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應用香港預製組件工場及預製組件的可能性之報告

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報告摘要

鑑於使用預製建築的趨勢日益增加，建造業議會的環境專責委員會已聘請奧雅納工程顧問（奧雅納香港）研究在香港使用預製構件的使用可行　性。為確定在香港設立預製場的對技術可行性和經濟合理性進行可行性分析。

可行性報告分析了香港的預製及其組件的使用歷史及發展（即在建築工地外的預製場，廠房，工廠或其他地方製造建築構件，然後運往建築地盤進行組裝）並對比日本和新加坡的先進做法。

雖然在 20 世紀 70 年代至 90 年代初期，香港的預製場已經存在，但所有的預製混凝土構件的都工廠都已向北上到中國內地。　目前，只有兩個政府批准的生產鋼筋的預製場仍在香港運作。

隨著技術的進步，以及熟練勞動力的短缺，對效率和質量的需求以及對預製構件的需求，新加坡政府採取了許多措施來促進預製件在開發中的應用。這些包括：

- 在住宅/商業項目開發中設置土地銷售條件以使用預製構件;
- 建立法定委員會，以發展和規範新加坡的建築業（即提高建築生產率和工藝）; 和
- 以低於市場價格的預製件製造商提供集成建築和預製中心（ICPH）。

目前，有 5 家製造商應用 ICPH 系統生產預製混凝土和結構鋼部件和模塊。

為了確定在沒有擬議預製場初步設計的情況下在香港設立預製場的初步基礎案例，我們利用在新加坡經營的若干可比製造商的現有規模和規模作為得出參數，例如佔地面積（GFA）及其碼頭設計和運營的生產能力。

根據“基準”的分析，假设已經得到一塊平均 19,000 平方米的土地面積，28,000 平方米的建築面積，年產 277,200 噸預製混凝土構件。 這些初步數字用於進一步確定香港可能建立的場地。

考慮到所需的土地面積，空間要求，法定規劃，運輸和環境因素，屯門 40 區被選為一個有利的地點，作為提出製造場地的例子進行參考。

就屯門第 40 區而言，可行性研究的基本情況為土地面積為 19,000 平方米，發展潛力為建築面積 33,500 平方米，相當於每年生產 331,650 噸預製鋼筋混凝土構件/模塊。

可行性研究基於預製鋼筋混凝土構件的使用。

為了確定預製鋼筋混凝土構件的未來需求，對住宅和商業房產的未來供應進行了研究和分析，以滿足對製造場地基礎案例預製構件的需求。

房屋供應預測是根據多項因素和香港政府公佈的數字估算的，包括香港的人口增長，住房類型，公共租賃住房申請數量，每年生產的公共住房單位數量

以及香港政府的土地供應情況。 為了進行分析，我們為 5 年的預測進行分析，2017 - 2021 年的住房供應總量預測約為 193,900 套（公共住房 97,200 套， 私人住宅發展 96,700 套）。

根據住房供應預測，估計可用於公屋和私人住宅發展的預製鋼筋混凝土構件/模塊的數量。 就公屋而言，我們從葵涌邨的一個試驗計劃獲得每層所用的預製混凝土構件總數及以噸計的重量。 我們使用這些數據並分析了平均住房項目每單位用預製混凝土構件的噸數約為混凝土總體積的 20%作為平均數字。

對於私人住宅開發，過往資料只有外牆構件是預製的，其中外牆相當於總建築面積的 1%。 公共住房和私人住宅單位 5 年（2017-2021）對預製鋼筋混凝土構件的預計需求量為 2,680,741 噸。 估計對住房預製構件的需求與基準測量工作所規定的每年預製場的估計生產力大致相同。

為了確定在香港進行預製場地開發的行業可行性，我們開展了初步的財務分析，研究了三（3）種情景（即工場業主，製造公司和場地所有者/製造公 司）。 財務分析基於高層級的分析方法，為每個方案開展財務模型。 因此， 為每個情況確定了基於淨現值（NPV）和名義價值的現金流量，資本成本， 運營成本和收入。

財務評估表明，對於基礎案例 1，工場業主（即工場業主購買土地和建造場地設施出租給製造公司進行操作）和基礎案例 3（即工場業主購買土地，建造場地和經營設施）不具備獨立的財務可行性。 只有基礎例 2，製造公司從預製場所有者租用庭院設施可以產生 10%的內部收益率（即 IRR）。 基於 10%的內部收益率，假設擁有符合當前市場租金的可用設備，製造業務是具有可行性的。

因此，對於預製構件的潛在需求以及製造公司租賃和運營預製場地的基本情況，在香港開發本地預製場地項目是具有可行性的。

1 簡介

1.1 背景

鑒於預製施工法及模組施工法在世界上的使用呈上升趨勢，因此建造業議會環境專責委員會聘請奧雅納工程顧问（奧雅納香港）進一步探索更廣泛應用預製施工法及模組施工法的可行性，以改善香港建築行業的生產力及可持續發展（本顧問服務）。

1.2 調查報告

本研究旨在在建造業議會於 2017 年 9 月發佈的「應用預製組件工場的可能性之調查—調查報告」（調查報告）的調查結果基礎上進一步延伸。調查報告中建議進一步研究的關鍵領域包括：

- 量化潛在需求，證明對本地預製組件工場的發展投入資源屬合理；
- 探索發展本地預製組件工場的基本要素，包括在香港經營預製組件廠所需的土地供應、技術要求、相關人才等；及
- 調查對本地現有勞工市場的影響。

1.3 可行性報告

根據諮詢服務的工作簡要範圍，與報告章節有關的研究目標如下：

條款	描述	報告章節
3.1(a)	確定在香港提議建立混凝土預製組件工場之可能性的要求和研究	4、5、6、7、9
3.1(b)	對比在香港境外建立混凝土預製組件工場，找出在香港建立預製組件工場的利弊	2、3、10
3.1(c)	列出混凝土預製組件工場的可行位置的標準	4、5
3.1(d)	探索在現場及在混凝土預製組件工場內採用更多技術和機械的機會	3、9.2
3.1(e)	評估將現場工作轉移至預製組件工場所節省的人力	9.1
3.1(f)	確定在預製組件工場中獲提供的任何設施以改善工作環境	9.4

條款	描述	報告章節
3.1(g)	研究在建築項目的整個價值鏈中採用預製施工法所需技能組合的任何變更	9.3
3.1(h)	透過舉辦利益相關者參與論壇及單獨進行採訪，諮詢利益相關者的意見並獲取信息	10
3.1(i)	準備可量化的及科學的理據來證明研究結論	7、8
2.6	研究製造及裝配設計（DfMA）的可行性，並確定哪個行業將最容易接受該模式改變	9.5

基於上述研究目標，研究報告分為十個章節，包含以下主題：

章節	描述
1	簡介
2	香港預製行業
3	其他國家預製行業
4	「初步基礎案例」的定義
5	可能工地的評估
6	「基礎案例」的定義
7	行業可行性的初步分析
8	需求分析
9	其他考慮因素
10	採訪及利益相關者論壇得出的主要調查結論

2 香港預製行業

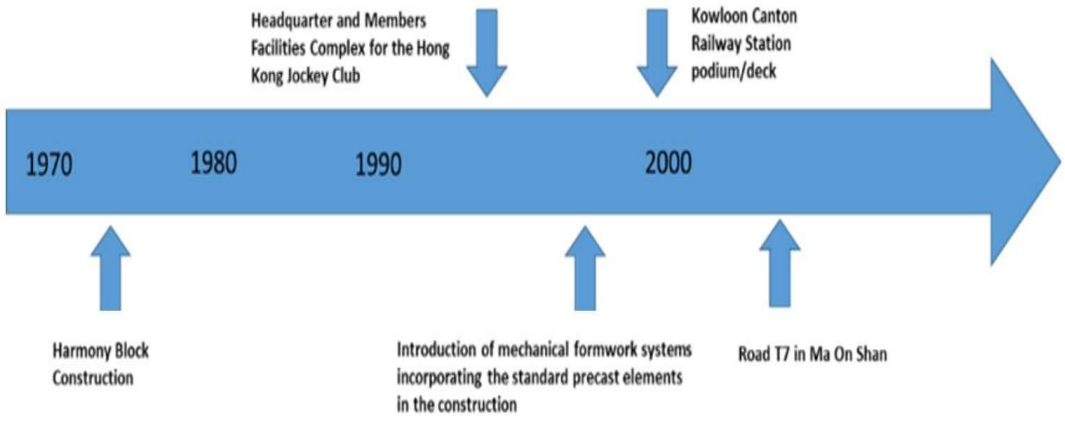
本報告章節描述香港預製行業（即在建築工地以外的工場、廠房、工廠或其他地方製造建築組件，然後運輸到建築工地進行裝配）的歷史及發展。

2.1 背景及當前狀況

預製技術在香港的使用可以追溯至 20 世紀 70 年代初，但直到 20 世紀 80 年代，建築業才大量採用預製組件。

預製建築中採用的最常用材料是混凝土、鋼材及木材。使用混凝土及鋼材（尤其是混凝土）的預製組件在香港最受歡迎。

下圖概述了預製施工法在香港的演變[1]。



[1] 資料來源：Raymond Wong，香港城市大學 Prefabrication Construction Practices（預製建築實務）Archive on Urban Studies and General Education related Studies（關於城市研究和通識教育相關研究的檔案）

預製組件在香港應用的演變進一步闡述如下：

20 世紀 70 年代 – 20 世紀 90 年代	香港使用預製技術的歷史可以追溯至 20 世紀 70 年代初，儘管當時推行了部分試驗項目，但直到 20 世紀 80 年代，香港房屋委員會才在公屋項目中大量使用預製組件（包括梯段、樓板及副梁）。 此後，許多其他里程碑項目採用預製技術，例如香港賽馬會總部及九廣鐵路紅磡站平台擴建。 自 20 世紀 90 年代後期起，香港政府推出整批工程，採用半預製方法建造一系列學校，並在 21 世紀初使用類似預製施工技術建造一系列政府駐在所建築。 香港房屋政策中承諾每年新增 85,000 套住房單位，導致香港公屋需求大幅增加。 為適應公屋工程量的飛速增長以及為縮短施工期和工程時間，對預製組件的需求大幅增加。
2002 年以後	新指南[2]鼓勵使用預製外牆，為建築增添環保構件（樓面總面積除外），因此 2002 年以後預製外牆在住宅建築中的使用廣受歡迎。[3] 除住宅項目外，橋樑及鐵路項目通常亦使用預製組件以節省施工時間。 由於施工的複雜性，該等基建工程所需的預製組件通常更為明確。
當前狀況	2017 年，香港發展局宣佈，將以試點形式在香港科技園及香港大學採用預製技術建造學生及員工宿舍。[4] 香港科技園「創新斗室」項目料樓高 18 層，合共提供 500 個房間，包含健身房和多功能廳。工程預計於 2018 年動工，並於 2020 年竣工，估計成本為 8 億港元。[5]

2 Second Package of Incentives to Promote Green and Innovative Buildings（推廣環保及創新樓宇的第二批鼓勵措施），http://www.landsd.gov.hk/en/images/doc/JPN02_text.pdf
3 Prefabricated Construction Systems for Building and Civil works adopted in Hong Kong（香港採用的建築和土木工程的預製施工系統） - Raymond W M Wong
4 Hong Kong prefabricated home trials to be launched at HKU and Science and Technology Park（香港將在港大及科技園試推預製房屋）–《南華早報》– Kimmy Chung
5 InnoCell project eyed for Science Park（科技園興建「創新斗室」）–《英文虎報》– Ellen He 及 Michelle Li

儘管香港對預製組件的需求，但香港目前沒有混凝土預製組件工場，僅有兩家生產鋼筋的獲批准預製組件工場，即 SW Construction Limited 和 VSC Construction Steel Solutions Limited：

- SW Construction Limited（「紹榮鋼鐵」）

該公司 45 年來一直是首屈一指的鋼筋製造商及零售商，亦是香港唯一的軋鋼廠。紹榮鋼鐵的鋼廠位於香港屯門石角，為混凝土鋼筋提供熱軋鋼筋，以及提供非現場切割及彎曲服務，以確保預製鋼筋的可靠供應。除預製螺紋鋼生產外，公司還分別在油塘、青衣及屯門運營三個廢料場，提供廢料收集、加工及循環再用服務。[6]

- VSC Construction Steel Solutions Limited（「VSC」）

VSC Steel Processing Limited 與新加坡 NatSteel Holdings Pte.Ltd.的合資企業。VSC 是香港首家自動化螺紋鋼加工和裝配廠，亦是獲土木工程拓展署批准的供應商，其產品包括按精確規格生產的鋼筋和聯軸器。公司亦提供自動剪切、自動彎曲、鐙筋彎曲及完整的可追溯性標簽和識別等服務。[7]

2.2 香港使用的預製組件的類型

香港使用的預製組件的種類多種多樣，例如外牆、樓梯、水箱、牆壁、樓板、管道、風管等。請參閱下表，了解在香港常用的預製組件照片 。

預製外牆	預製樓梯
	

[6] 紹榮鋼鐵有限公司網站

[7] VSC Construction Steel Solutions Limited 網站

預製地面水箱 	**預製板間牆** 
半預製樓板 	**立體預製浴室** 
預製鋼鐵工程 	**預製管道工程** 
隧道組件 	**橋樑組件** 

2.3 使用預製組件的優缺點

預製組件作為一種施工方法，其應用具有優點及局限性。與國外進口的預製組件相比，在本地採購預製組件亦有利弊。

2.3.1 預製組件的安裝與傳統施工方法的對比[8,9,10,11,12]:

2.3.1.1 優點

施工中使用預製組件有很多優點，例如：

1. 縮短工期，減少勞工人數

   由於預製組件可在施工期開始前在工廠由自动化系统製造，因此可縮短施工期，並可利用自動化系統減少所需的勞工人數。

2. 減少施工期間惡劣天氣的干擾

   預製組件在工廠環境中生產，施工不會因大多數天氣或季節性條件而中斷。例如，在雨天進行就地澆築時，由於水泥不能乾，混凝土鑄模無法完成，而在預製組件廠中，可透過鑄造預製混凝土磚解決該問題。

3. 標準化及機械化提高生產力，保證品質始終如一，達到極高的結構或建築標準

   與就地澆築施工相比，預製組件是在高度標準化及機械化的工廠環境下製造而成，因此生產效率更高、品質更好更穩定。與傳統施工相比，在工廠環境中生產的預製構件可以達到極高的結構或建築標準[13]。

4. 減少廢料量

   由於生產更加標準化，預製土磚可以在模具中澆注，多餘的材料可以重複使用，這將減少廢料量，從而降低生產成本。此外，工廠環境中的生產更精確，可減少所需原材料的數量，從而間接減少相關工廠的廢料， 如混凝土板和鋼板。例如，與傳統建築物相比，建造 T30 酒店僅產生 1% 的建築廢料[14]。這表明預製組件能在可持續發展建築中發揮重要作用。

[8] 加拿大按揭及住房公司（Canada Mortgage and Housing Corporation）
[9] 新加坡國家發展部（Ministry of National Development Singapore）
[10] 香港房屋委員會
[11] Prefabrication Construction Practices in Hong Kong（香港預製建築實務）- 香港城市大學
[12] 香港建造業議會
[13] 關於標準預製建築組件的參考指南，新加坡建設局
[14] Zhengdao Li、Geoffrey Qiping Shen 及 Mustafa Alshawi，Measuring the impact of prefabrication on construction waste reduction: an empirical study in Shenzhen, China（衡量預製對減少建築廢料的影響：中國深圳的一項實證研究）

5. 環境影響

   工廠生產亦可透過促進使用更優化的材料、循環再用、噪音捕獲、粉塵捕獲等，建造更環保的建築。

6. 工地安全

   在預製工廠工作的工人比在建築工地進行高空作業的工人更少發生事故。透過使用預製組件，可以減少工人進行高空作業的需求。此外，透過將 在工地工作的工人轉移到有遮蔽的工廠環境中，工作環境更優越，受天 氣的影響降低，來自機械人及電腦化機械的協助更有效。

2.3.1.2 局限性

儘管有上述優點，但使用預製組件仍存在一些缺點。這些缺點包括：

1. 運輸成本更高

   立體預製件的運輸成本可能高於其組分材料的運輸成本，組分材料通常在運輸過程中可以被更密集或高效地打包。

2. 安裝所需的重型起重機及機械

   由於模組單元（如預製浴室及預製樓梯）比傳統建築組件更重，體積更大，因此可能需要專門的機械及起重機進行現場安裝。

3. 存儲和裝卸成本

   在預製組件被運送到建築工地之前，它們需存儲在室內，以防止磨損及惡劣天氣的影響。預製件的存儲成本及裝卸成本尤應被考慮在內，在香港土地成本居高不下的情況下更是如此。然而，憑藉良好規劃，可最大限度減少存儲及裝卸需求，降低該成本。

4. 交通運輸限制

   在香港狹窄的街道內運輸體積較大的預製構件將會面對一些挑戰性。例 如車輛吊裝需要不超過道路表面 2.5 米寬、4.6 米高。所以在決定建設預製廠位置的時候需要詳細分析交通規劃，以及出產的預知件規格和重量。

與傳統施工方法相比，安裝預製組件的優點及局限性總結如下：

使用預製組件的優點	使用預製組件的局限性
加快施工時間，降低人工成本	運輸成本更高
不受天氣／季節性條件的影響	安裝預製組件需重型起重機和機械
標準化及機械化提高生產力及保證品質穩定	存儲及裝卸成本增加
廢料減少	交通運輸限制

使用預製組件的優點	使用預製組件的局限性
預製構件可達到極高的結構設計或建築設計標準	
更環保	
減少工地安全事故	

2.3.2 本地生產的預製組件與進口預製組件之比較[15]

2.3.2.1 優點

當比較本地生產的預製組件與進口預製組件時，本地產品的優點包括：

1. 降低運輸成本

   預製組件通常體積較大，從中國及其他國家運輸可能會很昂貴。如果在本地購買，可節省大量運輸成本。

2. 更好地監督及監測

   在本地完成品質控制讓人更放心，因為長時間運輸過程的損耗可被降至最低，當地承包商可監督品質檢查過程，以確保組件符合技術要求及本地設計標準。例如，如果組件在本地製造，本地工程師／質量保證人員可以在本地測試實驗室更好地測試及監測，免去長途奔波。

3. 減少運輸過程中的組件廢料

   在進口預製組件時，可能需要進行額外包裝以提供保護，部分預製組件在運輸途中因被損毀而可能在抵達時面目全非。使用本地預製組件可減少運輸造成的廢料。

4. 品質更穩定

   香港熟練工人深諳本地標準及細則，因此生產的產品品質更好及更穩定。

5. 提高本地勞工技術水平及加強培訓

   發展本地預製建築行業將會帶來本地對在工廠環境中工作的熟練勞工的需求。預製建築行業所需的熟練勞工需要掌握製造及建造技能。這可以鼓勵現有工人提高其對建造流程、技能及知識的認識。

[15] 在香港應用預製組件工場的可能性之調查 – 建造業議會

2.3.2.2 憂慮

另一方面，對使用本地生產的預製組件亦有一些憂慮，包括：

1. 更昂貴

   開展預製工程需要龐大的工作空間，這對寸土寸金的香港實屬挑戰，由於土地供應有限，因此租金成本可能很高。香港昂貴的租金成本及居高不下的勞工成本將不可避免地推升預製組件的價格。

2. 輔助行業水準低

   香港沒有任何運營的混凝土預製組件工場，因此輔助行業的水準可能較低，例如預製機械製造商及進口商。

3. 生產時間更長

   由於香港沒有任何運營的混凝土預製組件工場，新建的預製組件工場起　初可能比已運營良久的其他預製組件工場需要更長的時間才能全面投產。 因此，採用自動化系統可提高生產效率。

下表總結了使用本地預製組件的主要優缺點：

使用本地預製組件的優點	使用本地預製組件的缺點
降低運輸成本	由於土地成本及勞工成本更高，因此可能降低成本效益
更好地監督及監測	輔助行業水準低
減少運輸過程中的組件廢料	新建工場起初的生產時間更長
品質更穩定	
提高本地勞工技術水平及加強培訓	
減少檢驗及監督人員的差旅時間	

3 其他國家的預製實務

本部分概述了新加坡及日本等其他國家的預製實務。本研究之所以關注這兩個國家，是因為它們深諳預製組件的使用及製造。這兩個國家亦具有類似香港的特徵，例如土地供應有限及勞工技能／資歷。

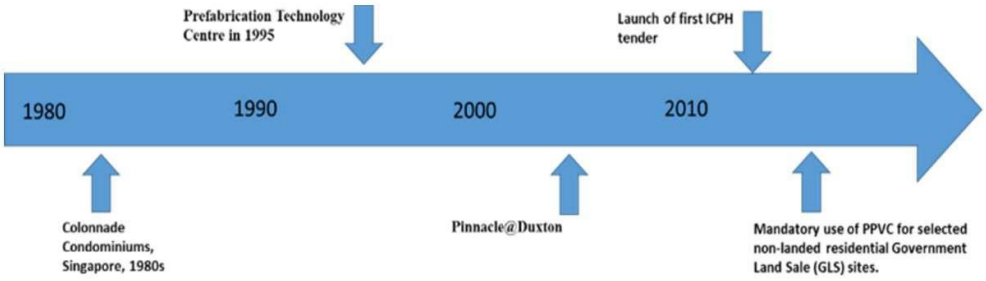
3.1 新加坡

3.1.1 背景及當前狀況[16]

新加坡預製廠的使用的問題可以作為標杆參考用以分析香港所面對的問題。例如勞動力成本的增加、人口老齡化以及土地本身的限制和高地價成本。

新加坡使用預知件的歷史可追溯至 20 世紀 70 年代。也是是東南亞第一個在建築行業中使用預製混凝土預製技術的國家。

下圖概述了新加坡預製行業發展的演變。



[16] 新加坡建設局（Building and Construction Authority of Singapore）

新加坡預製組件應用的演變進一步闡述如下：

20 世紀 70 年代 – 20 世紀 80 年代	新加坡是東南亞地區第一個在建築行業中使用預製混凝土預製技術的國家。 在 20 世紀 70 年代，採用傳統低效的就地澆築方法的承包商已不再能應付建築工程中的激增需求。 因此，新加坡建屋發展局（建屋局）於 20 世紀 80 年代在公共房屋中設立工業化計劃，以鼓勵該行業使用更高效的創新建築技術。 第一個預製工程是在後港、淡濱尼及義順建造三房式及四房式住宅單位，建屋局在 1981 年至 1983 年期間根據該項目向外國承包商授予五個重大合同。
20 世紀 90 年代	這五個工程竣工後，建屋局將重點從大規模工業化轉向小批量靈活預製。 這讓更多預製組件製造商（目前有 12 個）有了大展身手的機會，製造了各種各樣的組件。 到 1990 年，這 12 家製造商的總成交量佔新加坡建築業總額約 5%。儘管公共房屋仍是這些製造商的主要市場，但預製組件在私人發展項目中的使用卻在逐漸增加。 預製技術中心（PTC）於 1995 年成立，致力於發展及使用預製技術。該中心開展模型設計及實地技術測試，以培養發展日後大規模應用於建屋局房屋工程的新建造技術。 達士嶺組屋是一個實現工程學突破的發展項目的範例，因為幾乎整個 50 層建築是在工地外以模組施工法及預製施工法完成。
21 世紀後	新加坡建設局（建設局）於 1999 年成立，是新加坡政府國家發展部下設法定機構。 建設局的主要職責是發展及管理新加坡建築行業。 作為提高建築生產力及改善施工過程的計劃的一部分，建設局鼓勵建築業設計盡可能在受控的製造環境下在工地外開展工作的建造方式。 建設局與多家政府機構合作制定出一項總體規劃，在 30 年租期的土地上發展多樓層及高密度綜合建設預製樞紐（Integrated Construction and Precast Hub，簡稱 ICPH）。 截至 2017 年，建設局已為發展 ICPH 授出四項土地招標。2017 年 7 月啟動發展 ICPH 的第五項土地招標，於 2018 年 1 月截止招標。政府計劃到 2020 年建立 10 個此類樞紐。有關 ICPH 的更多詳情，請參閱創新／技術一節

3.1.2 創新與技術

為幫助解決新加坡勞動力短缺問題及提高建築行業的效率，新加坡政府大力推進預製施工及提高預製技術和自動化。

新加坡預製發展史上最重要的兩個里程碑是 PPVC（預製體積建設）及ICPH（綜合建設預製樞紐）。

3.1.3 預製體積建設[17]

什麼是 PPVC？

「預製體積建設」（PPVC）是根據任何認可的建造方法在經認可的建造設 施中進行構造和裝配組裝及／或製造和裝配的獨立立體模組（包括牆壁、地板及天花板批蕩），然後安裝在建築物中。

PPVC 的益處[18]

PPVC 應用於建築工程中有許多益處，包括提高生產力、減少工地內的人力、改善施工環境和提升品質控制等。詳情進一步闡述如下：

提高生產力	□ 建設局提出製造與裝配設計（DfMA）概念，以鼓勵盡可能多地在受控的製造環境中開展工地外的工作。PPVC 是支持 DfMA 概念以顯著加快施工進度的技術之一。 □ 使用 PPVC 可大大減少工地內的施工活動，PPVC 的建造可在工廠並行進行，而其他工地活動能同時開展以簡化施工過程。 □ PPVC 可提高生產力，省人力 40%，省時超 20%（視工程的複雜程度而定）[19]。
減少工地內的人力	□ 由於更多施工工作在工廠的受控環境下進行，因此工作場地的安全得以改善，在工地內進行高空作業的個人工時減少，從而導致事故降低和故障時間減少。
施工環境改善	□ 在工廠環境下進行的工地外的活動可最大程度減少灰塵及噪音污染，並降低對環境的影響。 □ 施工期間對周圍街區的負面影響減少。 □ 透過建築模組的預製，工地內及運輸途中產生的廢料減少
提升品質控制	□ PPVC 提供來自受控工廠環境的大部分最終產品，使可靠性增強，加工品質更高。

[17] 新加坡建設局
[18] PPVC 指南 - 新加坡建設局
[19] PPVC 指南 - 新加坡建設局

PPVC 的強制使用

自 2014 年 11 月 1 日起，新加坡的指定非有地住宅政府賣地地盤必須使用預製體積建設（PPVC）。強制性規定的詳情隨附於附錄 A。

3.1.4 綜合建設預製樞紐[20]

為鼓勵建築行業提高生產力，新加坡建設局與多家政府機構合作制定一個總體規劃，用於在 30 年租期的地塊上開發多樓層及更高密度的綜合建設預製樞紐（ICPH）並大量使用機械和自動化系統。

ICPH 的活動包括：

a. 個別組件的預製

b. 綜合局部裝配組件的預製；及／或

c. 預製體積建設（PPVC）

背景

2013 年，建設局宣佈透過公開招標，批准在加基武吉發展首個 ICPH。新 ICPH 竣工後，預計將配備最先進的自動化生產線，該生產線將擁有製造超過 100,000 立方米預製組件的年產能（比傳統露天預製工場多三倍）。

截至 2017 年底，建設局透過 GeBIZ（一個管理政府接收的所有公開招標的網上平台）授出發展 ICPH 的四項土地招標。發展 ICPH 的第五項土地招標於 2017 年 7 月啟動，於 2018 年 1 月截止招標 — 政府採購門戶。

有關過往招標的資料包括：

招標開始日期	批出標書日期	地點	地盤面積 (m^2)	最高總地積比率	中標者	投標價
2012 年 5 月 16 日	2013 年 2 月 28 日	加基武吉路 6 號（KB 1 及 KB 2）	20,385	1.6	SEF Construction Pte Ltd	每月土地面積 $4.30/$m^2$
2013 年 7 月 31 日	2014 年 6 月 16 日		20,051	1.6	海峽建築新加坡私人有限公司	$12,000,000（總價）
2014 年 10 月 30 日	2015 年 9 月 21 日	機場路（(Defu 1 及 Defu 2)	20,411	1.6	Soil-Build (Pte) Ltd	$22,889,000（總價）
2015 年 1 月 30 日	2016 年 5 月 12 日		20,410	1.6	Teambuild Engineering & Construction (Pte) Ltd	$16,800,000（總價）

ICPH 批出的標書

獲得 ICPH 地塊之一的四名中標者的摘要包括：

[20] 新加坡建設局

SEF SpaceHub	SEF Construction Pte Ltd.的 SEF SpaceHub 是首個開工的項目，其於 2013 年動工，佔地 20,000 平方米，建築面積達 32,000 平方米，擁有 5 條預製混凝土組件自動化生產線。 發展項目擁有亞洲首個高架自動化堆場來存儲成品預製組件，從而最大限度提高土地利用率。[21]
Greyform Pte Ltd	Greyform Pte Ltd 是海峽建築新加坡私人有限公司的一家成員公司，於 2015 年註冊成立。該公司是第二家在受控工廠環境中進行自動化生產的公司，只需相當少的人手即可管理工廠。該發展項目的成本約為 1.5 億新元。 樞紐僅有 60 名工人，10 天即可生產 48 個四房式建屋局住宅單位，所用時間是傳統露天工場預製設施的一半。[22] 樞紐的關鍵功能包括自動託盤循環、自動機械人鑄型、鋼筋預製及自動預製存儲。[23]
Soil-Build Pte Ltd.[24]	Soil-Build Pte Ltd.是 Soilbuild Construction Group Ltd.的全資附屬公司，在建設局於機場路的 ICPH 招標中中標。 土地面積約為 20,400 平方米，租期為 30 年，自 2015 年 9 月起生效。租賃總代價約為 2,600 萬新加坡元。 建築包括綜合預製樞紐的工廠、行政辦公室及工人宿舍，計劃於 2017 年第四季度開始運營
Teambuild Engineering & Construction Pte Ltd[25]	Teambuild 在雅尚苑共管公寓項目上採用了混凝土 PPVC；是首個採用 PPVC 的私人住宅項目。Teambuild 亦著手發展及建造自身的 ICPH。 ICPH 是生產預製建築構件的多樓層先進製造設施，將配備自動化及集成的生產、存儲及貨架系統。這將有利於本地 PPVC 模組的發展及製造，減少運輸並進一步削減所需的人力。

[21] SEF Construction Pte Ltd.網站

[22] 新加坡报业控股，《海峽時報》，建設局就建設需要高水平預製組件的工程發出事先通知

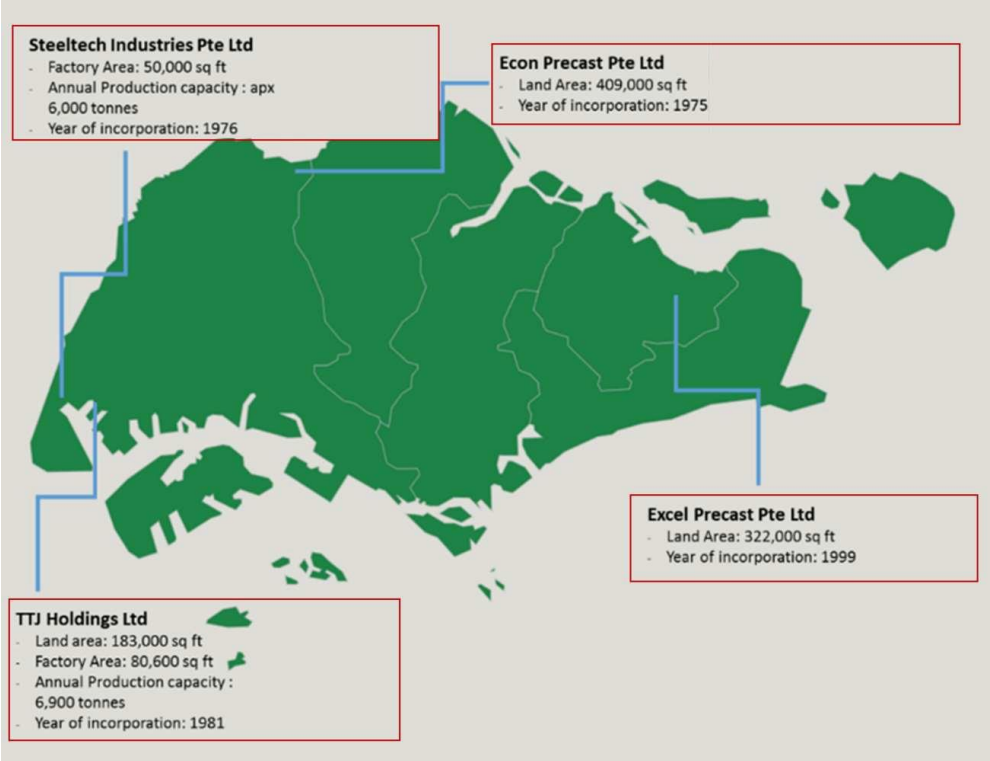
[23] 新加坡建設局

[24] Soilbuild Construction Group 新聞稿

[25] 新加坡建設局

3.1.5 新加坡首屈□指的預製件製造商[26]

新加坡首屈一指的部分預製件製造商包括 Steeltech Industries Pte Ltd、Econ Precast Pte Ltd、Excel Precast Pte Ltd 及 TTJ Holdings Ltd。這些公司的所在地參見以下地圖。



