CTBUH Journal

International Journal on Tall Buildings and Urban Habitat

Tall buildings: design, construction, and operation | 2014 Issue II

Council on Tall Buildings and Urban Habitat

Inside

18

26

40

"Mortality decreased with increasing floors: residents on the ground floor had a 22% greater hazard of death from any cause compared to residents of the eighth floor and above."

Panczak, et al. page 32

Asia and Oceania

Skyscrapers in Asia continued to push the boundaries of form and function in the second quarter of 2014.

Fanciful hole-punch shapes dominated the news in China's southern tier, as **Macau** was designated the host of the next Zaha Hadid skyscraper fantasia – **the City of Dreams.** The exoskeleton-centric hotel will stand 40 stories, consisting of two towers connected at the top and bottom, with non-linear, extruded skybridges crossing the void between.

Nearby, **Guangzhou** welcomed the completed headquarters building for the Hongda Xingye Group, a wheel-shaped building which looked to some like a doughnut. **Guangzhou Circle** was actually intended to form a lucky number "8" in its reflection in the waters of the Zhujiang River. Elsewhere in Guangzhou, the achievements rose ever-higher, as Hitachi announced it would deliver the world's fastest elevators to the under-construction **CTF Guangzhou.** Elevators reaching speeds of 72 km/h will get to the 95th floor in 43 seconds.

In **Beijing,** another kind of advanced technology was at play – Henn Architects said its proposed **Plot Z8 Tower** would achieve its 300-meter height through the use of prefabricated structural modules, though these would be fastened to a traditional concrete core. Just around the corner, work also began at a neighboring site on the new Central Business District on Plot Z2b, which will host **Samsung's China Headquarters** in a 250-meter tower that broke ground in April.

Wuhan, already known for its glittering Wanda shopping center exterior by UNStudio, adds another sparkling gem to the Wanda crown, in the form of the 30-story **Wanda Reign Hotel,** desigtned by Make Architects. Composed of highly reflective aluminum and angled in both plan and section, the 902 hexagonal modules of the façade protect interior rooms from solar gain, while the integration of LED lighting into each module adds an additional texture to the building at night.

Sounding a similar note in Samsung's home country of South Korea, UNStudio were putting a new face on **Hanwha headquarters** in **Seoul.** The opaque façade of the tower was

City of Dreams Hotel Tower, Macau. © Zaha Hadid Architects

CTF Guangzhou. © KPF/Atchain

Guangzhou Circle. © Joseph di Pasquale Architect

Plot Z8 Tower, Beijing. © Henn Architects

Samsung China Headquarters, Beijing. © Samsung

Wanda Reign Hotel, Wuhan. © Make Architects

Abeno Harukas, Osaka. © Hisao Suzuki

Toranomon Hills, Tokyo. © Primenon/CC-BY-SA-3.0

to be replaced with a "performative, integrated" façade featuring lighting displays, PV cells, and custom angling to optimize solar penetration and limit glare.

Japan's dueling megalopolises, Tokyo and Osaka, both laid claims to some lofty sleeping quarters. The nation's tallest building, the 300-meter **Abeno Harukas,** opened in **Osaka** in March, and also featured the nation's highest hotel suite, at 263 meters above grade, for the suitably astronomical nightly rate of US$3,410. Though considerably shorter, the 126-meter **Toranomon Hills Tower** in **Tokyo** is opting for haute couture over height – it will host Japan's first Andaz Hotel on its upper floors, complete with the city's highest wedding chapel.

It's almost two decades since the 452-meter Petronas Twin Towers became the tallest buildings in Malaysia, and a decade since they held the "world's tallest title." In March, the 600-meter **Warisan Merdeka** in **Kuala Lumpur** received its notice to proceed, and its developers enthusiastically predicted the new record for Malaysian tall would be set soon.

Further south in Australia, however, some plans were cut down to size. **Melbourne's Australia 108** had to reduce its planned height from 388 to 321 meters, after it was determined the original height would interfere with flight paths to a nearby airport. Undeterred, the city remains a skyscraper haven, as the 286-meter **250 La Trobe Street** was planned to rise to just one meter under the height limit for its plot, making it the city's tallest residential tower.

250 La Trobe Street, Melbourne. © Elenberg Fraser

Middle East and Africa

"World's Tallest" fever kicked up a few degrees as it was announced the **Kingdom Tower,** the kilometer-high building planned for **Jeddah,** Saudi Arabia, had broken ground in late April and was on its way skyward. Cue the round of

THEY SAID

"These new [tall building] developments are not just piggy-banks in the sky for the global plutocracy. The overwhelming majority – 80% – of tall buildings going up in London are residential, and the overwhelming majority of the habitations will be for Londoners."

London's Mayor Boris Johnson defending the quality of high-rise buildings being built across the capital following the launch of the AJ/Observer Skyline campaign. From "Boris Johnson: London's Skyline Must Evolve as Our City Grows," London Evening Standard, April 4, 2014.

High Performance Design Shapes Sustainable Supertall Building

Authors

Richard Tomlinson II, Managing Partner
William Baker, Structural Partner
Luke Leung, Director of Sustainable Engineering
Shean Chien, Project Manager
Yue Zhu, Associate Director

Skidmore, Owings & Merrill LLP (SOM)
224 S. Michigan Avenue, Suite 1000
Chicago, IL 60604, United States
t: +1 312 554 9090
f: +1 312 360 4545
e: somchicago@som.com
www.som.com

Richard F. Tomlinson II has played a central role in guiding the firm's design practice. He specializes in providing clients strategic solutions to large and complex problems, orchestrating the resources and multidisciplinary teams needed to bring bold and innovative vision to reality. Richard has led some of the firm's most significant global projects for clients in a wide array of private and public organizations.

William F. Baker is a Structural Engineering Partner for SOM. Throughout his distinguished career, Bill has dedicated himself to structural innovation. His most well-known contribution has been to develop the "buttressed core" structural system for the Burj Khalifa, the world's tallest man-made structure. While widely regarded for his work on supertall buildings, his expertise also extends to a wide variety of other structures. Bill is also a member of the CTBUH Board of Trustees.

Luke C. Leung is the Director of the Sustainable Engineering Studio for SOM. As a LEED AP with BD+C focus, his work includes over 40 LEED buildings either certified, or, in different stages of the LEED process. Luke's work also includes 2 of the current top 10 tallest buildings in the world, Nanjing Greenland Tower and Burj Khalifa. His work ranges from the low-rise LG Art Hall, one of the first displacement performing arts centers in the world, to the Burj Khalifa, the world's tallest man-made structure with a first-of-its-kind stack-effect control system.

Shean Chien worked as a senior project engineer with SOM's structural engineering team, assisting with the structural design for individual projects or groups of projects prior to joining SOM's project management team. As a Project Manager, Shean is responsible for the day-to-day coordination of projects and serves as the key liaison with the client throughout the design and development process. Shean has extensive experience working on large-scale mixed-use developments in China and internationally.

Yue Zhu joins the team with experience in architectural design, technical expertise, urban design and sustainable design. He is currently a studio head leading the project team on many high profile, highly complex, large-scale urban projects throughout the design and development process, leading to numerous awards and worldwide recognition in the industry.

Skidmore Owings & Merrill LLP (SOM)'s design for the 71-story Pearl River Tower in Guangzhou, China, was selected in a 2005 competition. The 309-meter-tall high-performance building was designed with energy efficiency as its top priority. Its design philosophy combines active and passive sustainable measures to reduce its impact on the local electrical grid, reduce carbon emissions, and provide the most comfortable interior environment possible for its occupants.

Background

The design brief developed by the client, the Guangzhou Pearl River Tower Properties Co., Ltd., called for a 214,100-square-meter headquarters tower in the newly developing Pearl River New Town area of Guangzhou. Even in 2006 – when sustainability was not nearly as recognized a concept as today – a visionary client team led by Chairman Jin Cheng Xiang and Director Zhi Ming Ye sought to create an iconic new home whose "high performance" would significantly reduce the building's energy consumption. The initial form was set by the architect's competition entry – but the evolution of the design's sustainable solutions was the result of a highly collaborative effort between client, architects, and engineers. As completed, the building uses approximately 30% less energy than would be used by a similar structure built to China's stringent energy codes.

The Pearl River Tower's setting and its evocative, curving shape are performance-driven – an example of a 21st century tower that responds appropriately to local climatic conditions and global energy concerns. Its generally rectangular floor plate has been shifted slightly from Guangzhou's orthogonal grid in order to maximize its utilization of prevailing breezes, and to better capture the sun's energy through the strategic location of photovoltaic technologies.

East and west elevations are straight, while the south façade is concave and the north façade is convex (see Figure 2). The south side of the building is dramatically sculpted to direct wind through four openings, two at each mechanical level, to accelerate the air and drive a two-meter-wide-by-five-meter-tall energy-producing vertical axis wind turbine (VAWT) located within each building aperture (see Figure 1). The building's geometry significantly enhances turbine performance. At night, LED lights at the mouth of the wind tunnel change color and intensity to indicate the amount of energy created by the wind.

The owner's offices are located on Floors 59 through 68; lower floors will be leased to other tenants who require a prime location and want to enjoy significant energy savings against a conventional office building. The top two floors – which sit under a dramatic glass-vaulted roof – will be completed as a club-level amenity. A distinctive circular international conference center sits at the northwest corner of the tower's base.

