Case Study: Baidu Headquarters, Shenzhen

What Makes a Tall Building “Innovative”?

Best Tall Buildings 2019: Dominant Trends

Tracking Fire Incidents in Tall Building Façades

Tallest Offset-Core Buildings

Robotic Construction of Tall Buildings: The Near Future
This issue is arriving in your hands as CTBUH commences the Tall + Urban Innovation Conference in Shenzhen, China. The three-day conference is a dramatic expansion of what had been a one-day event as recently as 2016. The Awards program at its core, now comprises 22 categories. In the program, in the affiliated Tall Buildings + Urban Habitat book, and in these pages, we are embracing the wide spectrum of disciplines and specializations that bring tall buildings to life, and, just as importantly, sustain and lengthen their lifecycles.

We therefore felt it appropriate to devote a portion of this edition to examining the many interpretations of “Innovation” that have been communicated by the Awards program since the category was created seven years ago (see What Makes for Tall Building Innovation?, page 18), as well as to the common threads to be drawn from this year’s crop of Best Tall Building Award of Excellence winners (see Best Tall Buildings 2019: Dominant Trends, page 26). We also want to familiarize our members with, and honor the hard work of people like Israel David, this year’s Fazlur R. Khan Lifetime Achievement Award winner (see Talking Tall, page 48); and Karl Fender, who has steered the Awards jury through several increasingly complex deliberations (see Meet the CTBUH, page 58).

Likewise, we are featuring a building that is very much “on-trend” with contemporary developments in office design, and a recipient of an Award of Excellence for Best Tall Building 100–199 meters: the headquarters of China’s Internet giant Baidu, in Shenzhen (see Case Study, page 12). It is somewhat ironic that the companies driving innovation in the digital economy are also the ones placing the highest importance on in-person collaboration. This is propelling architecture to new levels of creativity to create “collisions” of knowledge workers who otherwise might not interact. Moreover, creative knowledge workers overwhelmingly want to be in urban areas, which means turning college-campus-like workplaces vertical.

The desire for column-free floor plates is not new, of course. But it was somewhat stunning to learn how few of the world’s tallest 500 buildings have exploited the option of the offset core, though the practice dates back at least to the 1950s. The CTBUH Research Project captured in the paper Offset Cores: Trends, Drivers and Frequency in Tall Buildings (see page 36) and in the Tall Buildings in Numbers data study (see page 46) provides a succinct synopsis of, and a reasoned argument for the practice, which its authors expect to see happening more frequently, for reasons of sustainability as much as spatial flexibility.

But although celebration and recognition are the watchwords of the season, we should also be stunned, and moved to sue for change, when we look at the results of another CTBUH Research Project in the paper Façade Fire Incidents in Tall Buildings (see page 26). The database that was an outcome of the project reported that most of the identified fires occurred in buildings constructed within the last 10 years, and no fires were identified in a building higher than 30 stories before 2000. Even worse, 60% of fatal high-rise fires occurred in older buildings that had been refurbished. This, coupled with the knowledge that the infamous 2017 Grenfell Tower fire in London was attributed to a newly-installed façade, reminds us that we have in some ways backsld in terms of the fundamental objective of tall building safety.

To end on a positive note, let me be clear that we are living in a very exciting time for tall buildings and innovation is happening at a relentless pace. If Israel David and Schindler’s Thomas Oetterli (see Ask a CTBUH Expert, page 54) have anything to say about it, we will have plenty of time to reflect and innovate, because robots will be doing all the tedious work in a few decades. Here’s hoping!

All the best,

Daniel Safarik, CTBUH Editor
“I believe that, 10 to 15 years from now, tall buildings will be entirely built by robots.”

David, page 50
Americas

The skyline of New York City seems to be rising to infinity, and condominium prices are keeping right up with it. A penthouse at 220 Central Park South, designed by Robert A.M. Stern Architects and still under construction at press time, sold for US$238 million, the most expensive home ever sold in the United States. The lucky buyer was Chicago financier Ken Griffin. A few blocks away, the final segment of the topmost portion was lifted into place at 53 West 53, the Atelier Jean Nouvel-designed residential tower adjacent to the Museum of Modern Art. The building is expected to open before the end of 2019. As the competition along the southern edge of Central Park heats up, several buildings are taking on the guise of bystanders backing up and craning their necks to get the best view. Case in point, planning applications were submitted for Tower Fifth, which could become the city's second-tallest building if completed to a planned height of 473 meters. The Gensler-designed building would have all the bells and whistles, including a lap pool, yoga room, multilevel running track, and the city's highest observatory, featuring a transparent, 18-meter-high corkscrew slide.

The fevered Big Apple market is even redefining the concept of “highest and best use.” Despite its having been retrofit to the highest sustainability standards in 2011, demolition permits have been filed for the 1961 Union Carbide Building at 270 Park Avenue, whose owner, JP Morgan Chase, was set to build a new 70-story office tower in its place, giving the erstwhile predecessor the dubious distinction of becoming the tallest building ever peacefully demolished. The Union Theological Seminary, in the Morningside Heights neighborhood of Upper Manhattan, was said to be planning to construct a 42-story condominium tower on its campus, which would also house classrooms and fuel US$5 million worth of community investments.

