Building Materials and Technology in Hong Kong

Expanded Second Edition

香港建築技術及應用

第二版

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HKU PRESS
香港大學出版社

Hong Kong University Press
The University of Hong Kong
Pok Fu Lam Road
Hong Kong
https://hkupress.hku.hk

ISBN 978-988-8946-90-7 (*Hardback*)

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library.

10 9 8 7 6 5 4 3 2 1

Printed and bound by Hang Tai Printing Co., Ltd. in Hong Kong, China

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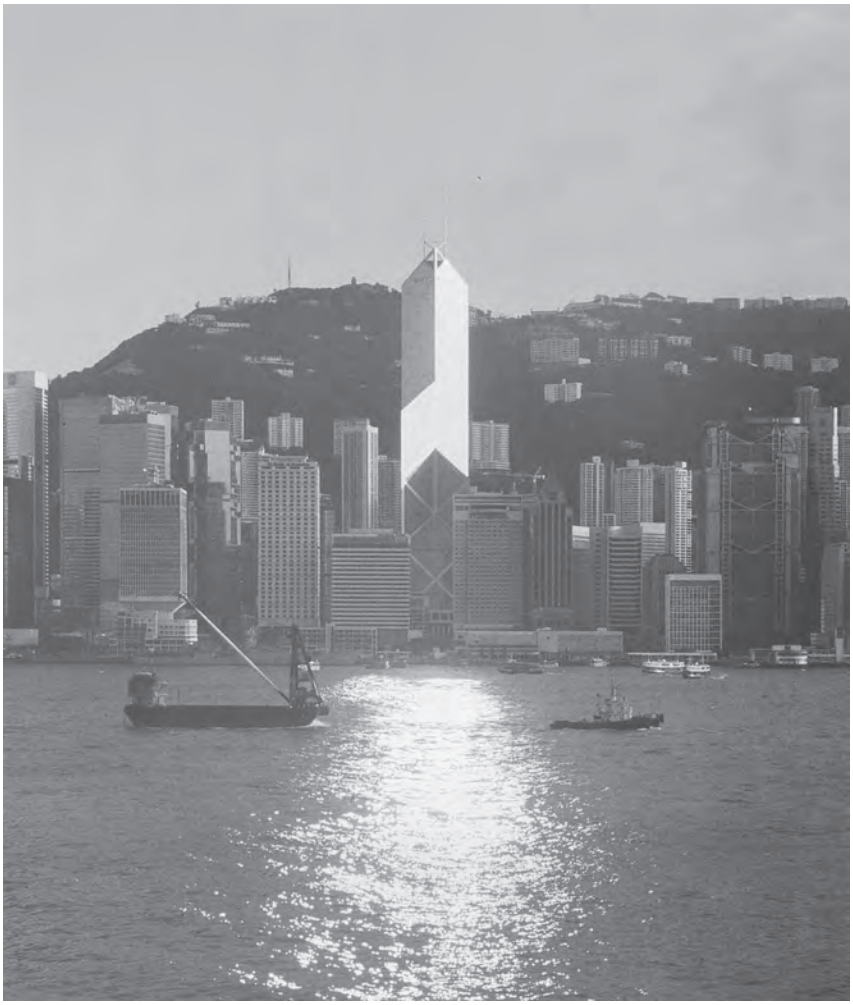
Chapter 1

General Introduction to Building Construction in Hong Kong

香港建築簡介

Wong Wah Sang 黃華生

The Bank of China standing amid shorter office buildings



> Much as the trapezoidal shape of the East Building's site had generated its triangular design motif, the compelling diagonals of the Bank of China were intimately related to its aesthetics. Rather than leave the roofs of the ascending shafts flat, as might have been expected, Pei set them at an angle, adding to the sense of thrust as the building rose. The skin was to be reflective glass. In true Modernist tradition, Pei chose to express the structural members that met the skin by highlighting them with aluminium cladding, creating facades of boxed Xs. At seventy stories, the tower would be the tallest building in the world, outside the United States, and its strikingly abstract form—topped with a pair of broadcast masts—would make a dramatic vertical gesture in the heart of the city.
>
> —Carter Wiseman, *I. M. Pei: A Profile in American Architecture*

In the late 1980s, people working in Central witnessed the construction of I. M. Pei's Bank of China Building in the non-Hong Kong-style construction method of using structural steel. This building with the 'trunk of a bamboo' metaphor is an example of continuous new technology being brought into the building industry, giving inspiration for Hong Kong architects. The 370 m height of the building is recorded as the highest in Hong Kong, offering a challenge to local architects.

Subsequently in 1992, the completion of Central Plaza, 18 Harbour Road, another corporate-looking office building became the tallest building in Hong Kong. And in 2010, another record was set by the 108-storey International Commerce Centre, 484 m high. Such are the continuous changes and impact that make Hong Kong construction so dynamic and interesting.

> 運用三角的意念於中國銀行大廈的設計，正好和斜形支架結構作了個和諧的組合。同時擺脫以往平平坦坦的頂部設計，貝聿銘的建築物造型配合了不同的取向和角度，並且在每個平面之外，披上一身反光的玻璃幕牆。在現代主義的傳統影響下，貝聿銘完全將建築物的結構顯露出來，利用鋁合金板和玻璃牆，成為整體的盒子形設計。整座建築物共七十層高，將會是美國之外最高的建築物了。超創意的靈感想像，還有，它在屋頂的一對巨型天線，成為市中心戲劇性的直立姿態。
>
> —Carter Wiseman, *I. M. Pei: A Profile in American Architecture*

1980年後期，我們在中環看到中國銀行大廈的建築過程——承重鋼鐵的結構建築法，並非一般香港式的釘板模、紮鐵、混凝土的方法。這比喻為「竹節」的建築，將新科技引進，也給予香港建築業一個嶄新的啟示和開始。全幢大廈高370米，是高廈設計上的一個新指標。其後1992年在灣仔海旁落成的中環廣場，更成為另一項高廈的紀錄。再後2010年，108層的環球貿易廣場，高484米，創下另一香港高廈的紀錄。

Construction speed

Construction speed is of prime importance in the Hong Kong building process, even outweighing quality. 'Time is money' is the slogan for the rich developers who are continuously inserting buildings to reshape Hong Kong's skyline. The amazing speed of construction is as fast as three to four days per concreting cycle for a typical floor. Large housing estates in Laguna City of Cha Kwo Ling and the residential towers in Kingswood Estate, Tin Shui Wai, at a four-day cycle are good examples of local construction speed. Citibank Plaza in Central went up at a three-day cycle.

A review of the high cost of land explains the emphasis on time. For example, the particular site in Wanchai for the tallest office building was acquired at a government auction on 25 January 1989, at HK$3,350,000,000 or HK$460,000 per m^2 site area. Interest on the cost of the land alone amounted to HK$918,000 per day at the prime rate of 10%. This would be enough pressure to produce building very fast (at a four-day cycle per floor). Subsequently in 2016, a business site, NKIL no. 6505, 7728 m^2, at Cheung Sha Wan, was sold at HK$7,794.38 million, about HK$1 million per m^2.

建築工程速度

在香港，建築工程中最重要的考慮因素是時間，其次才談到質素與品質標準。俗語云：「時間即是金錢」，是許多發展商的金句，他們不斷在香港擠壓出高廈，重組香港的天際線。一般來說，普通的一層樓面建築，從釘板到澆灌混凝土，可以快至三至四天的時間，就以大型屋邨如荃果嶺的麗港城、天水圍的嘉湖山莊等，都是以四天的建築週期速度興建的。在中區的萬國寶通廣場甚至可達成三天的建築週期。高

Construction of the steel frame for the Bank of China

Office building at no. 9 Queen's Road

Citibank Plaza at a three-day cycle per floor

New Hang Seng Bank headquarters

Central Plaza, the tallest offlice building located at the Wanchai waterfront, under construction

Residential tower at Bonham Road

Chapter 2

Trades of Materials and Technology

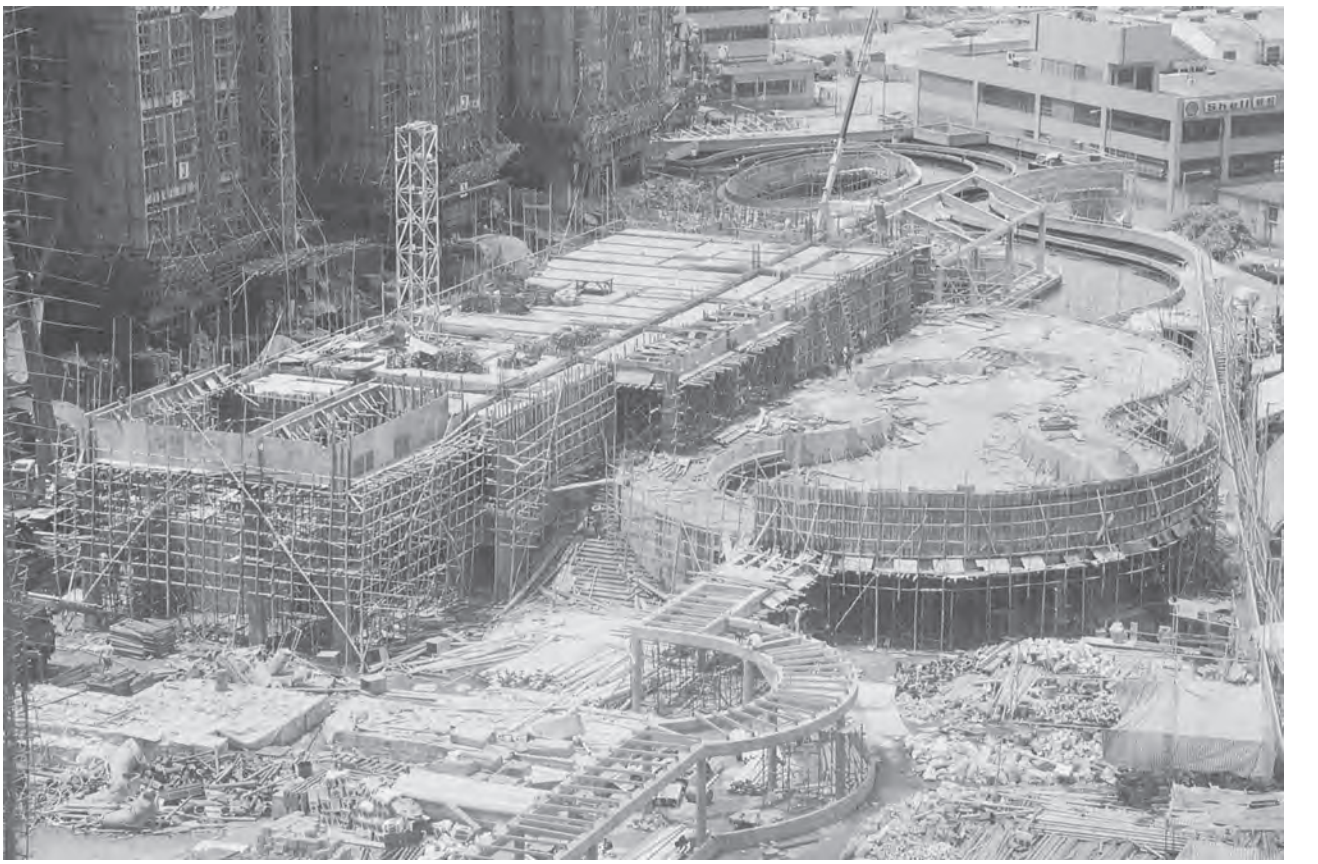
工料的類別及技術

Wong Wah Sang 黃華生

2.1

Preliminaries

整體施工預備工作



Construction of a tower

Preliminaries usually form the first section of the specifications, which is part of the tender document and will subsequently become part of the contract document. Items included in the preliminaries are:

1. Form of contract
2. Definition of terms
3. British standards and equivalent standard
4. Manufacturer's recommendations
5. Government regulations
6. General obligations
7. Temporary works and services
8. Administration, insurance, and attendance
9. Materials and workmanship

整體施工預備工作是招標文件中有關訂定規範的第一個章節部份，當協定達成之後，有關方面正式簽署文件和合同，便成為正式的合同書，同時具有法律效力。施工整體預備工作包括：

(1) 合同條款
(2) 名稱的定義
(3) 英國制度指標和國際認可的標準
(4) 製造商的建議
(5) 政府法律條例及標準
(6) 一般須遵守的規範
(7) 臨時工程工作及臨時水電設備
(8) 行政費、保險項目及其他
(9) 物料準則及工藝規格

Murray Building, where the Building Authority locates

Contract, standards, and regulations

The Standard Form of *Building Contracts: Agreement and Schedule of Conditions of Buildings Contract for Use in Hong Kong* (with or without quantities), published by the Hong Kong Institute of Architects, Hong Kong Institute of Construction Managers, and the Hong Kong Institute of Surveyors in 1976, is the basis to govern the execution of the construction work for the past four decades. This was updated in 2005 to deal with the new period in the construction industry. The latter version was written in simple English, with shorter paragraphs and subheadings for easy reading. New clauses were added to protect both employers and contractors. In addition, legal terms were more clearly defined for better understanding.

For government projects, a contract called 'General Conditions of Contract for Term Contract for Building Works' is issued by the Development Bureau.

合同、規格及法律條例

1976年由香港建築師學會、香港營造師學會及香港測量師學會出版的《香港建築合約條例及規格》，是過去數十年作為監管私營發展建築商從事建築工程的基本法律文件。為了迎合建造業的新時代，2005年修訂了新版。新版用簡潔的英文撰寫，輔以短段落和副標題，令條文變得更加易懂。新增的條款適用於同時保護發展商和建造承包商，且定義清晰明瞭。

至於政府工程，一般情況下使用的建造合同，則由發展局發出的文件為依據。

British Standards and Codes of Practice are available from the British Standards Institution (www.bsigroup.com). These include all amendments, revisions, and standards superseding the standards listed. The British standards are available for inspection at the following locations in Hong Kong:

1. Hong Kong Standards and Testing Centre
2. Main Library of the University of Hong Kong
3. Works Branch Library, Murray Building
4. Urban Council Yau Ma Tei Library, Kowloon

Administration, insurance, and attendance

Regular site meetings are held to monitor the progress of different trades and to coordinate various subcontractors.

Insurance means third-party insurance, employees' compensation insurance, contractor's all-risk insurance, and surety bonds.

Attendance for the nominated subcontractors, nominated suppliers, specialist contractors, government departments, and public utility companies are provided according to the following:

1. Use of plant, ladders, scaffolding, etc. as erected by the contractor. There is no obligation to retain such facilities longer than the contractor's own use.
2. Provision of space and lock-up rooms for storage of materials and tools.
3. Temporary water and electric supply.
4. Guards to safeguard the site.
5. Coordination with the contractor's programme of works.
6. Coordination with other trades such as provision of openings and chases, cuttings.
7. Cleaning and clearing away debris.

行政費、保險項目及其他

定期的地盤會議，能監管不同項目的工作進度以及協調各項目承建商的合作問題。保險項目泛指第三者保險、僱員勞工保險、承建商意外賠償保險及擔保金。

指定的其他項目承建商、物料供應商、特別項目顧問、政府部門、公共設施公司等可共同享有以下的設施，包括：

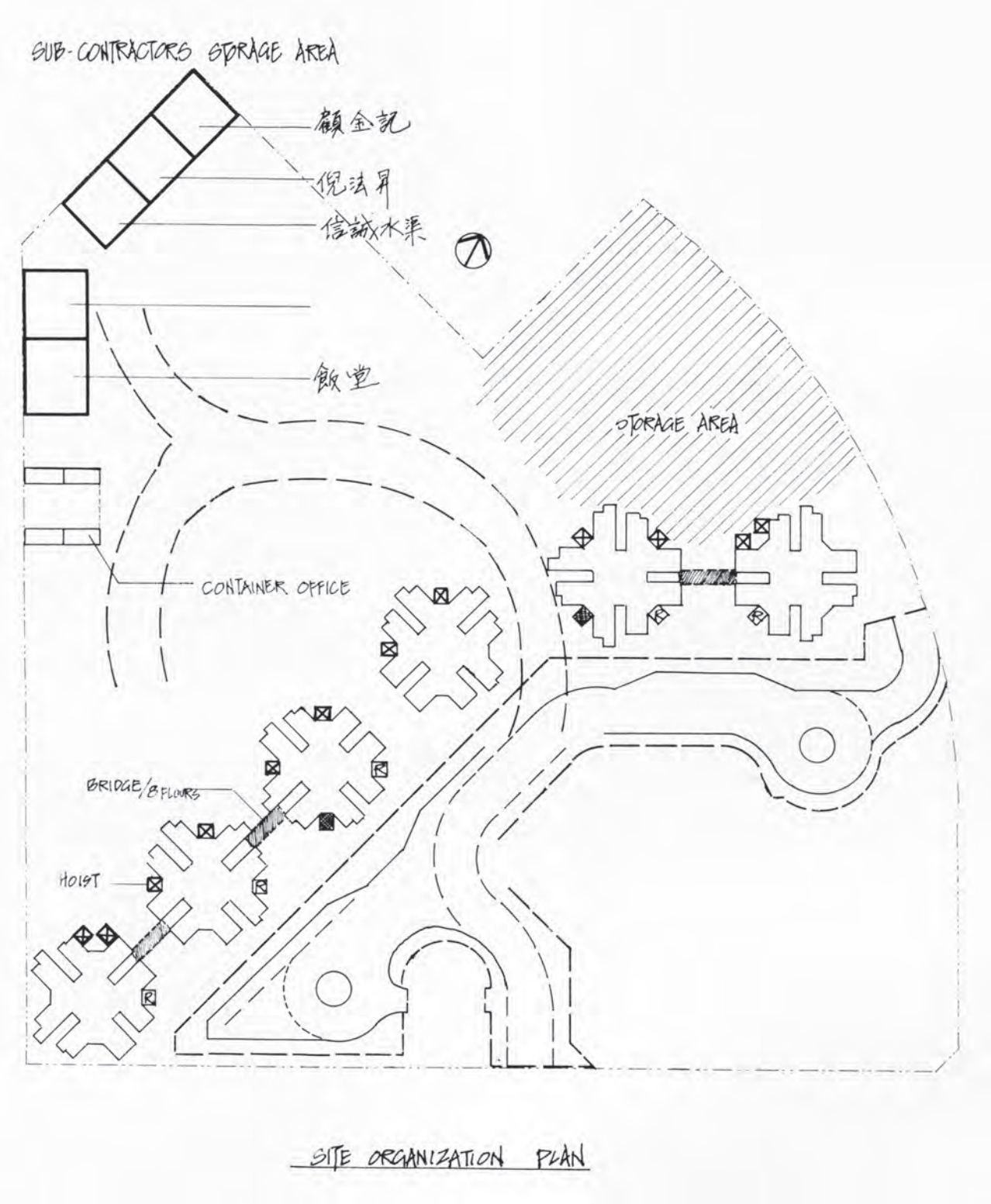
(1) 地盤的機械、梯級、竹棚等由總承建商負責的項目，但卻絕不能超過承建商工程訂立所運用的時間；
(2) 由承建商提供的貯物空間；
(3) 臨時水電的設備；
(4) 地盤看更；
(5) 配合承建商的施工計劃；
(6) 配合其他工作項目的施工過程；
(7) 清潔及移除一切廢料。

Materials and workmanship

In simple terms, the quality of work is required to be consistent with good building practice in Hong Kong and to comply with the relevant British Standards (BS) or Codes of Practices (CP) unless otherwise specified. Sometimes it is written in the specifications that quality must in every respect be to the satisfaction of the architect, giving the architect power to reject any 'unsatisfactory' work.

Submissions of samples, execution of mock-up, and preparation of shop drawings are all good practice for understanding between all parties before actual construction work begins.