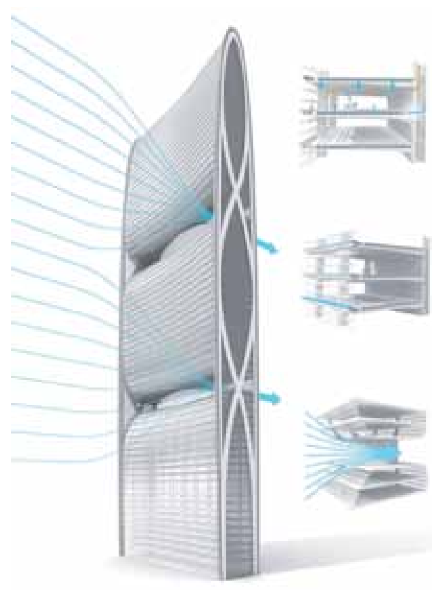


Figure 1. Sculpted façade directing wind through the vertical axis wind turbine (VAWT)

Structure

Pearl River Tower was shifted from Guangzhou's predominant grid to help capture the wind for energy generation. The broad face of the building is oriented perpendicular to the southerly prevailing winds, which occur approximately 80% of the year – a remarkably consistent directional bias for generating wind energy. But this orientation led to increased loads on the overall structure, especially because Guangzhou is a relatively high-wind region due to its proximity to the coast.

Wind tunnel testing by RWDI Laboratories predicted higher wind loads on the broad face than those calculated by the governing Chinese code. These higher loads were used for the design, with 100-year return period loads determining strength design and 50-year return period loads used for drift checks. Under these loads, accelerations and torsional velocities were well within accepted criteria.

The tower was classified as a Special Complex Supertall Building by Chinese codes since it was "over limit" based on both its height (over 190 meters) and aspect ratio (which, at 8.4, was above the code limit of 7.0). Guangzhou is in a moderate seismic zone in China, with a seismic intensity of VII and a design basic acceleration of 0.10 g. The baseline of the code in this area is the Frequent earthquake (80-year return period), but the tower's "over limit" status required that some elements of the lateral system be designed for Moderate (475-year return period) and Rare (2,475-year return period) levels. All elements of the lateral system were designed for response spectrum forces induced by a Moderate earthquake. Outrigger and belt trusses were designed to remain elastic under the Rare earthquake response spectrum. Additionally, seismic review experts required the performance of a nonlinear elasto-plastic time history analysis to validate that during a Rare earthquake, the maximum interstory drift would not exceed 1/100.

The tower's superstructure consists of a composite system, utilizing both structural steel and reinforced concrete elements to resist both gravity and lateral loads.

Figure 2. Pearl River Tower, Guangzhou.

"The building envelope's cavity is mechanically ventilated from the occupied space via low-level inlets under the inner monolithic glass… The movement of room air through the ventilated cavity is critical to limiting solar gain, especially on the south elevation."

Is Net-Zero Tall Possible?

Neil Chambers

Author

Neil Chambers, CEO/Founder
Chambers Design, Inc.
155 Water Street, Suite 33
Brooklyn, NY, 11201
United States
t: +1 917 592 8242
e: neil@chambersdesigninc.com
www.chambersdesigninc.com

Neil Chambers
Neil Chambers, LEED-AP has more than 20 years experience with high-performance buildings and renewable energy. For the last 10 years, he has lead Chambers Design, Inc. developing design solutions and energy modeling for award winning green buildings. Chambers has a track record for delivering innovative large-scale prestigious developments from conceptual design into operation and maintenance. He plays a key role in the technical and qualitative results of these major projects. He contributes to the community of design through authoring books such as Urban Green: Architecture for the Future and writing for Huffington Post and Metropolis Magazine's POV.

Are Net Zero tall buildings possible in dense city cores? Or are cities destined to lose ground on sustainable innovation to less-compact suburban areas? These are two questions asked at the onset of an ambitious research project undertaken by Chambers Design through the New York University (NYU)'s Green Grant Program.

Introduction

Net zero buildings, also known as Zero Energy Buildings (ZEBs), are an elusive but evergreen goal of architects and engineers. Many definitions exist for this building typology (Pless 2010) however the project covered in this paper defines ZEBs as buildings that produce as much energy as they consume on-site. They can be connected to the power grid. On-site renewable energy production and net-metering allows them to feed as much energy into the grid as they pull from it. ZEBs are not required to be off-the-grid edifices.

It has been widely suggested by design professionals that ZEBs are highly implausible for highly dense, urban infill projects. The National Renewable Energy Lab (NREL) reported that only 3% of buildings of four floors or more would be net zero by 2025 (Griffith 2007). However, with better technology for simulating energy performance for buildings on the market, and advances in on-site energy generation technology, a much higher percentage should be achievable than that predicted in the NREL report.

Other factors increase the likelihood of ZEBs in urban infill projects as well. A new focus on all aspects of energy efficiency, from plug-load reduction to thermally-active surface integration, is proving that all types of buildings are capable of achieving substantial energy savings. Lastly, the process of designing energy systems has become much more iterative and holistic, as sustainability has become the driving form-making force for buildings.

Because of these changes in the landscape of ZEB, the research team undertook an in-depth analysis of the Zipper Building (see Figure 1). The team included undergraduate and graduate students, administrators, and others from the university. The goal of this project was not to "achieve net zero," but to discover how close the building could get to it. The second goal for the project was to develop an approach that could be used for any type of capital project for the University at any location in the world.

Background – Above Ground

New York University's Master Plan for Greenwich Village was developed as preparation for the university's bicentennial in 2013 (NYU 2012). The strategic plan, completed by Grimshaw Architects, included up to 557,418 square meters of new space needed over the next 25 years (see Figure 2) with a split among four large buildings. The majority of the programming within the buildings is housing and academic spaces.

At the beginning of the research project, the Zipper Building, which encompasses just over 92,903 square meters, was first envisioned for

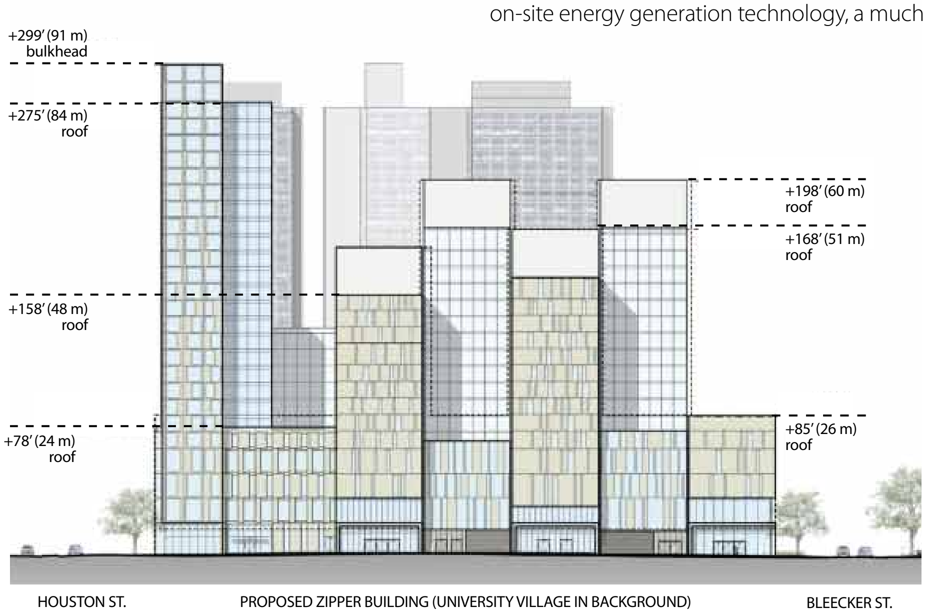


Figure 1. Zipper Building, New York. Source: New York University

an assortment of space requirements, including academic, hospitality, retail, recreational, and residential spaces. The complexity and potential intensity of the building made it a desirable research subject. The assumption was that if it could be net zero, then other, less-complex buildings could achieve net zero. The building was to rise at the corner of Houston and Mercer streets in Manhattan on a site currently occupied by Coles Sports and Recreation Center, a five-level building totaling 13,192 square meters. The Zipper Building, in contrast, would be nearly 91 meters tall at its highest point, with five other towers ranging from 51 to 69 meters. Since the study, some modifications have changed the height of the towers, based on New York City Council requests.

Along with the specifics of the case study of the Zipper Building, it was important that the analysis be able to not merely focus on projects within Manhattan, but also to create a process that was flexible enough to be used at the New York University (NYU)'s campus in neighboring Brooklyn, as well as buildings in China, the Middle East, and other potential locations for NYU satellite locations.

The Process – At the Beginning

At the beginning of the research, the Zipper Building was in late conceptual/early schematic design phase. There were no detailed designs for the mechanical, electrical or architectural systems of the building. The university was in the process of meeting with community and city groups and committees on modifications and other early stage approvals. An Environmental Impact Statement (EIS) was provided by the university that outlined the majority of the energy information for the project, such as energy consumption, grid-sourced energy, emissions, and the breakdown of energy types to be used for the building (natural gas and electricity).

The EIS stated that the project would pursue a LEED Silver certification as required by the NYU Sustainable Design Standards and Guidelines. The EIS indicated that energy performance would be 20% above the ASHRAE Standard 90.1-2004 and/or attain an energy performance score of 80 or higher under the USEPA Energy Star program.

NYU requested that no "morphological" changes be made to the Zipper Building. This meant that the volumes of the towers, the orientation of the building, the footprint, and other major architectural moves should be kept as-is. This added a level of difficulty to pursuing net zero for the building, and meant many of the options available to new construction were off the table. At times, it felt as if the team were redesigning an existing building within a significant set of constraints.

Fenestration, window-to-wall ratios, and other aspects of the skin could be altered, as long as the overall form of the building was maintained.