Across the river in Jersey City, crown installation was underway at 99 Hudson Street. At 274 meters, the 79-story residential building will have 781 units and become New Jersey's tallest building when complete. Both of its two penthouses will have a private garden.

In Toronto, timber is about to take a bow in a major way, as Sidewalk Labs, which shares a parent company with Google, revealed plans for the Quayside project on the city's lakefront, a 4.8-hectare “smart city” that would contain 12 mass timber towers, with the tallest reaching 30 stories. If completed as planned, it would be the largest timber project in the world. Participating firms include Heatherwick Studio, Michael Green Architecture and Snøhetta. Further inland, tower floors began construction in the Stanley project, designed by Core Architects. The 41-story building will contain 537 apartments when it opens in 2020.

In warmer climes, preleasing began at the Art Plaza Apartments in downtown Miami, currently under construction with move-ins anticipated by mid-2019. The pair of 34-story towers will offer 667 one- and two-bedroom apartments, targeted at Millennials seeking a

3 West 53, New York. © Griss Jr (cc by-sa)
more urban lifestyle. Further up the coast in downtown **Fort Lauderdale**, plans were floated for **RD Las Olas**, a residential tower set to match or possibly exceed the height of the 151-meter **100 Las Olas**, currently under construction, hitting the height limit for the city. The area has seen a construction boom lately, replacing a low-rise district of parking lots with higher density.

In **Chicago**, an ultra-luxury condo tower is planned to rise at **12 West Maple Street**, containing just 12 units in its 22-story height. Plans include a restaurant, private dining space, commercial space, an outdoor pool, and indoor and outdoor terraces. Meanwhile, **Lincoln Yards**, a US$6 billion development that would transform 22 hectares along the North Branch of the Chicago River, is a key step closer to becoming reality after winning over the Chicago Plan Commission. It would feature buildings up to 198 meters tall, a substantial walk-back from earlier proposals, which drew citizen and political opposition.

The appeal of urban living continues to make strides in places that had traditionally favored spread-out suburbia, including Texas. In **Houston**, construction on **Innovation Tower**, a 48-story mixed-use tower slated for Main Street in the Texas Medical Center, was set to start in mid-2019. The Gensler-designed tower is expected to go up in two phases, the first with medical and life-science office space; with the upper portion to follow later, containing either more office space or up to 410 residential units. Further north, designs were revealed for **The Preston**, a 46-story apartment building, containing 373 units. The penthouses are to boast fireplaces and outdoor kitchens with gas grills and outdoor kitchens. Opening is set for the third quarter of 2022. Even the horizontally-named city of **Plano** outside Dallas was getting into the vertical act, as **LVL 29**, a 21-story apartment high-rise finished up construction in the US$3 billion, 250-acre (101-hectare) Legacy West Development. The Humphreys & Partners-designed tower will welcome renters by June 2019.

**Los Angeles**, of course, has been chipping away at its horizontal, auto-oriented reputation for some time, with the biggest high-rise boom concentrated in and near downtown. On the one hand, that part of town is going at full tilt – the latest example being the appropriately-named **Sky Trees**, a two-tower complex clad in timber and meant to resemble, with one reaching 70 stories. Its upturned canopy near ground level has also been likened to the skirt of Marilyn Monroe flying upwards in a famous 1955 photograph. On the other hand, the local construction industry was rattled by news that work had stopped at **Oceanwide Plaza**, a three-tower complex designed by CallisonRTKL that was to have finished by mid-year. Instead, work ground to a halt on the US$1 billion project, against a shortfall in financing from its Chinese owners, Oceanwide Holdings. By mid-February, the owners owed more than US$52 million to the lead contractor. Oceanwide was also named in an active FBI corruption probe

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**THEY SAID**

“**Mjøstårnet may be the world’s tallest wooden tower, but we hope not to hold the record for long.**”

**Arald Liven**, Project Manager, Moelven, discussing Mjøstårnet, the world’s next-tallest timber building, now finishing in Brumunddal, Norway. From “Efforts to Make Buildings Greener are not Working.” The Economist, January 5, 2019.
Background and Opportunities

After 30 years of rapid development in China, it is now customarily accepted that cities are changing with each passing day, as large influxes of people arrive. In 2018, there were more than 80 cities with a population of more than five million in China. In total, the population adds up to 700 million urban dwellers in China, which is close to the entirety of Europe. In Shenzhen Bay Park, an office development known as “the Silicon Valley of Shenzhen”, there are some 500,000 workers and thousands of established companies. The strain on the land resources and the burgeoning of skyscrapers in the science and technology park have led to increasing density, posing enormous pressure on public transport and other urban infrastructure (see Figure 1). This is leading to an anxious and stressful atmosphere, which can have a negative impact on the work environment and productivity.

