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Case Study: International Commerce Centre

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David Malott specializes in the design and planning of supertall buildings and complex mixed-use developments. With over 15 years of experience as an architectural designer and project director working on projects throughout Asia, he has contributed to the firm's strong presence in China, Japan, and Hong Kong. He was made a director of the firm in 2009.

Since joining KPF in 1998, David has served as Senior Designer for some of the firm's most recognized achievements, including the 492-meter Shanghai World Financial Center, awarded the Best Tall Building Worldwide by the Council on Tall Buildings and Urban Habitat in 2008, and the 490-meter International Commerce Center in Hong Kong. He also played a key role in the design of Roppongi Hills in Tokyo, the largest private-sector urban redevelopment project in Japan's history, and the recently completed One Central luxury mixed-use development in Macau.

Presently, he is leading the design of the 588-meter Ping An International Finance Center in Shenzhen, currently under construction. With a floor area of over 460,000 square meters (5 million square feet) and 115 floors of retail, office, and observation facilities above grade, the PAIFC is targeted to be the world's tallest and largest LEED certified building when completed in 2015.

...skeletal

"If Miami is a city of surfaces, of pink plaster and deco doodahs, this building is skeletal, naked."

Rowan Moore, Architectural Review's journalist, describing Herzog & de Meuron's 1111 Lincoln Road, Miami. From "1111 Lincoln Road", The Architectural Review, June 2010

"More than an iconic statement, the Hong Kong ICC fundamentally alters the way tall buildings are seen today. Rather than just being objects in isolation, transit integrated tall buildings represent a sustainable model for future high-rise development."

Soaring 484 meters (1,588 feet) above Victoria Harbor, the International Commerce Centre (ICC) is the essence of Hong Kong in one destination: high-powered finance, global tourism, luxury shopping, and world-class hospitality, all gathered in a single tower built over a sophisticated transportation network spanning the Pearl River Delta.

The iconic image of twin lighthouses on opposite shores of the harbor is underlined by the three-minute subway link between ICC, sited at the tip of Kowloon Peninsula, with the central business district across on Hong Kong Island. With the design of ICC, the Architects addressed the challenge of bridging this divide, using expressive formal gestures and innovative technologies that connect the tower with Hong Kong's mass transit infrastructure.

Poetry of Motion

This case study explores the design of the building at three scales of connectivity. ICC, at the macro level, forms part of a sustainable urban network. The tower's internal mechanisms and form both physically and symbolically connect it to Kowloon Station. The details of the tower bring the poetry of motion into being.

Transit Integrated Tall Buildings: A Sustainable Paradigm

Beyond its picturesque profile, ICC speaks to the promise of the tall building as a sustainable paradigm, in which individual buildings form part of a larger ecosystem of vertical centers linked by horizontal networks of public transportation.

Increasing density in city centers is more effective in preserving land resources and reducing energy usage than the alternative of urban sprawl. Amongst high-income societies, Hong Kong ranks as the most efficient in annual per capita energy use at 2,600 kgoe (kilograms of oil equivalent) compared to 4,180 kgoe in Germany; 7,885 kgoe in the United States; and 10,350 kgoe in the UAE (OECD 2007, OECD 2008). And while Hong Kong is associated with images of busy streets and concrete jungles, only 2% of its total area is urban or built-up. Forest, grassland, and cropland constitute 72%, and wetlands and water bodies make up 25% of Hong Kong's total area (World Research Institute 2003). Examples of building high-rise density

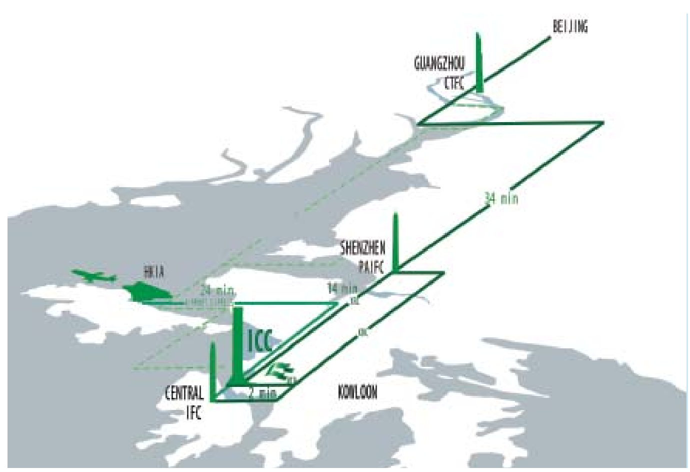

Figure 1. Public transportation connections from ICC

atop rail stations such as New York's Met Life Building over Grand Central Station (1960) and more recently KPF's JR Central Towers in Nagoya, Japan (2002) established fundamental principles for integrating the tall building with transit. In Hong Kong, the practice has achieved a level of integration and scale without precedent. This is made possible by the combination of strong central planning, a powerful transit authority (Hong Kong's MTRC), and an innovative development culture.

