Figure 7). Spanning the height of the structure, the core acts as the backbone of the building, carrying all major elevators and concentrating MEP services. The megacolumns are located at the perimeter, spaced approximately 25 meters apart, creating flexible, column-free office space and unrestrained city views. The core and megacolumns work together to counteract

"The weight of the concrete in Lotte World Tower's foundation alone is almost seven times that of the entire Eiffel Tower."

Figure 6. The elevator transfer lobby on Level 79 is pleasantly appointed, so as to smooth the experience for hotel guests.

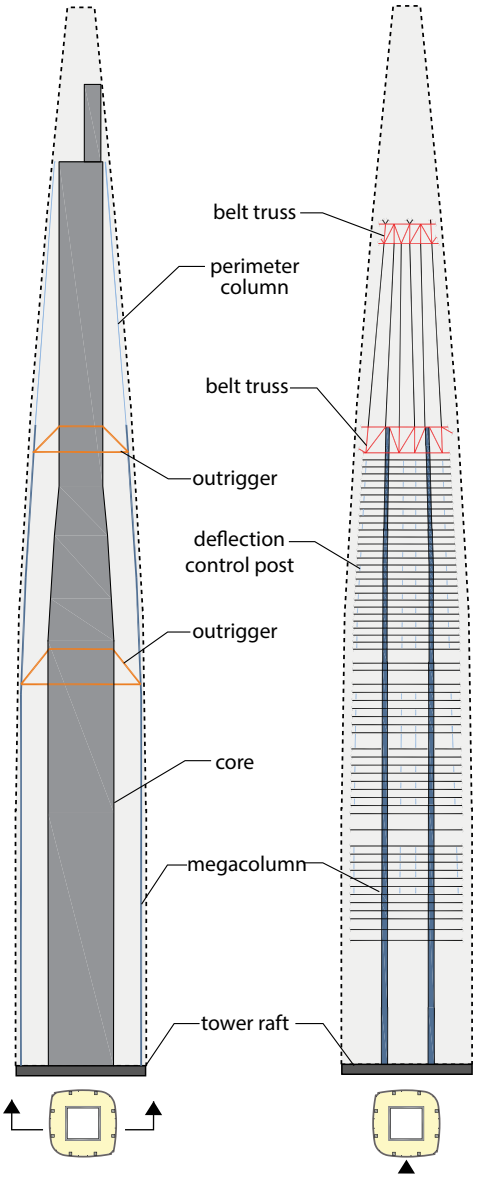

Figure 7. Simplified sections of the core-and-outrigger structure of Lotte World Tower.

Figure 8. Vertical fins define the character of the facade.

vertical gravity loads. Outrigger and belt trusses provide lateral support and augment the tower's overall structural stability. Located at every mechanical floor, they also offer greater flexibility in the location of MEP equipment.

Transparency and effective communication are important tools in building a solid relationship between a supertall tower and its community, especially in the case of a structure that supports a building the size of Lotte World Tower. To strengthen public confidence, the owner employs a highly integrated monitoring system that surveys safety conditions, such as potential structural issues or the effects of disaster-related events. The system consists of 400 sensors placed throughout the building, including accelerometers, which measure motion and vibration created by dynamic loads; and clinometers, which measure angular deviations in relation to gravity.

Designing for Comfort in Windy Conditions

The experience of a building at 498 meters – the highest occupied floor at Lotte – is dramatically different from that of the ground floor. Wind can have a critical impact, both in terms of perceived stability and noise issues.

Lotte World Tower's tapered shape is highly functional. Its elegant form increases stability against wind load, assisting the tower in its ability to hold steady against an instantaneous wind velocity of 75 meters per second. Intensive wind tunnel tests were conducted by leading wind experts to ensure that the building could withstand local wind loads, both in terms of structure and cladding.

A less obvious consequence of building height and the effect of wind is the potential for noise disturbance. The building's engineering team conducted extensive reviews and analyses of design drawings to determine any potential wind disturbance, noise or vibration that could result from the design strategy. Design features that were investigated for noise issues include the vertical fins on the building's façade, the canopy toward the base of the tower, and the crown (see Figures 8, 9, and 10).

Evacuation Assurance

Increasingly, a building's perceived safety relies heavily on the ability to quickly and efficiently evacuate in the event of an emergency. The striking heights of the world's supertall towers mean that occupants must trust building operators to protect them in an emergency situation with efficient exit strategies. Advances in elevator technologies have not only made supertall construction possible, but fulfill the expected standards of safety.

Following 9/11, it became painfully obvious that the traditional approach to evacuation, relying on dedicated exit staircases, was ineffective and unsafe. Extreme crowding and panic makes egress stairs inefficient, especially for occupants of the highest floors. However, the problem is not restricted to a panicked crowd attempting to escape. Mass descent also severely interferes with emergency personnel who are attempting to move up the tower by way of the same staircase. These conditions cause life-threatening conflict, chaotic traffic flows, and hinder emergency response efforts.

