CTBUH Journal

International Journal on Tall Buildings and Urban Habitat

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

Special Issue: CTBUH 2014 Shanghai Conference

Special Issue Sponsored by:

ARUP

Council on Tall Buildings and Urban Habitat

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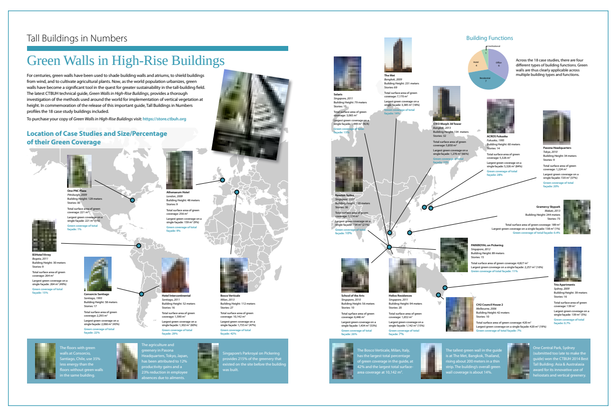

"While the research project aimed for a maximum use of timber, the construction of the prototype taught the engineers that 'less might be more.' Hybrid construction is the sustainable approach that now forms the basis of design."

Carsten Hein, page 40

Visit the daily-updated online resource for all the latest news on tall buildings, urban development, and sustainable construction from around the world at: ***http://news.ctbuh.org***

Asia and Oceania

Asia maintained its upward momentum and sought to continue shattering records from May through July 2014.

Plans have surfaced featuring a brilliant blue tower piercing the sky in **Jinan,** China. The **Evergrande Tower,** designed by TFP Farrells, could become one of China's ten tallest buildings if completed by 2020. The tower will form part of an 11-hectare residential and office complex, and will feature a streamlined form that tapers out at the base.

Not to be outdone, renderings have been unveiled of the 1,000-meter **Phoenix Towers** in **Wuhan,** which if completed would be the world's tallest pair of skyscrapers. This megatall twosome would be fitted with lightweight photovoltaic cladding, thermal chimneys, suspended air gardens, wind turbines, water harvesting systems, and hydrogen fuel cells at ground level. These environmental features are an attempt to avoid the pitfalls of other Chinese developments by incorporating the skyscrapers into a comprehensive sustainability plan for the surrounding region.

Jiangxi Nanchang Greenland Central Plaza Towers, Nanchang. © SOM

Evergrande Tower, Jinan. © TFP Farells

In other twin-tower news, the topping-out of the **Jiangxi Nanchang Greenland Central Plaza Towers** represents the 100th supertall (300 meters or higher) project to be topped out or completed around the world. At 303 meters, the Jiangxi project is now the tallest building complex in **Nanchang.** To offset some of the buildings' energy demands, wind turbines are being installed at the top of each tower which reportedly will power all of the elevators.

Continuing the trend of increasing environmental awareness in tall building design, the proposed **Gubei SOHO Tower** in **Shanghai** would take advantage of nearby Hongqiao Park in order to create opportunities for employees and visitors to relax in nearby green spaces. The 170-meter tower will serve as a medium between the urban density to the south and the openness of the park to the north.

7Point8, Jakarta. © Broadway Malyan

Further south, the **7Point8** development in **Jakarta** takes a fresh look at how land use diversity can rejuvenate a central business district. The proposal features two towers,

Phoenix Tower, Wuhan. © Chetwood Architects

PJ Sentral Garden City Office Tower, Petaling Jaya. © PJ Sentral Development Sdn. Bhd.

with the tallest standing 298 meters, and will combine office, retail, commercial, and residential uses. The towers will be situated at right angles around a centrally located open-air courtyard, which is intended to imitate a town square. 7Point8 will benefit from direct connections to the new Setiabudi rapid transit station, forming a vibrant hub of activity and commerce.

Kuala Lumpur is also seeking to reinvent itself, made evident by a string of mega-projects that are scheduled for completion over the next six years in the city center. Some of the largest projects include the **Tun Razak Exchange, Bukit Bintang City Centre,** and **Warisan Merdeka.** These immense projects are intended to showcase the Malaysian entrepreneurial spirit and its expertise in urban development.

Nearby in sister city **Petaling Jaya,** plans are in place to build a 65-story tower that will become the tallest building in the city. Located in the immense PJ Sentral Development, the **PJ Sentral Garden City Office Tower** is poised to achieve GBI and LEED certifications, continuing the steady progression of sustainable developments in Asia.

To the south in Australia, **Melbourne** planning authorities have approved new plans for **Australia 108,** after its height had to be reduced due to flight-path interference. When completed, the residential tower will be the tallest building in the southern hemisphere, standing at 319 meters and providing more than 1,100 residential units. Also newly approved in Melbourne are the 185-meter tower **88 Queensbridge Street** and the 241-meter tower called **Victoria One.**

Middle East and Africa

The City of Gold is living up to its reputation as **Dubai** prepares to receive the second tower of Downtown Dubai's BLVD Crescent development. **BLVD Crescent Tower II** will be home to more than 70 one- to three-bedroom apartments within a 20-story tower. Further south along the Persian Gulf, **Abu Dhabi**, the Stonehenge-like **Arc at Gate Towers** has begun leasing residential space, with apartments starting at US$16,880 per year. The Arc, completed in 2014, is a 23-floor crescent-shaped structure sitting beneath three large towers that are connected with a skybridge. The development of The Arc and BLVD Crescent Tower II appear to be appropriately timed, as rents in Abu Dhabi have steadily risen over the past few years.

Luxury high-rises continue to be well-represented in the Middle East, as **Beirut** noted the topping out of the residential **DAMAC Tower**, which will be the first Versace Home-branded residential high-rise in the region. DAMAC Tower is located in Solidere, one of the most sought-after locations in Beirut, and features sweeping views of the

BLVD Crescent Tower II, Dubai. © Emaar Properties

Damac Tower, Beirut. © DAMAC Properties

THEY SAID

"It started in 2009, and we still aren't finished. It's what I call the 'stress, tension and fatigue' factor. And we don't know yet if we're going to hit the building when we get to the top."

Ken Walerius, of Permasteelisa North America, on re-cladding a 1960s office building in New York during his presentation at the Chicago Council on High-Rise Buildings (CCHRB) Spring Seminar "Existing High-Rise Buildings: Refurbish, Repurpose, or Replace?", June 12, 2014

A Finely-Crafted Vessel in the New CBD Core

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Robert Whitlock, with over 25 years of professional experience, has developed an expertise on high-rise towers, mixed-use developments, and large-scale master plans. Robert is also responsible for several supertall projects, including Chongqing International Trade and Commerce Center and Suzhou International Finance Square currently under construction.

Li Lei has over 17 years of design experience on a wide spectrum of project types. As Senior Designer he has led design teams on a number of significant projects including China Zun Tower, Beijing Huaneng Headquarters, Nanning Airport Terminal, and American Commerce Center.