這些領先製造商的概要如下文詳述。

TTJ Holdings Limited[27]	TTJ Holdings Limited 於 1981 年註冊成立，是一家結構鋼專業公司，提供各種結構鋼材的設計、供應、製造及搭建，以用於建築、工廠、廠房及基建工程的建造。 公司在新加坡及中東贏得許多標誌性工程，包括樟宜機場 3 號航站樓、達士嶺組屋、新加坡新最高法院、濱海灣雙螺旋雙相不銹鋼橋、巴林世貿中心雙子塔，以及迪拜塔發展地塊 12 & 13。 公司目前有兩個預製組件工場，包括新加坡的 Pioneer Factory 和馬來西亞柔佛州的 Keluli Factory，其土地面積分別約 17,000 平方米及 86,198 平方米。這些設施當前的合共最大年產能為

[26] 資料來源：Steeltech Industries Pte Ltd 網站、TTJ Holdings Limited 網站、Excel Precast Pte Ltd 網站、Econ Precast Pte Ltd 網站、Seterra Online

[27] TTJ Holdings Limited 網站

	42,000 噸，使 TTJ Holdings Limited 成為新加坡最大的獨立結構鋼建造商之一。 公司的生產範圍廣泛，從重型起重機、海運平台、流體處理設備的管道系統，到高層建築構築物、石化綜合體、重型屋架、防空洞門、鋼模，以及橋樑和高速公路吊梁機、壓力船和水箱、鋁質防撞欄、高速公路和道路的伸縮縫和軸承。
Steeltech Industries Pte Ltd[28]	Steeltech Industries Pte Ltd 是長成工程私人有限公司的一家全資附屬公司，於 1976 年以 Tiong Seng Equipments Pte Ltd 的名義註冊成立。2005 年，公司員工僅有 12 人，目前擴大到超過 220 人（包括內部分包商）。公司參與了嘉佩樂酒店（聖淘沙島）、濱海灣度假村、聖淘沙名勝世界、皇家公園（皮克林街）、花拉路地鐵站、加利谷地鐵站及 Draycott Drive 等工程。 工廠位於新加坡 Tuas Link 2，樓面面積約 50,000 平方英呎，每年產量達 6,000 噸，其核心產品包括金屬及不銹鋼材、結構鋼材、鋼模建造及預製馬桶和浴室。
Excel Precast Pte Ltd[29]	Excel Precast Pte Ltd 於 1999 年 3 月 10 日註冊成立，承接預製混凝土設計及製造業務，以滿足新加坡對預製施工法日益增長的需求。公司提供混凝土預製體積建設（PPVC）系統、預製浴室（PBU）以及各種預製混凝土產品，例如梯段、帶橫樑的內嵌牆、混凝土外牆、水箱、門框和預應力樓板等。公司位於新加坡淡濱尼工業街的預製工廠佔地 322,000 平方英呎，而另一家預製工廠於 2009 年在馬來西亞柔佛州士乃設立，佔地 430,000 平方英呎。 Excel Precast Pte Ltd 過往項目包括「Trivellis」公屋發展項目：3 棟 40 層住宅單位、榜鵝西區 C30、新加坡 Aerohub、巴西立 The Palette 公寓、新加坡保健服務集團綜合診療所，以及萬禮火化場及骨灰安置所等。
Econ Precast Pte Ltd[30]	Econ Precast Pte Ltd 於 1975 年成立，已成長為新加坡預製鋼筋混凝土樁及建築組件的領先供應商。公司產品範圍廣泛，包括空間增加裝置、公用設施房及升降機井道等立體組件，主要用於建屋局的大型翻新計劃及升降機翻新計劃。 其他預製組件包括預應力梁和預製梁、立柱、鋼筋混凝土樁、鋼筋混凝土圓柱管、垃圾槽、梯段以及建築面牆牆板和外牆。

[28] Steeltech Industries Pte Ltd 網 站
[29] Excel Precast Pte Ltd 網站
[30] Econ Precast Pte Ltd 網站

	公司預製組件工場位於新加坡克蘭芝路，總面積約 38,000 平方米。除新加坡工場外，公司還在馬來西亞笨珍縣有一個工場，面積約 48,000 平方米。 Econ Precast Pte Ltd 參與了新加坡的多項工程，包括女王鎮的建築工程、盛港和芽籠的住宅建築，以及從怡豐城到聖淘沙的擬建木板路。
其他	□ SPP System Pte Ltd □ Integrated Precast Solutions Pte Ltd □ Vico Construction Ptd Ltd □ Unitised Building Pte Ltd □ Sembcorp EOSM Pte Ltd □ Moderna Homes Pte Ltd □ AM Modular (Singapore) Pte Ltd □ Quicksmart Technology (Singapore) Pte Ltd □ iMax Modular Pte Ltd □ TK Modular Pte Ltd □ Lightrus Pte Ltd □ Prefab Technology Pte Ltd

3.1.6 向新加坡借鑒預製經驗[31]

不論是生產、運輸及／或安裝預製組件，都有可以向新加坡借鑒的重要經驗。下表列出其中部分經驗。

由於更長的模組需要更周密的運輸規劃，因此使用 PPVC 建造長跨度構築物挑戰更大	根據陸路交通管理局的交通監管規定[32]，如果車輛參數超過規定（高度>4.5 米或寬度>3.4 米或載重>80 噸），則運輸需要警察護送。另外，大型模組的運輸須在夜晚的限制時間內進行。長跨度構築物通常需要更大／更長的預製組件，因此需要作出更具體的運輸規劃。
運輸空模組的成本高	新加坡南洋理工大學宿舍工程使用預製技術的成本，較使用傳統方法建造成本高 18%。其中一個原因是運輸了大量「空模組」。由於集裝箱按體積收費，而不是按重量收費，因此造成了巨大的運輸成本。對此的解決方法是將模組進行平板式包裝。如果香港擬建的預製組件工場計劃進口原材料或向其他國家出口成品，則應將此因素考慮在內。

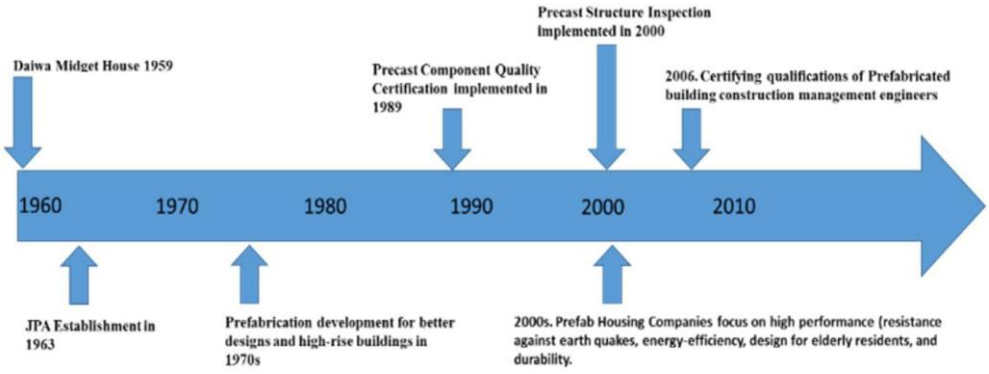
[31] 新加坡政府 – 建築職業
[32] 新加坡建設局

規劃必須精確，以最大程度減少存儲需求	使用 PPVC 需要額外的土地來裝配及存儲預製組件，以新加坡為例，大多數承包商使用新加坡或馬來西亞的土地。承包商務必應作出適當的規劃，以確保按時交付組件，以高效方法將存儲及土地成本降至最低。承包商可聘請工程管理顧問就施工時間表提出意見，以便「及時」交付預製組件。
政府間接補貼	儘管政府沒有直接補貼，但預製行業一直受益於各種政府政策及法規。例如，新加坡的指定非有地住宅政府賣地地盤必須使用 PPVC，迫使承包商在其建築工程中更大比例地使用預製組件。

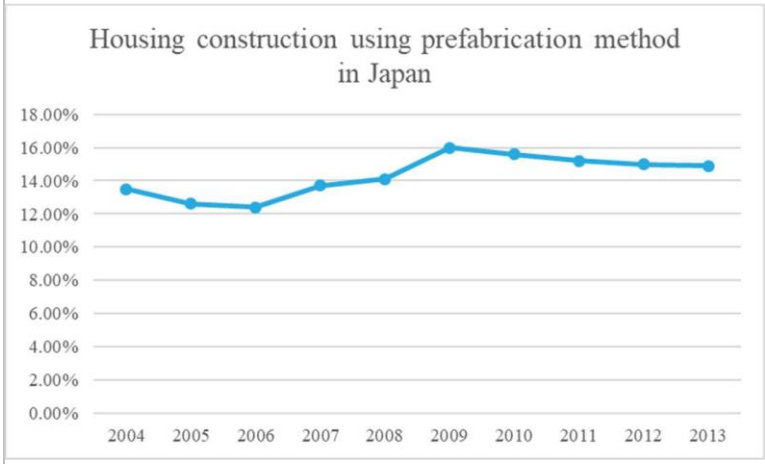
3.2 日本

日本預製業的發展與世界各地（包括第二次世界大戰和朝鮮戰爭）各種戰爭活動發生的時間息息相關。這些不幸的事件導致了住房嚴重短缺，從而引發了大規模生產預製房屋的需求。

下圖展示了日本預製業發展演變的概況。



日本預製組件應用的演變進一步闡述如下：

1945 年 - 20 世紀 50 年代	日本預製業的發展與時間息息相關。隨著 1945 年第二次世界大戰的結束，再加上 1950 年代為朝鮮戰爭中的美國軍隊提供鋼鐵生產的支持，日本工廠需要在戰後找到替代鋼鐵需求來源。經過多年的戰爭，住房缺口達 420 萬套。[33]。日本政府成立了政府住房貸款公司，為戰後恢復提供低息固定利率抵押貸款。[34]之後，房屋建造預製急速發展，但亦導致簡單的大批量生產產品淪為公眾眼中的劣質品。
20 世紀 50 年代 — 1963 年	為改善預製房屋的公眾形象，建設省及通商產業省於 1963 年聯合建立了日本預製建築協會(JPA)，以促進預製建築成為創造豐富居住環境的方式。
1963 年至今	自 1963 年至 2014 年，日本建造了約 900 萬套預製房屋，主要使用鐵／鋼、混凝土及木材[35]。截至 2014 年，共有 80 家註冊會員企業及 98 家贊助商。[36] 自 2004 年至 2013 年，使用預製法進行住房建設呈上升趨勢。[37] 

[33] Masahiro Kobayashi，The Housing Market and Housing Policies in Japan, 2016（2016年日本的房屋市場與住房政策）
[34] Masahiro Kobayashi，The Housing Market and Housing Policies in Japan, 2016（2016年日本的房屋市場與住房政策）
[35] Junichi Goda，Overview of prefabricated housing in Japan, 2015（2015年日本預製房屋概覽）
[36] 日本預製建築協會，Progress in Activities for Recovery from the Great East Japan Earthquake, 2014（2014年東日本地震恢復重建）
[37] Junichi Goda，Overview of prefabricated housing in Japan, 2015（2015年日本預製房屋概覽）

3.2.1 將住房作為長期投資在日本並不常見

在其他國家擁有房屋是一項長期投資。然而，日本房屋在 20-30 年內的貶值創造了一種一次性家居文化。這基本上創造出一種永續的市場，買家們透過更換住房來體現他們的生活方式。因此施工時間不僅會影響整體造價，還會影響預製施工所節省的時間。這一原因使得日本的房主可以更快地遷回，並直接影響節省的金額（即臨時住所）。

「與其把錢花在昂貴的改造上，人們更願意建造新的房屋。」據東京大學建　築系教授松村秀一介紹。20 世紀 70 年代初期，預製建築約佔新建房屋的 7%。到 2016 年，這一比例超過 15%。

日本住房市場多年來創造的另一個趨勢是建築師的湧入，根據國際建築師協會的統计，日本[38]每 1,000 名居民中有近 2.5 名建築師，而英國每 1,000 名居民中只有 0.5 名建築師。

3.2.2 日本預製建築協會 [38]

日本預製建築協會成立於 1963 年，是一個發展住房工業生產和促進建築業現代化及合理化的組織。

1989 年，協會推出了預製混凝土組件質量認證項目，以確保預製混凝土組件的質量和用於建築物的合格供應。

隨著 1999 年住房質量保證法以及 2000 年建築基準法中性能新規的實施，協會建立了預製混凝土結構檢查系統，以提高人們對確保預製混凝土建築具有適當結構安全性和可操作性的重視。

日本預製建築協會於 2006 年啟動了預製混凝土建築施工管理工程師資質認證系統。

3.2.3 日本的預製建築類型：[39]

日本使用的預製組件類型與新加坡和香港使用的組件類型略有不同。預製組件示例如下：

[38] UIA 建築師網站
[39] 日本預製建築協會網站

鋼鐵預製房屋和建築物 鋼框架構成主要結構部件，並使用帶鋼框架柱和樑的牆板	
組件預製房屋和建築物 將工廠生產的鋼或木製框架組件在施工現場組裝起來	
木製預製房屋和建築物 主要結構部件是面板和其他木製品	
混凝土預製房屋和建築物 主要結構部件是預製混凝土面板和其他預製混凝土組件（在工廠生產的預製混凝土面板）	

3.2.4 創新與技術

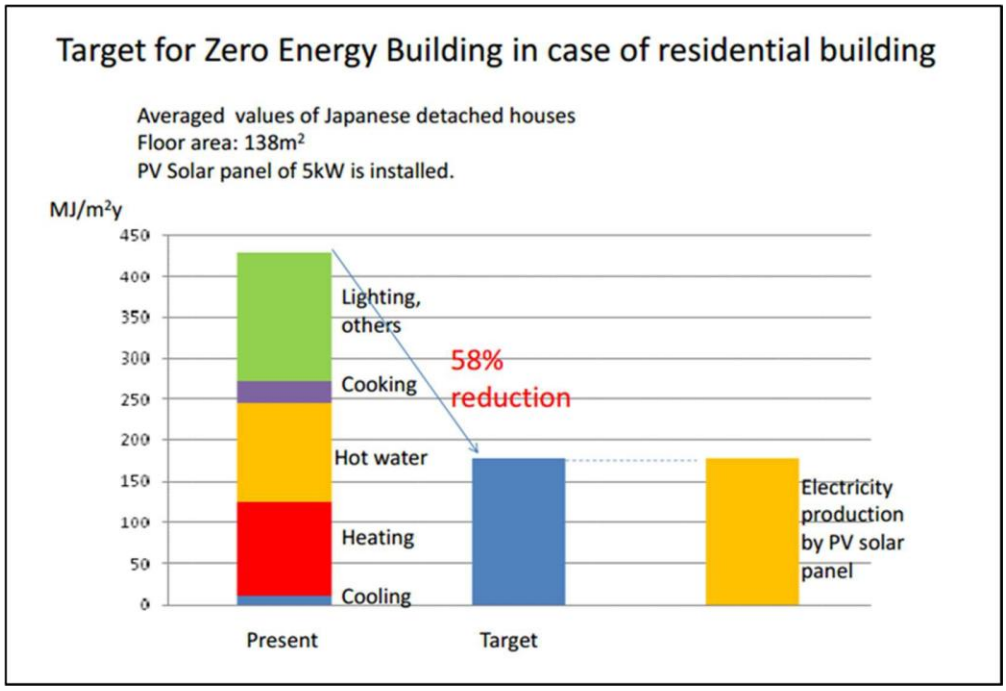
日本製造的預製組件通常具有能源效率，並且必須滿足抗震要求。詳情如下：

能源效率

目前，全國有幾家公司提供零能耗預製房屋或預製面板組件，適合零能耗建築。零能耗住房透過創造可再生能源（通常透過安裝在屋頂上的光伏電池） 使得每年所消耗的淨能源低於所產生的淨能源。透過使用零能耗方法，更新房屋可隨時添加太陽能電池板，以產生所需的所有電力。[40]

東京大學工業科學研究所 Ryozo Ooka 教授的一項研究表明，在日本建造零能耗住房理論上可行。如下圖所示，一所典型的 138 平方米（約 1,485 平方英尺）的獨立住房每平方米每年平均消耗 425 兆焦耳的能量。

隨著能源效率措施的改進，能源使用量理論上可以減少 58%。安裝在屋頂上的 5 千瓦光伏太陽能電池板可以產生剩餘的所需能量，從而形成淨零能耗住房。[41]



抗震

建築基準法於 1950 年頒布，涵蓋結構安全要求，而結構安全是所有建築物的重中之重，而結構安全亦涵蓋抗震。Sekisui Heim 等公司對其產品進行了嚴格測試。[42]

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[40] Zero Energy Project 網站，由Bruce Sullivan 發布，2016 年

[41] Real Estate Japan Inc，The present and future of net zero energy houses in Japan (日本淨零能源住宅的現狀和未來)

[42] Hasegawa Tomohiro 先生，Introduction to the Building Standard Law - Building Regulation in Japan, 2013 (2013年建築基準法簡介——日本建築法規)

3.2.5 日本領先的製造商

日本有許多領先的預製房屋製造商，其中包括積水房屋株式會社、大和房屋工業株式會社、三澤住宅株式會社、大成建設株式會社、無印良品等。各製造商的詳情摘要如下：

積水房屋株式會社[43]	積水房屋是 1960 年成立的最大的住宅建築商之一，總部位於大阪。從 2009 年開始，積水房屋將業務擴展至新加坡、中國、澳洲及美國，而在東北（宮城）、關東（茨城）、靜岡、兵庫及山口分別設有 5 家工廠。工業化房屋建設分部從事鋼結構、木結構及混凝土房屋及低層公寓樓的設計、施工及承包工作。作為最大的預製房屋製造商之一，積水房屋在 2015 年售出 13,612 套定制獨立屋。
大和房屋工業株式會社[44]	大和房屋工業株式會社成立於 1955 年，是最大的房屋建築商之一，專營預製房屋。大和房屋工業開發了小型住宅(Midget House)，它最初是一個可在 3 小時內建造的書房，據說亦是預製房屋的起源。從那時起，它已逐漸發展至今天擁有 92 家子公司，業務包括工廠、購物中心、衛生保健設施建設，以及其他行業的管理和營運。
三澤住宅株式會社[45]	三澤住宅株式會社成立於 2003 年，是一家日本住宅建築公司，擁有四個業務部門。集團業務規劃和管理部門、銷售和管理部門、生產和物流部門以及研究、開發和調查部門。規劃和管理部門負責預製房屋的製造和銷售、房屋材料採購及生產的規劃和管理、預製房屋的設計、施工規劃和管理。
大成建設株式會社[46]	大成建設株式會社成立於 1873 年，是日本最早的承包商。作為一家經重組的僱員所有公司，大成建設在日本和海外建造了許多民用建築項目，包括住宅房屋。大成建設亦因其抗災房屋品牌『Palcon』聞名於日本。
無印良品[47]	無印良品成立於 1979 年，是一家日本零售公司，銷售各種家用消費品，是 2017 年第三季度進軍住宅預製市場的最新公司之一。作為一家房屋預製領域的新公

[43] 積水房屋株式會社網站
[44] 大和房屋工業株式會社網站
[45] 三澤住宅株式會社網站
[46] 大成建設株式會社網站
[47] 無印良品網站

	司，它提供的面積不足 100 平方英尺的微型住宅設計簡約美觀，目前銷售只針對日本市場。
其他製造商	□ Orient House Co., Ltd. □ Sankyo Frontier Co., Ltd. □ Tachikawa House Industry Co., Ltd. □ Nagawa Co., Ltd □ Nittohkoei Co., Ltd □ Hokuto House Co., Ltd. □ Omachi World Co., Ltd. □ Kohri Co., Ltd. □ System House R & C Co., Ltd. □ Naito House Co., Ltd. □ Nissei Build Industries Co., Ltd. □ Fujisangyo Co., Ltd

3.2.6 日本的經驗

日本採用預製組件的原因與新加坡和香港不同。預製組件工場生產線上實現的自動化程度遠比中國大陸更受關注。相關經驗詳情總結如下：

日本客戶選擇預製房屋的原因	日本經濟產業省的一項調查顯示，客戶選擇預製房屋的主要原因是大型預製公司的可靠性，以及它們優越的工作品質和性能。此外，良好的客戶服務及員工的詳細講解亦是預製房屋銷售的主要動力。
高度自動化的生產線	日本的預製房屋方法類似於汽車工業。澳洲昆士蘭大學研究員 Matthew Aitchison 將這些房屋工廠描述為『到處都是機器人，房屋部件沿著裝配線緩緩移動，技術員把它們像汽車一樣裝配起來』。[48]積水房屋等公司長期以來一直採用高度自動化的生產線和計算機控制的自動化製造工藝（詳見第 9.2 節），這使得日本在缺乏建築勞動力的情況下每年仍能大量生產預製房屋。

[48] Asia Green Buildings，Lesson from Japan: prefabricated houses for green development（日本的經驗：用於綠色發展的預製房屋）

4 『初步基礎案例』的定義

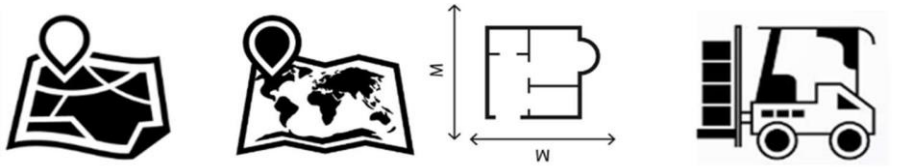
4.1 概覽

在我們開始評估可能工地位置（第 5 節）之前，我們需要定義提議的發展／項目。該起始點被稱為「初步基礎案例」。一旦確定了可能工地，並在開始進行行業可行性的初步分析之前（第 7 節），我們進一步分析並重新審視了初步基礎案例的定義，以確保其計及可能工地的關鍵規劃、土地用途、交通及環境因素，從而達成「基礎案例」（如第 6 節所示）。

4.2 方法

在沒有對有關預製組件工場進行初步設計的情況下，我們估算場地大小、樓面總面積及其生產能力的方法是利用若干可比基準的現有大小和比例。

以下圖表總結了我們進行評估所需的資料。



我們根據以下標準選擇了四個預製組件工場基準：

- 須為一座多層的一體化預製造工廠
- 不得是開放場地，須有受庇護生產區
- 年生產能力須在 10 萬噸以上

4.3 基準

由於缺乏在香港經營的本地混凝土預製件製造商，我們已採用若干於新加坡設立和營運的預製組件工場製造商的資料作為基準，來為我們的場地設計和營運估算場地大小、樓面總面積及其生產能力。詳見附件二預製生產商案例分析。

下表總結了我們基準測試的結果：

名稱	地塊大小（平方米）	建成區面積（平方米）	年產量（噸）	產量／建成區面積（噸／平方米）
SEF SpaceHub	20,386[49]	32,608[50]	241,000[51]	7.39
Greyform Building	20,051[52]	32,100[53]	>150,000[54]	>4.67*
長成預製件中心[55]	不適用	19,813	241,000	12.16
Poh Cheong Singapore Plant 1[56]	16,165	9,290*	93,990*	10.12
平均值**	19,000	28,000	210,000	9.9

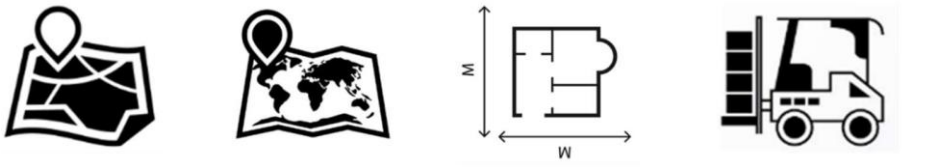
*我們已從分析中排除該等異常值。

**平均值乃根據可比基準總值除以可比基準數量計算得出（如，噸／平方米：(7.39+12.16+10.12)/3）。

[49] 建設局 – Integrated Construction and Prefabrication Hub tender（綜合建設預製樞紐招標）
[50] 建設局新聞稿，29 July 2013, New integrated construction and precast hub to boost precast production for building demands（2013年7月29日，新的綜合建設預製樞紐，促進預製生產，滿足建築需求）
[51] 建設局新聞稿，29 July 2013, New integrated construction and precast hub to boost precast production for building demands（2013年7月29日，新的綜合建設預製樞紐，促進預製生產，滿足建築需求）
[52] 建設局 — 綜合建設預製樞紐招標
[53] 裕廊集團，2016 年第四季度已完工主要工業項目清單
[54]《海峽時報》，BCA to give advance notice on building projects that need high level of prefabrication（BCA 關於需要高水平預製的建築項目的提前通知）
[55] 建設局新聞稿，2011 年 1 月 4 日，Tiong Seng's $26 million Prefab Hub - Singapore's 1st automated pre-cast facility and first to receive BCA funding（長成的 2,600 萬元預製件中心 — 新加坡首個自動化預製設施，並首次獲得建設局資助）
[56] Poh Cheong 網站 — 工廠及設施

4.4 「初步基礎案例」

根據上述『基準』測試，我們假定場地的開發將具有與上表提議場地大小和比例的「平均值」行中所示值中位數一致的特徵。



Land size	Location	GFA	Annual production capacity
19,000 sqm	??	28,000 sqm	277,200 tonnes (9.9* x GFA)

*9.9 噸／平方米乃基於第4.3 節所示的基準測試結果。

我們注意到，在下一章完成對適合工地的評估後，我們需要重新審視上述假　設，特別是有關土地大小和樓面總面積的假設，以計及選定工地的任何限制。

5 可能工地的評估

5.1 簡介

本節介紹對用於香港預製組件工場發展的可能工地的評估。為了確定開發和運營預製組件工場的合適地點，我們已對相關工地進行了分析，並計及土地大小、任何空間要求及法定規劃方面的考慮因素，以及運輸和環境因素。

5.2 方法

在完成對可能工地的評估時，我們的第一步是製定標準清單以篩選、確定和選擇潛在工地。我們將評估分為兩部分：

- A 部分：確定潛在工業區
- B 部分：確定潛在工地

以下圖表總結了我們在確定預製組件工場開發潛在工地的四步選擇過程。

5.3 A 部分：確定可能工業區

第 1 步：確定香港的工業區

正如初步基礎案例中所定義，預製組件工場的發展最有可能是 MSB。我們假設，提議的預製組件工場須為「工業用途」（基於工業用途的廣泛類別下的定義）設施[57]。該假設取決於城市規劃委員會的審查和預製操作的實際性 質。

重要的是，在我們的工地選擇評估過程中，我們需要尋找一個潛在的工地， 該工地位於規劃意圖和分區範圍內，與預製作業的使用相兼容。就我們分析 的目的而言，我們已將搜尋重點放在分區計劃大綱圖的「工業」地帶。此外， 該等「工業」地帶入圍由規劃署發佈的「《2014 年全港工業用地分區研究報告》」[58]，報告包含全港所有「工業」地帶的官方記錄和最全面的分析。

[57] 術語定義，請參閱 http://www.info.gov.hk/tpb/en/forms/dot_revised_broad.html。
[58] 資料來源：
https://www.pland.gov.hk/pland_en/p_study/comp_s/industrial_report_2014/index.htm

因此，我們的分析顯示，香港大約有 23 個可能工業區可用於發展預製組件工場，如下表所示：

地區	可能工業區	用途
葵青區	中葵涌	I
	西南葵涌	I
西區	堅尼地城	I
東區	柴灣	I
南區	田灣海傍道	I
	鴨脷洲西	I
	鴨脷洲海傍道	I
	布廠灣	I
元朗區	屏山	I
	新起村、唐人新村	I
屯門區	屯門第 9 區和第 12 區	I
	屯門第 16 區	I
	屯門第 40 區	I
	湖山路	I
	OU（港口後勤、貯物及工場用途）地帶	I
	OU（貯物及工場用途）地帶	I
粉嶺／上水	粉嶺第 48 區	I
	安樂村	I
	上水	I
沙田區	火炭	I
	沙田第 65 區	I
	小瀝源	I
	大灣	I

除了傳統的「工業」地帶，我們在分析中還考慮了以下新的土地用途分區：

- 洪水橋新發展區(HSK NDA)中的「其他指定用途」，註明「港口後勤、貯物及工場用途」（「OU（港口後勤、貯物及工場用途）」）；及
- 元朗南(YLS)房屋用地規劃及工程研究下提議的「其他指定用途」註明「貯物及工場用途」（「OU（貯物及工場用途）」）地帶。

香港政府正鼓勵發展 MSB，以適應上述「OU」地帶的物流及其他棕地用途（工業性質）。

倘潛在工地位於非工業地帶，則需要根據《城市規劃條例》（第 131 章）提出第 12A 條申請，[59]將該工地重新劃分為適當分區。就我們的分析而言，我們假設，除特殊情況外，不需要第 12A 條申請，因為申請程序可能會十分冗長，並可能對提議預製組件工場的發展帶來不確定性。第 12A 條申請將需要額外的技術評估（不限於交通、視覺、排水、排污、通風、環境、土工等評估），以證明提議預製組件工場的發展的可行性。

或者，倘預製組件工場的上述『工業』用途屬於該工地分區土地用途表第 2 欄，則需要《城市規劃條例》第 16 條申請，以獲得城市規劃委員會的預製組件工場發展規劃許可。儘管第 16 條申請程序可能不如上述的第 12A 條申請複雜，但在向城市規劃委員會提交第 16 條規劃申請時，會受到不確定性影響且須獲得城市規劃委員會的許可。

第 2 步：了解位置要求以及基礎設施的可用性

根據我們於 2017 年 11 月採訪會議的結果，我們獲悉，發展預製組件工場的首選地點應至少：

- 要求 1：靠近主要來自中國大陸的原材料及化學品來源；及
- 要求 2：擁有道路基礎設施，以便從中國大陸運輸原材料
- 要求 3：靠近海上運輸路線，以便由海路運輸原材料、大型集料和預製組件。

為了進行分析，我們在分析要求 2 和 3 之前，首先透過篩選滿足要求 1 的地區／區域進行了工業區評估。

機會

我們的分析表明，在八個選定地區中，只有三個滿足要求 1（即在原材料來源和可用道路基礎設施附近）。這三個地區包括：

- 元朗區：元朗潛在工業區距落馬洲邊界約 12 公里，距深圳灣約10 公里。
- 屯門區：屯門潛在工業區位於距深圳灣附近邊界約 14 公里處。
- 粉嶺／上水：粉嶺／上水可能工業區位於距文錦渡附近邊界 6 公里處。

由於我們對要求 2（擁有道路基礎設施，以便從中國大陸運輸原材料）的分析取得了進展，我們已經從分析中排除了粉嶺／上水，原因如下：

- 儘管上水／粉嶺經由文錦渡路、沙頭角公路及未來的蓮塘／香園圍口岸，位於最接近中國大陸的位置，但我們的分析顯示目前在粉嶺第 48 區和上水第 30 區有公營房屋發展計劃。

[59] 適當的法定規劃程序應視情況而定，並須經有關政府部門審核。

- 此外，上水／粉嶺的道路網及戰略公路（即粉嶺公路及吐露港公路）正經歷交通擠塞。未來的發展（即公營房屋計劃）將進一步增加該地區的交通需求。

我們的結論是，只有元朗區和屯門區被選為接受進一步分析的首選工業區，因為這兩個地區均符合以下三項要求：

- **元朗區**：元朗區距離大海約 5 公里。
- **屯門區**：屯門的可能工業區距離碼頭設施僅 1.0 米以內。

下表總結了我們對可能工業區的分析。

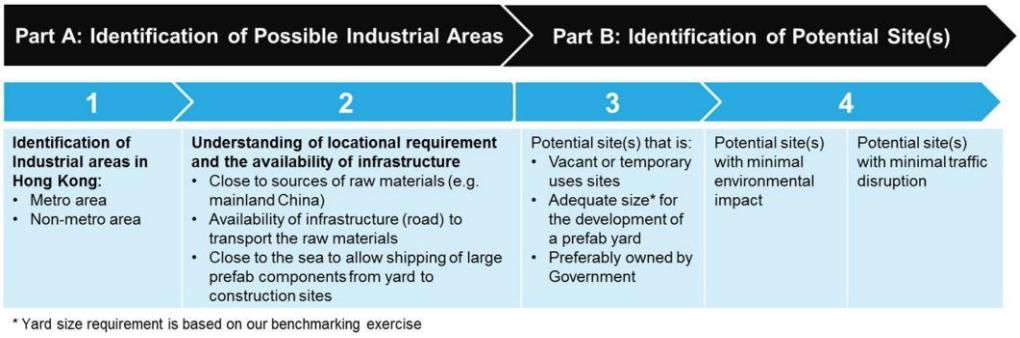
地區	可能工業區	要求		
		1	2	3
葵青區	中葵涌 西南葵涌	否	否	否
西區	堅尼地城	否	否	是
東區	柴灣	否	否	是
南區	田灣海傍道 鴨脷洲西 鴨脷洲海傍道 布廠灣	否	否	是
元朗區	屏山 新起村、唐人新村	是	是	是
屯門區	屯門第 9 區和第 12 區 屯門第 16 區 屯門第 40 區 湖山路 OU（港口後勤、貯物及工場用途）地帶 OU（貯物及工場用途）地帶	是	是	是 要求 1 至 3
粉嶺／上水	粉嶺第 48 區 安樂村 上水	是 要求 1	否	否
沙田區	火炭 沙田第 65 區 小瀝源 大灣	否	否	否