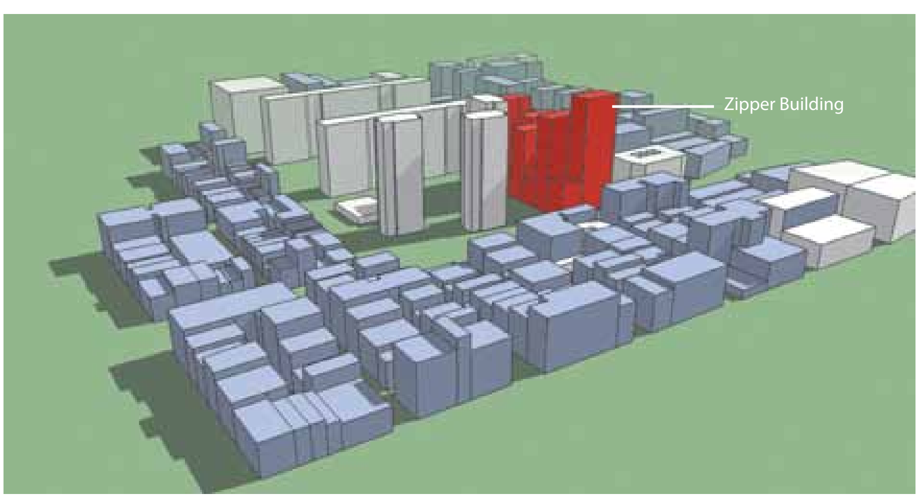


Figure 2. New York University (NYU) 2031 Core Plan.

The analysis undertaken in this study used two primary software packages for evaluating energy consumption, and tracking energy efficiency and generation. Extensive simulations were completed for the project, including: solar insolation analysis, solar thermal gain, bioclimatic integration, exterior and interior computational fluid dynamics (CFD), HVAC energy consumption, electric lighting analysis, daylighting analysis, photovoltaic (PV) electricity generation simulation, heating and cooling loads, and insulation optimization analysis. The team used IES-VE Pro and eQuest for all of the energy simulations. Both packages provide a visual virtual model for the process. eQuest was used to allow outside professionals to peer-review the simulations. A complete step-by-step outline of all modeling was provided to NYU within the final draft of the report.

The Process – Toward Net Zero Architecture

Based on the EIS and other information gathered at the onset of the project, it was determined that the ASHRAE baseline energy consumption of the Zipper Building would be approximately 80,215 MMBTU. This level is exactly equal to the ASHRAE 90.1-2004 standard. It also represents standard systems within the building, such as forced-air heating and cooling, the appropriate air exchanges and light power densities (LPD) based on space type. Other criteria of the building, and therefore the energy systems, were derived from drawings and renderings received from NYU. For example, the window-to-wall ratio varies along different areas of the building. Some exterior walls bore a 90–95% glazing application, while other areas were more modest at 50 to 75% glazing. However, in all cases, based on the given information, all glazing was floor-to-ceiling glass.

To attain the 20% energy savings, basic energy-efficient measures were applied to the building, such as high-efficiency forced-air HVAC systems, high-albedo roofing materials, occupancy sensors for lighting and climate control, improved light power density through basic energy-efficient light fixtures

An Innovative Braced Megaframe for Torre BBVA Bancomer in Mexico City


William H. Algaard


Tom Wilcock

Authors

William H. Algaard, Associate Director
Arup
13 Fitzroy Street
London W1T 4BQ
United Kingdom
t: +44 20 7636 1531
e: william.algaard@arup.com
www.arup.com

Tom Wilcock, Associate
Arup
77 Water Street
New York NY 10005
United States
t: +1 212 896 3000
e: tom.wilcock@arup.com
www.arup.com

William H. Algaard
William Algaard is an Associate Director at Arup and Partners Ltd, London. He works as a structural engineer in close collaboration with architects to develop innovative technical solutions to a diverse range of design problems. He has a background in advanced analytical methods and employs first-principles approaches to develop efficient designs. He seeks to optimize material use and develop more sustainable building designs. He recently completed a Masters Module in Sustainability Leadership at Cambridge University. William has worked on tall building projects in North and South America, Europe, and Asia.

Tom Wilcock
Tom Wilcock leads Arup's Advanced Technology and Research team in New York. He is an Associate with specialist expertise in performance based design and analysis of extreme events including blast and earthquake loading. Tom applies industry leading analysis to the delivery of specialist structures, including transport infrastructure, offshore platforms, and renewable energy installations. He has worked on high-rise buildings across the world including four in Mexico City.

This paper discusses the design and delivery of an Eccentrically Braced Megaframe (EBMF) for a 52-story building currently under construction in Mexico City. The EBMF for this project has been constructed external to the building's envelope and at an unprecedented scale. The large spacing of the external composite columns assisted in creating an inherently stiff structure and enabled the number and size of columns on the façade line to be minimized. A performance-based approach has been adopted to justify the design of this unusual building in the highly seismic zone of Mexico City.

Introduction

The focus of the paper is the deployment of advanced analytical techniques in the design of tall buildings. Using nonlinear response history analysis, the design team was able to demonstrate the likely performance of the building during representative earthquakes. Using the same analytical tools, the team undertook detailed analysis at a component level to understand the complex low-cycle fatigue behavior of the tower and satisfy a third-party peer reviewer of the design methodology.

The basic capacity design procedures of existing codes would have made this building uneconomic and even unfeasible to build. Through the use of nonlinear response history analysis, the design team has delivered a highly efficient and flexible building with a robust seismic resisting system.

Overview

When it opens in 2015, Torre BBVA Bancomer will be the Latin American headquarters of the BBVA Bancomer banking group. Designed by an Anglo-Mexican team of architects and engineers, the final level of the 52-story tower was erected in late 2013 (see Figure 11).

Standing in the heart of Mexico City's rapidly developing business district, the tower's location required the design team to contend with notoriously challenging ground conditions. Structural engineers from Arup worked alongside the building's architect LegoRogers, a joint venture between Rogers Stirk Harbour + Partners (London) and Legorreta+Legorreta (Mexico City) to develop a structural system that provides excellent seismic performance and architectural freedom in space planning.

Central to the design strategy is an Eccentrically Braced Megaframe (EBMF), which provides stiffness, strength, and ductility. The EBMF provides the tower's lateral stability, resisting design wind, and moderate earthquakes elastically. Energy from larger earthquakes is dissipated through nonlinear yielding of "seismic links" (see Figure 2). The nonlinear response of the Tower has been designed using performance-based approaches, including global response history analysis and detailed low-cycle fatigue modeling.

Mexico City has a subtropical highland climate; the temperature rarely goes outside the range of 3 °C to 30 °C. This benign climate enables the EBMF to be positioned outside of the building's thermal envelope, maximizing its effectiveness in resisting lateral loads and removing the need for a structural core. This solution helps reduce the seismic weight of the tower and the associated foundation loads. It also provides an interior that is largely free of structure. The absence of a concrete core enabled the architect to terminate the primary elevator core at Level 11. Below this level, the floor plates are open, maximizing the net usable area of the tower.

The design team's integrated approach to architecture and structure has produced a unique system that maximizes the developable area of a prestigious location. Through the application of a clear design strategy and sophisticated analysis, the project provides the client with an iconic, yet efficient, building.

Structural System

The EBMF system provides the complete lateral resistance for the tower; the seismic link elements provide ductility.

There were a number of particular drivers on this project that influenced the structural design:

- The site location is characterized by deep strata of soft soils, where foundation capacity comes at high cost.
- Mexico City is highly seismic. The soft soils on this site give rise to the classic Mexico City seismic hazard, where distant subduction-zone earthquakes are modulated and amplified to create long-duration, long-period ground motions.
- In order to comply with local parking requirements, extensive parking, and circulation was required in the tower footprint, not only in the basement, but also in the lower section of the superstructure. Consequently the office accommodation starts at Level 12.

The high seismicity and poor ground conditions created a clear rationale for a low-weight structural solution. The unusual location of the main elevator lobby at Level 12 meant that the primary vertical transportation only started at this level, such that core areas below this could be reduced. The combination of the low-weight driver and the desired flexibility of the height of the tower challenged the design team to consider solutions beyond a traditional concrete core, which would have been highly restrictive for vehicle circulation in the lower portions of the tower.

In order to achieve large column-free floor plates at a low structural weight, composite steel framing was selected for the floors. The framing layout requires only a single internal column in each of the two 33.5-by-33.5-meter triangular spaces. Three pairs of columns flank the vertical transportation and technical zone in the central diagonal band. This layout also enables provision of large external sky gardens, without the need for transfer structures (see Figure 3).

Figure 1. Torre BBVA Bancomer, Mexico City. © LegoRogers

A clear lateral structural system was developed at the competition stage of the design, and this was maintained through to construction. The system comprises an external megaframe with six perimeter columns, continuous eccentric bracing on the four orthogonal sides of the building, and intermittent eccentric bracing on the two shorter sides of the building. The structural system is described as an EBMF and is the first of its kind to be constructed (see Figure 2).