Dr. Luo Nengjun is responsible for the overall planning and operation control of project management, design, construction of the China Zun Tower. He has been engaged in many Chinese supertall building projects, including the Shanghai World Finance Center and Tianjin 117 Tower.

Dr. Liu Peng is the leader of the Arup Beijing structural team. He has substantial experience in tall building design, seismic design, and China projects. He has been involved in or responsible for the structural design of many projects in China, including the China Zun Tower.

China Zun Tower will be the flagship building of Beijing's comprehensively planned 30-hectare central business district core. The 528-meter-tall tower will stand far above its surroundings and become one of the most prominent icons of the city.

The tower's gently rising and curving form embodies the historic capital's gracefulness, and resembles an ancient Chinese ceremonial vessel, called the Zun (see Figures 1 and 2). During the project's land bid phase, this conceptual reference was established as a part of the 2010 master plan by TFP, BIAD, Arup, and MVA. Since project design began, KPF has interpreted the cultural reference as a generative motif for designing tower form, envelope, and major interior spaces, by distilling and applying the articulation techniques of the Zun vessel.

Beijing has the highest seismic fortification requirement of the major cities in China, making the structural system particularly sensitive to adjustments of the complex form. During the schematic and design development phases, the design architect and lead engineer teams implemented parametric modeling, using a common software platform that greatly expedited the design and coordination process. The tower design was a result of a careful negotiation of multiple design parameters, to achieve an optimized balance between a sculptural, elegant and iconic form, optimized structural and elevator systems, and efficient and effective interior program spaces.

The project has undergone the precertification process with the US Green Building Council (USGBC) and is on the path to achieve eventual LEED Gold certification. Key design aspects supporting sustainability include a high-performance building envelope with an optimized window-to-wall ratio and triple glazing, energy-efficient mechanical equipment, use of local materials, and application of greywater toilet systems and rooftop solar panels.

Urban Context

The new Beijing CBD core is located at the northeast side of the Third Ring Road and Jianguo Avenue intersection, approximately 5.5 kilometers east of Tiananmen Square and outside the historic center of Beijing. The urban center's infrastructure will be completely modernized to support its densification and transformation into one of China's key international finance, service, and media centers.

Around China Zun Tower in the CBD core, there are more than 20 tall buildings, ranging from 150 meters to 350 meters in height. A linear public park with underground retail and

Figure 1. China Zun Tower, located in Beijing CBD. © KPF

parking facilities runs through the middle of the core area, with the tower anchoring the northern end (see Figure 2). The tower forms an iconic backdrop to the park, and a prominent new destination for visitors.

Apart from being adjacent to a major bus station above grade, the tower will also be rooted in a vast underground transportation infrastructure network, encompassing the CBD core currently under construction. These include a pedestrian passageway system, lined with retail space at Level B1, linking together four subway lines across three stations; and an entire Level B2 roadway network for passenger and service vehicles, providing direct access to the tower basement and public parking levels under the Central Green.

Overall Tower Design

The tower contains 350,000 square meters of gross floor area spread over 108 floors above grade (see Figure 3). While the tower profile is curved, its floor plates are square with rounded corners (see Figure 4). Combined with a square core, leasable interior office space is optimized.

Under a six-meter-tall parapet that screens window-washing machines, the main body of the tower is organized primarily into eight zones above the ground floor lobbies and a conference center at Levels 3 and 4. There are three office sky lobbies, with meeting and staff dining facilities, located at the tops of Zones 2, 4, and 6. They are accessible via a set of dedicated high-speed double-decker shuttle elevators. The tower will primarily house the headquarters of CITIC Group and CITIC Bank, occupying four zones, while the remaining three zones will be leased to tenants. At the top of the tower, an observation deck, with a multi-functional business center, provides 360-degree views of Beijing.

Below grade, there are seven floors totaling 87,000 square meters, primarily accommodating lower-floor office elevator lobbies, a bank, retail, building management, and parking spaces.

Figure 2. China Zun Tower is the centerpiece of the new Beijing CBD. © KPF

"Around China Zun Tower in the CBD core, there are more than 20 tall buildings planned, ranging from 150 meters to 350 meters in height. Apart from being adjacent to a major bus station above grade, the tower will also be rooted in a vast underground transportation infrastructure network, encompassing the CBD core currently under construction."

Towards Sustainable Vertical Urbanism

Edited by Daniel Safarik, *CTBUH Editor*

The survival of humanity on this planet relies on a radical repositioning of our cities. In the face of unprecedented global population growth, urbanization, pollution increase and climate change, it is no longer enough to simply create buildings that minimize their environmental footprint. The reduction of operating and embodied energy consumption in every single building is, of course, vitally important – but even this is likely not enough to mitigate the huge issues at stake. We need to start considering how every building can start working with others in a harmonious urban whole – by maximizing urban/building infrastructure, sharing resources, generating and storing energy, and looking for completely new ways to improve the building's contribution to the city; physically, environmentally, culturally, and socially.

Cities thus need to be thought of, and buildings planned for, in all three dimensions – they cannot just be vehicles for isolated programs and expressed as products of two-dimensional zoning plans and height limits. Each stratified horizon of a tower has an opportunity to draw from the characteristics of the city and external environment, both of which vary widely with height. Wind, sun, rain, temperature, and urban grain are not the same through 360 degrees of plan or 360 meters of height, and our buildings need to both recognize, and draw opportunity from, that.

This primary subject of debate at the 2014 Conference is encapsulated in the highlighted presentations shown here. The discussion will drive thinking beyond just buildings, to considering cities as a whole. What best practices are some cities in the world already doing, and what else can be done? How can we work together to rethink our cities; to develop them beyond a collection of disparate icons, towards a vision of a connected, maximized, *Sustainable Vertical Urbanism?*

The Future Three Tallest Buildings in China

Opening Plenary - Wednesday, 17th September, 9:15 a.m. – 10:45 a.m.

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

Jianping Gu, *President and Board Director, Shanghai Tower Construction and Development Co., Ltd.*

The Shanghai Tower is one of the most ambitious skyscraper projects ever undertaken on the planet, let alone in China. While the distant silhouette and the proximate detail of the tower will be immediately distinctive, the purpose of the building is not simply to be seen as an iconic landmark; it is much more than that. Because it incorporates many advanced techniques, it will be a learning laboratory for the next generation of skyscraper designers. The building provides a vision of vertically-integrated space through the signature design move of a double façade that contains numerous sky gardens – filled with vegetation, the potential for socializing, and relief from the isolative nature of tall buildings without the necessity of descending to the ground.

Shanghai Tower. © Tansri Muliani

The statistics around the tower are formidable. Upon opening in 2015, at 632 meters it will be the tallest building in China, the second-tallest in the world, and one of only three megatall buildings of 600 meters or greater height in the world. Its sinuous double-skin façade and 14-story atria set into nine zones will redefine the experience of being in a tall building.

From the outset, the ambition behind Shanghai Tower was to make it one of the world's greenest and best-performing tall buildings, including a stringent requirement for an energy saving rate of 54% over the Chinese Efficiency Standard, and that investments in green technology pay back in 7–10 years. Passive solutions included the glass curtain wall's curvature, which reduced wind load by 24%, offered low reflectivity and, with louvers, a high shading coefficient. Active solutions include combined cooling and heating power (CHP), and grey and rain water recycling.