5.4 B 部分：確定潛在發展工地

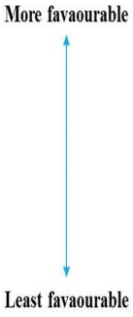
5.4.1 第 3 步：從規劃和土地用途分析中確定潛在工地

根據第四節的結果，我們進一步分析了元朗區和屯門區八個可能工業區各自適用於預製組件工場發展的情況。我們的分析基於以下標準／假設：

- **空置 / 臨時使用工地** — 我們只考慮空置工地或臨時使用工地。我們已將《2014 年全港工業用地分區研究報告》作為官方資料來源，以確定可能工業區內的特定工地是否為空置及／或臨時使用性質。
- **工地面積** — 我們假設，預製組件工場的發展將具有與第 4 節所示基準測試值的中位數一致的特性。如初步基礎案例所述，預製組件工場的發展 所需最小土地面積約 19,000 平方米，樓面總面積約 28,000 平方米。我們注意到，在本章完成對可能工地的評估後，我們需要重新審視初步基礎案例，以計及選定工地的任何限制。
- **土地所有權** — 我們的分析優先考慮政府擁有的土地，以避免因與多個私人土地所有者進行談判耗費時間而拖延發展計劃。



在第 3 步和第 4 步中，我們透過對每個可能工地提供以下評級來總結我們的主要發現：

圖例		描述
		滿足大部分要求及／或最少約束條件的潛在工地  並不滿足大部分要求及／或許多約束條件的潛在工地

有關各工地的詳細分析，請參閱**附錄C**。

下表總結了對選定用於分析的工地的主要發現。

地區	可能工業區	潛在工地數量及工地面積	結果
元朗區	屏山	1 個，約 28,000 平方米	○
	新起村、唐人新村	2 個，約 3,900 至 4,000 平方米不等	◔
屯門區	屯門第 9 區和第 12 區	1 個，約 3,000 平方米	◔
	屯門第 16 區	2 個，約 1,900 至 10,000 平方米不等	○
	屯門第 40 區	1 個，約 36,000 平方米	◕
	湖山路	1 個，約 600 平方米	○
	OU（港口後勤、貯物及工場用途）地帶	4 個，約 16,500 至 154,000 平方米不等	◕
	OU（貯物及工場用途）地帶	1 個，約 17,000 平方米	◔

5.4.2 第 4 步：從環境影響及交通狀況分析中確定潛在工地

結果		原理
環境影響	◐	▫ 靠近易受影響地帶將會使預製組件工場作業產生噪音和大氣排放問題
交通狀況	◐	▫ 靠近相鄰的港口碼頭 ▫ 持續的大規模發展將導致目前的交通模式發生變化

5.4.3 選定的潛在工地

根據上述工地選擇分析，我們選擇屯門第 40 區作為擬建預製組件工場的較有利工地。

下表總結了我們對有利工地的主要發現。

地區	可能工業區	規劃及土地用途	環境影響	交通狀況
屯門區	屯門第 40 區	◕	◐	◕
	OU（港口後勤、貯物及工場用途）地帶	◕	◐	◐

6 「基礎案例」的定義

6.1 概覽

正如第 4 節所討論，我們根據基準測試定義了「初步基礎案例」，作為我們選擇在香港發展預製組件工場的潛在工地的基礎。正如第 5 節所述，在考慮規劃、土地用途、交通狀況及環境考慮因素後，為了便於說明我們提出屯門第 40 區作為擬議預製組件工場的例子並進行參考。關於財務分析和需求分析，我們也選擇屯門 40 區的參數作為發展預知廠的條件。

本節主要目標是在繼續對行業可行性進行初步分析之前，重新審視「初步基礎案例」的定義（第 7 節）。我們進一步分析和重新審視了「初步基礎案例」的定義，以確保其計及屯門第 40 區的主要規劃、土地用途、交通和環境考慮因素。我們隨後將重新定義的「初步基礎案例」稱為「基礎案例」。

6.2 重新定義「初步基礎案例」

根據我們在工地選擇章節（第 5 節）的主要發現，屯門第 40 區的可能工地受到以下限制：

- 最高核准地積比率為 2.5；及
- 最大建築物高度為 26mPD[60]

在定義基礎案例時，我們研究了兩個關鍵變量：(1)地盤面積，及(2)樓面總 面積。

6.2.1 地盤面積

我們假設建立預製組件工場所需的地盤面積與「初步基礎案例」所述者相同，即 19,000 平方米。

6.2.2 樓面總面積

根據可能工地的最高核准地積比率及建築物高度，我們制定了擬建預製組件工場的高層設計方案，詳情如下：

樓層上限：

根據 26mPD 的最高建築物高度及 5mPD 的屯門 40 區工地水平高度，擬建預製組件工場最高為 21 米。根據我們的估算[61]，預製組件工場生產區的平均樓

[60] 指平均海平面以下 1.230 米的高度。
[61] 基於 Greyform 的建築物高度進行估算

層高度[62]約為 7 至 10 米，而辦公區約為 4 至 6 米。就我們的分析而言，我們假設擬建預製組件工場將為 3 層建築物：

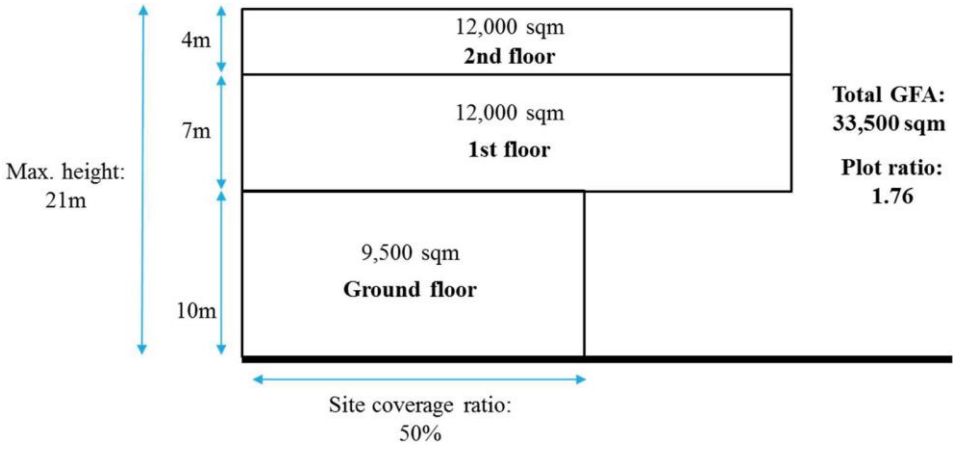
樓層	可能用途	高度（米）
2 樓	辦公	4
1 樓	製造	7
地下	製造	10
合計		21

地盤覆蓋率[63]

我們明白，預製製造工場須設有緊急車輛通道(EVA)及貨車裝載產品等操作用途所需的開放空間及儲存空間。根據我們對 SEF Spacehub 進行的高層分析，地盤覆蓋率約為 50%。簡言之，SEF Spacehub 將佔地盤面積的 50%，而另外 50%的地盤面積為用於各種操作用途的開放空間。由於缺少預製組件工場所需的最小開放空間資料，我們採用該比率重新界定「基礎案例」。

樓面總面積：

鑒於該分析的高層範圍，我們必須在估算擬建預製組件工場的樓面總面積時作出若干簡單假設。根據我們的高層分析，如下圖所示，在可能工地中擬建預製組件工場的最佳樓面總面積約為 33,500 平方米：

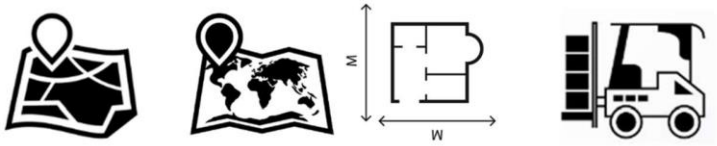


我們要強調的是，上圖僅作說明用途，而且我們必須作出相關假設以繼續進行初步財務分析。

[62] 每個樓層的高度根據房間的樓底高度加上各嵌板之間的地板厚度計算。
[63] 地盤覆蓋率是指總地盤面積除以總建築面積。

6.2.3 「基礎案例」

下圖概述擬建工場「初步基礎案例」及「基礎案例」面積與規模的重要假設：



"Preliminary Base Case"	Land size 19,000 sqm	Location ??	GFA 28,000 sqm	Annual production capacity 277,200 tonnes (9.9 x GFA)
"Base Case"	Land size 19,000 sqm	Location Tuen Mun Area 40	GFA 33,500 sqm	Annual production capacity 331,650 tonnes (9.9 x GFA)

* 9.9 公噸／平方米乃基於第4.3 條所示的基準測試結果。

7 行業可行性的初步分析

7.1 方法

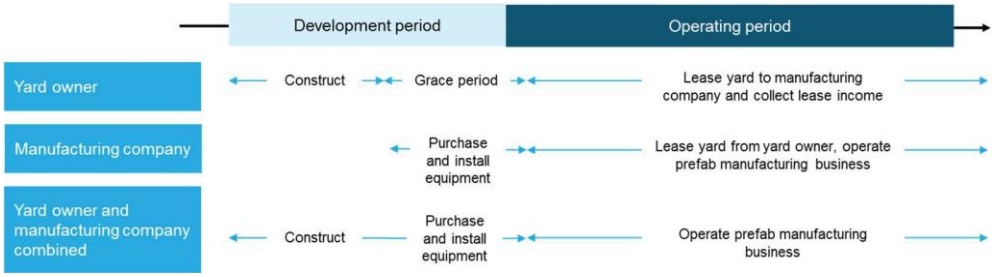
初步財務分析旨在分析於香港進行擬建預製組件工場發展項目的財務可行性。相關發展項目可能有兩方參與：

- **工場業主**：該方負責建造工場及收取租金
- **製造公司**：該方負責製造及銷售預製組件

就財務分析而言，我們與建造業議會協定，我們應當單獨分析下列商業實體的可行性：

- 基礎案例 1：工場業主
- 基礎案例 2：製造公司
- 基礎案例 3：工場業主及製造公司組合，即發展及擁有其設施的製造商

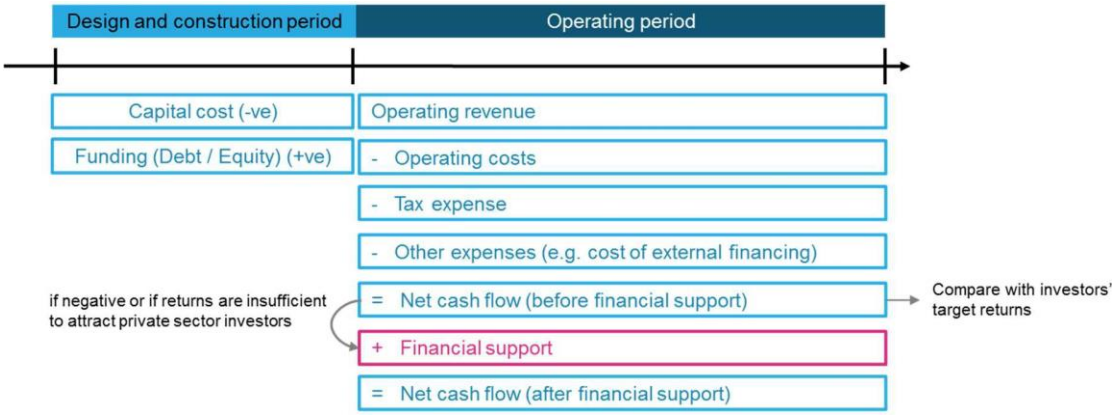
下圖概述各基礎案例下各商業實體的職責與責任：



我們已按照下列高級方法進行初步財務分析：

- 制定各基礎案例(1 – 3)的財務模型，以釐定各自的指示性現金流量預測；
- 使用財務模型釐定各現金流量來源：
  - 是否產生足夠的現金流量以應付開支
  - 是否產生商業上可接納的回報；及
  - 是否需要任何財務補貼以在財務上可行。

倘商業實體產生的現金流量淨額（包括任何財務補貼）足以支付該商業實體招致的所有成本（包括投資者所要求的回報），則其被視為在財務上可行。下表載列有關我們在每年的財務模型分析中如何構建商業實體現金流量的圖解概要：



財務分析結果以淨現值(NPV)及面值（亦稱作付款當日價格(MOD)）列示。 淨現值乃現金流入現值減現金流出現值計算所得。現值是指 2018 年價格中所列的價值。付款當日價格是指相關現金流量項目的實際金額，包括預期的通脹影響。

有關支持基礎案例分析的重要假設詳情，請參閱**附錄**E。

有關基礎案例 1（工場業主）、基礎案例 2（製造公司）及基礎案例 3（工場業主及製造公司組合）的財務分析詳情，請參閱**附錄**D。

7.2 主要結果

我們已從 3 個不同的角度分析於香港進行擬建預製組件工場發展項目的財務可行性：

- 基礎案例 1：工場業主
- 基礎案例 2：製造公司
- 基礎案例 3：工場業主及製造公司組合

財務評估顯示：

- 基礎案例 1：工場業主在財務上非獨立可行。為鼓勵工場業主建造所需的設施，須以財務補貼、地價優惠或兩者組合的形式提供約 724 百萬港元（淨現值）的財務支持。
- 基礎案例 2：製造企業可產生 10%的內部回報率(IRR)及 1,208 百萬港元的累積投資者現金頭寸。根據 10%的內部回報率目標，製造企業很可能可行。該結果假設適當可用的設施處於當前市場的行業租金水平。

- 基礎案例 3：鑒於香港土地成本高昂，發展項目組合僅在以現金補貼、地價優惠或兩者組合的形式資助約 579 百萬港元（淨現值）的情況下， 方可在財務上獨立可行。

基礎案例	1	2	3
主要關聯方	工場業主	製造公司	工場業主及製造公司組合
淨現值	HK$724m	-	HK$579m
內部回報	5%	10%	7%

8 需求分析

8.1 簡介

香港人口不斷擴增及勞動力短缺，令香港住房需求日益增長，從而推動預製組件需求增長。與其他亞洲國家相似，由於預製組件設計簡單及統一，香港大多數預製組件用於建造住宅建築（尤其是公共住房）。

我們進行預製組件需求分析的方法是分析下列各項的趨勢：

- 香港住房供應；及
- 香港住房行業的預製組件使用情況。

8.2 預製組件的需求分析

未來的物業（住宅及商業）供應及基建發展項目以及該等新建住房對預製組件需求的貢獻，是決定未來預製組件需求的因素之一。

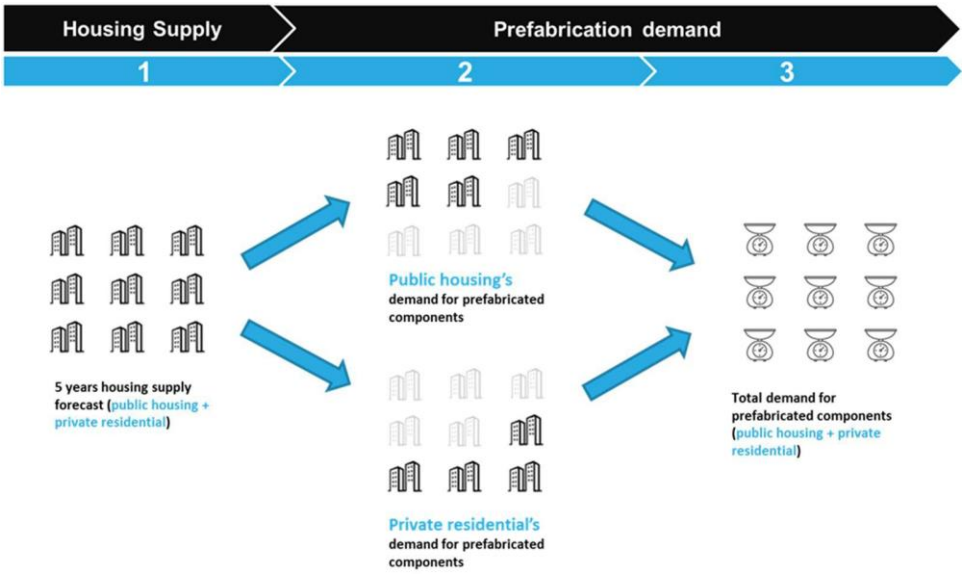
就我們的分析而言，我們僅考慮未來的住宅物業供應，並排除商業物業及基建發展項目。與預製組件相比，商業物業通常使用幕牆系統，而基建發展項目通常需要大型組件。我們在分析中假設，由於地盤規模，擬建預製組件工場僅將製造建築物的預製混凝土組件。

8.3 方法

根據我們的理解，香港公屋和私人住宅項目對於預知件的做法有很大不同。公屋項目中，預製構件的使用主要為預知外立面幕牆、半預製樓板、預知樓梯和預製浴室等。但是在私人住宅項目則主要使用預知外立面幕牆。

基於上述情況和我們掌握的資訊，我們首先分析香港的房屋供應，然後分別分析公屋和私人住宅項目對於預知構件的需求，最後綜合兩者的需求來與預製場的供給相比較。

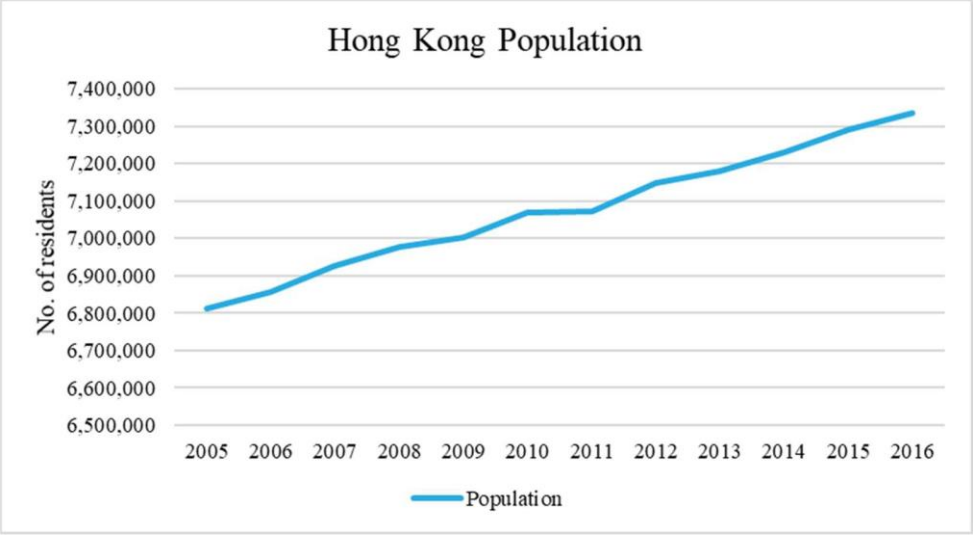
我們採用下圖所述的三步法估計預製組件的需求：



8.3.1 第 1 步：香港住房供應預測

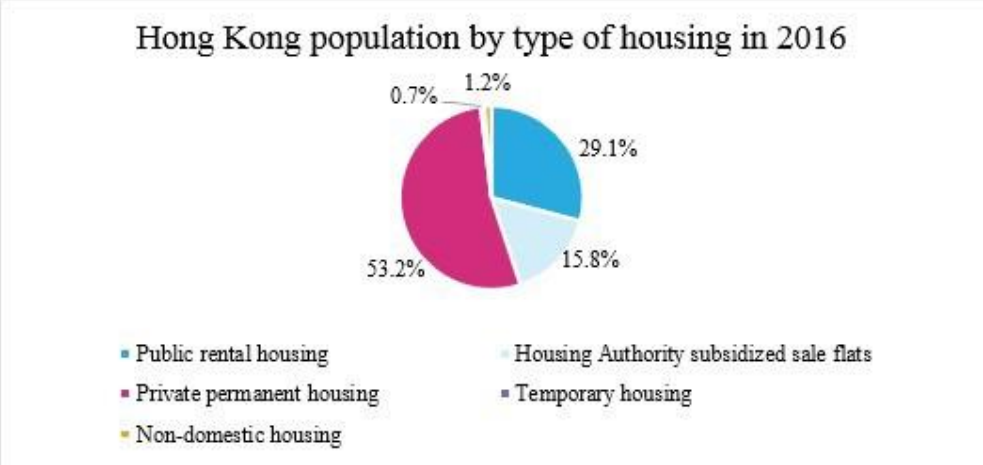
概覽

2005年至 2016年香港人口按年穩步增長約 0.7%。如下表所示，人口從 2005 年的 6.8 百萬人增長至 2016 年的 7.3 百萬人[64]。



[64] 香港統計年刊

從歷史上來看，香港日益增長的人口已經成為香港住房需求的推動因素。截至 2016 年人口普查[65]，香港有 45%人口居住在公共住房（包括租住公屋及政府補貼銷售的公共住房），53%居住在私人永久性住房，而剩下 2%居住在臨時及非住宅用住房。



香港公共住房：

為滿足中低收入家庭的住房需求，香港房屋委員會(HKHA)／政府制定多項 香港公共住房（租住公屋及政府補貼銷售的公共住房）補貼計劃：

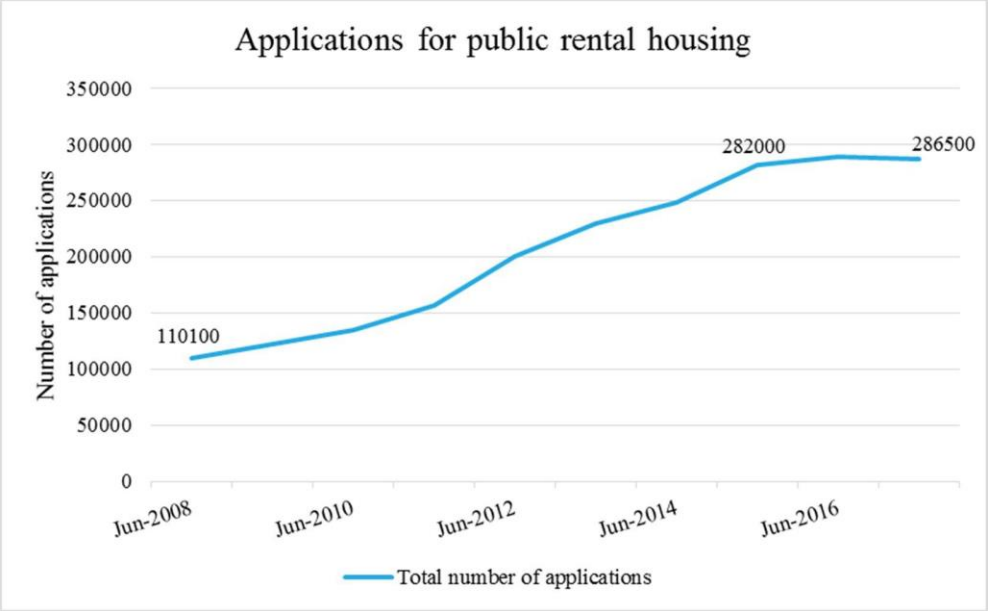
- 租住公屋計劃，該計劃向低收入居民提供租住單位優惠；
- 房屋所有權計劃，該計劃提供補貼銷售的公共住房單位，該等單位被指定按市價大幅優惠的價格銷售給低收入合資格人士；及
- 其他各項計劃，如租戶購房計劃、臨時住房及綠表置居先導計劃。

上述公共住房計劃通常附有若干限制及資格要求。

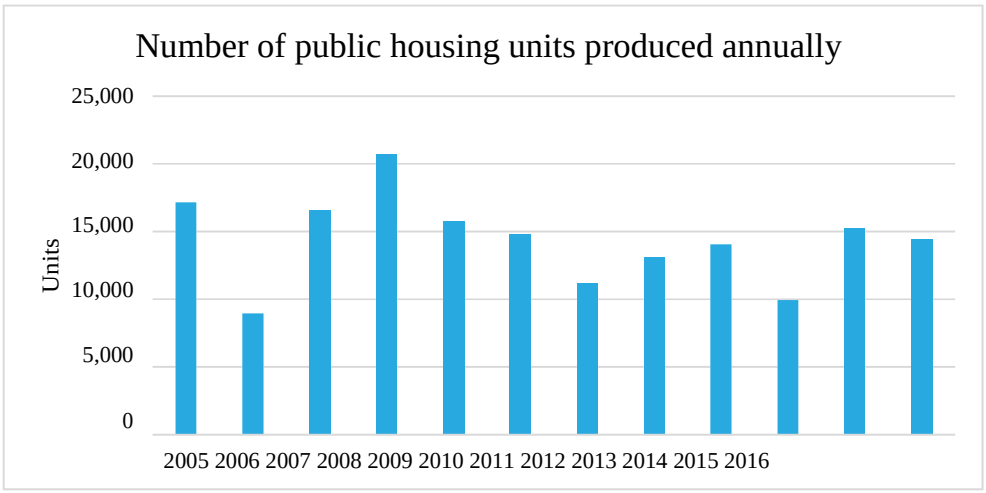
我們專注於租住公屋計劃分析，原因是該計劃佔香港公共住房的大部分。目前，該計劃已登記逾 760,000 個單位。

[65] 2016 年香港人口普查

我們的分析顯示，自 2008 年以來，該計劃的公共住房需求暢旺。舉例而言，如下表所示，申請者總數目從 2008年的 110,100人增至 2016年的 286,500人[66]：

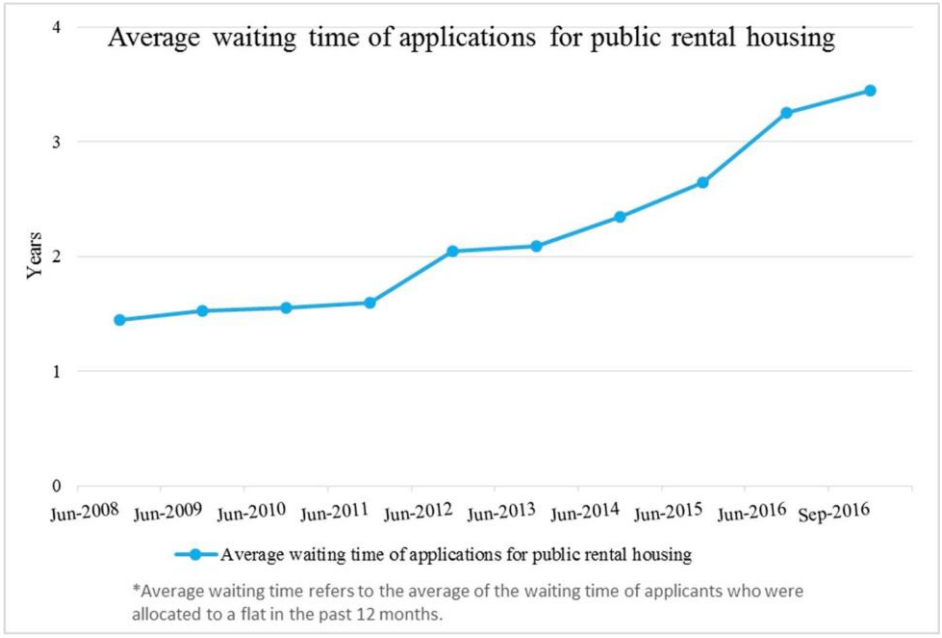


然而，我們觀察到，每年建造的公共住房單位並無改變，而且在數量上並無明顯增加。下表顯示香港房屋委員會在過去 10 年每年建造的新建公共住房單位平均約為 14,300 個單位[67]。



[66] 香港立法會– ISSH09/ 16-17
[67] 香港房屋委員會及政府統計處

供不應求的趨勢導致申請香港租住公屋的平均等候時間不斷增加[68]。

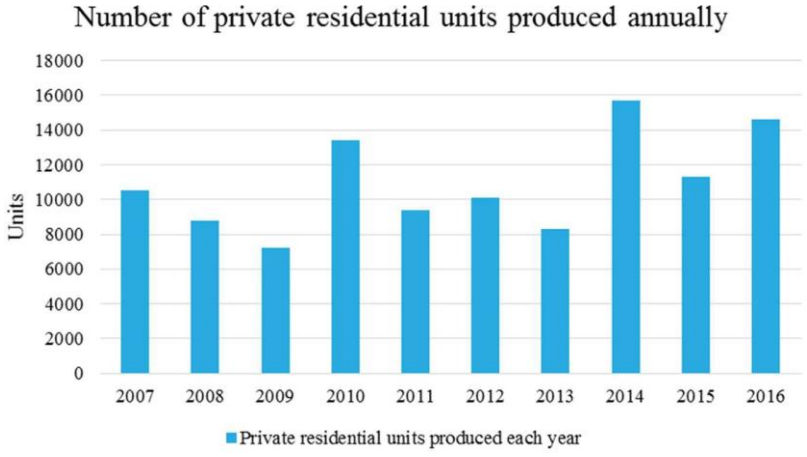


為應對供應短缺，香港政府推出長遠房屋策略(LTHS)，以增加公共住房產量，其目標是在自 2015-16 年度起至 2024-25 年度止十年期間內合共提供280,000個公共住房單位[69]。

香港私人住房

香港約有 53%的人口居住在私人永久性住房，佔香港住房市場的一半以上。

每年建造的私人住宅單位受香港政府規定的土地供應限制。如下表所示，2005 年至 2016 年每年供應的私人住宅單位平均約為 12,000 個單位[70]。



[68] 香港立法會– ISSH09/ 16-17
[69] 運輸及房屋局— 長遠房屋策略，2014 年
[70] 香港房屋委員會及政府統計處

香港住房供應預測：

就我們的分析而言，我們專注於 5 年期預測分析。根據 Knight Frank[71]提供的資料，2017 至 2021 年的住房供應預測總量約為下表所示的 193,900 個單位（97,200 個公共住房單位及 96,700 個私人住宅單位）。

類別	附註／資料來源[72]
公共住房	立法會文件 CB(1)110/16-17(02)的計劃供應單位
私人住宅	未來私人住宅單位的竣工情況基於 Knight Frank 的土地供應系統，該系統搜集屋宇署刊發的月刊 (Monthly Digest)若干章節的原始數據。 私人住宅單位面積的五年期預測基於差餉物業估價署發佈的《物業報告 2017》的短期預測，並按市場動態修訂

8.3.2 第 2 步：採用半預製施工方法的住房供應

8.3.2.1 公共住房

如第 1 步所示，預測的 5 年期公共住房供應總數為 97,200 個單位。根據公開研究[73]顯示，從歷史上來看，香港 100%的公共住房單位使用了半預製施工方法。因此，我們假設預測的 5 年期公共住房供應總數 97,200 個單位將在施工階段使用半預製施工方法。

[71] 資料來源：Knight Frank
[72] 資料來源：Knight Frank's data base
[73] Vivian Tam、C.M. Tam、S.X. Zeng 及 William Ng，《施工轉用預製件》(Towards Adoption of Prefabrication in Construction)

通過葵涌屋苑試點項目[74]，我們已經獲得並分析了每層樓層預製組件的總數 及各構件的噸數重量。

葵涌屋苑試點專案有 60%的混凝土量來自於預製組件。然而，為了保守及慎重起見，對於公共住房我們假設 20%的混凝土量來自於預製組件以供我們的需求分析。詳細分析請參考附件 F。

根據我們對於葵涌屋苑試點項目的分析，公共住房平均會使用 25.063 公噸的預製組件（假設公共住房 20%的混凝土量來自於預製組件）。因此，就預測的 5 年期住房供應（97,200 個單位）來說預製組件的需求估算量為 2,436,124 公噸。分析匯總如下表：

預測的 5 年期住房供應總單位數	97,200 個單位
香港公共住房內採用預製施工方法的百分比	100%
每個單位的預製組件使用量	25.063 公噸/單位
就預測的 5 年期住房供應來說預製組件的需求估算量	2,436,124 公噸

8.3.2.2 私人住宅單位

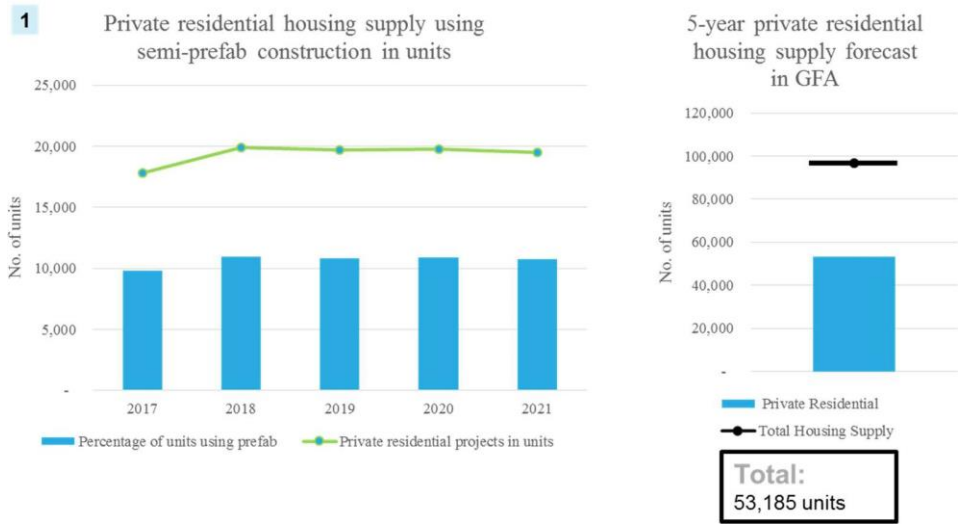
根據預測的 5 年期私人住宅單位供應總數為 97,600 個單位，我們進而估算有可能使用半預製施工方法的私人住宅數目。

公開研究[75]顯示，從歷史上來看，香港 55%的私人住宅單位使用了半預製施工方法。我們採用這一資料作為假設，推算將在施工階段使用半預製施工方法的 5 年期私人住宅供應的單位量。

