A Systems Approach to Conceptual Design Solutions for a Very Tall Building in Hong Kong

by

Frank Wolfgang Ungerer

B.A.Hons. (Cantab), Architecture (1993)
M.Phil. (Cantab), International Relations (1995)

Submitted to the Department of Architecture and the Department of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degrees of Master of Architecture and Master of Science in Civil and Environmental Engineering at the Massachusetts Institute of Technology

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Thesis Supervisors:

William J. Mitchell
Dean, School of Architecture and Planning
Professor of Architecture and Media Arts and Sciences

Jerome J. Connor
Professor of Civil and Environmental Engineering
Thesis Supervisor

Thesis Readers:

John de Monchaux
Professor of Architecture and Urban Planning
Director, Special Program for Urban and Regional Studies in Developing Countries

Andrew Scott
Associate Professor of Architecture
EDUCATION & TRAINING

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, USA:

Candidate for M.Arch. (Master in Architecture) and Certificate of Urban Design.
Candidate for S.M.CEE (Master of Science in Civil & Environmental Engineering),

Emphasis on CAD/CAM Design, Urban Design & Planning, Strategic Management Is-
sues, IT. Courses taken at Sloan School of Management, Center for Real Estate, Harvard
Graduate School of Design. Joint-Degree Thesis: A Systems Approach to Conceptual
Design Solutions for a Very Tall Building in Hong Kong.

UNIVERSITY OF CAMBRIDGE (TRINITY COLLEGE), ENGLAND:

M.Phil. (Master of Philosophy) in International Relations. Oct. 1993 – Aug. 1994

TECHNICAL UNIVERSITY OF BERLIN, GERMANY:


EXPERIENCE


Activities & Skills

TA to Dean W. Mitchell & Prof. P. Testa (Graduate Level III Studio). MIT. Autumn 1997.

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A B S T R A C T

The thesis represents a design investigation that seeks to reconsider the high-rise building. With changing uses and technologies, high-rise office towers may have become obsolete. Given the recent capabilities for communications networking, the need for businesses to occupy exclusive-use buildings in central city locations may be questioned. Instead the mixed-use building type, often encountered in Southeast Asia, may point at a way of rethinking the typology of tall buildings as such. When taken to an extreme, mixed-use buildings could include use and occupation patterns as comprehensive as cities themselves. These would need to be supported by a skeletal structure of building systems that would include structural, transportation, service, climate control and inhabitation systems.

Amongst designers and engineers there exists much discussion about building ‘super-tall buildings’. Yet there may be a need for departing from the current type of central-core high-rise buildings. In this light the thesis proposes conceptual solutions for building systems that may provide for sustaining more than 122,000 people.

The idea is based on the concept of a triangulated mega-frame structure of roughly 49,700 sqm footprint that rises at a 1:5.5 aspect ratio to 1560m of height. The building is organized hierarchically in components of varying sizes. Interspersed between habitable modules are lobbies and spaces that act much like public places of a city. The basic module is an adaptable and suspended eight-story unit (pod). Clusters of 30 such pods, connected in pairs by common atria, form one planning unit of 242 m height. This unit is serviced by a centrally suspended structure which acts much as a public plaza/square. Five + of these planning units rise to make up the building. Woven into this assembly of modules, lobbies and plazas are vertical and horizontal connections, like streets. These again are hierarchically organized to provide for movement at different speeds and distances, much like horizontal streets or rail networks.

The result is a building that provides an intense concentration of resources and delivers a degree of control, connectivity and adaptability that could suggest an alternative form of thinking about growing cities under such dense urban conditions as are prevalent in Hong Kong.

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B.A.Hons. (Cantab), Architecture (1993)
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Submitted to the Department Architecture and the Department of Civil and Environmental Engineering on January 16, 1998 in Partial Fulfillment of the Requirements for the Degrees of Master of Architecture and Master of Science in Civil and Environmental Engineering

Thesis Supervisors:

William J. Mitchell
Dean, School of Architecture and Planning
Professor of Architecture and Media Arts and Sciences

Jerome J. Connor
Professor of Civil and Environmental Engineering
To my parents,

in love and gratitude

for all their support.
The compilation of this thesis increasingly revealed the complexity of the issue of building high. Given the focus I chose many issues were left to remain unresolved. Since the building grew from a range of baseline assumptions to the scale of an entire urban entity, aspects of social order and organization, of political representation and military vulnerability could have served to make investigations of equal significance in their own right. The thesis thus only manages to shed light on but a few issues that are part and parcel of such a complex project.

In fact, at times the project controlled me more than I could control it. Despite the many shortcomings in the attempt to investigate a topic that is so open ended and encompassing, I do hope it may be appreciated for however little it was able to achieve or suggest. In the least I hope the investigation may serve to inspire those who may come in touch with it, both for its outrageousness but also for those aspects that may have successfully managed to address some of the core issues at stake.

The thesis investigation was not able to extend in challenging the performance criteria, that ultimately determine so many design decisions along the way. Accordingly, much work would be required to adjust details to fulfill the requirements of such a complex structure.

Equally, some technological innovations were assumed that are not currently feasible or economically viable, such as the vertical shuttle system. The line between what has been previously applied and tested and what could conceivably be applied has intentionally been blurred at times. It is the great potential of a master's thesis, in my opinion, that it innovatively and creatively explores an area of controversy and of unestablished ground. I hope that this thesis lives up at least to this belief.
At this occasion I would like to extend my sincere gratitude to my advisors, William Mitchell and Jerome Connor for providing me with valuable guidance and inspiration in kindly granting me their trust to embark on such a controversial endeavour. Similarly, I would like to thank my readers John de Monchaux and Andrew Scott for their consistently helpful comments and well placed constructive criticism. It was a great privilege to draw from the experience and intellectual capacity of such knowledgable men.

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INTRODUCTION

When embarking on this thesis investigation, one of the major repeated questions that arose in the process was: why build tall? Why at a time when the leading country in tall buildings, birthplace of the modern skyscraper, has seized to pursue this trend? Development in the United States today seems to suggest decentralization and horizontal development. Few American downtowns have seen tall buildings constructed within the last ten years. Instead, the major tenants of tall buildings (corporations and large businesses) are establishing themselves at the fringes of cities, where land prices are lower and the opportunities for large business parks with recreational facilities a reality. Certainly this goes hand in hand with increasing networking capabilities that allow corporations to move to the outskirts of cities, while not suffering substantially from deficient communication. Does this mean the death of the tall building as been suggested by scholars? (see William J. Mitchell, Do We Still Need Skyscrapers?) Or does it simply put a question mark over the high-rise towers as we know them today?

(1) Corporate development trends, USA - Asia
“Cities are the principal localities and residences of man as a biological group. They are the coral colony for man as a social being. Is there any point here in positing an opposition between the country and the city? One can find much that is weak and dangerous about cities, one can take sides in the conflict of the impulses that are fermented in them; but one cannot dismiss or in any way assume to appraise cities themselves, the focal points of the human urge to live in societies.”

Alfred Döblin, in The Spirit of the Naturalistic Age (1924)

This thesis seeks to explore the tall building as a concept for urban habitation. This is done mainly through the lens of the systems necessary to meet the challenges to an arguably new building type: a building type emerging out of the legacy of tall buildings, but proposing a new signification for living and working in the vertical. The idea is to look at a mixed use tower that accommodates uses that can be found in an active urban context: work, residential, entertainment/exhibition, recreation, sports, retail, education, health care, administration, and manufacturing. Given the need to provide such diverse services in a town, the conceptual extension to providing them in a single building seem potentially logical. Whether or not this is feasible seems to be substantially conditioned by the kind and amount of infrastructure the building provides so as to make the various uses sustainable.

Moreover, a building of sufficient size is needed to accommodate all the spatial and technical requirements for such an organism. Accordingly, the aim was to investigate conceptionally the possibility of creating building systems that would provide responses to the most critical issues of building at great scale. They are influenced by characteristics, such as modularity, prefabrication, and environmental responsiveness.
The setting is Hong Kong. It was chosen for a number of reasons which will be dealt with in more detail later. Some of the prime characteristics of Hong Kong that support the proposal are:

- Significant population growth
- High urban densities
- Geographical constraints to urban growth
- Economic power
- Urban culture tall buildings

Certainly building vertical brings about an array of additional complications and costs in both investment and cultural terms. However, more than 70 percent of Hong Kong’s population lives in tall buildings (between 12 and 60 floors). Unlike in London, where building high requires considerable justification for its effect on the skyline and the image of the city (example: Canary Wharf), the condition in Hong Kong is almost reverse. The population density and the scarcity of developable land, as well as the prosperity of the past 20 years have made tall buildings not only a necessary solution to the immediate challenges of rapid growth and development, but, moreover, have provided the image of technological achievement. This is not unique to Hong Kong, but can be found throughout most fast developing countries.
The project proposes to provide living and working space for Hong Kong’s growing population. In this effort it is connected to existing development plans for the Chek Lap Kok Airport and its link to Hong Kong Central. The project relies on the transportation infrastructure that is put in place to connect the new airport and the business district of Hong Kong. Within this context, the project may be conceived of as a landmark project that would certainly have a significant impact on the appearance of the city. Yet, its design is not focused on its role as a landmark but evolves from with the complex relationships of occupation and movement. The main design generators have been the systems enabling and supporting the multiple building uses, suggesting an inside-out design approach.

The project is an experiment, a concept of a massive building, a city in the air, that has had eminent predecessors. From the visionaries in the early 1910’s, such as Richard Rummer's frontpiece of the King’s Views of New York album, or Auguste Perret’s ‘L’Avenue des maisons-tours’ of 1922, Jacques Carlu's project for a 600 meter government building in La Défense of 1943. Even movements such as Archigram in the UK (Peter Cook et al.) or the Metabolists in Japan (Isozaki et al.), not to overlook Frank Lloyd Wright with his Mile High design proposal for Illinois, or Norman Foster’s 800m Millennium Tower in Tokyo have all dealt with the fascination of the massive building, some accommodating entire urban entities. The issue of building to the limits of achievement has captivated man throughout history. Not only of biblical society, but until today the notion of building tall, very tall, still bears some fascination and abhorrence. As Daniel H. Burnham (see Lockwood, p.85), one of the 19th century’s high rise pioneers stated:

“Make no little plans; they have no magic to stir men's blood.”
(4) Richard Rummell's frontpiece of the King's Views of New York, 1908

(5) Auguste Perret's 'L'Avenue des maisons-tours', 1922
Academics are divided when determining the beginnings of tall buildings. From the pyramids, religious spires to the first multistory steel enforced buildings, the debate is split which buildings represent the precursors to the modern skyscraper. As a result it is not the intention to compile comprehensive account of the development of tall buildings in this paper, but rather to look at some of the strongest design generators that have determined use and size of tall building structures up to the end of this millennium.