Lotte World Tower's evacuation strategy was incorporated into the building design at the very early programming phases and exceeds both international and local fire safety codes. The overall strategy includes five safety zones (refuge floors), two fire service elevators, four egress stairs, and a lifeboat elevator system. The tower's lifeboat system enables an effective evacuation strategy during catastrophic events. The 19 lifeboat elevators operate in normal mode during routine building operations, but can be switched into evacuation mode in the event of an emergency. During evacuation mode, the lifeboat elevators are only able to move between the designated rescue floors and the return floor. Additional safety is ensured through a pressurized system that encloses these elevator banks and prevents any accumulation of toxic gas or smoke.

The entire safety system of Lotte World Tower includes 161,000 sprinklers, more than 30,000 fire alarms, and the ability to sustain firefighting for five hours. Remarkably, the combined system of refuge floors and high-speed lifeboat elevators has the ability to move the entire population of the building to one of five safety zones within 15 minutes; 15,000 people can be evacuated in under 63 minutes.

At the Top of the World

A breathtaking experience awaits at the top of Lotte World Tower. Comprising the seven floors between levels 117 and 123, the observatory offers a completely panoramic view of Seoul and beyond (see Figure 11), including Incheon, Songdo and the Yellow Sea on a clear day.

To reach the observatory, visitors are served by two double-decker express elevators, known as the "Sky Shuttle," which travels between the basement and the observatory and can accommodate close to 900 people per hour, taking only one minute to reach the top of the world's fifth-tallest building.

The world's highest glass-floored observation deck also calls Lotte World Tower home. On

the 118th floor is the Sky Deck, featuring phenomenal views beneath visitors' feet to 480 meters below (see Figure 11). The floor is constructed of 45-millimeter-thick glass, with three layers of laminated glass and a SGP (SentryGuard Plus) interlayer. The glass assembly allows for five times the tear strength and 100 times the rigidity of conventional laminated glass. With this added strength, durability and exceptional clarity, the Lotte World Tower Observatory is extraordinary, in terms of both scope and safety.

Figure 9. A large curved canopy provides shelter at the ground level entrance.

Figure 10. The crown of the tower frames the protruding glass-floored observation deck.

Mediating the Base Condition

The commercial + community connection: Lotte World Mall

At the base of Lotte World Tower is the foundation for the project's intimate connection to the community of Seoul – the Lotte World Mall. The mall's 11 stories were designed with a specific intent to elevate the public experience, offering an array of entertainment options that includes local, international, and luxury retail, a cinema, a concert hall, and an aquarium (see Figure 12). The Lotte World Mall also establishes a ground-plane condition that surrounds the complex with areas that appeal to informal social gathering and more formal cultural events.

Figure 11. The observation deck features a glass floor.

Inspired by New York City's Rockefeller Center, long regarded as one of the world's best-functioning skyscraper-adjacent public places, Lotte World Mall's placement within its urban context prioritizes pedestrian experience by focusing on fluidity in circulation. Continuity of space and consistent, pervasive connections achieve an urban, public environment that achieves clear wayfinding and navigation (see Figure 13). A network of escalators and bridges provides convenient transitions, moving people through various shops, interior atriums, roof gardens, and parks (see Figure 14) with efficiency and ease.

Figure 12. The variance in scale and mass of the podium, and the setback of the tower from the street soften the project's ground-plane impact.

Traffic alleviation

Lotte World Tower is sited within the densest area of Seoul. The density and diversity of the

Figure 13. The pedestrian promenade mediates the scale of the tower and surrounding buildings and provides a transition to the vertically stacked program.

Figure 14. The podium rooftop includes serene moments like this one.

> “The combined system of refuge floors and high-speed lifeboat elevators has the ability to move the entire population of the building to one of five safety zones within 15 minutes; 15,000 people can be evacuated in under 63 minutes.”

area’s activities also posed some unique challenges in designing the tower’s base. The resulting design is precise in its full integration into the complexity of its context, using its gently rounded footprint and tapered vertical form to rest comfortably within the surrounding city. The subtle curves of the design cushion its presence and spatial relationship to adjacent structures. To successfully integrate Seoul’s only supertall tower into the city’s already overwhelmed infrastructure was both a challenge and an opportunity. The estimated increase in traffic, both vehicular and pedestrian, at the site was a serious concern for the city, prompting a comprehensive investigation into the project’s potential impact. Extensive testing of various design and siting options and detailed programmatic analysis were conducted to develop a design and site strategy that could accommodate a substantial hike in the volume of traffic.

Two traffic alleviation strategies were implemented to ensure the continued success of Lotte World Tower. The first responsibility was to fully integrate the tower into existing forms of public transportation, lessening the public’s overall dependency on automobiles by enhancing transit connections.