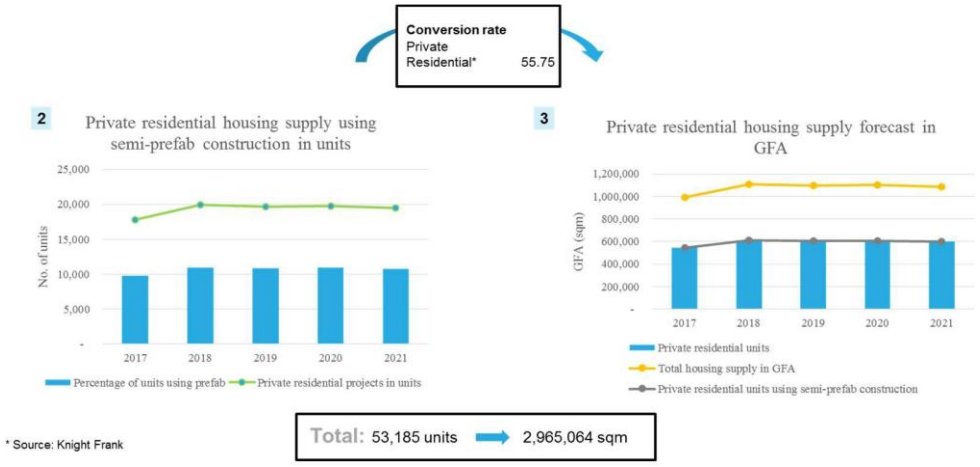
[74] Planning, design, and delivery of quality public housing in the new millennium, Housing Authority

[75] Vivian Tam、C.M. Tam、S.X. Zeng 及 William Ng，《施工轉用預製件》(Towards Adoption of Prefabrication in Construction)

根據這個假設（96,700個私人住宅單位的 55%），使用半預製施工方法的住宅單位供應量為 53,185個單位，如下圖所示：



這 53,185個住宅供應單位使用了預製施工方法，代表了約 297萬平米的樓面總面積（GFA）。單位數量對面積（平方米）的轉化率乃根據香港公共及私人住房的現有平均面積[76]計算。

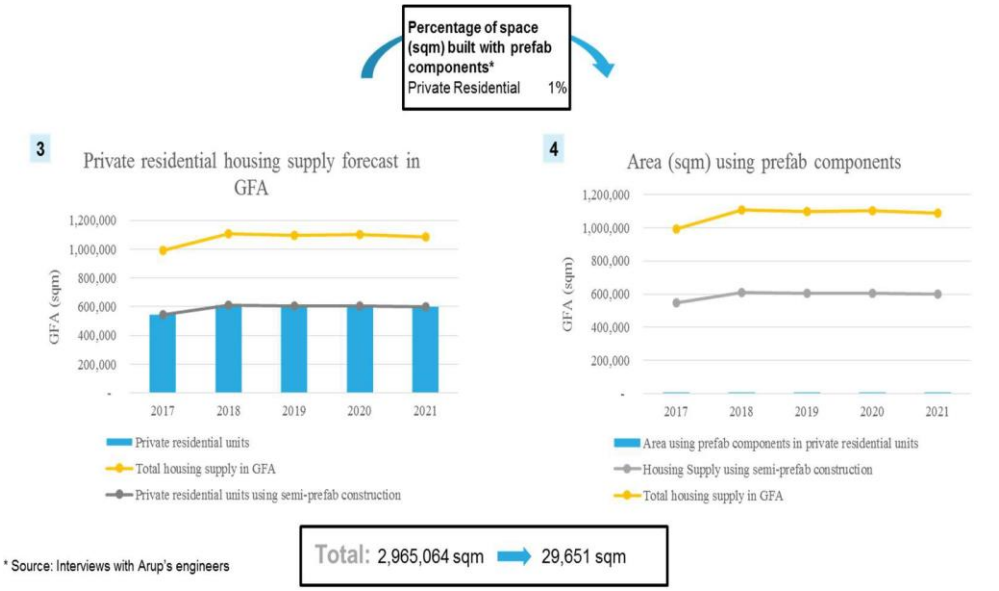


根據這 297 萬平方米的樓面總面積，我們繼續估算會採用預製組件的樓面總面積。

根據我們與奧雅納工程師的面談，我們瞭解到，從歷史上來看，私人住房建築僅有 1%的樓面總面積使用了預製組件。

[76] 資料來源於Knight Frank 及運輸及房屋局

我們採用該等數據作為計算採用預製組件建造的私人住宅單位樓面總面積的假設。如下圖所示，採用預製組件建造的估計樓面總面積約為29,651 平方米。



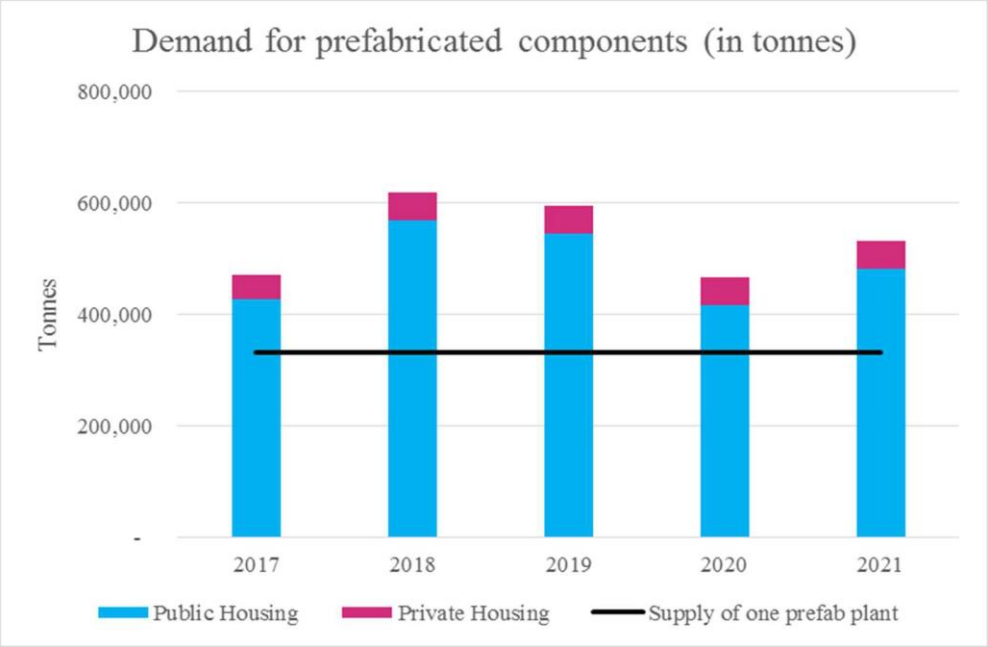
採用預製組件建造的估計樓面總面積約為29,651 平方米，代表了未來五年內會有約 244,618 公噸（例如使用密度為 2,450 公斤/立方米的鋼筋混凝土）預製組件需求。面積（平方米）對噸數的轉化率乃根據估算的預製組件平方米數對立方米數（1 平方米：3.3 立方米）再乘以鋼筋混凝土的密度來計算。

8.3.3 第 3 步：預製組件的需求預測

需求分析的最後一步是將預測的 5年期公共住房供應單位元的預製組件需求量及私人住宅供應單位元的預製組件需求量相結合。

根據上述分析，5年期公共住房預製組件的需求量為 2,436,124 公噸，5年期私人住宅預製組件的需求量為 244,618公噸。因此，5年期預製組件的需求總量為 2,680,741公噸。

如基礎案例所界定，擬建預製組件工場的年產量將約為 331,650 公噸。由此表明，擬建預製組件工場很可能在未來 5 年內滿足約62%的預製組件需求。



9 其他考慮因素

9.1 節省勞動力

於工地外預製件將對建築工地上的勞動力造成影響。根據 Tam 的研究（2002 年），倘現場現澆轉為預製件設計，工地勞動力最高可削減 43%。該削減乃屬假設，並可藉此根據高度預製（70%的構件為預製件）的一般公共住房住 宅建築計算所需的勞動力。這符合愛爾蘭混凝土聯盟組織(Irish Concrete Federation)的要求，該組織聲稱工地內的勞動力可根據完工情況削減 30-50%。

由於有趨勢顯示拗鐵工與扎鐵工、木匠、裝配工等建築工人嚴重短缺（建造 業議會，2012 年）且行業面臨急劇老齡化問題，故削減勞動力是一項重大 優勢。增加使用預製件的其他優勢亦包括對現場安全、產品品質及施工性能 的考量。此外，增加使用預製件預計可以節省工地內的勞動力，尤其是節省 技術工種（如模版、磚石或批蕩）的使用，這取決於所使用的預製構件類型。

9.2 採用更多技術及機械的機會

在預製行業的新技術及機械方面，特別是在美國及日本，大量預製組件的生產涉及高水平的自動化及計算機化。這種新技術有助提升整體品質、縮短生產時間，最重要的是可以減少勞動力需求。在勞動力成本高企且勞動力供應短缺的日本，該技術已被證明獲得成功及廣泛應用。

香港的勞動力市場動態與日本類似（成本高企且勞動力短缺），因而非常適合採用該等技術。聘請技術嫻熟的勞動力生產優質預製組件，將有助於在本地製造能與更廉價的境外預製產品相競爭的產品。

以下是日本及美國高度自動化的生產線示例。

9.2.1 積水房屋[77]

1. 在每個生產階段，憑藉專業人員及專家在工廠內生產高性能、高品質及高精度的建築組件。

   高科技機床與熟練工人的技術相結合。以最佳方式利用這兩個方面，意味著我們可以建造出高性能的房屋。

2. 計算機控制的自動化製造流程。高科技機床只有在工廠才有助於提高精度。

   可藉助激光測量設備即刻測量總共 16 個部分不同尺寸銲接及成品箱單元的水平和垂直精度，以檢查是否得以保持相關精度及品質。

[77]積水房屋株式會社網站、積水化學工業株式會社網站

每天進行拉伸測試以穩定強度，這意味著可透過品質控制維持穩定性、精度及銲接強度，而這在建築工地極難實施。

3. 在積水房屋工廠安裝了配備機器人的生產線，相繼實現了 95%的生產流程自動化。

用於 Heim 鋼架結構的鋼樑的切割、銲接及鑽孔所涉及的所有流程均使用計算機化的自動化機床進行。例如，鑽孔的精度維持在僅 0.1 毫米的誤差範圍內，同時使用大型機床進行重型外牆的安裝流程，並使用自動化打釘機製造大型地面底板。

9.2.2 Progress Maschinen & Automation AG[78]

1. 高度自動化及定製的卡魯塞爾設備

為預應力混凝土製品製造卡魯塞爾設備、線圈加工機械及設備、模具系統及設備。還可提供配料及混合設備、斗式輸送機、閘板、適用於預製構件的 3D 軟件，以及起重機、混凝土修整機等其他組件。

2. 電池模具、傾斜台、各種模具系統

提供定製尺寸的電池模具、多個澆注槽以及單電池或雙電池模具。傾斜台專為製造大面積鋼筋混凝土製品而設計。集成式高頻振動器有助於更好地壓實現澆混凝土。鋼板表面極其平整，從而保證實現高品質的混凝土表面。

3. 鋼筋機械及鋼筋網銲接設備

Versity 定製鋼筋網銲接機是一種適合中等生產需求的具成本效益的鋼筋網解決方案。鋼絲可從線圈或鋼筋饋入以適合供應。M-System PowerMesh HS 利用旋轉跳動及高效的棒材傳輸系統優化生產能力。鋼絲直徑會自動發生改變。

9.3 技能組合要求

隨著預製件的廣泛應用，預計許多現場工人將被預製組件工場的工廠工人所 取代。某些行業可能會消失，同時還會出現一些新的行業。這將改變工作性 質，並將導致建造業所需的技能組合發生改變。即使在傳統的現澆建築工地 及預製組件工場中應用相同的技能組合，在技術及自動化的幫助下，「技能」水平也可能有所不同。

[78] Progress Group 網站

下文展示了典型公共住宅建築的技能組合／技能水平的比較摘要：

技能類型／工匠	傳統的現澆混凝土施工	預製組件製造與裝配
	技能水平	
*鋼筋工	高	低
*模板工／模具工	高	低
*混凝土工	中	低
裝配工	中	中
起重機操作員	中	高
引導員	中	中
BIM 設計師／工程師	不適用	高
預製組件工場機器操作員	不適用	高
預製件裝配	不適用	中

傳統上，現澆混凝土施工需要技術嫻熟的勞動力，而這需要相對較長時間的培訓。隨著預製組件工場自動化的引入，一些工種被取代，如果工種相同， 則技能水平將不如傳統現澆混凝土施工中的技能水平高。

與現澆混凝土施工相比，採用預製組件需要技術水平較低的現場勞動力（起重機操作員除外，其需要更加熟練地操作重型起重機，以吊起可能超過 10 噸重的預製構件）。這是由於以堆放預製混凝土構件取代了熟練的活動。然而，預製工廠需要技術嫻熟的勞動力，尤其是在需要操作自動化設備及機器時。製造廠使用的技術嫻熟的勞動力範圍乃由所採用的製造方法確定，並且還取決於所製造構件的類型。

隨著科技的進步，自動化和機器人可能會取代傳統行業，例如鋼筋工、混凝土工和模板工。然而，預製組件工場的機器及設備操作員、預製組件安裝工／裝配、具備 DfMA 知識的 BIM 設計師和工程師等將會不斷培養新技能。

9.4 工人福利改善激勵措施

在香港，建築工人正面臨著勞動力短缺和老齡化的問題。由於建造業的工作 環境通常被認為艱苦而危險，因此加入該行業的新一代勞動力數量極少[79]。 透過在香港建立預製組件工場，建築工人可以在受天氣影響較小的更受控制、更舒適的室內環境中工作。擬建預製組件工場配備的設施可以進一步改善工 作環境，從而可能會吸引更多人加入該行業。

參考在新加坡建立的其他更先進及新建的預製件中心，為了改善工作環境和工人福利，在該等生產場地附近提供了各種福利設施及功能。

新加坡預製組件工場採用的福利設施及功能示例包括下列各項。

城市農業規劃 新加坡長成預製件中心(Tiong Seng Prefab Hub)在工人宿舍旁建有一個 900 平方米的城市農業區[80]，工人可在此種植自己的作物。這為工人提供了一個可以放鬆身心的綠色環境，以及在工作之餘從事其他活動的場所。	
綠色外牆 長成預製件中心已安設生態外牆，以讓植物在外牆上生長。生態外牆具備各種優點，例如減少聲音影響、改善空氣質素、實現建築美化及增強隔熱效果。	

[79] 香港政府新聞處，Construction manpower to use，2017 年3 月22 日
[80] 新加坡建設局新聞稿，2011 年1 月4 日

雨水收集

長成預製件中心的屋頂放置有雨水儲水箱，以收集雨水進行灌溉。這可以減少飲用水的使用量[81]及實現環境的可持續性。

娛樂設施

Greyform 預製件中心在工人宿舍附近設有籃球場等娛樂設施。這為工人在工作之餘享受娛樂活動提供了條件。

培訓中心

長成預製件中心還設有培訓中心。該中心可為工人提供僱員培訓，幫助他們改善技能組合及學習新技術。其可透過持續的自我完善為工人帶來工作滿足感。

除了我們從上述預製件中心所觀察到的設施外，我們還建議將下列設施納入擬建的預製組件工場，以改善工作環境和工人福利。

餐飲設施

餐廳或食堂等餐飲設施也可為僱員提供一個進行社交及分享想法的場所。如果擬建的工場規模受到限制，考慮到工人人數不多，修建較小的餐飲設施更為合適。

更衣室、淋浴間及儲物櫃

由於會接觸到化學品和建築材料，工人可能須穿著制服或防護服。私人更衣室應提供淋浴間及儲物櫃。淋浴設施可幫助工人保持衞生，儲物櫃則供工人存放私人物品。

[81] Robin Village Development Ptd Ltd 網站

除上述設施外，工作場所的環境也很重要。應對照明、通風、溫度和噪音等要素加以控制，以便提供舒適及安全的工作環境，並吸引新的工人進入該行業。

9.5 面向製造與裝配的設計

正如 Mott MacDonald 的 Paul Lengthorn 所指出的，香港要提升至下一階段，即面向製造與裝配的設計(DfMA)階段，就必須克服重重障礙。首先，它將 要求設計師和承包商密切合作，確定及詳述設計，準備好在工地外進行製造。這適用於「設計與建造」項目，因為設計師和承包商都在同一個團隊，但這 在香港並不是一種很常見的模式。[82] 透過將他們整合到同一個團隊中，溝通流程和變更程序會更有效率。Lengthorn 先生還指出，快速的招標流程使得可透過設計、製造與裝配增加重要價值的創新開發時間太少。提高對 DfMA 益處的認知將會鼓勵客戶支持該等項目。最後，他提到目前香港的建築法規 很適合傳統的施工解決方案，但會對 DfMA 項目構成挑戰。調整批准流程以適應這項新技術將鼓勵更多地採用預製件。正如他總結的那樣，「如果政府 和發展商與設計師、工程師和承包商密切合作，大力支持從事 DfMA 項目， 所有這些挑戰都可迎刃而解」。

在與承包商和預製件製造商舉辦的論壇中，有人提到工程師和建築師在最後時刻修改施工圖的設計在香港是一種常見做法。由於預製需要在製造預製組件前制定精心策劃的計劃表，因此在項目後期階段不斷作出改變的做法會使得在香港實施預製工作的難度增大及成本升高。

在私人住房方面，房屋的外形設計通常不規則。這主要是由於發展商試圖在有限的土地上實現樓面總面積最大化，以及透過構建不尋常的設計來呈現「奢華」的形象。因此，從成本角度來看，規模經濟所需的標準化預製組件會使其變得不可行。

工程師的反饋亦提到，香港缺少支持 DfMA 所需的掌握多種技能的勞動力。有建議表示如果 DfMA 可行，一旦香港擁有生產預製組件的此類設施，就需要提升技能。該等技能並不局限於混凝土構件，還包括涉及在設施內執行的管道工程和電氣工程的相關任務。

這項研究發現，最容易接受這種範式改變的人員包括環境、運輸、勞工、健康與安全以及公共部門的人員。與建設預製組件工場的益處類似，支持 DfMA 的人員亦會見證技術的進步，從而實現更高的效率、成本節約、更好的品質以及更低的風險。我們可以在設計階段更好地設法解決因天氣、材料供應、勞動力短缺、道路通行、傷害／死亡、污染等產生的風險。

富有遠見的設計師、工程師、承包商以及鼓勵採用 DfMA 方法獲得成功所需技術的政府和發展商，可像其他國家（例如新加坡）一樣獲得顯著效益。

[82] www.building.com.hk

截至 2018 年 1 月，新加坡政府已為建造業制定了達到 40%的 DfMA 採納率的目標，相比目前的 10%有所提高。在數字技術方面，迄今為止新加坡已有 70 多個項目使用了建築資訊模型(BIM)。到 2020 年，新加坡政府希望看到有 40 至 60 個項目採用集成式數碼傳輸(IDD)，不僅是在 BIM 中採用，而是在整個施工過程中採用。

9.6 預製方法的潛在好處和受益者

根據我們的研究，關於在香港開展預製工廠的潛在益處和受益者列舉如下：

預製造工廠的潛在優點	潛在受益者
工人	
工人將會在遮蔽環境下工作，而非暴露環境。	工人
工人的技術程度將會通過預製生產商的培訓而強化和提高。	工人
工人的生產率和效率將會通過使用新的技術而提高。	工人 預製生產商 建造業
優化的室內工作環境會吸引更多的年輕人加入到行業中來，緩解工人短缺的壓力。	建造業
安全	
在可控的工廠生產環境以及定期養護設備的條件下，事故率將會降低。	工 人 建造業
天氣條件不會影響安全和生產	工 人 建造業
使用技術性機械將減少現有的風險過程	工人
環境和健康	
地盤作業的污染，特別是粉塵和空氣流通的微粒將會顯著減少。其他的污水在排放前也會較為容易的處理。	附近居民 大眾
原材料的使用將會優化並減少大量生產。材料損耗率也會降低。	預製生產商 大眾（減少堆填和使用稀有原材料資源）
施現場的噪音污染將會降低甚至消失。	附近居民

技術和方法	
在建造業內潛在增加使用新技術，例如 BIM, DfMA 將會更廣泛應用。	建造業
新的施工方法帶入建造業，包括增加使用模組化施工技術。	建造業
增加使用自動化和機械人的機會進行預知生產，同時迎合香港轉化成為自動化技術中心的雄心。	建造行業 技術行業
潛在使用模組化施工，例如考慮在政府和私人專案中使用體積建築模組工藝。	建造行業
設計和溝通	
需制定一個認可的關於預製工廠方案以確保其品質系統	建造業 公眾（通過品質體系的控制）
生產	
潛在提升預製產品的品質	建造業
基於標準生產程式和使用新技術，生產率將會高於現澆工藝。	建造業
潛在減少從預製工廠到施工現場的運輸次數	建造業

儘管有向相關研究比較預製方法的潛在益處，而且是關於獨立個體的預製施工項目，我們在研究中無法找到關於預製工廠在“社會-經濟”層面的量化的益處分析。

其他層面關於詳細的量化益處分析反而可以提供關於在香港開展預製工廠的廣義的社會-經濟益處。這將有助於政府將來在相關產業投資的驗證條件。

綜上所述，建議政府或建造業議會在將來開展研究（例如經濟性分析）以量化在香港設立預製工廠的成本和收益分析。

根據可行性研究的發現，政府需要考慮如下方面：

1. 參考新加坡發展預製工廠的經驗以及新加坡政府採取的相關措施。例如：
    - 在住宅/商業發展項目賣地過程中中規定使用預製構件的要求；
    - 設立政府部門研究並規範新加坡的建造行業（例如提升施工效率和施工流程）；以及

- 使得預製生廠商能夠得到集成化施工和預製的技術支持並且低於市場價格。

2. 研發具體的易於香港市場的預製方法指引和技術規範。有些相關的文件已經在中國大陸使用，例如：

   - 混凝土預製拼裝塔機基礎技術規程 (JGJ/T197-201)
   - 預製預應力混凝土裝配整體式框架結構技術規程 (JGJ224-2010)
   - 預製帶肋底板混凝土疊合樓板技術規程 (JGJ/T258-2011)
   - 住宅衛生間模數協調標准(JGJ/T263-2012)
   - 裝配式混凝土結構技術規程(JGJ1-2014)
   - 住宅廚房模數協調標準(JGJ/T 262-2012)

3. 建立法定委員會管治項目
4. 設立適合預製構件的認可範圍
5. 考慮使用在預製工廠內生產的「組裝合成」建築法。

10 面談及利益相關者論壇的主要結果

10.1 面談

10.1.1 面談背景

為了更深入地了解香港預製行業和預製組件的使用情況以及建造業的模塊化，我們誠邀包括承包商、預製組件製造商及混凝土供應商在內的 7 家公司參與面談。在這 7 家公司中，有 4 家接受了邀請，我們在 2017 年 10 月下旬至 11 月上旬期間與他們進行了面談。

10.1.2 主要結果

根據與 4 家公司的面談，我們提取了重要資訊和意見，並將我們的面談分為下列 9 個關鍵方面進行討論：

1. 概覽與營運
2. 位置與規劃
3. 運輸
4. 環境影響
5. 設計、協調及技術問題
6. 勞工
7. 預製組件的成本及需求
8. 技術
9. 結論：關於在香港建設預製組件工場的看法

面談的主要結果概述如下：

概覽與營運
面談的這一部分的主要目標是在經營預製組件工場時提供營運及商業模式的初步概覽。4 家公司中有 3 家公司擁有預製組件工場，該等預製組件工場分別位於中國內地（廣東、惠州、深圳）。
其產品包括供公共和私人住房使用的預製外牆、預製樓梯、預製板和橫樑、預製浴室單元及預製窗戶。
預製組件在生產區域內用金屬模板製造。完成後，其將被轉移到一個無遮蔽的存儲區，然後被裝載到貨車上以供交付。

其預製組件的生產主要支持中國和香港的建築工地。
在製造的開始階段，工程師會駐紮在預製組件工場內，以確保對預製產品實施品質控制。此外，還會僱傭品質控制專業人員，以將每一步操作中的錯誤降至最低。
中國的預製組件工場在高峰期可以一天 24 小時不間斷運行。然而，值得注意的是，由於噪音許可問題，這種情況在香港不太可能會發生。
位置與工場規劃
我們進行面談的公司的預製組件工場佔地面積從 50,000 平方米到 160,000 平方米不等。然而，我們知道大部分工場屬於傳統的開放式工場／單層工場，因此需要更大的面積。
預製組件工場位於中國的主要原因是，與香港相比，中國的土地及勞動力成本更低。
除主要生產設施外，還應預留區域用於存放及配製混凝土。
由於原材料乃透過陸路運輸從中國輸送，因此預製組件工場的位置需滿足交通便利的條件。此外，如果成品透過海運運輸，則預製組件工場的位置需靠近碼頭／船塢。
運輸
根據各公司的經驗，在中國生產的預製組件通常會在下午運抵香港。然後，組件將在次日早上被運至工地，並在下午開始進行安裝。
運輸成品的陸地運輸車輛通常長 12 米，載重量達 30 噸。
預製組件的裝卸過程通常長達 1 小時。
在高峰期，成品的運輸每天需要大約 10 輛貨車。
在建築工地，安裝前需為預製組件預留大型存儲區域。由於香港的建築工地通常空間有限，因此在施工階段開始時需進行場地規劃，以便進行存儲規劃。
環境

與現場施工相比，在預製組件工場進行製造時，材料（包括有缺陷的預製組件）的損耗較少。損耗可從現場施工的約 5%降低至預製組件工場的約 0.5%至 1%。
存儲緩凝劑、增塑劑、顏料、防腐劑及粘合劑等化學外加劑進行混凝土澆注。
某些預製組件工場自身建有水處理設施，以處理生產中所產生的廢水。
設計、協調及技術問題
就預製組件的設計、法定批准及模板和模具的裝配而言，在生產開始前需提前約 7 個月進行協調。
一般而言，預製件施工需要 7 天，而現場施工通常需要 4 至 6 天，因此需要更多的施工時間。然而，由於天氣條件對施工的影響甚小，因此施工時間表更為確定。
在制定香港預製組件標準時，品質控制及法定批准流程將是一項技術難題。
勞工
傳統預製組件工場的勞動力包括技術水平較低的製造業勞動力、品質控制員、管理人員及專業技術人員[83]。
受訪者建議香港應安排足夠的管理及設計人員。然而，在香港很難找到像模板工這樣的製造業工人。
預製組件的成本及需求
根據過往及當前項目，公共住房建設大約可以使用高達 30%的預製組件。然而，由於公共住房在最近的建設中停止使用容積式預製浴室單元，預計未來的使用率會降低。
在私人住房建設中，施工中預製組件的使用率不足 15%。
在中國，預製組件的使用情況比香港更為普遍。在新加坡，由於他們採用預製橫樑和柱子，因而使用率可達 70%。

[83] 傳統預製組件工場所需的勞動力有別於自動化預製件中心所需的勞動力。

- 隨著樓面總面積寬免措施的減少（外牆寬免厚度從 300 毫米減至 150 毫米），香港未來對預製組件的需求可能會有所減少。對於公共住房建設，預製組件的預測需求量為每年 200,000 至 300,000 噸。對於私人住房，預計每年只有不到 10 個項目將採用預製件。

- 就建築成本而言，預製件施工的成本將比傳統現場施工的成本高。

- 成本及利潤佔預製組件工場收入百分比的大致明細如下：
  - 原材料：40% - 45%
  - 勞工：15% - 20%
  - 模具：8 - 10%
  - 雜項／間接成本：15%
  - 利潤：5%

- 預製組件的成本約為每噸 2,000 港元至 4,000 港元（即對於典型的混凝土預製組件而言），具體取決於預製組件的類型、複雜程度和尺寸。

技術

- 可在預製件生產中實施射頻識別設備、3D 建模及 3D 列印等新技術（用於設計協調目的），以提高生產力及產品品質。

關於在香港建設預製組件工場的看法

最後，我們要求受訪者就在香港建設預製組件工場發表看法。大部分受訪者對香港擬建預製組件工場的可行性表示擔憂，其主要關注點概述如下：

- 隨著預製行業的良好發展，新加坡在土地空間及勞動力（來自移民）方面擁有更多資源可用於構建及製造預製組件。此外，新加坡政府已制定各種政策來促進預製組件的使用（請參閱第 3.1 條）。在香港，為了與新加坡和中國的預製組件進行競爭，需提供更多政府補貼和支持來促進預製行業的發展。
- 有限的土地及勞動力資源仍然是建設預製組件工場需考慮的一大關切問題。建造業議會應向預製行業的工人提供培訓，而住房管理局應在其項目中更加廣泛地使用預製組件。
- 在香港建設預製組件工場對承包商有利，因為這樣可以減少承包商派遣工程師前往中國進行品質檢驗的需要。

10.2 利益相關者參與論壇

作為研究的一部分，我們舉辦了三場利益相關者參與論壇。舉辦論壇的目的是：參照預製組件的利弊以及未來 5 年的建造活動，討論建造業在技術嫻熟的勞動力短缺以及如何在香港本地的預製組件工場使得預製可行的問題方面將面臨的挑戰，並從利益相關者處獲取相關意見。

在 Arup 辦事處促進及舉辦的會議如下：

論壇編號	日期	利益相關者團體
1	2018 年 1 月 29 日	承包商及專業預製件供應商
2	2018 年 2 月 2 日	諮詢公司、專業協會及學術界人士
3	2018 年 2 月 2 日	發展商及政府機關

在論壇上，向參與者介紹了以下內容：

- 關於在香港建設預製組件工場之條件及障礙的初步調查結論
- 建造業觀察數據及所面臨的挑戰，例如勞動技能及勞動力短缺
- 新加坡預製組件工場的案例研究；及
- 項目採用 DfMA 方法

在三個論壇上提出供討論的議題取決於利益相關者團體，並且重點關注利益相關者與預製行業的關聯。請參閱下表了解所提出的議題。

利益相關者團體	提出供討論的議題
承包商及專業預製件供應商	勞動力供應、勞動技能、工作條件、工人安全性、成本及效益、技術（BIM、自動化）
諮詢公司、專業協會及學術界人士	設計的便利性及法定批准、創新(DfMA)、標準化及軟件技術、靈活性／挑戰
發展商及政府機關	監管／政策、規範及標準、激勵措施、成本／時間／選項

利益相關者論壇的結果概述如下：

- 參加三個論壇的所有利益相關者達成普遍共識，認為在施工中採用預製模組／組件將從安全、環保、可持續性、勞動力短缺及品質方面受益。
- 除非有真正的經濟利益，否則私營部門採用預製組件的百分比將不會大幅增加。
- 在施工中採用預製模組將消耗發展項目的許可樓面總面積。這對於私人發展商使用預製組件來說是一個「巨大的」遏制因素。
- 技術進步（即 BIM、自動化）使得預製組件的設計及製造更為高效。
- 建設本地預製組件工場將受益於法定檢驗的便利性、始終如一的品質控制以及易於滿足的本地勞動力需求。利益相關者普遍支持在香港建設預製組件工場，但他們對於從商業角度來看其是否可行或是否具備可持續性持保留意見。
- 政府在土地供給和購買承受能力、現有法規和政策的修訂（例如強制使用預制方法、建築面積豁免、設計指引的可採用性、高效的設計審批流程和時間等）可以促進預製方法在香港開展。

附錄 A

Requirements for Prefabricated Prefinished Volumetric Construction

Requirements for Prefabricated Prefinished Volumetric Construction

For the purposes of Regulation 4B(4)(b) of the Building Control (Buildability and Productivity) Regulations, the volumetric modules used for PPVC shall comply with the following requirements:

Minimum level of finishing and fittings to be completed off-site

The extent of finishing and fittings to be completed off-site for the volumetric modules shall comply with the minimum levels stipulated in Table 1. Where any deviation from these minimum levels is necessary, prior approval shall be sought from BCA.

Minimum level of finishing and fittings to be completed off-site	
Element	Minimum level of completion off-site
Floor finishes	80%
Wall finishes	100%
Painting	100% base coat, only final coat is allowed on-site
Windows frame & Glazing	100%
Doors	100%, only door leaves allowed for on-site installation
Wardrobe and Cabinets	100%, only wardrobe and cabinet doors to allowed for on-site installation
M&E including water & sanitary pipes, electrical conduits & ducting	100%, only equipment and fixtures to allowed for on-site installation
Electrical sockets and light switches	100%, only light fittings allowed for on-site installation

Water tightness and prevention of corrosion where steel is used as the primary structural material

The steel shall be galvanised in accordance to ASTMA 123/A 123M or alternative equivalent standards.

The volumetric modules shall be designed and fabricated to:

- prevent water from entering the modules (e.g. by means of waterproofing membrane or other means at the joints and gaps between the modules); and
- allow any water in between the volumetric modules and façade, and in between the modules to be properly discharged and drained completely.

Floor areas intended to be wet (e.g. bathrooms, kitchens) and areas that could be potentially exposed to water (e.g. fire sprinkled areas) shall be treated with waterproofing membrane to ensure water tightness.

Acceptance Framework for Prefabricated Prefinished Volumetric Construction (PPVC)

The acceptance framework consists of two parts – the Building Innovation Panel (BIP) and the PPVC Manufacturer Accreditation Scheme (PPVC MAS).

