CONSTRUCTION INDUSTRY COUNCIL
建造業議會

ARCADIS

Improving Time, Cost, and Quality Performance of the Hong Kong Construction Industry

Final Report

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ABBREVIATIONS

Abbreviation	Definition
A&A	Alterations and Additions ·
AAHK	Airport Authority Hong Kong
AAP	The Association of Architectural Practices
ACEHK	The Association of Consulting Engineers of Hong Kong
AP	Authorized person
APM	Association for Project Management
APSEC	Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers Committee
AutoCAD	Computer-aided design
B2B	Business-to-business
B2R	Business-to-research
BCA	Building and Construction Authority, Singapore
BD	Buildings Department, Hong Kong
BE LLF	Built Environment Living Laboratory Framework, Singapore
BEIS	Department for Business, Energy and Industrial Strategy, United Kingdom
BES(E)	Buildability Evaluation System for Public Engineering Works Projects
BETA	Built Environment Technology Alliance, Singapore
BETC	Business and Technology Education Council, Singapore
BIM	Building information modelling
BIP	Building Innovation Panel, Singapore
BO	Buildings ordinance
BSc	Bachelor of science
CABE	Chartered Association of Building Engineers
CAGR	Compound annual growth rate
CAPEX	Capital expenditure
CARES	Certification Authority for Reinforcing Steels, United Kingdom
CDBB	Centre for Digital Built Britain, United Kingdom
CDPSS	Common Digital Platform for Site Supervision
CEDD	Civil Engineering and Development Department, Hong Kong
CFA	Construction floor area
ChPP	Chartered Project Professional
CIC	Construction Industry Council, Hong Kong
CICID	Centre for Innovation in Construction and Infrastructure Development, Hong Kong
CIH	Construction Innovation Hub, United Kingdom
CIOB	Chartered Institute of Building
CIP	Construction innovation platform
CITAC	Construction Innovation and Technology Application Centre, Hong Kong
CITF	Construction Innovation and Technology Fund, Hong Kong
CITM	Construction Industry Transformation Map, Singapore

Abbreviation	Definition
CLC	Construction Leadership Council, United Kingdom
CMA	Construction Material Association
CoC	Certificate of Conformity
CoE	Centre of Excellence for Major Project Leaders, Hong Kong
CORENET	Construction & Real Estate Network, Singapore
COTS	Commercial-off-the-shelf
COVID-19	Coronavirus disease
CPD	Continuing professional development
CPS	Centralised processing system
CSC	Certificate of Statutory Completion
CSCEC	China State Construction Engineering Corporation
CSDE	Common Spatial Data Environment
CWP	Capital works programme
CWRS	Construction workers registration system
DBO	Design-build-operate
DEVB	Development Bureau, Hong Kong
DfMA	Design for manufacture and assembly
DOC	Declaration of Compliance
DWSS	Digital works supervision system
ECC	Engineering and Construction Contract
ECI	Early contractor involvement
EMSD	Electrical and Mechanical Services Department, Hong Kong
EPCCs	Enhanced precast concrete components
EPD	Environmental Protection Department, Hong Kong
ePM	Electronic Project Management, United States
ESH	Electronic submission hub
eSS	E-submission System
FSC	Fire Safety Certificate, Singapore
FSD	Fire Services Department, Hong Kong
FSP	Fire Safety Products, Singapore
FSSD	Fire Safety & Shelter Department, Singapore
GB Standards	Chinese National Standard
GBP	General building plan
GCC	General Conditions of Contract
GCSE	General Certificate of Secondary Education
GDP	Gross domestic product
GEO	Geotechnical Engineering Office, Hong Kong
GFA	Gross floor area
GLS	Government Land Sales, Singapore
GMP	Good Manufacturing Practices, Russia

Abbreviation	Definition
GSA	General Services Administration, United States
HDB	Housing and Development Board, Singapore
HKCAS	Hong Kong Certification Body Accreditation Scheme
HKCTC	Hong Kong Council for Testing and Certification
HKHA	Hong Kong Housing Authority
HKHS	Hong Kong Housing Society
HKIA	Hong Kong Institute of Architects
HKICM	Hong Kong Institute of Construction Managers
HKICW	The Hong Kong Institute of Clerks of Works
HKIE	Hong Kong Institution of Engineers
HKIPM	Hong Kong Institute of Project Managers
HKIS	Hong Kong Institute of Surveyors
HKQAA	Hong Kong Quality Assurance Agency
HKSAR	Hong Kong Special Administrative Region of the People's Republic of China
HKU	The University of Hong Kong
HOKLAS	The Hong Kong Laboratory Accreditation Scheme
HyD	Highways Department, Hong Kong
i3P	Infrastructure Industry Innovation Partnership, United Kingdom
IAB	Innovation advisory board
ICE	Innovative contractor engagement
ICPH	Integrated Construction and Prefabrication Hub, Singapore
ICU	Independent Checking Unit
ILAC	International Laboratory Accreditation Cooperation
IoT	Internet of things
IP	Intelligence properties
IPA	Infrastructure and Projects Authority, United Kingdom
ISCF	Industrial Strategy Challenge Fund, United Kingdom
IT	Information technology
I&T	Innovation and technology
JTC	Jurong Town Corporation
KPI	Key performance indicator
LandsD	Lands Department, Hong Kong
LUL	London Underground Limited, United Kingdom
MEP	Mechanical, electrical and plumbing
MiC	Modular integrated construction
MiMEP	Multi-trade integrated mechanical, electrical and plumbing
MND	Minister of National Development, Singapore
MPLA	Major Projects Leadership Academy, United Kingdom
MPLP	Major Projects Leadership Programme, Hong Kong
MSc	Master of science

Abbreviation	Definition
MTC	Manufacturing Technology Centre, United Kingdom
MTR Corporation	Mass Transit Railway Corporation
MWCS	Minor works control system
NEC	New engineering contract
OECD	Organisation for Economic Co-operation and Development
PAQS	Pacific Association of Quantity Surveyors
PBS	Public Building Services, United States
P-DfMA	Platform Approach to DfMA
PfV	Procuring for value
PgD	Postgraduate diploma
PLB	Planning and Lands Branch (PLB) of the Development Bureau, Hong Kong
PLS	Product Listing Scheme, Singapore
PMI	Project Management Institute
PNAP	Practice Notes for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers
PRINCE2	Projects IN Controlled Environments
QA	Quality assurance
QC	Quality control
QR code	Quick response code
QS	Quantity surveying
QSi	Quantity Surveyors International
R&D	Research & development
RFI	Request for Information
RFID	Radio frequency identification
RFP	Request for proposal
RGE	Registered geotechnical engineers
RIBA	Royal Institute of British Architects
RICS	Royal Institution of Chartered Surveyors
RPP	Registered project professional
RSE	Registered structural engineers
SCDF	Singapore Civil Defence Force
SCL	Shatin to Central Link
SFw	Skills Framework, Singapore
SID&GP	State Institute of Drugs and Good Practices, Russia
SMEs	Small and Medium-sized Enterprises
SSG	SkillsFuture Singapore
TA(C)	Technology Adoption (Construction) Index, Singapore
TA(D)	Technology Adoption (Design) Index, Singapore
TCMWCS	Technical Committee on the Minor Works Control System
TCP	Technically competent persons

Abbreviation	Definition
TD	Transport Department, Hong Kong
TOP	Temporary occupation permit
UK	United Kingdom
UKRI	UK Research and Innovation
URA	Urban Renewal Authority, Hong Kong
USA	United States of America
VTC	Vocational Training Council, Hong Kong
WKCDA	West Kowloon Cultural District, Hong Kong
WSD	Water Supplies Department, Hong Kong
WSG	Workforce Singapore
WSQ	Workforce Skills Qualifications, Singapore

Executive summary

EXECUTIVE SUMMARY

The construction industry has long been a powerful engine for Hong Kong's economic growth. Characterised by productivity and adaptability to innovation and change, Hong Kong has for decades established its construction sector as a benchmark in excellence globally. However, maintaining this reputation has been challenging over the past decade. Productivity has and continues to suffer due to a combination of social and economic factors, such as an ageing workforce, rising costs, and failure to rapidly capitalise on opportunities offered by digitalisation and off-site manufacturing, particularly in the private sector. Without acceleration and rapid change in construction, Hong Kong stands to lose out on substantial economic benefits.

In response, the Construction Industry Council (CIC) commissioned Arcadis Hong Kong (we) to prepare this report that aims to address key challenges and develop a series of strategies that may unlock barriers to change and accelerate productivity growth in Hong Kong's construction industry.

The specific objectives of this report are:

To establish the areas of greatest opportunity where change will bring clear performance improvements, at scale, that are implementable in a Hong Kong context

To define individual strategies with roadmaps for implementation that will drive measurable improvements in time, cost, and quality performance

Through extensive local stakeholder engagement, a review of current initiatives undertaken by the Hong Kong Government (the Government), international research on publications and best practices, as well as a review of previous studies conducted by the CIC and local academia to diagnose efficiency issues in the construction industry, we identified four areas that hold promising opportunities for improvement:

Shifting to high productivity construction: shifting from on-site operations to a controlled manufacturing environment, including greater modularisation, off-site production, and on-site assembly.

Driving innovation: establishing mechanisms to actively encourage and nurture development and implementation of new products, methodologies and ideas that support productivity, safety, and sustainability improvements.

Streamlining approval processes: focusing on improving existing approval processes through leveraging digital technologies and modifying existing communication mechanisms.

Enhancing project management and procurement: enhancing project management delivery capability and embracing alternative effective procurement options.

Within these four focus areas, we researched and explored a variety of strategies for improvement based on successful similar initiatives overseas, original ideas developed specifically for the Hong Kong situation, and input from interviews of more than 40 key stakeholders in Hong Kong. Amongst the many initiatives explored, we arrived at 13 strategies — the priority strategies — which provide a combination of high-impact potential, likelihood of success, and good evidence of successful application in other locations. These priority strategies, within their respective focus areas are:

- Development of a **digital library** to facilitate modular integrated construction (MiC) and multi-trade integrated mechanical, electrical and plumbing (MiMEP) adoption that maximises the use of interoperable building components across different asset types
- Promotion and support of **MiC and MiMEP adoption** through advocacy initiatives and development to educate industry stakeholders and practitioners on how the value-capture of adoption of modularised construction justifies and exceeds initial capital costs
- Expansion of **MiC Resources Centre** to build up the industry's capability on MiC and MiMEP by providing technical expertise and practices, sharing expert resources, and providing training and apprenticeships
- Improvement of **contract terms** to promote wider adoption of MiC and MiMEP by addressing risks to the supply chain

- Establishment of a **construction innovation platform** which provides a systematic approach for facilitating innovative ideas, conducting research and development (R&D) programmes, and streamlining test-bedding processes with a flexible funding mechanism
- Generation of an **eco-system for innovation through tendering** to incentivise adoption of new methodologies/technologies that support productivity, safety, and sustainability enhancements

- Development of an **integrated digital submission and approval process** that fully utilises the benefits of building information modelling (BIM), automated design checking tools, e-inspection procedures, and common spatial data systems
- Extension of the **list of minor works that without the need to obtain prior approval and consent** to reduce the workload in approval/consent submissions and eventually achieve a higher level of self-regulatory system performed by the private sector
- Assessment of proposals to **expedite the efficiency of the approval processes** including parallelisation of submissions, data-driven review on response time, and improving communication with the industry

- Development of an **integrated project digital platform** to create a centrally managed data platform that enhances project control and planning through big data enhanced with artificial intelligence (AI)
- Establishment of a **framework to enhance project management Skills** by providing professional training and accreditation as part of a structured career development path aimed at improving technical capability and attracting new talent to the industry
- Launch of **product certification scheme for construction materials** procurement system to shorten time on testing and approvals
- Promotion of benefits of **early contractor involvement** in projects to improve design quality

*The proposed strategies can improve time , cost , and quality .

This report attempts to provide the building blocks and tentative roadmap to achieve long-term strategic improvements for the construction industry by encouraging all stakeholders to fully engage in delivering the transition required for a more productive and sustainable future. At the same time, we recognise that the Government may have several initiatives with the same goals that are underway or planned. The purpose of this report is to provide suggestions for consideration which may be complementary or additional to current planning. The feasibility of the specifics of these recommendations can be examined by the Government and other relevant parties.

As such, if proven practical, the recommended initiatives will require the support of various entities in the public and private sectors to succeed and yield benefits to all involved in the industry and, by extension, to Hong Kong's society and economy.

01
Introduction

1 INTRODUCTION

1.1 Background of study

Hong Kong is a city unlike any other — a global financial hub that has earned a reputation as one of the leading trading centres on earth. It is supported by a public infrastructure network that is internationally recognised as amongst the best in the world and boasts a one-of-a-kind cityscape that is the backdrop for international investors keen to do business in China. The construction industry has always had a significant contribution to the Hong Kong success story and been integral in developing a built environment that has underpinned the economic accomplishments of Asia's World City, while improving the quality of people's lives.

The Hong Kong construction industry, however, has faced a number of growing challenges in recent years. Factors such as an ageing workforce and lack of appeal to new entrants, outdated labour-intensive practices, coupled with high construction costs have had measurable negative impact. These pressures have all contributed to a decline in productivity and competitive edge within the construction sector.

A consultancy study titled *Improving Time, Cost and Quality Performance of the Hong Kong construction industry* (Phase 1 Study) was initiated in September 2017 by the Construction Industry Council in response to the industry's concerns on programme control, spiralling costs, and quality performance. That study had two main objectives:

- To review the current performance of the Hong Kong construction industry in terms of time, cost and quality criteria
- To determine the causes and contributing factors of project delay, cost overspend and inferior quality throughout the industry.

The Phase 1 Study which was completed in 2019, outlined the main problems facing the industry and their impact on project outcomes. In total, 10 major root causes were identified across six distinct phases in a project's life cycle. These phases included: i) project approval, ii) procurement strategy, iii) delivery strategy, iv) detailed design, v) design approval, and vi) project delivery and close-out. The key issues, which are further discussed in Section 2, were:

- Industry lacking project management capability
- Optimistic initial budget and programme for approval
- Rate of increment in total work volume outrunning rate of increment in the labour pool and uncertainty of new work forecast
- Preference on the use of design-bid-build with fixed price lump sum procurement
- No incentive to implement innovation
- Conservative approval and stringencies regarding compliance
- Lack of appeal to new entrants
- Traditions regarding labour-intensive methods
- Limited labour pool
- Challenging natural and congested urban environment for construction

In 2020, the CIC commissioned Arcadis to conduct a further study (Phase 2 Study) with the aim of building on the earlier research and developing strategies and an implementable roadmap which will address the root causes and key issues identified in Phase 1. The findings of the Phase 2 Study are detailed in this report.

1.2 Objectives of the consultancy

As previously mentioned, there are two ultimate objectives in this consultancy:

To establish the areas of greatest opportunity where change will bring clear performance improvements, at scale, that are implementable in a Hong Kong context

To define individual strategies with roadmaps for implementation that will drive measurable improvements in time, cost and quality performance

Table 1 outlines the key mechanisms that we consider can help achieve these objectives.

	**Incentivisation to Improve time cost and quality performance**: granular methods to facilitate roll-out of incentivisation initiatives that will benefit industry performance
	**Policy enablement:** good evidence and industry backing, which will facilitate policy suggestions in Hong Kong. This could extend to approval processes for government bureau and regulatory departments, forms of contract that are allowed, finance mechanisms used for capital works, and workforce policy to cover possible gaps.
	**Ensuring practicality** for implementation within the power of the CIC and other bodies within the Hong Kong public sector
	**Bringing international best practice to Hong Kong,** both to private and public sector practitioners to promote innovative practices and streamlined approval processes
	**Gaining industry support and consensus** through consultations with key stakeholders and industry forums to validate the proposed strategies.

Table 1 - Key mechanisms to achieve key objectives

1.3 Methodology

A flow-chart of the methodology we followed is illustrated in Figure 1. As seen in this figure, there were three main stages in our consultancy:

Strategy development into four focus areas

Through a critical analysis of the Phase 1 Study, engagement of Arcadis market expertise, and review of industry thought leadership publications, the initial strategies are pillared into four focus areas.

Stakeholder engagement with industry leaders

Industry leaders provided feedback via in-person interviews on the proposed strategies, enabling ideas to be refined and enhanced.

Consultation through industry forums

These involved detailed discussion of final high-priority strategies to gather final comments and develop industry-wide support.

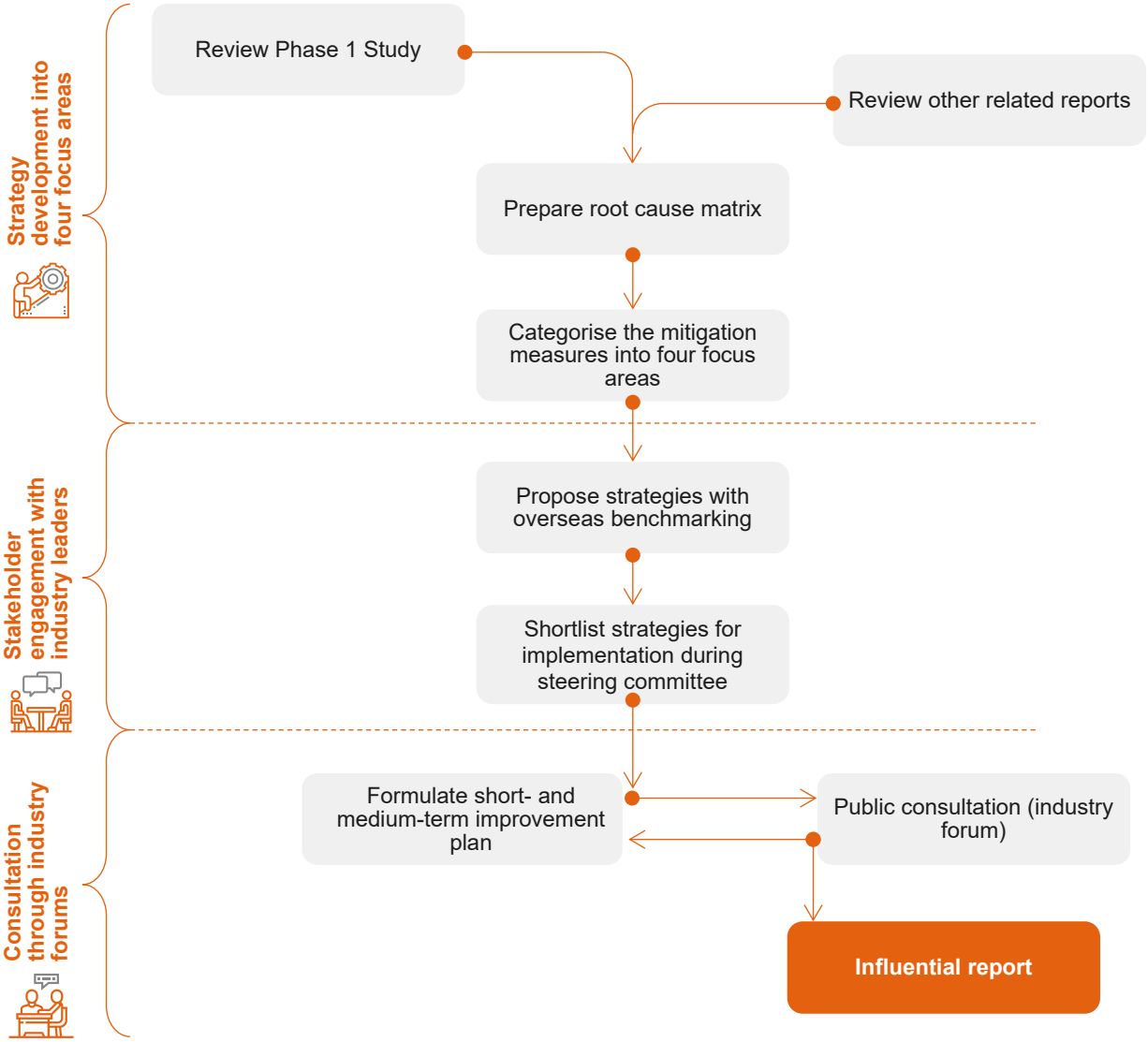

Figure 1 - Methodology flow chart

1.3.1 Strategy development

The strategy development phase was broadly broken down into the following activities:

- Arcadis carried out a critical review of the Phase 1 Study, assessed whether the issues identified provide an in-depth picture of the problems faced by the industry, and explored whether there is scope to further diagnose root causes and key issues at a more granular level.
- Research was undertaken on relevant industry reports and thought leadership publications to capture relevant themes and insights.
- Based on these findings, a period of consultation and engagement with local and international Arcadis experts was completed whereby a list of 34 preliminary ideas were identified for potential strategy development.
- Through further consultation, the strategies were categorised into four focus areas: shifting to high-productivity construction, streamlining approval processes, driving innovation, and enhancing project management and procurement.

While selecting strategies, we considered the following:

- Benefits for time, cost, and quality improvements
- Ability to address the root causes and key issues identified in the Phase 1 Study
- The picture today relating to application and legislation
- Focus on public or private sector, or both

- Relevant international best practices
- Proposed action plan and responsible parties
- Stakeholder consultation feedback and level of support from the industry
- Overseas benchmarking and industry practice in comparable markets, including Singapore, the UK, Japan, Australia, and the US
- Available relevant data to support the proposal.

It is worth mentioning that initiatives around the world constantly evolve, and periodic benchmarking studies on this evolution would help inform future strategies.

1.3.2 In-person interviews

The second stage of the study involved extensive stakeholder engagement with industry experts and professionals who were representative of the wider Hong Kong construction industry (refer to Section 3 for a detailed analysis of stakeholder engagement).

Through a set of structured questions, stakeholders were consulted on strategies that will affect their respective industry sector and, if implemented, will deliver improvements to time, cost, and quality project outcomes. In addition, these sessions also provided an opportunity to communicate the intentions to the industry and build support for the proposed strategies.

