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Shanghai Tower: Building a Green, Vertical City in the Heart of Shanghai

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The Shanghai Tower establishes a new paradigm for tall buildings and vertical urbanism. Innovation and new technology play a strong role in the superlative aesthetic, structural, and environmental achievements of this "disruptive" building, while reinforcing time-honored maxims of design that still hold true.

While the distant silhouette and the proximate detail of the tower will be immediately distinctive, the purpose of the Shanghai Tower is not simply to be seen as an iconic landmark. It is much more than that. Because it incorporates so many advanced techniques based on current skyscrapers, it will be a learning laboratory for the next generation of skyscraper designers. And it illustrates that architecture should not be constructed for its own sake, but for the people, which is the most fundamental factor.

Motivation: Built for People

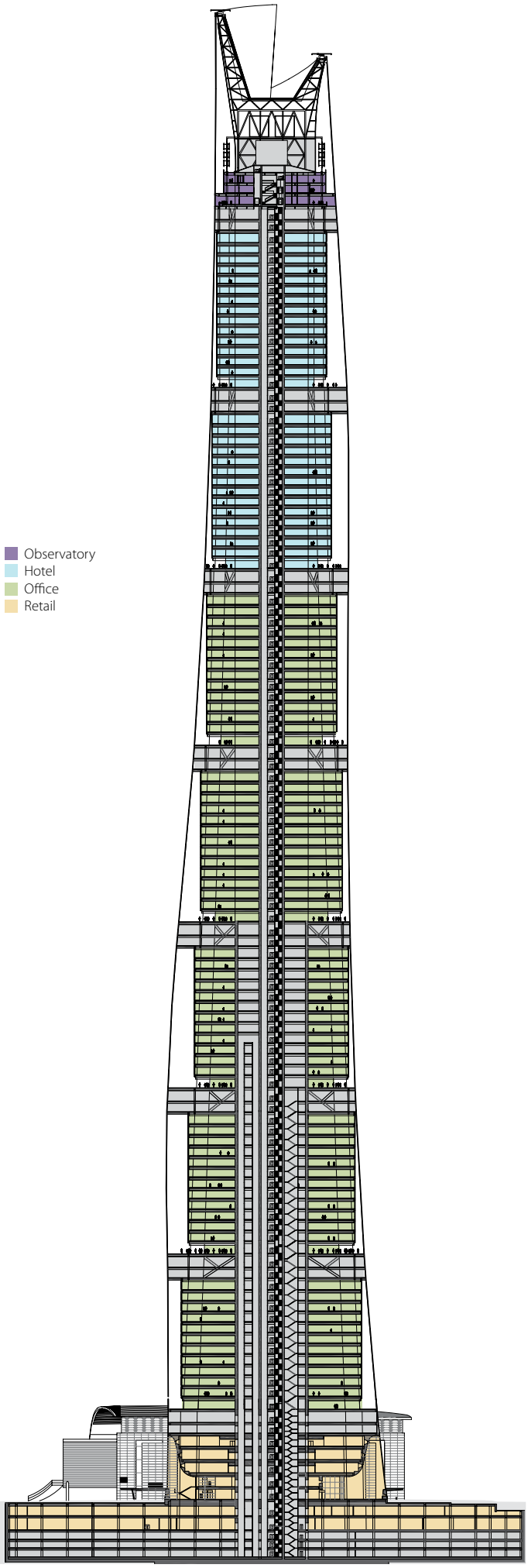
Tall buildings are often seen as iconic landmarks, which encourages one to take an external view only. But in order to achieve "sustainable vertical urbanism," skyscrapers must turn their focusing point from ROI of human experience to people and specifically the users' demands to become enjoyable, even exhilarating architecture.

Shanghai Tower provides a vision of vertically integrated space through the signature design of a double façade that creates unique sky lobbies, filled with vegetation, offering the potential for socializing, and providing relief from the isolative nature of tall buildings without the necessity of descending to the ground. But why do this? Is this design arrived at arbitrarily, or though assumptions?