Because of the new paradigm in structural and façade design envisioned by the project team, a new system, consisting of a hinges and vertical sliding joints, was devised for establishing the twisted and tapered outer curtain wall system, which is held at varying distances away from the main structure.

But why do this? What is the return on investment? An expanded return on investment (ROI) calculation considers that sustainably designed buildings can reduce sick time by two to five days annually and increase productivity by 4.8%. When one is designing a skyscraper to accommodate more than 30,000 people, the value of that productivity increase justifies the extra expense involved in sustainable design. The real ROI for Shanghai Tower is borne out by the unique spatial experience created by the double façade. The double façade integrates and synthesizes energy benefits, vertical transportation, fire and life safety requirements, mechanical planning, and structural design, all while providing users with additional amenities and an experience that is unique in the world of high-rise buildings.

Ping An Finance Center: The Development and Construction of a Megatall

Thomas Tsang, _CEO, Shenzhen Ping An Financial Center Construction and Development Ltd. Co._

Located at the center of Shenzhen, the Ping An Finance Center (PAFC) is a "transit-integrated tall building" that will occupy a major node in the increasingly connected megacity of Hong Kong/Shenzhen/Guangzhou: home to 120 million people and one-third of China's trade value. By 2017, Hong Kong and Shenzhen will be only 15 minutes from each other by train, and in Shenzhen, PAFC is strategically located at the terminus of the under-construction XRL line to Hong Kong, as well as Shenzhen Metro lines 1 and 3.

PAFC will be 660 meters tall, comprising 460,665 square meters of floor area across 115 levels, with a daytime population of 17,000. And yet, despite its size, it will also have significant sustainability credentials. With an extremely dense program and well-chosen materials and mechanical engineering strategies, PAFC is predicted to sustain an 18.25% energy savings beyond ASHRAE standards, and a 46% annual savings in energy costs over a conventionally constructed commercial office building of the same scale.

PAFC's design symbolizes its owner's image and title – "Ping An" is the combination of the Chinese characters for "peaceful" and "safety," while evoking the entrepreneurial spirit of Shenzhen. The design also epitomizes efficiency. Its stretched, needle-like shape is streamlined and notched with continuously tapering corners, for both aerodynamic performance and visual effect, as well as returning the maximum possible number of square, functional floor plates on a compact site. Overall, PAFC achieves a 32% reduction in overturning moment and 35% reduction in wind load compared to China code, due to the shape of the tower.

Ping An Finance Center, Shenzhen.
© Kohn Pedersen Fox

All of these design elements were validated with performance-based evaluations, rather than design assumptions made on current code, and further optimized and compared through sophisticated use of BIM.

Suzhou Zhongnan Center: Rising Above Engineering Challenges

Dong Shen, _Executive General Manager, Zhongnan Group_

The Suzhou Zhongnan Center will be a 729-meter-tall building, containing 375,000 square meters of gross floor area across 137 floors. The project site is located just west of the Jinji Lake central business district (CBD), on 16,573 square meters of land adjacent to Century Plaza and Suzhou Center. It is a building of virtually unprecedented scale and scope, even within China. Its extreme height, difficult soil conditions, and widely varied program require an advanced level of thinking beyond typical tall building planning, design and construction.

The design of the tower is intended to reinforce local Jiangnan culture, referencing its pagodas and springs, with the remainder of its geometry defined by its diversified program functions. Across nine zones, the tower contains retail, restaurants, entertainment functions, offices, luxury apartments, a seven-star hotel, and an observatory.

Suzhou Zhongnan Tower, Suzhou. © Zhongnan Group

The most notable design feature of the tower is its tapering form and needle-like apex, with a consistent look broken only by the louver systems at mechanical floors. The podium attaches to the tower via a translucent façade, lit by fritted glass to the outside. It lifts up its canopy in a welcoming "flying lantern" gesture, creating a public plaza at ground level.

Existing code provides very little basis for the structural design of a building of Zhongnan Center's height or complexity. Both wind loads and seismic conditions had to be accommodated. Thus, the team undertook performance-based design to enhance and tailor the special design elements to match stakeholder objectives and ensure safe, economical construction, while addressing issues such as seismic waves, wind-induced serviceability design, life-cycle cost, material weight, and story drift reduction. This required in-house development of structural optimization software – a move that saved more than 2,000 metric tons of steel over the original design.

The Suzhou Zhongnan Center tower is not just intended to be a high building; it is intended to be a high-performance building in every sense of the word. Measured in increments as minute as millimeters to massive as kilonewtons, it demonstrates the immense effort of coordination that goes into such projects and the incredible attention to detail required of all practitioners.

Closing the Gap between Fantasy and Reality: Pushing Current Technologies Into the Future

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She travels widely to present at international conferences and document buildings. Her photographs form the basis for her lectures, teaching and research – many appearing in the CTBUH Skyscraper Database.

She is a member of the CTBUH Skyscraper Center Editorial Board.

The tall building is a discrete architectural type. The causal aspects of its evolution can assist in determining which aspects will be of the most benefit in pushing the idea forward. If tower-type buildings are symbols of the ideals and aspirations of the civilizations of any period in history, then what should our current response be based upon our technical achievements?

The age of the iconic skyscraper has come to be dominated by a combination of the preference for the stylistically unique in conjunction with the quest to build tall. The uniformity and rectilinear nature of International Style architecture that dominated tall building design through the better part of the 20th century has given way to unrestrained expression that is reliant on pushing the limits of technology, including the structural capabilities of materials and systems, as well as the methods used to calculate and fabricate those systems. This encompasses many evolving areas of digital design.

Tall buildings present one of the most challenging design problems that we face. What is being constructed today will impact our environment for many decades to come. Skyscrapers are not readily demolished. They are massive buildings with extremely significant structural systems that must create livable spaces for thousands of people (inside and outside) as they engage the city, and which need to remain viable for a significant duration.

There is such a significant gap between the physical realities – and sheer mass – of skyscraper design and the fantastical images of skyscraper "dreams" that we see in visionary proposals and competition entries. We seldom see the same abandon in the design of museum types, for instance. Although conceptual explorations for smaller building types might push the limits on form and materials, often as a direct result of digitally driven liberation, they are usually grounded in some sort of material concern.

The *Evolo Skyscraper Ideas Competition* has been running since 2006 to inspire an interest in the design of tall buildings. The winning entries have become increasingly fantastic, as illustrated in Figure 1. This is not to suggest that "ideas competitions" are invalid approaches for eliciting innovation; rather, the lack of basic material and structural concerns makes such competition results more suited to a digital industry such as film, and limits their applicability to the practice of architectural design.

> "The Evolo Skyscraper Ideas Competition winning entries have become increasingly fantastic… the lack of basic material and structural concerns makes such competition results more suited to a digital industry such as film, and limits their applicability to the practice of architectural design."