In-person interviews were conducted between mid-July through to mid-October 2020, with 36 relevant stakeholders and industry experts. These were selected to include a balanced distribution of stakeholders and professions involved in different stages throughout the construction supply chain and in different sub-sectors of the industry who were consulted on strategies that would affect their respective areas.

The topics discussed during the stakeholder interviews were:

- Facilitating wider adoption of prefabrication and modular construction
- Digitalisation of project life cycle
- Adoption of advanced technologies and materials in construction projects
- Enhancing project management capability
- Alternative procurement strategies
- Streamlining government processes.

The results from the stakeholder engagement provided insights into the degree of support for and extent of potential impact on individual strategies combined with the respective challenges involved and suggested improvements. All of which enabled the refinement and re-prioritisation of the strategies and action plans. This was further supported by undertaking overseas benchmarking using Arcadis' global network of industry thought leaders to incorporate international best practices applicable to Hong Kong.

Based on the feedback received, a review process reprioritised the list which included elevation and merging and deselection, resulting in the refinement of the 13 high-priority strategies.

Importantly, the stakeholder engagement served as an opportunity to communicate intentions to the industry and, ideally, garner support for the proposals. Key findings from the stakeholder interviews are discussed in Section 3.

1.3.3 Industry forum sessions

The 13 refined strategies were communicated to the stakeholders through two industry forums. The sessions had two objectives:

- To communicate to the stakeholder community how the feedback from the in-person interviews shaped the final strategy recommendations and proposed roadmaps for implementation
- Provide a final opportunity to collect both feedback and develop buy-in for specific strategies.

The sessions were structured as follows:

- First industry forum on shifting to high productivity construction, and enhancing project management and procurement on 19 November 2020

- Second industry forum on driving innovation and streamlining approval processes on 19 November 2020.

Both forums followed the same format, whereby the latest strategies were presented, and an open discussion was held to collect final opinions/suggestions on the proposed improvement plan.

1.4 This report

The ensuing pages provide details on the methodology and stages followed, along with the resulting strategies for improvement; their scope, intent, and benchmarks; and a proposed implementation roadmap with suggested responsibilities allocated to the entities that are best positioned to drive these initiatives.

02

Review of Phase 1 Study

2 REVIEW OF PHASE 1 STUDY

Background

In June 2019, the Construction Industry Council (CIC) completed the Phase 1 Study titled *Improving time, cost, and quality performance of the Hong Kong construction industry* as a response to growing industry concerns. We quote the conclusions from that report —

- "The increasing cost of construction in Hong Kong, coupled with significant cost overruns on mega project"
- "Construction periods on these projects facing significant delays"
- "Inconsistent performance on design quality leading to inefficiencies and wastage of materials".

Against this background, the study was comprised of two key objectives, which were:

- Review of the current performance of the Hong Kong construction industry in terms of time, cost, and quality performance, and identification of the extent of the problem in each of these aspects
- Identification of the causes and contributing factors of project delay, cost overspend, and inferior quality in the industry.

As part of the Phase 1 Study review, the following activities have been undertaken:

- Identification of key trends facing the industry
- Analysis of 10 root causes across the project life cycle (see details in Appendix A)
- Development of an understanding of the key issues affecting time, cost and quality (see details in Appendix B).

2.1 Key trends facing Hong Kong construction industry

The Phase 1 Study evaluated the performance of the industry in 2019 in terms of time, cost, and quality, and identified the existing problems in each of these aspects. It recognised the causes and contributing factors of time overrun, cost escalation, and poor quality. These are outlined as below:

TIME

- Benchmark studies indicate that Hong Kong takes much longer to complete its standard highway projects when compared to international benchmarks, which may be related to the local practice of more time being spent on planning, approval, and design than on construction. However, benchmark data on the time needed for constructing private building superstructures shows that Hong Kong outperforms Singapore.
- On time forecasting performance, construction periods of some mega projects have been delayed on average by 27%. This performance can be attributed to programmes having little allowance for unforeseen events.

COST

- The cost of construction in Hong Kong is amongst the highest in developed economies, especially in Asia, and significantly higher than in Singapore. And they are higher than they ought to be.
- The cost of constructing buildings in Hong Kong is comparable with Sydney despite current labour wages being less than half of those in comparison. At the same time, Hong Kong construction costs are higher than those in Singapore and more than double those in Shanghai, in both cases correlating with similar differences in labour cost.

QUALITY

- Hong Kong's sporadic quality failures give rise to concerns. Furthermore, while Hong Kong achieves high rankings for its infrastructure quality, Singapore achieves similarly high rankings for much lower cost.
- The quality of the industry's final built products is usually good or at least satisfactory. However, there are concerns about the high cost of achieving this quality with large supervision teams and some inefficiencies.
- Unsatisfactory design quality is often found to result in inefficiencies and wastage of materials and effort throughout the project life cycle. Unsatisfactory site environments seem to jeopardise safety and give the misleading impression of carelessness, detracting new entrants from the industry's appeal. There have also been some significant failures in quality assurance and control.

2.2 Development of four focus areas

Findings from the Phase 1 Study were assessed in conjunction with feedback from other activities in Stage 1 (consultation with Arcadis industry experts and review of relevant thought leadership publications). This enabled Arcadis to develop the four focus areas as a framework to structure the strategy recommendation development.

This approach was endorsed by the CIC's Working Group and Steering Committee in July 2020.

The four focus areas viewed as fundamental building blocks to driving performance improvements in the Hong Kong construction industry are:

- **Shifting to high productivity construction:** acceleration of the transition from traditional in-situ construction to product-based methods, including wider adoption of modular construction, off-site manufacturing, and on-site assembly. The shift to high-productivity construction will enhance built quality and support continued cost and time improvements, as the supply chain matures.
- **Driving innovation**: incentivisation and acceleration of innovation and research and development (R&D) in construction with the aim to improve time, cost, and quality and enhance the efficiency and competitiveness of the industry.
- **Streamlining approval processes:** a more rationalised and efficient statutory control system that provides open and transparent approval processes with certainty and streamlines requirements to minimise potential submission duplication to multiple regulators. An improved building submission and approval process will facilitate the development of Hong Kong and contribute to better predict time and cost performance.
- **Enhancing project management and procurement:** a set of strategies to promote use of a common project collaboration tool allowing data analysis and learning; strengthen the industry's project management capability and expertise to solve the manpower challenge; allow the adoption of alternative procurement methods; and reduce the time required for approval of key construction materials in projects. The proposed strategies are expected to decrease the risk of time and cost overruns.

Figure 2 indicates how the four focus areas proposed will address time, cost and quality concerns identified previously in the Phase 1 Study.

Reduce time overrun

- Hong Kong's standard and highway projects take much longer to complete than their international benchmark.
- Time delay of mega projects ranges from approximately 6 months to more than 2 years.
- High achievability towards programmes for private housing projects.

Minimise cost overrun

- 58% of 12 mega-projects have cost overruns, compared with 12% of standard projects.
- Underruns outweigh overruns for all approved project estimates ranges, except megaprojects over HKD10 billion.
- Cost forecast for RMAA is better in public sector than private sector; about 50% of private RMAA projects encounter 10%-15% cost overrun.

Improve design quality

- Generally, stakeholders expressed that design quality is declining and there is an increase in percentage of resubmissions.
- Declining design quality due to insufficient design fee and period, causing delivery effort to be diverted to completing the design.
- Capability and competency levels largely relates to design quality.

Shifting to High Productivity Construction

- Generate demand for MiC and MiMEP
- Strengthen supply chain for MiC and MiMEP

Driving Innovation

- Promote R&D for advanced construction methods and materials
- Enhance adoption and commercialisation of innovation

Streamlining Approval Processes

- Provide open and transparent approval processes
- Fast track and streamline approval processes

Enhancing Project Management and Procurement

- Promote use of integrated project digital platform
- Strengthen capability and grow expertise

Figure 2 - Proposed focus areas to address time, cost and quality concerns identified in the Phase 1 Study

03

Aggregated points from stakeholder engagement

3 AGGREGATED POINTS FROM STAKEHOLDER ENGAGEMENT

Stakeholder engagement was a key aspect of the Phase 2 Study and was integral to the development of the final strategy recommendations and roadmaps.

This section covers the aggregated points from stakeholder interviews, including major findings, engagement progress timeline, methodology, and limitations. The full interview questionnaire can be found in Appendix C.

Summary of stakeholder engagement processes and the refined strategies

Throughout the stakeholder engagement, the names and groupings of the focus areas and strategies were constantly reviewed and updated based on feedback, with strategies added, merged, renamed, and removed. Once all interviews and engagements were completed, the strategies were updated to reflect the insights and opinions from the stakeholders.

This followed a structured process whereby the following actions were taken:

- **New strategies were added**, as the feedback supported the development of a new recommendation and action plan.
- **Existing strategies were merged**, where two ideas could be more effective if combined together.
- **Priority was either increased or decreased** to reflect the support from the stakeholders in their specialist area.
- **Some strategies were removed** for a number of reasons:
  - Overall feedback raised major concerns as to their feasibility
  - Received relatively little support from the stakeholders
  - Proposed strategies are already underway
  - Research on the feasibility of proposed strategies have been carried out or are in progress.

The final stage of strategy refinement involved consultation with and feedback from the CIC and members of the study working group. The rationale for selection was based on an overall assessment against the criteria of impact and practicality.

Section 3 records the strategies 'as-is' at the time we conducted the interviews and industry forums. Progressing on to Section 4, the focus areas and strategies were finalised. Table 2 summarises the major revisions made between the stakeholder engagement in Section 3 and the final recommended strategies in Section 4, which include the changing of strategies' code, numberings, and names.

	As at Stakeholder Interviews (Oct-2020)		As at Industry Forums (Nov-2020)		Final Recommended Strategies in this Consultancy	
Shifting to High Productivity Construction	I-1	Development of P-DfMA (platform approach to design for manufacture and assembly)	I-1	Development of P-DfMA	ID-1	Development of Digital Library to Facilitate MiC and MiMEP
	I-2	Support DfMA applications through government incentives	I-2	Support DfMA applications through government incentives	ID-2	Support and Promote MiC and MiMEP
	I-3	Guidelines for the Application of DfMA and MiC	I-3,4	Establish DfMA Excellence Centre with Technical Experts	ID-3	Build up Industry's Capability on MiC and MiMEP
	I-4	Establish DfMA Excellence Centre with Technical Experts				
	-	-	I-9	Improve Contract Terms to Promote Industrialisation	ID-4	Improve Contract Terms to Promote Wider Adoption of MiC and MiMEP

	As at Stakeholder Interviews (Oct-2020)		As at Industry Forums (Nov-2020)		Final Recommended Strategies in this Consultancy	
Driving Innovation	ID-1	Establish Innovation Advisory Board	ID-1	Establish Innovation Advisory Board	Removed (See details in Appendix E)	
	ID-2	Construction Innovation Platform	ID-2,5	Construction Innovation Platform	I-1	Establish a Construction Innovation Platform
	ID-3	Adopt Innovation and Creativity Screening in Tender Phase	Removed			
	ID-4	Expand Performance Report to include Innovation	Removed			
	ID-5	Establish an Overarching Entity and Incentive Mechanism to Encourage R&D Investment by Private Sector	Merged with I-1: Establish a Construction Innovation Platform			
	-	-	ID-11	Pay for Innovation Procurement	I-2	Generate Eco-system for Innovation through Tendering
Streamlining Approval Processes	AP-1	Establish Electronic Submission Hub (ESH) with BIM Submission for Streamlined Design Approval	AP-1	Establish Electronic Submission Hub with BIM Submission for Streamlined Design Approval	AP-1	Develop an Integrated Digital Submission and Approval Process, including: i. Encourage and Facilitate Submissions Generated from BIM Models to Buildings Department (BD) ii. Develop Automated Design Checking Tools for Accelerated Approval iii. Adopt a Full E-inspection System iv. Extend Spatial Data Requirements to the Private Sector
	AP-2	Standardise and Provide Training for BD Officers on Scope of Checking, Approval Criteria and Use of BIM	Removed			
	AP-3	Review and Streamline Existing Approval for Fast Track Processing	AP-3	Review and Streamline Existing Approval for Fast Track Processing	AP-3 I.	Review and Streamline Existing Approval for Fast Track Processing
	AP-4	Review of Communication Mechanism and Channel among BD, APSEC (Authorized Persons, Registered Structural Engineers, and Registered Geotechnical Engineers Committee) and the Industry	AP-4	Review of Communication Mechanism and Channel among BD, APSEC and the Industry	AP-3 III.	Improve Communication Mechanism amongst BD and other Regulatory Departments, APSEC and the Industry
	AP-5	Establish Key Performance Indicator (KPI) on Response Time for Critical Comments by Consulted Departments	AP-5	Establish Key Performance Indicator on Response Time for Critical Comments by Consulted Departments	AP-3 II.	Perform Data-Driven Review of Response Times by Consulted Departments

	As at Stakeholder Interviews (Oct-2020)		As at Industry Forums (Nov-2020)		Final Recommended Strategies in this Consultancy	
	AP-6	Incentivise the use of a Centralised Registration of Technically Competent Persons (TCPs)	Removed			
	AP-7	Develop Automated Design Checking Tools for Accelerated Approval	AP-7	Develop Automated Design Checking Tools for Accelerated Approval	Merged with AP-1	
	-	-	AP-8	Extending List of Minor Works	AP-2 Extend the List of Minor Works Exempted from BD Design Submission	
			AP-9	Adopt Full e-inspection System for Off-site Manufacturing	Merged with AP-1	
			AP-11	World Bank Doing Business	Removed	
			AP-12	Establish Common Spatial Data Platform	Merged with AP-1	
			AP-13	Self-regulatory System of Design Submission	Removed	
Enhancing Project Management and Procurement	PM-1	Shift Ownership of Project Collaboration Platform to the Government Project Managers	PM-1	Government Ownership of Project Collaboration Digital Platform	PM-1	Development of Integrated Project Digital Platform
	PM-2	Establish Project Management Qualification Standards for Project Leaders	PM-2	Establish Project Management Qualification Standards for Project Leaders	PM-2	Establish a Framework for Enhancing Project Management Skills
	PM-3	Drive Consultant Fee Assessment Practice that doesn't Result to "Race to Bottom"	Removed			
	PM-4	Introduce an Alternative Steel Reinforcement Certification System	PM-4	Introduce an Alternative Steel Reinforcement Certification System	PM-3	Introduce Project Certification Scheme for Construction Materials
	-	-	PM-8	Adopt Early Contractor Involvement Contracts	PM-4	Promotion of Benefits of Early Contractor Involvement in Projects
			PM-10	Establish a Framework for Enhancing Project Management Skills	Merged with PM-2	

Table 2 - Changes to focus areas and strategies

3.1 Selection of industry stakeholders

Arcadis identified 41 stakeholders and leading industry experts to participate in the study. They were selected across a balanced distribution of seven functional groups reflecting the breadth of the wider construction industry supply chain. These functional groups are as follows:

- **Policy**: Development Bureau (Works Branch and, Planning and Lands Branch)
- **Regulatory bodies**: BD, Fire Services Department (FSD), Water Supplies Department (WSD), Planning Department (PlanD), and Lands Department (LandsD)
- **Clients**: Airport Authority Hong Kong (AAHK), Mass Transit Railway Corporation (MTR Corporation), Hospital Authority

- **CIC**: three committees on Construction Business Development, BIM and Productivity
- **Industry experts**: contractors, professional consultancies, private developers and quasi-government project clients
- **Trade associations**: Construction Material Association (CMA), The Association of Consulting Engineers of Hong Kong (ACEHK), The Association of Architectural Practices (AAP), and Hong Kong Certification Body Accreditation Scheme (HKCAS)
- **Professional bodies**: Hong Kong Institute of Architects (HKIA), The Hong Kong Institute of Surveyors (HKIS), and The Hong Kong Institution of Engineers (HKIE)

In total, 36 interviews were conducted.

3.2 Methodology of stakeholder interviews

Shortlisting of strategies for discussion

The initial 34 strategies were scored based on priority level: high, medium, low. This process was undertaken based on feedback from the CIC and further consultation with Arcadis industry experts.

Due to time limitations, it was decided that only high-priority strategies would be discussed in the stakeholder interviews. This resulted in 20 high-priority strategies which covered the four focus areas.

The high-priority strategies were then screened against two criteria to support which strategies would receive the greatest attention from stakeholders. The criteria were:

- **Impact:** the ability, if implemented, to make significant performance improvements against time, cost, and/or quality
- **Practicality:** the level of ease at which the strategies could be implemented within the power of the CIC and other bodies

The strategies were grouped into three levels of priority, with ‘Priority 1’ being the most frequently asked strategy during the stakeholder interviews. Each interview covered a range of strategies selected based on the priority group identified, as well as the relevance, area of interest, and expertise of each interviewee.

Stakeholder interviews were conducted from July to October 2020. Figure 3 shows the strategies proposed during the first Steering Committee Meeting held on 18 August 2020[1].

Four Top Priority Strategies

1. **I – 1** Development of P-DfMA
2. **ID – 1** Establish Construction Innovation Approval Body
3. **PM – 1** Shift Ownership of Project Collaboration Platform to the Government Project Managers
4. **AP – 1** Establish Electronic Submission Hub with BIM Submission for Streamlined Design Approval

Implementation Timeline

- Short term
- Medium term

- I – 1 Development of P-DfMA
- I – 2 Support DfMA Applications through Government Incentives
- I – 3 Guidelines for the Application of DfMA & MiC
- I – 4 Establish DfMA Excellence Centre with Technical Experts
- AP – 1 Establish Electronic Submission Hub with BIM Submission for Streamlined Design Approval
- AP – 2 Standardise and Provide Training for BD Officers on Scope of Checking, Approval Criteria and Use of BIM
- AP – 3 Review and Streamline Existing Approval for Fast-track Processing
- AP – 4 Review of Communication Mechanism and Channel between BD, APSEC and the Industry
- AP – 5 Establish Key Performance Indicator on Response Time for Consulted Departments
- AP – 6 Incentivise the Use of a Centralised Registration of Technically Competent Persons (TCPs)
- ID – 1 Establish Innovation Advisory Board
- ID – 2 Establish Construction Innovation Platform
- ID – 3 Adopt Innovation and Creativity Screening (ICS) in Tender Phase
- ID – 4 Expand Performance Report to include Innovation
- ID – 5 Establish an Overarching Entity & Incentive Mechanism to Encourage R&D Investment by Private Sector
- PM – 1 Shift Ownership of Project Collaboration Platform to the Government Project Managers
- PM – 2 Establish Project Management Qualification Standards for Project Leaders
- PM – 3 Drive Consultant Fee Assessment Practice that Doesn't Result to "Race to Bottom"
- PM – 4 Introduce a Mandatory Steel Reinforcement Certification System

Figure 3 - Priority of strategies against 'impact' and 'practicality'

Structure of interviews

A set of eight discussion points were issued one week in advance to the interviewees to provide structure to the interview as well as allow time for the interviewees to collate ideas on their respective area.

The interview covered two distinct phases of questioning: i) standard eight questions for all interviewees, and ii) unique set of questions pre-selected based on industry category.

In first phase, the eight standard questions were asked to all interviewees with regard to the four focus areas and scores were collated, and additional comments were recorded. The questions were:

1. Do you find the four focus areas all-encompassing in terms of improving the construction industry in Hong Kong?
2. Which of these four focus areas do you feel is the most impactful in improving the construction industry in Hong Kong? Which is least impactful?
3. Do you believe this strategy is impactful in improving the time, cost, and quality performance of construction industry in Hong Kong?

[1] There were 20 high-priority strategies as of 18 August 2020.

4. Are there any challenges/ difficulties that you anticipate for the implementation of this proposed strategy? If so, what are they? Possibilities could be:
    - Regulatory
    - Industry readiness
    - Appetite or inertia
    - Special interests
5. What do you think are possible solutions to these challenges?
6. Who do you see as the natural owner of such an initiative? Beyond the owner, which industry stakeholders do you feel should be involved in the process?
7. Please assess the strategies under your allocated focus area according to its impact on time, cost, and quality and practicality/feasibility.

Impact on time, cost, and quality

Practicality	Not Significant	Moderate	High
Very Feasible	**Medium priority**	**High priority**	**High priority**
Somewhat Feasible	**Low priority**	**Medium priority**	**High priority**
Not Feasible	**Low priority**	**Low priority**	**Medium priority**

Table 3 - Impact on time, cost, and quality

8. Are there any other strategies beyond what we have identified that will achieve the objectives of this focus area? Any other strategies you wish to discuss?

In the second phase, pre-selected questions were asked based on the relevance of the strategy to the interviewee. The interviewee's feedback on the strategies was tracked and reviewed. The refinement of the strategies was made based on the interviewees' opinions as addressed in the next section.

3.3 Key findings from stakeholder engagement

3.3.1 Overview

The stakeholder engagement results were analysed based on the eight standard questions mentioned in Section 3.2.

The results provided feedback on the following categories of the identified strategies:

- Suitability of the four focus areas as a framework for developing industry-wide strategy recommendations
- Level of support
- Level of impactfulness
- Anticipated challenges
- Improvements to the focus areas and strategies.

All responses were categorised across the six stakeholder groups.

Figure 4 shows the dashboard after the results were collated in Power BI.