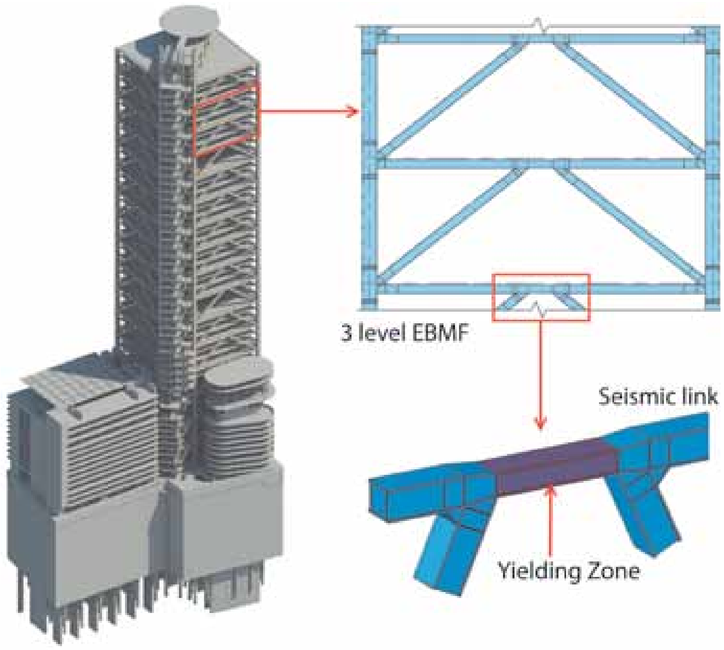


Figure 2. Overview of Eccentrically Braced Megaframe (EBMF).

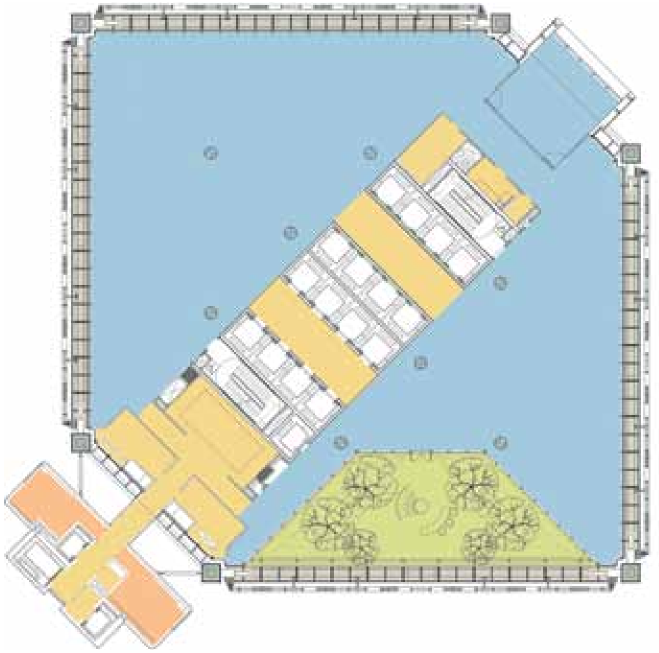


Figure 3. Typical sky lobby floor plan. © LegoRogers

High Life in the Sky? Mortality Rates in Swiss High-Rises

Authors

Radoslaw Panczak[1]
Adrian Spörri,[2] Senior Research Fellow
Marcel Zwahlen,[3] Associate Professor
Matthias Egger,[4] Professor
Institute of Social and Preventive Medicine (ISPM)
University of Bern
Finkenhubelweg 11, 3012 Bern, Switzerland
t: +41 31 631 3511, f: +4131 631 3520
e: [1]rpanczak@ispm.unibe.ch, [2]spoerri@ispm.unibe.ch, [3]zwahlen@ispm.unibe.ch, [4]egger@ispm.unibe.ch
www.ispm.ch

Bruna Galobardes, Senior Research Fellow
School of Social and Community Medicine
University of Bristol
Bristol, United Kingdom
t: +44 117 331 3380
e: bruna.galobardes@bristol.ac.uk
www.bristol.ac.uk/social-community-medicine

Radoslaw Panczak is currently part of the Health Services Research group at the University of Bern and contributes to the project on regional differences in the end of life care in Switzerland. His main areas of interest include social epidemiology and visualizations and modeling of spatio-temporal health data.

Bruna Galobardes is a senior research fellow and a Wellcome Trust fellow at the School of Social and Community Medicine at Bristol University. Her research focuses on understanding how socioeconomic circumstances across the life course "get under the skin," influencing health outcomes. This includes work on measuring socioeconomic position in a variety of contexts and countries and understanding the role of life course deprivation on asthma and allergy.

Adrian Spörri is a senior research fellow at the ISPM. He trained in Public Health (MSc) at the Universities of Basel, Bern and Zurich and in Epidemiology and Biostatistics (PhD) at the University of Bern. He's been head of the Swiss National Cohort, a nationwide longitudinal research platform, for several years and has been involved in large record linkage projects. Over the past few years, he has been supporting record linkage projects in South Africa and Malawi. Apart from linkage methodology, his research interest is in social and spatial epidemiology.

Marcel Zwahlen is an associate professor of epidemiology at the ISPM. His research is concerned with methodological aspects of analyzing surveillance & registry data and longitudinal studies including the Swiss National Cohort (SNC). He is also on the editorial board of the International Journal of Public Health and of Tropical Medicine & International Health.

Matthias Egger is a professor of epidemiology and Public Health at the ISPM. His research is concerned with substantive and methodological issues in epidemiology and international health, with a focus on socioeconomic inequalities and health, infectious diseases and cancer, and on meta-analysis, cohort studies, and clinical trials. Matthias Egger is an editor of the International Journal of Epidemiology and on the editorial board of Journal of Epidemiology and Community Health and European Journal Tropical Medicine & International Health.

High-rise housing continues to attract criticism in many countries as an unhealthy and unpleasant habitat that isolates people and attracts crime. Nearly one in six households in Europe are now in high-rise buildings and this number is likely to grow as space becomes more constrained (Guertler & Smith 2006). The authors of this study undertook to analyze the census records of more than one million people in Switzerland in an attempt to draw more definitive conclusions about human health and high-rises.

Editor's Note:

The study focused on more than 1,000 buildings, that were 8 stories or higher; the highest was 31 stories. Prior studies have addressed taller residential buildings, up to 69 stories, but have either been reviews of prior literature or studies undertaken by way of questionnaires distributed to a few dozen people in a handful of buildings (Lee et al. 2010). This is the first study, to our knowledge, to explore high-rise health using empirical data on such a wide population. Nevertheless, as more and higher residential projects are being built every day across the world, it's clear this is a ripe area for future study, which we would encourage.

Introduction

The World Health Organization (WHO) has identified inadequate housing conditions as an important factor contributing to injuries and preventable diseases such as cancer, respiratory, nervous system, and cardiovascular diseases (WHO 2012).

High-rise housing is of particular concern to public health. Some 36 million Europeans live in high-rise buildings (Guertler & Smith 2006). Most of these buildings originate from the high-rise construction boom of the 1960s and 1970s, and many are in poor condition, located in economically-deprived areas and include a significant share of social housing (Wassenberg et al. 2004). The influence of high-rise housing on the health of individuals and communities has been a matter of debate for decades. For example, in the 1970s some architects claimed that "there is abundant evidence to show that high buildings make people crazy" (Alexander et al. 1977: 115). High-rise housing has a persistent reputation as an unpleasant and unhealthy habitat that isolates people from their social environment and increases crime.

Still, in Switzerland and other industrialized countries, the construction of high-rise buildings has experienced a revival in recent years in the context of dwindling land resources in urban centers. Unlike the tower blocks of the 1960s and 1970s, these are often glitzy buildings located in prime locations that include offices and shops on the lower floors and luxury apartments on the upper and top floors. Living higher up in a high-rise is more prestigious than living in one of the lower floors, rents increase with height, and the most desirable flats are located on the top floor.

Most previous studies of high-rise housing and health have focused on the structural features of high-rise buildings or characteristics of their neighborhoods, largely ignoring differences within buildings in socio-economic position or health outcomes. Even fewer studies have reported on the effects of floor of residence on health outcomes (Evans et al. 2003). The research in this paper used data from the Swiss National Cohort to examine the association of the floor of residence with all-cause and cause-specific mortality in Switzerland.

Methods

Swiss National Cohort

The Swiss National Cohort (SNC) is a national longitudinal study of mortality based on the linkage of census data with mortality and emigration records. The linkages used a combination of deterministic and probabilistic methods based on sex, date of birth, marital status, nationality, religion, place of residence, and other variables (Bopp et al. 2009, Spoerri et al. 2010).

The database analyzed for this study consisted of 2000 census data that were linked to deaths and emigration records up to the end of 2008. The census consists of three questionnaires: one for the individual person, a household questionnaire, and a questionnaire on the building.

The floor of each dwelling was recorded on the household questionnaire. The building questionnaire provided information on the total number of floors in the building. In order to examine the gradient of mortality across floors, we restricted our analysis to residents of buildings with at least four floors. We included persons aged 30–94 years who participated in the census of December 5, 2000. We excluded persons aged below 30, because linkage is less complete in this age group (Bopp et al. 2009) and some individuals may still be in (tertiary) education. We also excluded individuals living in institutions, individuals with no exact information on the floor of residence, people living in temporary or provisional housing, and people with missing information on their highest achieved level of education.

Variables

We grouped civil status into the categories "Single", "Married", "Widowed", and "Divorced". Nationality was in three categories: "Swiss", "Europe other than Switzerland", and "Other/unknown"; religion in four: "Protestant", "Roman Catholic", "No religious affiliation", and "Other/unknown"; spoken language was also in four: "German", "French", "Italian", and "Other". We grouped highest educational achievement as "Primary or less", "Secondary", or "Tertiary". We collapsed the 33-grade socio-professional categorization of occupations developed by the Swiss Federal Statistical Office (2002) into eight categories of socio-professional status, capturing skill level and position of individuals on the labor market. "Type of household" was divided into four categories on the basis of the number of adults and children in the household: "Single-person household", "Couple without children", "Household with one or more children", and "Other". We grouped household ownership type into "Rented flat", "Owned flat", and "Other". Household crowding was defined as the total number of persons per number of rooms and treated as a continuous variable. The floors in the buildings were categorized into nine levels: "Ground Floor", Floors 1 to 7, and "Floor 8 and above". Flats located on the ground floor, raised ground floor, and basement were combined in the category "Ground Floor".