The origin of high-rise buildings can be traced back to the Industrial Revolution in the mid-19th century. Gradually, the development of the skyscraper as we know it – as a building that repetitively stacks floor plates – resulted from economic optimization exercises; it was the most efficient way to organize space on limited land. However, due to the conflict between the single-use spaces in high-rises, and the diverse needs of users, ascending to work in a confined space all day is no longer compatible with contemporary workplace trends. Outdoor spaces, both on the ground level and at height, can help to relieve the paradox of isolation and density that is the symptom of skyscraper efficiency. Humans fundamentally desire to ascend towards the skies, to extend our gaze toward nature, and to have freedom of movement. Regrettably, such desires are stifled in modern offices, as the work environment is often confined to similar, often monotonous office floors of the same height and dimensions. With the verticality of the working space reduced to the absolute minimum, even spaces with glass curtain walls can seem like cages, and even the best views cannot satisfy people's longing for communion with nature.

The design team has been researching this issue for almost 15 years. At the end of 2011, Baidu, operator of the predominant search engine in China, held a competition for the design of its regional headquarters in the Shenzhen Bay Park, which gave designers the opportunity to apply research findings to a real-life situation. The team devised a solution that involved building a close link between users and nature, so as to relieve this tension. Critical to the concept was the exploration of novel approaches to space utilization in skyscrapers, which can mitigate the high density and isolating characteristics of these buildings, allowing occupiers to cope in a more systematic and effective way.

Abstract

This case study analyzes the creative concepts and technical details of the Baidu Headquarters. The south China building complex is headquarters to Internet giant, Baidu, and is one of the world’s tallest office buildings for an Internet company, second only to Tencent Seafront Towers, also in Shenzhen. Upon undertaking the project, the design team realized the need to address the tremendous strain that might be placed on the city’s population density. The team devised a solution that involved building a close link between users and nature, so as to relieve this tension. Critical to the concept was the exploration of novel approaches to space utilization in skyscrapers, which can mitigate the high density and isolating characteristics of these buildings, allowing occupiers to cope in a more systematic and effective way.

Keywords: Headquarters, Urban Density, Connectivity, Active Spaces
buildings is how to effectively avoid their isolative tendencies without sacrificing their efficiency. The chosen response was to experiment with the idea of creating a continuum of scenes in vertical buildings, seeking a balance between the accessibility and versatility of spaces. This exploration must occur within the constraints of accepted codes and operational norms. The high profile of the client and the intensity of the site conditions increased the pressure, but also provided the opportunity to create an ideal paradigm for similar skyscrapers.

**A Unique Skygarden/Skystair System**

The two towers of Baidu Headquarters are set to the eastern and western edges of the site, in a roughly “V”-shaped plan configuration, such that the towers, slightly off-set on their east-west axes, “open up” towards each other; this is reinforced at the ground level by curving podia that frame the center of the campus. This orientation was chosen to make maximum use of landscape resources and show the best faces of the buildings to the square (see Figure 2).

Based on previous research on the working model of Internet companies, and on previous design experience in designing Tencent Headquarters in 2006, the team proposed a bold and creative goal, which was to create a unique office building that would enable Baidu employees to walk out of their work areas for communion with nature at any time. This was extremely challenging to accomplish on a skyscraper that was planned to rise nearly 200 meters. To reserve enough space to realize the idea, on the eastern building, the core was set to one side, creating a 12-by-18-meter trapezoidal skygarden on the opposite side, at an interval of every eight floors (see Figures 3 and 4). Each eight-floor notch is offset at the fourth floor, where the vertical enclosure overhangs two window frames’ width on one side, and steps back the same width on the opposite side. This gives the otherwise regimented grid of the building...
What Makes for Tall Building Innovation?

Abstract

In this paper, the Council on Tall Buildings and Urban Habitat seeks to define “innovation” in terms of the potentially transformative technologies and practices for tall buildings, which have received recognition through its Awards program since the designation was incepted in 2012.

Keywords: Innovation, Technology, Development, Visualization, Seismic, Façade, Structural Engineering

Introduction

As the 50th anniversary of the founding of the CTBUH, this year sees a broad campaign to examine historic achievements in the tall building industry over the last 50 years, and to look forward through the lens of innovations that will drive the next 50 years. The apex of that activity is the 2019 World Congress in Chicago this October on the theme of 50 Forward | 50 Back. In April, the Council holds its newly-expanded Tall + Urban Innovation Conference in Shenzhen, which incorporates the 2019 Awards program.

We’ve devoted a portion of this issue to commemorating that program, and in this paper, we provide a context of values that shapes how we define “innovation.” Given that “Innovation” is in the title of the Conference, and CTBUH has been bestowing a Tall Building Innovation Award since 2012, it seemed prudent to examine select awardees over the years as a way of tracing development in several key sub-disciplines, and as a way of evaluating the criteria itself.

This theme is further explored in the Conference’s Innovation Panel Discussion Track, which convenes six panels across two days, to discuss questions that span Awards categories as well as disciplines, such as “What Makes for Innovative Tall Building Engineering?” and “What Makes for Innovative Tall Building Façades?” Refer to the Conference Program for details.

Criteria

Although the criteria may be well-known to those who have participated in the program previously, it bears repeating in these pages, for the benefit of the uninitiated, and as a way of understanding the arc of awardees across several areas of practice, over time.