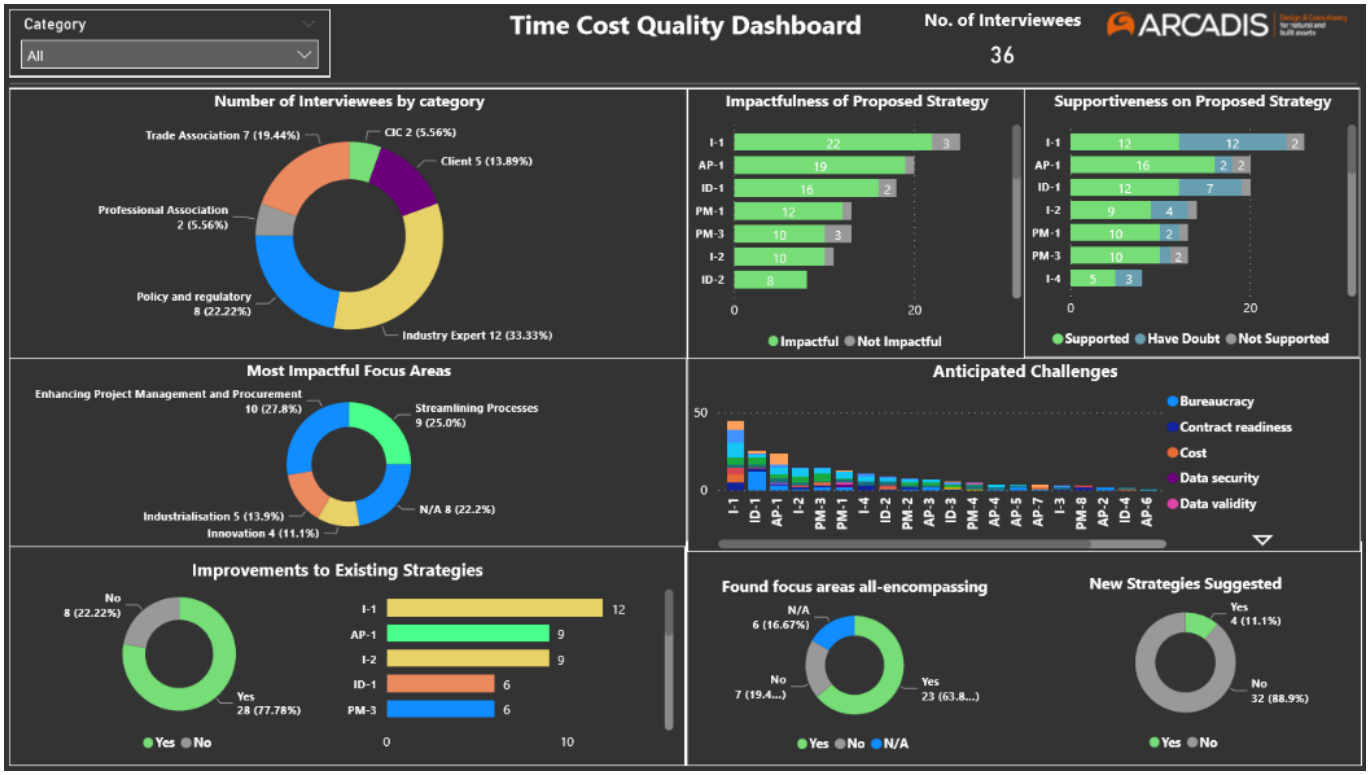

Figure 4 - Screenshot of the Power BI dashboard

3.3.2 Sample size

The stakeholder engagement process collected views from representatives of all sectors of the construction industry's supply chain.

Figure 5 shows the breakdown of interviewees across the six categories.

Industry experts contributed the most (33.33%) to the total number of interviewees, followed by policy and regulatory, trade associations, clients, professional bodies, and CIC members.

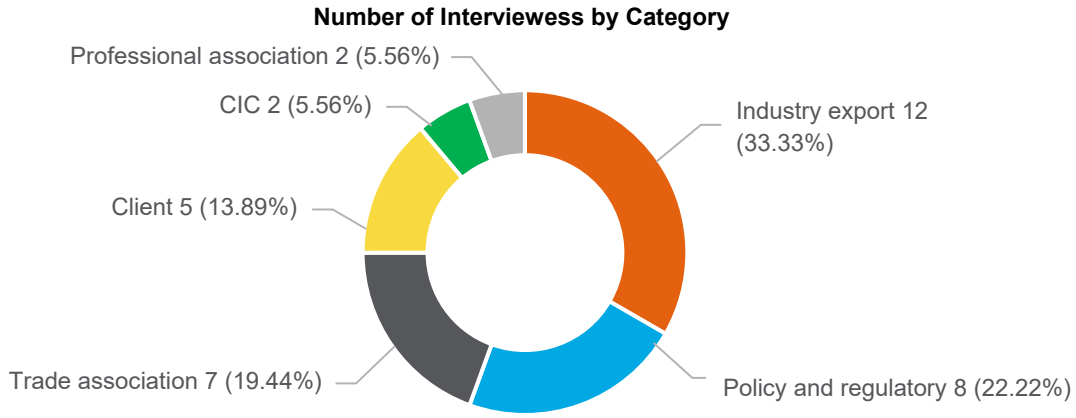

Figure 5 - Classification of interviewees

3.3.3 Found focus areas all-encompassing

The interviewees were asked whether the four focus areas were a suitable framework to represent the industry-wide strategy recommendations.

Figure 6 shows that more than half of the interviewees (~64%) found the four focus areas to be all-encompassing in terms of improving the industry.

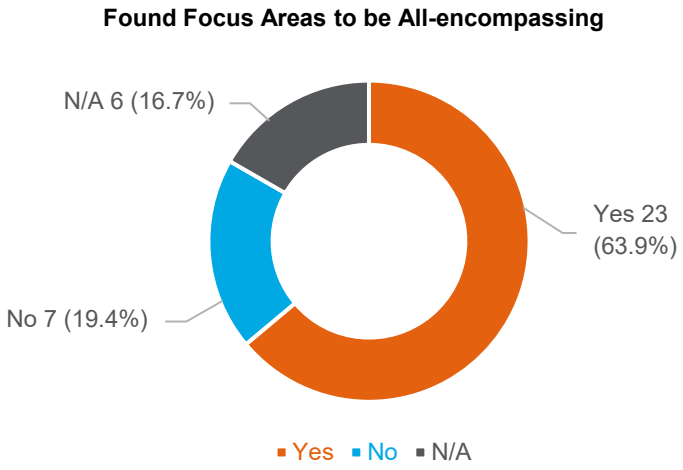

Figure 6 - Number of interviewees considering the four focus areas all-encompassing

3.3.4 Most impactful focus areas

The interviewees were asked to rate which of the four focus areas would be the most impactful in improving the construction industry in Hong Kong.

Figure 7 shows that **enhancing project management and procurement** was marginally the most impactful area for the interviewees in improving the construction industry in Hong Kong, with 27.8% of the interviewees rating it as the most impactful. **Streamlining approval processes** came in second, receiving support from 25% of the panel.

In addition to the four focus areas, the stakeholder engagement identified other topics for further investigation, including manpower / talent development, concept and early design management, capacity building, sustainability, safety, and digitalisation.

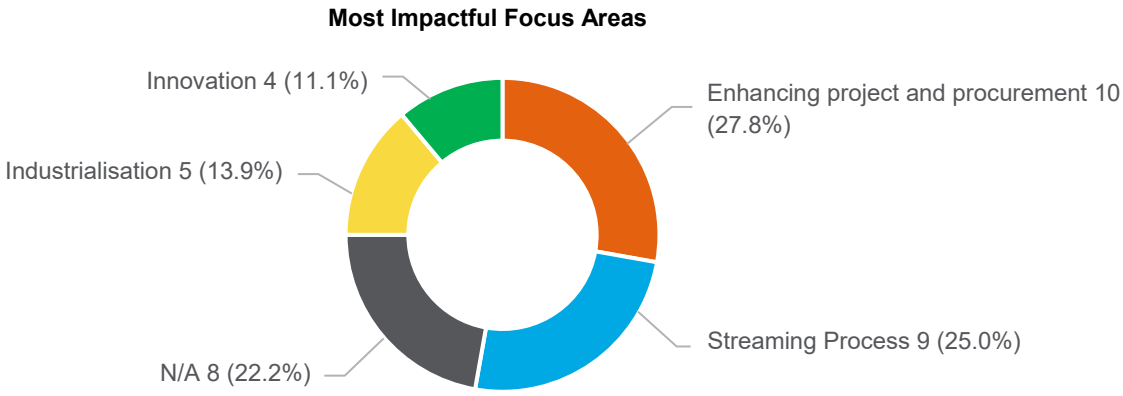

Figure 7 - Most impactful focus area

3.3.5 Degree of impact of proposed strategies

The stakeholders were asked to consider the potential impact of the proposed strategies in improving time, cost and quality performance of the construction industry.

Figure 8 shows that the most commonly cited strategies were:

- I-1: Development of P-DfMA
- AP-1: Establish electronic submission hub with BIM submission for streamlined design approval
- ID-1: Establish innovation advisory board (IAB)

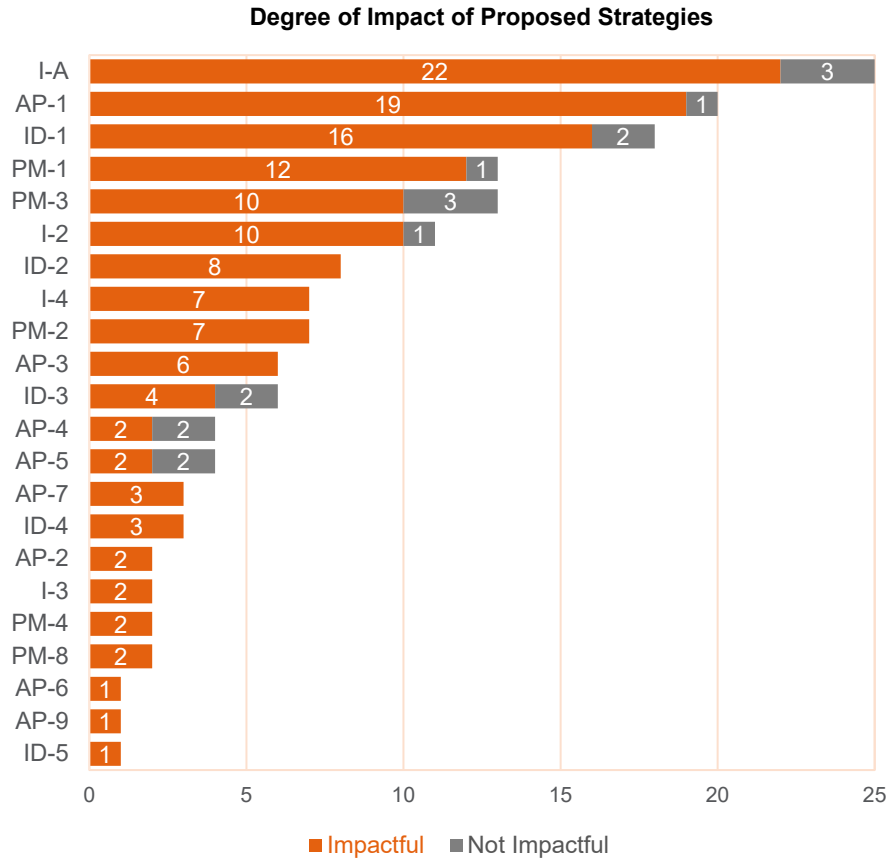

Figure 8 - Overview of the degree of impact of proposed strategy

3.3.6 Level of support for proposed strategies

The following table provides an overview of which proposed strategies the interviewees 'Supported', 'Have doubt', and 'Not supported'.

Strategies supported the most by interviewees	AP-1, AP-3, AP-5, AP-7
	ID-1, ID-2, ID-4
	I-2,
	PM-1, PM-2, PM-3, PM-4
Strategies partly supported by interviewees	I-1, I-4
Strategies least supported by interviewees	ID-3
	AP-4

Table 4 - Supportiveness on proposed strategy

It is noted from the results that few responses were received for some strategies, such as ID-5, ID-11, I-9, AP-6, and AP-9. This is due to the methodology as explained in Section 3.2 where not every strategy was covered in each interview and strategies were selected against 'impact' and 'practicality'. Further details will be given in Section 3.3.9 (Limitations of the stakeholder interviews).

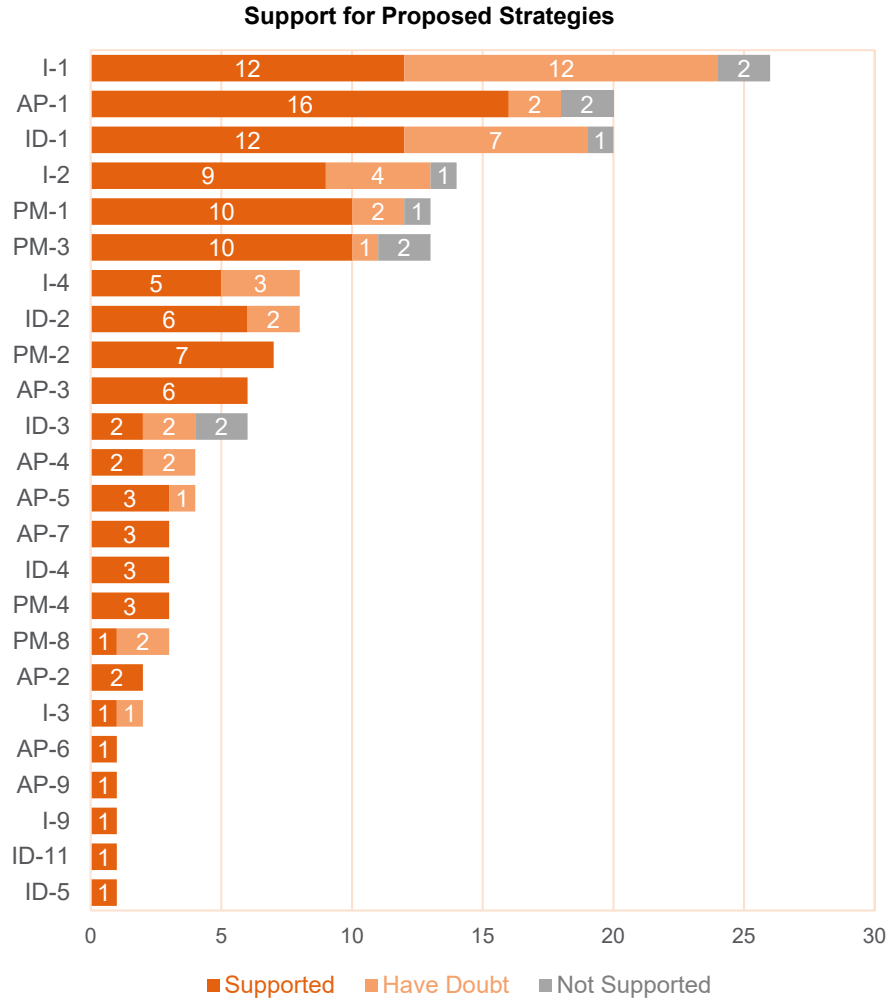

Figure 9 - Overview of support for proposed strategy

3.3.7 Anticipated challenges

Figure 10 summarises the challenges our interviewees anticipated in the implementation of the proposed strategies.

The most common challenges identified by the stakeholders during the interviews (across all focus areas) were:

- Bureaucracy
- Scepticism
- Supply chain readiness

It is worth mentioning that the anticipated challenges were based on views from an extensive stakeholder engagement and may not necessarily be conclusive and further analysis might be required.

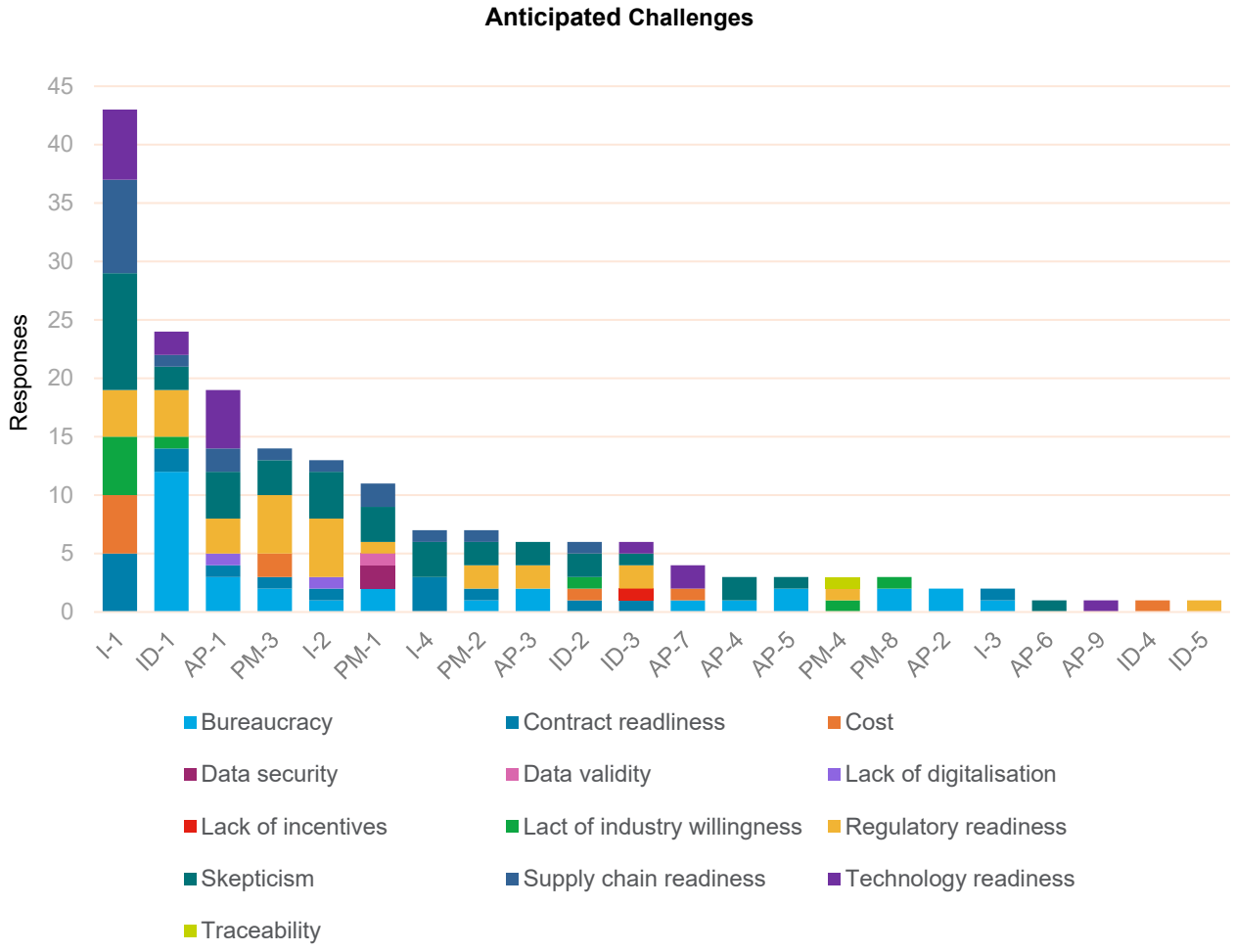

Figure 10 - Overview of anticipated challenges for the implementation of proposed strategy

3.3.8 New strategies suggested

The interviewees were asked whether new strategies should be included in the current list. Majority of them responded that the proposed strategies broadly cover the recommended areas for development. However, they provided numerous suggestions around improving existing strategies.

About 10% of the respondents suggested new strategies, including combining I-1 and ID-1, including talent development and promoting professionalism of project managers, and providing provision of incentives for innovation. In response, PM-2 was reviewed to include the discussion on establishing a project management framework with identified core competencies for the development of professionalism of project managers, while I-2 was added to establish a pay-for-innovation scheme to provide incentives for innovation.

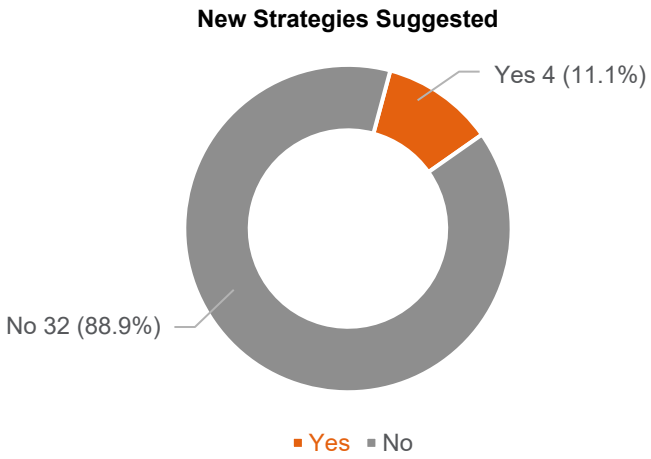

Figure 11 - New strategies suggested

3.3.9 Limitations of the stakeholder interviews

Below are the limitations observed based on the methodology of the stakeholder interviews:

- Not all strategies were covered with each interviewee due to time constraints and relevance to or area of interest of the interviewee.
- The selection of strategies asked to each interviewee was based on the priority group identified and relevance to the interviewee's area of interest and expertise. Hence, some strategies were asked less compared to others.
- Strategy development was evolving at the time of the stakeholder engagement. This meant that some strategies were established after the stakeholder interviews. Most interviews were completed by September 2020 which hindered the collection of sufficient views/feedback.

3.3.10 Further recommendations/insights

From the above sections, the stakeholders provided additional comments/suggestions on the four focus areas and strategies which were then incorporated into our refined strategies for further considerations:

- New focus areas suggested: manpower/talent development, concept and early design management, capacity building, sustainability, safety, and digitalisation
- New strategies suggested: talent development, promoting professionalism of project managers, and provision of incentives for innovation
- Modification to proposed strategies: combining I-1 and ID-1.

3.3.11 Industry forums

Two industry forums were held on the 19 November 2020. Forum 1 covered 'shifting to high-productivity construction' and 'enhancing project management and procurement' strategies while and Forum 2 focused on 'driving innovation' and 'streamlining approval processes'. In total, there were 32 attendees for both forums with representatives from government departments, developers, professional bodies, contractors, and industry experts.