Traditional bamboo scaffolding



Layout plan showing constractor's site organization, Kingswood Estate at Tin Shui Wai

References

The Building (Construction) Regulations, Cap. 123Q

Part 2: Requirements for Materials
Regulation 3: Materials

Part 4: Requirements for Design and Construction
Regulation 13: Design Methodology
Regulation 14: Strength and Serviceability Considerations
Regulation 15: Stability
Regulation 16: Construction Methods and Procedures

The General Specification for Building 2022 Edition Incorporating Corrigendum No. GS 2022-01 (Effective 1 December 2024) Published by the Architectural Services Department

Section 1: Preliminaries
General Obligations, Temporary Works and Services, Scaffold System, Administration and Attendance, Materials and Workmanship, and Sundry Requirements

The Practice Notes for Authorized Persons, Registered Engineers and Geotechnical Engineers (Application) Published by the Buildings Department
APP-23: Hoardings, Covered Walkways and Gantries
APP-53: Building (Construction) Regulation Appendix A Standards/Technical Criteria Acceptable by the Building Authority
APP-66: Metal Refuse Chutes at Construction Sites
APP-70: Use of Plastic Sheet to Cover Scaffolding outside Buildings
APP-106: Superstructure Works – Measures for Public Safety
APP-107: Precautionary Measures for Construction Sites
APP-118: Testing of Building Materials
APP-126: Erection of Signboards
APP-127: Contractor's Sheds
APP-158: Quality Supervision of Building Works
ADV-11: Suspended Working Platforms
ADV-19: Construction and Demolition Waste
ADV-27: Protection of Natural Streams / Rivers from Adverse Impacts Arising from Construction Works
ADV-29: Construction Site Safety – Pay for Safety Scheme
ADV-34: Building Information Modelling
ADV-36: Modular Integrated Construction

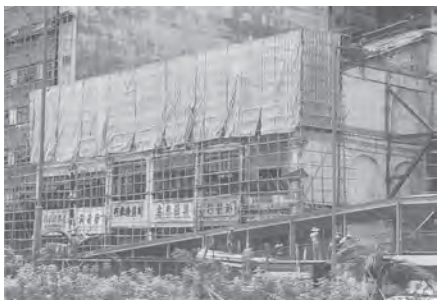
2.2
Demolition and Excavation Works
拆樓及挖掘工程

Preparation work

Before the commencement of demolition, a thorough survey is done and available drawings of structures are examined.

The authorized architect will arrange for disconnection of utilities services including gas, electricity, water, and telephone. Any fitting attached to the building in connection with tramway services, street lighting, electricity or other services is removed. Adjacent road signs, parking meters, hawker stalls, street lighting, etc., affected by the demolition are removed by the relevant government departments.

Apart from the hoarding, the contractor will erect at walls abutting any street, fans, or catch platforms at the first floor level or at levels as that may be necessary to prevent materials from falling to the gound. Dust screens are required to cover the whole wall area. Sewer and drainage connections are sealed, and glazed sashes and doors are removed before breaking down the structures. If necessary, shoring may be erected to prevent the accidental collapse of any part of the building or any adjoining building.



Commencement of demolition for some old tenement houses. Erection of screens and scaffolding.

Heavy machines imposing great loads on old buildings may not be permitted for demolition.

預備工作

樓宇拆卸工程進行前，應先檢查該樓宇及鄰近樓宇的結構和安全等問題。

政府認可的專業人士要負責有關拆樓前所需要的準備工作，包括通知有關部門暫停供應公共設施，如水、電、煤氣、電話等外，還要留意其他有關的設施，如電車服務、路燈、道路指示牌、泊車位、小販檔位等。

除了圍街板外，承建商需要在地盤向街的地方，由一樓起興建承接平台，以防範拆樓時跌落的沙石和雜物。此外，要在被拆卸樓宇的周圍架起防塵網。而有關渠務、水管等當然都要完全封閉妥當。至於門、窗及玻璃，都必須先拆除才可以進行其他的拆卸工程。

有時，還需要安裝支撐架構來保護鄰近的建築物，以避免因拆樓工程而導致鄰近樓宇倒塌。

Demolition works

The demolition works must be carried out under the supervision of an experienced person and the required procedures as stated in APP21. A notice in Form BA20 stating the name of the person in charge must be posted in a prominent position on the demolition site. Competent workers are employed

Timber raking shore

for the demolition of the structural frame, roof, staircase of a building, areas with risk of collapse, and for the cutting-up of structures.

It is essential that debris or materials not accumulate on floors so that floors are overloaded, as floors are not designed for such heavy loads. Great pressure exerted on adjoining buildings and on hoardings is not desirable either.

Some demolition methods, such as the use of a crane and a hammer, are considered to pose unacceptable risks or impose heavy loads on the building and are therefore unsuitable in certain circumstances.

In the demolition of buildings containing asbestos-based products, special care is exercised. The area concerned is cut off by dust-proof screens, and all workers must wear half-mask dust respirators.

拆樓工程

拆樓工程必須在經驗豐富的工程人員監管下進行，同時要履行《認可人士及註冊結構工程師作業備考》APP21 條內所說明的一切工作形式。尤其是當要拆除樓層的結構架、樓梯，或者是該部份有倒塌的危險，又或是涉及結構等的項目，都要聘請有經驗的技工。因此，在每個拆樓工程的地盤，都需要在當眼的地方張貼屋宇署表格 BA20，清楚列明地盤監管人的姓名資料。

當每層的拆卸物堆積而構成層面的承重力增加，或使圍街板和鄰近的建築物構成沉重的壓力，都是很危險的，因此，要定時把現場的堆積物移離。

有些拆樓方法，需運用到起重機、鐵槌等，會被列為危險類別。除非在不得已的情況下，否則不應考慮。

如拆樓工作涉及含「石棉」成份的建築物料，更需加倍謹慎小心。勞工處及環境保護署會要求承建商提交拆卸石棉工程的方法及處理方式，而該地方更要以防塵帳幕四面包攏起來，所有的工人則要配戴氧氣面罩。

Timber flying shore

Excavation

Excavation includes removal of the existing old foundation, cutting off pile heads to the required level, and removing and legally disposing of all surplus materials.

Planking, strutting, or shoring may be required to support the sides of the excavation. Work is carried out to prevent erosion or slips. Working faces are limited to safe slopes and height. Material must not be stockpiled to cause a landslide, and authorized persons, registered structural engineers, are required to take adequate precautions to ensure public safety whenever necessary during excavation as part of the work as stated in APP57.

It is essential that earthwork be sealed up after each day's work or when heavy rain is expected. Cutting is planned to prevent ponding. Temporary water courses or channels are provided to discharge the water, usually through a sand trap before going into permanent drains.

Steel sheet piling for basement excavation

挖掘工程

挖掘工程包括：

(1) 清除原有的地基；
(2) 切斷樁頭到指定水平；
(3) 清除所有剩餘的雜物。

在挖掘地方的兩旁，需要以木板或其他支撐方法來預防兩旁的結構倒塌。工作的範圍受安全高度和斜面所限制，挖掘的雜物不能堆積於任何地方而引致山泥傾瀉。而各認可人士及有關工程師應根據《認可人士及註冊結構工程師作業備考》APP57 所規定，作出適當的設計以確保公眾安全。

每天挖掘工程完成後，要小心把挖掘的地方覆蓋妥當。加設臨時水渠可疏導因工程或滂沱大雨後所引致的積水，而每個疏水導口都要裝置隔沙井，才可以接駁公共渠道。

Timber planking and strutting for trench excavation

Steel strutting for basement excavation

Chapter 3

Case Studies

實例研究

Wong Wah Sang 黃華生
Chan Wing Yan, Alice 陳詠欣

3.3

Domain: Redevelopment of Yau Tong Estate Phase 4, a Sustainable Commercial Building

「大本型」：油塘邨第四期重建發展——推動可持續發展的商業建築

The major façade of the Domain Mall

Yau Tong Estate Phase 4 is the latest phase of a comprehensive redevelopment of Yau Tong Estate. The Housing Authority aimed to create a vibrant retail space through a design which responds to the site, the environment, and the local community. Supported by the environmental consultant, the retail centre has introduced a number of special environmental features contributing to sustainable development. They are as follows:

1. Conserving energy through hybrid ventilation system
2. Enhancing environmental comfort through roof greening, light tube, and solar control
3. Conserving water through the use of reclaimed water
4. Providing a clean environment for food-waste collection by installing a food-waste pulping system
5. Achieving Platinum Rating under BEAM Assessment

From construction, material selection to environmental systems and features introduced, the development of the Domain Mall takes a leading role in fostering a more sustainable community in architecture.

油塘邨第四期是油塘邨最新一期的綜合重建項目。房屋委員會的目標，是建設一個場地環境適合本地社區的活力及商業空間。環保顧問為商業中心引入了幾個特別的環保項目，促進以下幾方面的可持續發展：

(1) 混合通風系統節能
(2) 屋頂綠化、自然光管和陽光控制，以提高環境舒適度
(3) 使用再生水節約水資源；
(4) 安裝廚餘收集系統，為剩餘食物提供衛生的環境；
(5) 達到建築環保評估協會授予的白金級別。

利用環保選材、建造和各種環保特色，大本型商場的發展領導了可持續社區建築發展的基準。

Sustainability in structural and construction aspects

The building was planned to sit on the Mass Transit Railway (MTR) of Yau Tong station. The challenge to the architect and the engineer was to optimize the foundation design, making use of the as-built foundation as much as they could without adding too many excess structures. The BIM was introduced to sort out the integration of the old and the new foundation structure. Minimal resources were introduced with no abortive design; the construction was also planning to achieve BEAM 04 Platinum sustainability credits.

結構和建造上的可持續性

這個建築項目建在油塘港鐵站上蓋，對於建築師和工程師的挑戰是，如何在現有的結構基礎上，不用增加過多的結構而能改善地基系統。此項目利用建築資訊模型（BIM）整合新舊結構，用最少的資源得到最優化的設計。同時，建造時也計劃角逐建築環保評估協會可持續發展獎項的白金級別。

Sustainability in architectural design aspects

The building form, orientation, and layout were designed to optimize cross-ventilation and harnessing of day lighting. Micro-climate studies were carried out in the early design stage. Computational fluid dynamics (CFD) wind analysis was carried out to identify thermal comfort zones for various outdoor activities. Maximized wall openings were designed for natural ventilation in the carpark and PTI, so that operation of the mechanical ventilation system can be optimized. Also, the public open space, podium, and greening of the roof were maximized to address the heat island effect.

The use of recycled materials in finishing is also a credit to sustainability. Concrete pavers with recycled glass aggregates were used in the PTI; recycled timber was used in all outdoor boardwalks, decking, and grilles; recycled medium-density fibreboard (MDF) was used for interior spandrel panels in the atrium.