Under the new acceptance framework for PPVC systems to be used at the mandated GLS sites, PPVC suppliers and manufacturers are required to submit their applications and proposals to the Building Innovation Panel (BIP).

1. The PPVC system and the in-built bathrooms (if any) shall comply with the requirements of the BIP. The accepted PPVC systems including the in-built bathroom (if any) and their respective suppliers/manufacturers will be listed on the BCA website at http://www.bca.gov.sg/BuildableDesign/ppvc.html. Relevant letters of In-Principle Acceptance (IPA) will also be issued to the PPVC supplier/manufacturer.
2. In addition, the production facilities producing PPVC systems which have been accepted through the BIP will be required to be accredited under the PPVC MAS, which is managed by the Singapore Concrete Institute (SCI) and the Structural Steel Society of Singapore (SSSS) as part of the effort to promote greater self-regulation by the industry. The accreditation criteria were jointly developed by SCI, SSSS and BCA. Further details on the accreditation scheme can be found at www.scinst.org.sg and www.ssss.org.sg.

附錄 B

Prefabrication Manufacturer Case Studies

Case Study 1 – SEF SpaceHub

Incorporated in 1994, the SEF Group acts as the main contractor in planning, coordinating, managing and undertaking works for new construction, addition & alteration, and interior fit-out.

SEF Group undertakes a wide range of projects for the private and public sectors encompassing high-end hotels, luxury residences, heritage buildings, recreation facilities, retail malls, commercial offices, and mixed-use developments.

SEF Group has 5 core divisions[84] including:

1. Construction Division;
2. Interiors Division;
3. Prefabricated Prefinished Volumetric Construction (PPVC) Division;
4. Prefabricated Bathroom Unit (PBU) Division; and
5. Structural Precast Division.

SEF Group won the first land tender by the Building and Construction Authority (BCA) for the development of an Integrated Construction and Prefabrication Hub (ICPH) at Kaku Bukit Road in 2013 with a 30-year lease term[85].

Opened in 2015, SEF SpaceHub is the first prefabrication hub in Singapore to have fully integrated modelling, production and delivery of prefabricated components.

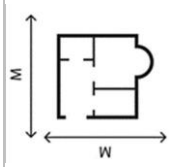
Some facts and figures of the SEF SpaceHub investment cost, development, operation, welfare facilities, automation, equipment and systems and types of prefabrication products manufactured and benefits are listed as follows

Investment Cost

 $100mil	The highly mechanised and automated facility was built at a cost of more than SG$100 million[86].

[84] SEF Group website
[85] Building and Construction Authority of Singapore website
[86] New hub to build precast parts with less manpower, Straits Times

The Hub

 20,000sqm	The hub is located at Kaki Bukit with approximately 20,000 sqm[87] in land size and a maximum gross plot ratio of 1.6[88].
 32,608sqm	The build-up area is approximately 32,608 sqm[89]. Comparing with traditional open yard, the development of a multi-story prefabrication hub allows a more efficient use of land and more workspace.
 5-storey	The hub occupies 5 floors. In land scarce Singapore, the vertical development of prefabrication hubs allows higher utilisation of land use.
5 automated production lines	The hub is equipped with 5 automated production lines. The highly mechanised and indoor factory environment enables high throughput and high productivity.

Other Facilities

 Worker's Dormitory	The hub includes a seven-storey workers' dormitory as part of the Phase 2 construction.
 Multi-tiered fully automated storage facility	SEF SpaceHub is the first in Singapore to use a multi-tiered fully automated storage system, which is capable of storing more than 100 trailers worth of completed components, including bulky 3-D components such as household shelters.

[87] Building and Construction Authority of Singapore news release – 29 July 2013
[88] Building and Construction Authority, ICPH tender
[89] Building and Construction Authority of Singapore website

 Office building	A 4-storey office building located next to the hub for engineers, designers and other administrative staffs allows closer alignment and coordination with work progress in the hub.
Automated concrete batching plant with underground storage system	The dust free automated concrete batching plant is equipped with technologically advanced concrete mixer to produce quality concrete. It also has an underground storage system that saves space.

Equipment, Systems and Automation

NEMETSCHEK GROUP Nemetschek - Precast Software Engineering	Nemetschek provided integration of Building Information Modelling (BIM) software with the control & management software to gather installation updates from project sites to achieve "Just in Time" production in order to cut down on storage space.[90]
RIB running together SAA SAA – prefabrication hub automation control system	SAA provides master computer systems and control systems covering software and technical requirements in connection with the automation of a prefabricated concrete plant. The fully automated system allows tracking of inventory of prefabricated components and the preparation to delivery.
Avermann - Automated prefabricated concrete production line	Automated production line consisting CAD systems, workstations for job preparation, production planning, mixing plants and bucket conveyors etc.
Nordimpianti – Prefabricated pre-stressed concrete machinery	Nordimpianti offers a wide range of pre-cast concrete manufacturing machines from casting machines to pre-stressing machines.

[90] Singapore awards landmark tender for integrated construction and precast hub, Yahoo Finance

EVG – Welded Mesh production and steel bars processing machinery	EVG provides machines for welded mesh production and cutting and bending of rebars.
 Pemat – Concrete mixing equipment	Pemat concrete mixer provides high levels of homogenisation and repetition.
 Terex Demag – Heavy lift cranes	Demag by Terex provides All terrain cranes, City cranes and Lattice boom crawler cranes.

Productivity

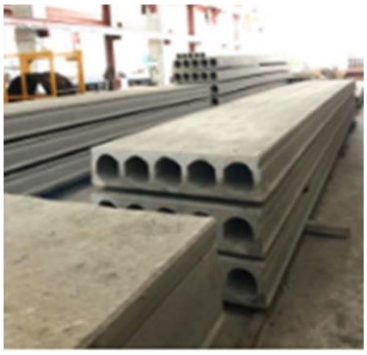
 240,000tonnes	The adoption of new technology and machineries, allows the hub to be two to three times more productive than traditional open prefabrication yards as work can go on non-stop and several processes can be carried out at the same time [91] . In addition, the covered environment also allows work to be carried out even during bad weather. The hub has an annual production capacity of more than 240,000 tonnes of prefabricated components[92].

[91] Going off-site to boost productivity, The Business Times
[92] Building and Construction Authority of Singapore news release – 29 July 2013

Prefabricated Products

SEF SpaceHub produces more than 25 types of components. Including columns, beams, planks, walls, façades, staircases, household shelters and prefabricated bathrooms in a factory setting. These components can then be transported for installation on site. Examples of similar products include:

Prefabricated Prefinished Volumetric Construction (PPVC / Modular Construction)	Prefabricated Bathroom Unit
	

Coloured Prefabricated Facades	Prefabricated Structural Components (Columns, Floors, Beams and Walls, Staircases, Slabs)
	

Benefits of the new SpaceHub facility

The prefabricated components were originally manufactured in an open yard factory and very labour intensive. Following the move from an open yard to a multi-storey building factory and advanced technology and automated production lines adopted, there has been vast improvements to its operational efficiency and productivity. Some of the improvements includes:

3x production capacity	Annual prefabricated components production capacity is three times more than a conventional open prefabrication yard[93].
 Better quality control, faster production	The hub setting speeds up the production process and provides better quality control of the prefabricated components.
 70% Manpower savings	The highly automated facility is expected to reduce the number of workers needed by up to 70 per cent[94,95].

[93] Building and Construction Authority News release July 2013
[94] New hub to build precast parts with less manpower, The Straits Times
[95] Prefab Hub to boost construction productivity: Khaw, Yahoo News

Case Study 2: Greyform Building

Greyform Pte Ltd, a member of Straits Construction Group, was incorporated in 2015 and specialises on precast and prefabrication production.

Greyform Pte Ltd manufacturers prefabricated concrete products such as the following:

- Prefabricated bath unit
- Prefabricated façade wall
- Prefabricated Staircase flight
- Prefabricated concrete column
- Prefabricated Slab

Greyform won the land tender from the Building and Construction Authority (BCA) for development of the second Integrated Construction and Prefabrication Hub (ICPH) at Kaku Bukit Road in 2014 with a 30-year lease term.[96]

Greyform Building is the second Integrated Construction and Prefabrication Hub (ICPH) awarded under a public tender by BCA. The multi-storey prefabrication hub was opened in 2017 and uses a high degree of automation to produce pre-fabricated construction elements such as concrete walls, columns and beams.

Some facts and figures of Greyform's investment cost, development, operation, welfare facilities, automation, equipment and systems and types of prefabrication products manufactured and benefits are listed as follows:

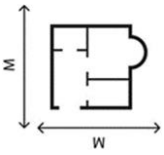
Investment Cost

 $150mil	The recently established Greyform Building equipped with advanced technology and machinery costed an SG$150 million investment[97].

The Hub

 20,000sqm	The land size occupied is approximately 20,000 sqm[98], with a maximum gross plot ratio of 1.6. It is located at Kaki Bukit next to SEF Spacehub.

[96] Building and Construction Authority of Singapore website
[97] The Straits Times, BCA to give advance notice on building projects that need high level of prefabrication
[98] Building and Construction Authority of Singapore

 32,100sqm	The Greyform Building has a gross floor area of 32,100 sqm. When compared to the traditional prefabrication yards that are housed in large open areas, it optimises the use of land better by developing vertically.
 4-storey	The Greyform Building comprises a four-storey prefabricated concrete components production factory and office. It allows workers to work in a controlled and safe environment, improving the working conditions.

Other Facilities

 Workers' Dormitory[99]	In addition to the 4-storey production factory, three blocks of 12-storey dormitory capable of housing 750 workers are also located next to the hub[100].
 Multi-storey storage and retrieval system	In order to store the prefabricated components, an automated, multi-level storage system has been built with the capacity to house up to 5,800 tonnes of products[101].
 Entertainment facilities	To improve working environment, entertainment facilities are built closely to the workers' dormitory such as basketball court.

Productivity

 150,000tonnes	The Greyform building is equipped with robots and digital modelling for automation, which can operate around the clock regardless of the weather. Productivity can be increased up

[99] Picture from ONG&ONG Corporate website
[100] The Singapore Engineer January 2018
[101] The Singapore Engineer January 2018

	to 40 % and the plant has an annual production capacity of more than 150,000 tonnes[102].

Prefabricated Products

The Greyform manufacturer can produce a wide range of products to fit different building needs. They emphasize on innovations that enable faster construction. Similar examples of Greyform Building's products include:

Prefabricated Stair	Prefabricated Bath Unit
	

Prefabricated Concrete Column	Prefabricated façade wall
	

Benefits of the new Greyform Facility

Advanced prefabricated technologies were adopted by Greyform in their new multi-story facility. Improvements to productivity and saving to manpower have been achieved. Details includes:

[102] The Straits Times, BCA to give advance notice on building projects that need high level of prefabrication

 Increased productivity and improved quality	Equipped with highly automated production line and precise designing with computer software, the hub is able to improve productivity and increase the quality of prefabricated components.
 66-75% Manpower savings	The automation manufacturing process also significantly reduces the amount of labour needed. The hub has only 60 workers, which is about one-third to one-fourth of what is needed for a traditional open yard[103].
 Creating new and higher-skilled jobs	These heavily automated facilities require high-skilled and trained workers as well as technical staffs such as engineers and designer. It creates new and higher-skilled job that attracts locals to work in the construction industry.

[103] The Straits Times, BCA to give notice on building projects that need high level of prefabrication

Case Study 3: Tiong Seng Prefab Hub

Tiong Seng Group was founded in 1959 who had been involved in earthworks and excavation projects. Later in 1970s, the company expanded into civil engineering and since 2002 they have started to extensively adopt the use of prefabricated technology.

Tiong Seng Group's key services include:

- Building construction and civil engineering
- Property development
- Prefabrication
- Green technology
- Metal works & steel works

Tiong Seng Group announced the launch of the Tiong Seng Prefab Hub in 2012 with SG$1 million funding from the Building and Construction Authority (BCA)[104].

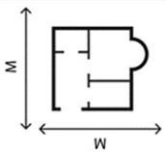
The Tiong Seng Prefab Hub is a multi-purpose facility. It houses the automated prefabricated plant and contains space for the building of prefabricated bathroom units and the pre-assembling, storing and maintaining of advanced formwork systems. It also includes facilities such as training centre, a Building Information Modelling (BIM) Centre and a workers' dormitory. The co-existence of these related activities under one roof makes managing resources easier while improving land productivity.

Some facts and figures of Tiong Seng Prefab Hub's investment cost, development, operation, welfare facilities, automation, equipment and systems and types of prefabrication products manufactured and benefits are listed as follows:

Investment Cost

 $26mil	The Tiong Seng Prefab Hub costs SG$26 million with a SG$1million funding from the BCA.[105]

The Hub

 19,813sqm	Tiong Seng Prefab Hub is located at Tuas, with a gross floor area of 19,813 sqm. Approximately 72% of the gross floor area is allocated for production purpose [106], the

[104] Building and Construction Authority news press, Tiong Seng's $26 million Prefab Hub – Singapore's 1st automated pre-cast facility and first to receive BCA funding
[105] Building and Construction Authority Singapore News Press, 4 January 2011
[106] Building and Construction Authority Singapore News Press, 4 January 2011

	other areas contain multi-purpose space designed with green building concepts.
5-storey	The 5-storey prefabrication hub consists of areas for production and several facilities as described below.
2 automated production lines	The hub has two automated production lines incorporating automated equipment from Germany [107] . While automated machines will perform complex work such as high precision of marking-out of dimensions, automated pallet circuits will be installed to transport products from one workstation to another for processing.

Other Facilities

Office area	Ancillary offices are located at all floors to closely align designers and engineers with the production line.
Workers' dormitory and urban farming plot	The workers' dormitory includes a 900sqm plot dedicated for urban farming where workers can grow their own crops[108].
Rainwater tanks	Rainwater tanks are located at roof top for rainwater harvesting for irrigation to reduce usage of potable water [109] and achieve environmental sustainability.
Various green building features	Besides the urban farming facility, Tiong Seng has also incorporated several green building features which include an eco-façade for

[107] Building and Construction Authority news press, Tiong Seng's $26 million Prefab Hub – Singapore's 1st automated pre-cast facility and first to receive BCA funding
[108] Building and Construction Authority Singapore News Press, 4 January 2011
[109] Robin Village Development Ptd Ltd website

	the office block incorporating a vertical green wall, an extensive green roof which provides natural cooling, monsoon windows to improve air ventilation, and rainwater harvesting[110].
Training Centre and BIM Centre	The hub features a training centre and a BIM Centre. It allows Tiong Seng to train their project partners and sub-contractors on the use of BIM, which is a 3D software that can improve coordination of the construction value chain and reduce the amount of reworking on-site.

Productivity

 240,000tonnes	As the facility can operate 24-hour production process, the output has doubled from previous plant with annual production exceeding 240,000 tonnes [111] . The facility can produce enough parts for approximately 5,000 Housing and Development Board flats.

Benefits of the new Tiong Seng Prefab Hub

Increase in the productivity capacity and saving to manpower has been achieved. Details include:

 70% Manpower savings	With automation, Tiong Seng Prefab Hub has reduced manpower needs up to 70%, requiring only a third of the workers to produce double the volume of prefabricated components[112].

[110] Building and Construction Authority Singapore News Press, 4 January 2011
[111] Building and Construction Authority Singapore News Press, Opening of Tiong Seng Prefab Hub
[112] Building and Construction Authority Singapore News Press, 4 January 2011

附錄 C

Site Analysis

Area 1: Ping Shan

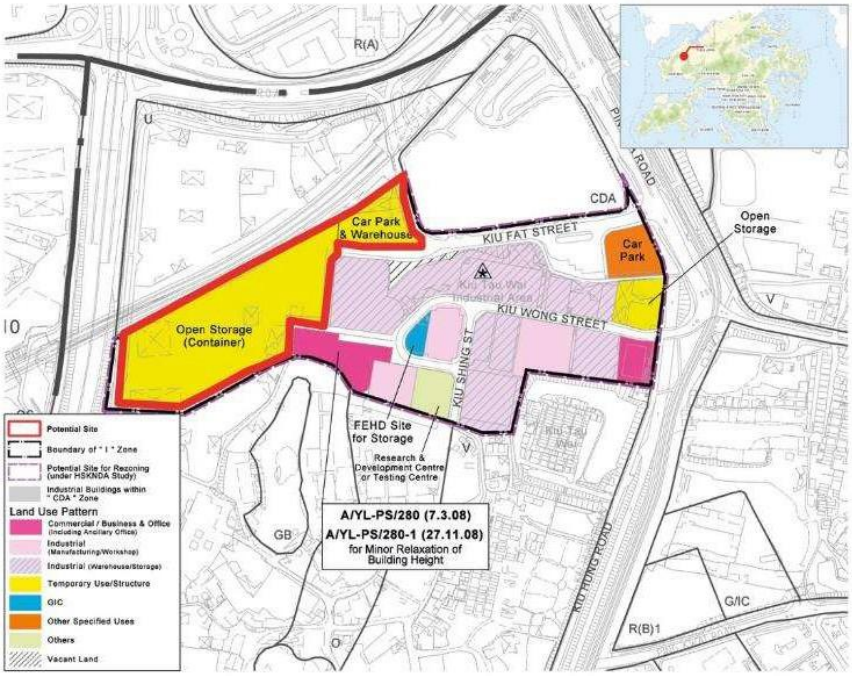
Site analysis:

Possible Industrial Area No.1 is located in between Hung Tin Road and Kiu Hung Road in Ping Shan. As of the year 2014, the predominant uses of this area are 48.2% for Warehouse/Storage and 23.4% for Manufacturing/Workshop.

Our analysis shows that there is currently no vacant site in this Possible Industrial Area, except for a temporary use land (currently occupied by open storage facility, car park and warehouse) on the western portion of the area. The size of this temporary use land is approximately 28,000 sqm (shown in red boundary in Figure 1.3.1). The whole Possible Industrial Area is currently under multiple private ownerships.

These existing uses would be compatible with the prefabrication yard, as the operation would involve both manufacturing and storage services.

Figure 1.3.1: Potential Site in Ping Shan[113]



[113] Adapted from Appendix 3.6 of Report on 2014 Area Assessments of Industrial Land in The Territory, from: https://www.pland.gov.hk/pland_en/p_study/comp_s/industrial_report_2014/appendices/a26.pdf. .

Table 1.3.1 Key Information of Ping Shan

	Description
Possible Industrial Area	Ping Shan
Total area (as in 2014)[114]	9.86 ha
District	Yuen Long
OZP	Draft Hung Shui Kiu and Ha Tsuen OZP No. S/HSK/1
Current Zoning	"C(2)" and "OU (Mixed Use)"
Predominant Uses (as of 2014)	Warehouse/Storage (48.2%) and Manufacturing/Workshop (23.4%)
Vacant Site (as of 2014)	0 site
Vacancy Rate (based on GFA as of 2014)	4.5%
Ownership (as of 2014)	Mainly private ownership
Number & Area of Potential Site(s)	No. of Potential Site: 1 Site area: 28,000sqm

Other considerations:

It is important to note that in the prevailing Draft Hung Shui Kiu and Ha Tsuen Outline Zoning Plan (OZP) No. S/HSK/1 gazetted published in May 2017, this temporary use land has been defined as "Commercial(2)" ("C(2)") and "OU (Mixed Use)" zone. The planning intention of the "C(2)" zone is "primarily for commercial developments" and according to the Explanatory Statement (ES), the "C(2)" zone will be developed as a secondary node for office, retail and hotel uses. The "OU (Mixed Use)" zone is intended "primarily for high-density residential development and commercial development in close proximity to the railway stations."

As such, the prefabrication yard being an "industrial" use, will not be in line with the planning intention of the current zonings of this area.

Key findings:

Table below summarises our key findings for the Ping Shan site assessment:

Results		Rationale
Site analysis	◯	Opportunities: Site area is adequate to fit the size of the prefabrication yard as suggested in Preliminary Base Case Constraints: Latest gazette mentioned that the whole industrial area has been rezoned and it is no longer intended for industrial use Multiple private ownerships

[114] Site A26 (Report on 2014 Area Assessment of Industrial Land in the Territory).

Area 2: San Hei Tsuen / Tong Yan San Tsuen

Site analysis:

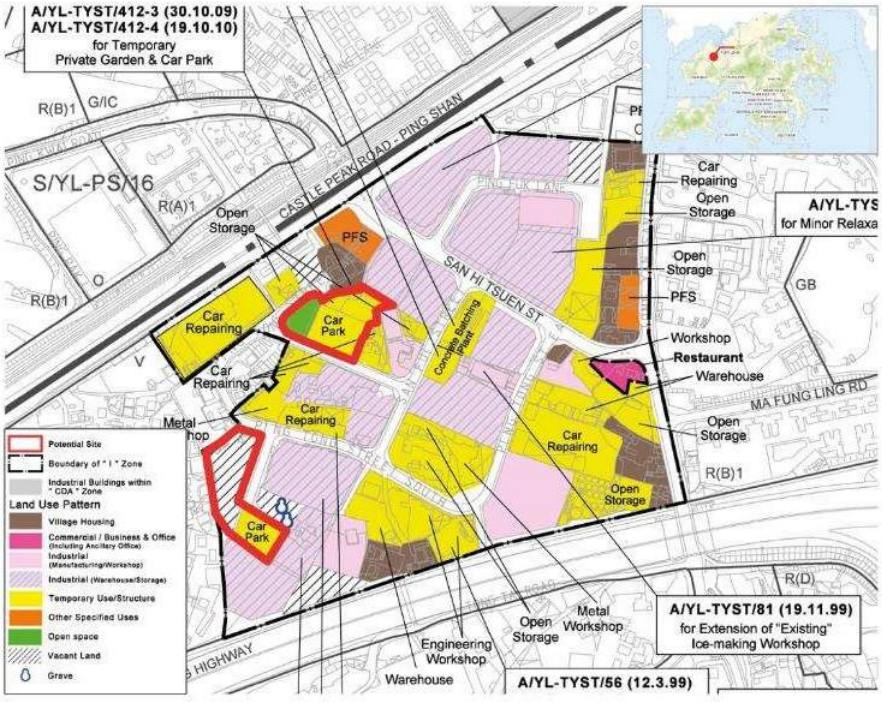
Possible Industrial Area No.2 is situated in-between Castle Peak Road – Ping Shan and Yuen Long Highway at San Hei Tsuen. As of the year 2014, the predominant use of this area is 78.2% for Warehouse/Storage.

Our analysis shows that there are two vacant sites within this Possible Industrial Area:

- Potential Site 1: It is currently used as open space and temporary car park, and has a site area of around 3,900 sqm
- Potential Site 2: It is partially vacant and partially used as a temporary car park. The site area is around 4,000 sqm.

The site area for Potential Site 1 and Site 2 are approximately 3,900 sqm and 4,000 sqm respectively.

Figure 1.3.2 Potential Sites in San Hei Tsuen/ Tong Yan San Tsuen[115]



[115] Adapted from Appendix 3.6 of Report on 2014 Area Assessments of Industrial Land in The Territory, from: https://www.pland.gov.hk/pland_en/p_study/comp_s/industrial_report_2014/appendices/a25.pdf.

Table 1.3.2 Key Information of San Hei Tsuen/ Tong Yan San Tsuen

	Description
Possible Industrial Area	San Hei Tsuen/ Tong Yan San Tsuen
Total area (as in 2014)[116]	14.80 ha
District	Yuen Long
OZP	Draft Tong Yan San Tsuen OZP No. S/YL-TYST/11
Current Zoning	"I"
Predominant Uses (as of 2014)	Warehouse/Storage (78.2%)
Vacant Site (as of 2014)	2 sites
Vacancy Rate (based on GFA as of 2014)	0.1%
Ownership (as of 2014)	Mainly private ownership
Number & Area of Potential Site(s)	2 nos., varying from about 3,900 sqm. to 4,000 sqm.

Other considerations:

These Potential Sites are subject to a maximum Plot Ratio (PR) of 3 and Building Height Restriction (BHR) of 4 storeys (15m). Minor relaxation of PR and BHR is possible through a S16 planning application to the Town Planning Board (TPB). If the operations of prefabrication yard involve bleaching and dyeing, electroplating/ printed circuit board manufacture, metal casting and treatment, an S16 planning application is also required.

Our analysis also shows that these Potential Sites are located adjoining to "Village" ("V") and "Residential (Group A)" ("R(A)") zones, which are predominately residential in nature. As such, it could lead to a potential Industrial / Residential (I/R) interface issues as well as public objections if a prefabrication yard of a substantial scale is to be developed at these locations.

[116] Site A25 (Report on 2014 Area Assessment of Industrial Land in the Territory).

Key findings:

Table below summarises our key findings for the San Hei Tsuen/ Tong Yan San Tsuen site assessment:

Results		Rationale
Site analysis		Opportunities: Zoning in line with industrial use. Potential Sites held under Government ownership Constraints: The site area is relatively small as compared to Preliminary Base Case requirement; May require S16 planning application for minor relaxation of building height restriction (4 storeys/15m) and max. PR (PR3) for the prefabrication yard use; May require S16 planning application should the prefabrication operations involve bleaching and dyeing, electroplating/ printed circuit board manufacture, metal casting and treatment; and Close proximity to "V" and "R(A)" zones, which may induce I/R issues or possible public objections.

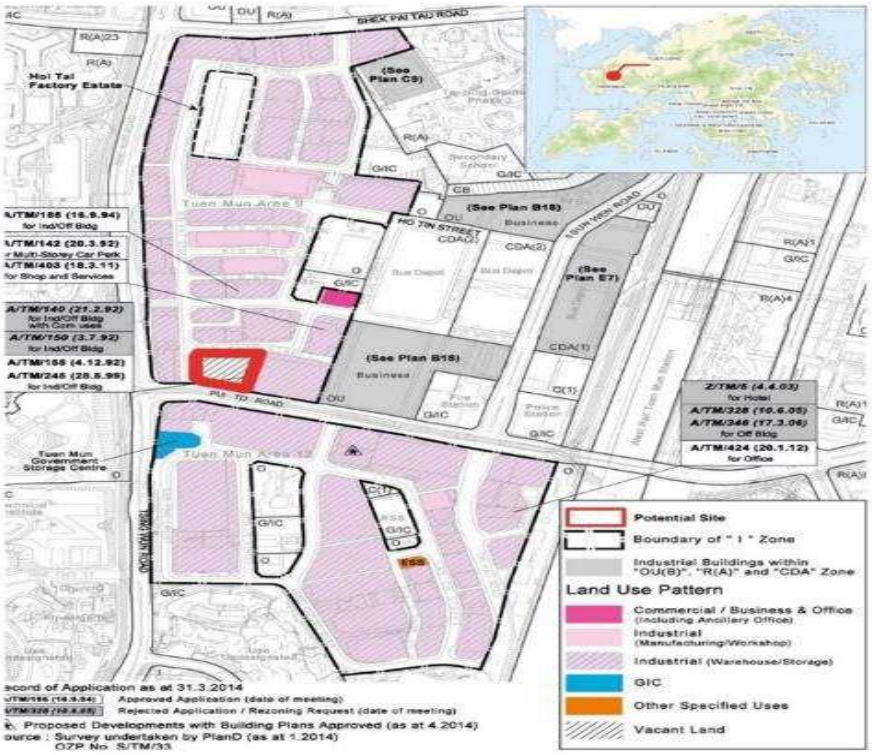
Area 3: Tuen Mun Areas 9 and 12

Site analysis:

Possible Industrial Area No.3 is located to the west of Tuen Mun Town Centre. As of the year 2014, the predominant uses of this area are 65% for Warehouse/Storage and 11.4% for Manufacturing/Workshop.

Our analysis shows that there is a small piece of vacant land, along Pui To Road, with an area of about 3,000 sqm. It is located in between warehouses and storages in the same "I" zone.

Figure 1.3.3 Potential Site in Tuen Mun Areas 9 and 12[117]



[117] Adapted from Appendix 3.6 of Report on 2014 Area Assessments of Industrial Land in The Territory, from: https://www.pland.gov.hk/pland_en/p_study/comp_s/industrial_report_2014/appendices/a20.pdf.

Table 1.3.3 Key information of Tuen Mun Areas 9 and 12

	Description
Possible Industrial Area	Tuen Mun Areas 9 and 12
Total area (as in 2014)[118]	26.19ha
District	Tuen Mun
OZP	Draft Tuen Mun OZP No. S/TM/34
Current Zoning	"I"
Predominant Uses (as of 2014)	Warehouse/Storage (65%), Manufacturing/Workshop (11.4%)
Vacant Site (as of 2014)	0 site
Vacancy Rate (based on GFA as of 2014)	3%
Ownership (as of 2014)	Mainly private ownership
Number & Area of Potential Site(s)	1 no., about 3,000 sqm

Other considerations:

This Potential Site is subject to a maximum PR of 9.5 and BHR of 100mPD. Our analysis also shows that the Potential Site is currently under a single private ownership.

If the prefabrication yard involves concrete batching operations, a S16 planning application would be required, as this use is under Column 2 of "I" zone in this OZP (Draft Tuen Mun OZP No. S/TM/34).

Key findings:

Table below summarises our key findings for the Tuen Mun Areas 9 and 12 site assessments:

Results		Rationale
Site analysis		Opportunities: Adequate site area. Constraints: The site area is relatively small as compared to Preliminary Base Case requirement; Held under private ownership; and May require S16 planning application if the prefabrication operations involve concrete batching operations.

[118] Site A20 (Report on 2014 Area Assessment of Industrial Land in the Territory).

Area 4: Tuen Mun Area 16

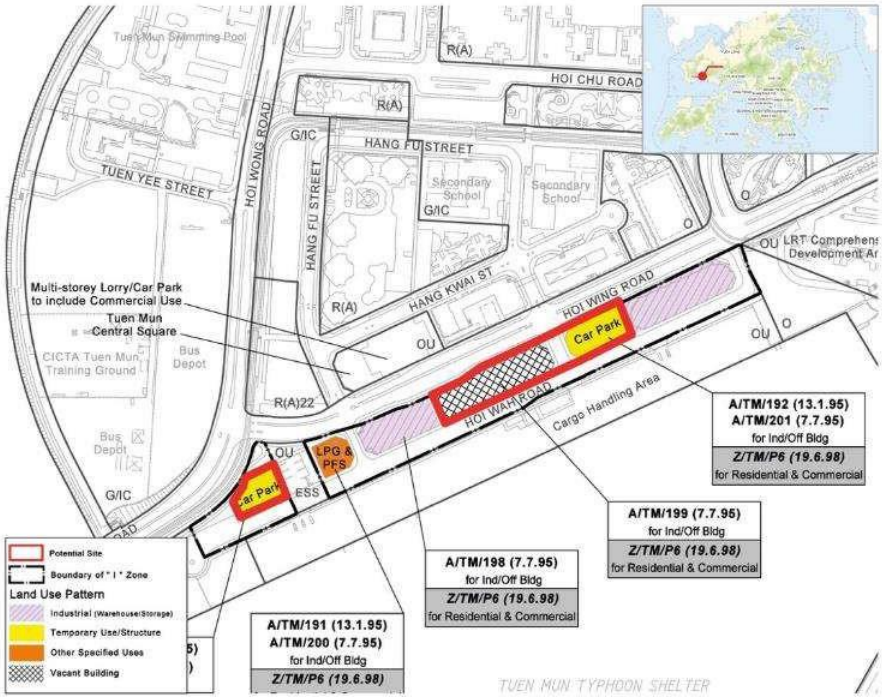
Site analysis:

Possible Industrial Area No.4 is located to the south of Tuen Mun Town Centre and in-between Hoi Wan Road and the Marine Department Tuen Mun Public Cargo Working Area. As of the year 2014, the predominant uses of this area are 18.2% for Warehouse/Storage, 12.9% for Office and 37.4% vacant.

Our analysis shows that there are two Potential Sites within this Possible Industrial Area:

- Potential Site 1: located on the western end, which is now used as a temporary car park and is Government-owned, with a site area of about 1,900 sqm.;
- Potential Site 2: located in the middle of the larger "I" zone, which consists of a vacant warehouse on private land and a temporary car park on Government land, with a site area of about 10,000 sqm. This site is segregated by a road connecting Hoi Wing Road and Hoi Wah Road.

Figure 1.3.5 Potential Sites in Tuen Mun Area 16[119]



[119] Adapted from Appendix 3.6 of Report on 2014 Area Assessments of Industrial Land in The Territory, from: https://www.pland.gov.hk/pland_en/p_study/comp_s/industrial_report_2014/appendices/a21.pdf.

Table 1.3.5 Key information of Tuen Mun Area 16

	Description
Possible Industrial Area	Tuen Mun Area 16
Total area (as in 2014)[120]	3.42ha
District	Tuen Mun
OZP	Draft Tuen Mun OZP No. S/TM/34
Current Zoning	"I(1)"
Predominant Uses (as of 2014)	Vacant (37.4%), Warehouse/Storage (18.2%) and Office (12.9%)
Vacant Site (as of 2014)	1 site
Vacancy Rate (based on GFA as of 2014)	37.4%
Ownership (as of 2014)	About half held under private ownership
Number & Area of Potential Site(s)	2 nos., varying from about 1,900 to 10,000 sqm.

Other considerations:

The whole area is zoned as "I(1)" and is subjected to a max. PR of 5 and an BHR of 35mPD on the Draft Tuen Mun OZP No. S/TM/34. Minor relaxation of building height restriction of PR and BHR could be sought via a S16 planning application.