Six strategies were presented in each forum to enable discussion and feedback from the attendees. The selected strategies were:

Forum 1 on 'shifting to high productivity construction' and 'enhancing project management and procurement'

- I-1 Develop P-DfMA
- I-2 Support DfMA applications through government incentives
- I-9 Improve contract terms to promote industrialisation
- PM-1 Develop a government-owned project collaboration digital platform

- PM-4 Introduce an alternative steel reinforcement certification system
- PM-10 Establish a framework for enhancing project management skills

Forum 2 on 'driving innovation' and 'streamlining approval processes'

- ID-1 Construction innovation platform
- ID-11 Pay for innovation procurement
- AP-3 Review and streamline existing approval for fast-track processing
- AP-5 Establish key performance indicators on response time for critical comments by consulted departments
- AP-9 Adopt full e-inspection system for off-site manufacturing
- AP-13 Self-regulatory system of design submission

The industry forums were structured so that each individual strategy was presented by Arcadis industry experts, followed by an open discussion to understand the challenges and opportunities and ascertain attendees' support.

Refinement of the strategies was undertaken to incorporate the feedback from the industry forums. Key changes are described in Section 3.

04

Final recommended strategies and way forward

4 FINAL RECOMMENDED STRATEGIES AND WAY FORWARD

4.1 Overview

The proposed strategies were classified into four focus areas and individually linked with time, cost, and quality parameters. In addition, the strategies were associated with relevant root causes which were identified in the Phase 1 Study. In total, **13 high-priority strategies** were proposed within this framework.

There are four main sections in the report which correspond to the four focus areas, and each is structured as follows:

- **Description**: introduction to the strategy and relationship with public and/or private sectors
- **Practical action plan**: how the strategy works, proposed methodology and roadmap in terms of short- and medium-term actions, potential responsible parties, identification of rationale, benefits and hypothesis criteria
- **Evidence**: local and international benchmarking as reference and support to the proposed strategy.

Each strategy was allocated a unique identifying prefix. 'ID' refers to the strategies under 'shifting to high-productivity construction', 'I' refers to 'driving innovation', 'AP' refers to 'streamlining approval processes', and 'PM' refers to 'enhancing project management and procurement'. This report provides details for high-priority strategies only. A list of other strategies that were explored as areas for further research during this consultancy are included in Appendix E.

Figure 12 summarises the high-priority strategies under the four focus areas.

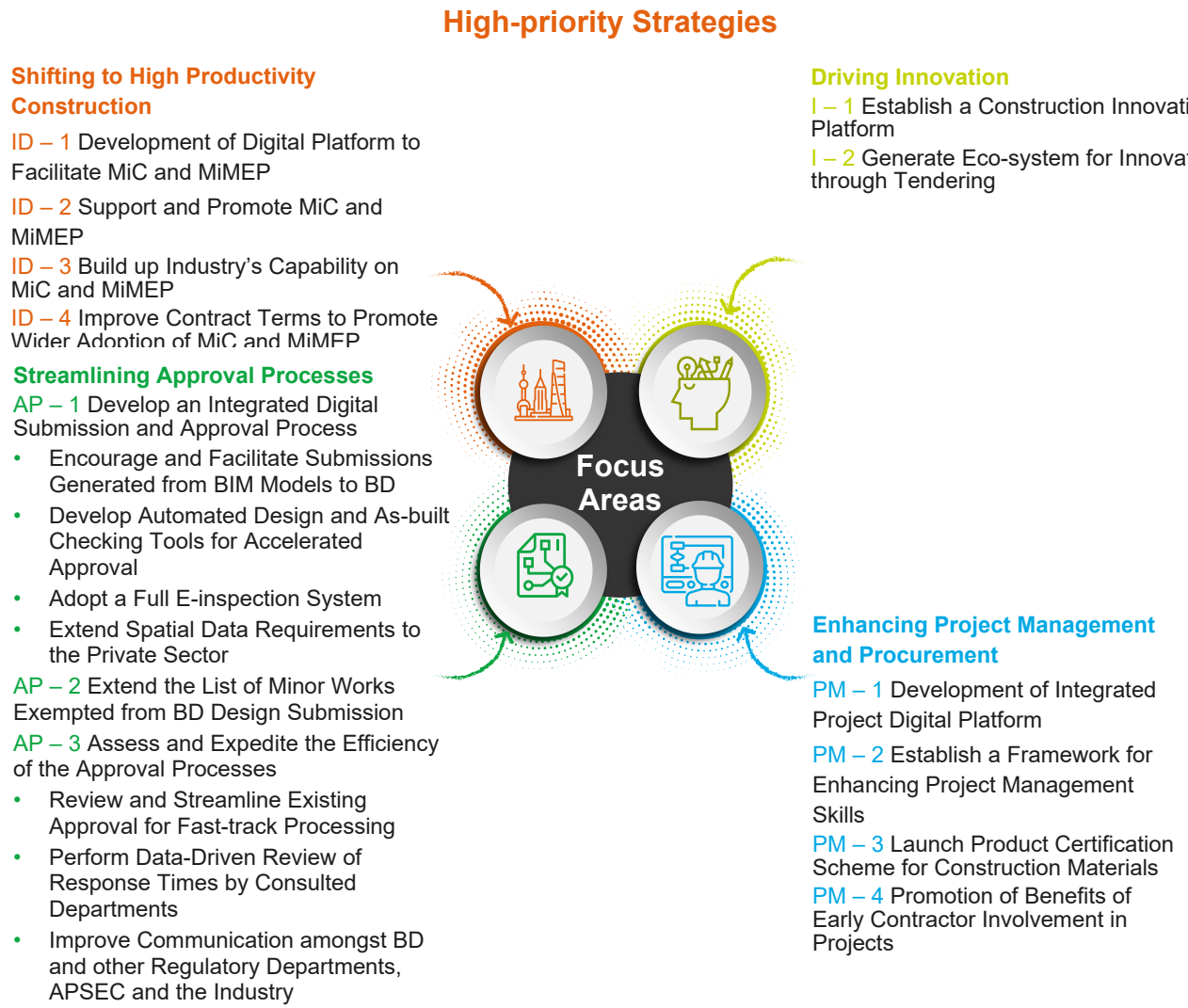

Figure 12 - High-priority strategies and respective follow-up groups under the four focus areas

4.2 Shifting to high productivity construction

Shifting from on-site operations to a controlled manufacturing environment through the application of a modern approach to design is an emerging global trend in the construction industry. In successful overseas cases, such design and construction methods helped achieve a 60% improvement in productivity and a 30% improvement in project schedules when 70% of construction is carried out off-site (Clucas, 2019).

BIM-enabled DfMA[2] — with MiC[3] and Multi-trade integrated Mechanical, Electrical and Plumbing (MiMEP)[4] being the highest end of DfMA products — can also yield significant socioeconomic benefits, including sustainability, improved working conditions, shortening construction time and subsequent reductions in health and safety incidents (Bertram et al., 2019; Construction Industry Council, 2020). Regionally, Singapore set a target of 35% of Housing and Development Board's housing projects to be constructed using MiC to a minimum of 65% construction floor area, and also set a productivity enhancement target.

Locally, there is clear support for high-productivity construction by applying three major design principles to maximise productivity: (i) off-site prefabrication; (ii) multi-trade integration and module maximisation; and (iii) plug and play. Since 2018, the CIC has been promoting MiC to both public and private sector clients, through the MiC Display Centre and the online MiC Resources Centre. The Development Bureau (DEVB) issued a technical circular — DEVB TC (W) No. 2/2020 — in March 2020 to promulgate a policy on adoption of MiC for new building works with total construction floor area larger than 300m² under the Capital Works Programme to be tendered on or after 1 April 2020, covering suitable building types and accommodations. The Chief Executive's Policy Address in 2020, made specific references to embracing an open mindset to expedite the construction of public housing with the adoption of MiC and to the opening of the MiC Display Centre in November 2018.

The Hong Kong Housing Authority (HKHA) has been leading the utilisation of prefabricated products for public housing since the early 1980s by introducing modular flat design and enhanced precast concrete components. Currently, the HKHA is making preparations to carry out a pilot project with MiC public housing block at Tung Chung Area 99 and Tak Tin Street in Lam Tin. In the private sector, the Buildings Department (BD) has been promoting MiC, viz., (i) providing general guidelines on the design and quality control requirements under the BO for MiC and setting up a pre-acceptance mechanism as promulgated in PNAP ADV-36; and, (ii) providing incentive in the form of gross floor area (GFA) concession for development projects adopting MiC having regard to repetitive double walls between MiC modules and thicker enclosure walls to cater for rigging and hoisting during transportation and assembly involved in MiC. In the Hong Kong 2022-23 Budget, the Government announced to introduce more concessionary measures for buildings adopting MiC, including increasing the concession of floor area from the current 6% to 10%, providing corresponding site coverage concession, and supporting applications for exceeding building height limits due to increase in floor area caused by the adoption of MiC.

Furthermore, the Hong Kong Housing Society (HKHS) plans to use MiC to build a 10-storey elderly home on a badminton court at Jat Min Chuen in Sha Tin and construct a 25-storey subsidised-for-sale house on Hung Ping Road, Hung Shui Kiu. In addition to MiC applications, the use of some prefabricated products such as MEP products may yield time, cost, quality, productivity, sustainability, and safety benefits for the industry. Moreover, in January 2017, the Government published its Climate Action Plan 2030+ which set a carbon emission reduction target for 2030 and outlined the city's action plans. In October 2021, the Chief Secretary, in her Policy Address, announced that Hong Kong would strive to achieve carbon neutrality by 2050. To achieve that, the choice of design and construction methods should be considered from an environmental perspective to reduce embodied carbon emissions during the construction process through adoption and promotion of MiC. This will reduce construction waste, resource consumption, and environmental pollution (Pan, 2020).

The strategies proposed in this focus area aim to reduce construction time and project cost, and enhance project quality by:

- Improving productivity and shortening construction time with better completion certainty by moving construction to an off-site environment
- Reducing reliance on labour intensive on-site construction and thus relieving bottlenecks for skilled labours and professionals

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[2] There is a commonly encountered misunderstanding that DfMA is equivalent to MiC. DfMA refers to a design approach that focuses on enabling off-site manufacturing and reducing on-site processes, whereas MiC is the most advanced form of DfMA.

[3] Modular Integrated Construction is an innovative construction method by which building components are approached as modules that are manufactured and assembled in a factory before installation at the project site (Construction Industry Council, 2020).

[4] MiMEP is a construction method whereby mechanical, electrical, and plumbing components and equipment are integrated into a sub-assembly off-site and then deliver to and installed on-site (Construction Industry Council, 2020).

- Reducing reliance on-site supervision and lowering administrative costs
- Reducing traffic impact and nuisance to neighbourhoods from the site activities
- Reducing material wastage, disposal cost, and pressure on landfills/public fill reception facilities
- Enhancing QC and safety in controlled environments thus reducing defects and accidents.

We acknowledge that challenges to the uptake of MiC/MiMEP include:

- Inertia and considerations on initial costs
- Regulatory issues regarding QA (Quality Assurance) /QC (Quality Control) in factories
- Contractual liability issues/ uncertainty around appropriate contract framework for MiC and MiMEP products
- Concerns, surrounding the possibility of potential charges by Lands Department on additional GFA
- Taxes and tariffs imposed by Mainland China customs, which add to the cost
- Concerns around preserving the distinct identity of physical assets and securing that the final asset considers both productivity and needs of users
- Concerns on the lack of MiC prefabrication facilities in Hong Kong and over-reliance on facilities outside the SAR
- Technology and market readiness.

The following sections provide details on each of the strategies in response to the benefits and challenges stated above, with support from data, feedback from stakeholders and benchmarking. Table 5 illustrates the link to the expected time, cost, and quality impact of each strategy in this section.

STRATEGY	TIME	COST	QUALITY
ID-1 **Development of Digital Library to Facilitate MiC and MiMEP**	• Off-site construction provides improvement across construction cost; design and build quality; and productivity, safety, and sustainability performance. • Promotion of supply chain integration with the Greater Bay Area will enable performance improvement through provision of scale.		
ID-2 **Support and Promote MiC and MiMEP**	N/A	Advocacy initiatives and possibly other incentives will address the initial cost barriers associated with adopting MiC and MiMEP.	Assessment will help measure MiC/MiMEP efforts of different construction sectors and ultimately drive improvements in construction quality progressively.
ID-3 **Build up Industry's Capability on MiC and MiMEP**	N/A	N/A	Expansion of MiC Resources Centre will drive industry-wide improvements in the quality of implementing MiC and MiMEP by offering technical standards, professional consultation, and training services.
ID-4 **Improve Contract Terms to Promote Wider Adoption of MiC and MiMEP**	Introduction of suitable contract terms and provision of payment mechanisms for off-site manufacturing will facilitate the adoption of MiC and MiMEP.		

Table 5 - Time, cost, and quality impact of high-priority shifting to high productivity construction

4.2.1 ID-1 Development of digital library to facilitate MiC and MiMEP

4.2.1.1 Description

This strategy suggests the adoption of a digital library to facilitate MiC and prefabricated MEP components. By collecting interoperable key building components across a portfolio of design assets, the approach reduces the need for entirely bespoke design and enables key building components to be combined with several predefined ways, thereby driving value through high-productivity construction. We noted that some steps towards embracing prefabricated products and expediency in approvals have been taken with the adoption of a pre-accepted MiC systems/components list which is available on BD's website.

One of the challenges associated with the development of the library is Hong Kong's relatively small market size. Because of this, the digital library can be more successful by leveraging the emerging supply chain of the Guangdong-Hong Kong-Macau Greater Bay Area (GBA). The GBA is estimated to generate over HKD110 billion added value of construction, more than 300 relevant enterprises, more than 100,000 practitioners, and 2.5 million m^2 of production capacity of prefabricated components.

We are cognisant of issues that would relate to difference in standards across the boundary; as such, opportunities should be sought to harmonise the standards of prefabricated elements commonly used in the GBA with standards accepted in Hong Kong.

In response to the challenges associated with prefabrication for Hong Kong's smaller domestic market, the CIC is leading an initiative to help the industry connect to the wider GBA MiC/MiMEP supply chain by developing an 'e-business directory'. This directory will be on a digital exchange platform and serve as a central library for collecting and disseminating information with regard to selected MiC and MiMEP products in the GBA. Such an initiative can form an important element of a future digital library.

There are different levels of DfMA products, and suitable application in off-site construction can facilitate innovative design and advanced construction methods. Generally speaking, off-site construction application of DfMA can be categorised into four levels. The outcomes of these four levels can be summarised as follows:

Level of DfMA Application	Outcome
Level 1 **(Manufactured elements)** **(廠製元件)**	Relatively labour-intensive and low productivity (e.g., standard-size pipeworks, tiling, building/paving blocks, fittings, etc.)
Level 2 **(Pre-assemble components)** **(預裝部件)**	Moderate improvement in productivity due to reduction of on-site construction works (e.g., pump set, precast facades pre-assembled in factory / off-site yard)
Level 3 **(Multi-trade integrated units)** **(多工合成構件)**	Significant improvement in productivity due to reduction in on-site interfacing works (e.g., MiMEP including MEP ceiling units integrated with A/C, electrical, FS, and lighting systems)
Level 4 **(MiC modules)** **(組裝合成組件)**	Highest project productivity due to minimal on-site construction works (e.g., MiC modules consist of highly completed works of all disciplines including architectural, structural, and MEP)

The outcomes from Level 2 to Level 4 are increasingly productive and innovative, consisting of both standard manufactured elements and non-standard designs.

The proposed digital library could be strategically used to reduce construction costs by allowing for bespoke architectural designs while mass customisation of non-architectural elements are carried out in factories (Arcadis, 2019). These non-architectural elements cover structural and prefabricated MEP, including building services installation modules or sub-assemblies, that require conventional labour-intensive MEP construction processes especially those in the critical part of building construction. MiMEP is proven to improve manpower and time performance by up to 60%, and it can also enhance workplace safety and sustainability standards by reducing

dust and noise pollution and construction waste from rectifications (Building and Construction Authority 2020). Prefabricated MEP components have wide applications for multiple building types as illustrated in Table 6.

Potential Areas of MiMEP Application	Residential	Commercial	Hotel	Office	Industrial	Healthcare	Institutional	Data centre
Prefabricated duct	•	•	•	•	•	•	•	•
Prefabricated horizontal or vertical MEP module, including pipes, cable trays, and ducts	•	•	•	•	•	•		•
Prefabricated riser module	•	•	•	•	•	•	•	•
Prefabricated horizontal module, including ceiling board, duct, pipe lighting, etc.		•				•		•
Prefabricated plant module, including pumps, pipes, valves, pump skid	•	•	•	•	•	•	•	•
Prefabricated MEP module integrated with work platform/catwalk		•	•	•	•	•	•	•

Table 6 - Potential areas of MiMEP application

MiMEP has enjoyed support and successful applications internationally. In Singapore, the BCA supports MiMEP through a number of initiatives and published a guidebook in 2018 on prefabricated MEP to help practitioners understand the benefits and good practices regarding prefabricated MEP systems. The BCA also promotes wider adoption of prefabricated MEP through allocation of additional points for MEP modules under the Buildable Design Appraisal framework, where 65% of such modules are produced off-site (Arcadis, 2019).

From the feedback received through our stakeholder engagement, the industry seems supportive of exploring and incentivising the use of MiMEP in Hong Kong. Some local projects, such as the West Kowloon Government Offices, which adopted MiMEP demonstrated significant efficiency gains (Fong, 2019).

In December 2020, the DEVB issued a circular to promulgate policy and requirements for adoption of BIM technology. Under its roadmap for BIM adoption on government projects, the bureau selected projects to try BIM technology for rebar prefabrication and modular MEP/building services installations (Hong Kong SAR Developmen Bureau, 2020). Leveraging these initiatives, this strategy proposes to further apply the technique to more building types by developing a digital library to strengthen the supply chain of off-site products.

The CIC and The Hong Kong Federation of Electrical and Mechanical Contractors Ltd. held a tradeshow conference on 2 March 2021 and an associated sharing forum on 5 March 2021. The term ‘multi-trade integrated mechanical, electrical, and plumbing’ was coined at the conference. Many speakers presented the implementation and benefits of MiMEP in a wide range of projects, and there was good industry support for the promotion and facilitation of adopting such an approach in Hong Kong’s construction industry.

4.2.1.2 Practical action plan

There are four main enablers to facilitate MiC and MiMEP adoption in Hong Kong:

1. **Development of a MiC and MiMEP digital library**

   The proposed centralised digital library will be `user-driven, comprising project clients, component suppliers, and service providers in the GBA. Leveraging the ongoing development of a MiC e-directory in the CIC’s MiC Resources Centre, the CIC could be the leading party for developing the library. The library is proposed to contain the following components:

   - An e-directory of MiC and MiMEP supply chain
   - Clients’ requirements

- Prefabricated components with standards and specifications, for building and non-building construction.

2. **Identifying products for mass customisation**

   For effective use of resources, care is needed to select MiC and MiMEP products that are likely to be widely used in the building sector to be included in the digital library.

3. **Standardising quality assurance and test requirements**

   Cross-border inspection of common, widely used prefabricated products can be facilitated in the following ways:

   - For products of merit from previous local applications, preparation of a list of such products (and the manufacturers and factories, with the accepted GB Standards (Chinese National Standard) equivalent to local standards) can be considered to streamline the use of these products in local construction contracts. Only periodic checks would be required for the approved products used successfully in local construction contracts
   - As elaborated in strategy AP-1, an e-inspection system can be deployed to digitally enhance the inspection process and reduce the frequency or need for cross-border physical inspection.

4. **Customs**

   Under Article 41 of the Regulations of the People's Republic of China on Import and Export Duties and rules and regulations regarding 'processing trade', there is a provision for refunding import duties collected on goods that enter Mainland China for manufacturing products that will be exported (General Administration of Customs of the People's Republic of China, 2003). In addition, goods that enter the Guangzhou Free Trade Zone can enjoy tariff exemption if not destined for the Mainland market. As such, it could be beneficial to solicit the assistance of the Trade and Industry Department under the Commerce and Economic Development Bureau to assist and lead industry efforts in harmonising customs matters.

Short and medium-term action plans include:

Short Term

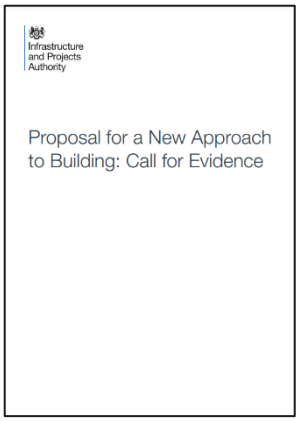
- **CIC** to assess the resources required and cost effectiveness of implementing a digital library and conduct stakeholder engagement to gauge the support of the industry
  - The operating mechanism, as well as the manpower and other resources involved will have to be assessed as part of the study. The library could start small with a collection of suitable MiC and MiMEP products, common clients' requirements, related local standards and specifications, and an e-directory of approved or recognised suppliers.
- Provided that the study and stakeholder engagement yield a positive outcome, the **CIC** can support the development of the proposed digital library by engaging relevant project clients, consultants, contractors, manufacturers/suppliers, and associated trade associations to act as advisors and contributors.
- **CIC** can then oversee the strategy to develop a holistic framework for the MiC and MiMEP digital library. The development plan may include:
  - Identifying products for mass customisation
  - Reviewing and facilitating the use of e-identification (e.g., RFID (Radio Frequency Identification)) and block chain and/or other suitable technologies for ensuring robust product traceability and quality assurance (Koutsogiannis and Berntsen, 2019).