建築設計上的可持續性

建築的形態、方向及佈局設計，都是為了達到最好的對流通風和日光能源。在設計的早期就展開微氣候的研究。計算流體動力學（CFD）風向分析，用以辨別不同室外活動的氣候舒適區。最大的外牆開口給停車場和公共運輸交匯處（PTI）提供了自然通風，因此室內的機械通風可以減少。此外，項目盡量綠化公共開放空間、平台和屋頂，以減少熱島效應。

使用回收的材料同樣是為延續可持續發展的理念。於公共運輸交匯處，使用回收玻璃碎料於混凝土作鋪設行人路用；回收木材則用於室外木板路、戶外地板和柵欄；回收的中密度纖維板（MDF）用於中庭的樓層飾板。

Sustainability in building system aspects

The glass panel of the curtain wall is an IGU consisting of two panels of glass with an air gap in between. The advantage is isolation and reduction of heat absorption. Having an IGU in the curtain wall design means the use of air-conditioning can be minimized but at the same time retain the natural light harnessing, which in turn reduces the use of artificial lighting.

The curtain wall design is connected to the BMS for a hybrid ventilation system. Openable windows were installed for intake of cool ambient air and exhaust of hot air. When the outdoor temperature, humidity, and air velocity meet the preset criteria for a comfortable natural ambience, the automatic operation system will be activated to turn off the air-conditioning and open the windows. Natural ventilation is usually provided during spring and autumn. The resulting annual operation hours of natural ventilation are about 582, contributing to 13.3% of the total operation time of the shopping mall.

建築系統上的可持續性

幕牆的玻璃面板是由兩塊玻璃和中間空隙組成的 IGU（中空玻璃），有隔離和降低吸收熱能的優點。幕牆裝置中空玻璃，有助減少使用空調，同時保持吸收自然光，減少使用人工照明。幕牆的設計連接到混合通風的建築管理系統，可用開啟的窗戶攝入冷卻的鮮風和排除熱空氣。當室外溫度、濕度和空氣流速達到舒適的預定標準，自動作業系統將啟動去關閉空調和打開窗戶。自然通風通常是在溫和的春季和秋季提供。每年的自然通風時間約為 582 小時，為商場運營時間的 13.3%。

The use of an MDF panel for the spandrel design

Bird's-eye view of the Domain Mall

Water conservation

Condensate water collected from the air-conditioning system is used for irrigation of landscaped areas. The air-conditioning system per day can irrigate 8,700 m^2 of green area. The estimated cost savings for water consumption is around HK$19,000 per year.

節約用水

從空調（A/C）系統所收集的冷凝水會用於景觀區的灌溉。空調系統每天可以澆灌 8,700 平方米的綠化面積，每年節省用水的成本估計約為港幣 19,000 元。

Reuse of kitchen waste

Pulpers were installed in the refuse storage and materials recovery room from the first floor to the third floor of the shopping mall. Kitchen waste is collected regularly by the food-waste pulping system and delivered to a laboratory for manufacturing of spent mushroom compost (SMC). The SMC is then transported back to the PTI area of the shopping mall, growing in panels to improve the air quality in the PTI.

廚餘回收

碎漿機安裝在購物中心第 2 至 4 層的垃圾及物料回收房。廚餘垃圾由廚餘垃圾回收系統定期收集，並提供給實驗室製造蘑菇堆肥（SMC）。堆肥會運回商場公共運輸交匯處生長面板上，以改善該處的空氣質素。

Solar light tube system and solar panels

As a device to harness day lighting, the solar light tube system captures natural light for the toilets located below the roof garden. Also, solar panels are used to generate hot water for the baby care room in the shopping mall.

This project has set a very good example for commercial buildings to promote the concept of sustainability to the general public. As the shopping mall has a close relationship with the community, the architect and the interior designer put great effort into the public area to show environmental awareness in order to educate our next generation. And in return, the concept of sustainability makes this mall standout from ordinary shopping centres.

太陽光管系統和太陽能光伏板

作為一個利用日光的設備，太陽光管系統既為位於屋頂花園下方的廁所捕捉自然光，也為購物中心的育嬰室產生熱水。作為一個商場項目，能落實可持續的概念，能大大提升商場的層次。建築師及室內設計師也著重於公眾地方，展示及推廣環保意識給社區人士，讓他們更加留意可持續的概念，並以此教育下一代。

Chapter 4

Drawing Practices: From Design Sketches to Tender Drawings

從草圖到招標圖

Kee Yee Chun, Tris 祁宜臻

> I prefer drawing to talking. Drawing is faster, and leaves less room for lies.
>
> — Le Corbusier

Drawings are the fundamental tools for architects to communicate. This communication exists on multiple hierarchical levels, ranging from that between architects and clients, architects and contractors, to contractors and suppliers. At the very gestation stage of a design concept, the sketch is often the architect's first tool to explore different ideas. This earliest stage of concept formation is bounced back and forth, traced and retraced on the sketch papers—a fundamental way to communicate between the eye and the mind. When the architect begins to move from the initial conceptual stage to subsequent stages of built work, these drawings take on a completely different set of tones and voices. For instance, at the conception stage, drawings tend to be less technical and more poetic and impressionistic. The objective of these first drawings is to provide the client the opportunity to endorse a design direction from a decidedly emotional level.

> Drawings are the expressions of one's striving to reach the spirit of architecture.
>
> — Louis Kahn, 'Space and the Inspirations' (1967)

> 比起交談，我更喜歡繪畫。繪畫省時，且不會謊言連篇。
>
> —— 勒 • 柯比意 (Le Corbusier)

對建築師而言，繪畫是最基本的交流方式。建築師、客戶、供應商之間的溝通就是以圖像作交流的。建築師們在醞釀概念初期，亦常會將不同的想法速寫於草稿紙上。於是，畫紙上便會重複出現各個想法的雛形、概念演變以及再生的痕跡，這是逾越感官的一種基本交流方式。當建築師完成初期的概念創作，進而開始更深入設計時，這些繪圖所發揮的功能與作用，則大不一樣。舉個例子，概念初稿僅注重整體架構，構圖方面相對而言較抽象，欠缺細節的描繪。初期的繪圖旨在為客戶呈現設計概念的基本雛形，讓客戶釐定設計方向，因此，概念形成時期的繪圖相對而言較簡潔。

> 建築師均以繪圖及設計致力達到建築的精神。
>
> ——路易斯 • 康 (Louis Kahn), 'Space and the Inspirations' (1967)

The evolution of drawing practices

Today, the tradition of drawing on yellow sketch paper and tracing and retracing the master's work to develop a project has given way to contemporary digital design. Computer-aided tools have changed the culture and comprehension of architects' drawings in an unprecedented way. Three-dimensional modelling can be coupled with fabrication methods, so even tentative thoughts may appear to be rendered 'final'. These first drawings are meant to provide the client a means of cultivating the architect's ideas and spatial concepts. The craft and intelligence of executing new work is apparent in all drawing methods, whether generated by tedious hand tracing on vellum with technical ink pens and T-squares, or through the quick click of a computer mouse.

This chapter opens with discourse of the evolution and development of drawing practices. Through examples ranging from the old—construction drawings on vellum, personal sketchbook narratives, and abstract ink or

charcoal paintings—to the new, including sophisticated parametric-formulated geometries, the array of works shown here not only reflect how architectural works are conceived and perceived but showcase their diversity and beauty which transcend mere function to become art.

Though it is inevitable that the old modes of drawing have been more or less replaced, there remain a few practitioners who are reluctant to surrender their T-squares and triangles. Some find themselves nostalgic for the meditative intellectual spaces that open up as they trace lines on paper. Like a sculptor working on a piece of wood or a musician stringing an instrument, an architect can yield to the joy of developing thoughts through the act of drawing and find emotional peace in its slow emergence.

An architect's repetitive tracing and retracing of lines amounts to more than a mere transfer of information but is in and of itself a meditative indulgence into the plan, a kinaesthetic reviewing of information. The pen in the hands of an architect is not qualitatively different from wood in the hands of a sculptor or an instrument in the hand of a musician. The drawing takes repetition to perfection; hence, architects love to trace and retrace their sketches to perfect the scheme and channel the vision from mind to hand.

In his recent book *Why Architects Still Draw* (2014), Paolo Belardi, an architect and professor in the Department of Civil and Environmental Engineering at the University of Perugia, wrote 'drawing by hand is an active way of thinking'. In our era where drawing software and AutoCAD are widely available and 3D-scanners and GPS devices are so close at hand, the question is: why do architects still draw by hand? Here, Belardi offers an elegant and ardent case for the value of the organic relationship that drawing creates between the mind and the hand without shunning new digital media for design.

Belardi suggested that drawing is the holistic manifestation of a particular design. 'It is the paradox of the acorn: a project emerges from a drawing—even from a sketch, rough and inchoate—just as an oak tree emerges from an acorn. Citing examples not just from architecture but also from literature, chemistry, music, archaeology, and art' (Belardi 2014).

Belardi further argues that 'drawing is not a passive recording but a moment of invention pregnant with creative possibilities'. Over the centuries, architects' drawings have evolved in style and philosophy, from Piranesi's eclectic etchings (1720–1778), to the modernist approach of training architects to develop ideas through the very act of drawing. This approach, while 'modern', was actually developed as early as 1937 by Walter Gropius, who initiated the then new notion of using drawing as a focus to train architects in the pedagogical program for his modern paradigm of architectural education.

This chapter consciously chooses not to dive into the discourse that drawing is the underpinning principle of architectural education but rather the simplest way to digest discussion on the approach of setting out to draw from a simple sketch on vellum to a full set of production drawings.

Those who appreciate Kahn's preference for sketching on vellum and his devotion to repetition watch raptly as his squares shift, turn, and interact in countless forms of spatially orientated variation. In the chapter 'Drawn on Yellow Paper: Toward a Culture of Lingering' (Merrill 2010), Kahn explains his preference for the thinnest of yellow paper: 'this is like a painter's flag, for work in progress, that however detailed and elaborate that which is drawn upon it may be in fact, still "wet", in flux, subject to change, criticism, rejection.'

This chapter will not be a full survey, nor will it indulge in the history and culture of architectural design and drawings; rather, it offers an overview of

the development of a set of 'informed drawings' as well as things to consider when a beginner assumes the task of drawing. The discourse opens with the introduction of the various types of drawing and their trajectory, from the preparation of tender drawings, to detail drawings, and finally a set of construction drawings. The complete set of tender and construction drawings may convey similar information; however, depending on whether the drawings are intended for communication to potential tenderers or to the worker on site, they will cater to each accordingly. We would like to thank the architects who have contributed their drawings and images to this chapter as illustrations.