The criteria state:

The Tall Building Innovation Award recognizes a specific area of recent innovation in a tall building project that has been realized in a design, implemented during construction/operation, or thoroughly tested and documented for its suitability in a high-rise.

Vertical Transportation

Stated simply, there could be no modern tall buildings without elevators. The rise of the skyscraper in the 1880s was coincident with advancements in electrical distribution and lighting, which made the passenger elevator a viable technology. However, it is also true...
that the basic model of a steel-cable-supported elevator cabin, one to a shaft, went essentially unaltered for more than 120 years. Of course, there have been advancements in speed, comfort, capacity and efficiency, but the central proposition, with its attendant limitations, remained unchallenged. Two CTBUH Award-winning projects stepped up to that challenge, and made it possible to envision a near future of our built environment very different from today’s.

UltraRope (Innovation Award Category Winner, 2013) is made of carbon fiber and a high-friction epoxy coating, rather than steel (see Figure 1). By developing a product that was only 19% the weight of steel-cored ropes for the same lifting capacity, the industry could move beyond height limitations that had been dictated by the steel rope’s weight and its limited ability to bend before secondary looping wheels are required, meaning that the amount of energy required to lift a car increases exponentially with height. The reduced rope weight means a dramatic reduction in elevator moving masses – the weight of everything that moves when an elevator travels up or down, including the hoisting ropes. With this innovation, the energy and space savings now mean that elevators can ascend up to 1,000 meters in a single run. At a time when we are producing more supertall (300-meter-and-higher) buildings than ever before, the implications of lowering the number of required transfers and the number of shafts are enormous, even for shorter buildings and those due for renovations.

The next evolution took only five years to arrive, with the emergence of MULTI (Innovation Award Winner, 2018), an elevator technology that dispenses with ropes altogether, using magnetic linear induction to travel along rails. This theoretically eliminates the mechanical limitation on shaft heights – though the limiting factor of people’s patience for long elevator rides remains. Combined with an “exchanger” machine that can turn the traveling motor on a horizontal axis, it allows the elevator to move sidways or diagonally while its cabin remains upright (see Figure 2). Intriguingly, the lines between horizontal and vertical transportation begin to blur, opening the door wider to creating 3D cities that efficiently move people not only within, but between buildings. Though the imagination races at the possibilities, here too, there are more mundane but highly valuable applications, such as the ability to run multiple elevators in one shaft, independently of each other, or increase capacity by running cars in a continuous loop.

Construction Materials and Methods

Constructing a tall building has always been a delicate ballet with heavy masses, as the paramount needs of safety, logistics and cost-effectiveness drive innovation ever higher. Add the relatively new considerations of environmental protection, energy and materials conservation, and the challenges become even more pronounced. These CTBUH Award-winning materials and methods shine a light on multiple potential paths forward.

The Broad Sustainable Building Prefabricated Construction Process (Innovation Award Category Winner, 2013) is a prefabricated construction process that front-loads fabrication to a factory before assembly on-site, the main module of which is a concrete-filled, profiled steel sheet, which is affixed to a cage of steel beams (see Figures 3 and 4). Only 7% of construction time is on-site; the rest is inside the controlled conditions of a factory. The system’s developer, Broad Group, stunned the world with a YouTube video showing a 30-story building being constructed in 15 days, and then went on to build several more, including a 57-story building in 19 days. Though clearly not applicable in all labor markets, for those contemplating rapid construction of projects in the developing world, it was serious food for thought.

“Broad Group stunned the world with a YouTube video showing a 30-story building being constructed in 15 days, and then went on to build several more, including a 57-story building in 19 days.”
As much as skyscrapers are celebrated for their iconic presence on the skyline, the projects showcased here attest to the growing investment the tall building industry has made in city-making. The singular focus on skyline presence and attribution to an individual architect or financial mastermind has served the mythology of the skyscraper well, but the reality is something altogether different. The full spectrum of the creation process of tall buildings – a sophisticated act of mass collaboration – is increasingly rising to public prominence and recognition in this global industry.

It has become evident to CTBUH that the regional classification of competitive categories in the Best Tall Building contest was problematic, especially as the story became one of more than height alone, and as broader considerations of cultural context and environmental performance become prominent, even essential characteristics of Best Tall Building entries. In 2019 the Best Tall Building program was divided into height categories for competition, so that a 100-meter building in South Korea would be compared to a building of similar height in Argentina, as opposed to a 300-meter building in Australia, for example. This was not an uncontroversial decision (see Debating Tall, page 5) and comes with its own set of challenges.

Although CTBUH’s mission has always been to establish and maintain criteria for measuring tall building height, in this enterprise, it is meant to be used as a way of fairly comparing buildings with similar challenges. The assessment of individual tall buildings remains a predominantly qualitative task. In this paper, we seek not to rank by height or group by geographical region. Instead, we elucidate some of the common qualities and unifying themes around this year’s Award of Excellence recipients, all of which are described here, and all of which are seeking the Best Tall Building designation, in height and function categories, and the ultimate overall category winner status, Best Tall Building Worldwide. We are not seeking to reveal the actual deliberations of the jury; instead, we hope to provide another mode of understanding the tall buildings the world is producing each year.