It may be argued that in every period the perception of what represented a tall building was the result of a relative perspective to the height of existing structures. It follows that it is not absolute height that matters as much as the technological standard of the systems that allowed for a building to be constructed higher than other structures previously. It may be possible to identify a short list of primary systems that eventually led to buildings that could rise as high as the recently completed Patronas Towers (452 meters). These are:

- Structure & enclosure
- Vertical transport systems (elevators)
- Services and environmental systems

(6) Tall buildings in comparison
In this regard, it may be possible to mark a significant innovation in architecture and construction with William Le Baron Jenney's *Home Insurance Company Building* in Chicago, 1884–85. For the first time a building appeared that boasted both a metal structure and a mechanical elevator. The building is significant not for its tremendous height, but for making use of two technologies that were to enable buildings to grow, and to become increasingly light and mechanically accessible, even at higher altitudes. Not long afterwards, famous icons of 'tall office buildings', such as Burnham's 1905 Flatiron Building, emerged only to be dwarfed by Shreve, Lamb & Harmon's renown Empire State Building of 1931.

What led to such buildings may be too encompassing to find mention here. Suffice to say that construction technologies had to develop along with organizational techniques and the engineering skills to evaluate forces and material strengths in buildings. In fact, it was substantially the development and growing sophistication of emerging building systems that allowed to push the complexity of buildings higher and higher. This was greatly supported by an increasing capability to predict the performance and safety of the buildings for extreme conditions, such as 100-year-storms, earthquakes, typhoons etc. This led to a remarkable understanding of dealing with lateral loads (sway, torque), and developing frames capable of complex load distributions with ever greater precision. Still in the 1850's, Paxton's much famed Crystal Palace had to be tested in parts to determine the strength and durability of its components. The technique was rather humble and involved sending a company of military men across jacked-up beams (for equally distributed, dynamic loads). Today computer aided modeling tools allow for precise anticipation of component behavior and critical material failures. This technological leap substantially buttresses all of the developments in building tall to arrive at more daring gestures and more efficient systems.
(8) The 'Flatiron' Building
Paired with increasing predictability of building behavior was the ability to bring tall buildings closer to extreme performance. The major development involved using composite structures and assigning optimal behavior components to individual requirements. This meant that compressive and tensile combinations were explored that minimized the weight of buildings and the cubic volume of materials used. Today frame structure buildings are the norm, typically using rigid frame, rigid core, braced core, or rigid/braced frame tube technologies. The famous Hancock Tower in Chicago is a good example of a frame building for its explicitly expressed structure.

The so-called high-tech gestures of contemporary architects, such as Rogers, Grimshaw, Hopkins and Foster, are indicative of an extreme attitude towards emphasizing force distribution in architecture. The Hong Kong and Shanghai Bank represents one such example: The designer used a mega-structure as the building frame from which floor plates were hung. Similar to the Hancock Tower, the frame becomes an architectural devise which finds distinctive expression on the building envelope.

It can be argued that structural technologies and expertise have been developed to such an extent that stability presently does not represent a real limitation to building high. The same may be said for enclosure technologies that have become increasingly sophisticated, involving high capacity alloy metals for fixture components or composite (laminated) and hardened glass products, as well as cladding technologies that perform ever more reliable against corrosion and the danger of wind damage (suction/compression).

In comparison, the early facilitator to building vertically, the elevator, has not kept pace with the race to exceed the 500 meter barrier. With cable lengths exceeding 400 odd meters, natural sway occurs that transmits onto the passenger car and even onto a building's resistance to external sway (weight at building top).
Equally, mechanical systems for supporting and operating the dead load of cables becomes inefficient with increasing cable lengths. Ways have been found to circumvent the problem by introducing sky-lobbies at mid height where passengers transfer to regional elevator systems. The problem of excessive elevator travel lengths and of massively increased transportation footprints seemed somewhat resolved.

With view to these constraints, OTIS elevators is exploring alternative elevator systems that would be capable of serving the next generation of tall buildings, namely the 'super high-rise' buildings. For this, the 'Odyssey' system was developed to act as an integrated building transit system, handling both vertical and horizontal movement. The project represents an important innovation in how to perceive of a building’s internal movement patterns. This system, however remains based upon the conventional hoistway elevator with passenger cars moving independently between lifting mechanisms. Improvements were made to make passenger boarding and deboarding times more efficient and to allow for capacities of individual hoistways to be increased. Nevertheless, many limitations exist, some as a result of building on hoistway technologies, some due to human constraints to resist pressure differentials. This becomes an issue when elevator systems move vertically at great speed, in particular between sky lobbies. Nevertheless, even elevator systems are changing to live up to the changing requirements for moving people (and goods) within very tall structures. Maybe one day Frank Lloyd Wright’s image of independently motorized, five-story-high, atomic powered elevators may come true. Maybe. The vision though remains with us and has certainly influenced the transportation strategy proposed on the pages hereafter.

Given the increasing sophistication in perfecting structures (and transportation systems), modern high rise buildings still manage to display a remarkable ignorance with regard to two major conventions: the central core and artificial
climate control. Especially the 1970's office towers enjoyed the technical opportunities of large glass facades paired with wasteful mechanical systems and uninspiring floor plate designs. True, investor driven high rise buildings seek a maximum of rentable floor area and maximum efficiency in space distribution, with limited consideration to maintenance costs (as those will be paid for by tenants, anyway). The result is — with exceptions — that cities became littered with glass boxes, aquariums filled with lemon-scented air and inhabited by a population of workers. An image of the modern office environment has been represented ingeniously in Monty Python's film *The Meaning of Life*.

Only in recent years has this image of the insulated office box been challenged technically and stylistically. This change has come about through movements outside of high-rise architecture, movements that expressed an attitude to environmental responsiveness and responsibility. As a consequence, technological innovations within the building industry began to follow.

Sir Norman Foster's Commerz Bank tower in Frankfurt, Germany, is a good example of a tall building that very much revolutionizes the common perception of what and how a tall building can perform. The design displays a comprehensive approach to create a building that uses intelligent internal control systems and passive means to make more efficient use of weather, temperature and wind. The political climate and certain regulatory reasons may have forced the architect to look into environmental issues with greater care. Yet, the lessons that can be learned are multiple and point at the question how tall buildings can take advantage of control technologies paired with a changing attitude to energy and operation standards of modern high-rise buildings. That a building of this kind would go up in Germany is not surprising where critical voices condemning tall buildings are not easily overheard. The voices may be less loud in some of the developing countries in Asia. It is here that the issue of energy awareness is particularly urgent since it is here that the major portion of today's tall buildings goes up.
One thing that one can learn from looking at the legacy of tall buildings is that at any time the tallest buildings also represented the height of the technological possibilities. The tallest structures were much admired as they represented the ultimate in achievement. In the course of progress structures were built that made past achievements pale in comparison. But as the limits of technological achievement are pushed higher and higher and super-tall buildings seem a reality, the criteria for the relative advantages need to be redefined. In the future it may not outrage to see buildings climb a mile high. But the need has to be constituted for such buildings to fill a gap in human habitation that cannot be filled otherwise. Whether that gap will ever open up may be seen in the years and decades to come.

For now the an attempt will be to critically reconsider some major shortcomings of buildings as we know them today: Slabs vertically stacked, often repetitive, linked by services and unidimensional transport systems.
The initial design approach and resulting design strategy is based on a critique of a number of identified shortcomings of existing high-rise buildings. These shortcomings are as much limitators as they can be facilitators to alternative building forms and higher building structures. As was outlined in Chapter II., tall buildings have developed yet have remained within relatively similar development patterns for the last 60 years. In most designs studied, the central core plan is the predominant pattern for building high. Whatever the structural system, the decisive aspect is the common spatial arrangement of repetitive vertical stacking.

- Shortcomings of vertical stacking:

As much as it is appreciated that vertical buildings need to be stacked, the lack of horizontal relationships or cross relationships, however, is quite apparent. Given the high density of tall buildings, communication and connection seems an asset that, arguably, is not fully maximized in the common building arrangement.

Communication studies, such as Professor Tom Allen's studies of communication patterns in business environments at MIT's Sloan School of Management, have pointed at a phenomenon of communication barriers between vertically arranged groups and groups arranged horizontally. In fact the same departments when separated by a floor communicated less with one another than different departments on the same floor.

Without trying to get into the details of these studies, the interesting finding is that in order to make communication an asset in a tall building one has to rethink relative spatial arrangements, both of vertically separated spaces, but also of shared/meeting spaces. The proposed building takes this into consideration when arranging pod systems (and their physical connections) and when organizing them in a hierarchical system.
• Inefficiencies in core design:

   The second critique is directed against the conventional concept of the concentrated core. Apart from certain structural benefits, single-elevator hoist ways, as used in today's high-rise buildings, create considerable proportions of dead space within buildings. Typically very tall buildings (+200 floors) would need to assign on average 34%-43% of total floor area to building cores (this increases to 58%-73% at lower levels). This problem is further exacerbated when high intensity transportation requirements exist at top levels (such as viewing platforms etc.). The question becomes whether it makes sense to build so high with only 66%-57% of gross floor area available for rental.

   Over the years the provision of skylobbies has helped to make better use of core space. Yet the relative inflexibility and incapability to adapt to the fluctuating needs within the building persists.