Mortality

We explored associations of floor of residence at the time of census with all-cause and cause-specific mortality between December 5, 2000 and December 31, 2008. The deaths were coded according to the tenth revision of the International Classification of Deaths, Injuries and Causes of Death (ICD-10).

Outcomes were: deaths from all causes, cardiovascular diseases, myocardial infarction, stroke, respiratory diseases, alcohol-related deaths (ONS 2012), stomach cancer, lung cancer, breast cancer, prostate cancer, transport accidents, suicide, and suicide by jumping from a high place.

Statistical Analysis

We modeled the hazard ratio of death across floors of residence for all-cause mortality and specific causes of death using Cox regression models. Time of observation was from the date of census (December 5, 2000) to the date of death, the date of emigration, or December 31, 2008, whichever came first. We adjusted for age by using age as the time scale in the models. We compared the residents of ground floors to those living on the eighth floor or higher. We used two models with different levels of adjustments:

1. Adjusted for age and sex
2. Adjusted for age, sex, civil status, nationality, language, religion, education, professional status, type and ownership of household, and crowding (fully adjusted).

Models were stratified by building, thus allowing the baseline hazard to differ between different buildings. Stratification by building also meant that analysis were controlled for degree of urbanization, language region, and socioeconomic position of the neighborhood.

In additional analysis, we examined whether the association between mortality and floor of residence was modified by the socioeconomic standing of the area. We used the Swiss neighborhood index of socioeconomic position (Swiss-SEP) (Panczak et al. 2012) for this purpose. Swiss-SEP is a composite measure based on four domains (income, education, occupation, and housing) which describes the socioeconomic position of 1.27 million overlapping neighborhoods. We also explored whether the observed associations might be due to reverse causality, where sicker individuals choose to live on lower floors, whereas healthier people tend to live on higher floors.

Firstly, we narrowed the study population to individuals who had lived on the same floor for five years or longer prior to the census, thus excluding those who moved to the high-rise more recently. Secondly, we assessed whether the association of floor of residence with all-cause mortality differed between the first four years of follow-up

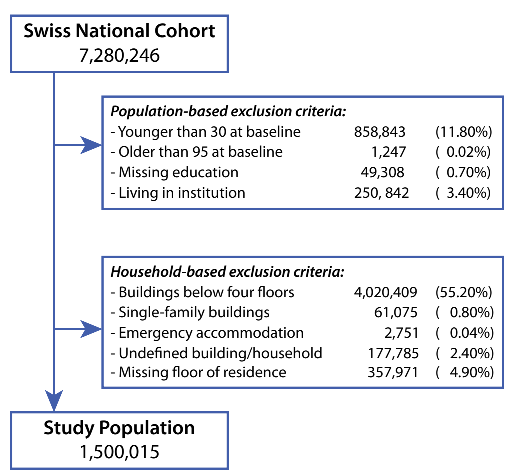


Figure 1. Flowchart of selecting the eligible study population

The "Sky Neighborhood" Layout

Mazlin Ghazali

Anniz Bajunid

Mohd. Peter Davis

Over the last 50 years, many researchers have concluded that high-rise apartments by and large are not suitable for children and young families. Creating small neighborhoods by way of sky courts can be a step toward solving this intractable problem. We attempt to demonstrate that a prototype design, whereby sky courts are provided to all units, with a minimal loss of saleable area due to circulation. This study compares the residential portion of this new concept against other types of apartment layouts, including single-loaded balcony corridor access, with double-loaded central corridor access, central-lobby tower blocks, and "scissor" style internal and external corridors.

Authors

Mazlin Ghazali, Principal
Mohd. Peter Davis
Arkitek M. Ghazali
19-1, Jalan 1/76, Desa Pandan
55100 Kuala Lumpur, Malaysia
t: +60 12 221 1652, f: +60 3 9281 1140
e: tessellar@gmail.com
www.tslr.net

Anniz Bajunid, Senior Lecturer
Centre for Environment-Behaviour Studies
Universiti Teknologi MARA (UiTM)
40450 Shah Alam, Selangor D.E., Malaysia
t: +60 3 5521 1553, f: +60 3 5544 4353
e: toanniz@gmail.com
http://fspu.uitm.edu.my/cebs/

Mazlin Ghazali set up Arkitek M. Ghazali in 1993. Since 2000 this firm has built up nearly 12,000 units of affordable housing projects, many using system construction methods. Mazlin has also collaborated with his co-authors in thermal comfort and courtyard-based housing layouts which has yielded patents for the key aspects of that work. He is now working on commercializing the new "Sky Neighborhoods" concept providing cost efficient courtyards to high-rise apartments.

Anniz Bajunid is trained as an architect with experience in Malaysia, United States, United Kingdom, and Japan. He is presently a senior lecturer and a PhD candidate at Universiti Teknologi MARA, Malaysia. His current research pursuits are in understanding the social and physical dynamics of tessellation planning, particularly the environment-behavior of cul-de-sac courtyard micro-neighborhoods.

Mohd Peter Davis is a biochemist from UK. He was a lecturer and researcher in modern sheep production in Malaysia. Struck by the absurdity that sheep in barns were living more comfortably than humans in Malaysian terrace houses, he changed his research direction to design and build cool, affordable IBS houses on campus which led to his collaboration with his co-authors – Mazlin Ghazali and Anniz Bajunid.

Background

Subsidized and affordable high-rise housing has plenty of critics. Cappon wrote: "Young children in a high-rise are much more socially deprived of neighborhood peers and activities than their single-family-dwelling counterparts; hence, they are poorly socialized and at too close quarters to adults, who are tense and irritable as a consequence" (Cappon 1972).

A more even-tempered Gifford, in a 2007 review of 129 high-rise research papers over 56 years on the human experience of tall buildings, concluded that:

- Most people living in high-rise housing found it less satisfactory than other housing forms
- Social relations in high-rise housing were more impersonal, and residents were less likely to help each other than in other housing forms
- Crime and fear of crime was greater
- Living in high-rises may independently account for some suicides

However, on the issue of raising children, he was trenchant: "…Numerous studies suggest that children have problems in high-rises; none suggest benefits for them." (Gifford 2007). Even 30 years earlier, Conway concluded that for "…families with small children, the evidence demonstrates that high-rise living is an unsuitable form of accommodation." (Conway & Adams 1977). Dalziel suggests that the defects of high-rise housing spring mainly from the quality of the spaces between the street and the apartment – the "intermediate spaces," and laments them as "weird, anonymous space… neither public nor private."

Indeed, high-rise housing necessitates providing access from the building entrance at street level to the front door of every apartment on the upper levels of the buildings. Elevators, staircases, lobbies, and corridors provide passage to individual apartment units.

And so it is that conventional high-rise apartment layouts are often categorized by the method of access to each apartment – for example, single- or double-loaded corridors for slab blocks, and central lobbies for tower blocks. However, all these alternatives involve spaces such as lobbies, elevators, and corridors that are not only costly, but are not considered saleable space. To save costs, these areas are largely devoid of plant life, unsuitable for children's outdoor play, and usually used by residents who remain strangers to each other.

The "Sky Neighborhood" Concept

This paper proposes the "Sky Neighborhood" concept as a new kind of arrangement, whereby access to each unit is through six-story-high landscaped courtyards. In this way, corridors can be eliminated, and as such, not only can the social and environmental quality of intermediate spaces in high-rise housing be improved; the cost of constructing unsaleable circulation space might be reduced. Through a comparison with a selection of other types of high-rise housing layouts, its aim is to demonstrate that, indeed,

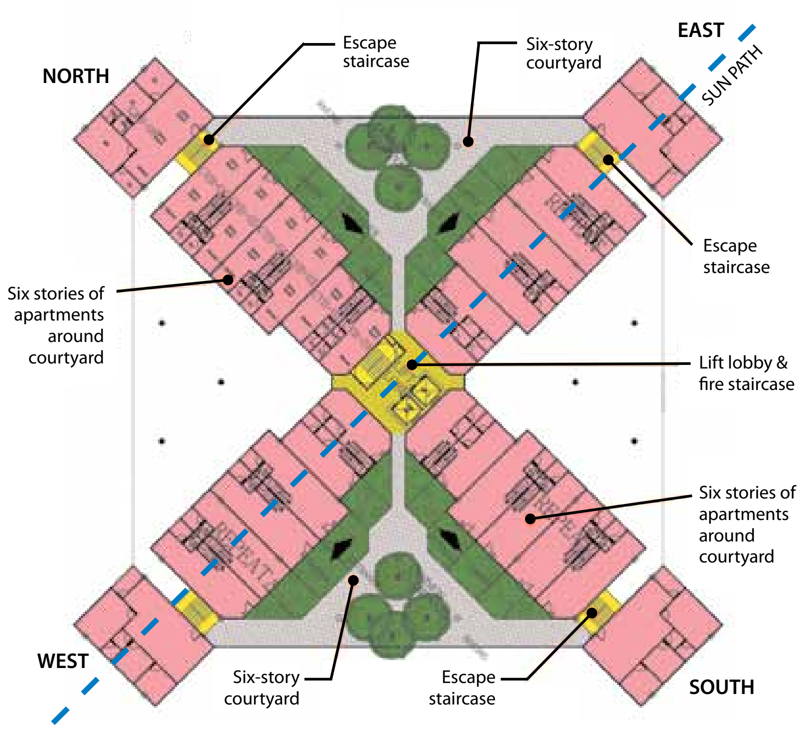


Figure 1. Sky Neighborhoods apartment layout.