Residential, Reconfigured

As high-rise living becomes more ubiquitous, it is also becoming more varied, moving well beyond the standard double-loaded-corridor, rectilinear model. The amenities that have traditionally been more characteristic of low-rise, single-family districts, such as access to greenery and usable outdoor common space, are now being offered at height. Great creativity has been displayed in reconciling the demand for amenities with the requirements for privacy, the contextual appropriateness of a tall building in a given neighborhood, and access to light and views, both for residents of the towers and for those who live near them.

There is growing recognition that high-rises in general should be “good citizens” – custodians of the urban habitat of which they are part – and this is particularly true of residential towers, which are increasingly being inserted into neighborhoods that did not have a substantial skyline initially.

The Forma Itaim apartment tower is located in Itaim Bibi in São Paulo, a neighborhood undergoing a significant transformation, from the traditional fabric of low-slung single-family homes to a skyline of tall
buildings. These towers are being constructed to meet the growing residential demand of a prosperous upper-middle-class in the economic capital of Brazil. The tower, highly conditioned by the volumetric limitations imposed by local regulations and the strict requirements of functional optimization, hosts small units with large individual terraces. Its colorful façade is interrupted by a large communal space with significant open-air decks (see Figure 1). The ground plane is equally neighborly. Access to the building is through a garden space separated from the street by a glass partition. This gives a visual extension of the street, and at the same time creates a pleasant, private and enclosed waiting space.

A similar guiding philosophy was undertaken at One Park Taipei, situated across a highway from a large park (see Figure 2). The twin-tower development is staggered in order to give all apartments views to the city and surrounding mountains. Like their contemporary in São Paulo, these towers make extensive use of color, in this case to accentuate the stair cores with translucent red panels that glow at night. Its two swimming pools at the ground level are surrounded by vegetated trellises and topped with a brightly painted, louvered steel canopy. The atmosphere of the landscaped area of the development grounds and that of the neighboring park are thereby blurred, breaking down the discontinuity created by the adjacent busy, elevated road.

In Manhattan, the context, of course, is already one of dense settlement. The 277 Fifth Avenue project needed to meet certain design parameters to be viable, including the promise of sweeping views for residents. But it also had to fit into the existing setting, which is a combination of high-rises, five-floor brownstones, and pre-war mid-rise apartment blocks (see Figure 3). To generate a uniform floor plate and units of the desired size, the building is cantilevered over an existing five-story brownstone. A series of open-air, double-height loggias provide outdoor space for residents, as well as break down the scale of the tower.

In some cases, tall buildings have risen in a context of regeneration, with strong desire lines and embedded infrastructure, but little in the way of built history. Manhattan Loft Gardens, London, is situated between one of London’s largest and newest transport interchanges and the Queen Elizabeth Olympic Park. The project stands at the intersection between four main axes in the Stratford City Master Plan, at the crossroads of two distinct urban grids; one oriented north–south, and the other diagonally, from northwest to southeast. The intersection of these two grids informs the building’s unique geometry, which addresses both grids, resulting in the tower’s triangulated plan and cantilevers. This triangulated geometry informs the opening of the triple-height lobby piazza at ground level, and also creates openings for the building’s three skygardens (see Figure 4). The variations in scale across the aspects of the tower reflect the inspiration from the diverse range of housing types that comprise London.
Façade Fire Incidents in Tall Buildings

Abstract
Following recent tall building façade fire incidents, Research Seed Funding provided by CTBUH has supported exploratory research into identifying existing reviews of façade fires on tall buildings, creating a database of relevant façade fire incidents and examining where the emerging field of machine learning might be applied to the analysis of the incident database. The database included the general characteristics of the buildings, the regulatory environment in which the buildings were constructed, the types of materials used to create the façade, and the associated test standards with which the materials complied. This database will be used to identify areas of new work that should be advanced in conjunction with funding bodies and research partners. This paper provides a summary of the research work undertaken to generate the database.

Keywords: Fire, Façade, Database, Risk, Machine Learning

Background
The architectural tone of a building is often set by the choice of façade. Apart from its visual impact, the design of the façade system is influenced by many factors. Examples include desired features such as balconies and glazing; environmental conditions and resulting weathertightness; and long-term durability and maintenance requirements; installation and material cost; and structural implications.

Tall buildings have become more common in cities. For example, statistics compiled by the CTBUH show that the number of buildings of 200 meters’ height or greater increased by 441% from 2000 until the end of 2016. That number grew another 26.5% between 2016 and 2018 (CTBUH 2018).

Numerous high-profile fires have recently occurred involving the façades of tall buildings around the world. Incidents such as these pose a life-safety hazard to the building occupants and to people in neighboring property, cause damage to the building, present a challenge for the fire and emergency services, and affect the operation of the building after the event. This additionally results in major news items around the world that damage the reputation of tall buildings.