• Exclusive use patterns:

   The third critique is directed at the pattern of occupation that exists in single use buildings. Particularly office buildings suffer from numerous endemic problems: high congestion at short peak periods (resulting in over-designed transportation systems), lack of heat/cool air distribution between occupied and unoccupied building parts (on/off extremes), wasted space provisions for parking, and insufficient supportive services (entertainment, sport etc.), amongst others. Particularly the first point seems to suggest that reducing commuting peaks may reduce the requirements for over-designed transportation means and may alleviate the need for peak/off peak parking provisions. Business commuting patterns are as much a
burden to public street networks as they are to transportation facilities in buildings. The objective is to reduce the effects of the ‘rush hour’ by co-locating residential and commercial uses as well as seems desirable. For this it is not sufficient to provide high-income dwelling units alone, but some degree of equilibrium needs to occur within the building to accommodate all income levels in proportion to the employment structure of the building.
To adequately understand the basis for proposing a very tall building it is important to be aware of the forces shaping Hong Kong at the present moment. The city is currently in the process of undertaking $21 billion worth of substantial infrastructure projects. These are mostly connected with the Airport Core Program. The program encompasses the new Chek Lap Kok airport off Lantau Island (with 33.9 million expected passengers upon opening in 1998, rising to 40.7 million in 2001), 35 km of new highways and railway lines, two large bridges (one of which supposedly is the largest rail/road suspension bridge in the world) and two crossings underneath Victoria Harbor, linking Kowloon and Hong Kong Island. In addition new railway stations at Tung Chung, Tsing Yi, Tai Kok Tsui, Kowloon and Hong Kong are planned. Both Hong Kong and Kowloon stations will be constructed within a development complex that includes a landmark tower of 400 m height each. (see Mass Transit Railway Corporation's *Building Hong Kong's Future* and Kosowatz, John J.) The result of such massive infrastructure investment is to equip Hong Kong for its role as a competitive economic center in Southeast Asia. The regional implications stretch far into Hong Kong's hinterland and enforce the city's powerful position within the Pearl River Delta and beyond.
Hong Kong's Recent Growth:

The scale and speed of the Airport Core Program can be appreciated when considering the massive growth Hong Kong has experienced in the past 50 years. The Hong Kong government issued a development master plan (Metroplan) for greater Hong Kong in 1990 where the need for expansion was identified and options presented.

- Population Growth

Due to massive immigration, Hong Kong's population quadrupled since 1945. Today about 6.3 million people live in Hong Kong. More than 4 million of which live in the Metro Area alone (comprising Hong Kong Island, Kowloon, New Kowloon and Tsuen Wan-Kwai Tsing). Hong Kong's overall population is meant to increase to 7.5-8.0 million within the next 15 years. This implies estimated land requirements of 900ha to 1,500ha. Infrastructure and major public facilities need to be constructed to support this population increase. (see Hong Kong Government, Planning Environment and Lands Branch. A Consultative Digest Territorial Development Strategy Review '96, p.1, 17) With such growth rates, Hong Kong easily qualifies as a member of a club of cities that the World Bank coined as Mega-Cities of 21st century. Together with neighboring Guandong region, Hong Kong's population is been estimated to reach 14 million.

(14) Hong Kong's population increase 1842 - 1995 (relative to land increase (perpendicular rising line))
• Geographical Constraints

Despite Hong Kong’s territorial size of 1,000 sqkm the actual Metro Area, occupies only around 200 sqkm (ca. 20%). Currently, 12% of Hong Kong’s territory is occupied by urban uses and special facilities. Within the Metro Area, this figure rises to roughly 45% or 86 sqkm (86,000 ha).

One difficulty Hong Kong always suffered from is the limitation of developable land due to severe geographic conditions. As can be seen in the photograph, only a limited strip of urbanized land frames Victoria harbor. As a result of this natural limitation, Hong Kong has continuously been reclaiming land to satisfy the requirements of its growing population.

With the building of the New Towns (a program initiated in 1972) a development has taken place to decentralize Hong Kong’s build-up to designated sites in the northerly New Territories. Nevertheless, still today about 80% of all jobs are located in the Metro Area. The New Town Program thus may have alleviated some of the problems arising from too high housing densities, yet, at the same time has created a commuter pattern and a resulting need for massive infrastructure projects. Comprehensive development approaches have supported the development of the New Towns (the ninth to be completed soon within the Airport Core Program) through a massive rail and road network.

(17) Urban development constraints & New Town developments towards the north
• Urban Conditions

Overall densities in the Metro Area currently lie at 480 persons/ha, however, extreme densities reach as high as 660 persons/ha (Mongkok, northeast of the project area). To deal with the high densities, the government has released a total of some 680ha for public and private housing developments between 1986 and 1996. Ever since on average 41,000 public and 31,000 private housing units went up annually (translating to about 200 units per day). The improvement in housing has been remarkable and 'inadequately housed families' have declined from 30% in 1986 to 9% in 1996. Still average waiting times for public housing lie at around 6.5 years with a sharp demand for moving into more modern and comfortable housing units. In this development, two points stand out:

(1) the demand for housing has increased with growing wealth, as young affluent families prefer to live in non-shared units (thus leaving the older generation behind), and
(2) the demand for housing has increased with rising demand for more per capita living space.

In past years housing construction had to satisfy the demands of new immigrant populations from China, and respond to a socially generated redistribution of housing units. For the next 8 years, the demand has been estimated to average 80,000 units annually (these projections were made by the Government’s Working Group on Housing Demand in July 1994).

Of the housing built in 1996, 39.3% was public rental housing, 23.3% subsidized sale flats, and 37.4% private permanent housing. Of the private new buildings completed in 1996, 42% were residential, 23% commercial, and 23% industrial (all figures from the Government Homepage).
Economic Power

Since the 1980's Hong Kong's population growth has largely translated to its economic prosperity. Given the favorable developments in South China ("Open Door Policy"), Hong Kong has managed to diversify its economic base from the secondary (manufacturing) to the tertiary sector (services). This has created a rapid boom in office construction and a rapid buildup of Hong Kong's central districts. It has also led to architectural icons such as Foster's Hong Kong and Shanghai Bank (1985) and I.M. Pei's Bank of China Tower (1989). External investments in Hong Kong were considerable, totalling $69.2 billion in 1994 alone. Hong Kong's GDP in 1994 was $130.6 billion, GNP $131.6. Per capita equivalents were GDP $21,640 and GDP $21,797. The result is the rise in spendable income on entertainment, living/rent and consumer items, amongst others. The increased purchasing power and the transition to a third sector economy provide a good base for a high-standard construction development and may well prove a necessary basis for the proposed project.

Equally, an active and strong construction sector seems to suggest sufficient investment capability and necessary demand. Construction activity in 1994 was estimated at 4.9% of total GDP ($6.4 billion) with an upward trend in 1995 – 1997 (all figures from the Government Homepage).
The proposal:

- Site Choice:

  The site chosen for the thesis proposal corresponds with the site of the existing Kowloon Station Development. The site itself has been created in the past years in the context of large scale land reclamation west of Kowloon (some 340 ha). The site is centrally located amidst major transportation links (road and rail) thus ensuring intense accessibility. Both the Airport Express Line and the Lantau Line pass through the site. Estimated travel times to the airport is 20 minutes and to Hong Kong, 3 minutes. In addition, the newly built West Kowloon Expressway (passing through the third harbor crossing) is adjacent to the site (westwards). The streets north and south of the site reconnect to Kowloon's existing street network. Accordingly, the site is at a node point and provides for the characteristics that would support intense development.

  Another significant feature of the site is its spectacular views onto Hong Kong Island. Equally the proximity to Kowloon's commercial district provides for opportunities. Since the site is as yet unrestricted by existing structures, other than the infrastructure lines, the planning basis arguably offers tremendous potential for an urban project implementation. Objectives are ambitious to use the potential of the land and the site to give Kowloon (itself notoriously overcrowded) a recreation zone embellished with modern and up-market facilities. Provisions are under way to make the heart piece, the Kowloon Station Development, a "clean, well-planned and balanced residential and commercial focus" (see Mass Transit Corporation's Building Hong Kong's Future, p.18).

For information about existing development strategies, consult Appendix 1: Support Documents.
Following a preliminary study of the site, subsoil conditions seem to support tall (heavy) structures. Following a study by Ove Arup & Partners (see Terry Farrell & Partners' Kowloon Station Development, section 3.2.2.) superficial deposits consist primarily of sand fill. Natural soils left in place during dredging works consists of marine and alluvial sands and clays. Below this layer, completely or highly decomposed granites. The deepest zone of weathering runs from northwest to southeast. The depth of grade II bedrock (suitable for the existing proposal of a 400m landmark tower) lies at around 22 meters below grade. Since underground trenches run through the bedrock, more investigation and study would be required.
Current Proposal:

The objective of the current development proposal is to develop 1.09 million sqm of fully integrated residential, office, retail and hotel facilities. Over a site area of almost 14 ha, the following structures are planned:

- 18 residential towers with 5,125 units of 102 sqm average.
- Three office towers totaling 264,450 sqm of floor space.
- 80,000 sqm of retail space (accommodated in a two level podium structure) with additional 9,550 sqm of ancillary retail space.
- Four deluxe hotels/serviced apartments, providing around 2,400 rooms.
- Transport Interchange for public buses, taxis etc.
- More than 6,000 car parking spaces.
- Extensive open spaces (private & public) with neighborhood community facilities.

The development period is 12 years. The entire development is conceived of as a distinct residential community and a new quality office location. (see Mass Transit Corporation's Building Hong Kong's Future, pp.16-21)
(23) Kowloon Station Development
In concluding this brief account of Hong Kong's dynamic development efforts, one is left with predictions for growth and expansion that, despite the recent economic set-backs, will continue to make Hong Kong an significant place for building activity and large scale investments. Growing population and growing prosperity create demand for improved urban conditions and new space provisions, accompanied by modern conveniences, comfort and safety. In this climate, the proposed thesis project takes urban development to another extreme by acknowledging the potential for high intensity development within the Metro Area. It is not the aim to explore the most viable solution for urban development or study the viability of building a very tall building on the selected site. The proposal rather argues conceptually for the qualities of density within the present supportive conditions of urban expansion.

Against this background, this paper sets up a framework for development by proposing an extreme building type: a nearly self-contained city within one tower.
In order to constrain the scope of the thesis investigation, it was necessary to rely on a number of assumptions. However, it is appreciated that all assumptions do deserve consideration and require critical evaluation. The primary assumptions are as outlined:

- Continuing expansion well into the next century is anticipated and need for habitable space is acute. Accordingly, the Metroplan provides for 80,000 units annually of new housing. It is assumed that this trend will continue and that the recent Asian crisis will not substantially impact the midterm development of Hong Kong. The proximity to the Pearl River Delta points at economic and social activity which will continue to affect Hong Kong’s growth and future development.

- The building is expected to perform economically with regard to real estate returns, taxation etc. However, it is similarly believed that the building may not be fully economically supportable at the beginning. Instead political backing (such as limiting development in other places) is required. It is assumed that political decisions in favor of the proposed development are made and that the government uses direct and indirect measures to support the building within reasonable limitations. Market forces are not barred from challenging the project to succeed. However, to find investors and to ensure a successful jump-start, political support is crucial to reduce overall risks.

- The current height limit of 400m (due to aviation requirements for the airport) does not apply. Redefining the flight channels for approaching/departing planes represents a viable option.

- It is assumed that the Metroplan strategy of gradually reducing densities in the Metro Area was chosen for it represents a viable option at present. The New Terri-
tories still have land fit for urbanization and this trend may continue for some while. At the same time it is believed that urban sprawl will increase commuting times which in return may challenge this development strategy. The underlying assumption is that most of the activities (at least in the service sector) will remain concentrated in the Metro Area. This is a result of the business culture in Hong Kong.