Medium Term

- **CIC** to work with public body clients with major projects to conduct an equivalency study with regional suppliers to identify the high-demand MiC and MiMEP products for admission into the local industry
- **CIC** to support adopting the proposed digital library to further drive the market demand of MiC and MiMEP products
- **CIC** to conduct evaluation of the reception of the proposed digital library in the market. As a recurring requirement, components of similar user needs can be considered for addition into the library

4.2.1.3 Evidence

P-DfMA in the United Kingdom



In the UK, a proposal on P-DfMA implementation was developed by the Infrastructure and Projects Authority (IPA) and the Department for Business, Energy, and Industrial Strategy (BEIS). Backed by a GBP170-million fund in the Construction Sector Deal, the proposal defined three key principles for P-DfMA, including: 1) design for manufacturing (i.e., use a set of standardised components at scale), 2) use a platform approach to maximise the use of standardised components, and 3) open for manufacture, use and procurement to enable a range of firms/clients to design, manufacture and use different components together in a single building.

With the proposal currently in pilot stage, government departments that could adopt P-DfMA across their capital programme in the next few years were identified, including Transport for London's Northern Line Extension and Department of Health and Social Care's 'ProCure 22', a construction procurement framework. To enable P-DfMA in the industry and avoid reliance on a single supplier, research on intelligence properties information and accessible platforms is also being conducted. IPA and BEIS will analyse results on a portfolio level to inform the development of P-DfMA strategy for the industry as part of the upcoming spending review.

The scheme successfully progressed from pilot government projects to successful P-DfMA application in commercial projects in the private sector. Efficiency gains were recorded in the Landsec office development in Southwark, a commercial project currently at design stage. The time, cost, and quality improvements include predicted CAPEX reduction of 9.5% against a target of 10% and programme reduction of 13% against a target of 15% (Mann, 2020).

4.2.2 ID-2 Support and promote MiC and MiMEP

4.2.2.1 Description

The Phase 1 Study indicated that the lack of incentives to drive high-productivity construction hindered the implementation and eventual benefits of prefabrication from being fully captured. Additionally, feedback from our stakeholder engagement showed that the primary barriers to wider adoption of modularised construction include the costs associated with the initial set-up, changeover to the manufacturing modes, coordination of different trades for site assembly, as well as adopting BIM from early design stage and conducting early contractor/supplier engagement.

Recognising the lack of incentives and to mitigate the associated challenges, the Government introduced concessionary measures to encourage a wider adoption of MiC and offered financial subsidies under the Construction Innovation and Technology Fund (CITF).

In November 2020, the CIC released two new funding modes under the CITF as incentive for MiC applications. The new funding modes provide subsidies to project consultants for additional costs incurred in adopting MiC technologies and for obtaining in-principle acceptance of MiC systems to the BD's lists of pre-accepted MiC systems/components. These, in addition to the funding modes, provide subsidy to project consultants for employing a specialist MiC consultant and to contractors for the purchase or off-site production of MiC modules, as well as the purchase or rental of MiC-specific construction plant. Table 7 and Table 8 provide additional details on CITF incentives and subsidies, respectively.

To help the industry overcome initial cost barriers associated with adopting MiMEP, consideration should be given to further promote and support MiC and MiMEP adoption through advocacy initiatives and development to educate industry stakeholders and practitioners on how the value-capture of adoption of modularised construction justifies the higher initial capital costs. For instance, to help promote a more positive image of MiC/MiMEP, academic specialists could be invited to appropriate events for knowledge sharing.

Current CITF incentives for project adoption of MiC

Funding model	Co-fund with 70% grant from CITF for costs involved	Financial subsidy for costs involved
Funding ceiling	1) Consultant Support the project consultant in employing specialist MiC consultant: HKD2.5 million per project 2) Contractor Purchase or rental of MiC-specific construction plant: HKD2.5 million per project 3) Contractor Purchase/off-site production of MiC modules: HKD5 million per project	Consultant Support the project consultant in paying for additional costs when implementing MiC project on top of the subsidy for the project consultant to employ specialist MiC consultant: HKD4 million or 15% of the consultancy fee accepted by the client per project, whichever is lower.

Table 7 - CITF funding options for project adoption of MiC

Current CITF subsidy for entry of MiC systems to the Building Department's lists of pre-accepted MiC systems

Funding model	Financial subsidy

Funding ceiling	Consultant
	Support the firm of authorized person (AP) and registered structural engineer (RSE) and architectural and engineering consultant firms for costs incurred in its application for in-principle acceptance of MiC systems to the BD's lists of pre-accepted MiC systems:
	• A funding ceiling of HKD1 million per application
	• An extra subsidy of HKD200,000 for each tier of more complex MiC design
	  ○ 1st tier: MiC for buildings of 6–10 storeys, entitling to HKD400,000
	  ○ 2nd tier: MiC for buildings of 11–29 storeys, entitling to HKD600,000
	  ○ 3rd tier: MiC for buildings of 30 storeys or above, entitling to HKD800,000

Table 8 - CITF funding options for entry of MiC systems to the Buildings Department's lists of pre-accepted MiC systems

In Singapore, a combination of the Buildable Design Appraisal System and Constructability Appraisal System is in place to provide a quantitative measurement tool for site labour and productivity performance in the building design. The Buildable Design Appraisal System assigns a score for appraising building components comprising the structural system, wall system, and DfMA technologies. During its initial introduction, the appraisal included a GFA concession of 3% as an incentive for the industry to participate in the scheme, which was withdrawn when the system achieved full implementation across the industry.

In Hong Kong, in addition to support and advocacy initiatives, measuring and benchmarking the level of MiC and MiMEP adoption at an industry level is an important step towards the future development of key performance indicators that can drive MiC and MiMEP adoption in the industry.

4.2.2.2 Practical action plan

Short Term

- **CIC** to continue to assess the productivity impact of MiC and MiMEP adoption in building projects
  - We acknowledge that DEVB commissioned the Centre for Innovation in Construction and Infrastructure Development of The University of Hong Kong to study the performance of two high-rise MiC pilot projects and assess the benefits of this innovative construction method to Hong Kong. The findings of this study could be used to support a proposal to introduce an appropriate assessment mechanism for different types of public sector and private sector projects.
- Based on available data, **CIC** to encourage and drive the further implementation of MiC and MiMEP in the industry

Medium Term

- **CIC** to collaborate with the industry to develop an assessment mechanism to further drive MiC and MiMEP adoption

4.2.2.3 Evidence

Experiences in Singapore and the UK provide a strong case for promulgating DfMA/MiC through incentivising its application. Both governments have successfully driven the supply and demand of resources for off-site construction by introducing a series of policy incentives aimed at both public and private projects as outlined below:

Singapore: a systematic approach

Singapore's Building and Construction Authority outlined a road map in 2016 to promulgate DfMA applications in both public and private sectors.

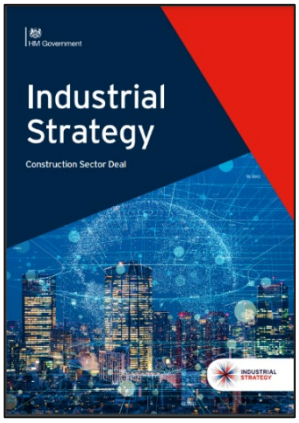
To push forward a wider adoption of DfMA, the public sector has taken the lead in the following:

- Raising the weighting of productivity components in public sector tender assessments to 20% for consultancy services and 10% for construction services.
- Forming a productivity gateway framework as a structural framework to enable public agencies to develop their own productivity roadmaps in line with national productivity targets.
- Establishing a SGD150-million Public Sector Construction Productivity Fund to fund the cost premium for implementing innovative technologies in government projects.
- Imposing conditions on adoption of productive technologies under Government Land Sales (GLS) and industrial GLS programmes, PPVC and steel requirements for instance, and concept and price tender approach to give tenderers the flexibility of proposing any productivity innovation that best suit a site to achieve required outcomes.
- Provision of supply-side incentives by setting aside land to develop integrated construction and prefabrication hubs to support local DfMA production.

While efforts to promote DfMA adoption are still ongoing, Singapore has seen an 8% increase in DfMA adoption rate from 2019 to 2020 (Building and Construction Authority, 2017). Through GLS, the number of construction sites adopting PPVC increased from 15 in 2017 to 32 in May 2019.

The holistic systematic approach of the BCA provides a reference for Hong Kong to drive the supply and demand for DfMA in both public and private sectors.

The UK: driving commercialisation of ideas through competitions



The Industrial Strategy Challenge Fund was introduced to support the industry in adopting modern construction processes and techniques that can deliver built assets 50% faster and 33% cheaper and with 50% less lifetime carbon emissions and improved life-long performance. UK Research and Innovation (UKRI) invested GBP172 million into the fund, which is matched by GBP250 million from industry (Pitts, 2018). As part of this fund, a series of R&D projects encouraging cross-sector collaboration are introduced periodically. An example of which is the 'Increase productivity, performance, quality in UK Construction" competition.

The said competition was introduced in July 2018 to call for projects that design and manage buildings through digitally enabled performance management; construct quality buildings using a manufactured approach; and power buildings with active energy components. UKRI set out the competition eligibility, scope, and application information online, calling for projects from UK-based businesses, academic organisations, charity, public sector organisations, and research and technology organisations. The competition closed in September 2018, with demonstrator projects beginning in December 2018 for 12 to 24 months (Innovate UK, 2018).

Twenty-three projects were awarded a sum of GBP12.5 million in fund investment. A number of funded projects, including 'Standardisation of school components' and 'Advanced industrialised methods for the construction of homes' demonstrated 25% cost reduction and 30% reduction in programme time (Winder, 2019).

The competition provides a good reference for Hong Kong to incentivise commercialisation of ideas that could result in time, cost, and quality improvements.

Adoption of MiC in hospitals and healthcare facilities

The COVID-19 pandemic necessitated a rapid increase in medical facilities' capacity. This accelerated the application of MiC in such facilities. For instance, the Huoshenshan Hospital, an emergency hospital in Wuhan, was built in 10 days by the local government through the use of MiC in response to the severe outbreak of COVID-19 in Wuhan (China State Construction Engineering Corporation, 2020).

In 2022, the fifth wave of the COVID-19 pandemic in Hong Kong sparked a dramatic surge in the number of severe cases and isolation orders, overwhelming the healthcare system and causing hospitals to run out of beds. To alleviate the pressure on the medical system, the Government built the Tsing Yi COVID-19 isolation centre, sometimes referred to as a mobile cabin hospital, which provided 3,900 beds for those diagnosed with COVID-19 and those who were asymptomatic or had mild symptoms. Through the use of MiC, this hospital was completed in only seven days. Each of the standard wards holds three beds, and there are shared bathroom and toilet facilities at the location.

In addition to emergency hospitals and isolation facilities, MiC can also be adopted across a range of healthcare facilities, from pharmacies, clinical laboratories, and operating rooms to emergency rooms and diagnosis areas. With flexible modular design, the room systems can be configured and adapted in diverse ways with a range of room systems and building services, allowing them to be modified to suit the individual requirements of the customers and users with regard to the room size, design, and equipment.

For instance, operating rooms, which are among the most demanding and complex areas of a hospital, are usually equipped with electricity, video and data lines, medical gases and sometimes special ventilation systems. All these requirements can be considered during the modular design process. Furthermore, in the case of intensive care units, the spatial design and equipment differ from standard hospital wards to meet the particular requirements involved in caring for seriously ill people. For these areas, which are usually downstream from operating theatres, modular design solutions include all the components required for the room systems, including room-high glass fronts and sliding doors and a wide range of solutions such as ceiling-mounted hoist systems, healing light installations, furniture and room management systems (HT Group, n.d.).

By transferring on-site construction processes to a controlled factory environment, a variety of MiC modules can be substantially completed off-site, such as residences, hospitals, hotels, schools, and data centres. Ongoing efforts have been made by the Government to demonstrate MiC technology and its multiple benefits.

Local Benchmark: Construction Innovation and Technology Fund

Established in 2018, the HKD1-billion CITF was designed to incentivise the wider adoption of innovative construction technologies and methods and build up the capacity of industry practitioners in the construction industry.

The funding scope of the CITF includes technology adoption and manpower development. Under technology adoption, applications are open to projects adopting BIM, advanced construction technologies, MiC with funding opportunities for co-funding, and financial subsidies capped at a ceiling (Construction Industry Council, 2020).

From the feedback of stakeholder engagement, the funding mechanism for MiC is believed to be a valuable reference model for incentivising other selected forms of DfMA. Details of the funding model can be found in Table 7 and Table 8 in Section 4.2.2.1.

4.2.3 ID-3 Build up industry's capability on MiC and MiMEP

4.2.3.1 Description

To support the development of the MiC and MiMEP digital library (see details in ID-1), we propose to expand the MiC Resources Centre with technical experts to build up the industry's capabilities for advanced construction technologies and methods associated with high-productivity construction. We believe that this development would be most successful through the expansion of available resources and offerings under the already existing MiC Resources Centre. This way, duplication would be avoided, and the development would benefit under the umbrella of the existing platform.

The primary objective of the proposed strategy is to provide a nexus for dialogue between regulators, supply chain, industry experts, and projects teams on both technical and non-technical aspects of major and long-term development projects, such as the Lok Ma Chau Loop of Hong Kong-Shenzhen Innovation and Technology Park, public housing, and government facilities. Moreover, the proposed strategy also aims to showcase and promote the products and design solutions of MiC and MiMEP that were successfully adopted in major projects.

The Centre can additionally support training and apprenticeships for capability development on industrialised construction. Training can be offered through module-based programmes, targeting university graduates, prospective professionals, and managers. Apprenticeships can be offered through partnerships with major academic/research institutes and professional bodies. The resources of the Centre can include access to technical experts.

Funding may be required for the proposed expanded services and resources of the Centre. The Centre can run on a tier-based membership system. Members of higher tiers will pay higher fees while enjoying access to wider range of services. Figure 13 illustrates the general composition of the expanded MiC Resources Centre.

The expanded Centre will lead a shift of mind set among practitioners, hence promulgating the adoption of MiMEP and enhancing the time, cost, and quality performance, safety, and productivity of projects adopting MiMEP, by providing the following services:

- Expanding the currently available technical expertise and knowledge on the online MiC Resources Centre with specific focus on MiC and MiMEP
- Sharing expert resources to facilitate adoption of high productivity construction, with particular focus on MiC and MiMEP
- Providing a platform for technical consultation, particularly related to MiC and MiMEP, such as operation and maintenance, design and construction methodologies
- Providing module-based training programmes and apprenticeships to enhance the industry's readiness for MiC and MiMEP
- Publishing guidebooks or reference materials for the adoption of MiC and MiMEP applications.

MEMBERSHIP MODEL

The expanded Centre is proposed to run on a tier-based membership system with Tier 1 (higher fee) having access to wider range of services:

Tier 1 **$$$** Access to:
- Technical consultation platform
- Expert resources
- Training/apprenticeships
- Research outputs

Tier 2 **$$** Some access to:
- Technical consultation platform
- Expert resources
- Training/apprenticeships

Tier 3 **$** Access to:
- Training/apprenticeships

COMPOSITION OF EXCELLENCE CENTRE

The expanded Centre is proposed to be composed with the following MiC and MiMEP technical experts who would be responsible for delivering the Centre's key services:
- Factory and advanced production operations experts
- Structural engineer
- Digital engineering expert
- Manufacturing engineering expert
- Assembly engineering expert
- Cost engineering expert
- Traffic engineer
- Road regulator

TRAINING AND APPRENTICESHIPS

The expanded Centre is proposed to provide training and apprenticeships to enhance industry capacity on MiC and MiMEP applications. Training can be offered through module-based programmes at a competitive market price, targeting university students, prospective technicians and managers. Apprenticeship can be offered through partnerships with major academic institutions and professional bodies.

Figure 13 - Operational model, charging mechanisms and service offerings of the expanded MiC resources centre

4.2.3.2 Practical action plan

Short Term

- **CIC** to expand the MiC Resources Centre's services to the industry (rather than its physical capacity) by providing the latest MiC and MiMEP technology training programmes and other services to facilitate adoption of MiC and MiMEP (as listed in Section 4.2.3.1).
    - The expansion plan should include identifying industry experts, professional organisations, and academia/research institutes to support the development of the operating model and help develop the right mix of expertise for Hong Kong by building a network of international strategic partnerships.
- **CIC** to identify funding requirements and examine the membership model option

Medium Term

- **CIC** to undertake ongoing reviews of the operation of the Centre and assess performance data to measure success against pre-defined criteria, including membership take-up, number of technical documents issued, apprenticeships, training sessions delivered, and resources engaged on projects.

4.2.3.3 Evidence

Examples on how the UK and Singapore implemented standard to support DfMA are illustrated below.

Manufacturing Technology Centre in the UK

Manufacturing Technology Centre (MTC) is part of a larger network of sector innovation centres. It is an independent research and technology organisation with more than 700 employees and an advanced R&D facility. It aims to provide integrated manufacturing system solutions and help companies in improving manufacturing productivity by partnering with industry and academia.

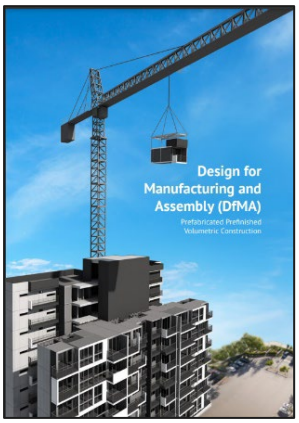
MTC helps enterprises deliver cutting-edge manufacturing solutions by offering the following services:

- **Technical solutions.** MTC applies its technical expertise, experience, and cutting-edge technologies and provide clients with manufacturing system solutions to mitigate customer challenges, particularly in areas of component manufacturing systems, assembly systems, and data systems.
- **SME support.** MTC offers expert know-how, including toolkits, methodologies, and transferable best practices to help SMEs best achieve their desired results. MTC also provides 'full day review/line walk' services to manufacturer where a consultant from MTC engages with the client to conduct a full business review.
- Other services include manufacturing support, product manufacturing incubator, capability explorer, apprenticeships, and online training courses.

Since its establishment in 2010, MTC has served hundreds of companies across various industries, of which more than 100 have become members. Clients observed significant cost savings, 45% reduction in man-hours, and improved turnovers (Manufacturing Technology Centre, n.d.).

By providing expertise knowledge and technologies, MTC facilitated the introduction of new manufacturing solutions with a number of impactful examples in the UK. A similar centre can be set up in Hong Kong by concentrating industry expertise to provide GBA-wide support on issues regarding lean construction manufacturing.

Singapore's guidebooks on design for manufacturing assembly



With DfMA identified as a key strategic direction to enhance the construction productivity in Singapore, the BCA (2019) developed a series of guidebook on DfMA technologies, of which the first instalment focused on PPVC. This guidebook provides practical guidelines and good practices on how PPVC is designed, fabricated, inspected, delivered, and installed to achieve functional requirements and workmanship standards. Example of contents covered are PPVC considerations and key factors, design considerations, and list of related regulations.

Together with other initiatives since 2017, the guidebook is underpinned by the Construction Industry Transformation Map (CITM) to drive the adoption of DfMA in construction projects by 2020 to 40% (Singapore Building and Construction Authority, 2020). A working committee composed of technical agencies and industry representatives was engaged for the guidebook's development. Another technical committee, including members from industry associations and practitioners, was formed to review the contents.

Since the launch of initiatives listed in the CITM in 2017, the Singapore's construction industry has seen a steady increase in DfMA adoption rate, from 22% in 2018 to over 30% in 2019 and is likely to achieve the 40% target by the end of 2020. The industry has also seen an increase in the adoption of DfMA in construction projects between 2019 and 2020. Out of 71 DfMA construction tenders expected during this period, 45 tenders, or more than 60%, exceeded SGD85 million.

4.2.4 ID-4 Improve contract terms to promote wider adoption of MiC and MiMEP

4.2.4.1 Description

Feedback from the stakeholder engagement suggested that contracts frequently used in construction can inadvertently discourage prefabrication and the advent of high-productivity construction. In particular, main contractors, especially small and medium enterprises, can face cash-flow challenges as interim payment mechanisms for off-site fabrication are frequently not in place. The issue is more pronounced in the private sector, and the Hong Kong Government is aware of this problem.

For the public sector, it is now a standing policy to make interim payment for off-site fabrication in public works contracts involving major off-site fabrication works as a measure to enhance contractors' cashflow. The application of these measures is not universal to all prefabrication of all value, as Appendix 5.55 of the PAHCEW 2020 defines criteria for the adoption of SCC on interim payments for off-site prefabrication, such as minimum value of items, maintenance of bonds and others. Moreover, beyond interim payments for prefabrication there are additional considerations that can be examined in contracts, such as bonds and insurances, liabilities, off-site storage, and resolution planning.

There is an opportunity to look at transferring some of the learnings from the above standing policy to contracts in the private sector. The CIC is also cognisant of the challenge and is currently undertaking a consultancy study on MiC procurement which, in part, aims to assess current regulations, government policies, and procurement practices of E&M Works in Hong Kong. The intention is to identify barriers and opportunities for improvements to enhance productivity through MiMEP adoption.

Taking stock of these past and current initiatives, we propose a further review to improve contractual provisions and payment mechanisms for prefabrication in the private sector focused on MiC and MiMEP. This will involve setting up a review programme of existing contract provisions, associated guidelines, technical circulars, and practice notes, and identifying possible amendments to better support off-site construction. To facilitate off-site payment schedules and approvals of off-site payments, a wider and formal application of e-inspections can be considered as an enabler as detailed in AP-1. Such a review could also potentially consider whether there is value to be captured by modifying the criteria in the aforementioned Appendix 5.55 of the PAHCEW 2020. Examples could be the potential waiving of some criteria or relaxation of others, e.g., minimum value of single type of off-site prefabrication items.

By providing clear guidelines for the implementation of MiC/MiMEP within current or revised contract provisions, the industry can better support the overall adoption of off-site fabrication and better contracts to this goal.