Figure 1. *Light Park Floating Skyscraper,* Evolo 2013: 3rd place. © Ting Xu/Yiming Chen. Source: http://www.evolo.us/category/2013/

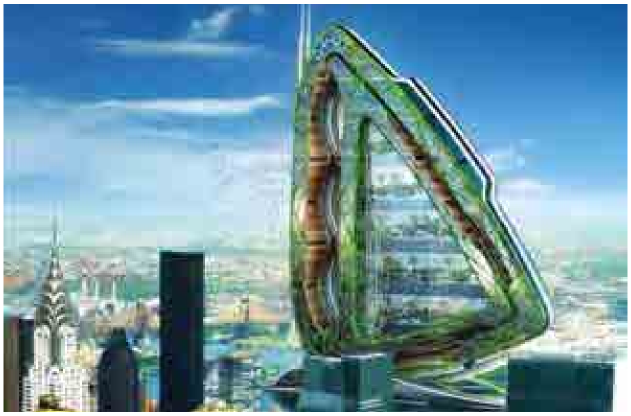

Figure 2. The *Dragonfly* urban vertical farm concept in New York. © Vince Callebaut Architects. Source: http://inhabitat.com

Figure 3. The *Asian Cairns* farmscraper concept in Shenzhen. © Vince Callebaut Architects. Source: http://hyperallergic.com

The technology of building tall has advanced significantly in the past 15 years – with major progress in megacolumns, outriggers, diagrids, composite construction, concrete pumping technologies, high-performance envelopes, and vertical transportation. But it has not necessarily kept up with the fantasy visions of towers that we see in renderings and competition entries, many of which ignore present-day material and construction realities – and gravity. Many of these proposals may include genuinely inspirational ideas, but they presently belie construction. However, it is the nature of "ideas competitions" to bring forward compelling visions of the future of architecture (see Figures 2 and 3). What should be the focus of future skyscraper developments?

The winning entries from the 2014 Evolo Competition clearly acknowledge the need for towers that integrate high-speed vertical transport systems, capture carbon, improve the air quality of cities, incorporate new materials, use 3D-printing technologies, and generally push a sustainable agenda. These are "fantasies" deserving of realistic exploration.

The situation may require that we step back and reconsider the tall building typology going forward, to better direct our energies towards understanding how we can effectively build upon current technologies to create a more socially and environmentally responsive framework. There is a need to reconcile current digital fantasies with the technical realities of what we *can* do in light of what we *should* do. The typology of the 21st-century tower has evolved from a commercially driven optimization problem to a dynamic, compelling and often controversial area of design. As the planet urbanizes, the tall building is being claimed as the solution. However, the questions "how tall?" and "how dense?" have not been properly addressed.

The Design Potential of Controversy

Recent stylistic and structural changes in tower typology have potentially made the tall building a more engaging building type, as well as perhaps a more contentious one. This provides an interesting opportunity for debate, particularly with reference to project proposals as they are introduced in the media.

Many of these blur the lines between digital design, technical aspirations and present realities. A great number of the most speculative skyscrapers have a "green" agenda. Sustainable themes include the incorporation of wind turbines and vertical farms that push the limits well beyond what has been accomplished to date in projects such as the Pearl River Tower in Guangzhou by SOM or the Wuhan Greenland Center by Adrian Smith + Gordon Gill Architecture (see Figures 4 and 5).

Figure 4. Pearl River Tower, Guangzhou uses its sculpted form to direct wind toward turbines situated at the recesses in the façade. © Tansri Muliani

Figure 5. Wuhan Greenland Center's distinctive floor slots help to reduce the vortex shedding. © AS + GG Architects

Developing Hybrid Timber Construction For Sustainable Tall Buildings

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Carsten Hein
Carsten Hein is a structural engineer by profession and joined Arup in 1996, where he developed a strong interest in designing timber structures. In 2004 he started working with Jürgen Mayer H. on the Parasol Metropol in Seville, Spain, leading the timber team in the office. In 2009, he led the design team for the multidisciplinary research project LifeCycle Tower. At the same time, the Multi-story Timber Research Network global timber network within Arup began operations.

Carsten has worked on various timber projects, always investigating the possibilities of the material and trying to push the boundaries for the use of timber.

In the near future, timber will form a much bigger part of the built environment. This paper chronicles projects that redefine the possibilities of timber to help support this development. Working on the LifeCycle Tower (LCT), the author and colleagues investigated the full and still largely-undiscovered potential of using wood for high-rise buildings. Using engineered wood combines the potential for prefabrication and rapid construction with lower embodied energy and the potential to delay carbon emissions for a building's lifetime. It recognizes that timber is best used in conjunction with other materials, taking advantage of the attributes of each material. Use of timber is optimized when it achieves full integration with building services, matching the acoustic, dynamic and fire performance of conventional alternatives.

CREE/Haus der Zukunft Project, 2009

A multidisciplinary approach is essential to achieve the aim of sustainably using timber in the urban environment. While the environmental advantages of timber are widely recognized, the cost efficiency of sustainable construction will be the main driver of an increased use of timber. In 2009, the Arup team carried out research in cooperation with the Austrian developer CREE, funded by the Austrian government initiative "Haus der Zukunft." The architect was Hermann Kaufmann ZT GmbH, Austria. Further collaborators included Wiehag, an Austrian timber fabricator, and the Technical University of Graz, with a former colleague of the author, Prof. Brian Cody.

From the outset, the team considered a modular construction system to allow for maximum prefabrication capability. The team developed the concept for a 20-story high-rise tower, attempting to use timber for as much of the structure as possible. The research comprised building permit calculations for all engineering services involved, including structure, MEP, façade, fire, acoustic, and building physics. The construction was designed to meet the requirements of European standards, and of the German and Austrian building regulations.

The floors of the LCT were conceived as timber-concrete-composite (TCC) slabs, using a concrete slab supported by timber beams, with a stiff connection between the two to provide composite action (see Figure 1).

While the structural requirements could have been fulfilled by timber alone, or by a 60- to 80-millimeter-thick concrete flange for the timber beams, fire regulations required 100 millimeters of thickness; acoustic requirements called for 120 millimeters. Notches in the tops of the beams created a structural interlock

> "The floors of the LifeCycle Tower were conceived as timber-concrete-composite slabs, using a concrete slab supported by timber beams, with a stiff connection between the two to provide composite action."

Figure 1. Timber-Concrete-Composite (TCC) slab. After all the walls are installed, the floor slabs, which were fabricated with a hole in each corner, slide over the pins in the glulam posts. © CREE

Figure 2. LCT One, Dornbirn, Austria. © CREE/Architekten Hermann Kaufmann

Figure 3. Illwerke Zentrum Montafon, Montafon, Austria. © CREE/Norman A. Müller

between concrete and timber to enable composite action. The stability core and the columns were designed to use glue-laminated wood panels (glulams), the core being assembled from 2.4-meter panels. The façade was conceived as consisting of 2.7-meter-wide modules with integral glulam columns. An approximate cost comparison of the chosen TCC construction for the LCT with a traditional concrete frame structure indicated that using timber would generate 10% to 15% higher costs. It was therefore agreed that a prototype would be constructed, minimizing the sizes of all the members to achieve a more economical solution.