- Motorization will be a growing problem for the city as a whole. Despite a policy of expanding public transportation into the new development areas, an increase in motor vehicles will be unavoidable, thus adding further burdens on commuter traffic and on infrastructural requirements (particularly for central district areas). This will bring along costs (financial and time) for commuters and for the government. The development will lead to a reevaluation of centrality and relative location. If commuting can be reduced and work and residential zones connected, it is believed that this may present an option over congested transportation lines. Comparisons may be drawn for cases of opposite extremes: Bangkok and Tokyo. In both cases transportation and relative location have developed to burden individuals as well as the economy as a whole.

- Services for supporting an increased population of 122,000 on the specified site are ensured, especially as the infrastructure for the West Kowloon reclamation has yet to be put in place. This allows to plan for increased provision of services and utilities beforehand.

- The Airport Express rail line is compatible (in parts at least) with cargo carriers. As a result supplies can be delivered to the building and waste can be collected.

- It is assumed that podium conditions are largely separated from the system investigation of the building itself. Nevertheless, the Podium represents an interchange
node for passengers and goods arriving/departing by rail or motor vehicle. For passengers or limited goods arriving by helicopter a Heliport at roof level acts as the node to the building transportation system. It is assumed that the podium and heliport provide for sufficient capabilities to adequately serve their functions (operationally and with increasing passenger/goods capacities).

- It is assumed that foundation design is separated from the systems approach. The foundations and the soil conditions support the structure fully and do not need further exploration in the framework of this investigation.

- Finally, compatibility exists between the main transportation unit (the capsule) of the building and standard shipping containers, pallets etc.).
Systems Design:

As a response to some of the most urgent shortcomings of conventional tall buildings, the design proposal chose to explore a set of systems that would possibly offer an alternative framework for responding to the most crucial functional and structural requirements of a very tall building. As a consequence, the primary design investigation occurred around a skeleton of core functional requirements. In rather general terms, the organizational framework is characterized by:

- modularity,
- hierarchical assembly and composition,
- flexibility and
- system component exchangeability.

The systems approach is dependent on a contextual framework which is determined by the site context, service compatibilities, overall building aesthetics & image, and practicality & efficiency.
• Site Response:

The proposed building occupies the designated station development site. Of the available site area of 139,600 sqm, the building footprint occupies around 49,700 sqm (around 35% of total site area). This does not include the podium, which essentially covers the whole site (similar to the existing development proposal).

The proposed building needs to be understood as a product of the larger metropolitan conditions. It takes into consideration the strategic advantages of the upgrade that is occurring with the construction of the railway and road corridor in West Kowloon. The proposal acknowledges Hong Kong's need for expansion and seeks to provide use and space allocations in approximate accordance with the strategic guidelines as set out in Hong Kong's Metroplan. However, the building does not attempt to offer an alternative to the urban buildup by way of dispersed, decentralized development (as is suggested by the Metroplan). Instead, it seeks to intensify the existing Kowloon Station Development proposal of 1,090,026 sqm by a factor of about 3 (to a total gross floor area of ca. 3,320,800 sqm). This seems feasible only if the building does not negatively impact the transportation infrastructure of West Kowloon. To achieve this, emphasis is laid on the use of mass transportation means. Accordingly, parking provision is restricted to 11,000 cars (of which 5,000 will be accommodated in the deep-plan lower pods and 6,000 in the podium structure) as opposed to a typical amount of 18,000 cars (1 car per 6.3 persons).
Services & Compatibilities:

There is a need to create a service interface at Podium level so as to establish compatibilities between commonly used service infrastructure (cars, rail etc.) and the building services. The latter are designed for performance in the building. However, compatibility with standard cargo and other freight deliveries is seen necessary for successfully operating the two in parallel.

Access and servicing of the proposed building is largely supported by the planned rail line that traverses the site (north-south). Equally the street network feeds the site and enters the lower levels of the podium at multiple points. One of the greatest amended requirements to existing services is to design for cargo transport capabilities to Kowloon station for deliveries and supplies. This involves a loading and unloading platform both underneath the building and at a remote location, possibly outside the metro area and in proximity to a road system/harbor loading facility.

Also, given the scale of the proposal, additional utilities for water, sewage, electricity and telecommunications need to be planned for. This may well involve separate waste water treatment plants, additional high voltage power supplies etc. The increased need for utilities is expected to be proportionally higher than for transportation upgrades. This is largely a consequence of the relative autonomy of the building. The building is designed to operate partially as a self-supportive unit. As a result, a 60% in-house occupancy rate has been targeted (60% of adult residents/households work or remain within the building for most of their affairs). Nevertheless, the proportion of outsiders coming in to the building for work/other business and affairs is considerable and is estimated to lie at around 71,000/day (58.5%).
• Aesthetics & Image:

Aesthetics and image go hand in hand. The pronounced structure lends itself to an imagery that suggests technological achievement. However, it is not a design criterion to celebrate technology for its own sake, but to allow the building’s functions (sun shades, air ducts etc.), organizational devices (pods, bridges, atria etc.), and structure (supercolumns) to express the building’s architectural components. Throughout the design, the systems are displayed in their organizational composition. The structure is expressed externally and internally. A limited vocabulary of colors and materials was chosen (aluminum cladding for its practicality and resistance to weathering) and tinted green glass. The potential for monotony is offset by the plasticity of the building surface that is expected to perform well with changing light conditions.

An important feature of the building’s dynamic appearance is the explicit display of the mechanical systems. It is intended that the building comes alive with use. Horizontally moving capsules will be seen from outside (or inside), external sun shades move and change angles as the day progresses, internal balconies get greened, occupied and inhabited. The transformation of the skin will lend the building an almost robotically animated image. Thus there exists a notion of an ‘aesthetic of the machine’, which is more pronounced on the exterior where the facade represents a functional interface between different climate conditions. In contrast, the interior is rather more ‘humanized’, ‘messy’ and appropriated by the occupants.

The triangulated plan shape stems largely from structural considerations, yet is intended to make the building appear iconic when seen from different angles. A comparison to the drama of the Flatiron’s sharp corner condition may be suggested. Also, despite its overall size, a 5.0 aspect ratio could make the building look bulky. However, given the fleeting perspective of the building’s sides (except when viewed perpendicular to any of the three sides) it is expected that the relative perception of volume to height is supported quite favorably.
Practicality & Efficiency:

An important aspect of a tall building’s efficiency is its ‘sway factor’ (usually 1:600). Wind is the predominant force that will affect the building’s requirement for stability. Especially typhoon winds are a consideration reaching speeds well over 250 km/h at top levels. Accordingly, it must be an objective to design the building so that it lends itself to a complex transfer of cumulative live loads through the structural frame.

For that reason a triangulated mega-frame structure was chosen. It acts like a vertical truss. It is extremely stiff and performs well in twist/torque and sway. Tests would have to confirm exact dimensions of the structural members. The design objective was to propose a complex, reinforced frame structure that extends to accommodate three separate towers (initial design approach). With increasing design development the three towers eventually became integrated to perform as one system. This was deemed necessary to fulfill structural efficiency requirements.

Equally, the transportation system needs to be reconsidered to provide for enough capacity to move an estimated 10% of total occupants (12,200) around the building at any moment in time (estimated extremes). By omitting the notion of a central core, movement becomes more dispersed and hierarchically broken down. As a consequence, a system is being proposed that seeks to organize transportation much along the lines of public horizontal transportation. This fundamentally changes the conception of movement through the building and requires for users to think of transportation as they would of urban multiple-user or mass transit systems. The resulting transportation system is intelligently controlled and operates flexibly to provide for fluctuations in the building’s use patterns.
The design intends to relieve the overall passenger loads by introducing three distinct scales at which transportation systems prove most convenient and efficient. At the largest scale, the use of motorized shuttles on a vertical track system for long distance connections (stops every 45 floors only) introduces a flexibility which allows to reduce relative space allocation for vertical movement dramatically and increases travel speeds. Through an interchangeable capsule unit (capacity 30 persons), a link with the intermediary scale system (stops every 9 floors) is ensured. At lowest scale, conventional elevators move passengers between individual floor levels.
- Building Form (plan)

The first step in the process of reconsidering the building form was to use the central core building as a point of departure and to strip the floor plates from the core. By angling the half-floor plates at 60°, light can enter from both sides (especially since the glass to glass distance has been reduced significantly). At the same time they can be serviced by a relocated and resized common vertical spine (former core).

The spine may have a shared space/lobby added to it. Together the building assumes a v-shape configuration with added exposure to natural light, a common spine shared amenities (at the tip).

When multiplied this v-shaped unit extends to form an equal lateral triangle. Since the central space (central core) requires some form of lighting, the three v-shapes were exploded, allowing light to enter from the sides. When multiplied, the triangular building configuration could possibly extend and form a hybrid pattern. However this proliferation was not explored in further detail.
Building Composition

Instead the triangulated configuration was at first conceived of as three distinct towers that were structurally and spatially connected at different heights. It was at first considered leaving the central core open and using the wind for natural cooling. However, with high wind speeds, fixtures and building enclosures would have had to withstand tremendous pressure/suction. At the same time the central core would have become uninhabitable, leaving the building with a tremendous exterior surface area. Eventually the core was enclosed with controlled louver openings to allow for natural airflow.

As the design development progressed, the towers became increasingly integrated to form one unified building. Equally, the towers became structurally more expressed to create a mega-frame that would be structurally capable of resisting unequal lateral load application.
Plan geometry
• Structure:

The structural members are largely exposed and contribute to the building's character and appearance. The structure is highly hierarchical so as to minimize weight and make selective use of compressional and tensional qualities of the individual components.

Of all requirements to the overall building structure, the response to lateral forces represent one of the greatest challenges. With maximum wind speeds of around 250km/h, the forces that affect the building are considerable. Lateral forces of more than 6.3 KPa have to be transferred through the building frame. At the same time, building sway needs to be minimized for guaranteeing use comfort (maximum permissible sway factor should lie below the standard ratio of 1:600 (2.3m); see Neufert p.302). Mixed use buildings provide particularly stringent requirements for controlling building sway as the levels of comfort vary greatly between commercial and residential use. Since luxury condominium units sell very well at top levels, real estate considerations make it almost an imperative to provide a minimum of sway throughout the entire building. This means that the structure needs to be stiffer and — in most cases — larger.