> “The basic module in this layout comprises two double-story apartments, which occupy three floors, one placed on top of the other, such that access to both apartment units is on the courtyard level, with the first unit connected to another floor below the courtyard level, and the second joined to another floor above the courtyard level.”

circulation space can be minimized, even as communal space is maximized.

In the next section, a detailed introduction to the “Sky Neighborhood” concept illustrates how duplex apartments can be arranged to create six-story courtyards with access to all apartment units. The section also presents the case for the “Sky Neighborhood” as an improvement to conventional types of apartment layouts and as a cost-reducer of key aspects of high-rise housing.

We then explain the methodology of the study of the circulation space in the “Sky Neighborhood” model, as compared with other examples of apartment layouts. This is followed by results and discussions, and concluding remarks in the final section.

Introduction to the “Sky Neighborhoods” Apartment Layout Concept

This concept presents the idea of multistory housing with apartments grouped around large covered courtyards, six stories high, which have one side open to the exterior. Typically, two-story apartments are stacked one on top of the other, such that each apartment unit is either on the access level or one level removed from it. Four or more pairs of these apartment units are arranged around and accessed directly from each courtyard. Elevators are suitably located off one or more of the courtyards, providing access to the courtyards and the adjacent units (see Figure 1). Escape staircases are located where necessary, and the dimension and layout of the structure allows lower-level car-parking facilities to be provided efficiently.

The basic module in this layout comprises two double-story apartments, which occupy three floors, one placed on top of the other, such that access to both apartment units is on the courtyard level, with the first unit connected to another floor below the courtyard level, and the second joined to another floor above the courtyard level (see Figure 2). However, stacking these apartments on top of each other, such that the courtyards flip from one side to the opposite side, produces a six-story high courtyard (see Figure 3).

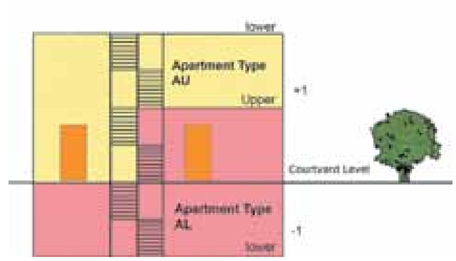


Figure 2. Basic interlocking apartment module.

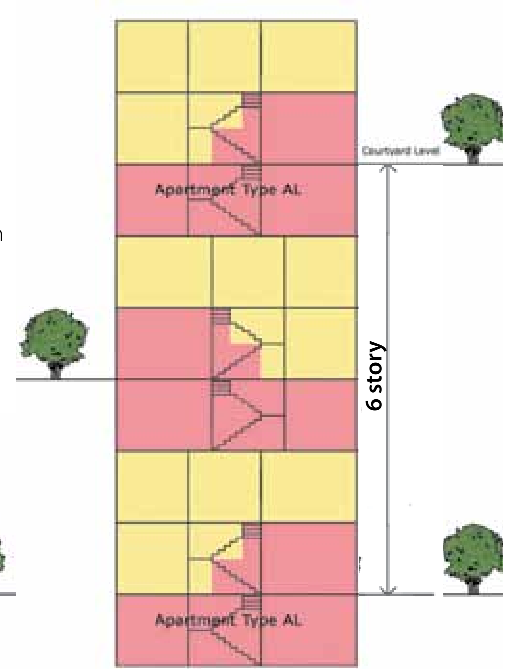


Figure 3. Basic apartment module stacked to create a six-story-high courtyard.

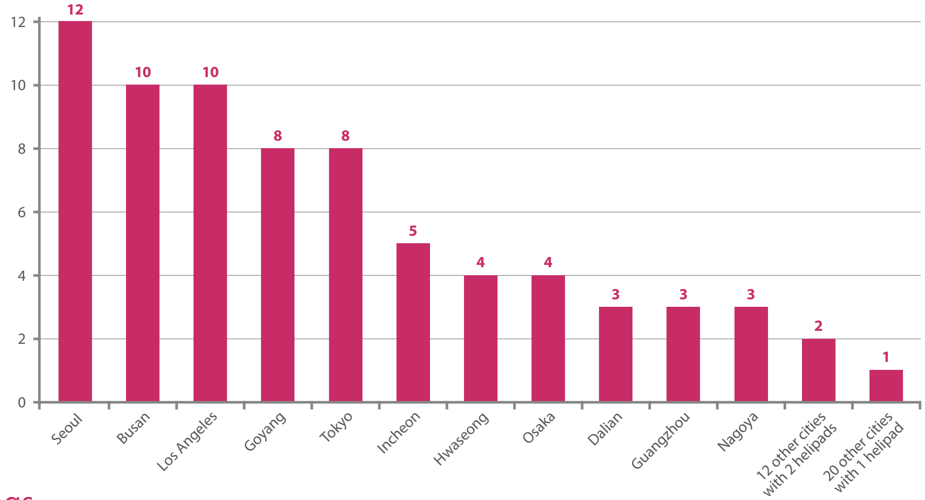
Highest Helipads

The question posed in our inaugural "Ask a CTBUH Expert" feature ("Helipads as a Tall Building Evacuation Tool?" See page 54) prompted us to consider how helipads are used on skyscrapers, and which are the highest in the world. The results were somewhat surprising, as displayed here. One hundred and fourteen buildings over 200 meters have helipads globally, across 13 countries.

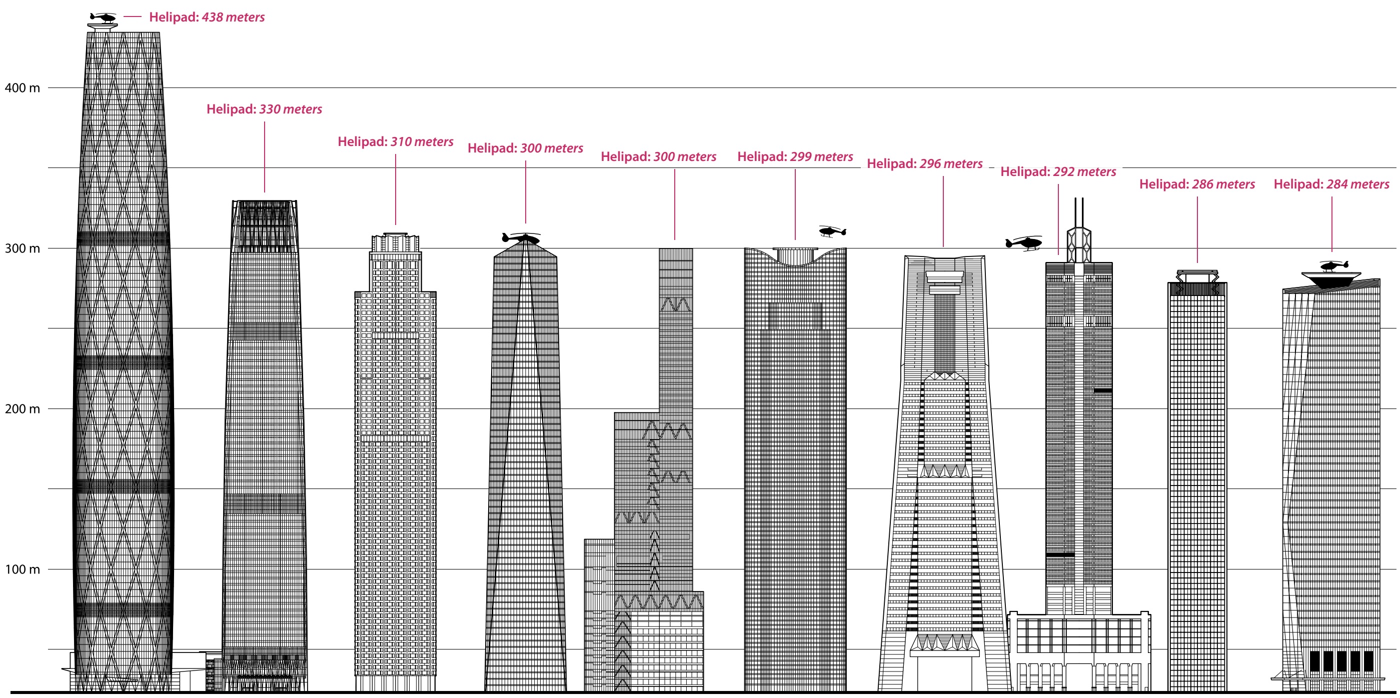
Note: All data as of May 2014

200 m+ Buildings with Helipads by City

Cities with the most 200 m+ buildings with helipads: 43 cities overall

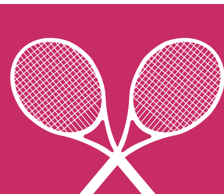


Ten Highest Helipads on Tall Buildings



Guangzhou International Finance Center	**China World Tower**	**U.S. Bank Tower**	**Northeast Asia Trade Tower**	**Abeno Harukas**	**Doosan Haeundae We've the Zenith Tower A**	**Landmark Tower**	**SEG Plaza**	**United International Mansion**	**Three International Finance Center**
439 m / 1,439 ft	330 m / 1,083 ft	310 m / 1,018 ft	305 m / 300 ft	300 m / 984 ft	300 m / 984 ft	296 m / 972 ft	292 m / 957 ft	287 m / 942 ft	284 m / 932 ft
Guangzhou	*Beijing*	*Los Angeles*	*Incheon*	*Osaka*	*Busan*	*Yokohama*	*Shenzhen*	*Chongqing*	*Seoul*
2010	2010	1990	2011	2014	2011	1993	2000	2013	2012