Kowloon Station Development

Sited above Kowloon Station, ICC is integrated with a public transportation infrastructure that carries 11 million passenger journeys per day (Hong Kong Special Administrative Region 2009). ICC's success as a development stems from is its seamless connections with Central, Hong Kong International Airport, and mainland China via a network of high-speed rail, subway, buses, and ferry terminals (see Figure 1). Comprising over one million square meters (10.77 million square feet) of built-up area on 135,630 square meters (1.46 million square feet) of reclaimed land, the Kowloon Station Development (KSD) is billed as a "super transport city." According to Sun Hung Kai Properties Group, the developer of ICC, "The density of construction around the station reflects how modern rail can provide a catalyst for the creation of a highly-compact and efficient 'vertical city' (Luk et al. 2003)."

KSD features nearly 675,000 square meters (7.27 million square feet) of high-rise residential and service apartments, 100,000 square meters (1.07 million square feet) of retail, 232,500 square meters (2.50 million square feet) of class "A" office space, and two hotels – the W and the Ritz-Carlton – the latter of which is located at the top of ICC. This small city is built entirely around Kowloon Station, linked by a superblock podium that spans the rail corridor to create an elevated ground plane with gardens, public plazas, and outdoor cafés on the station roof. The KSD superblock will extend into the future West Kowloon Cultural District, a HK$21.6 billion (US$2.7 billion) government-financed venture that will feature 17 arts and culture venues including performing arts theatres, concert halls, museums, and a 15,000-seat outdoor performance venue along a waterfront park.