In order to counteract shear sway (horizontal displacement of the mega-frame), the triangulated form of the mega-frame is composed of laterally stiffened supercolumns. They act as vertical trusses in their own right and provide both vertical and to some extent lateral stiffening. The supercolumns are constructed using 3m diameter steel tubes with reinforced concrete filling. The vertical tubes are connected by horizontal and diagonal cross bracing. Two sets of triangular vertical tubes compose one supercolumn frame.
The total footprint of every supercolumn is around 250 sqm and large enough to accommodate the pod-specific services: emergency stairs, four conventional cable elevators (4 sqm each), drainage, electricity, telecommunications wiring etc. The supercolumns also support the pods via two supertrusses spanning 42m in length. On the exterior they are clad for protection from weathering and can simultaneously act as reflectors for the pods and light wells.
Emergency stairs

Two-level walkway
(track above, pedestrian below)

Cross bracing

Utilities

Local elevator

Balconies towards central core

Supercolumn integrated services
Arrangement of supercolumns and lateral stiffeners
Lateral stiffener:

1. section of supercolumn with socket
2. pin
3. tensile cables

(works both in compression and tension)
The columns are connected by stiffeners at every 9 levels and by plaza platforms at every 45 levels. Horizontally the columns are connected to one another through the supertrusses and through a cross-bracing structure spanning a 52m gap that allows light (and air) to enter the central core of the building. Due to the height of the building, the central core is lit exclusively from these openings ('light wells') and from any light that filters through the atria or the pods. For this reason the dimension is quite considerable.

Apart from the need to glaze such large openings (with an outward curving enclosure for additional pressure resistance), it was necessary to connect the atrium-pod units horizontally with structural bracing. This happens over eight floors. Between each 8-floor glazing unit, two-level bridges are suspended. They provide for pedestrian and capsule movement between the atria (lower level). The support structures for the glazing (1632 sqm per unit) functions both as cross bracing between the two adjacent supercolumns as well as a major support to the glazing mullions and the bridges. As a result of these requirements, a double-curved structure was designed that stiffens the total building frame and also supports itself against horizontal deformation.
Single curved tubular bracing member
Compression Pin
Tensile cables

Light well: prior to bridge, bracing and glazing.

Crossbracing structure & structure with frame

Bridge suspension support

Window frame structure
Person

Light well: crossbracing and glazing/bridge support structure
Habitation Systems:

There exist three main habitation systems that are organized hierarchically within the mega-frame structure. They accommodate the space for the multiple building uses and internal activities of the occupants. Comprised they represent the main rentable floor area.

Pods:

As mentioned earlier, the pod is the basic system of inhabitation. Since it is repeated 162 times throughout the building it needs to accommodate most of the building's prime uses. As a result a 1.5 m grid was selected for its great versatility (for office, residential and hotel/institutional uses). The standard pod is an 8-floor unit with net floor plates of 40.5m x 24 (26m with balconies) and 4m floor-to-floor height. Each floor plate has two distinct sides. The outer side is composed of a double skin facade that acts as a climatic zone for heat insulation, ventilation and shading/surface cooling (see pages 79–81). The internal facade is made of conventional glass enclosure components. The facade is arranged in a staggered way to provide for balconies etc. towards the central core. The configuration of this facade can vary depending on the uses and on the owner and may come to life as the building becomes inhabited. It is believed that a vital part of providing a successful basic system is to allow it to be adaptable to changing uses and changing tastes. The main point being that the building should adopt an urbane quality around the central core, especially as designs for the internal facades are not as restricted by functional requirements as is the case for the external building skin.
Internal Facade
At the building base the pods are enlarged (up to triple the regular size) and taper upwards. The main reason is the provision of deep floor space to accommodate parking facilities, storage, and light industries. Secondary effects may lead to a distribution of downwards air movement, thus reducing wind turbulence at podium level.

Support cranes          Entrance Canopy          Tapering pod (40.5 x 74m at bottom level)

![Building image and diagram](image-url)
Pods are generally supported by two serviced supercolumns and are suspended from two super trusses. With a vertical depth of 8m the supertrusses accommodate the pod-specific mechanical equipment and the horizontal movement corridor (which eventually leads into the two-level bridges). Pods hang from eight central suspension members off the trusses. The internal obstruction is limited to four suspension members of roughly 1m diameter each. As a result of suspending the pods, the use of light weight materials is crucial. Therefore each floor is a composite frame system of steel beams, tubular supports and tensile cables. The frames are then covered with corrugated metal and layered with a screed. A raised internal flooring system allows for services to be distributed as needed (see p. 61).

The idea behind the composite design of the floor systems is that they perform as horizontal trusses to resist the lateral wind forces (again, in suction and compression), especially since the floors are suspended they are not supported against lateral forces in the central portion. Accordingly it was considered more efficient to compose a floor frame with compressive and tensile components rather than rely on the stiffness of a thick, reinforced concrete slab. Each floor systems is connected at the ends to a supercolumn. The design therefore tries to distribute the forces to the supercolumns with minimal deflection of the pod shell.

The shape of the floor frames (of the beams) is curved downwards, approximating the moment diagram. This minimizes materials and weight. Accordingly the floor to ceiling height varies with the curvature of the ceiling. The frame tapers to the outer edge of the pods, thus raising the ceiling to around 3.2m. This allows light to enter deeper into the center of the pods and reduces the need for extensive artificial lighting. In addition a doubly curved light reflector is installed on the inside facade of the external wall, that throws light up against the ceiling and thus, through multiple light refractions, provides for greater natural light gain. At the same time the ceiling curvature facilitates used air to flow out of the internal spaces.
Screed reinforcement
Curved beam
Tensile supports
Under-floor ducting and services
Floor frame (1 & 2) - raw, w/ corrugated decking
Floor frame (3&4) - w/ screed, w/ raised flooring & services
to either the cavity between internal and external skin, or, on the internal building side, to flow into the central core. Stack effect further accelerates the air movement (as will be described in greater detail below).

As shown, a typical pod floor was tested for its suitability to provide minimal (low income) housing. It was considered that office divisions would not probe the dimensions of the pod floor plates. Even though the floor plate measures only 24 (26m) in width — a size which seems convenient for large scale offices, public halls etc. — fitting minimal residential units (31.5 sqm) onto it resulted in units of only 3m width (below). The proportions are not ideal, yet with internal windows seem acceptable, given Hong Kong's tight housing standards. The next larger unit (50.6 sqm), with a width of 4.5m (above) seems much more agreeable. To introduce light into the depth of the unit, an internal balcony was carved out that would be shared by two units (with possibility of glass divisions for privacy). The enlarged surface of the unit facade provides greater exposure to light and may provide for an attractive, versatile space. The balcony is still within the outer skin of the double skin facade and is thus protected from winds etc. The units on the inward facing half of the pods may suffer from need for better lighting. Especially the units closest to the atria and nearest under a plaza level will suffer to some extent. To alleviate the problem, the emergency stairs (on the inner sides of the supercolumn) are fully glazed so as to allow light to filter through to the units (see page 50, nr. 4).
Atria:

As the central elevator core dissolved, new space around the transportation lines became the atria: tall open spaces with six suspended levels for meeting rooms, day care facilities, cafeterias, even health care units etc. Around 25%-30% of the 1830 sqm atrium was intended to accommodate gardens (for recreational value to the occupants of the two adjacent pods).

Every pod is connected at one end with an atrium. One atrium and two pods form a local unit, a ‘neighborhood’. The atria are essentially 9-floor units (two floor levels: lower level for mechanical and horizontal transportation transfer node; upper level as main lobby to the two pods) at the corners of the triangular building. They are wide, open and brightly lit spaces. Structurally they function almost as triangular vertical trusses. Supported by two supercolumns at the far ends and a hybrid-column towards the outwards tip, the atrium horizontally connects the supercolumns and provides for a stiffened and cross braced edge condition. This is important, since it is expected that the three edges of the building will be exposed to particularly severe torque and bending stresses. For that reason they have been stiffened and horizontally braced. The cross-braced pattern at the very tips performs against bending and torque in two directions. At the same time it defuses the corners with regard to (very basic) Fung Shui principles (to dampen the aggressive, cutting characteristics of the corners).

The atria all have two main levels. The lower level accommodates mechanical equipment and a departure/arrival platform for horizontally moving capsules. The platform is reached via a set of escalators from the upper atrium level (the main lobby level). Apart from the horizontal movement system, the lower level accommodates emergency equipment and various mechanical equipment (air handling units, intermediary water storage etc.). The upper level is the main arrival level for the regional vertical transportation system. The lobby may also be the
arrival lounge for a hotel or a corporate tenant, if they occupy at least the two adjacent pods. Its use and fittings are adaptable to the use and occupation of the adjacent pods. The main feature is the public character of the atrium as a 'neighborhood square'. For that reason it is encouraged that the suspended levels support public activity in the atria and reinforce the distribution of shared social or communal amenities.
Atrium lobby (seen from the footbridge of the 6th floor)

Regional elevator within the atrium on the left; further to the left a shuttle can be seen (outside of atrium)

Transfer platform for horizontal capsule can be seen on lower level (center), accessible by escalators
Plazas:

The next organizational unit is a cluster of five levels of 8-floor pods and atria to form one regional unit rising 45 floors (see p. 63). These regional units are services by a large 23,500 sqm plaza platform. Its suspended size (spanning up to 138 m) is the equivalent of almost 4.5 football fields. Its structural depth is large enough to accommodate two separate floors (mechanical/refuge & storage/facilities).

The plaza is the main public unit in the building. It can be compared with a large public square. Each one of the five suspended plazas accommodates general recreational amenities, such as lawns and trees, as well as particular uses, much like social centers in a city. Specialized functions include sports facilities (swimming pools, tennis courts, running track, squash/volleyball/badminton courts etc.), retail (department stores, cafes, boutiques, service centers, specialty stores etc.), entertainment (cinemas, theaters, concert halls, restaurants, discos, a convention center, broadcasting studios etc.), and helicopter services (storage and typhoon shelter of a helicopter fleet, terminals, lounges, technical services etc.).