The highest helipad in the world is 6,400 meters above sea level; it is on top of the Siachen Glacier, located in the Himalaya Mountains

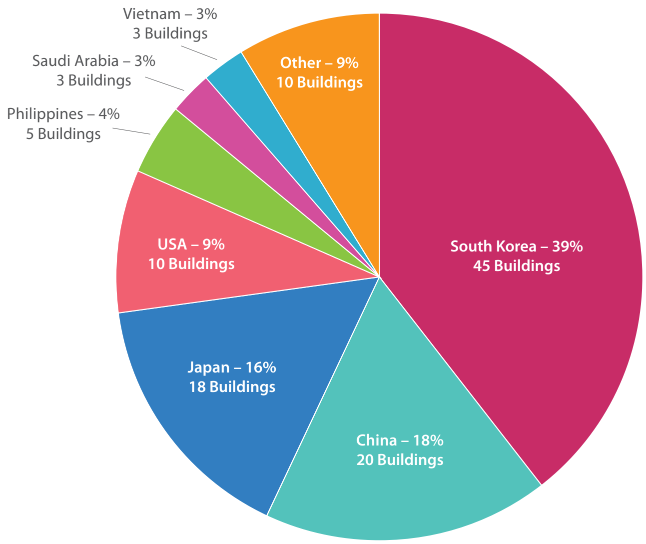


In 2005, Andre Agassi and Roger Federer squared off in a tennis match on the helipad at the Burj Al Arab, 210 meters in the air

A portion of the Los Angeles Municipal Code, written in 1974, states that all tall buildings must have a rooftop emergency helicopter landing facility

200 m+ Buildings with Helipads by Country

Figures represent each country's percentage of the global total of 114 tall buildings, of 200 meters' height or taller, with helipads

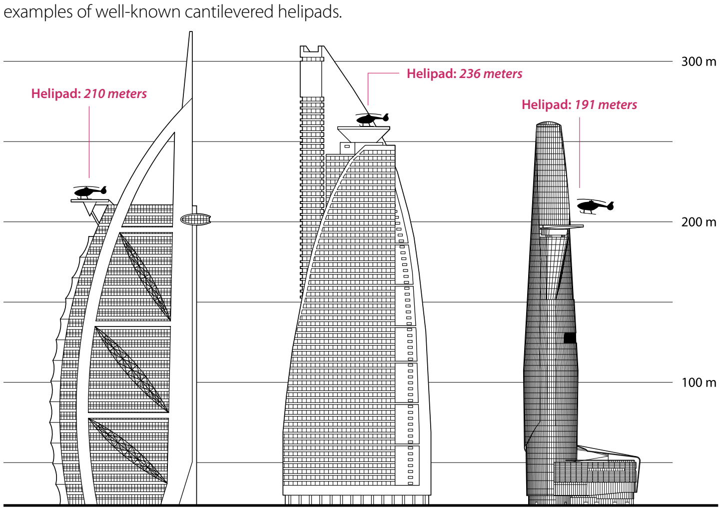


A total number of 13 countries have 200 m+ buildings with helipads

Total number of 200 m+ buildings with helipads = 114. Countries represented in the "Other Countries" slice each have two or less 200 m+ building with a helipad; they are: Malaysia (2), Mexico (2), Thailand (2), United Arab Emirates (2), Panama City (1), Qatar (1)

Cantilevered Helipads

Cantilevered helipads allow the architect to design the building without a flat roof. Here are three examples of well-known cantilevered helipads.



Burj Al Arab
321 m / 1,053 ft
Dubai
1999

Menara Telekom
310 m / 1,017 ft
Kuala Lumpur
2001

Bitexco Financial Tower
263 m / 861 ft
Ho Chi Minh City
2010

The original plan for the under-construction Kingdom Tower included a 630-meter high helipad, to be used by the Level 157 penthouse owners; it was converted into a sky terrace after it was deemed unsafe

The Met Life Building, New York City, used to offer helicopter service to John F. Kennedy International Airport, a 7-to-10-minute flight from the rooftop helipad

The World's 70 Highest Helipads on Tall Buildings

Ranked by Helipad Height

Italic figures indicate a helipad height that is different from the building height

No.	Building	City	Helipad Height (m)	Building Height (m)	Completion
1	Guangzhou International Finance Center	Guangzhou	*438*	439	2010
2	China World Tower	Beijing	330	330	2010
3	U.S. Bank Tower	Los Angeles	310	310	1990
=4	Northeast Asia Trade Tower	Incheon	*300*	305	2011
=4	Abeno Harukas	Osaka	300	300	2014
6	Doosan Haeundae We've the Zenith Tower A	Busan	*299*	300	2011
7	Landmark Tower	Yokohama	296	296	1993
8	SEG Plaza	Shenzhen	292	292	2000
9	United International Mansion	Chongqing	287	287	2013
10	Three International Finance Center	Seoul	284	284	2012
11	Doosan Haeundae We've the Zenith Tower B	Busan	282	282	2011
=12	WBC The Palace 2	Busan	265	265	2011
=12	WBC The Palace 1	Busan	265	265	2011
=12	Doosan Haeundae We've the Zenith Tower C	Busan	265	265	2011
=15	Tower Palace Three, Tower G	Seoul	*262*	264	2004
=15	Aon Center	Los Angeles	262	262	1974
17	Yuyang Tower	Fuzhou	260	260	2014
=18	Rinku Gate Tower	Izumisano	256	256	1996
=18	Osaka World Trade Center	Osaka	256	256	1995
=18	Mokdong Hyperion Tower A	Seoul	256	256	2003
21	Haeundae I Park Marina Tower 2	Busan	*255*	292	2011
22	Nation Towers Residential Lofts	Abu Dhabi	*254*	268	2012
=23	China Merchants Bank Tower	Shenzhen	249	249	2001
=23	Hwaseong Dongtan Metapolis 101	Hwaseong	249	249	2010
25	KLI 63 Building	Seoul	*248*	250	1985
=26	Hwaseong Dongtan Metapolis 104	Hwaseong	247	247	2010
=26	Midland Square	Nagoya	247	247	2007
28	JR Central Office Tower	Nagoya	245	245	2000
=29	Tokyo Metropolitan Government Building	Tokyo	243	243	1991
=29	Dalian Futures Square 2	Dalian	243	243	2010
=29	Dalian Futures Square 1	Dalian	243	243	2010
32	Philippine Bank of Communications	Makati	*241*	259	2000
33	Bucheon Kumho Richensia Tower 1	Bucheon	*240*	241	2012
34	Mokdong Hyperion Tower B	Seoul	239	239	2003
=35	Nanjing Jinling Hotel Phase II	Nanjing	*238*	242	2014
=35	Vista Tower	Kuala Lumpur	238	238	1994
=35	Roppongi Hills Mori Tower	Tokyo	238	238	2003
=38	The First World Tower 4	Incheon	237	237	2009
=38	The First World Tower 3	Incheon	237	237	2009
=38	The First World Tower 2	Incheon	237	237	2009
=38	The First World Tower 1	Incheon	237	237	2009
=42	Menara Telekom	Kuala Lumpur	*236*	310	2001
=42	Haeundae I Park Marina Tower 1	Busan	*236*	273	2011
=44	Opera City Tower	Tokyo	234	234	1997
=44	CCTV Headquarters	Beijing	234	234	2012
46	Tower Palace One, Tower B	Seoul	*233*	234	2002
=47	Abraj Al Bait Qibla Tower	Mecca	232	232	2012
=47	Abraj Al Bait Maqam Tower	Mecca	232	232	2012
49	Sankee Plaza	Nanning	231	231	2014
=50	Tanhyun Doosan We've the Zenith 105	Goyang	230	230	2013
=50	Megapolis Torre 1	Panama	230	230	2011
52	Two California Plaza	Los Angeles	229	229	1992
=53	Gas Company Tower	Los Angeles	228	228	1991
=53	Trade Tower	Seoul	228	228	1988
55	Al Faisal Tower	Doha	227	227	2008
56	JR Central Hotel Tower	Nagoya	226	226	2000
=57	Suseong Leader's View Tower B	Daegu	225	225	2010
=57	Suseong Leader's View Tower A	Daegu	225	225	2010
=59	Diwang International Commerce Center	Nanning	*224*	276	2006
=59	Tanhyun Doosan We've the Zenith 104	Goyang	224	224	2013
=59	Bank Of America Plaza	Los Angeles	224	224	1975
=59	Hwaseong Dongtan Metapolis 102	Hwaseong	224	224	2010
63	Torre Mayor	Mexico City	*222*	225	2003
=64	777 Tower	Los Angeles	221	221	1991
=64	Jewelry Trade Center	Bangkok	221	221	1996
66	Wells Fargo Tower	Los Angeles	220	220	1983
67	Figueroa at Wilshire	Los Angeles	219	219	1989
68	Shiodome City Center	Tokyo	216	216	2003
=69	Tanhyun Doosan We've the Zenith 106	Goyang	215	215	2013
=69	Tanhyun Doosan We've the Zenith 103	Goyang	215	215	2013

Standing Out by Blending in: Tower Infinity – The "Invisible" Tower

Charles Wee

In September 2013, GDS Architects received planning approval for the 450-meter, US$400 million Tower Infinity in Cheongna, South Korea, between Incheon International Airport and Seoul. The crystalline observation tower quickly got picked up by the world's media as the "invisible" tower, due to its clever use of an array of LEDs and HD cameras built into the façade, which give the ability to become "almost invisible." CTBUH Editor Daniel Safarik spoke to GDS principal Charles Wee about the plans for executing this audacious project.