A typical return on investment (ROI) calculation subtracts the cost of investment from the gain from investment. But when planning buildings as vertical cities, they must be thought of as systems. Importantly, traditional ROI calculations also overlook the value of human capital – the people who occupy the building.

Opposite: Shanghai Tower standing among the World Financial Center and Jin Mao Tower. Source: Gensler

Bottom: Tower base at street level. Source: Gensler



Left: Building section highlighting the different functions.
Source: Gensler

Opposite: Rendering of the "Community Square" space.
Source: Gensler

An expanded ROI calculation considers that sustainably designed buildings can reduce sick time by two to five days annually and increase productivity by 4.8 percent. When one is designing a skyscraper to accommodate more than 20,000 people, the value of that productivity increase justifies the extra expense of what we call "reinventing the chassis of the high-rise."

The biggest distance between the outer curtain wall system and the main structure in Shanghai Tower is 15 meters, which prevents about 20,000 office staff and hotel guests from directly facing the outdoors at an altitude of several hundred meters and eases people's anxieties about extreme heights. The presumable five percent of people who suffer from acrophobia could work calmly in Shanghai Tower. This is another return on design investment that increases productivity.

What's more, 10 times a year, five percent of the people who work in the Tower (about 1,000 people) either need to be in the same places in the city for face-to-face working or activities, and as a result spend at least half an hour in transportation. If they only need several minutes to come together to meet, 5,000 hours of transportation time could be saved, along with the related traffic congestion and pollution caused by automobile exhaust.

Community: More Than Mere Constructions

As modern buildings have become more and more extravagant, the economics are becoming the dominant factors of evaluation, while the interior communication spaces for occupants have been gradually ignored. However, with rapid improvement of financial conditions and living standards, the call to go back to nature, enhance communication, and provide cozy and convenient living space has been amplified, and is consistently inspiring architects to design tall buildings more creatively.

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Shanghai Tower has introduced the concepts of "Vertical Community," "Community Square," and "Sky Gardens." The concept of "Vertical Community" is meant to stack traditional horizontal blocks into nine vertical communities, each equipped with private space. "Community Square" is the unique participatory space between the layers of the double-skin façades, which are over 10 meters wide. Every community has three sky lobbies, called "Community Squares," whose heights range from 50 to 60 meters. The tower has 21 "Community Squares" in total. They fulfill the requirements of energy efficiency, vertical circulation, fire defense and life safety, and at the same time provide complementary services of relaxation, social contact, viewing, catering and finance. "Vertical Community" is reinforced by planting flowers and trees in the "Community Square" at various heights, and create vertical greenery. Shanghai Tower has systematically introduced the design of communities, squares, and gardens into skyscrapers, which is a unique feature to tall buildings around the world.

Shanghai Tower has adopted the design approach of "vertical compound functions." In addition to the traditional shopping mall (Zone 1), office (Zone 2 – Zone 6), hotel (Zone 7 – Zone 8), and sightseeing (Zone 9) there are additional versatile function blocks. Public museums (37th floor), Galleries, lifestyle centers (B1, 52 floor, 53 floor), fitness facilities (22 floor), art exhibitions, and cultural activities are introduced into the "Community Squares," providing fresh life experiences for the people in the communities.

Technology: Innovate for Sustainability

Besides fulfilling the requirements of construction Shanghai Tower is also a primary case study of the innovative technologies of sustainability.

The external view catches the attention of designers and investors. Shanghai Tower not only presents an elegant form, but

Bottom: The tower's double-skin façade. Source: Gensler

Opposite Top: Model shake test. Source: Gensler

Opposite Bottom: The different design considerations determined twisting the tower 120 degrees is the solution. Source: Gensler