4.2.4.2 Practical action plan

A structured review of contract conditions in different forms of contract, including new engineering contract (NEC) and general conditions of contract (GCC), can be considered. Whilst private sector clients customise clauses based on project scale and type, the advantages of contractual revisions relevant to high-productivity construction could be promoted to them through different communication channels, such as professional bodies and trade associations. Feedback from the stakeholder engagement suggests contract terms in the following areas should be examined:

Considerations for review of contractual terms

Payment mechanisms	• Value of the items • Trigger mechanisms for the payment • Mechanisms and responsible party for the 'establishment cost'
Warranties and insurances	• Application of bond warranties and insurances • Potential for damage during off-site storage and transport
Ownership of items [5]	• Liability for the materials once delivered to site (loss or damage) • Liability for the correct and defect free assembly of components
Storage off-site	• Contract clauses pertaining to storage yard • Safety obligations • Inspection and testing obligations • The party responsible for security • The party responsible for inspection • The party responsible for handling and maintaining off-site materials
Resolution planning	• Legal rights in the event that the contractor becomes insolvent, especially when the items are constructed in a different legal jurisdiction • Imposition of penalties for late completion of fabrication or loss of items

Table 9 - List of items for contractual review

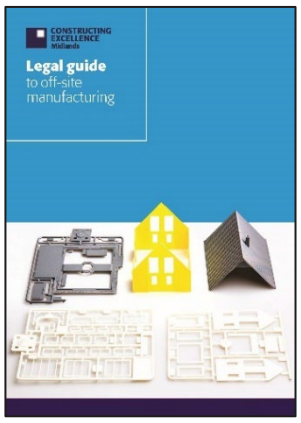
Short Term

- **CIC** to establish a working group comprising industry experts to oversee a study, including undertaking industry-wide consultation and structured review of existing contract types (e.g., design-bid-build and design-and-build contracts), to identify revisions to specific contract clauses that could be beneficial to private sector projects with off-site prefabrication. The scope of the study should include the list of considerations in Table 9 above.
- **CIC** to engage with the relevant contract owners (i.e., for NEC 4, the respective contract board, and drafting team) and legal professionals to develop a range of recommendations to the existing contract clauses that could support wider adoption of MiC/MiMEP through a more equitable sharing of risk across the supply chain
    - CIC should draw references from DEVB's practices in public project to develop some terms for the private sector.
- **Working group** to review the impact of contract revisions on pilot projects in private sector and to consider a rollout on suitable projects in the private sector.
- **CIC** to prepare guidance notes and industry best practice communications to assist private sector projects adopt the contract recommendations
- **CIC** to identify and facilitate appropriate communication channels (e.g., professional bodies and trade associations) to provide suggestions around improving contract terms for high-productivity construction to private sector clients and service providers.

4.2.4.3 Evidence

UK Constructing Excellence legal guide to off-site manufacturing

[5] 'Ownership of items' concerns the shift of ownerships, obligations and liabilities throughout the project life cycle.



A guide was published by Constructing Excellence South West's technologies and procurement groups (2019) to provide recommendations in regard to legal perspectives for off-site manufacturing processes in the construction industry. The guide highlights the legal considerations for a number of attributes in regard to off-site manufacturing including procurement, contracts, off-site rules, and dispute management.

This guide provides a good reference for Hong Kong to explore means to further enable off-site manufacturing.

4.3 Driving innovation

The role of innovation as a driving force behind economies is well documented globally. With specific reference to the construction industry there are a large volume of publications that emphasise this fact. Some examples include *Construction 2.0: Time to change* (Hong Kong SAR Development Bureau, 2018), *Priority sector report: construction industry* (European Commission, 2019), *Reinventing construction through a productivity revolution* (Barbosa et al., 2017), *Future-ready index* (KPMG, 2019)*, Reinventing innovation: five findings to guide strategy through execution* (Staack and Cole, 2017), and *Procuring for value* (Construction Leadership Council, 2018). In addition, as Hong Kong gears up for carbon neutrality before 2050, the importance of technological development in driving greater efficiency and decarbonisation has been a key topic in the local industry. Examples are *Hong Kong's Climate Action Plan 2030+* (Environment Bureau, 2017), *Hong Kong's connected future: Building a smarter and greener city* (KPMG, 2022), and *Towards a Better Hong Kong: Pathways to Net Zero Carbon Emissions by 2050* (Civic Exchange, 2020).

A 2019 report published by Our Hong Kong Foundation suggested that innovation can boost Hong Kong's growth as long as the city increases its innovation capabilities through new science and technological initiatives. The report also identified some blockers to the funding process, such as a lack of efficiency and flexibility in funding (Tsui, Lun, & Cheung, 2015). This is aligned, to an extent, with the findings of the *Phase 1 Report*, which identified the enhancement of innovation in Hong Kong construction as an important factor in the improvement of time, cost, and quality performance in the industry. According to the report, novel solutions can reduce reliance on traditional labour-intensive construction and mitigate bottlenecks caused by a lack of skilled labour and professionals while improving the quality of the construction product. Similarly, a report entitled *Building for a better future – vision 2030 for the Hong Kong construction industry* developed for the CIC recognised the value of innovation in construction and observes that the industry lacks incentives to introduce fresh ideas, while it identified that the cycle of developing, prototyping, and commercialising inventive solutions lags behind the construction sectors in some other advanced economies[6].

To summarise the above, the main challenges associated with innovation in the Hong Kong construction sector include:

- Inefficient knowledge on innovation and its benefits
- A lack of client effort towards innovation adoption
- Uncertainty around approvals and time required for accepting new materials or design approaches/methodologies
- Limited incentives for the private sector to invest in new technologies
- A lack of incentives for adopting innovations in projects
- A shortage of knowledge-sharing mechanisms and fragmented available information
- A lack of procurement-related innovation incentives
- Intellectual property rights issues.

In this report, we propose two types of strategies for responding to these challenges. Specifically,

Strategies to incentivise and shorten the cycle from R&D to prototyping to commercialisation

Beyond the application of existing solutions, we developed propositions for strategies aimed at mobilising the knowledge base and creativity of the Hong Kong construction industry with the intention of enhancing the local innovation output. We developed these strategies by drawing on successful regional and global experiences that demonstrably enhanced the application of R&D in the construction cycle and led to the commercialisation of new solutions that have added measurable efficiency to the industry.

Strategies for encouraging the adoption of innovation in procurement

The driving factors for promoting innovation include how to procure construction works in better and more efficient ways. In 2014, the DEVB issued DEVB TC(W) No. 4/2014 for the public sector to set out tender evaluation

[6] The report indicated that the Hong Kong construction industry currently lacks an industry-wide research agenda that prioritises R&D areas with the opportunity to improve its competitiveness and productivity, while centralised construction research institutes and programmes are established in other economies, including Korea Institute of Construction Technology Education, South Korea; Institute for Research in Construction, Canada; European Network of Construction Companies for Research and Development, EU; European Construction Institute, the UK; and Construction Industry Institute and National Science Foundation, the US (p. 112, McKinsey and Company, 2016).

methods for works and term contracts (excluding design, build, and operate contracts) which do not involve prequalification of tenderers, including formula approach and marking scheme approach. In particular, the standard marking scheme was revised to place more emphasis on the contract-specific attributes than the corporate-general attributes of tenderers to enhance competition in the technical quality of tenders that spans safety, innovation and creativity, productivity, and constructability. Innovation and technology will play a more significant role in the coming public works projects by gradually increasing the importance of technological content in works contracts.

For the private sector, apart from the commercialisation of innovative solutions, we provided strategies that help assess and measure innovation performance and fundamentally drive increased new and innovative ideas from stakeholders in private procurement processes.

The following sections provide details on each of the strategies in response to the benefits and challenges stated above, with support from data, feedback from stakeholders, and benchmarking. Table 10 illustrates the time, cost, and quality impact of each strategy in this section:

STRATEGY	TIME	COST	QUALITY
I-1 **Establish a Construction Innovation Platform (CIP)**	The CIP will shorten the cycle of innovation from R&D to prototyping to commercialisation.	N/A	N/A
	The CIP will facilitate more innovative solutions to be developed and applied to address time, cost, and quality issues.		
I-2 **Generate Eco-system for Innovation through Tendering**	The proposed mechanism is believed to be one of the potential measures in encourging development and implementation of innovative methods and technologies that can improve time, cost, and quality and achieve additional value for the project.		

Table 10 - Time, cost, and quality impact of high-priority driving innovation strategies

4.3.1 I-1 Establish a construction innovation platform

4.3.1.1 Description

While commonly characterised by lagging productivity growth and slow innovation, the construction industry is undergoing a critical transformation driven by the introduction of advanced technologies, greater attention to environmental sustainability, and energy efficiency. This transformation towards a smarter and greener construction industry requires new collaboration along and across value chains, the integration of multiple sectors and service suppliers, and massive R&D investments (European Commission, 2019).

The Hong Kong Government continues to increase its R&D expenditure[7]. Between 2000 and 2018, the expenditure has risen from HKD6.2 billion to HKD24.4 billion (refer to Figure 41 in Appendix D). However, Hong Kong ranked 34th globally in terms of R&D expenditure which amounted to 0.86% of the GDP compared to a 2.4% average for OECD countries (refer to Figure 42 in Appendix D) (World Bank, 2018; OECD, 2018). Benchmarked against a selection of other developed economies, including Japan, Singapore, and the UK, Hong Kong needs to catch up (refer to Figure 43 in Appendix D). In the Government's Five-Year Plan (2017-2022), the R&D expenditure of Hong Kong would be doubled from 0.73% to 1.5% of its GDP indicating the local authority's determination to improve the productivity and efficiency of the economy (Tsui, Lun, & Cheung, 2015). As a key pillar of Hong Kong's economy, the construction industry represented 4.1% of its GDP, delivering HKD112 billion in 2019 (Census and Statistics Department, 2020). Under the impact of the government policy, the R&D expenditure in the construction industry is expected to reach HKD1.68 billion (HKD112 billion*1.5%) in 2022.

In the private sector, a recent study by McKinsey suggested that the COVID-19 crisis accelerated radical changes expected in the construction value chain in the next five to 10 years. The signs of change include a 77% increase

[7] R&D expenditure refers to the gross domestic expenditure on R&D (GERD). According to the OECD, GERD is defined as the total in-house expenditure on R&D performed in a national territory during a given period. R&D activities are 'creative work undertaken on a systematic basis in order to increase the stock of human knowledge and to devise new applications based upon it' (OECD n.d.). The GERD index provides a comprehensive measure of R&D activities carried out by all resident firms, research institutes, academic bodies, government laboratories, etc. within a country or region.

in R&D spending among the major 2,500 construction firms globally since 2013 (Maria J. R. et al., 2020). Although the private construction firms have raised R&D investment in areas like modularisation, digitalisation, and new materials, the private sector is in need of guidance from policymakers to identify and agree the research agenda and investment priorities that will bring the most value to Hong Kong (McKinsey and Company, 2016).

To respond to the challenges, this strategy suggests to set up a construction innovation platform which will bring construction enterprises together and work collaboratively with academic and research institutes and solution providers to explore innovative solutions for the local industry. This systematic approach shall facilitate innovative ideas, promote R&D programmes, streamline test-bedding processes, and establish a flexible funding mechanism. As a result, the platform will stimulate more significant involvement of both the public and private sectors in R&D investment and introduce better materials, more cost-effective design and construction methods, and labour-saving equipment to the industry. Ultimately, it will increase the R&D expenditure in the construction industry to deliver value.

In general, the CIP will be a B2B and B2R (research) platform that operates within the Hong Kong construction industry, convening and aligning companies and key stakeholders around a shared and aspiring innovation agenda.

The four core features of the platform are:

- Membership-based digital platform
- Multiple project types
- Test bedding
- Intellectual properties marketplace

Membership-based digital platform

For innovations to be practical, there is a need to ensure that new technologies and capabilities are efficiently shared and adopted by industry players. The platform will convene members who will work collaboratively and derive value in different ways:

- **Client members** represent a customer voice that will provide challenges and clarity on what innovative solutions they want and need. This shall lead to collaboration through or across the supply chain. Examples of client members are government departments, quasi-government corporations/public bodies, and influential developers. In Hong Kong, examples of quasi-government corporations/public bodies include AAHK, MTR Corporation, Hong Kong Jockey Club, Hong Kong Convention and Exhibition Centre, etc.
- **Supply chain members** could engage with a centralised client voice and other solution providers that drives improved time, cost, and quality. This will facilitate a more confident adoption of innovation methodologies and materials. Supply chain members comprise major consultant and contractor firms.
- Other supply chain companies (e.g., SMEs) and relevant companies (e.g., technology start-ups and solution providers) in the community can obtain more industry exposure by providing them access to the 'market' and potential to further scale solutions and opportunities.

Beyond the client and supply chain, the platform will invite participants including

- **CIC committees** who will provide strategy guidance to the platform and explore innovations that will be conducive to the long-term development of the construction industry.
- **Universities and research institutes in Hong Kong, the Greater Bay Area, and elsewhere** that will serve as strategic partners, assist in identifying unsolicited ideas and innovations and technologies with potential to be applied in the local environment, and conduct necessary R&D activities to validate their feasibility and benefits.

As a membership-based community, the CIP will also provide a digital platform that is committed to activating collaboration to leverage innovative ideas from the industry into practice. The portal shall gather business needs of client members and theme-based challenges raised by CIC committees and invite innovative ideas and technology suggestions from supply chain members to address different construction design and delivery challenges. The CIP panel will gather proposals from both sides and review if the proposal is appropriate to be uploaded onto the platform. Subsequently, the panel will play a matchmaking role to promote practical applications, field trials, or necessary R&D on development of technology for industry application and proof-of-concept.

In addition to the digital platform, the CIP will hold physical discussions and forums to facilitate knowledge and best practice exchange, showcase global technologies, unlock innovation hidden in the supply chain, and

ultimately, provide positive impacts and business growth via dissemination of knowledge and best practices and publication of reference materials, such as model specifications.

Figure 14 demonstrates the CIP structure and innovation ecosystem.

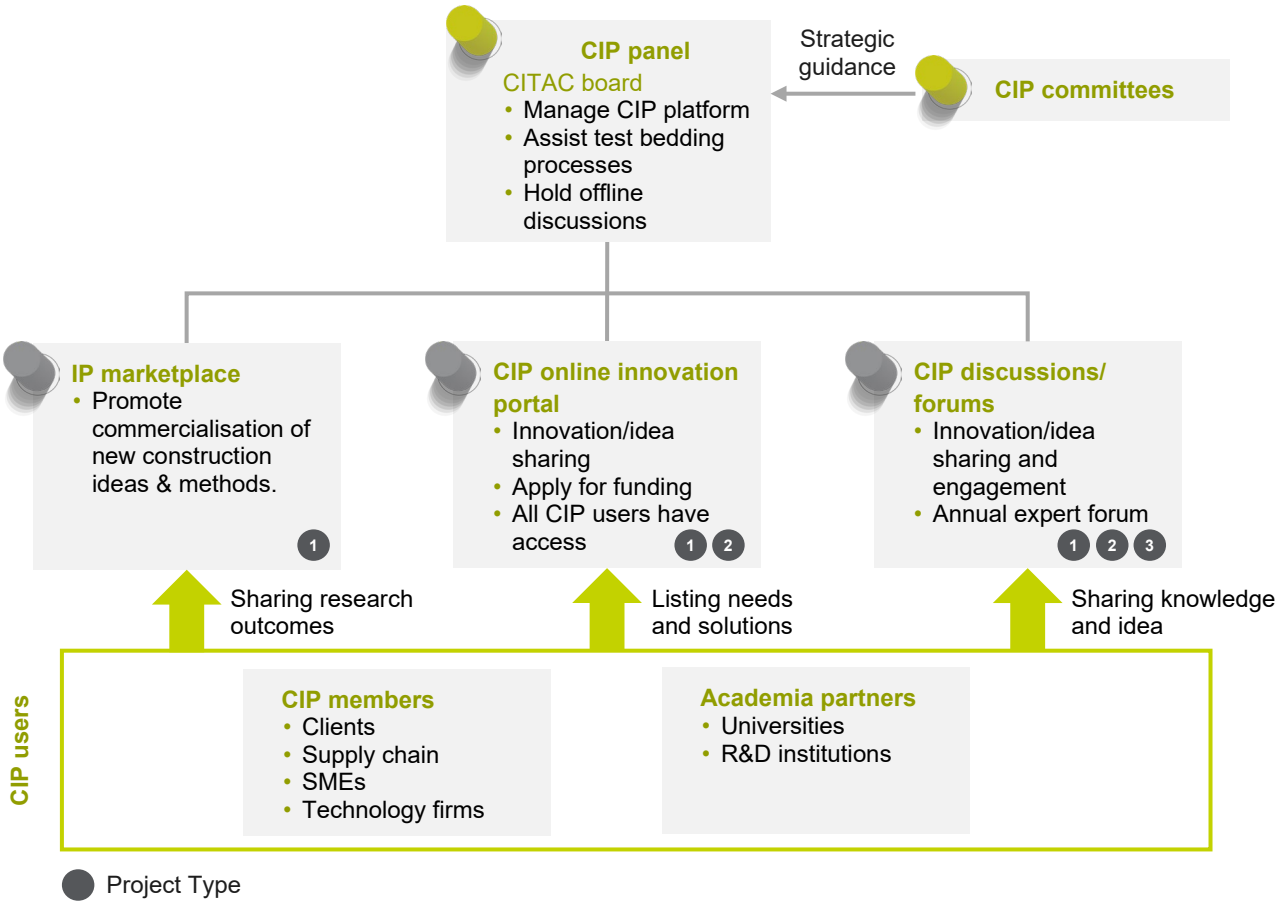


Figure 14 - Construction innovation platform structure

Multiple project types

There are three types of innovation projects which will be promoted in the platform.

1. **Applied research projects** will aim to address **specific issues or challenges raised by client members** for their current or upcoming construction or infrastructure project. Fellow members can subsequently review, discuss, and provide solutions to these issues and challenges.

   For proposals that are successfully matched and ready for deployment, the client member will hire the supplier for their project or purchase/license in the patents through the IP marketplace of the CIP (see the section on the IP marketplace below).

2. To solve **broader industry challenges** currently faced in the local built environment, the CIP panel will identify and prioritise topics and areas with the most potential to benefit the Hong Kong construction industry. The CIP panel could work collaboratively with relevant CIC committees and boards to spearhead the development of new concepts and initiatives by launching a HKD10 million two-year theme-based research. The fund can be derived from CIC's existing funding schemes (R&D Fund) or a new fund launched by the Government. The CIP members will submit proposals to address the challenges, and the project would involve multiple parties who contribute to the project collectively to produce results that benefit the overall industry.

   Depending on the applicability and readiness of the proposal, the proposal may be connected with government projects for pilot trials or academia/research institutes or solution providers for further R&D on the development of technology for industry application and proof-of-concept. The R&D could seek financial support from the private sector (the CIP consortium), CIC funding schemes (R&D Fund), other government R&D funding schemes (Innovation and Technology Fund), or new fund. Depending on the contributing parties and collaboration level, the research benefits and outcomes (IP rights) shall be shared through the IP marketplace (see the section on the IP marketplace below).

3 The CIP panel will continuously explore and identify **new construction innovations and methods/technologies approved/proven for use overseas**. The panel shall host an annual forum for CIP members to present findings and chair open discussions. The forum will review innovative construction technologies, materials, or methodologies that are suitable for use in Hong Kong.

For solutions beyond local codes and standards, the panel will facilitate proof-of-concept and field trials in public works projects (see details in the test bedding section). The innovations and methods/technologies viewed with potential long-term industry value can seek funding from the Construction Innovation and Technology Fund (CITF) for wider adoption.

The project types are demonstrated in Figure 15:

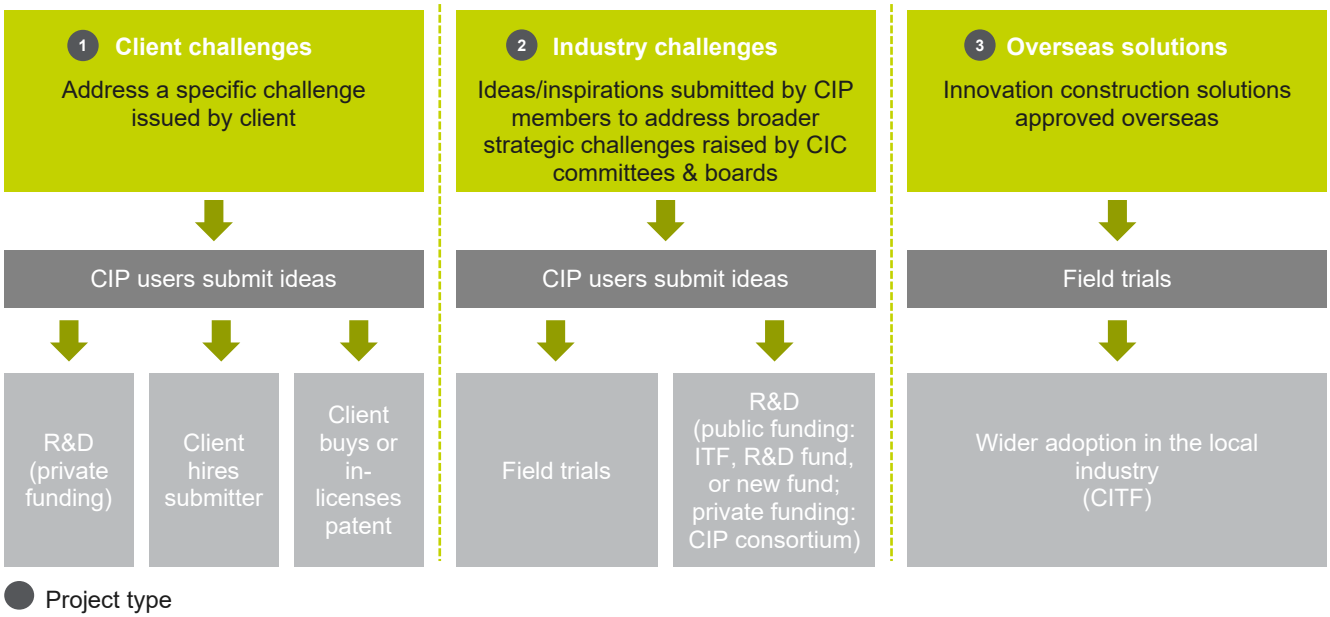


Figure 15 - CIP project types

Test bedding

The CIP Panel shall also act as a one-stop shop to assist members with the overall process of pilot projects from innovation initiation to test bedding, as well as with liaising with government agencies for assistance. We note that the wide adoption of useful new technology needs to be enabled by updating policy, specification and/or regulation, or practice notes. Therefore, the relevant government policy bureaux and regulatory bodies shall be included and engaged in the CIP ecosystem to facilitate endorsement and the needed updates.