Interviewee

Charles Wee, Design Principal
GDS Architects
719 East Union Street
Pasadena
CA 91101
United States
t: +1 626 535 9370
f: +1 626 535 9371
e: collins@gdsarchitects.com
www.gdsarchitects.com

Charles Wee
Charles' professional experience includes a wide range of large-scale master planning and mixed-use development projects throughout the world. Prior to founding GDS Architects, Charles worked as a designer under Anthony Lumsden for AECOM and AJLA.

His current projects include some of the largest and tallest high-rise mixed-use projects in Korea and China, including Tower Infinity, the "World's First Invisible Tower" in South Korea, recent winner of Time magazine's "Most Innovative Project" of 2013 and "The Most Contagious" Design award.

His work has been featured in numerous worldwide publications. Charles graduated with a Master of Architecture degree from the University of California Los Angeles.

Give us a little background on the project.
I think the invisible tower thing just somehow captures imaginations. It's got a crazy history. We've actually been working on this project for seven years.

Basically, there have been two presidents, two ministers of construction, two presidents of the land and housing corporation since I've been working on this project. So each time those guys change, the project dies and then another guy comes in and revives it. Finally, in 2013 we were able to get the building permit.

What inspired you to make something that was presented as invisible?
Back in 2007 when we entered the design competition, this "invisibility" thing really came about starting with the notion of redefining a "landmark" or "monument."

We've been working in Korea since 1991 and have probably done 30 competitions in Korea alone, and I don't think I remember a single brief that did not say they wanted a "monument" or "landmark."

I really got sick of that, actually, because that means an entire country would just be filled with landmarks and monuments. We started saying, "let's throw that preconception out." Let's call this an "anti-monument" and just take an opposite approach to everything.

So you deliberately went against the culture with this design.
I'm a Korean-American. I was born in South Korea, and I came to the United States when I was very young. Being in Korea as a professional from 1991, I kind of have a love/hate relationship with the country. I see so many vanity projects, and I wonder, "Why do you guys need another polished building in the world?" This design was almost a commentary to say, "Let's not fall into that trap of a meaningless race." Instead, let's have the chance to show the world that Korea is not really worried about making the tallest, most pristine buildings. Let's do something more powerful in its meaning.

Korea already has a pretty amazing position in the world. We don't need to show off anymore. And so our first design-panel catchphrase was, "It's the most visually striking landmark in the world – because it's invisible."

The first practical question that comes to mind is, how is this not an aerial navigation hazard? I've seen some renderings that seem to have been taken from a nearby airplane.
Yes. It is actually 20 kilometers from Incheon International Airport, so we had to do a lot of

> "I really got sick of [the relentless briefs for 'landmarks' and 'monuments'], because that means that an entire country would just be filled with landmarks and monuments. We started saying, 'let's throw that preconception out.' Let's call this an 'anti-monument' and just take an opposite approach to everything."

Figure 1. Tower Infinity, Cheongna.

simulations. Fortunately we were just outside of their primary flight paths. There will be aircraft warning lights at the top intersections, where our facets are. People are confused right now because they really think that the tower is shrouded and invisible constantly, and while we really would have loved to have done that, it would have been an astronomical cost.

It's basically designed so that it is shrouded from an eye-level perspective from right up close, about 20 meters, all the way back to about 2 kilometers. As you enter Seoul via the Incheon Bridge, the tower is strategically located along that view corridor. But from above you will always be able to see the tower in full (see Figure 1).

So a pilot will see it like an ordinary building?

Oh yeah, it is not at all a navigation hazard. We had to get a permit for it. In fact, a main obstacle was the North Korea threat. A few years ago their missiles were fired from a spot not far from our site. So, during our permitting process, South Korea officials put the whole thing on hold for about three months, because they objected to the positioning of our tower. They were concerned that it would be in the line of fire if North Korea were to attack. I don't think that I can get into all of the specific security stuff, but we worked with the military to satisfy their concerns. It was actually harder to get that permit than the aviation permit.

So was your original plan accepted in full?

They accepted most of our program. But the issue that they have now – and it's a pretty big issue – is that the original design calls for this 450-meter-tall tower, but all these program elements were scattered around: a theme park, a wedding ceremony place, a water park, and a museum. Because of the budget, the land and housing corporation would only pay for the tower. So what they are looking for now is a partnership to codevelop the podium, but they are going ahead with the tower. These programs were intermingled with the business plan, to make money for the building. We are looking for an operator now. And maybe when the operator comes in, some of the programs will change, but some of those primary programs are already set as part of the plan, like a 300-seat IMAX theater right at the middle, at around 240 meters above grade.

How exactly does this LED system work? The impression that I got is that it reflects back the landscape adjacent to the tower, so it appears to disappear.

It's a little bit more than that. The system we decided on is simple and reasonable in cost. You can have a pitch [distance] of 229 millimeters between bulbs, so that, as you are looking at the surface from so far away, you can see it in higher resolution. So at the bottom third was a 15-millimeter pitch, and it transitions to a 300-millimeter pitch at the top. At each facet intersection, we have 18 high-definition cameras. We have three sets of six cameras, one at every intersection of the hexagon, and they capture everything at 360 degrees. So we would have people gather at the time when we would cloak the building, and all the cameras that are capturing the people who are looking from one direction would get captured and projected to the other side. What the people are looking at gets processed on this HD video software that simultaneously edits, rotates, adjusts, and stitches this seamless picture, which gets projected on the side opposite the view it captured, and blends the projection surface into the background.

What kind of images can people expect to see?

Hopefully trees, or sky, or sunset – whatever is happening on the opposite side. The same technology becomes a billboard at night. Imagine the revenue potential of the tower becoming a giant TV screen. There are 35 million passengers that come to Incheon per year, and if 20 million of them go across the bridge, that means 20 million potential visitors.

How did you control the budget?

A really good curtain wall can run 15 to 25% of the budget. But remember, this is not a full

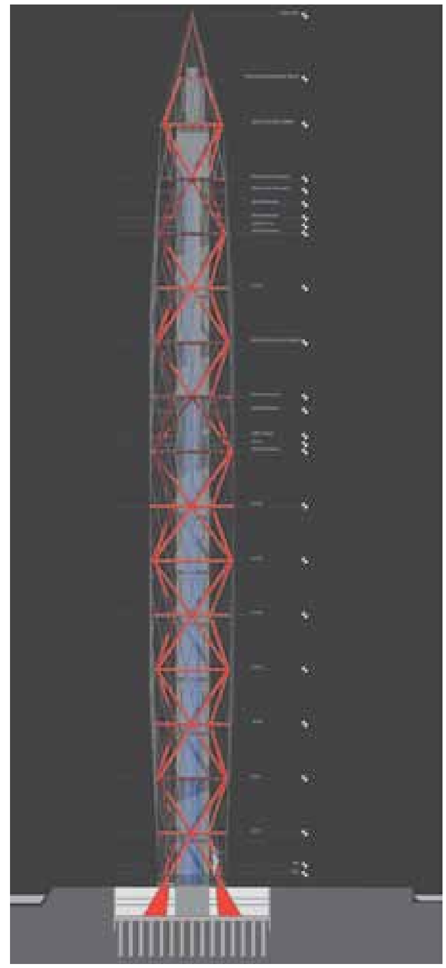


Figure 2. Overall section.

office building. So only 30% of the spaces are occupied, and the other 70% is just sky rides. We have one kind of glass for each condition.

What kind of design adjustments did you have to make to support an exterior skin that would incorporate the LED system?

The structural system integrates a reinforced concrete core, which acts like a giant megacolumn (see Figure 2). That gets linked to a steel-floor beam system with a perimeter link beam at every 28 meters. So as the tower goes up 450 meters, these horizontal systems basically come in every 28 meters. It is connected by what we call a double-helix

About the Council

The Council on Tall Buildings and Urban Habitat, based at the Illinois Institute of Technology in Chicago, is an international not-for-profit organization supported by architecture, engineering, planning, development, and construction professionals. Founded in 1969, the Council's mission is to disseminate multi-disciplinary information on tall buildings and sustainable urban environments, to maximize the international interaction of professionals involved in creating the built environment, and to make the latest knowledge available to professionals in a useful form.

The CTBUH disseminates its findings, and facilitates business exchange, through: the publication of books, monographs, proceedings, and reports; the organization of world congresses, international, regional, and specialty conferences and workshops; the maintaining of an extensive website and tall building databases of built, under construction, and proposed buildings; the distribution of a monthly international tall building e-newsletter; the maintaining of an international resource center; the bestowing of annual awards for design and construction excellence and individual lifetime achievement; the management of special task forces/working groups; the hosting of technical forums; and the publication of the CTBUH Journal, a professional journal containing refereed papers written by researchers, scholars, and practicing professionals.

The Council is the arbiter of the criteria upon which tall building height is measured, and thus the title of "The World's Tallest Building" determined. CTBUH is the world's leading body dedicated to the field of tall buildings and urban habitat and the recognized international source for information in these fields.

Council on Tall Buildings and Urban Habitat

Council on Tall Buildings and Urban Habitat

S.R. Crown Hall
Illinois Institute of Technology
3360 South State Street
Chicago, IL 60616

Phone: +1 (312) 567 3487
Fax: +1 (312) 567 3820
Email: info@ctbuh.org
http://www.ctbuh.org

ILLINOIS INSTITUTE OF TECHNOLOGY

ISSN: 1946 - 1186