LCT One: The Prototype, 2011

Based on the engineer's concept, the developer built an eight-story prototype in Dornbirn, Austria (see Figure 2), followed by a 10,000-square-meter office building nearby in Montafon (see Figure 3). These projects were designed by local engineers Merz Kley Partner, with Hermann Kaufmann again as architect. As agreed during the research, both these projects pushed the boundaries of timber construction, as all the main elements were slightly undersized compared to code-based fire and acoustic calculations. Testing was then undertaken of the slab system to demonstrate compliance. The test results were used to further develop the system.

The slab had been built with concrete of 80 millimeters' thickness. Additional aggregates had to be used for production of the concrete slab to avoid flaking of concrete cover, and to guarantee concrete integrity for the required 90 minutes. For acoustic performance, a sound-absorbing raised floor was required, as well as an additional self-levelling floor screed. The system returned an adequate performance. As expected, tests proved a 3-to-6-dB higher sound insulation than listed by product specifications. But it remained questionable if this was the most cost-effective solution.

However, in terms of fire performance, it was very successful, achieving an REI 90 (90 minutes fire resistance) certificate from the PAVUS Test Institute in the Czech Republic (see Figure 4). As the concrete contractor was not commissioned at this point, it was decided to use the Czech facility and a nearby concrete contractor to build the test elements – so only the timber had to be transported from Austria.

The eight-story LCT One used a concrete core for stability, which also provided the main exit route in case of fire. While the fire concept had envisaged a fully-sprinklered system, the building permit allowed removal of the sprinkler system because of the robust fire-safety strategy.

The façade system was also slightly modified from the research concept. It now featured up to 12-meter-wide prefabricated panels, with the columns mounted to the back of these panels. This was a valuable step to reduce the cost of construction and to improve the speed of erection.

At this point, the cost assessment was still not satisfactory; additional measures for the concrete and certification for fire resistance resulted in extra costs. The cost comparison became more difficult with more details at construction stage – there was no corresponding concrete version against which

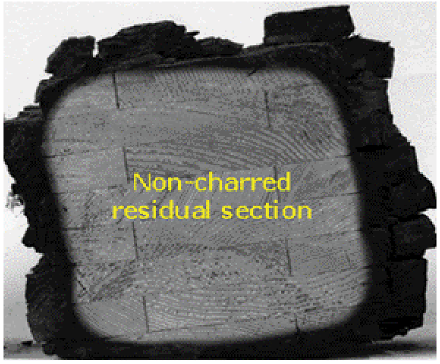

Figure 4. The prototype slab of LCT ONE was tested for fire resistance. After some modification the test proved 92 minutes of fire resistance, confirmed by an REI 90 certificate from PAVUS.

Building Services as A Force for Achieving Sustainable Vertical Urbanism in China

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Malcolm Laverick
Malcolm Laverick is the AECOM China Regional Director responsible for Building Services and has been based in China for five years. He has over 40 years of experience in building services consultancy and is a chartered engineer, a fellow of HKIE and CIBSE and a member of ASHRAE. His extensive list of projects have been completed in Hong Kong, United Kingdom, the Middle East, and now mainland China, where he acts not only as the Regional Director but also as lead Project Director for large multi-disciplinary building engineering teams.

A selection of his experience in tall buildings in Asia includes: AIG Tower, Chater House, and UBS Bank relocation from Exchange Square into IFC 2 in Hong Kong, Asia Square Towers 1 and 2 in Singapore; Shenzhen Kerry Centre, 688 Nanjing West Road in Shanghai; and Google's relocation into the Shanghai World Financial Centre. He is currently the MEP Project Director for a mixed-use development in Chongqing of 475,000 m^2 floor area, with five towers up to a height of 170 meters, and in Xian, a single tall tower of commercial offices of 130,000 m^2 floor area, and 200 meters height. Within China, he has led the development of enhanced engineering design, both in terms of the application of BIM and in-built sustainable design.

The introduction of vertical urbanism, with its necessary increase in population density per square kilometer of ground surface area, has a significant impact upon the primary engineering networks and building services required to support such developments. While urban planners promote vertical living as releasing the ground level for green areas and recreational use, the task of concentrating services is still a significant undertaking for consultants. The sizing requirements for the transportation network that brings people laterally to, and then upwards in, the development – which increasingly involves very little exposure to the external environment – is becoming larger, in order to maintain acceptable internal conditions. Rather than view this obligation as a burden, the services designer should consider it an incentive to introduce energy-efficient solutions that are sustainable and adaptable.

The integration of smarter and enhanced construction techniques, in both international and local developments, along with efforts to reduce energy and operational costs, is a national priority in China. Design solutions that were once considered unfeasible in China are now being adopted, and while there remain large sectors of the built environment that follow traditional solutions, the number of more ambitious clients that recognize the benefits of investing in improved performance is growing. From a construction perspective, contractors with a desire to improve and follow the new trends are actively developing their business around such models and growing their teams in order to implement new designs that have been reinforced with highly efficient building services. They will learn quickly from the building services consultants, who are developing these highly efficient strategies and have a stronger role to play in the future.

Responding to End User Requirements: The Building Services Manager's Role

Direct research for optimizing today's workplace

Providing facilities that can foster a healthy

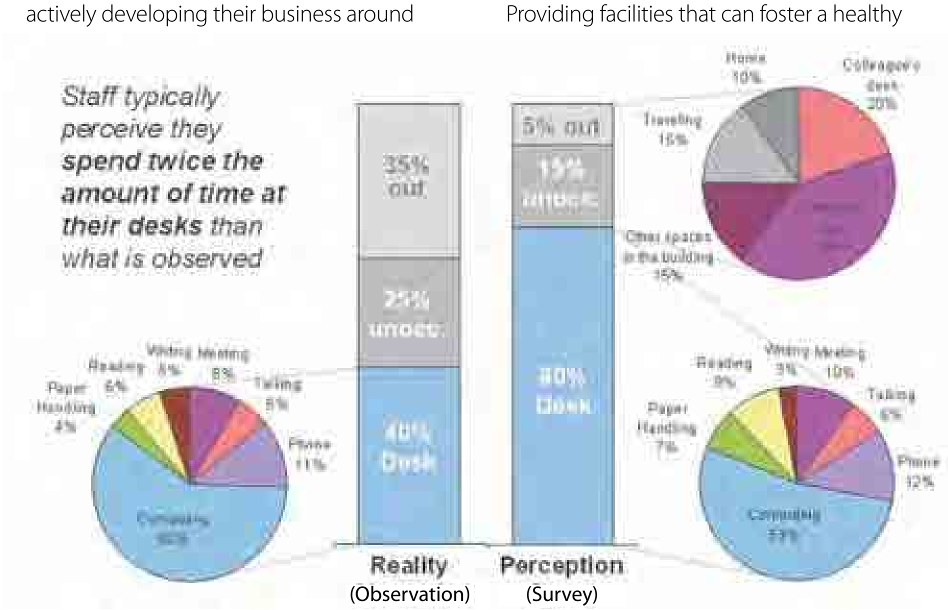


Figure 1. Working patterns – spaces and equipment are valuable assets but under-utilized. Source: AECOM Workplace Management

> “Sustainable solutions that may be common place outside China are sometimes viewed with caution within China. The potential for conflict between the desire to obtain certified products and the client’s wishes to retain the production of such materials within China must be considered.”