In addition to the specific characteristics of the façade system, there are several other related aspects that need to be considered. During design and construction, and similarly, if a building later undergoes refurbishment, the building regulatory system and the adoption of various national or international test standards can have a critical impact on the performance of a façade in a fire incident. The installation of passive and active fire protection systems may also have a bearing on the building design and fire performance. Lately, there has been increased discussion on the role that suppression systems, and in particular, automatic fire sprinkler systems, might play in the mitigation of façade fire incidents. The prevailing wind conditions have been shown to have a potential positive or negative influence on a façade fire incident. All these factors contribute to the complexity inherent in the design of façade systems with regards to fire safety.
Façade Assemblies

A typical building façade uses an assembly of products, each of which consists of several components. These components may be made of one or more materials, each with a range of thermo-physical properties. The exact configuration of the assembly and the characteristics of the constituent products can have a major bearing on its performance in a fire incident.

Two of the most common assemblies involve the use of metal composite material (MCM) panels or exterior insulation finish systems (EIFS). MCM panels are made up of two layers of metal skin with a core material in-between. The metal skins may be surface powder-coated or anodized aluminum (Al), stainless steel or titanium, and the core materials may include polyethylene (PE), polypropylene (PP) or a fire-retardant formulation. Panels are then typically attached to the building structure by fixing them to horizontal and/or vertical rails forming the outermost rainscreen component of the façade assembly. EIFS uses a layer of insulating material such as expanded polystyrene, polyurethane, or polyisocyanurate on a non-combustible substrate and one or more thin outer finish layers that may include a reinforcing mesh layer and coatings. Both assemblies can vary in complexity depending on the specific circumstances.

Figure 1 provides a simplified representation of the two common assemblies which have been adopted herein, in which four characteristics are identified in terms of the presence of a ventilated cavity, a face material, a core material and an insulation material. All four may not apply, depending on the particular façade assembly. There are typically additional elements relevant to specific façade assemblies in terms of fixings, moisture barriers, etc., along with many specific construction details for windows, doors, other penetrations, joints, corners, and edges for any given building, which were not addressed in this research.

Database

In developing the tall building façade fire incident database, fields were chosen to capture pertinent factors that could possibly influence fire outcomes, while remaining generic enough to allow comparison between incidents. Building configuration fields included height/number of stories above ground; construction material; geographic location; years of completion and renovation if applicable; and whether a sprinkler system was present. The database also holds fields that describe relevant fire incident parameters, including the reported cause of the fire; where fire started in relation to the façade (for example, whether the fire originally started inside the building before spreading to the façade or whether the incident was the result of an external fire, such as the burning of rubbish, etc.); on what floor the façade initially became involved; any wind effects; and whether there was reported manual intervention (i.e., fire service) or sprinkler system activation.

A total of 59 incidents from 21 countries have been included in the dataset. A baseline set of incidents were taken from the earlier studies by Wade and Clampett (2000), White and Delichatsios (2014), Valiulis (2015), and Evans (2017), in which news media reports were often used as their primary material. Additional information and further incidents were identified through various sources, including web-based resources, again including the news media. The certainty that the database has captured all relevant fire incidents and details of the identified incidents decreases farther into the past, due to the diminished availability of source material.

The database has buildings that range from five to 86 stories in height. Incidents related to “low-rise” buildings, such as single-story industrial units and single-family residences, are not included in the database. The buildings comprise hotels, residential, office and multi-use buildings, with a majority (45 incidents) being primarily residential. The oldest incident was in Canada in 1990, and the most recent was in the United Arab Emirates in 2018.

Analysis

Examination of the database shows that in 50% of incidents, the cause of the fire was reported as “unknown.” For the remaining 50%, identified causes included electrical equipment, comprising electrical short circuits (11 incidents); smoking materials, including cigarette butts (five incidents); mixed solid fuel items found in rubbish (five incidents); welding activity (three incidents); fireworks (two incidents); cooking appliances, including barbecue grills (one incident); and lightning (one incident).
Offset Cores: Trends, Drivers and Frequency in Tall Buildings

Abstract

This research explores the trends, drivers and frequency of offset cores in the world’s tallest buildings. It charts the history of tall building layouts, exploring the motivation behind offset-core morphologies emerging in the second half of the 20th century. Drawing from the literature, it then provides a definition for central, perimeter, mixed and offset cores, allowing for the categorization of the future 500 tallest buildings in terms of core position. It also identifies the tallest 20 buildings in the world with offset cores. The Hanking Center Tower in Shenzhen, at 358.9 meters in height, was confirmed as the world’s tallest building with an offset core, as of the end of 2018. Given a recent increase in the vertical development of smaller sites in dense urban environments, and increased emphasis on passive design and environmental performance, the authors expect a greater diversity of core locations to emerge among the world’s tallest buildings in the future.

Keywords: Tall Building Design, Offset Core, Skyscraper, Layout, Efficiency

Background

The location of the service core in any tall building is one of the most fundamental design decisions, impacting efficiency, structural system, services, environmental performance, views, access and egress, and more. Yet, despite the opportunities available to the design team, the central-core skyscraper has remained a ubiquitous typology throughout history, predominantly due to the spatial and structural efficiencies such an arrangement offers.