繪圖的進化史

將概念繪於黃色素描紙上不斷進行修改、潤飾的傳統設計方式，已不復存在，取而代之的是當今新興的各類電腦設計軟件。這些新興的電腦設計工具以前所未有的方式，改變了建築師們對於繪圖的理解及實踐。三維立體模型配以加工法，能夠將臨時性的設計想法表達得相當精細，所呈現的設計圖已似最後成品。然而，即使新舊設計方式所採用的平台及工具有所不同，兩者都能培養建築師的概念及空間感。不論是用專業墨水筆和丁字尺，不厭其煩地在牛皮紙上慢慢勾勒，還是簡便快捷地輕按電腦滑鼠，都能夠將創作一份新作品的工藝及智慧，詮釋得淋漓盡致。

本章會介紹大量的案例，以講解繪圖的進化史，從舊式畫在牛皮紙、素描簿上，以及用水墨或炭筆作抽象畫，到新式基於標準參數以繪製幾何圖形。案例中所涉及到的一系列作品，不僅為大家講解了建築的構思及感知，且詮釋了建築作品的多樣性及美感，令建築昇華為藝術品。

儘管舊的繪圖模式無可避免會被取代，但仍然有少數從業者不願意擯棄丁字尺和三角板。在紙上繪圖能夠勾起懷舊的思緒，沉醉於設計的空間中，好像一位雕塑家努力雕琢一塊木頭，或是一位音樂家細心彈奏一件樂器。通過繪圖這個動作，一名建築師總能夠在構思概念的過程中找到樂趣，並在概念漸現的過程中，找到內心的滿足感。保羅 • 比拉迪（Paolo Belardi）是佩魯賈大學土木與環境工程系的教授，同時作為一名建築師的他於新書《為什麼建築師們仍然作畫》(2014）中這樣寫道：「手工繪圖是一種積極的思考方式。在當今繪圖軟件廣泛應用、三維掃描儀以及全球衛星定位裝置唾手可得的年代，我們該問的是為何建築師們仍然會選擇手工繪圖？」比拉迪認為繪圖是一種直接的方式，讓大腦向雙手傳達訊息，而不用迂迴地透過電子媒介表達設計意念。

比拉迪認為圖則可以表達設計的整體性。「這種設計的過程就像橡果悖論一樣有違常理：一個項目始於一張圖，甚至有可能是一幅粗糙的原始畫作，就好比一棵橡樹始於一顆小小的橡果。」（Belardi, 2014）所引述的例子不僅僅涵蓋了建築學，且包含文學、化學、音樂、考古學以及美術。

比拉迪進一步論證繪圖不是被動地將想法記錄下來，而是一種「創意的厚積薄發」。在過去的幾個世紀裏，我們見證著建築師們創造出一系列非凡的作品，從最早期皮拉內西（Piranesi）不拘一格的蝕刻版畫，到以現代主義形式訓練建築師的繪圖技術及思考方式。沃爾特 • 格羅佩斯（Walter Gropius）亦於 1937 年提出新的訓練建築師的方法，將繪圖作為現代建築學教育中的重點內容。

本章不會將重心放在「掌握繪圖技藝為建築教育的基本原則」這一話題上，而將著重探討由牛皮紙上的簡單素描，到最終完成的設計圖所採用的方法。

路易斯 • 康堅持在牛皮紙上重複地素描，在每個繪畫的角落變化著、互動著，以無數的組合嘗試不同的建築空間。在〈繪於黃紙上：走向勾留的文化〉一章中，路易斯 • 康這樣解釋他對最薄的黃紙的偏好：「未完工的作品，就好比是畫家的一面旗，不管該作品事實上已有多麼精細靈巧，它仍未『晾乾』，仍可改動，並隨時受制於外來的需求、批評甚至乎拋棄。」

一名建築師於畫紙上所勾勒出的原始線條，以及後期多次加工的痕跡，不僅僅傳遞著一種簡單的訊息，其創作本身便是一種認知的過程，一種對設計的深度反思。建築師手中的筆，從本質上相當於雕塑家手中的木頭，抑或是音樂家手中的樂器。熟能生巧，於是建築師鍾情於不斷修改和加工手中的繪圖，直至其完美。

本章的重點既非對建築繪圖史進行一場深入探索，亦非追溯其歷史與文化，而是提供針對一系列知情繪圖的概述，以及相關的初學者需知。

本章開篇會介紹不同類型的繪圖以及它們的製作方式，包括最初的招標圖則，到細節圖及最後的施工圖。一套完整的初期招標圖，則與最後的施工圖有可能非常相似，取決於圖則是否用於招標或施工參考。作者必須感謝為這章提供圖則和照片作插圖的建築師。

Tender drawings and contract documents

Built environments are often complex, involving many designers, planners, consultants, and contractors in different fields and multiple stages of operation. The documents defining the contract are also complex and need to be comprehensive to accommodate the diversified backgrounds of each specialist. The task of preparing them for tendering therefore requires close attention to detail and a uniformity of approach, so as to achieve a coherent set of documents, forming an unambiguous and manageable contract. Aside from a series of drawings, a typical set of documents needed for tendering include the following:

- general conditions
- site preliminaries
- instructions to tenderers
- general and particular conditions of contract
- specification
- bill of quantities
- tender and appendices

For the built industry, the tender is a formal invitation to suppliers to make an offer to the buyer for the supply of goods and services as set out in the specification document within the formal tender document. In architecture, a contract is the formal agreement between the client and the contractor; it states the various services and deliverables expected of the contractor within the requested timeline and the expected contract price.

Contracts form an important part of the materials needed in calling tenderers to submit for a construction project. In the built/construction industry, the contract is a legally binding agreement between two parties with respect to the obligations of each party to the other and the liabilities.

There are several components to the formation of a complete contract.

招標圖及合同文件

建築環境是一個相當複雜的概念，因其涉及多個階段、多個行業的不同設計師、規劃師、顧問及承包商。正因所涉及的行業眾多，合同文件的條文則變得相當複雜，所涵蓋的內容亦因此必須相當全面。為準備該合同，創建者與相關協助者需十分注重細節以及方案的統一性，方能成功完成一份合理、清晰、可行的合同。除了一系列的繪圖，一套典型的招標文件還需包括下列內容：

- 一般條款
- 地盤的基本資料
- 投標指引
- 一般以及特別合同條款
- 規格/詳細說明
- 工料清單
- 標書與附錄

對於建築業界來說，投標是一份正式邀請函，邀請各供應商為某商品或者服務競價，具體競價商品或服務，則記錄於正式投標文件中的規格/詳細說明中。對建築界來說，合同指的是客戶與承包商在指定時間內提供指定價格的服務。

合同在一個工程項目招標的整個過程中，扮演著一個非常重要的角色。建築業的合同為雙方針對責任與義務所制定的合法並具有約束力的協議。

一份完整的合同需包括以下部份。

Instructions to tenderers

Instructions to tenderers inform the contractor where and when to deliver the tender as well as information regarding guarantees, bonds, and issuance. They may also contain information regarding items that will be supplied by the employer and sources of materials to be used in the contract, as well as proposed methods for construction.

投標指引

投標指引詳細說明了承包商該於何時何地投標以及所需相關保證書、債券、保險等信息。指引中亦有可能同時包括僱主所提供的特定條件、所採用的具體材料以及預計的施工方案。

General and particular conditions of contract

The general conditions of the contract may include any of the forms of contract. These may be amendments or additions that the employer wishes to make to the standard conditions. Standard conditions are not usually reproduced in the tender documents but will be named by specific reference, and a schedule will show the changes that have been made to them.

Chapter 5

The Importance of Construction Specifications

施工規格的重要性

Wai Chui Chi, Rosman 衞翠芷

The role of specifications

Construction specifications are important documents that communicate the design intent of the architects and the engineers to the contractors. They are written descriptions of the project and are used to govern the quality performance of its construction works. The specifications, together with the agreement, conditions of contract, drawings, and the bills of quantities (BQs) in traditional design-tender-build projects, are major components of tender documents for bidding on the construction of projects. These documents will subsequently become contract documents for construction work after signing the agreement, which is the contractual agreement between client and contractor that the former will pay the contract sum when the latter performs the construction work as specified.

During the construction stage, specifications are essential documents for contract administration. The specifications spell out clearly the acceptance standards of the architect or the engineer on materials, workmanship, and other obligations under the contract. They are also important documents in determining any variations from the contract, measuring interim payments and imposing penalties for substandard work. In the final account stage, specifications provide a strong reference in ascertaining variation costs and claims, as well as settling disputes in contracts.

While drawings are graphic descriptions of the work to be performed by the contractor, specifications are the text description of it, and the BQs detail the quantities and cost. These documents complement each other and are essential for the complete understanding of the work. Whenever there are discrepancies among these documents, the contractor should seek clarification from the architect or engineer, who will clarify his or her intention through the instructions of the architect or engineer.

施工規格的作用

施工規格是建築師和工程師用來傳達設計意圖予承建商的重要文件。它們是項目的文字描述，用以管理建築工程的質量。在傳統的設計－招標－建造項目的招標文件中，施工規格，連同協議、合同條件、建築圖紙和工程量清單，是投標文件的主要組成部份。而這些文件在業主與工程承建商簽署協議後，將成為合同文件。簽署協議，代表著業主承諾當承建商完成執行規定的建設工程後將支付合同款項。

在施工階段，施工規格是合同規管的必要文件。該規格註明了建築師或工程師對材料、工藝和一般須遵守規範的明確驗收標準。它們也是用來決定何為合同中的改動，和計算中期付款，以及當工程質量低於合同標準時，計算罰款款額的重要文件。在決算階段，施工規格更為確定合同中的變動成本及索賠，以及在解決合同爭端中，提供重要的參考。

圖紙是用圖像，而施工規格卻利用文字，向承建商描述合同裏的工程，至於工程量清單則詳盡地列出工程內有關材料與工藝所需要的數量和成本。這些文件對理解整個工程內容是相輔相成、缺一不可的。每當這些文件之間的資料有差異時，承建商須向建築師或工程師查明，讓他們透過建築師指示或工程師指示澄清設計的本意。

Format of specifications

Most common construction specifications used in Hong Kong are of the prescriptive type. Some may use the performance type of specifications, or a combination of both prescriptive-based and performance-based specifications. In the prescriptive specifications, all requirements of the work in materials, workmanship, and other obligations are specified in every detail. In the performance specifications, only the functional performance requirement of the completed work is specified, so the contractor is free to develop his or her own method to achieve the result. Prescriptive specifications give the architect or engineer more certainty of the final outcome of the construction and make process-control during the construction possible, but his or her knowledge of the construction activities is required when drafting the specifications. Performance specifications are more suitable for construction works that require the contractor's input in a portion of the design work, which is associated with construction technique, or works that call for the contractor's innovation in construction approach.