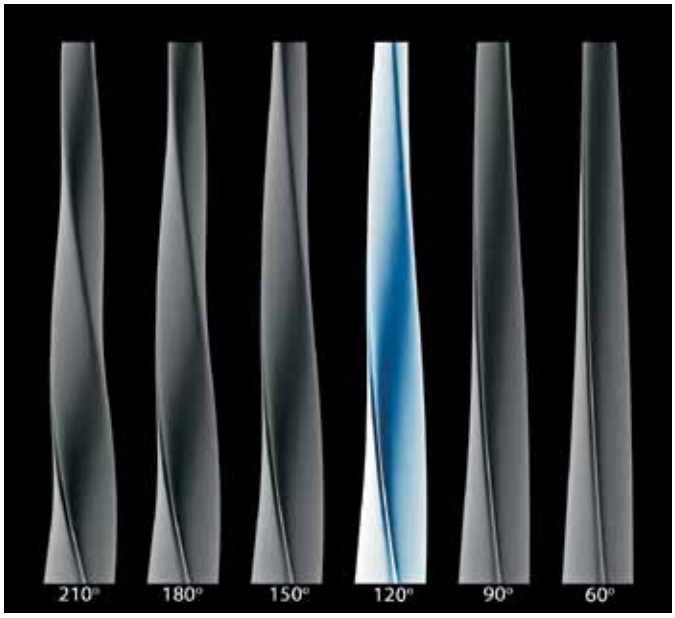
also represents significant achievements in structural safety and cost savings. It shows the elegance and fashionable characteristics of Shanghai by twisting the outer enclosure by 120 degrees while spiraling up. Through wind-tunnel tests, its designers determined that we know that the wind load could be reduced 24 percent, which is quite considerable in a city that suffers from typhoons every year, saving 20,000 metric tons of steel in the process.

Given the complexity of the building, it was incumbent upon the designers to continue to measure its performance, even as it was being built, with a view toward continuous monitoring after completion. The structural health monitoring (SHM) system helps dynamically observe risks, quality level and structural states under loads, providing safety warnings and information for maintenance and inspection. The SHM monitors seismic response, displacement and settlement, structural temperature, stress and strain, and tower structure inclination.

Shanghai Tower has distinguished itself as an exemplary "smart" building. The design and construction of Shanghai Tower has been contemporaneous with developments in sophisticated digital technology and major IT advances, such as cloud computing, and, for the first time in commercial buildings, the integration of the "Internet of Things," and Building Information Modeling (BIM). The tower's technology consists of a basic support level (cabling system, equipment), a middle layer of 31 intelligent subsystems (fire-alarm and public-address systems, Building Control System for facilities, energy monitoring systems, a one-card security pass system, and an integrated communications system); and a top layer consisting of the Intelligent Building Management System (IBMS), which integrates the collection storage, processing, analysis and display of data from all subsystems). The transmission system for all of this data is Internet-Protocol (IP)-based, and a 10-GB backbone and 1-GB IP network serve 90 percent of the intelligent subsystems.

The objective behind using BIM to design Shanghai Tower was to execute the project by using Lean management techniques and to realize the full life-cycle monitoring concept. To achieve this, Shanghai Tower's design team used Autodesk Vault Professional, a data-management platform that can manage and integrate data from various programs. The client established a working group, involving all the BIM teams from design to construction to material supply, and formed a working framework and standards unified by a clear hierarchy.

For example, by using BIM on the external curtain wall, the efficiency of drawing processing maps increased by 200 percent. The conversion efficiency of processing



map data has increased by 50 percent, while the measurement efficiency of complex components increased by 10 percent. For the MEP disciplines, using the BIM framework cut 60 percent from onsite workloads and allowed pipeline assembly to be 70 percent prefabricated. All told, using BIM cut three to five percent of the total project cost that is normally devoted to post-design changes and human error, while cutting clashes had a value of more than 100 million RMB (US $16 million). The role of BIM technology does not end on Shanghai Tower's opening day. The project team has studied how to apply BIM in the asset management of the tower and continue to use it as part of a Property Asset Operations Platform (PAOP), comprising BIM, Facilities Management (FM) and IBMS technologies.

Environment: Responsible Development

Tall buildings have a significant influence on the urban features and regional environment. Thus, the the client and designer must hold a principal responsibility for the contemporary appearance and enduring visual, environmental and cultural relevance of such structures.