The vacant warehouse building in Potential Site 2 has been renovated recently and is held under private ownership. Hong Kong Christian Service Pui Oi School is located across Hoi Wing Road, less than 50m away from Potential Site 2.

Key findings:

Table below summarises our key findings for the Tuen Mun Area 16 site assessment:

Results		Rationale
Site analysis	◯	Opportunities: Zoning in line with industrial use; Existing uses are either vacant or temporary. Constraints: The site areas are relatively small as compared to Preliminary Base Case requirement; May require S16 planning application for minor relaxation of building height restriction; May require S16 planning application if the prefabrication operations involve concrete batching. May cause nuisance to nearby school; and Not wholly Government-owned.

[120] Site A21 (Report on 2014 Area Assessment of Industrial Land in the Territory).

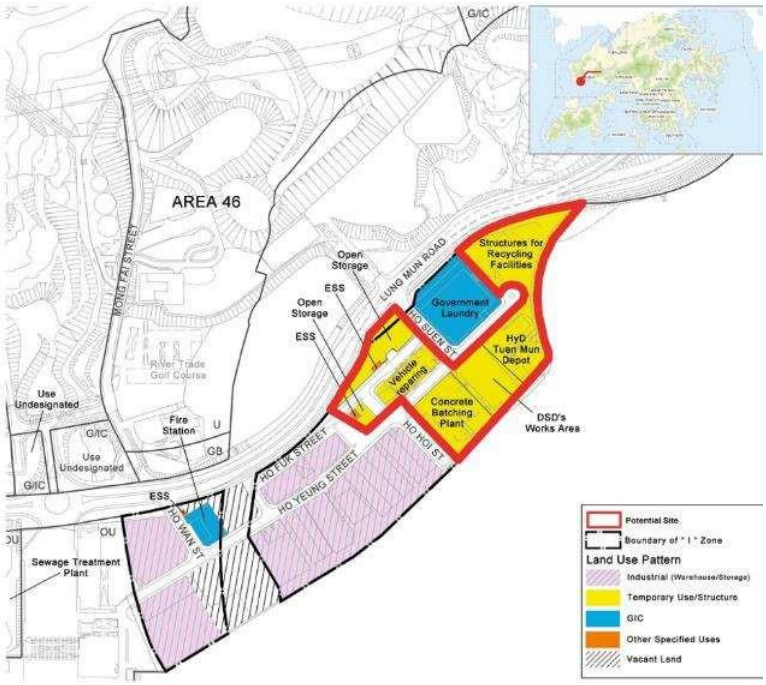
Area 5: Tuen Mun Area 40

Site analysis:

The Possible Industrial Area No.5 is located to the west of Butterfly Beach and to the south of Lung Mun Road along the waterfront in Tuen Mun 40. The area is fully occupied by warehouse and storage uses.

Our analysis shows that there is a Potential Site (36,000 sqm.), located at the north-eastern corner of the area. A number of temporary uses such as structures for recycling facilities, Highways Department (HyD) Tuen Mun Depot, concrete batching plant, vehicle repairing, open storage and two electrical substation (ESS), are currently occupying the Potential Site.

Figure 1.3.4 Potential Site in Tuen Mun Area 40[121]



[121] Adapted from Appendix 3.6 of Report on 2014 Area Assessments of Industrial Land in The Territory, from: https://www.pland.gov.hk/pland_en/p_study/comp_s/industrial_report_2014/appendices/a23.pdf.

Table 1.3.4 Key information of Tuen Mun Area 40

	Description
Possible Industrial Area	Tuen Mun Area 40
Total area (as in 2014)[122]	10.78ha
District	Tuen Mun
OZP	Draft Tuen Mun OZP No. S/TM/34
Current Zoning	"I(3)"
Predominant Uses (as of 2014)	Warehouse/Storage (100%)
Vacant Site (as of 2014)	2 sites
Vacancy Rate (based on GFA as of 2014)	0%
Ownership (as of 2014)	Majority Government land
Number & Area of Potential Site(s)	1 no., about 36,000 sqm.

Other considerations:

This whole area, zoned as "I(3)" is subject to a maximum PR of 2.5 and MBH of 26mPD on the Draft Tuen Mun OZP No. S/TM/34. The Potential Site is located on a Government-owned land.

We understand that currently there is an on-going study on "Planning and Engineering Study for Tuen Mun Area 40 and 46 and the Adjoining Areas". One of the possible scenarios suggested in the Study indicates that there is an intention to develop this Possible Industrial Area No.4 into modern logistics/ green industry use in MSB with a development scale of approximately PR4 (6-8 storeys high)[123]. The future planning intention seems to be in line with the industrial nature of the prefabrication yard. These premises could allow for the development of a prefabrication yard in the form of MSB as the ICPH model.

The limitations of this Potential Site would be the uncertainty imposed by the abovementioned on-going study. Also, given its relatively low BHR of the Potential Site and the typically high floor-to-floor height of manufacturing, minor relaxation of the building height restriction might have to be sought via a S16 application, which could be an element of uncertainty for the development of prefabrication yard[124].

[122] Site A23 (Report on 2014 Area Assessment of Industrial Land in the Territory).
[123] See http://www.tm4046.hk/download/digest/tm4046_digest1.pdf. This study is, however, on-going and might be subject to further changes.
[124] But this will depend on the detailed design of the prefabrication yard.

Key findings:

Table below summarises our key findings for the Tuen Mun Area 40 site assessment:

Results		Rationale
Site analysis		Opportunities: Zoning in line with industrial use; Future planning intention in line with industrial use; Possible scenario of development of MSB for industrial use; Existing uses are temporary; Wholly Government-owned; and Site area is adequate to fit the size of the prefabrication yard as suggested in Preliminary Base Case
Results		Rationale a
		Constraints: On-going study could impose uncertainty to future use; May require S16 planning application for minor relaxation of building height restriction; and May require S16 planning application if the prefabrication operations involve concrete batching.

Area 6: Wu Shan Road, Tuen Mun

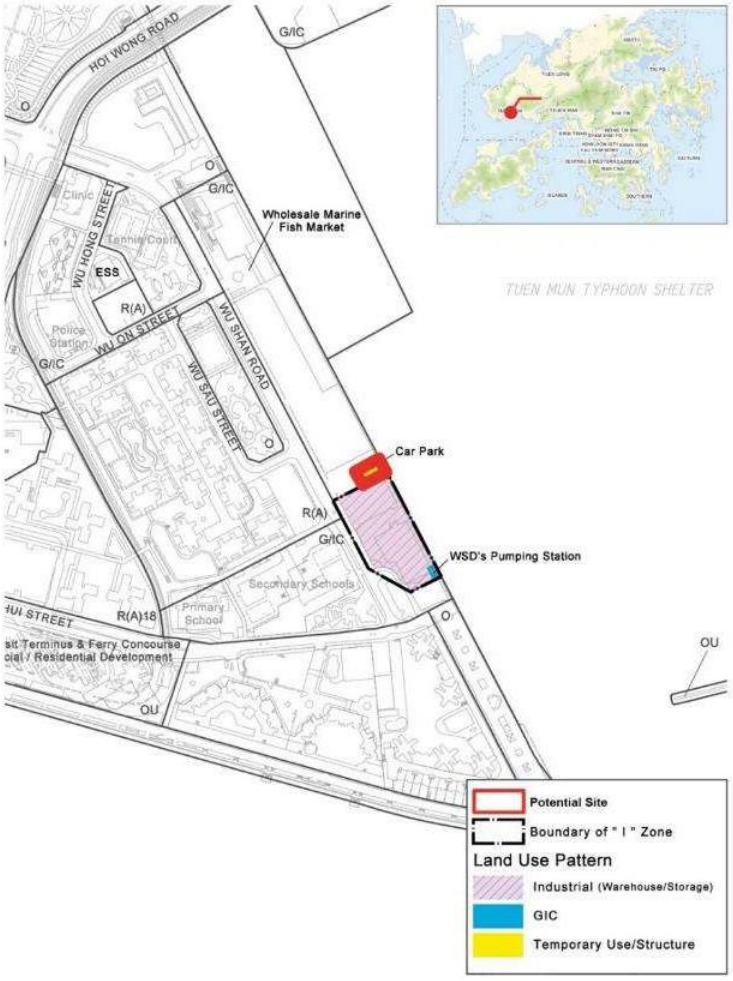
Site analysis:

Possible Industrial Area No.6 is located at the east of Yuet Wu Villa along Wu Shan Road. Currently zoned as "I(2)" in the Draft Tuen Mun OZP No. S/TM/34, the whole area is almost fully occupied by a warehouse named Sun Wah Cold Storage, a Water Services Department (WSD) Pumping Station and a temporary car park.

Our analysis shows that there is a temporary car park, with a site area of approximately 600sqm. within this Potential Industrial Area. This Potential Site is wholly owned by the Government.

This area is subject to a max. PR of 3 and an BHR of 50mPD.

Figure 1.3.6 Potential Site in Wu Shan Road, Tuen Mun[125]



[125] Adapted from Appendix 3.6 of Report on 2014 Area Assessments of Industrial Land in The Territory, from: https://www.pland.gov.hk/pland_en/p_study/comp_s/industrial_report_2014/appendices/a22.pdf.

Table 1.3.6 Key information of Wu Shan Road, Tuen Mun

	Description
Possible Industrial Area	Wu Shan Road
Total area (as in 2014)[126]	0.84ha
District	Tuen Mun
OZP	Draft Tuen Mun OZP No. S/TM/34
Current Zoning	"I (2)"
Predominant Uses (as of 2014)	Warehouse/Storage (73.7%) and Office (26.3%)
Vacant Site (as of 2014)	0 site
Vacancy Rate (based on GFA as of 2014)	0%
Ownership (as of 2014)	Mainly single private ownership
Number & Area of Potential Site(s)	1 no., about 600 sqm.

Other considerations:

The Potential Site is located next to a residential development (Yuet Wa Villa) and three schools (Ka Chi Secondary School, South Tuen Mun Government Secondary School and Lung Kong World Federation School Limited Lau Tak Yung Memorial Primary School).

Key findings:

Table below summarises our key findings for the Wu Shan Road, Tuen Mun site assessment:

Results		Rationale
Site analysis	◯	Opportunities: Zoning in line with industrial use; Existing use is temporary; and Government-owned. Constraints: The site areas are relatively small as compared to Preliminary Base Case requirement; May require S16 planning application should the prefabrication operations involve concrete batching; and May cause nuisance to nearby residents and school.

[126] Site A22 (Report on 2014 Area Assessment of Industrial Land in the Territory).

Area 7: "OU (PBU, Storage & Workshop Uses)" Zones in HSK NDA

Site analysis:

Possible Industrial Area No.7 is located at Ha Tsuen in Yuen Long and west of Kong Sham Western Highway.

This area is not included in the Report on 2014 Area Assessments of Industrial Land in The Territory. However, we have considered this zone in our analysis as it is intended for the development of MSBs to accommodate port back-up, storage and workshop facilities.

This zone is subjected to a maximum PR of 7 and an MBH of 110mPD. The planning intention for this zone is "primarily to cater for the port back-up facilities and container related uses" and "port back-up related development such as container freight station, logistics centre, container vehicle park and container storage, repair yard and rural industry workshop."

Our analysis shows that there are a few Potential Sites within this area and the size varies from about 16,500 to 154,000 sqm. This zone's planning intention leans towards logistic uses, but is also industrial-orientated, as evidenced by its planning intention.

Despite their size and relevant planning intention, the amount of land that would be available for MSB particularly for prefabrication uses will be subjected to concurrent studies, as this zone is primarily intended to provide alternative spaces for the existing brownfield users that are affected under the HSK NDA and YLS PDAs.

The land ownership will also be subjected to the results of the concurrent studies. Also, if the prefabrication operation involves cement manufacturing, concrete batching, metal casting and treatment, and open storage of cement/sand, a S16 planning application would be required.

Figure 1.3.7 Potential Sites – "OU (PBU, Storage & Workshop Uses)" Zones in HSK NDA[127]

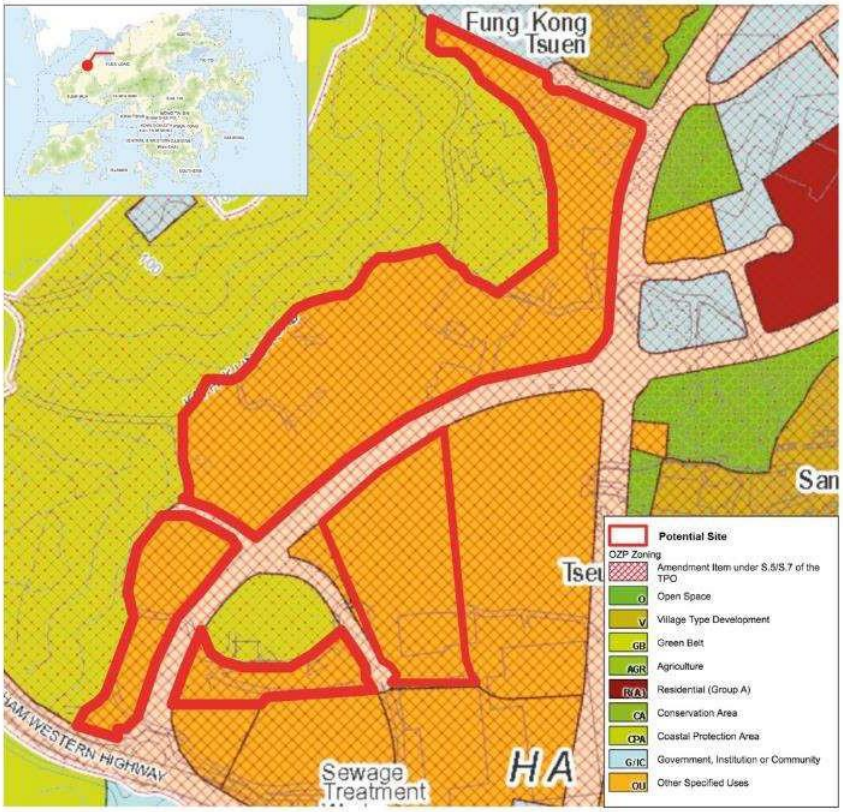


Table 1.3.7 Key information of "OU (PBU, Storage & Workshop Uses)" Zones in HSK NDA

	Description
Possible Industrial Area	"OU (PBU, Storage & Workshop Uses)" Zones in HSK NDA
Total area (as in 2014)[128]	24.80ha
District	Yuen Long
OZP	Draft Hung Shui Kiu and Ha Tsuen OZP No. S/HSK/1
Current Zoning	"OU (PBU, Storage & Workshop Uses)"
Predominant Uses (as of 2014)	Mainly container storage[129]
Vacant Site (as of 2014)	--
Vacancy Rate (based on GFA as of 2014)	--
Ownership (as of 2014)	--
Number & Area of Potential Site(s)	4 nos., varying from about 16,500 to 154,000 sqm.

[127] Adapted from Statutory Planning Portal 2, from: http://www2.ozp.tpb.gov.hk/gos/default.aspx#.
[128] Draft Hung Shui Kiu and Ha Tsuen Outline Zoning Plan No. S/HSK/1.
[129] As observed from the aerial photo on Geoinfo Map.

Key findings:

Table below summarises our key findings for the "OU (PBU, Storage & Workshop Uses)" Zones in HSK NDA site assessment:

Results		Rationale
Site analysis		Opportunities: Zoning in line with industrial use; Zoning will take in consideration of MSB development; Sufficient site area; Adjacent to Kong Sham Western Highway could facilitate import of raw materials; and Constraints: Available land and land ownership is subject to on-going and further studies; and May require S16 planning application should the prefabrication operations cement manufacturing, concrete batching, metal casting and treatment, and open storage of cement/sand.

Area 8: "OU (Storage & Workshop Uses)" proposed under YLS PDA

Site analysis:

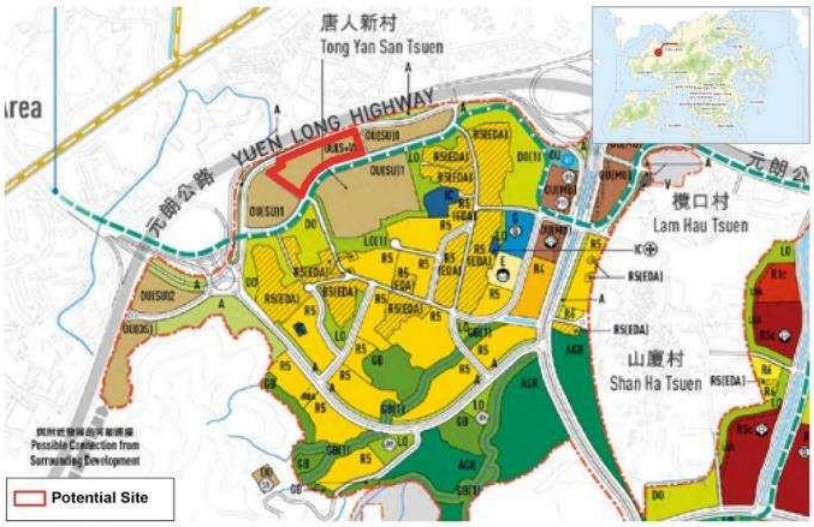
Possible Industrial Area No.8 is located along the south of Yuen Long Highway and north of Tong Yan San Tsuen. Our analysis shows that there is a Potential Site, which is a strip of "OU (Storage & Workshop Uses)". Currently zoned as "I(D)". Its planning intention is "primarily for industrial uses that cannot be accommodated in conventional flatted factories due to extensive land and/ or high ceiling requirements" and it is also "intended for the redevelopment of existing informal industrial uses". Studies are currently being undertaken to re-plan for the OU zone.

Under the latest RODP of the YLS study, this strip of OU is intended to be developed as the Employment Belt where MSBs will be constructed.[130].

This Potential Site is of 17,000sqm and comply with the Industrial land use classification and MSB development. and within close proximity to Yuen Long Highway, which is one of the main arterial roads.

As the YLS Study is still on-going, and the proposed "OU(Storage & Workshop Uses)" has yet to be reflected in statutory OZP, there could be uncertainties to the current site analysis conditions.

Figure 1.3.8 Potential Site - "OU (Storage & Workshop Uses)" proposed under YLS Study[131]



[130] Please refer to the Information Digest of YLS study, from: http://www.yuenlongsouth.hk/links/information_digest.pdf.
[131] Adopted from the RODP of YLS study, from: http://www.yuenlongsouth.hk/links/RODP.pdf.

Table 1.3.8 Key information of "OU (Storage & Workshop Uses)" proposed under YLS Study

	Description
Possible Industrial Area	"OU (Storage & Workshop Uses)" proposed under YLS Study
Total area (as in 2014)[132]	Approx. 1.7 ha[133]
District	Yuen Long
OZP	Draft Tong Yan San Tsuen OZP No. S/YL-TYST/11
Current Zoning	"I(D)" (intended for "OU (Storage & Workshop Uses)" under YLS Study)
Predominant Uses (as of 2014)	Mainly storage/warehouse[134]
Vacant Site (as of 2014)	--
Vacancy Rate (based on GFA as of 2014)	--
Ownership (as of 2014)	--
Number & Area of Potential Site(s)	1 nos., about 17,000 sqm.

Key findings:

Table below summarises our key findings for the "OU (PBU, Storage & Workshop Uses)" Zones in YLS PDA site assessment:

Results		Rationale
Site analysis		Opportunities: Zoning in line with industrial use; Zoning will take in consideration of MSB development; Constraints: Insufficient site area; Uncertainties on the future zoning Land ownership not fully captured at present

[132] Recommended Outline Development Plan (RODP) in Planning and Engineering Study for Housing Sites in Yuen Long South – Investigation, from: http://www.yuenlongsouth.hk/links/RODP.pdf.
[133] Estimation from the RODP of YLS.
[134] As observed from the aerial photo on Geoinfo Map.

附錄 D

Financial Analysis

Base Case 1: Yard owner

Overview

Under Base Case 1, we have assumed that the yard owner would:

Acquire the land for the establishment of the prefabrication yard;

Construct the prefabrication yard;

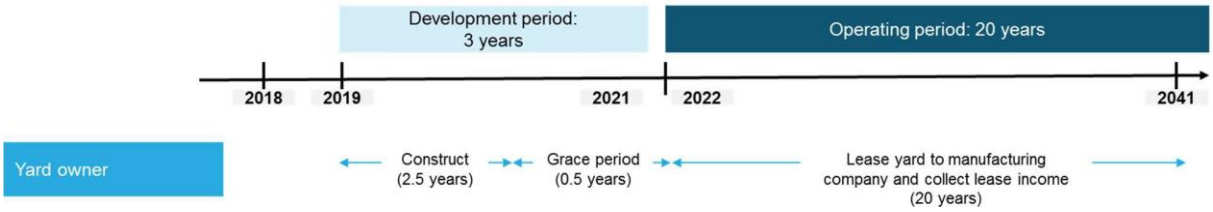
Fund the development cost (land and construction cost) through a combination of debt and equity in line with market norms;

Lease the prefabrication yard to the manufacturing company upon completion of construction; and

Receive lease rental over the operating period; and

Receive a suitable return from its equity investment based on industry benchmarks for investments at this nature and with similar risk profiles.

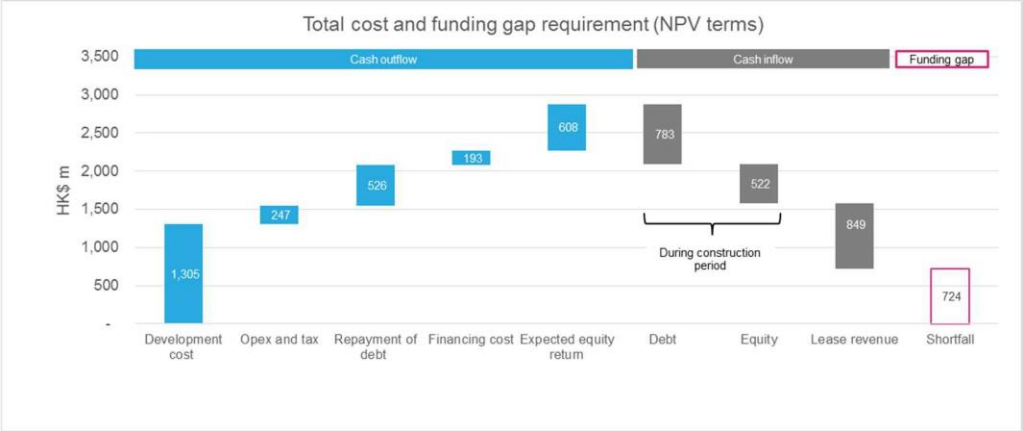
Diagram below illustrates the project timeline and key events in the financial analysis for Base Case 1: Yard owner:



Findings and results

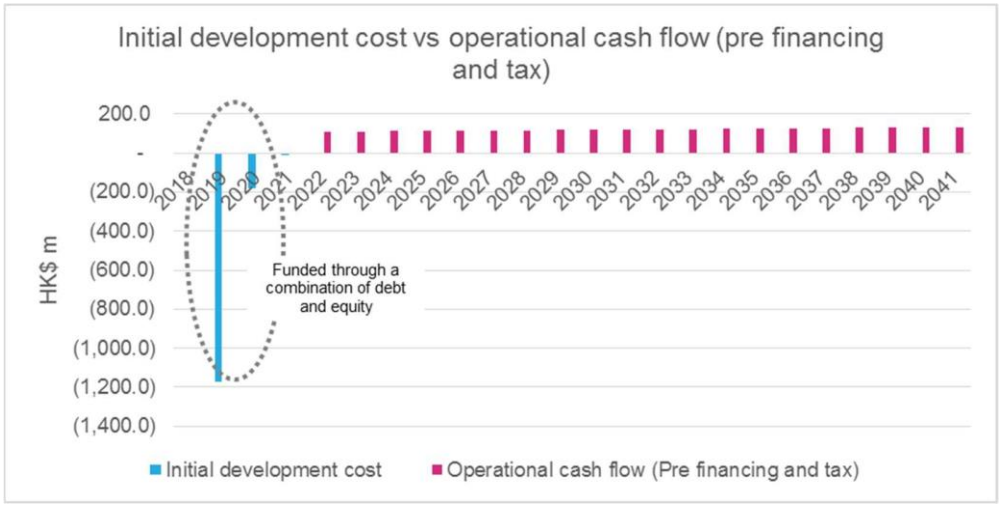
Overall result:

Based on the approach and assumptions above, the yard development (Base Case 1: Yard owner) would not be independently financially viable. Our analysis shows that the level of shortfall / funding requirement is approximately HK$724m (NPV value).



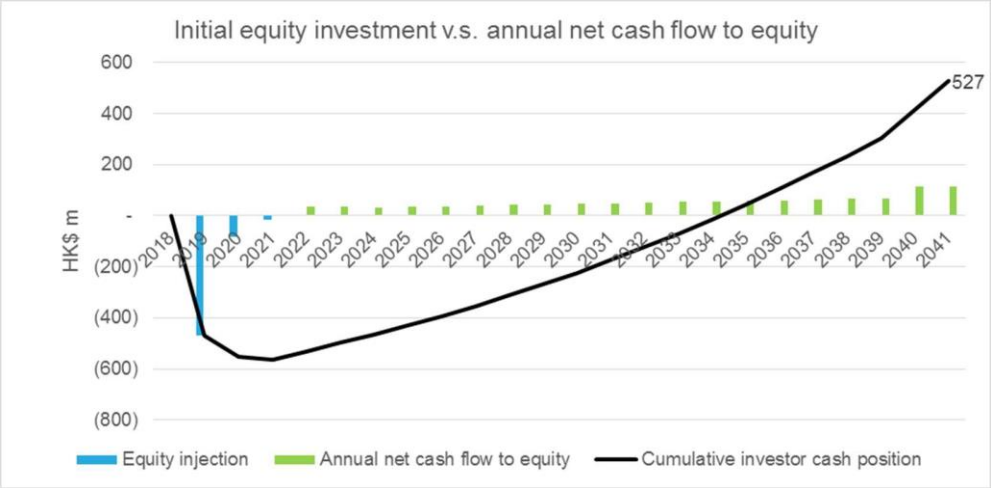
We have assumed that during the construction phase, the yard owner would fund the development cost through a combination of debt and equity. The shortfall represents the financial subsidisation required during the operating period in order to be financially viable i.e. enabling the yard owner to pay off all relevant costs / expenses such as operating costs, tax expense and payment of principal and interest of debt. In addition, the operational cash flow would need to provide the yard owner (equity holder) with a suitable return.

Using the financial model, we have determined the annual operational cash flow (i.e. cash flow pre-financing and tax) of the yard leasing operation. Our analysis shows that the annual operational cash flow, pre-financing and tax is relatively small as a proportion of initial development cost requirement as shown in diagram below:

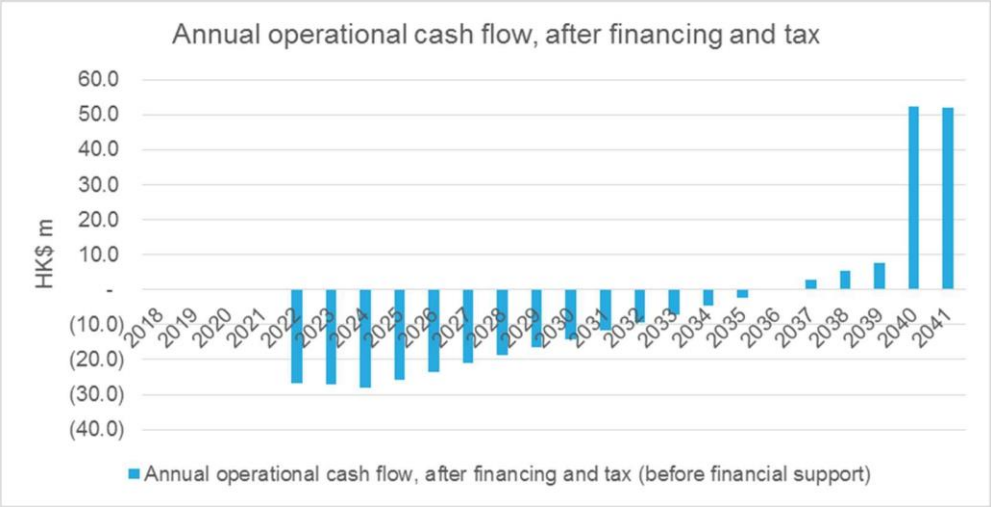


We have calculated the expected return based on industry benchmarks for investments at this nature and with similar risk profiles i.e. based on a target IRR of 5% [135] . The diagram below shows the relationship between the initial equity investment and the expected annual net cash flow to equity in order to achieve the target IRR of 5%.

[135] Please see Appendix E for further details.

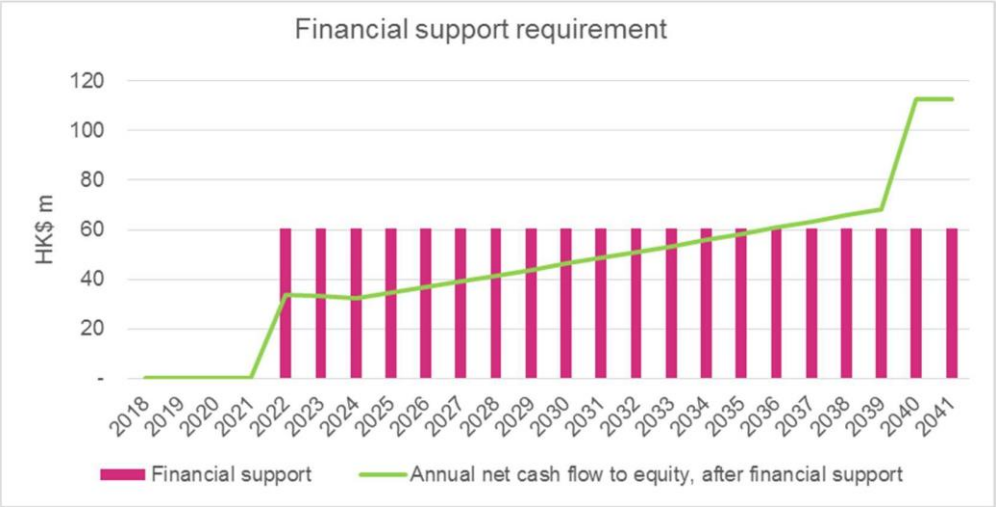


The operational cash flows analysis continues to build up to include the tax payment, debt repayment, financing cost and expected equity return to the yard owner (equity holder) during the operating period. After incorporating tax and financing into the analysis, the financial assessment shows that Base Case 1: Yard owner would generate negative cash flow in some years over the operating period as shown in chart below:



Based on the analysis above, it is estimated that Base Case 1: Yard owner would require approximately HK$724m (NPV value) of financial subsidisation in order to be financially viable.

Diagram below shows the annual financial subsidisation over the operating period:

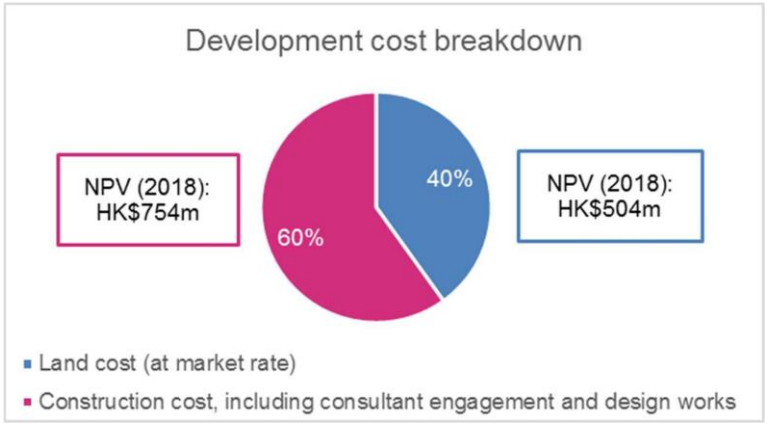


We have explained in detail below the results of each cost and revenue items for Base Case 1: Yard owner analysis:

Development cost:

In the absence of preliminary design of the proposed prefabrication yard, our approach to deriving an estimated construction cost has been to rely on the average market land selling price and construction cost.

Our high level assessment suggests a total development cost of approximately HK$1,258m (NPV values), with 40% for land cost and 60% for construction cost, including consultant engagement and design works. Detailed assumptions underlying this cost estimate are in Appendix E.



Financing structure:

We have assumed that the yard owner would finance the development through a combination of debt and equity. We have assumed a capital structure of 60% debt and 40% equity, which is generally in line with completed property development transactions in Hong Kong.

Other financing parameters in our analysis are consistent with our understanding of the current project financing market in Hong Kong:

A financing tail of two years and no principal repayment during construction, resulting in a 18 year repayment term. We have assumed a straight line principal repayment profile.

An interest rate of 3.5% p.a., comprising a base rate of 1.5% and a credit margin of 2.0%.