Different construction specifications are used for different contract types, including site investigation, site formation, foundation, superstructure, nominated subcontracts, etc. The specifications usually contain two parts: one is the general specifications, which are standard requirements and conditions of construction. They are usually used for all similar contracts in the same architectural or engineering firm. The other part is the particular specifications, which are specifications clauses particular to the contract works, and can take precedence over the general specifications.

施工規格的格式

在香港，最常使用的施工規格是規範類的。有些會使用工作性能類的規格，或集合規範類和工作性能類為基礎的規格。在規範類的規格中，材料、工藝和一般須遵守規範裏的所有要求，均詳細列明。然而，在工作性能類的規格裏，只須指明工程在完成時的工作性能要求，承建商可以自由地選擇自己的方法來完成工程。規範類的規格讓建築師或工程師更能掌握工程落成時的效果，並能控制施工過程，但它要求建築師或工程師對各項建築活動有所認識，才能起草施工規格。而工作性能類的規格，比較適合一些需要承建商投入與他們施工工藝相關的設計工作的項目，或一些要求承建商在施工技術方面有所創新的工程。

不同的合同類型會使用不同的施工規格，包括現場勘察、地盤平整、基礎、上層建築、指定分包合同等。施工規格通常包含兩個部份：第一部份是一般規格，這是一般標準的要求和建築條件。它們通常適用於同一建築或工程公司所有類似的合同。另一部份是特殊規格，這是特別為該工程合同訂定的規格條款。而特殊規格的要求是可以凌駕於一般規格的要求的。

Organization of specifications

Most of the specifications are arranged in sections by construction trade in the chronology of the works, but some specifications may be arranged by the building components, for example, windows and doors, in which all trades of the same components grouped together. Specifications arranged by trade is more

convenient for subcontractors of each trade to find their own work scope in the specifications. Arrangement by components has the merit of grouping all necessary trades in building the components, thus making it an easier reference for the manufacturers and subcontractors of the building components.

For specifications arranged by trade, both the general specifications and particular specifications are arranged according to the working sequence of building works on site. Take specifications for building works as an example. The typical arrangement of the various sections is as follows:

1. demolition
2. earthwork
3. concrete
4. masonry
5. structural steel
6. roofing
7. carpentry and joinery
8. ironmongery
9. curtain walls
10. metal works
11. finishes
12. sanitary appliances
13. glazing
14. painting
15. internal fittings and fixture
16. plumbing and drainage
17. landscape works

For complex projects, separate contracts are used for site formation, demolition, foundation works, interior decoration, and so on. Like the building contracts, the requirements for materials, workmanship, and other obligations of these contractors for the individual works are spelt out clearly in the specifications of these contracts. Similarly, the nominated subcontracts of the building service works, such as air-conditioning installation, fire services installation, water services installation, and electrical installation, will have their own specifications in each nominated subcontract.

施工規格的結構

大部份的施工規格，都是根據各建築行業在工程進度中出現的時序來編寫的。但有一些施工規格，則是使用建築構件來分類的，例如窗戶、門等，把所有製造該建築構件裏的各建築行業組合在一起來編寫。根據建築行業編寫的施工規格，有利於每一個行業的分包商，讓他們在施工規格裏更方便地找到自己的工作範圍；而使用建築構件來分類的施工規格，則方便那些建築構件製造商和分包商。

以建築行業為本編寫的施工規格，無論是一般施工規格或特殊施工規格，都會根據建築工程在現場工作的時序來編寫。以建築工程的施工規格為例，各部份的標準安排如下：

1. 拆卸
2. 土方
3. 混凝土
4. 石工

5. 結構鋼鐵
6. 屋頂
7. 木工和細木工
8. 小五金
9. 幕牆
10. 金屬
11. 塗飾
12. 潔具
13. 玻璃
14. 油漆
15. 內部配件及固定裝置
16. 給排水
17. 園景工程

對於複雜的工程項目，通常會把地盤平整、拆卸、基礎工程及室內裝修等工程，分開使用個別獨立的合同。但一如建築工程合同，這些合同也必須註明對材料、工藝和一般須遵守規範的要求。同樣，對於屋宇裝備的指定分包合同，如空調安裝、消防安裝、供水服務安裝、電器安裝等，也需要在每個指定分包合同中，列出個別的施工規格要求。

Preliminaries

In the common arrangement of the specifications, there is a section on preliminaries preceding the works sections mentioned above. The preliminaries give an introduction to the specifications, explaining the applicability in the contract and the meaning of the terms used. The main part of preliminaries is on the general obligations of the contractor, detailing his or her obligation in (1) taking care of the works and the site; (2) maintaining existing services, features, and trees; (3) maintaining the safety of the workers and the work on site; (4) avoiding any environmental nuisance to the surroundings; and (5) spelling out any special requirements on site personnel, contractor's submissions, materials, and workmanship in general. The preliminaries also specify requirements on any temporary works and services on site, including those of the access roads, site offices, hoardings, and scaffoldings. They also specify the contractor's obligation in providing attendance to all the nominated subcontractors, specialist contractors, government departments and utilities undertakings on site for completion of the work.

初步總覽

在常見的施工規格中，通常會在上述有關建築行業規格的前一章，編寫初步總覽，介紹該施工規格及其適用範圍，以及各名稱的定義。初步總覽的主要部份，是有關承建商一般須遵守的規範，包括：(1) 維護項目工程和工地；(2) 保護現有的公共服務，特別結構和樹木；(3) 保障工人和工程現場的安全；(4) 避免造成任何對周邊環境的滋擾；以及 (5) 指明對工地人員、承建商呈交方案、用料和工藝的任何特殊要求。初步總覽還指定工地上任何臨時工程和裝備的需求，包括那些進出道路、工地辦公室、圍板及棚架。此外，還規定了要協助所有指定分包商、專門承建商、政府部門和公用事業在工地現場上完成合同工程。

Contents of specifications

In writing the specifications, the following should be specified in each trade: (1) design requirements, (2) materials and submissions, (3) workmanship, and (4) testing and commissioning.

施工規格的內容

編寫施工規格時，各個行業中均需要規定下面各項，包括：(1) 設計要求；(2) 材料及方案呈交；(3) 工藝；(4) 測試和調試。

Design requirements

While the majority of the work is designed by the architect or the engineer, there are some items for which the contractor's design input is required to better suit his or her construction methods or where some specialist supplier's items are being used, such as precast façade, curtain walling, skylight, windows, kitchen cabinet, drywall partition, playground equipment, or shop front. In the specifications, the design parameters and the performance requirements of these items have to be stated. The contractor will be required to submit design drawings and a method statement for the installation for the architect or the engineer's approval.

Some of the design parameters, such as dimensional tolerances in construction, or wind loading requirements, or building services requirements for certain elements, have to be specified in the specifications to govern the quality of the contractor's construction product and the performance requirement during the construction process.

設計要求

雖然工程的主要部份是由建築師或工程師設計的，但亦有少部份項目是需要承建商協助設計，以配合他的施工方法，或是當使用一些專門供應商的產品時，例如：預製外牆、幕牆、天窗、窗戶、廚房櫥櫃、乾牆間隔、遊樂場設備、店面等。這些項目的設計參數和性能要求，都需要在施工規格裏予以說明。承建商亦須就該等項目提交設計圖紙和施工組織設計給建築師或工程師批核。

Table 5-1 Example of writing design requirements for structural concrete work
表5-1 編寫結構性混凝土設計要求的例子

DESIGN REQUIREMENTS

Loadings for design and construction

Design and construct formwork and falsework to withstand the worst combination of the following without causing bulging or deflection:

(i) Total weight of formwork, reinforcement, and wet concrete.
(ii) Construction loads, including dynamic effects of placing, compacting, and construction traffic.
(iii) Wind loads.

Extracted from Architectural Services Department (2012), *General Specification for Building 2012 Edition*. Retrieved 10 June 2017, from https://www.archsd.gov.hk/media/15041/e225.pdf.

摘自建築署（2012），《2012年版建築物的一般規格》。見https://www.archsd.gov.hk/media/15041/e225.pdf。瀏覽日期：2017年6月10日。

Chapter 6

The Vibrancy of Modular Integrated Construction

「組裝合成」建築法的動力

Choi Kam Lung, Franky 蔡錦龍

Introduction

The concept of capsule architecture—featuring habitable units that could be transported around the world like travelling suitcases in an era of advancing space technology—blossomed in the 1960s and 1970s. The ideas of modularization and mass production were further developed, and the project *Habitat* became a major exhibition at the 1967 Montreal World Exposition. It served as a pioneering demonstration project, consisting of 354 prefabricated concrete modular housing units of 17 feet 6 inches (W) × 38 feet 6 inches (L) × 10 feet (H) and weighing between 70 and 90 tons. After casting, each modular unit was completed with window frames, insulation, fixtures, kitchens, bathrooms, and then installed by crane (Expo 2025).