In the determination of the final scheme of Shanghai Tower, the project team undertook sufficient consideration of the influence that architectural form and building height would have on the city. The tower spirals up in a gentle curve, and harmonizes with the two skyscrapers nearby, while maintaining its own characteristics. In determining the building height, current technology was not a limiting factor. In fact, the tower could have been substantially taller. However, in order not to break the proportions of the city's skyline, the team eventually choose 632 meters, which is 210 meters higher than the Jin Mao Tower and 140 meters higher than the Shanghai World Financial Center, thus these three building form a altitude difference of 70 meters and 140 meters, respectively.

From the outset, the ambition behind Shanghai Tower was to make it one of the world's greenest and best-performing tall buildings and to meet the stringent requirements of Chinese Green Building Standard, as well as achieve LEED Gold certification by integrating 47 sustainable energy-saving technologies. Although this would increase the project investment by 3 percent to 5%, the building supports an energy-saving rate of 54 percent over the Chinese efficiency standard and 22 percent over the American efficiency standard. Active solutions include: a double-layer curtain wall, which saves 50 percent more energy than single-layer façade; a combined cooling and heating power (CHP) system; two energy centers (at Level B2 and 82); a wind-turbine system that could generate 1,190, 000KWh of electricity every year; 25 percent greywater recycling to flush lower-area toilets and irrigate greenery; 92 percent material acquisition within a radius of 800 miles (1,287 kilometer); 60 percent waste recycling and reuse; most space illumination with the highest efficiency LED lights, controlled by a automatic ON and OFF system with brightness sensors.

In the operations phase, Shanghai Tower will continue to deploy a substantial monitoring system, in order to ensure the operation of sustainable measures and to monitor and control energy consumption. A Central Energy Management Control System (CECS)integrates the energy conditions in different seasons and time periods and calibrates the most efficient and appropriate operating periods for energy equipment. With the successful application of CECS, 10 percent to 15 percent more energy will be saved. The use of CECS in Shanghai Tower represents the debut of this technology in such mega-scale, complicated buildings worldwide.

Revive: Contribution for the Regional Development

Iconic buildings usually have a significant influence on regional development. Therefore, investors should not only focus on their own benefits, but have sufficient consideration of how to contribute to the regional development and functional improvement.

Shanghai Tower is located in Lujiazui, the Central Business District (CBD) of the Shanghai's Pudong area, but it offers an expansion of the concept of the typical CBD. Traditional CBDs are often restricted in their commercial concept. Shanghai Tower raises a new definition of CBD, with social development goals in mind: **C**ommunity, which here is vertically overlapped; **B**usiness, which stands for leadership in business; and **D**iversity, which emphasizes diversified culture. This extends the meaning of CBD from mere commerce to include community and culture.

Opposite: Close exterior view of the double-skin façade. Source: Gensler

Bottom: Ground lobby interior. Source: Terri Boake Meyer

Considering the monotonous facilities that currently dominate the Pudong Lujiazui District, Shanghai Tower's development team had an planned for more than just luxury retail during the programming phase., Rather, we started with a typology of "experience, technology, culture, future life, supporting service" and inserted a public museum, galleries and supporting, everyday commercial facilities that could 20,000 tower occupants and 100,000 office workers in the neighborhood.

From the beginning, Shanghai Tower planned and constructed public passageways in the B2 level, connecting to Jin Mao Tower, Shanghai World Financial Center, Shanghai International Financial Center, and Metro lines 2 and 14, establishing a complete pedestrian system underground.

Shanghai Tower was always conceived as more than a superlative of height, although it is also that. It was conceived as a new prototype for vertical cities, and its success is a reflection of the hard work of the thousands of people involved in the project. Despite the obviously critical role that technology and innovations play in creating a vertical city with "height, pride, and delicacy," it must never be forgotten that buildings are for people, and the objective of any building, no matter how awe-inspiring, is to function well in the support of human wellbeing.