In early skyscrapers that emerged out of late-19th- and early-20th-century Chicago and New York, a central core location was common due to a reliance on natural light and ventilation for comfort and productivity. Artificial lighting capabilities were poor and air-conditioning unavailable in large commercial buildings until the 1930s (Oldfield et al. 2009). This meant the façade was the primary facilitator of thermal and visual comfort, with lease spans typically limited to between 6 and 8 meters to ensure access to light and air. With the façade conditioning occupiable workspace, the core was typically placed in the center of the building, since access to natural light was far more trivial in lift lobbies and fire stairs.

However, with the widespread development of mechanical conditioning in the postwar era, workspaces became liberated from the natural environment, and therefore the façade. This in turn liberated the high-rise service core from the center of the building. The Inland Steel Building (Chicago, 1958, SOM) was one of the first high-rises to capture the freedom that mechanical conditioning provided in terms of spatial layout and core position. Here, the core is offset far outside the primary building perimeter, into a distinct 25-story service tower. This freed the occupiable floor plan to be 18 meters wide by 54 meters long – totally unobstructed by structure or services. The concept was simple: to displace all interior obstructions, whether structural or mechanical, to the exterior of the building, creating the ultimate “open plan” (Abalos & Herreros 2003). A desire for unobstructed workspaces fueled the emergence of other offset-core towers, many becoming global icons, across the latter half of the 20th century (see Figure 1).

Contemporary towers continue to use offset cores for these reasons. The Leadenhall Building in London (2014) – often referred to as the “Cheesegrater” – uses an offset core to provide open, flexible office space on a tight urban site. The offset core also becomes a key part of the building’s visual identity,
Beyond functionality, architects and researchers are calling for a greater diversity in core design and location for reasons of sustainability. Yeang (1999), for example, describes how core location can be a key driver to energy performance, noting that in hot and tropical climates, perimeter or offset cores can be used to self-shade occupied spaces, reducing cooling loads (see Figure 3). Such designs would also offer natural light, ventilation and views to service areas, such as lift lobbies and staircases, that are typically artificially conditioned, with little outlook or prospect, in the heart of the building.

While such innovation has long shown potential, most built examples of offset cores have been limited to outside the world’s tallest buildings, where the central core typology dominates due to its inherent structural efficiency — providing lateral stability in the center of the building mass. However, the emergence of greater levels of structural innovation and heterogeneity in the world’s tallest building designs is seeing taller and taller buildings emerge with alternative core placement for increased performance. In the design of the 358.9-meter Hanking Center Tower, the primary service core is offset outside the main perimeter of the building to increase open floor space, but also to provide a public-private gradient across each floor plate (see Figure 4). A hybrid braced tube provides the lateral support to achieve this unique supertall building arrangement (Xu et al. 2015).

This research seeks to explore these developments, examining innovation in core placement in the world’s tallest buildings. It determines the location of the service core in the world’s future tallest 500 buildings. In doing so, it identifies the frequency of offset-core skyscrapers emerging on skylines around the world and presents the current 20 tallest buildings with offset cores.

### Classification of Central, Perimeter, Mixed, and Offset Cores

The service core can be defined as “an element that gathers together the spaces necessary to provide visual, physical and functional vertical connections that work effectively to distribute services through the building” (Trabucco 2010). Effectively, this consists of areas that enclose some of the following elements: elevator banks, stairs, lobbies, toilets, service risers and plant rooms, along with some vertical and lateral structural components, such as megacolumns and shear walls.
There has long been an interest in separating the service cores of tall buildings from the main programmed areas – to create more column-free, easily-configured floor space; to symbolically express “service” and “served” portions of the building; to limit nuisances caused by elevators, trash chutes, etc. The practice is not widespread in buildings over 250 meters, but interest in sustainability and creating unique spaces in tall buildings has begun to change that, resulting in some key divergences from the standard central-core model of the past decade. This study, a companion to Offset Cores: Trends, Drivers and Frequency in Tall Buildings (p. 36) examines the tallest buildings with offset cores.

» See the full list of the Tallest 500 Buildings and their core locations at ctbuh.org/offset-cores

Tallest 10 Buildings with Offset Cores

-Chase Tower, Chicago (264.8 meters, 1969) is the oldest offset-core building over 250 meters. 44% of all off-set core buildings (8 No.) were built in 2010 or later.

-Inland Steel Building, Chicago (101 meters, 1958) was an early offset-core success, yielding clear-span floor plates of 18 by 54 meters.
Core Location of the Tallest 500 Buildings by Height and Completion Date

includes buildings that are currently under construction and excludes buildings with central cores

Many tall buildings, such as Salesforce Tower, London, deploy offset cores as shading devices.

Hanking Center Tower, Shenzhen, is the "most-offset" core building above 250 meters' height; with the core 10 meters from the perimeter.

Balfron and Trellick Towers, London (84 m, 1967; 98 m, 1972), have all services, including laundry chutes, in offset cores, connected by skybridges to residential units. Both are landmarked.
What got you interested in tall buildings?
I got my first degree at the Technion, the Israel Institute of Technology. After I finished my bachelor’s degree in engineering, I started to get my master’s degree in science in 1981–82. I chose the topic of tall buildings because it was something different and new; I could see it would be something the next generation would have to work with. I was excited about being one of the first and taking the academic discussion up to a practical discussion.