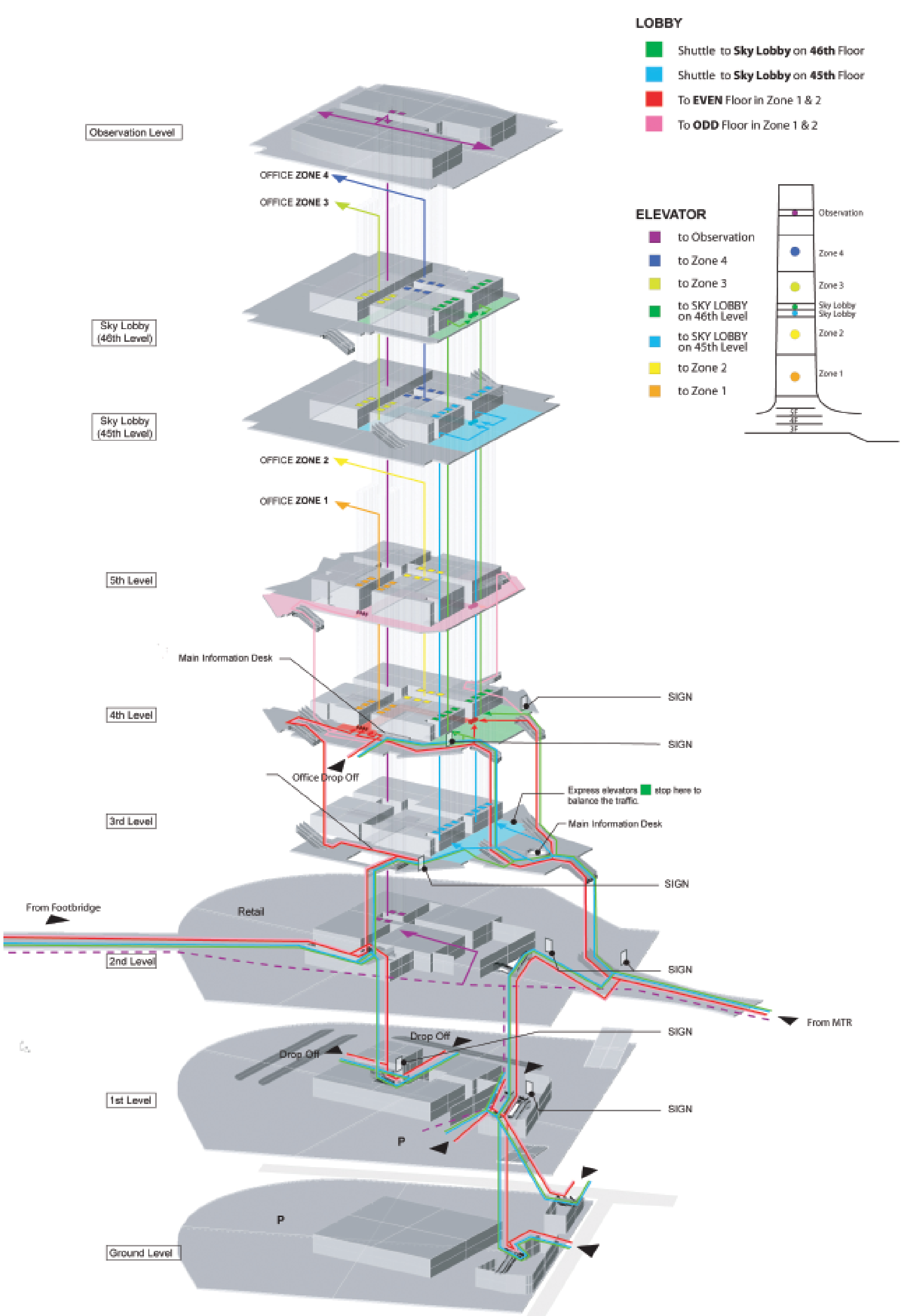

Figure 2. Vertical circulation zoning

Connection to Mainland China

In 2015, the introduction of the Express Rail Link (XRL), connecting Hong Kong with the major cities in the Pearl River Delta, will transform the region into a transportation supercity of 120 million people, which will produce five percent of the world's manufactured goods and one-third of China's trade value. The XRL terminal, to be constructed adjacent to ICC, will carry 100,000 passengers per day across one of the world's most heavily trafficked borders. Travel time from ICC to Shenzhen's central business district will

Figure 3. The tower under construction

be reduced to 15 minutes – less than a commute between New York's downtown and midtown business districts.

The string of supertall buildings under construction along the XRL corridor is emblematic of sustainable networking between vertical centers. Soon to join ICC are the 648-meter (2,126-foot) Ping An IFC and the 530-meter (1,739-foot) Chow Tai Fook (CTF) Center, both targeting LEED Gold certification for completion with the XRL launch in 2015. Principal James von Klemperer explains, "Office tenants in ICC in Hong Kong, Ping An in Shenzhen, and CTF in Guangzhou can move from floor to floor, from tower to tower, from region to region, without leaving one continuous physical network."

Vertical Transportation

With a projected daily occupancy of 30,000 workers and visitors, ICC is a virtual city within a city. To meet the challenge of moving this vast population through the tower, the Architects conceived the tower's internal circulation as a vertical extension of Kowloon Station. A multi-level lobby connecting the various transportation modes filters different user types and directs them to a system of local elevators and high-speed shuttles to sky lobbies for the upper office floors, observation gallery, and hotel (see Figure 2)

Commuters approaching by metro or Airport Express are led through the Elements shopping mall to arrive in the tower atrium, where a three-tier system of cascading escalators divides the office population evenly between local and shuttle elevators , upper deck and lower deck. ICC features the latest in elevator technology, including the world's first application of destination-dispatch, double-deck elevators. An integrated building operating system linking the turnstile smartcard reader to the dispatch system assigns commuters to the elevator that will transport them to their assigned floor in the shortest interval.

To address the tower's immense population and multiple functions, vehicular drop-offs are organized vertically in multiple layers. Buses and public vehicles enter at street level, while an elevated station perimeter road provides accesses to the different transport modes. Private vehicles ascend to the station roof, where an exclusive drop-off for the office anchor tenants and the Ritz-Carlton Hotel are sited on the promontory overlooking Victoria Harbor.