For oversight, the CIP panel shall evaluate the proposals before applying for test-bedding to ensure a proposal can meet industry needs with high positive impact, is ready for wide adoption, and is likely to meet local regulations. The evaluation criteria should be based on the proposal's benefits for the built environment (i.e., contribution towards achieving liveability and sustainability) and how it can improve current construction processes (e.g., reduce time overrun with programme certainty; save cost; reduce construction waste; nuisance and traffic impact; and improve safety, productivity, and design and built quality).

Intellectual property marketplace

In order to foster a truly collaborative culture of innovation across members, the platform shall be equipped with an intellectual property (IP) marketplace to promote the commercialisation of new construction ideas and methods, ultimately leading to incentivised contributions from members. As an online display window, CIP members could post their patents up for sale or for out-licensing, search for IP rights to buy or in-license, or look for R&D partners for innovation projects that build on patentable knowledge.

With respect to innovations that are fostered in the platform, depending on the type of project and collaboration level, there are three proposed models for how the IP of innovations is owned and managed (Egner 2016).

- For a **one-to-one project** (i.e., developed by a single member), the company owns all generated IP
- For **government-backed collaborative R&D projects**, IP ownership will be determined by the partnership.
- For **collaborative R&D projects funded by members**, CIP will have full ownership of the IP, while the members will be given free licensing rights for a limited time.

In response to the challenges associated with introducing new ideas into the Hong Kong construction sector, CIP will be committed to shortening the cycle of innovation from R&D and prototyping through to commercialisation. Emphasising collaboration, CIP's mission will be the transformation of industry performance and the delivery of improved productivity and growth and smarter infrastructure to the local built environment. In conclusion, the platform calls for a holistic view that accounts for stakeholders from both public and private sectors along with the industry value chain. In preparation, policymakers will need to embrace such complexities and provide sustainable support to the industry.

4.3.1.2 Practical action plan

As one of the CIC's innovation initiatives, the Construction Innovation and Technology Application Centre (CITAC) was established to explore and identify innovative techniques and technologies, both local and internationally, that are suitable to the Hong Kong construction industry for the improvement of its productivity, sustainability, and safety. Another item in CITAC's terms of reference is to establish a global research network and serve as a collaborative platform to encourage interdisciplinary research activities and collaboration. To facilitate CITAC's work, the CIC set up an interactive and membership-based platform known as i-Club.

As an interactive and membership-based platform, i-Club's membership ranges from individuals to organisations, covering a diverse spectrum of construction business activities. This membership structure provides excellent opportunities for knowledge sharing and collaboration, and many of CITAC's functions are designed for this purpose. For instance, CITAC organises i-Club members networking events and CPD events (e.g., conferences, seminars, and webinars), and provides a range of services (e.g., newsletters, e-library, forums, etc.) to keep members informed, inspired, and connected. Overall, CITAC and i-Club have laid the foundation for a collaborative space that enables industry stakeholders to identify areas for potential improvement, exchange ideas, and co-create innovative solutions. Specifically, the members of i-Club could provide a membership base for the CIP community.

Based on the above discussions, the short- and medium-term action plans are proposed below.

Short Term

- **CIC/CITAC** to lead the development of a collaboration platform framework with reference to the E&M InnoPortal and the Smart Government Innovation LAB. We recommend a feasibility study, particularly with reference to the IP ownership models.
- **CIC/CITAC** to form a CIP community to be built up on i-Club's existing membership
- **CIC/CITAC** to formalise a membership model that will increase member engagement and retention. The operation of the platform could be supported by:
    - CIC funding,
    - Suitable research funding
    - A subscription business model.
- **CIC** to raise interest in industry stakeholders to participate in the platform by addressing the benefits of the platform (i.e., test-bedding and IP marketplace)
- **CIC** to sign memoranda of understanding with universities and research institutes to establish strategic partnerships
- **CIC** to appoint a panel for the platform and officially launch the platform for operation

Medium Term

- **CIC** to collaborate with the private sector to conduct trials in low-risk sections of works in pilot projects for users to accept innovations, technologies, and new materials. Reference may be made to the Task Force on Applied R&D in Public Works Projects established by the DEVB, with representatives from Works Departments for steering applied R&D towards better performance in public works projects
- **CIC/CITAC** to recruit members on an ongoing basis.

4.3.1.3 Evidence

The Infrastructure Industry Innovation Partnership (i3P) in the UK, Built Environment Technology Alliance (BETA) in Singapore, and InnoPortal (E&M) and Smart Government Innovation Lab (IT) in Hong Kong provide strong cases that demonstrate the significance of innovation collaboration in the construction industry.

Infrastructure Industry Innovation Platform by the UK Government

As one of the initiatives funded by the Industrial Strategy Challenge Fund (ISCF), Infrastructure Industry Innovation Platform (i3P) is an independent membership-based community that aims to accelerate innovation to address major challenges faced by the industry (Knowledge Transfer Network, n.d.). Through i3P projects and programmes, strong linkages formed between the UK construction sector and the government lead to mutually supportive relationships that ensure full alignment between the private and the public sectors' needs.

Originally, i3P started as Innovate18, Crossrail's innovation programme which ran from 2012 to 2017. Crossrail is a major infrastructure project developing an east-west railway line across London and its region. The project involves numerous contractors and consultants working over a dozen construction sites. Such context makes it challenging to adopt a top-down approach to promote innovation. Hence Innovate18 was initiated to allow contractors/consultants of Crossrail to submit innovation ideas that solve a specific problem within their role on the project. As a result, the Innovate18 portal received more than 800 innovations covering a broad range of problems from simple time saving tips to alternative new ways of executing a specific task of the works. The *Crossrail innovation programme – innovation evaluation report* (Vernet, 2016) developed for Innovate18 estimated the total economic benefits of the innovations, ranging from GBP2.7 million to GBP5.4 million. Apart from monetary returns, the study showed that there are intangible benefits, such as efficiency, improved collaboration, welfare, and health and safety. For instance, the programme not only encouraged an innovation and collaboration culture but also created a paradigm shift in the mindset of organisation members towards a systematic problem-solving approach through critical thinking.

Crossrail's Innovate18, which witnessed participants invest their money in shared interest matched by Crossrail to provide seed funding for innovative ideas, has now evolved into a new scheme, i3P. The success of Innovate18 shows that people are central to innovation, and this legacy has been taken forward through i3P.

Figure 16 shows that i3P members include clients (major infrastructure projects and construction programmes) and their supply chains (tier 1 contractors and consultants). The membership fee of i3P is GBP25,000 per client and GBP15,000 per contractor and consultant. The aggregate amount of the membership fee and the project investment is up to GBP1 billion a year. Supported by an online innovation portal that is accessible by all member organisations' staff, i3P creates a trusted collaborative space and a 'toolkit' for sharing industry expertise and innovative ideas.

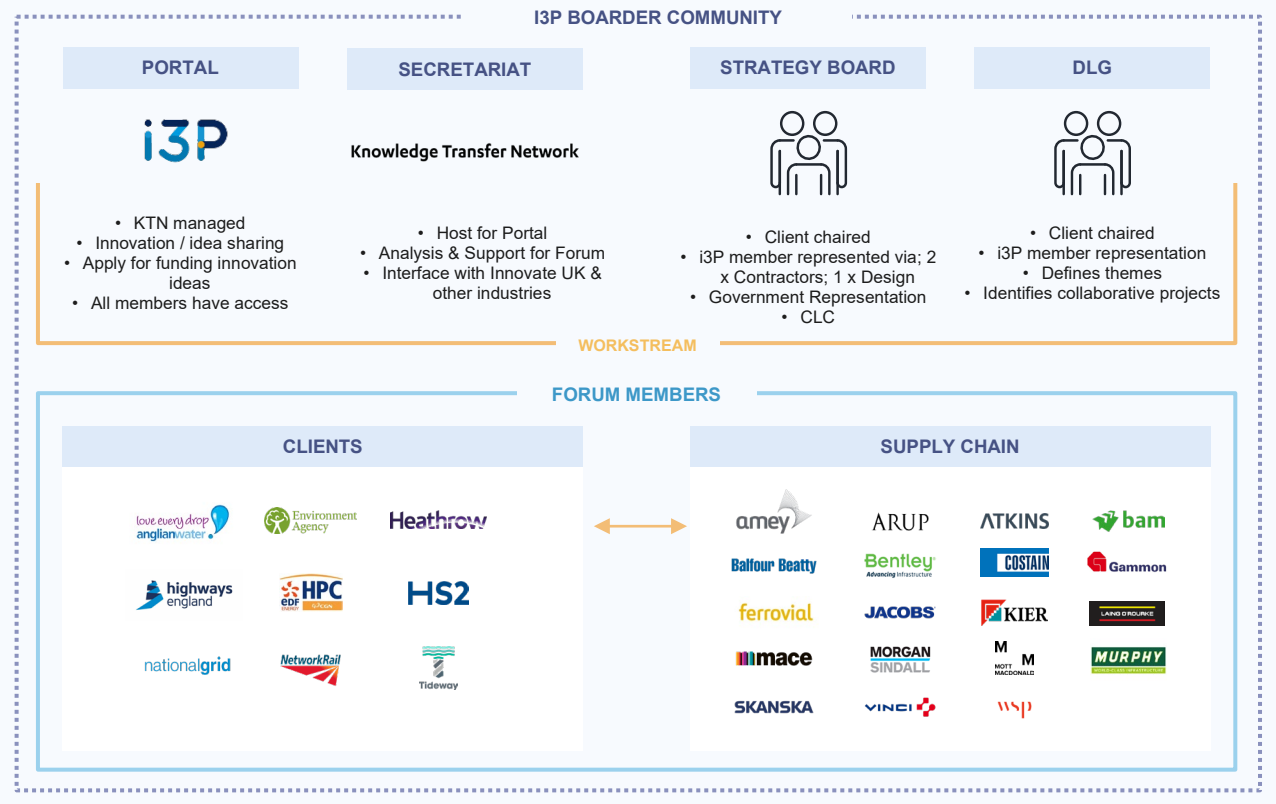


Figure 16 - i3P structure and list of members

Within the i3P community, there are three types of projects.

- **Discovery projects** are launched to realise strategic targets set by the UK Government under its Construction 2025 strategy and the three strategic themes formulated by the Construction Sector Deal (Manufacturing Technology Centre, n.d.). The Manufacturing Technology Centre (MTC) is appointed to work with i3P to select and review opportunities related to specific technology work packages and technical strands through surveys and exchange of best practice information between i3P members. The outcome of the discovery projects is a technology road map for the sector as shown in Figure 17.

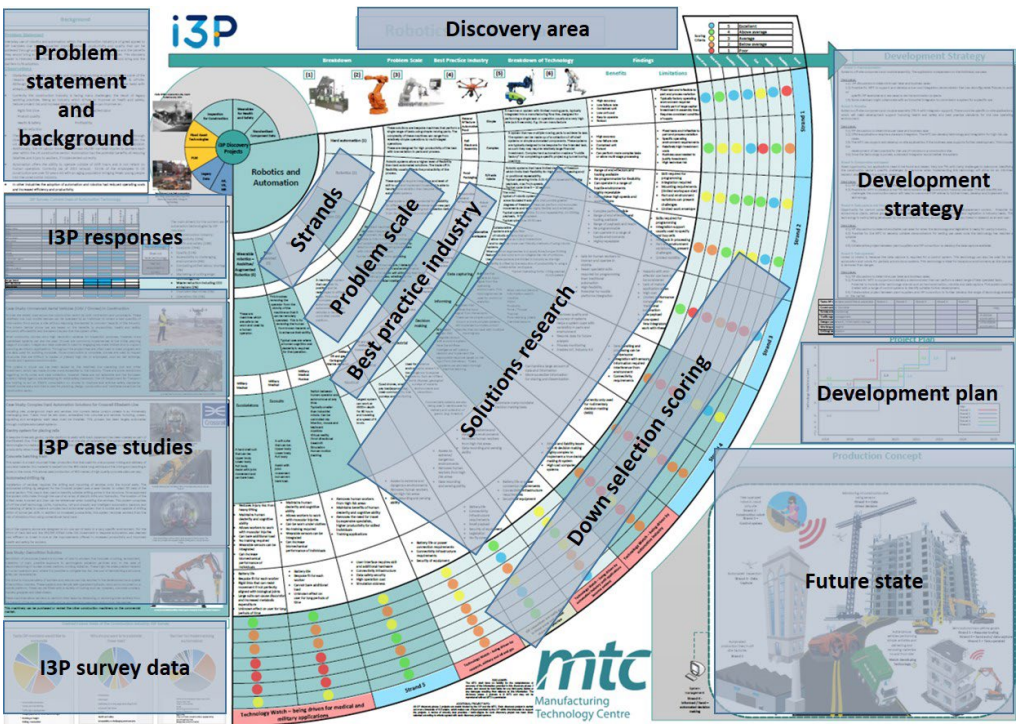


Figure 17 - MTC discovery project poster template

- Members of i3P, by initiating **impact projects**, can ask for solutions from supply chain members who can provide applied research to address specific challenges encountered in infrastructure projects. The results of the research will have an immediate impact either through the direct application of a technology or practice and can possibly influence the regulations and standards applied to that original challenge area.
- **Spark project** could be related to any topic with industry-wide relevance and will usually address broader thematic challenges or elements. Spark projects must be collaborative in nature and involve two or more i3P members or non-i3P parties. Three spark projects are selected annually by members through a competition with an award of GBP100,000 of seed corn investment sponsored by i3P members.

As of today, i3P has partnered with 10 client organisations and 19 tier 1 consultants/contractors. The i3P engagement has facilitated 492 conversations, inspired 160 ideas, and brought 893 innovations to the industry. Beyond that, i3P participated in the first round of Industrial Strategy Challenge Fund's Transforming Construction competition, and its members gained funding for 8 of the 23 projects.

Based on the discussion above, reference can be made to the source of funding and operations of the platform to inform the development of a similar knowledge-sharing platform in Hong Kong.

Built Environment Technology Alliance in Singapore

In September 2020, the Built Environment Living Laboratory Framework (BE LLF) was initiated by the BCA and Minister of National Development (MND) with the intention of opening up opportunities for built environment firms to harness and apply emerging construction technologies along with urban development (Built Environment Technology Alliance, 2020). Through this new initiative, companies in the built environment and technology sectors will be able to gain access to living laboratories (e.g., designated areas within certain projects) to test their innovations and receive assistance from agencies to ensure a smooth roll-out.

To implement this, the Built Environment Technology Alliance (BETA) was set up by the BCA and the National Research Foundation, with support from the Agency for Science, Technology and Research, JTC (Jurong Town Corporation), and Housing & Development Board. BETA carries out two functions:

First, BETA acts as a secretariat to serve as a focal point for all firms in Singapore who submit innovative test-bedding proposals. BETA will link them up with relevant government agencies and living projects for a trial test. As a result, firms will receive support from local regulatory agencies (i.e., temporary regulatory waivers) to test out their promising innovative solutions that could benefit the built environment.

Second, BETA serves as a research and innovation platform that is only open to its members to facilitate collaborative works, drive idea-sharing and R&D activities, derive knowledge of domain experts, and transform knowledge to business value. Members can access national laboratories, test-bedding facilities, and R&D equipment at a favourable price.

Within this exclusive membership community, BETA firms can engage in two categories of projects:

- **Core projects** are three projects selected by BETA members by voting. The IP rights of core project are owned by BETA and can be adopted by all BETA members.
- **Member specific/joint projects** are projects that build up members' specific capabilities and whose IPs are owned by the contributing parties.

The BETA member structure, including fees and annual commitment in research and innovation, is illustrated in Figure 18.

Members of BETA enjoy certain benefits as illustrated in Figure 19.

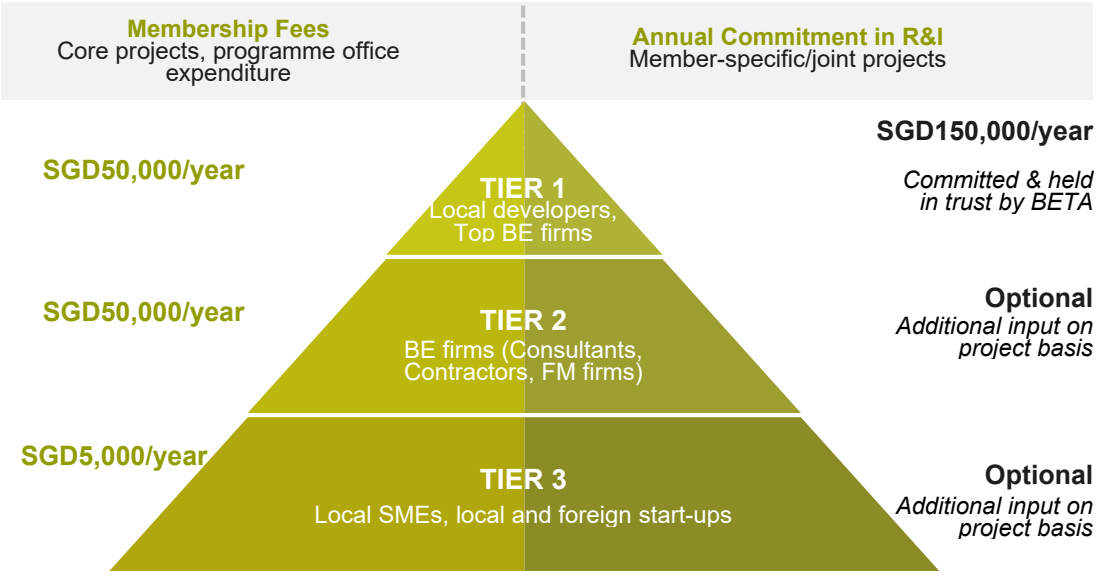


Figure 18 - BETA member structure

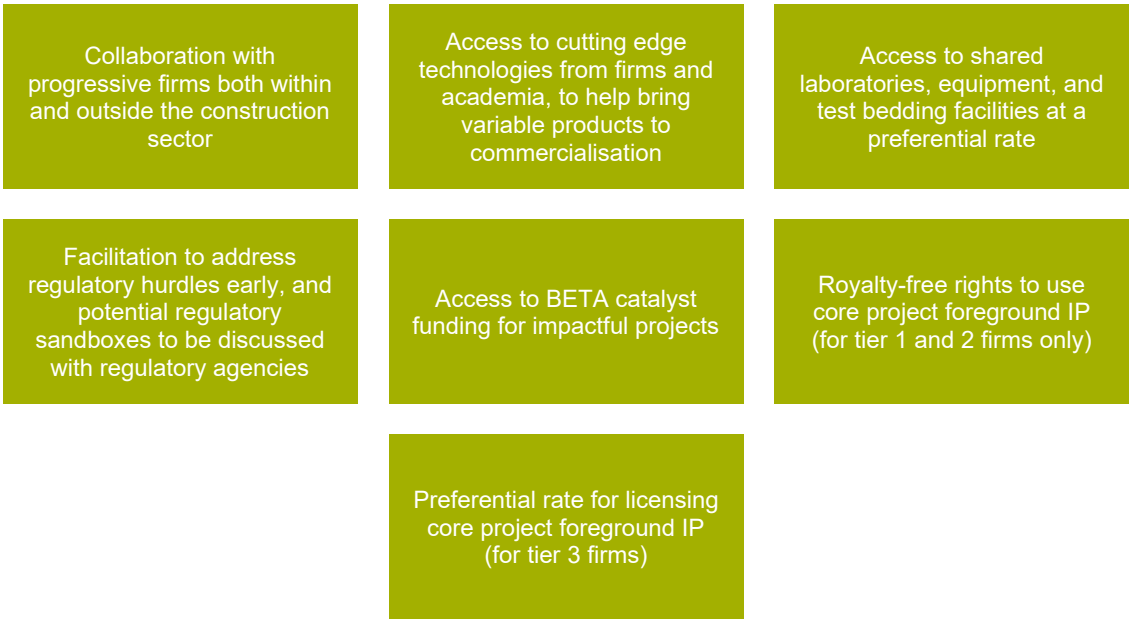


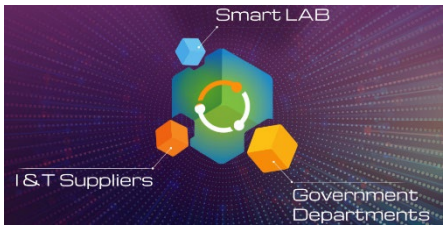
Figure 199 - BETA member benefits

To date, 15 private firms consisting of developers, builders and consultants have expressed their interest in BETA. The two roles of BETA, IP right ownership mechanisms, and membership fee policy can be referenced to set up and operate the Construction Innovation Platform.

E&M InnoPortal and Smart Government Innovation LAB

In Hong Kong, the E&M InnoPortal was launched in 2018 by the Electrical and Mechanical Services Department (EMSD) to match technological challenges of government departments and public organisations with R&D results from start-ups, SMEs, and academia to enhance service quality in public works projects through innovative solutions.

As of January 2020, the platform has matched over 50 cases involving a total estimated project sum of HKD35 million (Au, 2020). Until November 2020, the platform has collected 320+ innovation and technology (I&T) challenges and 600+ I&T solutions. Drawing from the challenges and solutions matched, EMSD has carried out more than 100 trial projects with a significantly larger project spending expected (Hong Kong SAR Electrical and Mechanical Services Department, 2018).