膠囊建築的概念在20世紀60至70年代太空技術迅速發展的時期興起，其居住單元可如行李箱般在全球範圍內運輸。模組化和大規模生產的概念進一步發展，其中「棲息地 Habitat」計劃成為1967年蒙特利爾世界博覽會的一大主題展覽。這是一個先鋒示範項目，共有354個預製混凝土模組化住房單元，每個單元尺寸為17尺6寸（寬）×38尺6寸（長）×10尺（高），重量介於70–90噸之間。模組在預製階段已完成窗框、隔熱材料、固定裝置、廚房、浴室等安裝，並以起重機進行現場組裝（Expo 2025）。

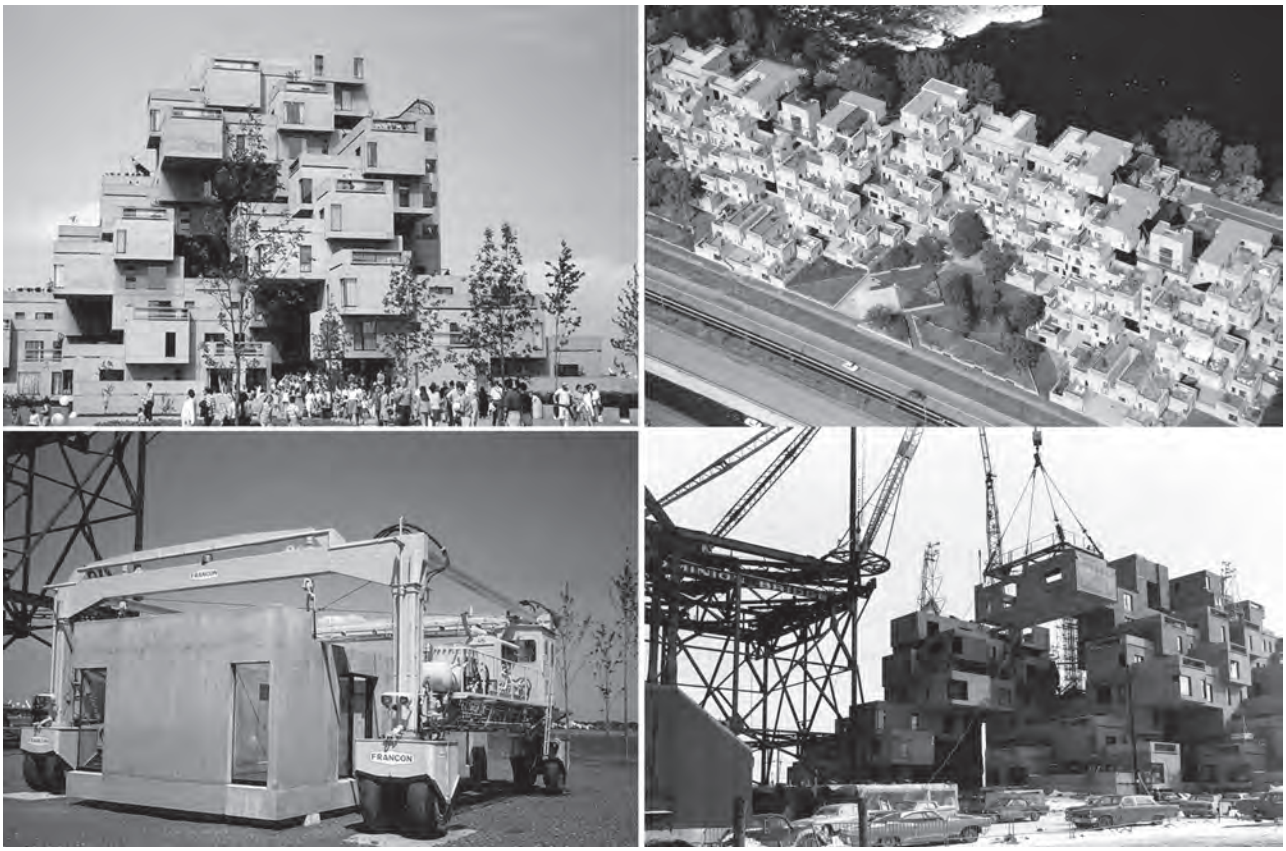


Figure 6.1: 'Habitat' outlook. Courtesy of Bill Cotter and Safdie Architects.

This concept of Modular Integrated Construction (MiC) is now flourishing in Hong Kong. The first building constructed using MiC in Hong Kong is the CIC MiC Resources Centre, completed in 2020, which serves as an exhibition venue for MiC technologies. The project comprises 10 MiC units and one prefabricated Fire Services Installation unit, with a gross floor area of approximately 335 square metres and a compact footprint of 14 m (W) × 17 m (L) × 9.8 m (H). The exhibits showcase construction technologies such as patented wall connection and module connection systems, Design for Manufacture and Assembly (DfMA) practices, and a Multi-trade Integrated Mechanical, Electrical and Plumbing (MiMEP) system commonly applied to chillers, generator sets, elevators, air handling units and switch boards. The centre also features MiC lift system, MiC tower crane machinery, lightweight concrete, and precast construction connection techniques (CIC 2020c).

「組裝合成」建築法（MiC）這一概念現已在香港蓬勃發展，香港首個採用 MiC 建造的項目是於2020年竣工的「組裝合成」建築法資源中心，用於展示 MiC 技術。該工程擁有10個 MiC 單元及1個預製消防裝置單元，總樓面面積約335平方米，組合單元佔地14 m（寬）×17 m（長）×9.8 m（高）。資源中心展示內容包括專利牆體連接和模組連接施工技術、「可供製造和裝配的設計」（DfMA）系統，以及「機電裝備合成法」（MiMEP）系統，涵蓋冷凍機、發電機、電梯、自動扶手梯、空氣處理機組、配電箱、MiC 升降系統、MiC 塔吊機械、輕質混凝土及預製建築連接等（CIC 2020c）。

With the exploration of adapting high-rise construction technologies to resolve various local externalities and the continuous strengthening of the supply chain in the Greater Bay Area, MiC has become increasingly applicable to Hong Kong's building industry and market, serving both public sector and private sector projects. Leveraging the prefabrication experience gained from external façade walls, staircases, and other construction components in public housing construction, the entire building industry is moving towards a revival of modulization with a high level of sophistication in unit delivery. The HKSAR Government stated:

Figure 6.2: CIC Resources Centre. Image by Franky Choi.

Figure 6.3: Patent wall connection, DfMA system, MiMEP system. Image by Franky Choi. Courtesy of CIMC Modular Building Systems Holding Co. Ltd., Hilti (Hong Kong) Ltd., Paul Y.–iMax Ltd., Wo Lee Green Solutions Ltd., and ATAL Engineering Ltd.

> The Government has been actively promoting the implementation of MiC since 2017, and mandated the adoption of MiC for designated buildings such as schools, dormitories, hospitals and office buildings under the Government's Capital Works Programme . . . The construction industry in Hong Kong is facing various challenges, including manpower shortage, declining productivity, high construction costs. To enhance the industry's productivity and cost effectiveness, the Government has been actively promoting the adoption of high productivity construction methods such as Modular Integrated Construction (MiC), Multi-trade Integrated Mechanical, Electrical and Plumbing (MiMEP). (HKSARG 2023)

隨著大灣區供應鏈的不斷成熟，以及利用高層建築技術解決各種本地外部性問題的探索，MiC 已逐漸應用於香港建築業和市場的公共和私人建築項目。憑藉在公共房屋外牆、樓梯和其他建築構件的預製經驗，整個建築業正復興模組化技術，朝向精細複雜的單元建造。香港特區政府表示：

> 政府自2017年起積極推展 MiC，並要求在政府基本工程計劃下指定的建築物，例如學校、宿舍、醫院和辦公大樓……香港建造業正面對人手不足、生產力下降、建造成本高等挑戰。政府積極推動業界採用高效建築，例如『組裝合成』建築法、『機電裝備合成法』等，以提升建造業的生產力和成本效益。(HKSARG 2023)

Figure 6.4: HKU Student Residence at Wong Chuk Hang outlook. Image by Franky Choi.

Chapter 7

Artificial Intelligence and Generative AI in Architecture

建築中的人工智能與生成式人工智能

Kee Yee Chun, Tris and Xie Jingxuan, Lila 祁宜臻、謝婧萱

From AI to Gen AI: A historical perspective

Artificial Intelligence (AI) has been transforming human behaviour since its introduction (Ertel 2024). AI can analyse big data, recognize patterns and make decisions based on input data to benefit many professions. In the Architecture, Engineering, and Construction (AEC) industry, AI offers unprecedented computational efficiency, creating new possibilities for a smarter and more resilient built environment and a sustainable construction paradigm (Rane 2023). Architects have leveraged AI-driven tools to optimize designs, utilizing predictive analytics to enhance project outcomes while automating mundane tasks, allowing teams to focus more on innovation and collaboration.

Initially theorized in the 1950s by Alan Turing and John McCarthy, AI rapidly advanced across various fields such as finance, medicine, and engineering (Rojas 2024). In the 1980s, early CAD-CAM systems enabled architects to achieve digital fabrication for complex geometries and design flexibility. Later, parametric design allowed for aesthetically pleasing forms using parameters and rules and optimized plans by 3D digital aggregation (ZamaniGoldeh et al. 2025). While early twenty-first-century AI had limitations in synthesizing large data and supporting real-time decision-making, the emergence of generative AI (Gen AI) and ChatGPT—driven by big data and enhanced computational power—has revolutionized the AEC industry. Gen AI offers generative design, real-time responsiveness, contextual intelligence, automatic optimization, and predictive analytics, ushering in a new era of efficiency, creativity, and sustainability.

從人工智能到生成式人工智能：歷史視角

人工智能（Artificial Intelligence, AI）自從面世以來，便悄然改變著人類的日常生活方式（Ertel 2024）。這項技術不只能分析龐大的數據、辨識複雜的模式，還能根據輸入的資料作出智能決策，從而提升各個專業領域的效率，讓工作變得更高效更有趣。在建築、工程及建造（Architecture, Engineering, and Construction, AEC）行業，人工智能帶來了前所未有的運算效率，讓我們能夠打造出更智能、更耐用的建築環境，同時也開拓了智能化和可持續建造的全新路徑（Rane 2023）。如今，建築師們廣泛應用人工智能驅動的工具來優化設計，透過預測分析提升項目成果，同時把那些單調的重複工作自動化，讓團隊能更專注於創新和合作，真正釋放出大家的創意潛力。

人工智能的概念最早是由艾倫 • 圖靈（Alan Turing）和約翰 • 麥卡錫（John McCarthy）於 1950 年代提出，隨後在各行各業迅速發展（Rojas 2024）。至 1980 年代，早期的電腦輔助設計與製造（CAD-CAM）技術問世，使複雜的幾何形態得以數碼化製造，從而開啟更具靈活性的設計方式。之後出現的參數化設計（parametric design）利用參數和規則，創造出美觀的形態，透過三維數碼聚合來優化各種方案（ZamaniGoldeh et al. 2025）。雖然在 21 世紀初，人工智能在處理大數據和即時決策方面還有些不足，但隨著大數據技術的進步和運算能力的提升，以及生成式人工智能（Generative AI, Gen AI）以及 ChatGPT（Chat Generative Pre-trained Transformer）的出現，AEC 行業迎來了革命性的改變。生成式人工智能不僅能實現生成設計（generative design），還提供即時反饋、情境智能（contextual intelligence）、自動優化，以及預測分析等功能，為 AEC 行業開創了一個充滿效率、創意和可持續性的新時代。

Gen AI in the built environment as a new frontier

Generative design is one of the earliest architectural applications of Gen AI. Architects use text-to-image algorithms to create innovative designs and uncover imperceptible trends. For instance, an architecture critic used AI to generate speculative designs for future Serpentine Pavilion, exploring how AI predicts trends through related images on social media, with outputs that were bizarrely intriguing (Ravenscroft 2022). Besides design, Gen AI can rapidly produce spatial mock-ups and diverse style renderings, accelerating plan assessment.