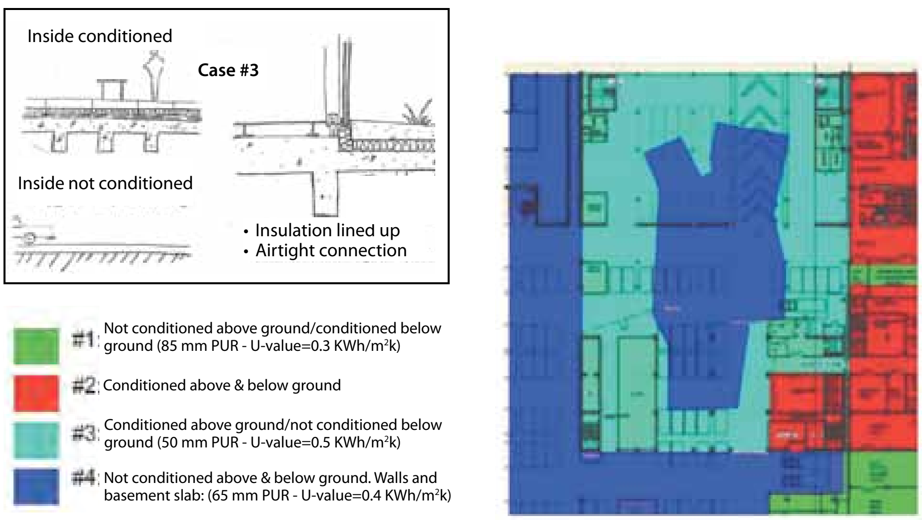


Figure 2. Building envelope - thermal performance.
Source: Multi-story Research and Development Campus Project, Shanghai

environment for people who live and work in vertical developments must be the prime consideration during the design process if such developments are to be sustainable. We must consider longer life cycles for such developments, as these have significant investment cost.

In many cases the design solutions are driven around a known set of parameters documented in such advisory or mandatory standards as ASHRAE or CIBSE (Chartered Institution of Building Services Engineers), the GB (Guo Biao / National Standard), or local Chinese municipal code. This information is essential; however, while it is of course a requirement to follow code in our designs, there is a also need to question the applicability of code mandates to the specific project we are designing.

As an example, the reality of how we work and how we behave in the office environment are often different in reality from what we perceive (see Figure 1). The working pattern as understood by the individual and as measured in reality are quite different. This difference affects the way we create a comfortable environment for the occupants. This is a considered opinion that can only be arrived at through face-to-face communication. Therefore, the design approach has to incorporate such communication. Rather than simply design services “by the book,” the building services engineer has to adopt such best practices when considering the working environment in terms of temperature, humidity, ventilation, and air movement. For the building services engineer, this may require asserting oneself in the design process at an earlier stage and more aggressively than may be the custom, as many still follow the code-mandated approach without engaging in the primary research of client needs.

In today’s modern office designed for the new generation, the provision of sport- and food-related activities are integrated with the normal working environment. The provision of physical activity rooms, showers, kitchens and breakout areas – all of which will have different HVAC requirements – must often be accommodated. Working hours have become much more flexible, which means systems must adjust accordingly. The ability to set automated timings, and use real-time activity sensors and a system of engineering that acknowledges such activities, is essential.

Choosing the envelope

Considering the architectural vision and desire of developers to individually distinguish their properties, the choice of building envelope requires careful consideration (see Figure 2). With the increase in variety of envelope solutions, the interior space systems must adapt intelligently to the envelope and external conditions. Glare, thermal performance, radiant effects, and the impact on the air conditioning vary in terms of

Green Walls in High-Rise Buildings

For centuries, green walls have been used to shade building walls and atriums, to shield buildings from wind, and to cultivate agricultural plants. Now, as the world population urbanizes, green walls have become a significant tool in the quest for greater sustainability in the tall-building field. The latest CTBUH technical guide, *Green Walls in High-Rise Buildings*, provides a thorough investigation of the methods used around the world for implementation of vertical vegetation at height. In commemoration of the release of this important guide, Tall Buildings in Numbers profiles the 18 case study buildings included.

To purchase your copy of *Green Walls in High-Rise Buildings* visit: **https://store.ctbuh.org**

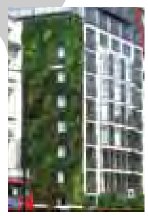
Location of Case Studies and Size/Percentage of their Green Coverage

One PNC Plaza
Pittsburgh, 2009
Building Height: 129 meters
Stories: 30

Total surface area of green coverage: 221 m²

Largest green coverage on a single façade: 221 m² (5%)

Green coverage of total façade: 1%



Athenaeum Hotel
London, 2009
Building Height: 48 meters
Stories: 9

Total surface area of green coverage: 256 m²

Largest green coverage on a single façade: 159 m² (9%)

Green coverage of total façade: 9%

B3Hotel Virrey
Bogota, 2011
Building Height: 30 meters
Stories: 9

Total surface area of green coverage: 264 m²

Largest green coverage on a single façade: 264 m² (49%)

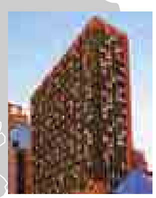
Green coverage of total façade: 15%

Consorcio Santiago
Santiago, 1993
Building Height: 58 meters
Stories: 17

Total surface area of green coverage: 2,293 m²

Largest green coverage on a single façade: 2,066 m² (43%)

Green coverage of total façade: 22%

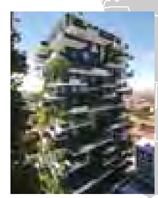


Hotel Intercontinental
Santiago, 2011
Building Height: 52 meters
Stories: 16

Total surface area of green coverage: 1,590 m²

Largest green coverage on a single façade: 1,302 m² (60%)

Green coverage of total façade: 29%

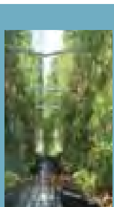


Bosco Verticale
Milan, 2013
Building Height: 112 meters
Stories: 27

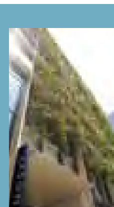
Total surface area of green coverage: 10,142 m²

Largest green coverage on a single façade: 1,735 m² (47%)

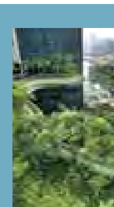
Green coverage of total façade: 42%



The floors with green walls at Consorcio, Santiago, Chile, use 35% less energy than the floors without green walls in the same building.

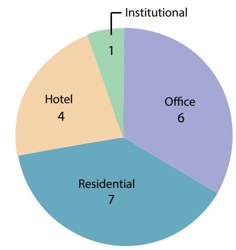


The agriculture and greenery in Pasona Headquarters, Tokyo, Japan, has been attributed to 12% productivity gains and a 23% reduction in employee absences due to ailments.