Vertical Phasing

The tower's vertical organization facilitated the construction of ICC in multiple stages. ICC is the largest project ever to be vertically phased. An image of the tower under construction shows the lower zones occupied, the middle zones enclosed for fit-out, and the upper floors still under construction (see Figure 3).

The multiple ground planes – street, podium roof, sky lobbies – provided the temporary work platforms that enabled this complex engineering feat to be undertaken by Sanfield, the construction subsidiary of Sun Hung Kai Properties. When the first tenants moved in, the south and west quadrants of the tower base were used as construction staging areas for the upper tower levels. Concrete trucks docked at a pumping station in what would later become the hotel lobby. Cranes lifted steel beams onto the future tenant drop-off directly from flat bed trucks idling at street level. Building maintenance units moved on temporary tracks at the sky lobby, to be lifted up and installed at the tower crown upon completion.

Delivering the project in phases provided the developer with early returns on investment. Also, timed release of smaller quantities of office space minimized the developer's risk of saturating the market. Critically, the first phase

Figure 4. Tower base

of the tower provided the initial pool of workers needed to populate and bring vitality to the KSD's public spaces and large retail mall.

Tower Design

KPF won the commission to design ICC through an invited competition in 2000. For the competition entry, a partnership was formed with Leslie E. Robertson Associates to create a tower form that would combine the best possible structure with the best possible floor plate. For instance, a tower geometry based on a circular floor plate would perform well in the wind, but would be undesirable to Hong Kong's financial tenants, who prefer the efficient layout of square floors. Conversely, a perfectly square floor plate would perform poorly in the wind and lead to an increase in steel and concrete – an unsustainable proposition. An analysis of preliminary wind tunnel studies indicated that a square with notched, or "re-entrant," corners would exhibit nearly the same wind response as that of a circle.

From this initial form, the massing was refined by gradually widening the re-entrant corners towards the top and inclining the upper third of the main façades by one degree to create the tower's elegant silhouette and improve its wind response. The tower's eight mega-columns splay out three degrees to widen the tower's dimension at its base, significantly reducing the tower's overturning moment, while providing longer clear spans for hotel and exhibition facilities.

The tower's chiseled façades give way to gently sloped curves at its base. These curves lift off from the structure as a cascade of overlapping shingles to create sheltering canopies for the office and hotel entrances on the three sides overlooking the harbor (see Figure 4). At the north, the façade sweeps down in a dramatic gesture towards the center of the Union Square development, enclosing the "dragon tail" atrium (see Figure 5). This atrium serves as the public face of the tower and the primary connection to the rail station.

The main façades are articulated as four planar elements extending partially beyond the re-entrant corners and rising above the tower roof as sheets of glass to form the tower crown. Initially designed as cantilevered curtain wall panels, the façade extensions later incorporated a triangular return to create enclosed bay windows at the corner offices to direct views of the harbor. At the tower base, the triangular returns split from the main façade to form distinctive markers framing the lobby entrances (see Figure 6).

Design Principal William Pedersen sculpted the tower's curtain wall into a series of overlapping panels, each one-story high, which he likened to shingles on a roof or the scales of a dragon. The shingled curtain wall generates a kaleidoscopic play of light and shadow, as it mirrors different parts of the sky, de-materializing the tower's immense mass while relating to the viewer through the repetition of tangible human-scale elements. Viewed from below, the serrated profile formed by the underside of the shingled panels gives the impression of the building skin breathing like a giant bellows. Combined with the curved lines of the dragon tail and canopies, the articulation of the façade provides a gentle lift as the tower just barely hovers above the podium promontory. It is at this moment, as the tall tower kisses the ground, that the expression of connectivity finds its poetic resolution.

Tower Façade

The architect collaborated with the façade engineers at ALT Cladding Consultants to break down the apparent complexity of the curtain wall system into a few highly repetitive components. Each shingled panel is rotated exactly five degrees with respect to the "smooth" geometric surface, yielding just three wall types consisting of 5, 6, and 8-degree panels from the base to the top. The catenary, or curve, of the dragon tail was approximated by three tangential arc segments of varying radii that, when subdivided, yielded panels of equal dimension which were similarly rotated five degrees from the defining geometry. According to Permasteelisa, who fabricated and installed the curtain wall, three-quarters of the total façade area was built up from only 134 panel types.