Each plaza level is surrounded by six pods of five floors each (5m floor-to-floor height), accommodating services such as libraries, museums, exhibition centers, schools, possibly even a small university or higher training institution etc. The main plaza levels extend across the entire building plan (not just between the inner walls of the surrounding pods) thus giving them a spacious atmosphere. The views should contribute to make them bright and exquisite spaces. Some plaza levels have extra floors in central locations for up to three levels of stores and retail. All plazas are open towards the next higher plaza level (200 m above). This height is deemed necessary for two reasons: (1) the critical occupant mass for the services provided is estimated between 20,000 and 30,000 (corresponding to small towns), (2) the plazas must be spaced so as to allow sufficient light to enter the central core.
Since every plaza structure itself acts as a large scale lateral stiffener, the structural complexity of suspending such big structures from the supercolumns adds to the overall performance of the mega-frame. Nevertheless, at intervals of every pod-level, additional pin-stiffeners were added to give further stability (see pp. 43, 52 & 69 (D)). Equally it is expected that they provide for sufficiently dramatic objects in the central core space.
Top plaza level: helicopter port and communications equipment
A: Space for flight control equipment (radars etc.)
B: Main landing field for helicopters
C: Moveable helicopter platforms (to bring helicopters under neath main landing level for service, shelter etc.)
D: Lateral stiffeners
E: Windshield at plaza level
Transportation:

The greatest requirement for the transportation systems is ensuring the capacity and the adaptability to handle the loads prescribed by the building. This includes passengers as well as goods that need to be delivered to retail areas, hospitals, restaurants etc.

For the primary system a vertical track technology was chosen. Double decked shuttles run up and down the tracks, powered by linear induction motors or other compatible technologies. The shuttles represent the fastest transportation system in the building. Accordingly they only stop at the 5 plaza levels and the podium. The shuttles have the capability of loading and unloading two capsules at once. This saves time, as boarding and deboarding do not require the shuttle to be available during these periods. Instead people could board, similar to an airport shuttle, and await departure. During a brief waiting period the capsule could be pressurized to allow traveling at greater speeds. Typically speeds do not exceed 8 m/s (meters/second). However jets climb at rates of 15-20 m/s. It is conceivable that shuttles could reach similar climbing speeds, but may need to descend at slower rates since natural pressure equalization is more uncomfortable during downward movement - if capsules are not pre-pressurized for express routes of more than 2–3 plaza intervals.
Diagram of shuttle, regional (hoist) elevator and horizontal track interchange node at plaza level
At plaza levels, the lower capsules could be transferred to the regional transportation system (serving 5 atria). The regional system would stop only at atrium levels. From there capsules would move either vertically via a cable operated lifting mechanism or horizontally to any other atrium at the same level. The vertical lifting mechanism simply attaches to the capsule and moves it upwards.

An option is that the upper level capsule (at main plaza level) would correspond to conventional elevator transportation and passengers would simply deboard at grade (no capsule exchange). If the capsule is delivered at the lower level, it could transfer to the horizontal track system. Once lifted/lowered to the atria, passengers would be required to transfer to local elevator systems (accommodated in the supercolumns) to arrive at their final destinations (if these are located in the pods). Additional cable operated elevators depart from the upper level of the atrium level to service the suspended levels with common amenities (see p. 64).
Due to the hierarchical organization of transportation, it would be possible to move through the entire building only using the local elevators (unless privacy issues would restrict access, such as single ownership of entire pods etc.). In other words, there are multiple ways of moving through the building. This would ensure a degree of flexibility that is desirable. Especially the track systems allows for substantial capacities.

Diagrammatically the connections within one regional unit (five levels of pods in-between two plaza levels) can be represented as is shown on the right. The triangular floorplan was folded out and is represented in elevation. In tables 1–6 the hierarchical arrangement of the varying transport systems is shown. At the same time the respective connection nodes are illustrated to give a better understanding of the connections in all three dimensions. This is deemed particularly important as connectivity and ease of access is one of the supporting qualities of a tall building.
3 - Connections between atriums (for capsules)

4 - Connections between atriums and pods (for pedestrians)

5 - Local Connections (via atrium bridges)

6 - Vertical emergency connections (emergency stairs) and collection spaces at plaza levels.
Given that the system's capacity is aimed at handling 10% of the building's occupants at any time and the load required by the shuttle service is 50% thereof (the remaining 50% is distributed on regional, local and horizontal systems), there would exist a requirement to move 6,100 passengers on three sets of four shuttle tracks at any one time. The total (given an average of 40 passengers per shuttle) would imply that over the length of the building 51 shuttles would be moving up and down the tracks. That is only feasible if the shuttles can avoid each other and move in-between tracks.

Accordingly the tracks would have 6 switches between every plaza level (at intervals of 42m). That would provide innumerable possibilities for any one shuttle to weave its way up or down. In fact, disregarding systems behaviors and other systems theories, the number of different options to get from the bottom to the top would exceed \((36 \times 4)^{25}\). Surely this is a theoretical number, but the bottom line is that with an intelligent transportation system, movement through the building could be organized efficiently and effectively.
Movement of shuttle across different tracks
(note: switches)
Generally there exists a need to rethink the concept of transportation within the building. Individuals could not expect current elevator standard (less than 30 seconds waiting times) to be upkept in a building of this scale. As was mentioned earlier, it would seem appropriate to compare the proposed system to urban public transportation networks. Following form that analogy, passengers moving between plazas need to allow for waiting times. Commuters may well take 10-20 minutes from one corner of the building to the opposite. Maybe fees would be charged or tokens required. Possibly parties could order a capsule (like a taxi service) and be transported to the nearest point of their destination without changing the capsule once.

The organization of the entire system, however, is considerably more complex than a conventional urban transportation network since movement needs to be controlled and synchronized in all three dimensions simultaneously. Intelligent transportation coordination and sensor systems will be indispensable. At the same time they represent an efficient way to control and regulate movement (much like traffic light control systems or variable inbound/outbound lane conversions on 3 or 5-lane highways/tunnels etc.)

Scenarios that may benefit from the regulatory potential of the system may involve emergency services (ambulance) to transport injured persons to the nearest hospital unit. This could be done with a priority override to give a designated capsule absolute priority. The system could also monitor individual capsules located near dangerous areas and direct them to a safer location during an emergency. During night hours when passenger circulation may be low, specified deliveries, garbage transports and other services could be directed through the building. The great advantage would be to minimize any negative impact by preempting unintentional queuing effects (as happens frequently on motorways: traffic jams from nowhere).
Capsule units may vary.
Above: passenger capsule fittings within standard capsule shell.
Right: capsule shell with dual-directional movement mechanism.
- Environmental Response:

As was briefly touched upon, one design objective was to reconsider natural climate control for a building type that commonly relies on artificial cooling. For this, the idea was to make use of the verticality of the building in two significant ways: (1) by using stack effect and internal winds to cool and ventilate the entire building, and (2) to use the considerable external wind speeds for energy generation (electricity). The result is a concept whereby climate control would be conducted at both regional and local (pod) levels - independently and interdependently.

The regional system would control airflow within the central core. Internal winds would occur over the 200m core height (see p.67). The strategy would thus be to control air intake through automated louver systems in the light well glazing systems and at the mechanical level of the pods (supertruss level; see p.80). The air would warm up and rise to be either pumped out through large turbines just beneath the plaza platforms, or (in case the winds have enough velocity) would even power the exhaust turbines and generate passive energy.

At pod level, the double skin facade uses solar heat gain to draw air in at the lower level and extract hot air at the top level. The air movement is further enhanced by attaching wind scoops/shields to the bottom and the top of the pods. Wind will be directed up through the cavity between the two skins and can pull out used air form internal spaces. At the same time, high wind velocities directed into the cavity through the wind-scoop could be dampened by wind turbines. This technology would both slow down the wind and convert the released energy into electric power.
A rough quantification could be as follows:

Slot area available per pod: 80sqm (usable: 60sqm)

Wind power density at 100 km/h:

\[
\frac{(h/3600)^3 \times 0.5 \times (100 \text{ km/h})^3 \times (1.5 \text{ kg/m}^3)}{50 \times 10^6}
\]

\[
\text{kg m}^2/\text{s}^2 = (0.015 \times 10^6) \text{ w/m}^2 = 15 \text{ kW/m}^2
\]

Given an assumed efficiency ratio of 50%, the energy produced would amount to 7.5 kW/m². Over an area of 60m² that would yield 450 kW per pod (per hour).

At an average consumption of say 3 kW per single occupant unit, the amount of energy gained through wind could support 150 units. Especially since wind speeds tend to be more regular with increasing height, this figure would seem to suggest considerable savings of energy costs.

Further more:
- Rainwater, when collected in basins above individual pods could reduce (solar) heat gain of the pods by providing additional thermal mass. When sprayed against the external skin of the building, the water could help cool the surface through evaporative cooling.
- When looking at cooling the building heat transfer systems could equalize differences in temperatures between sun-exposed facades and non-exposed facades as well as between higher levels (cooler) and lower levels of the building.
- Furthermore, sun shades (to block out light) and sun scoops (to gain more natural light) may provide additional passive sources to control internal lighting and undesired heat gain.
Following from this brief and rather conceptual outline of a few rudimentary technologies, the potential for making the building responsive, using the benefit of the building’s altitude and reducing the need for external energy provision may make this building an exception amongst its kind. It seems that passive and smart climate control systems are more about an attitude to invest in installation and equipment costs than about complex and costly technologies.

• E&M Measures:

One of the biggest problems for the mechanical systems is getting water supplies to the top of the building. Given the accumulative pressures in ducts and pipes at lower levels, it seems necessary to pump the water up in intervals. As a result storage tanks need to be provided at plaza levels. They require a holding capacity large enough to provide the pods and atria below with water. At the same time they could possibly be used as dampers to avoid cumulative sway within the building. Much like hydraulic systems, water tanks could be fixed on movable tanks and controlled to support other high mass damping devices in place.

Provision of all other services seems less problematic. However, it should be noted that conceptually E&M is hierarchically broken down and provided at every pod level. Accordingly, the pods would serve as the smallest autonomous units. The supercolumns accommodate most of the services. Water supply and sewage discharge would be dealt with at plaza or atrium levels (mechanical floors). These tanks are serviced through ducts and pipes running within the service spaces of the hybrid atrium columns (see p. 64). Intermediary holding tanks and other storage/pumping devices at atrium level would then supply the pods or deal with waste treatment at the local scale.
• Safety:

Risk of Fire:

Risk of fire is immanent. This is true in particular with regard to exploding life lines, or collision of airborne vehicles with the building. The risk of local fires, is minimized through the use of materials with particular fire-resistance factors (fit-tings, carpets etc.), the use of local sprinkler systems, and the provision of rapid fire fighting units with small scale fire fighting equipment. At larger scale, fire stations (high pressure water supplies etc.) and fire fighting units (with specialized cap-sules) are provided.

Avoidance of fire-related accidents is possible by evacuating occupants within the building laterally. Since the greatest threat of fire is upward-rise, lateral evacuation to other parts of the building will reduce the risk of injury.