Singapore's Parkroyal on Pickering provides 215% of the greenery that existed on the site before the building was built.

Building Functions



Across the 18 case studies, there are four different types of building functions. Green walls are thus clearly applicable across multiple building types and functions.

Solaris
Singapore, 2011
Building Height: 79 meters
Stories: 15

Total surface area of green coverage: 3,065 m²

Largest green coverage on a single façade: 1,449 m² (N/A)

Green coverage of total façade: 15%

The Met
Bangkok, 2009
Building Height: 231 meters
Stories: 69

Total surface area of green coverage: 7,170 m²

Largest green coverage on a single façade: 3,385 m² (18%)

Green coverage of total façade: 14%

IDEO Morph 38 Tower
Bangkok, 2013
Building Height: 134 meters
Stories: 32

Total surface area of green coverage: 5,850 m²

Largest green coverage on a single façade: 1,276 m² (66%)

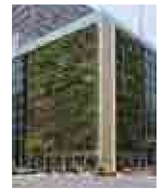
Green coverage of total façade: 23%

ACROS Fukuoka
Fukuoka, 1995
Building Height: 60 meters
Stories: 14

Total surface area of green coverage: 5,326 m²

Largest green coverage on a single façade: 5,326 m² (84%)

Green coverage of total façade: 28%



Pasona Headquarters
Tokyo, 2010
Building Height: 34 meters
Stories: 9

Total surface area of green coverage: 1,224 m²

Largest green coverage on a single façade: 720 m² (37%)

Green coverage of total façade: 20%

Newton Suites
Singapore, 2007
Building Height: 120 meters
Stories: 36

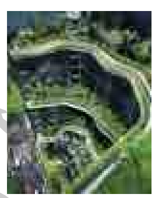
Total surface area of green coverage: 1,274 m²

Largest green coverage on a single façade: 734 m² (21%)

Green coverage of total façade: 10%

Gramercy Skypark
Makati, 2013
Building Height: 244 meters
Stories: 73

Total surface area of green coverage: 189 m²
Largest green coverage on a single façade: 138 m² (1%)
Green coverage of total façade: 0.4%



PARKROYAL on Pickering
Singapore, 2012
Building Height: 89 meters
Stories: 15

Total surface area of green coverage: 4,827 m²
Largest green coverage on a single façade: 2,257 m² (16%)
Green coverage of total façade: 11%

Trio Apartments
Sydney, 2009
Building Height: 39 meters
Stories: 16

Total surface area of green coverage: 139 m²

Largest green coverage on a single façade: 139 m² (5%)

Green coverage of total façade: 0.7%

School of the Arts
Singapore, 2010
Building Height: 56 meters
Stories: 10

Total surface area of green coverage: 6,446 m²

Largest green coverage on a single façade: 1,434 m² (53%)

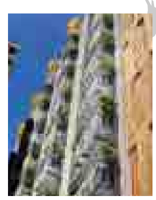
Green coverage of total façade: 26%

Helios Residences
Singapore, 2011
Building Height: 94 meters
Stories: 20

Total surface area of green coverage: 1,652 m²

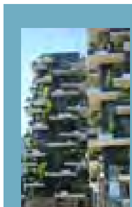
Largest green coverage on a single façade: 1,142 m² (15%)

Green coverage of total façade: 7%



CH2 Council House 2
Melbourne, 2006
Building Height: 42 meters
Stories: 10

Total surface area of green coverage: 420 m²
Largest green coverage on a single façade: 420 m² (19%)
Green coverage of total façade: 7%



The Bosco Verticale, Milan, Italy, has the largest total percentage of green coverage in the guide, at 42%, and the largest total surface-area coverage at 10,142 m².

The tallest green wall in the guide is at The Met, Bangkok, Thailand, rising about 200 meters in a thin strip. The building's overall green wall coverage is about 14%.

One Central Park, Sydney (submitted too late to make the guide) won the CTBUH 2014 Best Tall Building: Asia & Australasia award for its innovative use of heliostats and vertical greenery.

Talking Tall: James Robinson

Learning From 50 Years of Hong Kong Skybridges

James Robinson

Interviewee

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James Robinson
James Robinson was appointed Executive Director of Hongkong Land Limited in June 2002, and is responsible for the project management functions of the company's Asia Pacific investments.

Robinson joined the company in 1988 and has been responsible for a number of major high-rise/tall building development projects, including Chater House in Hong Kong, One Raffles Quay in Singapore, the One Central luxury mixed-use development in Macau, and the ongoing Marina Bay Financial Centre in Singapore, as well as the nearly completed World Trade Centre 2 for Jakarta Land in Jakarta, Indonesia.

Before joining Hongkong Land, Mr. Robinson worked for 10 years with the Hong Kong subsidiary of the American architectural/engineering firm, Leo A Daly, gaining extensive regional design and project coordination experience in Hong Kong, Korea, China, and the Philippines.

Hongkong Land, which now ranks in the top 25 among the world's largest property companies by market capitalization, has been a Patron/Sponsor member of CTBUH since 1991, and its senior management have actively attended CTBUH world conferences since the Fourth World Congress in 1991.

In 2014, Hongkong Land, which owns more than 450,000 square meters of central Hong Kong, is celebrating its 125th year in business. The company was instrumental in developing not only the commercial, retail, and hotel market in Hong Kong, but also the city's famous network of skybridges between buildings, which has grown to encompass many kilometers, much of it air-conditioned and supporting a "street" life all its own. CTBUH Editor Daniel Safarik spoke to James Robinson, Executive Director of Hongkong Land about the past, present, and future of skybridges in an increasingly urbanizing world.

What are some of the main reasons why Hongkong Land decided to start building skybridges between its properties?

Footbridges are a big part of our history after World War II, and you have to go to the early founding of Hong Kong as a cosmopolitan city and the way the government laid out streets and the sizes of the sites to understand their importance. It became very obvious that with a very dense city, the building sites were relatively small in the big scheme of things. As the city developed, many lanes between buildings were absorbed into larger sites, but there wasn't a critical mass between buildings. Hongkong Land actually tried to purchase existing buildings adjacent to our original properties that we bought in the late 1890s so that we could either merge them, or link the buildings across the street with footbridges. After WWII, rent controls made it such that we could not do any major redevelopment of our first buildings in Central until the mid-1950s, when we demolished the old Alexandra Building and adjacent Royal Building, and created the then-new, art-deco Alexandra House, which amazingly was redeveloped again in 1976 along with the Mass Transit Railway Corporation (MTRC) system in Central. At this point, all of our buildings were 50 or 60 years old. They were the original four-story buildings that we built in the early 1900s.

Hongkong Land's leadership at the time were very intuitive thinkers, and they built the first Mandarin Hotel (now the Mandarin Oriental Hotel), which stands in the same place today. The Mandarin Hotel was built and opened in 1963. The senior managers at the time, who were redeveloping the old Prince's Building, said, "We don't have enough critical mass in the Mandarin Hotel site, so let's link it with an air-conditioned footbridge across the road." The new Prince's Building was completed in 1965. The government granted us a usage license to build, operate, and manage that first footbridge, which has become one of the most iconic footbridges in the world, and very frequently photographed.