Table below summarises the sources and uses of capital during the construction phase:

Sources		NPV	MOD
Debt	HKD mil	783	849
Equity	HKD mil	522	566
Total	HKD mil	1, 305	1, 414

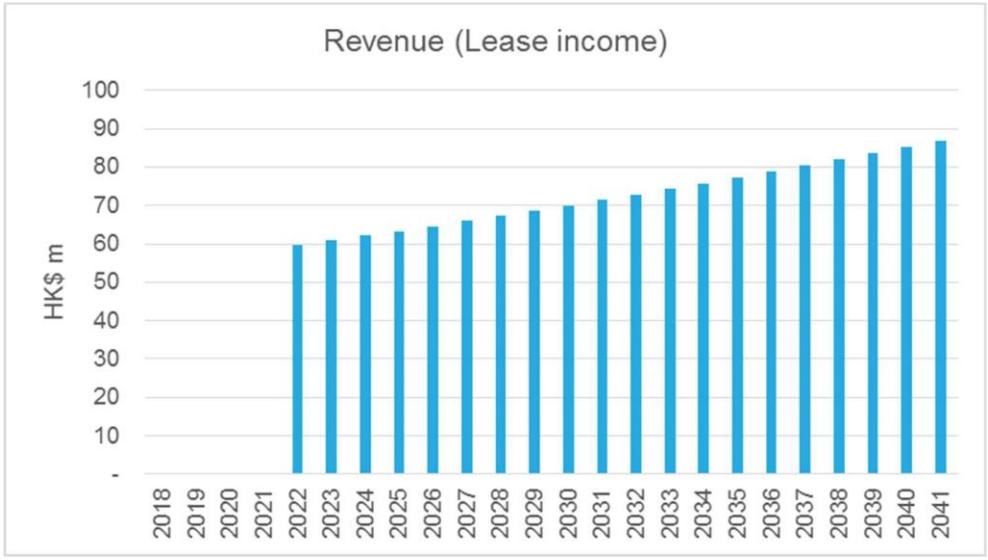
Uses		NPV	MOD
Development cost	HKD mil	(1,258)	(1,361)
Interest during construction	HKD mil	(47)	(53)
Total	HKD mil	(1, 305)	(1, 414)

Note: MOD refers to the true dollar amount of the relevant cash flow item, including the expected impact of inflation

Revenues:

Our approach to deriving an estimated lease rental income has been to determine benchmark average lease rental unit rates per sqm per month in the Tuen Mun area. Knight Frank has advised that the average lease rate in Tuen Mun Area is approximately HK$10 – 15 per sqft per month. For the purpose of our cash flow analysis, we have applied a 2% p.a. increase to the lease rental unit rate. This represents Hong Kong's historical rental escalation trend from 1997 to 2016 and is a proxy for future growth.

The cash flow analysis shows that the prefabrication yard would be able to generate lease revenue of HK$60m in the first year of operation, growing to HK$87m by the end of operating period.



Other key parameters to our analysis:

We have assumed the following parameters when undertaking the analysis of Base Case 1: Yard owner:

Operating expenses: Based on analysis of industry benchmarks, developers / landlords of industrial buildings would typically incur operating expenses of approximately 16% of revenue.

Taxes: We have assumed that the yard owner would be subjected to Hong Kong's standard corporate tax rate of 16.5% per annum.

Depreciation: In line with accounting standards in Hong Kong, we have assumed a 20 year straight line depreciation of the capital expenditure (yard building) and a 99 year straight line depreciation of the land cost.

Discount rate: Discount rate is used to determine the net present value (NPV) of the future cash flows of the Project, reflecting the project company's weighted average cost of capital (WACC). WACC has been estimated at 3.75%, see assumptions in Appendix E for more detail.

Summary of key assumptions

Table below shows a high-level summary of the key assumptions used in the financial analysis for Base Case 1: Yard owner. Further detail on the assumptions and how they have been derived is included in Appendix E.

Key driver	Assumption
Construction period	2.5 years (30 months)
Operating period	20 years
Land size	19,000 sqm
Land selling price at market rate (2017 price)	HK$26,910 per sqm
Yard GFA	33,500 sqm
Construction cost per sqm (2017 price)	HK$16,550 / sqm
Financing assumptions:	
- Gearing	60% debt
- Interest rate	3.5% p.a.
- Repayment period	18 years
- Financing tail	2 years
Average rental rate (2017 price)	HK$134.55 / sqm / month
Key driver	Assumption
Rental price inflation	2% p.a.
Operating expenses	16% of lease income
Expected return	5%

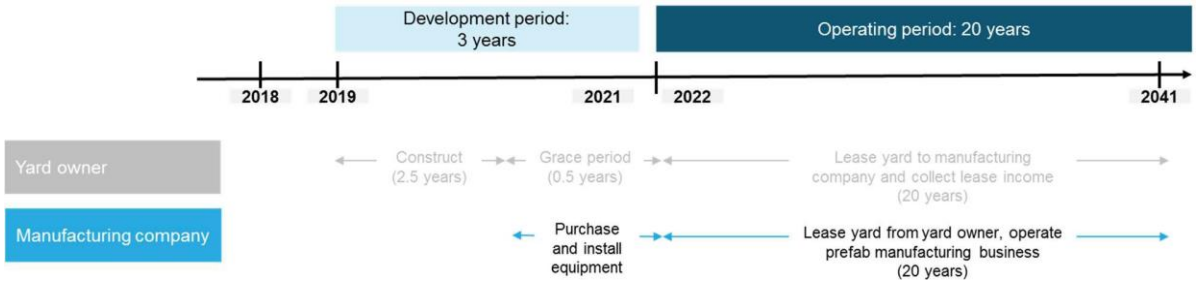
Base Case 2: Manufacturing company

Overview

Under Base Case 2, we have assumed that the manufacturing company would:

- Acquire the equipment for prefabrication operations through a combination of debt and equity in line with market norms;
- Lease the prefabrication yard from the yard owner and pay monthly rental for the premises;
- Maintain and replace the equipment when it is fully depreciated;
- Operate the facility to manufacture and sell prefabricated components; and
- Receive a suitable return from its equity investment based on 5-year Hang Seng Index return on equity as a proxy for suitable return of 10%

Diagram below illustrates the project timeline and key events in the financial analysis for Base Case 2: Manufacturing company:



Findings and Results

Overall result:

Based on the approach and assumptions above, the manufacturing business (Base Case 2: Manufacturing company) generates an IRR of 10% for its investors, just shy of the return expectation implied by the ROE of the Hang Seng Index of 10%. The financial model shows the following results:

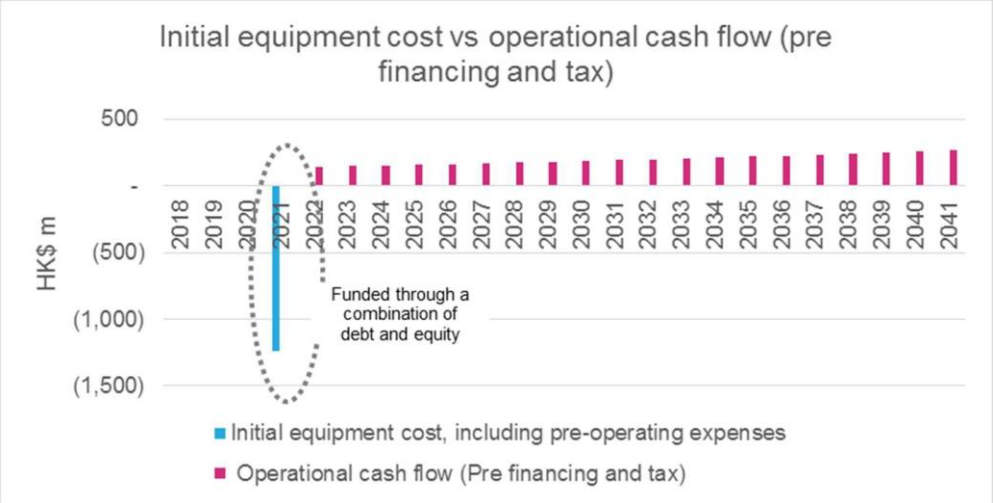
Key metric	Result
IRR	10%
Cumulative investor cash position*	HK$1,208m

* refers to the cumulative sum of free cash flows to equity, excluding terminal value

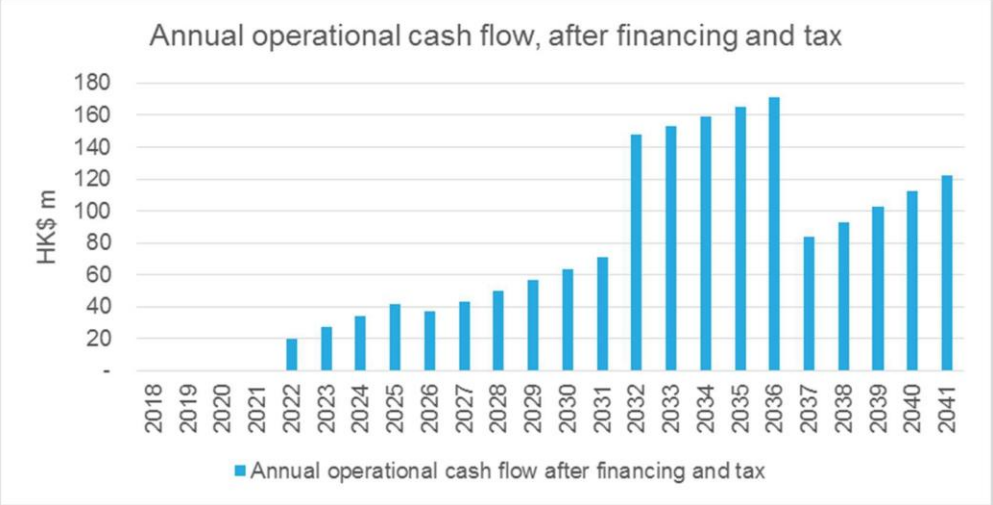
The results above indicate that there is little or no financial subsidisation required during the operating period. The manufacture and sale of prefabrication components itself is sufficient to pay off all costs / expenses such as cost of sales,

administrative expenses and tax. The business can also make payments of interest and principal to lenders and provide a 10% return to the equity holders.

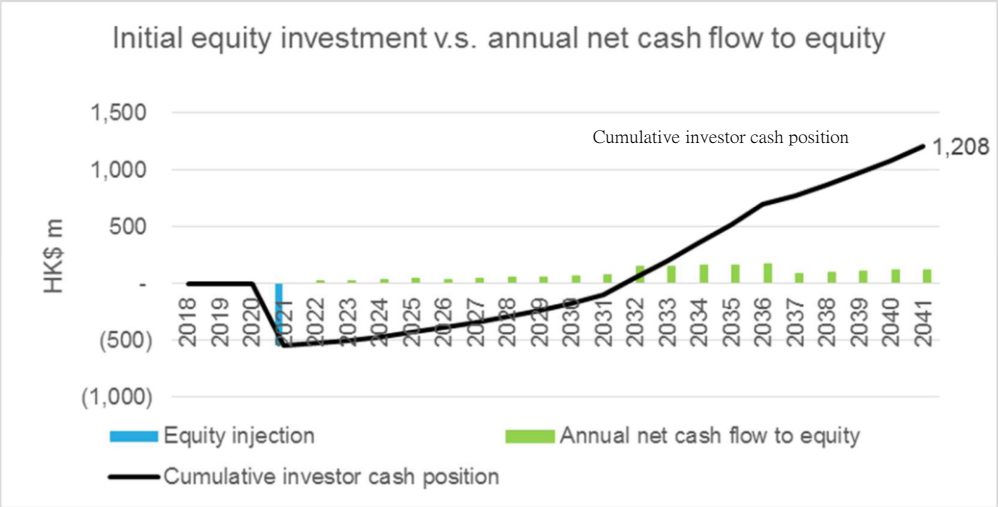
Using the financial model, we have determined the annual operational cash flow (i.e. cash flow pre-financing and tax) of the manufacturing business. Our analysis shows that the annual operational cash flow, pre-financing and tax is relatively higher as there is a proportion of initial equipment cost requirement as compared to Base Case 1: Yard owner, as shown in diagram below:



The operational cash flows analysis continues to build up to include the tax payment, debt repayment, financing cost and expected equity return to the yard owner (equity holder) during the operating period. After incorporating tax and financing into the analysis, the financial assessment shows that Base Case 2: Manufacturing would generate positive cash flow throughout the operating period as shown in chart below:



The manufacturing business generates an internal rate of return (IRR) of 10% and cumulative investor cash position of HK$1,208m as shown in diagram below. Based on a target IRR of 10%, the manufacturing business would likely be viable.



Our analysis also shows that the viability of the manufacturing business is highly sensitive to the assumptions used. For example, a 3% increase in cost / expenses will alter the result from an independently financially viable business to non-viable. Please refer to Appendix D for further details on the sensitivity analysis.

In the absence of comparable business model in Hong Kong, our assessment of the manufacturing business is highly dependent on the outcomes from our interviews with prefabrication concrete manufacturers in China and Hong Kong, in particular on the operating cost items. On this basis, we would recommend further detailed analysis to be undertaken at a subsequent stage in order to capture a more accurate operating cost based on a specific operating environment of the proposed prefabrication manufacturing business.

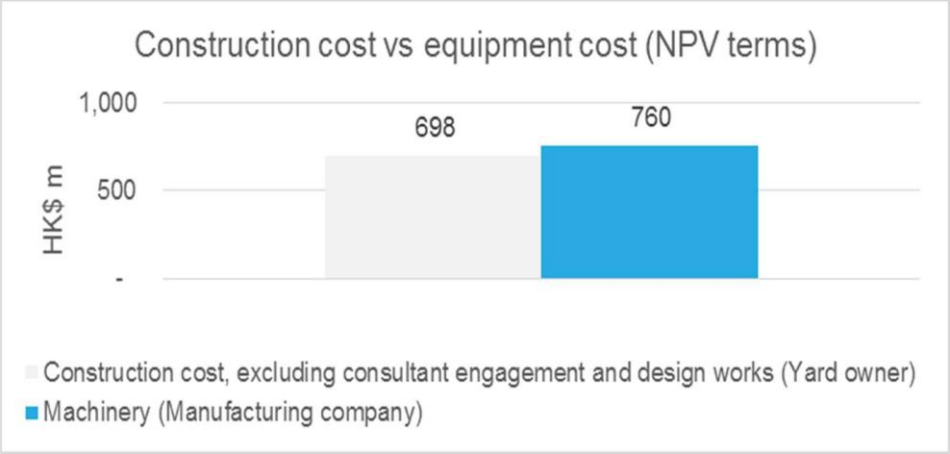
We have explained in detail below the results of each cost and revenue item for Base Case 2: Manufacturing company analysis:

Equipment cost:

We have assumed that the responsibility of purchasing, installing and maintaining the machinery / equipment would lie with the manufacturing company.

In the absence of preliminary design of the proposed prefabrication yard and type of equipment required, our approach to deriving an estimated equipment cost has been to rely on the experience of other prefabrication yard/hub projects constructed within the region. Based on comparable prefabrication yard/hub projects, it is estimated that the equipment cost is approximately 119% of the overall yard/hub construction cost.

Our high level assessment suggests a total equipment cost of approximately HK$760m (NPV values):



Financing structure:

We have assumed that the manufacturing company would fund the equipment cost through a combination of debt and equity. We have assumed a capital structure of 70% debt and 30% equity.

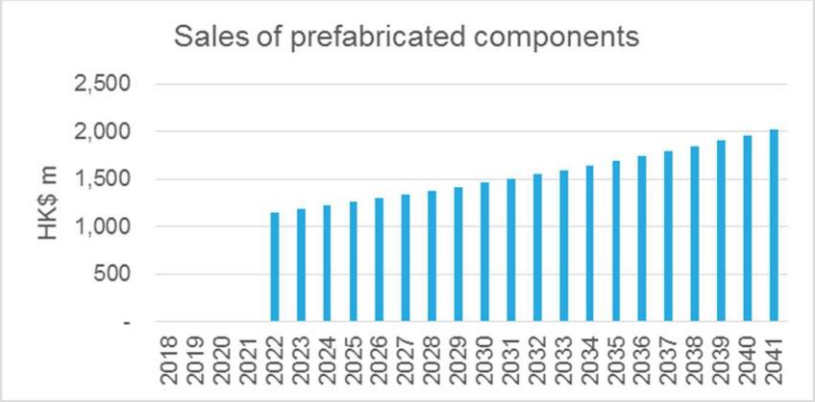
Other financing parameters in our analysis are consistent with our understanding of the current financing market in Hong Kong:

- A 10 year repayment term, with a straight line repayment profile.
- An interest rate of 3.5% p.a., comprising a base rate of 1.5% and a credit margin of 2.0%.

Revenues:

Our approach to deriving an estimated sales price of prefabricated components has been to utilise the outcomes from our interviews with prefabricated concrete manufacturers in China and Hong Kong. We have been informed that the average selling price for prefabricated components for public housing projects in Hong Kong is approximately HK$3,000 per tonne. For the purpose of our cash flow analysis, we have applied a 3% p.a. escalation rate per annum to the selling price, representing the inflation rate in Hong Kong.

The outputs of the cash flow analysis (below chart) shows that the manufacturing company would be able to generate revenue of HK$1,153m in the first year of operation, growing to HK$2,023m by the end of operating period.



Operating cost:

In the absence of comparable business model in Hong Kong, our assessment of the manufacturing business is highly dependent on the outcomes from our interviews with prefabrication concrete manufacturers in China and Hong Kong, in particular on the operating cost items. As the manufacturers were reluctant to share in detail their operating cost items, we were only able to obtain the high level breakdown of the operating cost as a percentage of manufacturing revenue.

The outcomes from the interviews suggest that approximately 90% of the revenue is used to cover the operating cost such as raw materials, labour, moulds, transport and miscellaneous expenses as shown below:

Key driver	Percentage of revenue
Cost of sales:	
- Raw materials	42.5%
- Transport	11.5%
- Cost for moulds	10.0%
- Labour cost	11.5%
Selling, general, admin expenses	15.0%
Total	90.5%

We have applied the above breakdown in our analysis, however have adjusted the following to be based on Hong Kong manufacturing sector benchmark[136]:

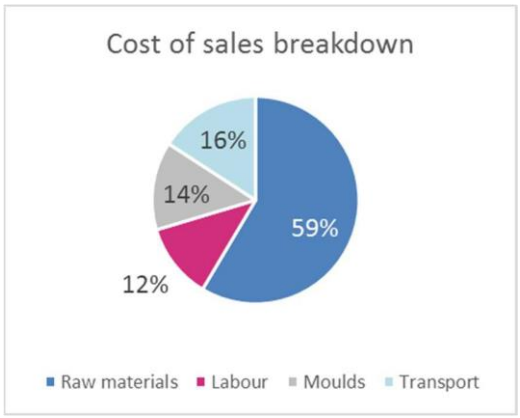
labour cost

Selling, general and admin expenses

[136] Please refer to Appendix E for further details

Cost of sales:

Cost of sales refers to the direct costs attributable to the production of the goods sold in a company (i.e. prefabricated components). We have obtained the following breakdown of cost of sales based on the outcomes of our interviews. The estimation for labour cost is based on worker density guidelines per the Planning Department of Hong Kong and the average monthly salary published by Census and Statistics Department of Hong Kong.

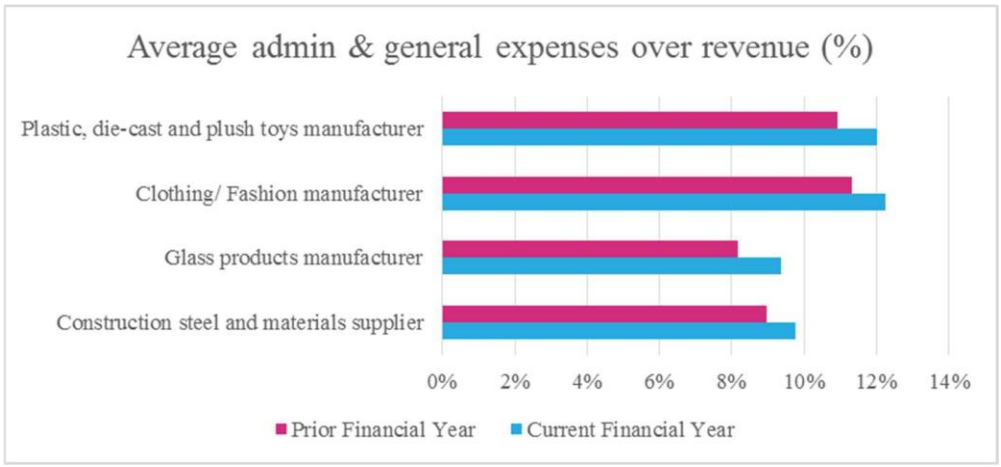


We have applied the above breakdown in our analysis. We note that this breakdown is a simplified assumption and results in cost of sales increasing over time in line with sales of prefabricated components.

In practice, we would expect a combination of fixed and variable costs. We would suggest that further analysis is undertaken to determine the suitability of these numbers once a more detailed business / operating model can be identified.

Selling, general and admin expenses:

Our benchmark analysis on selected manufacturing companies in Hong Kong shows that on average, the companies incur approximately 10% of their revenues for general and administrative expenses. We have assumed selling, general and admin expenses of 10% of revenue based on the mid-point of values of our benchmarking exercise as shown below:



Other key parameters to our analysis:

We have assumed the following parameters when undertaking the financial analysis of Base Case 2: Manufacturing company:

Taxes: We have assumed that the manufacturing company would be subjected to Hong Kong's standard corporate tax rate of 16.5% of taxable profits.

Depreciation: In line with accounting standards in Hong Kong, we have assumed a 15 year straight line depreciation for equipment.

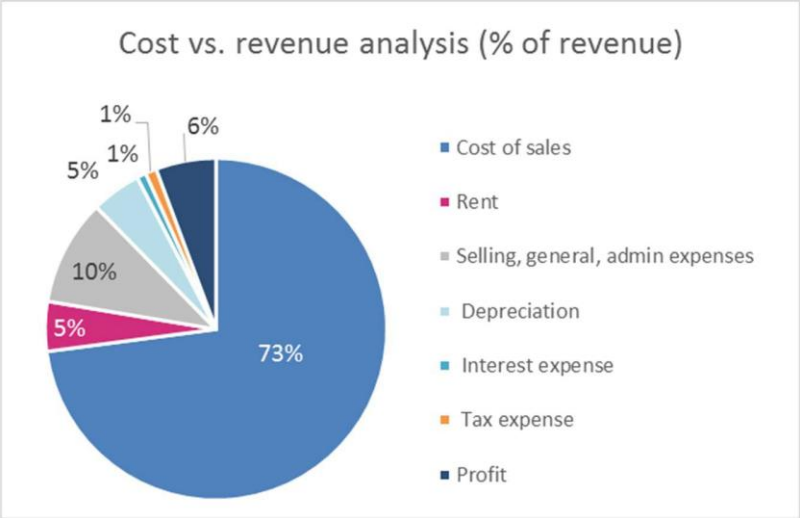
Equipment replacement: While we have assumed an operating period of 20 years, the manufacturing company would need to replace the equipment by year 15 (the useful life implied by the deprecation assumption). We have also assumed that this equipment replacement cost would be funded by a combination of debt (70%) and free cash flow (30%) from the operations / business. A maintenance reserve account (MRA) has been set up in the financial model to allow sufficient cash to be set aside by the operator to fund the 30% of the replacement cost.

Working capital: In order to ensure that sufficient cash is available during the first few months of the operation, we have included a working capital requirement for the manufacturing business. We have assumed that the working capital amount is equal to one quarter (3 months) of the first year's operating expenses and this working capital amount would be funded entirely through equity.

Discount rate: Discount rate is used to determine the NPV of the future cash flows of the Project, reflecting the operator's WACC. WACC has been estimated at 6.85%, see assumptions in Appendix E for more detail.

Cost versus revenue analysis (% of revenue):

Our analysis shows that the largest cost component of the manufacturing business is cost of sales (raw materials, labour, etc) which is approximately 73% of overall revenue as shown in chart below:



Summary of key assumptions

Table below shows a high-level summary of the key assumptions used in the financial analysis for Base Case 2: Manufacturing company. Further detail on the assumptions and how they have been derived is included in Appendix E.

Key driver	Assumption
Equipment procurement / installation	Year 1: 0% Year 2: 0% Year 3: 100%
Operating period	20 years
Equipment cost	119% of plant cost,
Financing assumption:	
- Gearing	70% debt
- Interest rate	3.5%
- Repayment period	10 years
- Financing tail	2 years
Yard GFA	33,500 sqm
Production p.a.	331,650 tonnes
Selling price per tonne (2017 price)	HK$3,000
Cost of sales:	
- Raw materials	42.5% of revenue,
- Transport	11.5% of revenue,
- Cost for moulds	10% of revenue,
- Labour cost	
o Worker density	75 sqm per worker
o Average salary per month (2017 price)	HK$15,913
Selling, general, admin expenses	10% of revenue,
Rental expense (2017 price)	HK$134.55 / sqm/ month
Equipment replacement:	
- Useful life	15 years
- Equipment replacement cost	NPV: HK$395 m
- Equipment replacement funding - Gearing - Interest - Tenure	70% debt, 30% free cashflow 3.5% 10 years
Working capital:	
- Working capital requirement	Prior to operation of the yard
- Working capital amount	One quarter of first year's expenses
- Working capital funding	100% equity

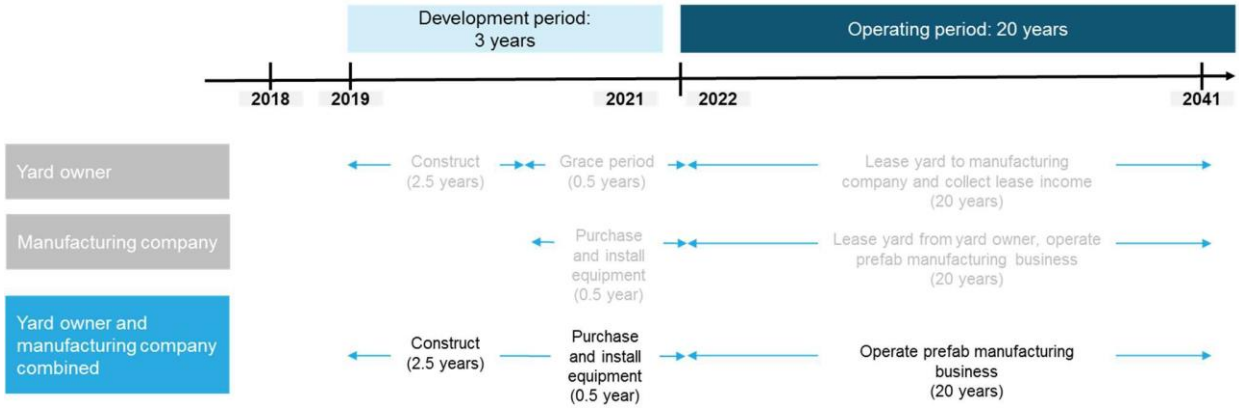
Base Case 3: Yard owner and manufacturing company combined

Overview

Under Base Case 3, we have assumed that the Project Company would undertake both the role of yard owner and manufacturing company. The Project Company would:

- Acquire the land for the establishment of the prefabrication yard;
- Construct the prefabrication yard;
- Acquire the equipment for prefabrication operations;
- Fund the development cost (land, construction and equipment cost) through a combination of debt and equity in line with market norms;
- Operate the prefabrication manufacturing facility; and
- Maintain and replace the equipment

Diagram below illustrates the project timeline and key events in the financial analysis for Base Case 3: Yard owner and manufacturing combined:



Findings and Results

Overall result:

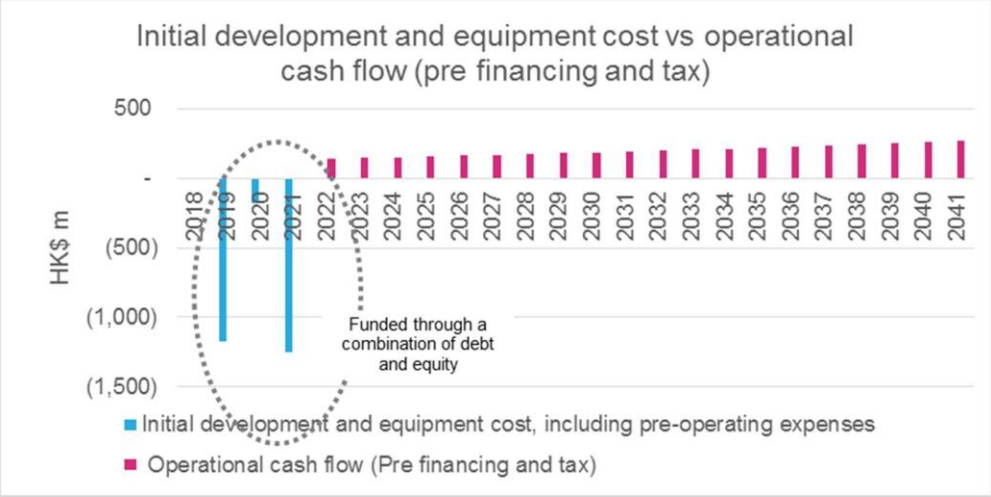
When undertaking the analysis for Base Case 3, we have combined the operating cash flows (before any financial subsidisation) of both the yard owner and manufacturing company derived in Base Case 1 and Base Case 2 respectively.

Base Case	1	2	3
Key metric	Yard owner	Manufacturing company	Yard + Manufacturing
Shortfall / funding requirement (NPV)	-	-	??
IRR	-10%	10%	3%
Cumulative investor cash position*	(HK$682m)	HK$1,208m	HK$525m

* refers to the cumulative sum of free cash flows to equity, excluding terminal value

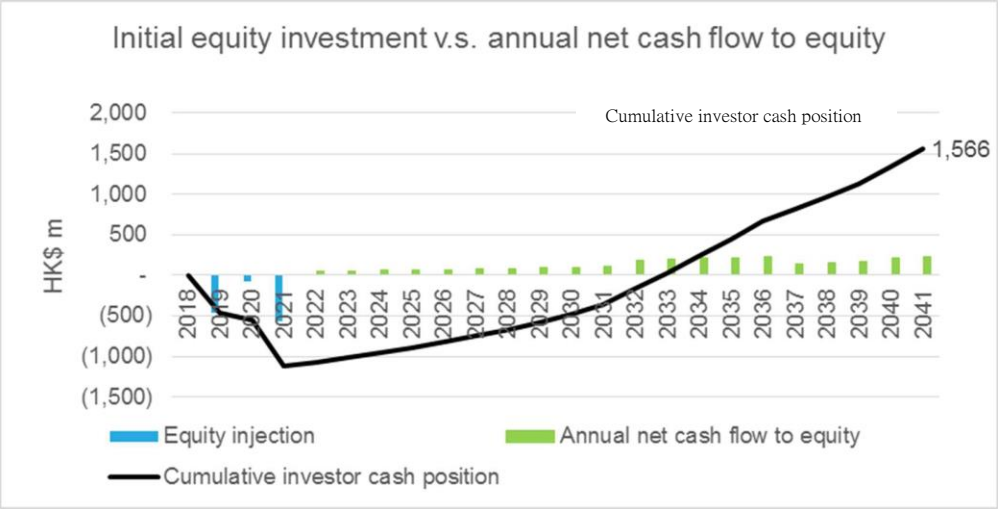
Our analysis shows that the combined developments (Base Case 3: Yard owner and manufacturing company combined) provide an IRR of 3% and positive cumulative investor cash position of HK$525m. In order to make the combined developments attractive to private investor, financial subsidisation is required in order to provide suitable return to an investor. Our benchmark analysis shows that manufacturing companies, which own their plants, typically generate return on equity of approximately 7%.

Using the financial model, we have determined the annual operational cash flow (i.e. cash flow pre-financing and tax) of the manufacturing business. Our analysis shows that the annual operational cash flow, pre-financing and tax is relatively low as a proportion of initial development and equipment cost requirement as shown in diagram below:

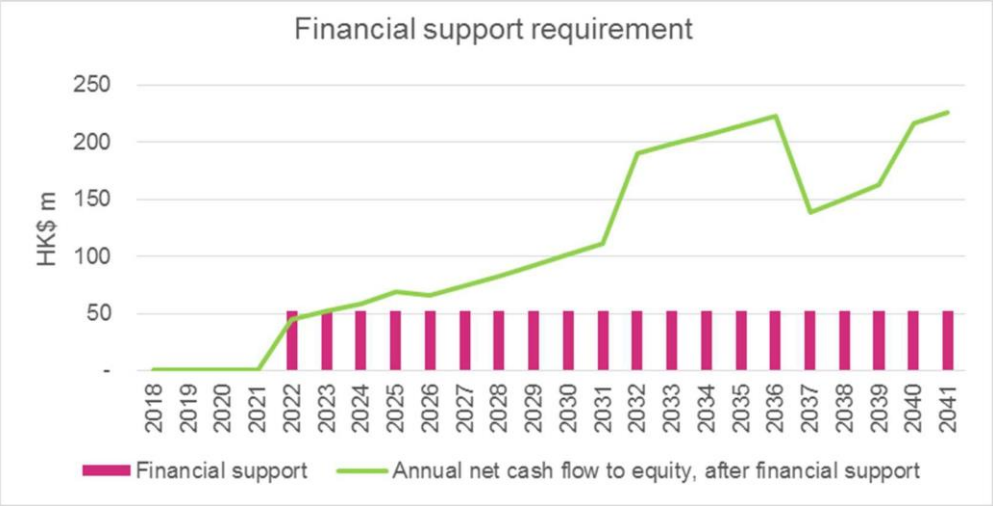


We have calculated the expected return based on industry benchmarks for investments at this nature and with similar risk profiles i.e. based on a target IRR of 7% [137] . The diagram below shows the relationship between the initial equity investment and the expected annual net cash flow to equity in order to achieve the target IRR of 7%.

[137] Please see Appendix E for further details.