Evacuation:

In the extreme case of an all-out evacuation, the building needs to be cleared within the span of 2-3 hours. Special fire resistant evacuation capsules provide for rapid egress of all inhabitants. The capsules represent the highest safety level evacuation system. Similar to life boats on cruise ships, a sufficient number of these capsules could be provided for exclusive emergency use and stored at atrium lev-els. They could be equipped with seats and security belts for rapid downward ac-celeration. They are meant to be manned before being launched from the edge of the building (tracks provided). Once all security measures have been executed (security belts, locking of opening etc.) they are pressurized and automatically di-rected towards the launch pad. From here they are dispatched, controlled by a smart coordination system (to avoid mutual collision) and reach the unloading sta-
tion at ground level in free-fall. Accordingly the capsules would descend at terminal velocity until nearing touch down. A breaking system sets in, slowing the capsules down and softening ground contact. Once at ground level they are automatically directed away from the free-fall track to an unloading or medical treatment area.

As mentioned, this evacuation method represent the extreme end of available options. Others would include:

- Emergency shuttles to get occupants of plazas down. These shuttles are essentially standard shuttles that are priority directed to the evacuation hot-spots.

- Roof level helicopter evacuation. The present helicopter fleet will evacuate priority cases. Nearby helicopter services will similarly be drawn in for reinforcement.

- Emergency stairs (located in all pods) and emergency gathering areas (at atrium and plaza levels) provide for local evacuation and redistribution of occupants within the building. From there they may be picked up by automatically directed capsules to relocate them further away from the safety hazard. There exist refuge area at atrium levels (lower floor) and in the plaza platform. The refuge floors would serve as gathering spaces until transportation capsules can be dispatched for evacuation.
### PROJECT DATA

- **Summary of Project Data:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site area:</td>
<td>139,600 sqm</td>
</tr>
<tr>
<td>Gross floor area:</td>
<td>3,864,400 sqm (incl. all mechanical and vertical services)</td>
</tr>
<tr>
<td></td>
<td>3,320,800 sqm (excl. vertical duct services)</td>
</tr>
<tr>
<td>Net floor area:</td>
<td>2,657,077 sqm</td>
</tr>
</tbody>
</table>

  The net usable floor area is ca. 80% of gross floor area (excluding vertical duct services), or ca. 69% when including vertical duct services. This later ratio includes all provisions for vertical and horizontal circulation as well as all vertical and horizontal mechanical infrastructure, ducts etc.

  **Proposed FAR:**
  - 23.8 (calculated against gross floor area excl. vertical duct services)
  - 27.7 (including vertical duct services)

  **Building occupants** (residents, visitors etc.): ca. 122,000.

  **Floors** (including mechanical floors above Podium level): 284

  **Building height** (above Podium level): 1410m
  + Telecommunications equipment (ca. 150 m): 1560m

  **Aspect ratio:** 1:5 (top of occupiable floors)

  **Building division:** 6x40-floor units, with 5x8-floor pods each.
• Net Floor Area Distribution (% of total):

Net floor area of rentable pods (162 in total): 1,720,440 sqm (65%).

Net floor area of atriums and common amenities (81 in total): 371,223 sqm (14%).

Net Floor area of plaza pods (surrounding the plazas and commonly public use (institutional, retail etc.)): 202,680 sqm (7.6%).

Net area of retail/ entertainment/ athletics & recreation plazas (amount 4, not counting 1 heliport): 257,200 sqm (9.7%).

Heliport, ground level entrance atriums and roof atriums (for flight control, telecommunications equipment, lounges etc.): ca. 98,300 sqm (3.7%).
- Respective Floor Areas:

<table>
<thead>
<tr>
<th>Single Units</th>
<th>Gross Floor Area (sqm)</th>
<th>Net Floor Area (sqm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pod (per floor)</td>
<td>1,053</td>
<td>1,000</td>
</tr>
<tr>
<td>Supercolumn (per floor)</td>
<td>250</td>
<td>70</td>
</tr>
<tr>
<td>Inter-pod walkways/tracks</td>
<td>1,065 (each)</td>
<td>1,065 (each)</td>
</tr>
<tr>
<td>(per pair of Pods at two levels)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atrium (lobby level)</td>
<td>1,850</td>
<td>1,830</td>
</tr>
<tr>
<td>Atrium (suspended levels)</td>
<td>290 (each)</td>
<td>280 (each)</td>
</tr>
<tr>
<td>Atrium bridges (per floor)</td>
<td>72</td>
<td>72</td>
</tr>
<tr>
<td>Atrium (mechanical floor)</td>
<td>1,850</td>
<td>1,830</td>
</tr>
<tr>
<td>Plaza (main level)</td>
<td>36,550</td>
<td>36,100</td>
</tr>
<tr>
<td>Plaza (structures)</td>
<td>9,500</td>
<td>9,300</td>
</tr>
<tr>
<td>Plaza (mechanical, refuge, storage at two levels)</td>
<td>54,000</td>
<td>18,900</td>
</tr>
<tr>
<td>Plaza pod (5-floors; gross incl. mechanical)</td>
<td>7,765</td>
<td>5,700</td>
</tr>
<tr>
<td><strong>Total Building Footprint</strong></td>
<td><strong>49,700</strong></td>
<td></td>
</tr>
<tr>
<td>Composite Units</td>
<td>Gross Floor Area (sqm)</td>
<td>Net Floor Area* (sqm)</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Single Pod</td>
<td>12,424</td>
<td>9,120</td>
</tr>
<tr>
<td>(8 floors with local elevator lobbies; gross with mechanical)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Atrium</td>
<td>7,984</td>
<td>4,583</td>
</tr>
<tr>
<td>(includes 6 suspended levels; gross with mechanical floor &amp; inter-pod walkways)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double Pod Cluster</td>
<td>32,832</td>
<td>22,823</td>
</tr>
<tr>
<td>with Atrium (gross with mechanical floor &amp; inter-pod walkways)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical inclusive 8-floor</td>
<td>98,496</td>
<td>68,469</td>
</tr>
<tr>
<td>section of total building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical 45-floor unit (no Plaza)</td>
<td>492,480</td>
<td>342,345</td>
</tr>
<tr>
<td>Typical 45-floor unit</td>
<td>663,072</td>
<td>454,594</td>
</tr>
<tr>
<td>(incl. plaza; gross with mechanical, refuge, storage at two levels)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Section</td>
<td>731,580</td>
<td>571,596</td>
</tr>
<tr>
<td>(above podium, excluding plaza)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heliport &amp; heli pods</td>
<td>161,092</td>
<td>47,949</td>
</tr>
<tr>
<td>(heliport counts as full mechanical: gross only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roof section</td>
<td>480,532</td>
<td>267,105</td>
</tr>
<tr>
<td>(gross incl. heliport (counts as full mechanical: gross only) &amp; heli pods)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Building</strong></td>
<td><strong>3,864,400</strong></td>
<td><strong>2,657,077</strong></td>
</tr>
<tr>
<td>(above podium level)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(incl. all mechanical &amp; vertical duct services)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3,320,800</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(excl. vertical services)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Usable Floor Areas exclude elevators, mechanical floors and vertical service zones.

In the case of atriums and plaza levels, around 35% of the mechanical zones are used either as transportation boarding/deboarding zones or leasable storage space and figure into net area calculations.
Vertical services (pipes, ducts, fire stairs etc.) were added at every floor level of gross floor area calculations. They account for ca. 543,600 sqm for the total building, or ca. 2,160 sqm per calculated floor level. Without these services the gross floor area of the total building would be 3,320,800 (85% of the above Total).

- Mixed Use Distribution:

Largely based on the Metroplan’s selected attributes for the optimal hybrid development strategy, the following ratios would be applied to the building as follows:

<table>
<thead>
<tr>
<th>Use</th>
<th>% of net floor area</th>
<th>actual floor area (sqm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential:</td>
<td>50% (=)**</td>
<td>1,328,539</td>
</tr>
<tr>
<td>Low Income</td>
<td>10%</td>
<td>265,708</td>
</tr>
<tr>
<td>(4782 units; average unit 50 sqm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid Income</td>
<td>27%</td>
<td>717,411</td>
</tr>
<tr>
<td>(8070 units; average unit 80 sqm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Income</td>
<td>13%</td>
<td>345,420</td>
</tr>
<tr>
<td>(2760 units; average unit 125 sqm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Estimated resident population (3.24/household): 50,582)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial:</td>
<td>23.4% (+)</td>
<td>621,756</td>
</tr>
<tr>
<td>Offices</td>
<td>13.2%</td>
<td>350,734</td>
</tr>
<tr>
<td>Retail/Hotels</td>
<td>7%</td>
<td>185,995</td>
</tr>
<tr>
<td>Entertainment/Cultural</td>
<td>3.2%</td>
<td>85,027</td>
</tr>
<tr>
<td>(Estimated employees: 53,150)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** (=), (+) or (-) indicate changes from Metroplan**

Schematic use distribution (early study)
Industrial: 6% (-) 159,425

High Technology 3.5% 92,998
Light/Medium Manufacturing 2.5% 66,427
(Estimated employees: 6550)

Institutional/ Administration: 10.3% (-) 273,679

Education 3% 79,712
Health Services 2% 53,142
Public Services (Police, Fire etc.) 2.8% 74,398
Building Administration 2.5% 66,427
(Estimated employees: 15,350)

Facilities (within building): 10.3% (-) 273,679

Gardens 3.2% 85,026
Sports Facilities 2.4% 63,770
Parking (5,000 cars of 11,000) 4.7% 124,883

Estimated total jobs in building: 75,050
Estimated visitors/business visits: 15,000

Estimated percentage of residents employed within building: 60% (of total resident working population = 18,734)
Total average building occupancy: 122,000 persons (average of 21.8 sqm/person)
Population per ha of site area: 8,740
Comparative scales:
gross floor area compared to equivalent scale superimposed on Kowloon (at 1 floor height and 8 floor height)
The proposed project will inevitably have to be measured against existing conditions of Hong Kong with view to understanding what the relative benefits for building very tall may be. For this, a list of strategic strengths and weaknesses is provided, that by no means claims to be complete. True evaluation of a building of this scale would be difficult to obtain, but necessary for understanding the risks of undertaking such an endeavour.

- **Strengths:**

  - **Connectivity and adjacency** is one of the greatest advantages of building tall. In fact, the horizontal expanse of the building, paired with the vertical, allows relationships of units to be more complex than ordinary vertical layering would permit. Particularly as a result of Hong Kong’s geographic and urban conditions, adjacency is a great asset. Victoria Harbor still today acts as a natural divider between Hong Kong Central and Kowloon, two major centers of activity. Accordingly, development (especially in the financial and business sectors) has typically moved to Hong Kong Island. With greater adjacency to Mainland China in the course of increased interaction with neighboring Guangdong, the proposed site may boast some distinct strategic advantages. The location of the proposed project thus may benefit from Hong Kong’s increased focus on activity in the Pearl River Delta.