To create the shingled panels economically, KPF and ALT deviated from the conventional floor-to-floor unitized curtain wall. A hybrid system, derived from older window-wall systems, consists of 3-meter (10-foot) wide fixed spandrel units concealing the slab edge and perimeter beam, with 1.5-meter (5-foot) unitized vision "infill" panels slotted between spandrels above and below. Division of the

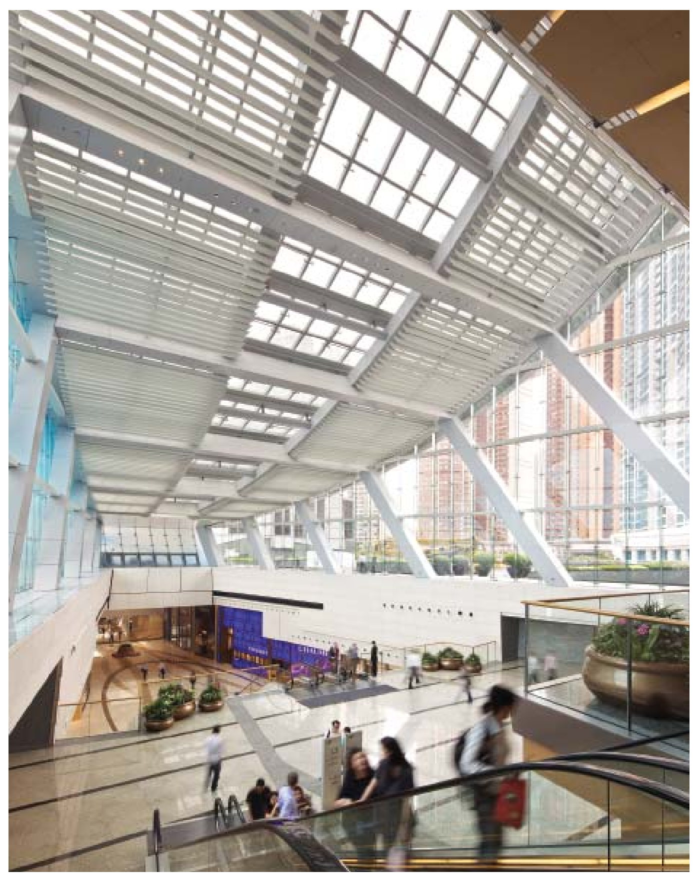

Figure 5. "Dragon tail" atrium

Figure 6. Main lobby

wall into separate vision and spandrel components eliminated the need for Z-shape panels, which would have been required had the system been fully unitized, and which would have created logistical difficulties in packing, transporting, hoisting, and installation.

The advantages of the hybrid system were fully realized during installation. The phased construction of the tower required large gaps in the façade around the staging floors, rendering it impractical to install the panels sequentially from the ground up, as with a conventional curtain wall. Since the spandrels and vision panels could be installed independently, Permasteelisa was able to work simultaneously at different levels of the building with multiple crews. And, when a certain tenant required an additional mechanical floor to suit their requirements, the vision infill panels were simply popped out and replaced with louvered infill panels.

Environmental Performance

The aesthetic appeal of the tower's external envelope is matched by its environmental performance. Sheathed in silver, low-emissivity insulating glass, the tower's single layer skin provides the maximum protection from solar heat gain while deploying a minimum amount of façade material. The silver coating has the unique quality of reflecting the heat-generating spectrum of sunlight (infrared, ultraviolet), while allowing the desirable visible light spectrum to transmit through the façade. The optical properties of the glass, supplied by Shanghai Yaohua Pilkington, include an emissivity rating of 0.15, a visible light transmission of 4%, and a shading coefficient of 0.27 – more than three times the protection of uncoated glass. Moreover, the shingled panels provide self-shading of the main façades, with horizontal baffles in the re-entrant corners providing additional shading of the façade.

In conjunction with the high-performance façade, ICC features the "Energy Optimizer" system developed with the Hong Kong Polytechnic University. Integrated sensors and energy consumption monitors analyze data for day-and-night and seasonal variations to provide a baseline for adjusting the building's HVAC system to reduce energy consumption. According to Sun Hung Kai Properties, ICC will be the first building equipped with the new technology, which is expected to reduce energy consumption by 15% compared with the average office building.