Based on the analysis above, it is estimated that Base Case 3: Yard owner + manufacturing would require approximately HK$579m (NPV value) of financial subsidisation in order to be financially viable. Diagram below shows the annual financial subsidisation over the operating period:



Applying this assumption, our financial analysis shows that the level of shortfall / funding requirement is approximately HK$591m (NPV value).

Base Case	3
Key metric	Yard + Manufacturing
Shortfall / funding requirement (NPV)	HK$579m
IRR	7%
Cumulative investor cash position*	HK$1,546m

* refers to the cumulative sum of free cash flows to equity, excluding terminal value

Limitations and Exclusions

We have had to make numbers of simplifying assumptions given the limited information available in the market and that there is no precedent of such development in Hong Kong. In addition to those outlined on the previous pages, we specifically wish to highlight that our analysis:

- Is based on research undertaken on a best efforts basis to determine relevant comparable metrics / data points in the market. We have also depended on the outcomes from interview sessions with selected Chinese prefabricated concrete manufacturers in our analysis. Such prefabrication business are typically private endeavours and so information available in the public domain is limited
- Has not considered any specific design for the estimation of GFA and capital costs, and we have not involved our design and quantity surveying team in detail in this analysis. We would recommend further analysis of likely construction cost be undertaken once a preliminary design is developed
- Has not considered the type of prefabricated components to be manufactured by the proposed prefabrication yard and the specific equipment / machinery that may be required for such production. We would recommend further analysis to be undertaken.

Sensitivity Analysis

Overview

Given the accuracy of financial outcomes is highly dependent on the quality of underlying assumptions used, we have undertaken a sensitivity analysis on key assumptions within the financial model.

The objectives of the sensitivity analysis are to:

Identify key assumptions that have the greatest impact on the financial model's outcomes and therefore, should be the subject of greater effort and scrutiny as analysis progresses; and

Test the impact of positive and negative movements to total funding requirement under the three Base Case analyses.

We have undertaken sensitivity analysis on the following key assumptions:

Sensitivity	Description
A	Construction cost (+/-), keeping other Base Case assumptions constant
B	Rental rates (+/-), keeping other Base Case assumptions constant
C	Equipment cost (+/-), keeping other Base Case assumptions constant
D	Selling price per tonne (+/-), keeping other Base Case assumptions constant, including cost of sales and other expenses
E	Sales volume (+/-), keeping other Base Case assumptions constant
F	Labour cost (+/-), keeping other Base Case assumptions constant
G	Selling, general, admin expenses (+/-), keeping other Base Case assumptions constant

Findings and Results

The key results of the sensitivity analysis are summarised below:

Whilst maintaining the target IRR of 5% for Base Case 1 and 7% for Base Case 3, a 15% reduction in construction cost will result in potential upside of HK$116m and HK$112m savings in financial subsidisation for Base Case 1 and Base Case 3 respectively.

Changes in rental rates has minimal effect to the overall viability analysis.

Movement in selling price per tonne has the largest impact on the overall results in Base Case 2 and Base Case 3. A 15% increase in selling price per tonne leads to a 26 percentage point increase in IRR in Base Case 2. Under Base Case 3, the combined development is independently financially viable (i.e. no financial subsidisation required) and is able to generate an IRR of 16%.

In addition, Base Case 2 is also highly sensitive on the upside/downside to changes in operating cost. We have tested this analysis on Sensitivity G – selling, general and admin expenses. Our analysis shows that a 3% decrease in selling, general and admin expenses leads to a 6 percentage point increase in IRR, from 10% to 16% under Base Case 2. The downside of 3% increase in expenses results in an increase in funding requirement for Base Case 2 from HK$0m to HK$329m and Base Case 3, from HK$579m to HK$1,090m.

Sensitivity A: Construction cost (+/-), keeping other Base Case assumptions constant

	1. Yard owner		2. Manufacturing company		3. Yard owner and manufacturing company combined	
Impact to	Funding requirement (HK$m, NPV value)	Target IRR (%)	Funding requirement (HK$m, NPV value)	Resulting IRR (%)	Funding requirement (HK$m, NPV value)	Target IRR (%)
-15%	608	5%	-	10%	467	7%
-10%	642	5%	-	10%	500	7%
-5%	683	5%	-	10%	557	7%
Base Case	724	5%	-	10%	579	7%
+5%	763	5%	-	10%	636	7%
+10%	808	5%	-	10%	670	7%
+15%	849	5%	-	10%	703	7%

Our analysis shows that a 15% reduction in construction cost will result in potential upside of HK$116m and HK$112m savings in financial subsidisation for Base Case 1 and Base Case 3 respectively.

On the downside, a 15% increase in construction cost will result in additional financial subsidisation of HK$125m and HK$124m for Base Case 1 and Base Case 3 respectively.

Sensitivity B: Rental rates (+/-), keeping other Base Case assumptions constant

	1. Yard owner		2. Manufacturing company		3. Yard owner and manufacturing company combined	
Impact to	Funding requirement (HK$m, NPV value)	Target IRR (%)	Funding requirement (HK$m, NPV value)	Resulting IRR (%)	Funding requirement (HK$m, NPV value)	Target IRR (%)
-15%	831	5%	-	12%	579	7%
-10%	796	5%	-	11%	579	7%
-5%	760	5%	-	11%	579	7%
Base Case	724	5%	-	10%	579	7%
+5%	690	5%	-	10%	579	7%
+10%	654	5%	41	10%	579	7%
+15%	619	5%	41	10%	579	7%

Our analysis shows that a 15% reduction in rental rates will result in a (1) potential downside of additional HK$107m financial subsidisation for Base Case 1 and (2) potential upside of 2% increase in equity IRR for Base Case 2.

A 15% increase in rental rates will result in a (1) potential upside of HK$105m savings in financial subsidisation for Base Case 1 and (2) potential downside of HK$41m increase in financial subsidisation for Base Case 2.

Changes in rental rates will have no impact to Base Case 3.

Sensitivity C: Equipment cost (+/-), keeping other Base Case assumptions constant

	1. Yard owner		2. Manufacturing company		3. Yard owner and manufacturing company combined	
Impact to	Funding requirement (HK$m, NPV value)	Target IRR (%)	Funding requirement (HK$m, NPV value)	Resulting IRR (%)	Funding requirement (HK$m, NPV value)	Target IRR (%)
-15%	724	5%	-	13%	418	7%
-10%	724	5%	-	12%	487	7%
-5%	724	5%	-	11%	533	7%
Base Case	724	5%	-	10%	579	7%
+5%	724	5%	-	10%	649	7%
+10%	724	5%	62	10%	707	7%
+15%	724	5%	-103	10%	777	7%

Our analysis shows that movement in equipment cost will impact the IRR of Base Case 2 and the overall funding requirement in Base Case 3. A 15% reduction in equipment cost leads to a 3.0 percentage point increase in IRR in Base Case 2 while the total financial subsidisation for Base Case 3 reduces from HK579m to HK$418m.

On the downside, a 15% increase in equipment cost leads to an increase in financial subsidisation of HK$103m for Base Case 2 whilst maintaining the target IRR at 10%. The total financial subsidisation for Base Case 3 increases from HK579m to HK$777m.

Sensitivity D: Selling price per tonne (+/-), keeping other Base Case assumptions constant, including cost of sales and other expenses

	1. Yard owner		2. Manufacturing company		3. Yard owner and manufacturing company combined	
Impact to	Funding requirement (HK$m, NPV value)	Target IRR (%)	Funding requirement (HK$m, NPV value)*	Resulting IRR (%)	Funding requirement (HK$m, NPV value)	Target IRR (%)
-15%	724	5%	1,728	10%	3,056	7%
-10%	724	5%	1,152	10%	2,238	7%
-5%	724	5%	535	10%	1,409	7%
Base Case	724	5%	-	10%	579	7%
+5%	724	5%	-	19%	-	8%
+10%	724	5%	-	28%	-	12%
+15%	724	5%	-	36%	-	16%

* Refers to working capital shortfall i.e. amount required to avoid negative annual cash flow

Our analysis shows that movement in selling price per tonne has the largest impact on the overall results in Base Case 2 and Base Case 3. A 15% increase in selling price per tonne leads to a 26 percentage point increase in IRR in Base Case 2. Under Base Case 3, the combined development is independently financially viable (i.e. no financial subsidisation required) and is able to generate an IRR of 16%.

Sensitivity E: Sales volume (+/-), keeping other Base Case assumptions constant

	1. Yard owner		2. Manufacturing company		3. Yard owner and manufacturing company combined	
Impact to	Funding requirement (HK$m, NPV value)	Target IRR (%)	Funding requirement (HK$m, NPV value)	Resulting IRR (%)	Funding requirement (HK$m, NPV value)	Target IRR (%)
-15%	724	5%	370	10%	1,174	7%
-10%	724	5%	247	10%	979	7%
-5%	724	5%	103	10%	773	7%
Base Case	724	5%	-	10%	579	7%
+5%	724	5%	-	13%	431	7%
+10%	724	5%	-	15%	249	7%
+15%	724	5%	-	17%	68	7%

Our analysis shows that a 15% increase in sales volume leads to a 7 percentage point increase in IRR, from 10% to 17% under Base Case 2. This upside also results in a reduction in funding requirement for Base Case 3, from HK$579m to HK$68m.

On the downside, a 15% decrease in sales volume leads to an increase in financial subsidisation of HK$370m for Base Case 2 whilst maintaining the target IRR at 10%. The total financial subsidisation for Base Case 3 increases from HK579m to HK$1,174m.

Sensitivity F: Labour cost (+/-), keeping other Base Case assumptions constant

	1. Yard owner		2. Manufacturing company		3. Yard owner and manufacturing company combined	
Impact to	Funding requirement (HK$m, NPV value)	Target IRR (%)	Funding requirement (HK$m, NPV value)	Resulting IRR (%)	Funding requirement (HK$m, NPV value)	Target IRR (%)
-15%	724	5%	-	13%	398	7%
-10%	724	5%	-	12%	477	7%
-5%	724	5%	-	11%	523	7%
Base Case	724	5%	-	10%	579	7%
+5%	724	5%	-	10%	659	7%
+10%	724	5%	62	10%	716	7%
+15%	724	5%	103	10%	784	7%

Our analysis shows that a 15% increase in labour cost leads to an increase in financial subsidisation of HK$103m for Base Case 2 whilst maintaining the target IRR at 10%. This downside also results in an increase in funding requirement for Base Case 3, from HK$579m to HK$784m.

Sensitivity G: Selling, general, admin expenses (+/-), keeping other Base Case assumptions constant

	1. Yard owner		2. Manufacturing company		3. Yard owner and manufacturing company combined	
Impact to	Funding requirement (HK$m, NPV value)	Target IRR (%)	Funding requirement (HK$m, NPV value)*	Resulting IRR (%)	Funding requirement (HK$m, NPV value)	Target IRR (%)
-3%	724	5%	-	16%	171	7%
-2%	724	5%	-	14%	307	7%
-1%	724	5%	-	12%	443	7%
Base Case	724	5%	-	10%	579	7%
+1%	724	5%	82	10%	738	7%
+2%	724	5%	206	10%	908	7%
+3%	724	5%	329	10%	1,090	7%

* Refers to working capital shortfall i.e. amount required to avoid negative annual cash flow

Our analysis shows that a 3% decrease in selling, general and admin expenses leads to a 6 percentage point increase in IRR, from 10% to 16% under Base Case 2. The downside of 3% increase in expenses results in an increase in funding requirement for Base Case 2 from HK$0m to HK$329m and Base Case 3, from HK$579m to HK$1,090m.

附錄 E

Assumptions

Assumptions

Overview

This chapter outlines the key assumptions underpinning the Base Case analyses as presented in Chapter 7, and as used in the financial model to support our analyses. The calculation of the high level cash flow forecasts drew upon the following key parameters:

- General assumptions such as inflation and taxation rates, discount rate, and depreciation;
- Project timeline;
- Size or productivity;
- Development cost;
- Revenue;
- Cost of sales (applicable to manufacturing company only);
- Operating expense estimate ("opex") or selling, general, admin expenses;
- Equipment replacement cost;
- Working capital requirement (applicable to manufacturing company only);
- Financing structure and associated terms.

We describe in detail the approach, rationale, key assumptions and sources in each aspect in the following sub-sections.

Base Case 1: Yard owner

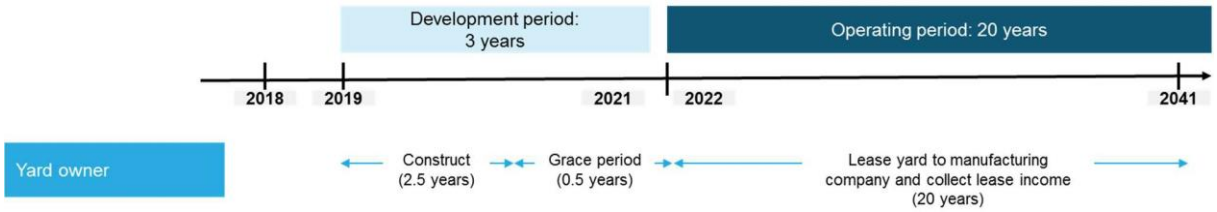
General assumptions

General assumptions that are applicable for the financial analysis are summarised below:

Key driver	Assumption	Source / rationale
Inflation rate	3.0% per annum	Based on Hong Kong long-term inflation rate as forecasted by The Long Term Financial Planning Working Group and reported in the Public Engagement Exercise on Retirement Protection Annex 4.
Corporate tax rate	Flat rate of 16.5% per annum	Hong Kong's corporate tax rate from 2009 onwards as published by Inland Revenue Department (IRD).
Discount rate	3.75%	Discount rate is used to determine the net present value (NPV) of the future cash flows of the Project, reflecting the project company's weighted average cost of capital (WACC) Source: Arup's analysis
Useful life / depreciation	1% - 5%	Based on straight line depreciation method Yard/Building: 5% per annum Land: 1% per annum Source: Yard/Building: EY Worldwide Capital and Fixed Assets Guide 2016 Land: Land lease assumption of 99 years

Project timeline

The figure below provides a high level view of the project implementation timeline for Base Case 1: Yard owner:



<table>
<tr><th>Key driver</th><th>Assumption</th><th>Source / rationale</th></tr>
<tr><td>Construction period</td><td>2.5 years (30 months)</td><td>Estimates per Arup's technical team based on similar developments in Hong Kong:
<table>
<tr><th>Project name</th><th>Building area</th><th>Project duration[138]</th></tr>
<tr><td>HKTV Multimedia & E-Commerce Centre</td><td>30,000 sqm</td><td>30 months</td></tr>
<tr><td>China Unicorn Global Centre</td><td>38,000 sqm</td><td>40 months</td></tr>
<tr><td>NTT Financial Data Centre</td><td>35,000 sqm</td><td>28 months</td></tr>
<tr><td>Average</td><td></td><td>32</td></tr>
</table></td></tr>
<tr><td>Grace period</td><td>0.5 year</td><td>Provision of lease contract that allows lease rental payments to be received 6 months after the obtainment of Building Occupation Certificate to allow the tenant to proceed with installation of equipment.</td></tr>
<tr><td>Development period</td><td>3 years</td><td>Refers to the period required to construct the yard and to install all the required equipment before operation.</td></tr>
<tr><td>Operating period</td><td>20 years</td><td>The collection of lease income shall commence upon the completion of construction of the prefabrication yard. The operating period is assumed to be 20 years.</td></tr>
</table>

Development cost

The development cost for the development of prefabrication yard include (1) land cost, (2) construction cost and (3) consultant engagement and design fee.

(1) Land cost: Key assumptions to derive to the estimated land cost include:

Key driver	Assumption	Source / rationale
Land sale transaction	Early 2019	This is a high level assumption, It is assumed that the developer would need to pay 100% of the land cost before commencing the construction
Land size	19,000sqm	Based on comparable prefabrication hub projects in the region. Please refer to Section 4 for further details.

[138] Includes consultant engagement, design, works tender, construction and obtainment of Building Occupation Certificate

Key driver	Assumption	Source / rationale
Land selling price	HK$26,910 per sqm (HK$2,500 per sq ft)	There was no transaction for industrial type land use in Tuen Mun in the past 10 years. Given limited publicly available data on land price in Tuen Mun area, we have assumed that the average land price of HK$2,500 per sq ft. This is a simplified assumption – a next phase study, in particular on land valuation, is recommended once the potential site is confirmed. Source: Knight Frank
Land price escalation rate	3% per annum	Based on Hong Kong long-term inflation rate as forecast by The Long Term Financial Planning Working Group and reported in the Public Engagement Exercise on Retirement Protection Annex 4.

(2) Construction cost: Key assumptions to derive to the estimated construction cost include:

Key driver	Assumption	Source / rationale
Area / Gross floor area (GFA)	33,500 sqm	Based on Arup's analysis. Please refer to Section 6.2 for further details.
GFA to Construction floor area uplift	20%	Based on "Estimating rules of thumb and design norms – GFA to CFA ratio" in Hong Kong. Source: Arcadis Construction Handbook 2017
Unit cost of construction	HK$16,550 / sqm	Based on the average construction costs for industrial property in Hong Kong. Type of building / HK$ / sqm Landlord, high rise [A] 10,100 – 12,400 End user, low rise [A] 13,600 – 20,500 Owner operated factories, low rise [B] 18,800 – 23,900 Average 16,550 Source: (A) RLB Levett Bucknall - Hong Kong Construction Cost Update Report December 2017, (B) Arcadis Construction Handbook 2017

(3) Consultant engagement and design fee:

Key driver	Assumption	Source / rationale
Consultant engagement and design fee	Additional 8% of construction cost	Estimate per Arup's QS team based on similar developments in Hong Kong. We assume this cost to incur within the first 6 months of the development period.

Other assumptions: For the purposes of the financial analysis, we have applied price adjustment factors to the total development cost to derive to the MOD estimates. The adjustment takes into account the following:

Key driver	Assumption	Source / rationale
Construction cost profile	Year 1: 76% Year 2: 23% Year 3: 1%	Estimate per Arup's technical team based on similar developments in Hong Kong.
Construction cost escalation	6%	Based on Hong Kong's construction price adjustment factors per annum from 2017 to 2020. Source: Note for Public Works Subcommittee of Finance Committee, PWSCI (2016-17)6

Results:

The resulting total development cost is approximately HK$905m in NPV terms or HK$978m in MOD prices.

Development	NPV (HK$m)	MOD prices (HK$m)
Land cost	504	542
Construction cost, including consultant engagement and design fee	754	819
Total development cost	1,258	1,361

Financing structure and associated terms

We assume that the yard owner would fund the development cost through a combination of debt and equity. The key financing assumptions are summarised as follows:

Key driver	Assumption	Source / rationale
Gearing (debt to total capital ratio)	60% debt	In line with real estate lending market. Actual gearing level will be a function of market dynamics at the time of development and would be a negotiated outcome.
Interest rate	3.5%	Comprising a base rate of approx. 1.5% p.a. (10-year HIBOR swap rate) and a credit risk margin of 2%. Interest is paid as incurred, but capitalizes during the construction period.
Loan repayment term	18 years (2 years financing tail)	The loan is repaid on a straight-line basis from completion of construction. Full repayment 2 years prior to the end of the operating period. Repayment terms to be tested further in the next stage of analysis.

Key driver	Assumption	Source / rationale
Expected return	5%	Based on publicly stated return on equity of industrial property investment funds between 4.0% to 5.6%. Our assumption is at mid-point (rounded).  Source: Reuters and selected industrial REIT's websites

Revenue

The main revenue stream of the yard owner is lease income from the manufacturing company. The key drivers to arrive to the revenue forecast include (1) gross leasable area, (2) expected occupancy rate, (3) lease rental unit rate and (4) lease rental escalation rate.

Key driver	Assumption	Source / rationale
Gross leasable area (GLA)	100% of GFA	Gross leasable area refers to the amount of floor space in a property available for rental. We assume 100% of the GFA would be available for leasing 33,500sqm.
Occupancy rate	100%	Occupancy rate refers to the ratio of the rented space compared to the total amount of available GLA. We assume a 100% occupancy rate for the prefabrication yard throughout the operating period.
Lease rental unit rate	HK$134.55 / sqm / month (2017 prices)	Lease rental unit rates refer to the average industrial use lease rental unit rate per sqm per month in Tuen Mun area (HK$10-15 per sq ft). Source: Knight Frank's data base
Lease rental escalation rate	2% p.a.	Based on Hong Kong's historical rental escalation rate from 1997 to 2016. Source: Rating and Valuation Department, Private Flatted Factories - Rental and Price Indices

Operating expenses

Key operating expenses ("opex") of the yard owner include repair and maintenance cost associated with the common area of the prefabrication yard.

Key driver	Assumption	Source / rationale
Opex	16% of revenue	Based on industry benchmark analysis. Developer / Landlord of industrial buildings would typically incur operating expenses of approximately HK$2.00 to HK$2.50 per sqft per month. This represents a 16% of the rental unit rates of HK$10 to HK$15 per sqft per month. Source: Knight Frank's data base

Base Case 2: Manufacturing company

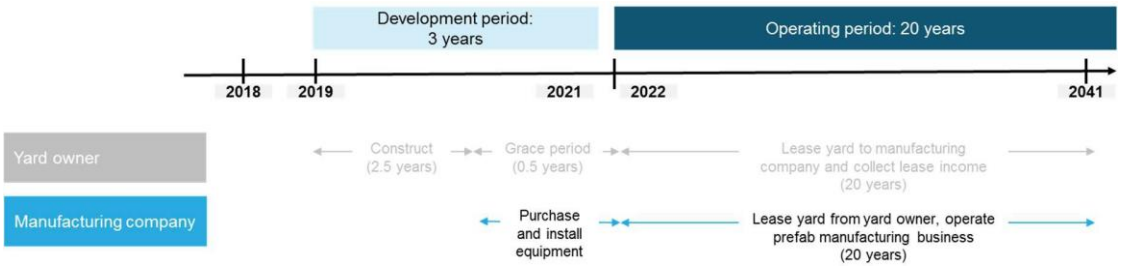
General assumptions

General assumptions that are applicable for the financial analysis are summarised below:

Key driver	Assumption	Source / rationale
Inflation rate	3.0% per annum	Based on Hong Kong long-term inflation rate as forecast by The Long Term Financial Planning Working Group and reported in the Public Engagement Exercise on Retirement Protection Annex 4.
Corporate tax rate	Flat rate of 16.5% per annum	Hong Kong's corporate tax rate from 2009 onwards as published by Inland Revenue Department (IRD).
Discount rate	6.85%	Discount rate is used to determine the net present value (NPV) of the future cash flows of the Project, reflecting the project company's weighted average cost of capital (WACC). Source: Arup's analysis

Project timeline

The figure below provides a high level view of the project implementation timeline for Base Case 2: Manufacturing company:



Key driver	Assumption	Source / rationale
Purchase and install equipment	0.5 year	The installation of equipment shall commence upon the obtainment of Building Occupation Certificate.
Operating period	20 years	The manufacturing activities shall commence upon the completion of the installation and testing of equipment.

Equipment cost

Under Base Case 2: Manufacturing company, we have assumed that the responsibility of purchasing, installing and maintaining the machinery / equipment rest with the manufacturer.

Key assumptions to derive to the estimated equipment cost is based on mid-point benchmark range as shown in table below:

Name	Size (sqm)	Development cost (SG$m)	Plant cost (SG$m)	Equipment cost (SG$m)	Equipment cost to plant cost ratio (%)
SEF SpaceHub	32,608	100[A]	53[D]	47	89%
Greyform Building	32,100	150[B]	59[D]	91	153%
Tiong Seng Prefab Hub	19,813	26[C]	12[E]	14	117%

Note	Source / Description
A	Source: The Business Times, Better quality control, faster production at SEF SpaceHub
B	Source: The Straits Times, BCA to give advance notice on building projects that need high level of prefabrication
C	Source: Building and Construction Authority news press, 4 January 2011, Tiong Seng's $26 million Prefab Hub – Singapore's 1st automated pre-cast facility and first to receive BCA funding
D	We have derived the plant cost based on the size of the plant and the average cost per sqm for heavy industrial building in Singapore as published by Singapore Construction Cost Handbook.
E	Source: Building and Construction Authority Construction Productivity Award 2013

Other assumptions: For the purposes of the financial analysis, we have applied price adjustment factors to the total development cost to derive to the MOD estimates. The adjustment takes into account the following:

Key driver	Assumption	Source / rationale
Equipment cost profile	Year 1: 0% Year 2: 0% Year 3: 100%	The purchase and installment of equipment is expected to happen in Year 3 of the development period.

Equipment cost escalation	6% p.a.	Based on Hong Kong's construction price adjustment factors per annum from 2017 to 2020. Source: Note for Public Works Subcommittee of Finance Committee, PWSCI (2016-17)6

Results:

The resulting equipment cost is approximately HK$760m in NPV terms or HK$990m in MOD prices:

Year	Equipment cost profile (%)	2017 price (HK$m)	Cost inflation (HK$m)	Equipment cost in MOD prices (HK$m)
2018	-	-	-	-
2019	-	-	-	-
2020	-	-	-	-
2021	100%	792	198	990
Total	100%	792	198	990
NPV: HK$760m				

Financing structure and associated terms

We assume that the manufacturing company would finance the equipment through a combination of debt and equity. The key financing assumptions are summarised as follows:

Key driver	Assumption	Source / rationale
Gearing (debt to total capital ratio)	70% debt	In line with market practice.
Interest rate	3.5%	Comprising a base rate of approx. 1.5% p.a. (10-year HIBOR swap rate) and a credit risk margin of 2%. Interest is paid as incurred.
Loan repayment term	10 years	The loan is repaid on a straight-line basis from the following year upon drawdown. Repayment terms to be tested further in the next stage of analysis.

Revenue

The main revenue stream of the manufacturing company is sales of prefabricated components. The key drivers of the revenue forecast include (1) production volume per built up area (tonnes/sqm), (2) selling price per tonne and (3) selling price escalation rate.

Key driver	Assumption	Source / rationale
Production volume per built up area	9.9 per sqm	Based on mid-point of benchmark range (refer to Section 4)
Selling price per tonne	HK$3,000 / tonne	Based on outcomes from our interviews with prefabrication concrete manufacturers in China and Hong Kong Source: Interview outcomes[139]
Selling price escalation rate	3.0% per annum	Based on Hong Kong long-term inflation rate as forecasted by The Long Term Financial Planning Working Group and reported in the Public Engagement Exercise on Retirement Protection Annex 4.

Cost of sales

Key cost of sales of the manufacturing company include (1) raw materials cost, (2) transportation cost, (3) cost for moulds and (4) labour cost.

Key driver	Assumption	Source / rationale
Raw materials cost	42.5% of revenue	Based on mid-point of interview outcomes.[140]
Transportation cost	11.5% of revenue	
Cost for moulds (project basis)	10% of revenue	
Labour cost:		

[139] Interviewees include Chinese contractor, prefabrication concrete manufacturers and construction company
[140] Interviewees include Chinese contractor, prefabrication concrete manufacturers and construction company

a) Worker density	75sqm per worker	Based on Planning Department of Hong Kong's guidelines for worker densities for Special Industrial Use – Industrial Estate category. Source: Planning Department of Hong Kong
b) Average salary per month	HK$15,913	Based on wages and labour earnings statistical reports published by Census and Statistics Department of Hong Kong as at 2017, indexing at annual inflation. Source: Census and Statistics Department of Hong Kong

Other expenses

In addition to cost of sales, the manufacturing company will also need to pay for (1) selling, general and admin expenses, (2) yard rental and (3) yard rental escalation rate.

Key driver	Assumption	Source / rationale
Selling, general and admin expenses	15% of revenue	Based on mid-point of interview outcomes.[141]
Yard rental	HK$134.55 / sqm / month (2017 prices)	Please refer to Base Case 1: Yard owner for further details.
Yard rental escalation rate	2%	Based on Hong Kong's historical rental escalation rate from 1997 to 2016. Source: Rating and Valuation Department, Private Flatted Factories - Rental and Price Indices

[141] Interviewees include Chinese contractor, prefabrication concrete manufacturers and construction company

Equipment replacement

We have included in our analysis an equipment replacement cost based on the following assumptions:

Key driver	Assumption	Source / rationale
Useful life	15 years	Source: United States Internal Revenue Service – 2017 Publication 946
Equipment replacement cost	HK$395m (NPV terms) / HK$1,388m (MOD prices)	Derived based on the following: Initial equipment cost (2017 prices): HK$792m. Please refer to Equipment cost assumptions above for further details. Price adjustment factor: Based on Hong Kong's construction price adjustment factors per annum: □ 6% from 2017 to 2020 □ 5% from 2021 to 2023 □ 4.5% thereafter Source: Note for Public Works Subcommittee of Finance Committee, PWSCI (2016-17) 6
Equipment replacement funding and maintenance reserve account:		
Gearing	70% debt, 30% MRA	The manufacturing company would fund the equipment cost through a combination of debt and operating cash flow. In order to ensure that sufficient cash is set aside to fund these replacement costs, a maintenance reserve account (MRA) has been established in the financial model to set aside funds over the operating period.
Interest	3.5%	Comprising a base rate of approx. 1.5% p.a. (10-year HIBOR swap rate) and a credit risk margin of 2%. Interest is paid as incurred.
Loan repayment term	10 years	The loan is repaid on a straight-line basis in the following year after the drawdown of the loan.

Working capital

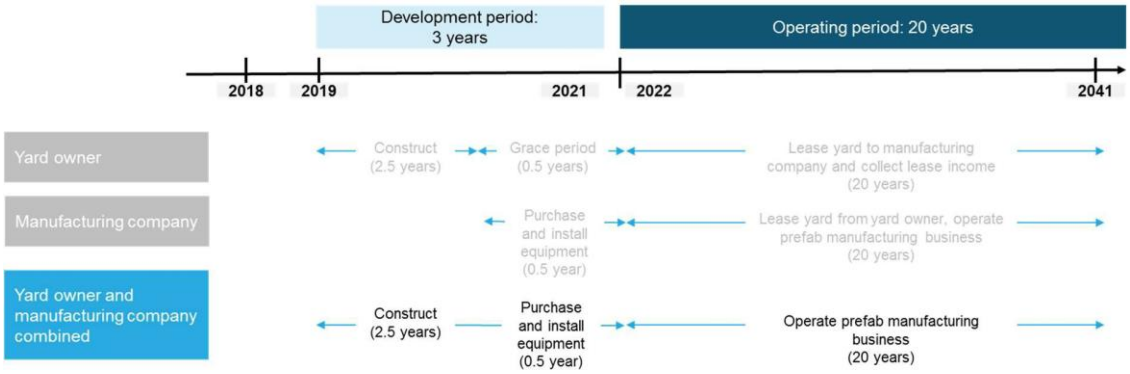
In order to ensure that sufficient cash is available during the first few months of the operation, we have included a working capital requirement for the manufacturing business. The assumptions for working capital include:

Key driver	Assumption	Source / rationale
Working capital requirement	Prior to operation of the yard	In order to ensure that sufficient cash is available during the first few months of the operation, we have included a working capital requirement for the manufacturing business.
Working capital amount	One quarter of first year's operating expenses	The working capital amount is set to be equal to one quarter (3 months) of the first year's operating expenses.
Working capital funding	100% equity	The manufacturing company would fund the working capital entirely through equity.

Base Case 3: Yard owner and manufacturing company combined

Project timeline

The figure below provides a high level view of the project implementation timeline for Base Case 3: Yard owner and manufacturing company combined:



Financing structure and associated terms

The key financing assumptions are summarised as follows:

Key driver	Assumption	Source / rationale
Expected return	7%	Based on publicly stated return on equity of manufacturing companies (which also owns the yard) between 6.1% to 7.5%. Our assumption is at mid-point (rounded).  Source: Reuters and selected industrial REIT's websites

附錄 F

Prefabricated Component Usage in Public Housing Projects

	A		B	C = A x B	D	E = A X D
		60%	40%		20%	
Precast Elements	Weight tonnes per precast element	Number of precast element per floor based on 60% usage	Number of precast element per floor based on 40% usage	Total Precast Elements per floor based on 40% usage (tonnes)	Number of precast element per floor based on 20% usage	Total Precast Elements per floor based on 20% usage (tonnes)
Precast Facades	4.5	36	24.00	108.00	12.00	54.00
Semi-precast Slabs	4.5	118	78.67	354.00	39.33	177.00
Precast Staircases	4.5	4	2.67	12.00	1.33	6.00
Precast Partitions	4.5	8	5.33	24.00	2.67	12.00
Welded Walls (fully precast)	7	12	8.00	56.00	4.00	28.00
Semi-precast Walls	6	20	13.33	80.00	6.67	40.00
Precast Bathrooms	9	16	10.67	96.00	5.33	48.00
Precast Bathrooms-cum-kitchens	8.5	4	2.67	22.67	1.33	11.33
Precast Lift Cores	6.5	8	5.33	34.67	2.67	17.33
Precast Stair Cores	9	2	1.33	12.00	0.67	6.00
Precast Lintels	0.5	8	5.33	2.67	2.67	1.33
	Based on published data*		Precast Elements per floor (tonnes)	802		401
			Number of units per floor	16		16
			Precast Elements per unit based on 40% usage (tonnes)	50.13	Precast Elements per unit based on 20% usage (tonnes)	25.063

*Source:
Green construction | Prefabrication and Precasting | Innovative Precasting and Prefabrication – Pilot Project in Kwai Chung Estate, including Arup's analysis