How were things different then, in terms of how the engineering problems of tall buildings were approached?
In those days, there really were no personal computers; there was only one computer on campus, and you had to wait all night for it to do a calculation. It was the size of a car, and it could not do what you can do today on your smartphone. Everything was done by manual procedures and basic mathematics. When you study earthquakes, you understand in your stomach how to design; it’s not about putting some model in the computer, so you don’t understand the output. This way of studying allows you to really feel the building. This was very important for my engineering life, because I start by touching and feeling a building, not by having some pre-set procedure and putting a model into a computer. These tools I developed to become a creative engineer, and it has served me for the last 28 years in my office. I was open-minded and felt I could do anything, because I understood the basics in my stomach.

Was there already a program in place at the Technion that was emphasizing tall buildings?
No, it was a general study of engineering, but there were two or three professors who specialized in tall buildings and seismic engineering, one of whom was an Israeli who had taught at MIT. This was the first time we really understood and started to use finite element analysis. Today it is something obvious; we have systems that are automated, and don’t “need” to understand...
why and how. But I had to learn an innovative new system [manually].

What has changed about the built environment in Israel since you started your office?

In 1991, when my office was established, the Israeli population was four million people; 28 years later, we have almost nine million people. I don't think that there is any other country in the world that in a half-generation has seen this population increase of almost 200%. We are expecting by 2040 to be at 16 million. This means we have to work on infrastructure, such as trains, roads, hospitals. Our prime minister said in his election campaign that he intends to spend US$50 billion on infrastructure. Today our firm has more than 400 projects, and more than 50 of these are towers in Tel Aviv, which is booming (see Figure 1).

It seems that in such a rapid growth market, it is prudent to consider infrastructure before building a large agglomeration of tall buildings.

Yes, and there is another economic engine that is increasing our building production: technology innovation and the urban lifestyle that comes with it. Tel Aviv is a 24-hour city. We now have a lot of innovation and development in high-tech, natural gas and energy. This has brought a lot of international companies, such as Facebook and Noble Energy. I’m working on offices for both. We built a campus for Microsoft. All these high-tech companies are coming to Israel and hiring our people. Intel is building a second large project that will be subsidized by the government, with about US$10 billion worth of investment on a new site in the south of Israel. Tel Aviv is now completely out of office space. We have to build more.

What does the residential situation look like?

With the growth in population and entrance of high technology, young people want to live near a center of culture and lifestyle, as well as employment. If we are going to be able to accommodate this desire, especially as people want to live near the center, we will have to build many more high-rise buildings.

Fortunately, we don’t have a problem with parking that we otherwise might have, because when you build a high-rise office building you need to build a lot of parking. There were a lot of restrictions, previously. Now regulations have changed, so that you don’t have to build so much parking. We are developing a light rail network with two core lines, and along these, you can have a tower without too much parking. At the same time, a lot of high-rise building is much more sophisticated than previously.

What’s interesting is there is competition between the developers to be iconic, if not especially practical. These buildings are much more challenging from an engineering perspective. The intense competition is drawing internationally renowned architects as well, which is exciting.

What role do you think your involvement in CTBUH has played in getting you to this point?

I’ve been a part of CTBUH for the past 20 years, and I’ve learned a lot about what has been done everywhere through my exposure to international colleagues and the sharing of data that CTBUH facilitates. I’ve learned from the conferences, the books, the newsletters. I don’t think anyone [in Israel] is competitive with us, partly because of my history with CTBUH.

My first experience with CTBUH was at a conference in London, in a hotel near the center of London and not far from Heathrow. It was an old hotel; we were sitting on chairs that were very uncomfortable, but everyone was so excited. I saw a presentation of an engineer from Kenya; he was talking about a high-rise building in Nairobi. Through that, I understood that, if I wanted to be an expert, that I needed to be involved with CTBUH.

The importance of acquiring information and knowledge from outside is very important. Twenty-five years ago, we didn’t have the Internet, we didn’t have the engineering journals we have today. We were in the dark. So, when you come to a CTBUH conference, be it London, Kuala Lumpur, New York or
About the Council

The Council on Tall Buildings and Urban Habitat (CTBUH) is the world’s leading resource for professionals focused on the inception, design, construction, and operation of tall buildings and future cities. Founded in 1969 and headquartered at Chicago’s historic Monroe Building, the CTBUH is a not-for-profit organization with an Asia Headquarters office at Tongji University, Shanghai, a Research Office at Iuav University, Venice, Italy, and an Academic Office at the Illinois Institute of Technology, Chicago. CTBUH facilitates the exchange of the latest knowledge available on tall buildings around the world through publications, research, events, working groups, web resources, and its extensive network of international representatives. The Council’s research department is spearheading the investigation of the next generation of tall buildings by aiding original research on sustainability and key development issues. The Council’s free database on tall buildings, The Skyscraper Center, is updated daily with detailed information, images, data, and news. The CTBUH also developed the international standards for measuring tall building height and is recognized as the arbiter for bestowing such designations as “The World’s Tallest Building.”