Dragon Tail

The dragon tail – the symbolic gesture of ICC's pairing with Kowloon Station – proved to be the most challenging aspect of the façade design by any reasonable measure (see Figure 7). Contoured to deflect the downdrafts generated by the tall tower and to shelter pedestrians from tropical rains, the dragon tail takes the brunt force of typhoons, which pass through Hong Kong regularly.

The challenge facing KPF and consulting engineers Ove Arup Partnership and J. Roger Preston was to give lightness to the structure and enclosure while addressing the wind and rain. The wind design load at the dragon tail reached 4.5 kpa – three times the force applied to "ultralight" structures in Europe. To comply with local building regulations, the canopies were required to collect all the rainwater streaming down the entire surface area of the tower's 480-meter (1,575-foot) high façades (see Figure 8).

In addressing the structure of the dragon tail, the Engineers orientated the vertical supports normal to the surface curvature to create the most direct load path for the wind force to the dragon tail foundation. These "leaning portals" are pulled together by segmented curved beams running the length of the dragon tail, forming a rigid frame that allowed the façades to float free of the structure to maximize transparency. To compound the challenge, the dragon tail crossed a major expansion joint running diagonally through the atrium (the location had been pre-determined as part of the station master plan prior to the design of

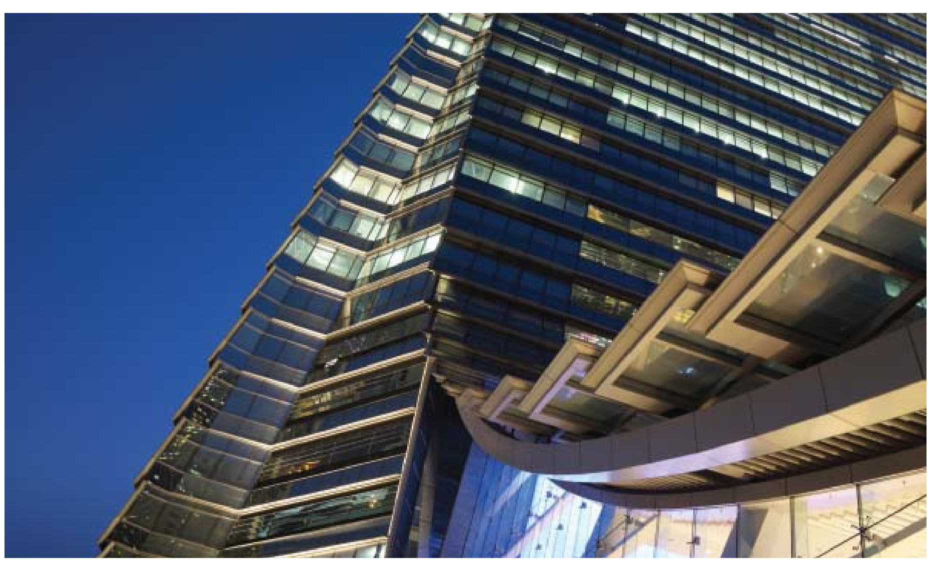

Figure 7. Façade detail

the tower). The Engineers devised a "floating slab" under the dragon tail that straddled the expansion joint, bridging the tower and station substructures.

The drainage of the dragon tail proved particularly complex. Due to its tapered geometry, the shingled roof was required to catch rainwater runoff from the wider tower façades. The architect devised a system of miniature gutters at the edges of each row of shingled panels, which feed into two concealed drain pipes running under the roof eaves to a catchment basin at the tip of the dragon tail. Water cascading down the middle of the dragon tail is allowed to flow directly to the catchment basin, which, remarkably, is cantilevered 12 meters (39 feet) towards the station plaza as the emphatic conclusion of the 484-meter (1,588-foot) tower.