This footbridge provided a link for the luxury hotel guests to wake up in the morning and walk across to the adjacent building that

"Putting in the footbridges and allowing retail to expand both vertically and horizontally across buildings has driven enough traffic that it now comprises at least 30 to 35% of our total annual retail profits in Hong Kong."

Figure 1. Skybridges at Alexandra House, Hong Kong. © Hongkong Land

accommodated three levels of retail. Then, hotel guests who had business in the Prince's Building could use the footbridge to access the office lobbies. It was also our first building where we put the office lobby above the ground floor. The original design had the main office lobby at the second level, linked with double-height escalators on the east and west sides. This was important to maximize traffic to ground- and first-floor shops, many of which were double-height, even back then.

So in a sense, this is a clever way of capitalizing on their adjacency by treating them as one building?

Yes. Both sites are two of the bigger sites in Central, but we still felt that doubling the size of the site by combining them would give them a greater critical mass and would give us an opportunity to blend hotel, retail, office, and restaurants in an integrated link. Once it became obvious that it was successful, we started saying, "Wow, this is the way to go; let's start planning this for all of our other buildings that need to be redeveloped."

This was the trigger for us to create the Central Redevelopment Master Plan, which focused on two major planning decisions: the next redevelopment of the critical Central nodal site, Alexandra House (see Figure 1), to allow for multiple footbridges to radiate out in all directions to our adjacent properties, and more importantly, the massive amalgamation of sites along Queens Road Central and Des Voeux Road Central. Today this stands as The Landmark complex of luxury retail, and contains three office towers, and now the world-famous Landmark Mandarin Oriental Hotel.

When you redeveloped those buildings, did you tear them down and build new or were they gut-rehab projects?

Back then we tore down and built anew, because all of the buildings were way under the allowable gross floor area that we were permitted to build on-site. Essentially all of the buildings were four stories. With the new codes in Hong Kong, you could build with 80% site coverage up to 24 floors, so the plot ratio was a maximum of 18 or 19. But 10 years later, Hong Kong scaled back to a plot ratio of

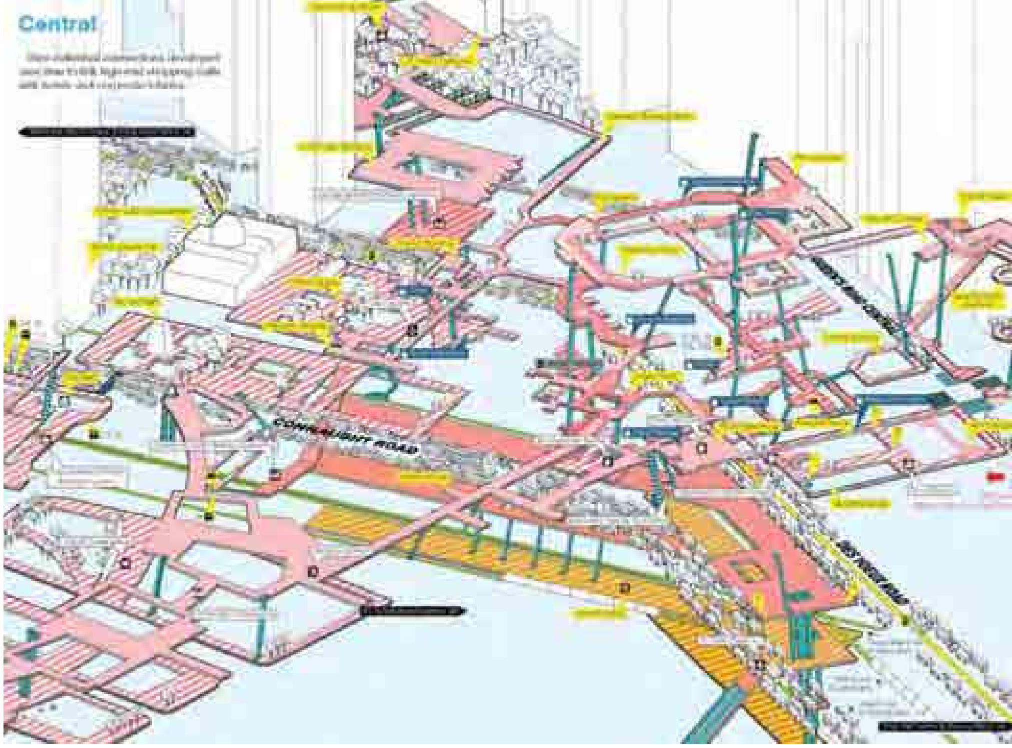

Figure 2. Hong Kong Central elevated skybridge.
Source: Frampton, A. et al., 2012, *Cities Without Ground: A Hong Kong Guidebook*

15. At this time, Hong Kong was growing at a tremendous pace, from 600,000 people at the end of WWII to 2.5 million by the mid-1950s, with many coming in from China.

What were some of the competing private interests that had to be dealt with as the network was extended beyond the properties that HKL owned directly?

The Hong Kong government was, and still is, very supportive of the footbridge network. With some developments like the Connaught Centre, there was a requirement that a footbridge be built across Connaught Road. The government has also built its own unbelievable array of footbridges, extending the network that we started in the 1960s (see Figure 2).

If a developer has a number of contiguous sites, they have typically connected their buildings with footbridges. Rarely have competing developers connected their buildings. It comes down to the fact that they don't want to share the costs of construction and maintenance. Some developers only see the initial dollar sign; not realizing that the potential increase in footfall and rentals in 20 or 30 years will render huge profits compared to the initial capital costs.

Have you determined how much value footbridges bring to a project?

It's a hard number to determine, but putting in the footbridges and allowing retail to expand both vertically and horizontally across buildings has driven enough traffic that it now comprises at least 30 to 35% of our total annual retail profits in Hong Kong. That's because we are able to go up a couple of extra floors and move office lobbies to upper floors in order to provide more space for ground-floor retail. Also, the linkage between buildings adds value to all the retailers.

One of our current priorities right now is to convince the public and overseas tourists that our four main inter-connected retail podiums in Central south of Connaught Road are actually in fact one integrated retail development. Several years ago, we rebranded all of these connected retail podiums into what is now called "The Landmark" (see Figure 3).

This way, you're within Central, but you're also within The Landmark. It's been a challenge because people still know the buildings as the Prince's Building, Alexandra House, Chater House, and the original Landmark. Nonetheless, we're making headway with a number of other initiatives that convince people that they're in the same retail setting. We use the same floors, signage, branding, music, and smells to project an image to people that they're in the same cohesive horizontal development.

What actions have you taken to reinforce this branding?

The footbridges were renovated 15 years ago to be the same, but all of the buildings were

About the Council

The Council on Tall Buildings and Urban Habitat, based at the Illinois Institute of Technology in Chicago and with a China office at Tongji University in Shanghai, 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

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ISSN: 1946 - 1186