In construction, Gen AI enhances project planning, using machine-learning (ML) algorithms to automate routine tasks and predict risks such as delays, budget overruns, and safety incidents. In Hong Kong, Gen AI-powered path intelligence improves the speed and quality of 3D-printed modules for Modular Integrated Construction (MiC). During assembly, AI-assisted robotics boost productivity, address labour shortages, and enhance worker safety.

In facility management, Gen AI reinforces building operations and maintenance through powering smart building systems that predict maintenance needs and monitor equipment conditions, ensuring peak performance throughout the building life cycle.

生成式人工智能在建築環境中的應用：重新定義香港的建築前沿

以生成創意革新設計

香港作為一個高密度發展的城市，工程週期緊湊，可持續發展的要求又相當嚴格，這些因素共同塑造了我們獨特的建築環境。生成式人工智能為本地建築師帶來了強大的助力，不僅能突破土地資源短缺和專業人才青黃不接的困境，還能將設計創意推向全新的高度。

生成式人工智能最突出的優勢之一，就是它的生成設計能力。系統可以根據用戶設定的參數和規範（如空間限制、建材偏好或節能目標），自動產生各種各樣的設計方案。以香港的實際應用為例，建築師只需輸入本地嚴格的建築條例和地盤限制條件，生成式人工智能就能快速優化旺角高密度住宅的平面佈局，在滿足功能需求的同時，也兼顧建築美學和實用性。現在，像 DALL·E 和 Midjourney 這樣的人工智能工具，能即時生成逼真細膩的效果圖，將活化再利用設計無縫融入香港獨特都市景觀。這些文字轉圖像（text-to-image）技術，不僅突破了傳統設計的框架，還能從海量數據中挖掘出隱藏的設計趨勢。例如，在 2023 年倫敦蛇形畫廊展亭（Serpentine Pavilion）概念設計中，人工智能透過分析社交媒體上的數百萬張圖片，成功預測設計潮流，創造出既前衛又吸引人的建築形態（Ravinscroft 2022）。在香港，恒基兆業地產集團推出的「Realising Our New Central Harbourfront × AI 企劃」，同樣運用這項技術，邀請市民輸入創意提示詞（prompts），透過生成式人工智能將大眾的想像力轉化成具體的設計方案（恒基兆業地產有限公司 2023），這開創了公眾參與建築設計的全新模式。生成式人工智能還能深入分析社會文化變遷和用戶行為模式，精準把握客戶和社區的需求，推動真正以人為本的創新設計（Keytton 2023）。在昇華設計內涵的同時，這項技術也大大提升了設計效率，將傳統上需要數週的修改流程縮短到僅數小時，對香港這種快節奏的發展環境來說，實在是難得的助力。

以預測智能精簡建造流程

在 AEC 行業，生成式人工智能透過自動化那些常規的日常任務，並提前預防潛在風險，來大大提升整體效率。機器學習（Machine Learning, ML）演算法能深入分析歷史項目數據，預測出項目延誤、成本超支和安全事故等風險，這對經常面對颱風的香港來說特別實用。例如，人工智能可以幫助工程團隊提前準備臨時覆蓋物，防止土壤不穩，並在較乾燥的月份建議最佳挖掘工程的排期，從而有效減少像西九龍文化區這樣的大型項目的停工時間。

生成式人工智能也為「組裝合成」建築法（Modular Integrated Construction, MiC）帶來強大助力，幫助我們應對香港長久以來的房屋短缺問題。人工智能驅動的路徑智能（path intelligence）就是一個生動的典型應用——建築師和承建商能優化三維（3D）打印預製組件的精準度，促進精確裝配，將誤差降到最低並加快交付速度。人工智能驅動的機械人技術進一步提升現場生產力，有助解決長期專業人才短缺的問題，同時透過自動化危險任務來保護工人的安全。

以智能建築系統提升設施管理

除了設計和建造之外，生成式人工智能還能為智能建築系統優化設施的管理，讓日常運作變得更順暢和高效。在香港密集的高樓大廈裏，人工智能能夠實時監測設備的性能，提前預測維護需求，從而避免那些突如其來的故障，確保一切安全可靠。在辦公大樓群中，人工智能透過分析物聯網（Internet of Things, IoT）感測器的數據，優化供暖、通風及空調（HVAC）系統，降低能源消耗，這也完美配合了香港 2050 年碳中和的目標，讓我們的都市生活更環保、更舒適。人工智能系統還支援預測性維護（predictive maintenance），確保電梯或其他關鍵基礎設施在香港這種高壓的城市環境中可靠運作。

Benefits and drawbacks of Gen AI in architecture and built environment

Integrating Gen AI into the AEC industry offers numerous benefits. It accelerates conceptual development and iteration through rapid generation, as seen in Zaha Hadid Architects' use of Midjourney to develop design ideas (Barker 2023). AI analyses historical construction data to identify patterns such as frequent weather-related delays during excavation work and suggests preventive measures such as temporary covers to prevent soil instability. Gen AI visualization facilitates early collaboration in the BIM process by generating spatial mock-ups to communicate complex concepts and align stakeholders on shared objectives. Furthermore, Gen AI integrates sociocultural changes and user patterns to better interpret client and community needs, promoting human-centric designs (Keytton 2023). Additionally, AI enhances sustainability through energy consumption simulations and thermal performance optimization, improving energy efficiency and promoting the use of renewable resources.

However, Gen AI adoption faces challenges. Developing and deploying AI systems involves high software, hardware, and training costs, while insufficient funding may prevent many small- and medium-sized enterprises (SMEs) from handling the technical complexity of AI tools, creating a skills

gap and competitive disadvantages. Unregulated AI development and use raise legal and ethical concerns. Effective Gen AI relies on big data; thus, irresponsible data collection may compromise security. Training datasets built on copyrighted materials may also infringe intellectual property rights and cause inadvertent plagiarism. Besides, Gen AI outputs may include objectionable content, and strict regulations could reinforce interest in taboos (Baran 2023). Additionally, Gen AI may lack human-like creativity, as its designs often fail to capture nuanced understanding of human emotions, society, and culture that architects seek to empress.

推動生成式人工智能在 AEC 業界的未來：挑戰與解決方案

AEC 業界應用生成式人工智能的挑戰

雖然生成式人工智能為香港 AEC 行業帶來了極大的革新潛力，但實際應用起來還是會遇到不少挑戰，尤其是對香港這個競爭激烈的市場中，那些充滿活力的中小型企業（Small and Medium-Sized Enterprises, SMEs）來說，這些障礙往往讓人感到有點棘手。

財務限制就是最先碰到的難題。開發和部署生成式人工智能系統，需要投入大量資金去購買高性能運算硬件、專有軟件許可證，以及專業培訓計劃。小型建築事務所可能根本負擔不起這些昂貴的人工智能工具，還有將它們融入現有工作流程所需的培訓，這無形中會拉大他們與大型企業的差距，讓競爭變得更不公平。資金短缺再加上香港高昂的營運成本，更進一步阻礙了中小型企業掌握這些複雜的人工智能工具，結果導致技能缺口擴大，壓抑了原本該有的創新活力。

法律和倫理問題也讓這一切變得更具挑戰性。生成式人工智能依賴大量數據，這自然帶來數據隱私的隱憂，我們必須嚴格遵守香港《個人資料（私隱）條例》對數據處理的規範，以保護每個人的權益。不當的數據收集，比如從本地建築數據集隨意取用未經審查的項目資料，就可能引發數據洩露，損害客戶的信任，讓合作關係變得尷尬。另外，生成式人工智能的訓練數據往往基於受版權保護的建築圖則或效果圖，這就有機會不小心侵犯知識產權，讓創作者感到不公。而且，生成式人工智能的輸出有時會意外包含一些令人反感的內容，而嚴格法規或強化對禁忌題材的興趣（Baran 2023）。更麻煩的是，它很難捕捉人類的情感和文化背景，所以創造出的設計可能缺乏文化敏感度，例如某些形態（如中銀大廈）無意中違背了香港的風水原則，讓人覺得不合時宜。這就引發了一個關鍵問題：作為香港建築師，我們該如何確保生成式人工智能真正尊重我們獨特的本地文化和監管環境，讓科技成為助力而不是障礙？

Future recommendations for AI in the built environment

To fully realize AI's potential in the AEC industry, governments and industry organizations must lead the effort. Incentives, standardization, and a supportive environment are essential for legal AI innovation and proper AI use. In the long term, universities and institutions should invest in education and training—such as offering AI-related courses and certification programmes—to bridge skills gaps and enhance the AI literacy of the future workforce. Moreover, a sound governance body should supervise ethical AI use by promoting transparency, fairness, and accountability, and clearer regulations for data privacy and algorithmic integrity.

BUILDING MATERIALS AND TECHNOLOGY IN HONG KONG

EXPANDED SECOND EDITION

香港建築技術及應用

第二版

This book is a thorough documentation of tectonics in the Hong Kong construction industry. It looks at how buildings have been designed and built in a high-density city in a subtropical climate. Written in both Chinese and English, it covers almost all aspects of building materials and technology in Hong Kong with a succinct sequence that follows the construction process of a building project. Providing invaluable information on the application of building materials and technology, case studies bring together 18 local projects that embrace a wide range of building types: single-storey buildings and high-rise towers; private developments and public institutional constructions; offices and residences. In addition to introducing new case studies, this expanded second edition presents modular integrated construction, or prefabricated units, and demonstrates how pilot projects have enhanced the efficiency and quality of construction of cross-border developments. This edition also explores the future use of AI tools in design and building information modelling, as well as operations and management throughout the building life cycle.

Building Materials and Technology in Hong Kong is an indispensable reference for students in architecture, surveying, and construction, as well as professionals and practitioners involved in building design and construction.

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Architecture /
Construction Engineering /
Methods & Materials

ISBN 978-988-8946-90-7

9 789888 946907

香港大學出版社
HONG KONG UNIVERSITY PRESS

https://hkupress.hku.hk

Printed and bound in Hong Kong, China