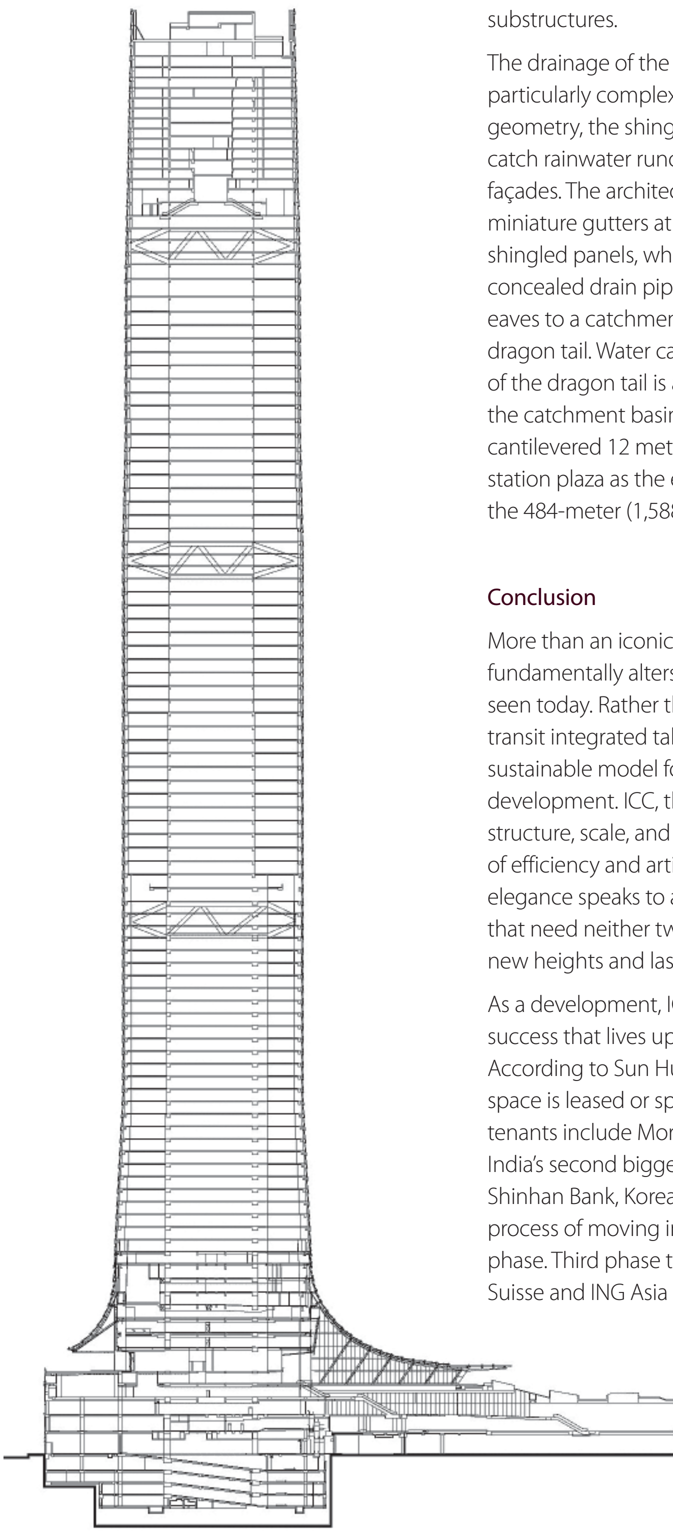

Figure 8. Overall section

Conclusion

More than an iconic statement, ICC fundamentally alters the way tall buildings are seen today. Rather than objects in isolation, transit integrated tall buildings represent a sustainable model for future high-rise development. ICC, through its economy of structure, scale, and form, achieves a balance of efficiency and artistry. Its understated elegance speaks to a future of tall buildings that need neither twist nor strain to achieve new heights and lasting relevance.

As a development, ICC is a strategic real estate success that lives up to the building's name. According to Sun Hung Kai, 90% of the office space is leased or spoken for. First phase tenants include Morgan Stanley and ICICI Bank, India's second biggest. Deutsche Bank and Shinhan Bank, Korea's largest, are in the process of moving into the tower's second phase. Third phase tenants include Credit Suisse and ING Asia Pacific. ■

Acknowledgements

ICC rises as a testament to the creative and dedicated effort of many individuals involved throughout the design and construction of the project: to the leadership at Sun Hung Kai Properties for their vision and support throughout the project, to their project team including N.H. Sitt, Augustine T.S. Lee, and David S.K. Chan who worked tirelessly to execute this vision, to William Pedersen and Paul Katz for their guidance and leadership; to the dedicated architects at Wong and Ouyang and KPF, and finally, to the workers who braved gravity and the elements.

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...eco-cities

"A lot of eco-cities are in the wrong place – where there is no water for instance. Find a place where you have water, and wind say, for energy and then plan."

Anne Kerr, Mott MacDonald, on leader on sustainable cities. From New Civil Engineer, July 15, 2010