Second, an innovative design scheme was developed to drastically reduce ground-level traffic congestion during peak hours. By depressing an existing, major road that occupies the southern part of the site, major drop-off zones could be located at level B1 (see Figure 15). This moved the auto entrance below grade, and reduced the prominence of vehicular access as a driving design feature of the project, allowing for a more compelling use of the ground plane.

An added benefit of Lotte World Tower’s thoughtful approach to traffic congestion is a design that offers some respite from the urban condition through landscaping and access to nature. The lowering of the main roadway allowed for an extended landscape that connects to the adjacent lake, a popular place for recreation in the neighborhood. The development of Lotte World Tower allowed

for free movement between the tower and the lake, without pedestrians having to cross a six-lane highway (see Figure 16).

Conclusion

As the world becomes increasingly denser, and buildings taller and taller, the human experience must remain at the forefront of architecture and design. Lotte World Tower is the product of a strategy for supertall construction that caters to the individual experience, and provides a mediated transition from the ground plane, even as it stands as one of the tallest in the world. ■

Unless otherwise noted, all image credits in this paper are to Kohn Pedersen Fox Associates..

Project Data

Completion Date: 2017
Height: 554.5 meters
Stories: 123
Total Area: 304,081 square meters
Function: Hotel/office/retail
Owner/Developer: Lotte Property & Development
Architect: Kohn Pedersen Fox Associates (design); BAUM Architects (architect of record)
Structural Engineer: Leslie E. Robertson Associates (design); Chang Minwoo Structural Consultants (engineer of record); Thornton Tomasetti (peer review)
MEP Engineer: SYSKA Hennessy Group (design); WSP | Parsons Brinckerhoff (peer review)
Main Contractor: Lotte Engineering & Construction
Other CTBUH Member Consultants: ALT Limited (façade); Aon Fire Protection Engineering (fire); CBRE (access); Fortune Shepler Consulting (vertical transportation); Lerch Bates (façade maintenance); Rider Levett Bucknall (cost); RWDI (wind); WSP | Parsons Brinckerhoff (energy concept, LEED)
Other CTBUH Member Suppliers: Dow Corning Corporation (sealants); Otis Elevator Company (elevator)

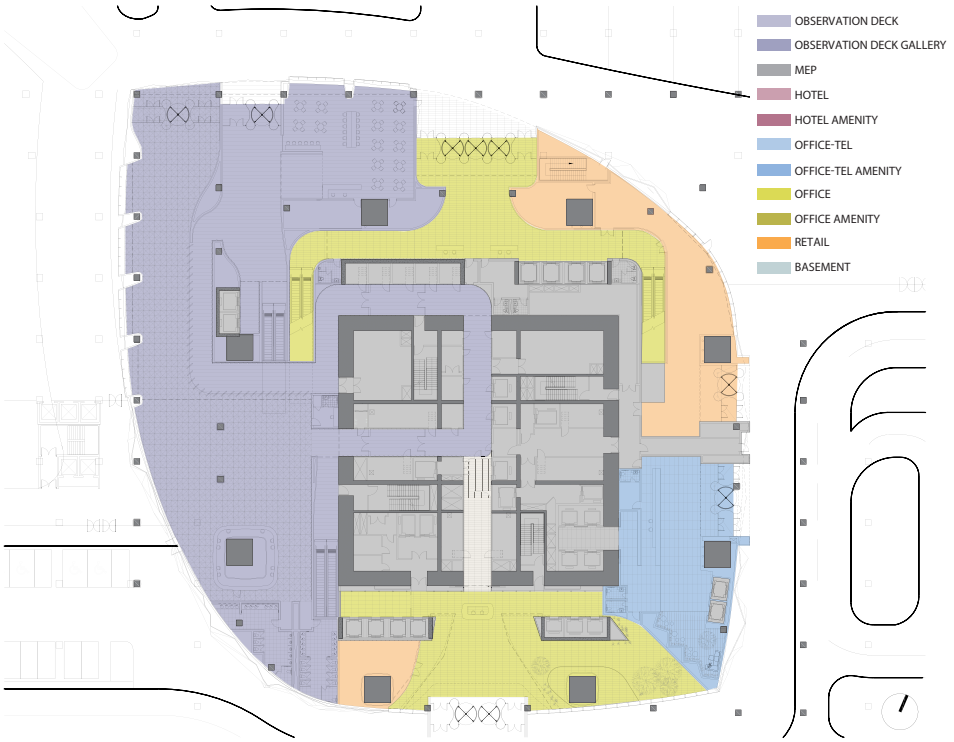

Figure 15. Level B1 plan, showing location of drop-off zones and zoning.

Figure 16. Lowering a road allowed occupants of Lotte World Tower to directly access the adjacent lake.
© Lotte Property & Development