  - **Mixed Use:** As was mentioned earlier, a building of this size must provide the amenities that occupants require to conduct their business and their lives agreeably. The decision to provide a substantial residential component in the building, together with the other uses, concentrates resources and minimizes travel distances and times. In addition, mixed use developments (especially when their system components (pods etc.) are flexibly designed and may easily be converted for different
uses) are better to market. Slumps in rental markets may be counterbalanced by reassigning uses -within limits - and/or tapping alternative markets with higher demands/returns.

• Given that the marketability has been enhanced with the flexible multiuse pod systems, the chances for finding investors willing to acquire control over particular building units (one pod, multiple pods etc.) is likely to spread and reduce investment risks.

• The systems design approach provides for a high degree of adaptability to changing uses and technologies. It also allows obsolescent building components to be more easily replaced or upgraded. This is as true for the habitation systems, the mechanical systems as well as the transportation systems. The biggest advantage is the relative separation of the systems, so that repairs can be conducted without necessarily interfering with other systems. It is more difficult to replace units in conventional high-rise buildings or upgrade urban infrastructure.

• Potentially the building can be conceived of as a kit-of-parts that may be expanded as required. This may include (in limits) upward expansion and well as horizontal expansion (enlarging lower pods and even whole building units.

• Space requirements for transportation and services/utilities infrastructure within the building are lower than in urban conditions (20% vs. 30-40%). This is due to two major factors: (1) the compactness of the building reduces total material requirements and largely makes vehicular traffic provisions redundant, and (2) compact and 'clean' infrastructure spaces (within the supercolumns, mechanical floors etc.) function as 'fillers' and occupy strictly planned and organized spaces. There exists considerable control over infrastructure expansion, for the building is in itself an arguably more organized entity than a horizontal city.
• By concentrating development and resources, the building offers to leave unencumbered publicly appreciated or rare resources of Hong Kong, such as waterfronts and outdoor open spaces. This has always served as a possible justification for assembling structures vertically. However, it does require commitment from the part of the planning and regulatory bodies, or else very tall buildings may easily become as amassed as many of the high rise developments on Hong Kong Island today. The logic only holds, if the determination exists to protect the unencumbered resources.

• Weaknesses:

  • The building costs are likely to be substantially higher than those of conventional buildings. Whether the relative additional costs could be compensated by the high reclamation costs to create buildable land, or by the relative cost for infrastructure projects to New Town developments outside the metro area would have to be investigated.

  • The building would certainly dominate West Kowloon and may create undesirable conditions of shading and wind turbulence at lower levels.

  • The absolute concentration of people and goods could overburden existing infrastructure if changes in living patterns occur. Given that the building needs a critical mass of occupancy, any changes in life-style, habits etc. which may have an effect on the infrastructure (like popular weekend trips etc.) would be difficult to disperse/decentralize if the critical mass were to be endangered (i.e. reducing density/building occupancy). Therefore upward investment and expansion seems the only alternative to adapt infrastructure shortcomings.
• It seems difficult to predict how a building of this magnitude could be disposed of if ever it should become irreversibly obsolete.

• Vertical transportation is not energy efficient and would possibly be significantly more expensive than horizontal systems.

• The coordination of residential and occupational patterns for the building would need to be continuously monitored if a notion of relative autonomy wants to be maintained (thus alleviating existing urban systems).
(24) Gateway to Hong Kong (landmark role)
CONCLUSION

The project displays a considerable number of flaws and weaknesses (extensive assumptions were made, lack of revealing impact assessments, need for concise performance criteria etc.). Nevertheless, the building conceptionally distilled at least one major quality in the course of the design exploration, namely the intensity of interaction within a hierarchically organized, three dimensional urban structure. Given the building’s scale and nature of its support systems, the potential for amassing internal activities in mutually interdependent relationships might represent the most noteworthy characteristic.

The proposed project represents a critique of a major limitation that high-rise buildings commonly suffer from, namely the conventional treatment of vertical spatial arrangements and connections (transport), resulting in structures with repetitive, isolated slabs and cells. Qualities of public exposure play no part in their spatial arrangements. Unlike urban entities with their diverse opportunities for interaction (streets, squares, house entrances etc.), common high-rise buildings become containers for mostly exclusive uses and one-dimensional movement patterns. They often find themselves reduced to containers for existence, not vessels for life. The proposed project thus argues for greater connectivity within a highly subdivided structure that provides a framework for occupations and uses to higher and qualitative superior intensities of interaction.

It is an assumption that the -- predicted -- death of the high-rise building (as proposed by developments in the United States) calls for equipping tall buildings with attributes and characteristics that may allow them to stand the challenge of newly emerging technological alternatives to physical adjacency. All along it remains true that there exist critical factors and economies of scale that are vital for very tall buildings to function. Thus considerations follow two major paths: (1) the contextual requirements that support a very tall buildings in general (population growth, high urban densities, geographical constraints, economic power, and ur-
ban culture; see Chapter 1.), and (2) the relative strategic advantage to building very tall.

As was pointed out in the introduction, there are powerful alternatives for a number of strategic advantages for building very tall. Spatial distance and communication have become denominators in need for redefinition. The challenge to extreme building density comes no longer from considerations of zoning, FAR, investment costs, market risks etc. alone but, increasingly, from new technological substitutes for kind, extent and quality of adjacency.

Through digital communication technologies, the choice has become broadened as to how we define adjacency and to what extent we control our exposure. The technologies provide us with a new perspective to evaluate qualitative distinctions between exposure and isolation, between adjacency and distance, between what represents wanted — or good — communication and what does not. We communicate face-to-face where we deem the interaction to be more rewarding/useful. Where we prefer to avoid physical presence, we have an increasingly sophisticated selection of technological means that allow us to minimize our exposure/wasted time etc. This implies that technologies have reshaped the type of physical communication we seek. Accordingly, a new building type needs to provide for the convenience and the organization to enhance the spectrum of communication that is desirable. This makes connectivity/communication a strategic asset, the value of which is defined by its alternatives as much as by its relative qualities.

A basic assumption in arguing that density is not necessarily an undesirable condition (especially in the context of Hong Kong) may be further supported by taking a rather philosophical perspective: Humans — if we are to believe Döblin (page 11) — are fundamentally social beings. Arguably what brings them to live under dense and burdened conditions of modern metropolises is largely the urge to
live in societies, the urge to attain a sense of identification. Identification provides for 'placeness', for an interpretive differentiation of what carries meaning to one's existence. In other words, the sense of place involves a sense of orientation in both spatial and metaphoric terms. And orientation has to do with information processing which is largely fed by interactive communication. The argument therefore is that there exists a fundamental need to be surrounded by a stimulating environment that provides for exposure to experience and information so as to reestablish one's relationship to one's personal identity and one's niche in society and in life. 'Good' cities stimulate all senses as they feed us with sensations that become transformed to a perceptual framework within which we explain our values and orientations. Good buildings should not be different.

In order to provide the stimulation that would serve to make a high density building an option, a skeletal framework was created in the design proposal. System components are the main architectural elements. They are organized hierarchically and at different scales to allow internal uses to be similarly hierarchical (private to public) and yet simultaneously interconnected. Breaking down the scale of the building into local units, neighborhoods, and regional clusters with 'quartier' plazas serves to structure the framework for activities. At the same time the mere fact that a building is an organized and planned entity may introduce a degree of leniency and efficiency that would reduce the disadvantages of common conditions of urban density, such as pollution, smell, and congestion. In other words, to promote connectivity-adjacency-communication in an age of growing telecommuting, the building — it is argued — needs to provide qualities, such as differing scales of reference and identity, efficiency (to reduce the burden of density), and accessible centers of public activity (plaza levels), amongst others.
In the end, addressing the design of an urban entity by investigating the required systems and their interdependent relationships may lead to a dangerous neglect of the quality and attitude towards non-predicted patterns of life that need to occur and be part of a building of this scale. The question is whether an organized structure such as the building provides for sufficient eventualities, for consequences of unordered life. Will squatter settlements invade the structure? Will mechanical spaces and crevices be inhabited by the poor and needy? Will street vendors offer their goods, night bazaars emerge? Or, conversely, will the building represent a more perfect entity where regulation and monitoring provides for precision that even exceeds Singapore’s reputation for efficiency? Those are scenarios to which there exist no easy answers. Yet, if the systems become animated through the lifelines that make up its functional framework than the building may in fact succeed in proposing an alternative to dispersed and sprawling urban life. And who wouldn’t enjoy sitting in front of his computer, drinking a nice Martini on the Rocks and looking down on an approaching airplane from the 232nd floor?
APPENDIX 1: SUPPORT DOCUMENTS

Transportation Strategy
(from: West Kowloon Development Statement, p.15)
APPENDIX 1: SUPPORT DOCUMENTS

Functions Strategy
(from: West Kowloon Development Statement, p.16)
APPENDIX 1: SUPPORT DOCUMENTS

Form Strategy
(from: West Kowloon Development Statement, p.17)
Recreational Facilities
(from: West Kowloon Development Statement, p.19)
APPENDIX 2: IMAGE SOURCES

Reference list of included images:

(1) Scientific American, December 1997, p. 113.
(2) Scientific American, December 1997, p. 103.
(3) Frank Lloyd Wright, p.170.
(4) Der Schrei nach dem Turmhaus, p. 32.
(5) Der Schrei nach dem Turmhaus, p. 35.
(6) Bauentwurfslehre, p.306.
(7) Skyscraper, p.25.
(9) Sir Norman Foster, p.68.
(10) The Tall Building Artistically Reconsidered, p. 54.
(11) Sir Norman Foster, p.129.
(12) Government of Hong Kong (published map material)
(13) Hong Kong - City of Vision, p.81.
(14) Hong Kong - City of Vision, p.8.
(15) Hong Kong Architecture, p.106.
(16) Over Hong Kong, p.12.
(18) Hong Kong's Highways, p.8, West Kowloon Development Statement, p.4,
(19) Hong Kong - City of Vision, p.92.
(20) Hong Kong's Highways, p.36.
(21) The Shape of Things to Come, p.70.
(22) Planning Hong Kong's Future, p.16.
(23) Planning Hong Kong's Future, p.17.
(24) Courtesy of Cesar Pelli & Associates (with amendments)
APPENDIX 3: BIBLIOGRAPHY

Books:


**Journals & Periodicals:**


Engineering News-Record. various publications.

**Reports and Other Source Material:**

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