One year after the establishment of the E&M InnoPortal, the Office of the Government Chief Information Officer launched the Smart Government Innovation Lab to connect government departments with the information technology (IT) sector, including local start-ups and SMEs. With the objective of 'connect, inspire, co-create', the platform aims to connect service needs of government departments with the service/product suggestions of the industry to identify solutions for enhancing public service delivery. The matched I&T solutions are tested to enable departments to have a better understanding of their effectiveness and limitations. The Smart LAB located in Cyberport exhibits solutions that have undergone or are undergoing proof-of-concept. Examples include smart sensing technology and geographic information services for monitoring tree stability, video analytics for monitoring traffic conditions, etc.

4.3.2 I-2 Generate ecosystem for innovation through tendering

4.3.2.1 Description

This strategy is designed to promote and encourage the adoption of innovative solutions in private construction projects by making use of a mechanism in construction contracts that would allow clients to pay for innovative technology solutions not stipulated in the contract but can be proposed at various times during the execution of the contract by consultants or contractors. Such a mechanism would allow for the acceptance of proposals and payment for the implementation of innovative technology solutions in situations where the client and provider can agree that a proposed innovative technology solution will convey benefits.

The concept is modelled after the CIC Safety Incentive Payment Scheme. The critical difference is that this proposed tendering mechanism can remain agnostic in terms of what the innovative technology solutions will be. The payment for such solutions will be determined by outcome-based KPIs that can be included in the contract and are related to time, cost, quality, productivity, sustainability, and/or safety performance. It will be the responsibility of the proposer to demonstrate to the client that the innovative technology solution will meet KPIs associated to payments, and the acceptance of the estimate will be subject to the client's approval.

Another incentive could be considered as part of the same mechanism, i.e., the addition of a gain-share mechanism that can be demonstrated to be a result of an innovative technology solutions at pre-defined milestones in the project.

Feedback from the stakeholder engagement suggests that there is currently a lack of motivation for project teams (designers and contractors) to implement innovation and technology proposed in the tender stage, and the proposed tendering mechanism could provide a better motive.

As briefly outlined above, such a mechanism would suggest that the value of adoption of construction innovation and technology should be assessed by a set of outcome-based KPIs with pre-defined baseline and measurement methods, including improvements in construction time and cost and quality of the materials, methods or processes, safety, sustainability, and/or life cycle performance. For instance, the KPIs can be associated with (Hong Kong SAR Development Bureau, 2020):

- Reducing life cycle costs
- Reducing construction period
- Reducing labour intensity
- Reducing reliance on skilled labour especially at peaks of labour demand
- Reducing injury and accident occurrence on construction site
- Reducing design changes during construction and rework on-site
- Reducing nuisance to neighbourhoods such as noise, dust, vibration, and traffic impact.

Examples of innovative technology-related items could include those not explicitly specified under the contract (Hong Kong SAR Development Bureau, 2020):

- BIM uses not mandated under the contract
- Robotic/autonomous systems
- Advanced materials (e.g., low-carbon footprint materials, self-healing materials, and carbon-capturing materials)

- Application of virtual reality/augmented reality
- Predictive analytics for monitoring site safety or streamlining construction and maintenance works
- Application of internet of things (IoT) and sensor technologies.

The abovementioned items are not intended to be exhaustive. Considerations could be given to any other items of similar nature. It is important to note that the intent of the strategy does not involve subsidy of technologies under the scope of the CITF or other government funding schemes.

This proposed strategy will provide an incentive mechanism for consultants and contractors to consider and offer the use of innovative methods/technologies (e.g., BIM, off-site fabrication, advanced technologies, etc.) that can reduce the time and costs associated with abortive work caused by traditional methods and/or improvements to the project value needed by clients. Innovations that add value will no longer be perceived by clients as introducing risk. Employers can review the proposal and accept an innovation proposal in project delivery only when it is deemed beneficial. Consequently, the strategy shall create the tendency for consultancies and contracts to be awarded to the best value instead of the lowest price, which will leverage consultants' and contractors' offerings accordingly.

4.3.2.2 Practical action plan

The following action plans are recommended to develop this value-added feature for the existing procurement models in Hong Kong.

Short Term

- **CIC** to conduct a study to explore the potential benefits of applying the proposed tendering mechanism in the private sector, and identify appropriate measurement methods for quantifying the value of innovative solutions in building projects
- **CIC** to review of existing contract provisions and recommend ways to promote the adoption of innovative technology solutions in private construction contracts, and reward the effort of service providers and achievement of KPIs useful for the project in the private sector
- **CIC** to identify trials beginning with small-scale and less complex sections of works in suitable private works projects.
    - The construction contracts shall require the contractor to consider the use of innovative technologies to achieve improvements in construction time, cost, quality, safety, productivity, and sustainability. The clauses of the CIC Safety Incentive Payment Scheme could be modified to meet the objectives of 'pay for innovation'.
- **CIC** to review the trial scheme involving selected pilot projects in the private sector. This will include the use of an innovative technology checklist (a list of outcome-based KPIs that are able to quantify and measure) to check the performance and certify the payment. We recognise that developing a baseline from which to measure performance can be challenging, so it needs to be an essential part of the review.
    - The checklist shall include a list of outcome-based KPIs that are able to measure performance improvement, such as percentage increase in productivity of the industry average, and percentage reduction in the number of reportable accidents of industry average including no serious accidents.
    - The pay-for-innovation scheme shall aim to develop quantitative performance measurement metrics to allow the consultant or contractor to obtain task- and performance-based payments pre-agreed by the project client prior to the commencement of proposed works in the private sector.

Examples of adoption of innovation and technology

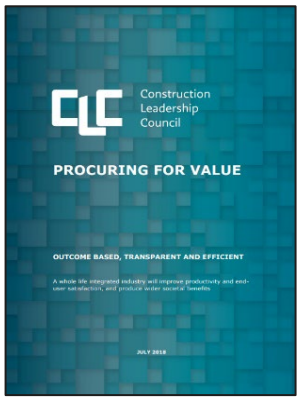
- **Smart infrastructure** could provide higher quality infrastructure information systems that enhance decision-making, speed up project delivery, reduce costs, and improve user experience.
- **Novade Digital Site Supervision System,** through the utilisation of big data, can improve site operation management, stakeholder communication, and collaboration.
- **Converge's system of concrete strength sensors** is equipped with wireless and cloud-based technologies to monitor real-time concrete temperature. It could enable earlier removal of formwork/falsework and stressing of prestressed tendons, which enhances construction productivity.

Medium Term

- **CIC** to conduct a review of the contract provisions adopted (including types of payment, KPIs, and IP rights) for the trial scheme and prepare guidance notes for the private sector.
- **CIC** to promulgate the wider use of the scheme, provided that the scheme demonstrates tangible benefits to the private sector.

4.3.2.3 Evidence

Procuring for Value by the Construction Innovation Hub



Following the publication of the *Construction sector deal* (Great Britain Department of Business, Energy and Industrial Strategy, 2017), *After Carillion: Public sector outsourcing and contracting* (House of Commons Public Administration and Constitutional Affairs Committee, 2018), and *The Farmer review of the UK construction labour model* (Farmer, 2016), *Procuring for value* (Construction Leadership Council, 2018) was published by the Construction Leadership Council (CLC) in July 2018.

The report made recommendations for leveraging the significance of the sector deal and setting up a sustainable business model for the industry (Construction Innovation Hub, 2020). It suggested the development of an industry-wide definition of 'value' that goes beyond capital investment and allows procurement on the basis of whole-life value and performance. The report also put forward potential solutions for 'procuring for value'; for instance, standardisation of the pre-qualification process means to measure performance, the revision of retentions, and new forms of contracts. As a whole, the report set out a fundamental strand of government policy and outlined the best practices for the construction sector.

In the wake of the *Procuring for value* report, the Construction Innovation Hub (CIH) recognised that projects can fail to deliver the intended value even if they are delivered on time and budget. CIH stated that the definition and measuring of value should go beyond the construction phase of projects, allowing consideration for a broader range of metrics beyond financial cost. To address that, Royal Institution of Chartered Surveyors, Royal Institute of British Architects, Chartered Institute of Building and Social Value UK have worked directly with the CIH to develop a new industry-wide definition of value, taking into account wider social, economic, and environmental factors across the whole investment lifecycle (Construction Innovation Hub, 2020). Figure 20 shows the examples of project value. Instead of having a narrow focus on financial cost, four additional ingredients (i.e., natural, social, human, and manufactured) are proposed to be added to the scoring equation.

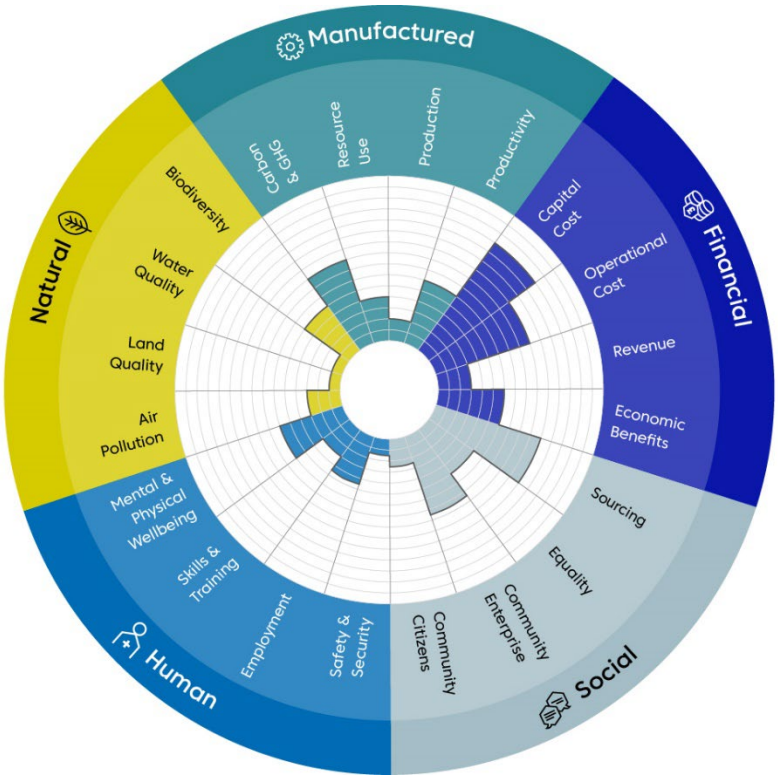


Figure 20 - Example project value profile

To achieve the intended value, the CIH proposed an approach that better reflects strategic policy objectives and meets the expectation of clients, users, and operators. The approach was developed as the Value Toolkit that ensures faster value-based decision-making throughout all stages of the project life cycle — from business case through procurement and delivery and into operation. The toolkit, which has four modules, is summarised in Table 11.

VALUE TOOLKIT OVERVIEW *A suite of tools to support faster value-based decision-making across the whole investment lifecycle*				
	MODULE 1 **Value definition**	**MODULE 2** **Delivery model**	**MODULE 3** **Procuring for value**	**MODULE 4** **Ongoing measurement**
Overview	Defining the unique value profile for a given project and creating value indices through which informed decisions can be made	Section of a delivery model and commercial strategy that best meets the value drivers of the project	Helping the market to shape offers and clients to make procurement decisions based on the value drivers of the project	Continuous forecasting and measurement of value performance throughout delivery and operation
Tools	• Value profile • Value indices	• Delivery model selector • Commercial strategy developer	• Procuring for value-bid optimisation • Procuring for value-client evaluation	• Project monitoring • Asset monitoring • Analysis
Aimed to	• Policymakers • Clients • Advisors	• Clients • Advisors • Industry	• Clients • Advisors • Industry	• Clients • Industry • Policymakers

Table 11 - Value toolkit overview

Specifically, Module 3: Procuring for value (PfV) helps the industry make procurement decisions to be made on delivery of best whole-life value. It provides the market with knowledge on understanding how to identify successful bidders based on a set of quantifiable measurements. In this module, 'value' is considered in the procurement process and is labelled as 'outcome', which reinforces the significance of measuring the entire life

cycle of a building. Additionally, this module enables bidders to test their proposals prior to submission and check if the proposals comply with all key-value criteria required for the project.

As a new initiative, PfV reflects the UK Government's commitment to developing a universal methodology for procurement that embraces sustainability and boosts productivity. With the Value Toolkit only being recently issued, it is expected that this suite of tools will encourage the construction industry in the UK to consider innovation and creativity as a key 'value' during procurement. The concept of PfV can be referenced during the development of the pay-for-innovation scheme in Hong Kong. Incorporating innovation and creativity can be introduced as a key-value criterion in the procurement process.

4.4 Streamlining approval processes

A robust framework of building control and statutory legislation is widely acknowledged as a key contributor to Hong Kong's world class infrastructure quality and built environment, as well as upholding high safety and environmental standards. However, the regulatory environment in Hong Kong is complicated and has evolved over time to include multiple departments with different objectives and control regimes — all of which make the process of obtaining the necessary vetting and approvals more challenging.

The *Phase 1 Report* highlighted the industry demand for improved transparency, efficiency, and response/ approval time certainty of the existing approval process. The following areas of opportunities were identified, and suggestions were made during our stakeholder engagement:

- The procedural burden for obtaining approvals from multiple departments requires a significant investment of resources from the project team, and this has held up the overall project delivery programme posing risks to time and cost overruns.
- The need to increase transparency, clarity of acceptance criteria and alignment between various standards and requirements involved in seeking approvals from different departments, which would reduce cost and risk of delay
- Obtaining approvals from various departments (PlanD, LandsD/ District Lands Offices (DLOs), BD, FSD, Civil Engineering and Development Department (CEDD), WSD, Highways Department (HyD), Transport Department (TD), EMSD, EPD (Environmental Protection Department), etc.) across the whole building development process can take a long time. While the Government has set up a joint sub-committee on streamlining development control under the Land and Development Advisory Committee and is taking streamlining actions, it was suggested that more should be done to streamline the procedures faster, clarify the acceptance criteria, and establish a one-stop authority at senior directorate level to resolve multi-department issues and respond in a timely manner
- There are challenges for regulatory departments in handling peaks in submission workload due to fixed staff resources and in vetting specialist and innovative designs and materials. It was suggested to introduce digital technologies to help reduce the manpower resources required for regulatory control work.

The Government acknowledged these challenges and following the Chief Executive's Policy Address in 2017, a steering group on streamlining development control was set up under the Planning and Lands Branch (PLB) of the Development Bureau to streamline the approval process without prejudicing the relevant statutory procedures and technical requirements (Hong Kong SAR Development Bureau, 2019). There are five major objectives:

- Align technical definitions and approval standards
- Remove duplicate control under different regimes
- Enhance transparency and certainty in processing proposals
- Consolidate approval authority and procedures
- Streamline processes and shorten processing time.

To achieve the abovementioned objectives, the steering group promulgated batches of streamlined control measures covering eight topics, including building height restriction; site coverage on greenery; landscape requirements; building separation and building setback in Sustainable Building Design Guidelines; application of design and disposition clause under lease; non-building areas; site coverage restriction; and calculation of gross floor area through the joint practice notes, departments' practice notes, and documents.

In this report, we have identified three key bottlenecks in the existing workflow:

- Limited use of electronic submission and distribution system
- Insufficient BIM tools to facilitate plan preparation and processing
- Insufficient adoption of BIM.

In order to address these bottlenecks, we propose three strategies which aim to improve the existing submission and approval mechanisms through digitalisation, streamlining processes and reducing documentation

requirements, and strengthening communications. The proposed strategies are expected to drive major benefits across the following areas:

- Accelerated approvals which reduce processing time in the project critical path
- Synchronised updates (e.g., using BIM models) to revisions during approval to avoid inconsistency and improve transparency, leading to an overall improvement of project quality
- Reduced time and cost by minimising multiple and repetitive submissions
- Reduced demand on the regulators' staff resources without compromising public safety and health.

In addition, it is suggested that the steering committee on streamlining development control could continue to tap feedback from the industry regularly and examine those processes which cause long delays and concern, and to take prompt action to streamline the regulatory and/or consultation processes, clarify the acceptance criteria, and establish a one-stop authority at senior directorate level to resolve multi-department issues and respond in a timely manner with KPIs on response time.

STRATEGY		TIME	COST	QUALITY
AP-1 **Develop an Integrated Digital Submission and Approval Process**	Encourage and Facilitate Submissions Generated from BIM Models to BD	Will reduce processing time by: • Omitting circulation of hard copy submissions • Enhancing efficiency of overall submission process	N/A	Automated tools for BIM models could effectively screen out major deficiencies, errors, and non-compliance items.
	Develop Automated Design and As-built Checking Tools for Accelerated Approval	• Automated tools could effectively and objectively screen out major deficiencies, errors, and non-compliance items. • Will facilitate approval and reduce processing time		
	Adopt a full E-inspection System	• Will enhance the efficiency of the inspection and approval processes by reducing time for arranging on-site inspections and audits involving a lot of parties • Will improve the efficiency of data collection, analysis, and reporting for contractors	Will save cost and manpower travelling to sites	N/A
	Extend Spatial Data Requirements to the Private Sector	Will reduce time for obtaining the information from scattered sources and resolving conflicts with the stakeholders	N/A	N/A
		Will enhance the predictability of the project programme, which may impact on-time performance and the quality of design and construction work, and offer		

STRATEGY		TIME	COST	QUALITY
		opportunity for exploring cost and time savings and alternative designs or project delivery options		
AP-2 **Extend the List of Minor Works Exempted from BD Design Submission**		Reduce approval time by decreasing the workload of regulatory bodies	N/A	N/A
AP-3 **Assess and Expedite the Efficiency of the Approval Processes**	Review and Streamline Existing Approval for Fast Track Processing	Need regular review to further streamline the approval processes and explore the potential to further reduce the impact of approval time on the project delivery programme	N/A	N/A
	Perform Data-Driven Review of Response Times by Consulted Departments	KPI on response time could provide an objective basis for an increase in the productivity of the approval process.	N/A	N/A
	Improve Communication Amongst BD and Other Regulatory Departments, APSEC and the Industry	Enhanced communication amongst BD and other consulted departments, APSEC, and industry practitioners could increase the overall efficiency and quality of the projects.	N/A	Enhanced communication amongst BD, APSEC, and the industry practitioners could increase the overall efficiency and quality of the projects.

Table 12 - Time, cost, and quality impact of high-priority streamlining approval processes strategies

Table 13 summarises the existing practice on BD submissions with linkage to the proposed strategies.

Existing practice on submissions	Related proposed strategies
AP/RGE/RSE ensures that the number of paper copies and the quality of submissions are sufficient, and the BD circulates to relevant government departments.	AP-1 Develop an integrated Digital Submission and Approval Process AP-2 Extend the List of Minor Works Exempted from BD Design Submission
The BD conducts curtailed checks on fundamental aspects, including health and safety standards and as-built records for building works.	
AP/RGE/RSE is required to apply for consent for commencement of works after obtaining approval from the Building Authority.	
The BD communicates with industry through BSC, APSEC, discussion forum, and discussions and ad-hoc meetings with representatives of relevant professional institutes and building stakeholders.	AP-3 Assess and Expedite the Efficiency of the Approval Processes
Consulted relevant departments	

Table 13 - Proposed strategies in relation to existing practice on submissions

Figure 21 illustrates the current flow of submissions to BD and how the proposed strategies can facilitate the process at different stages.

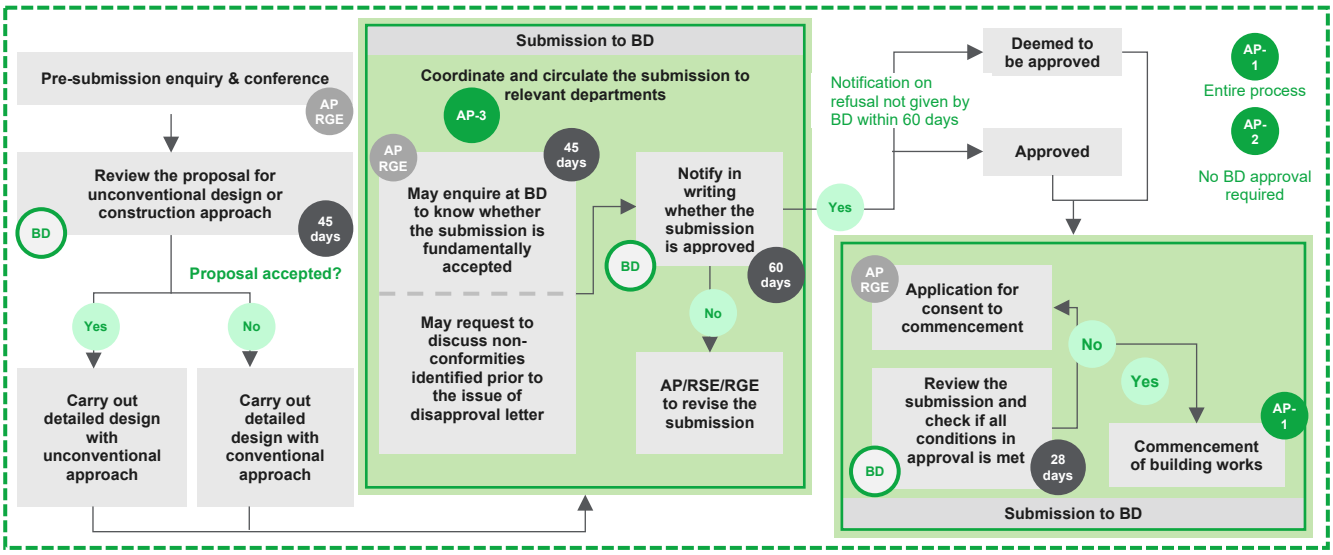


Figure 21 - Approval process and strategy recommendations

Other than BD submissions, there are some submissions that are required to be sent to other government departments for obtaining approval/agreement after getting approval for the general building plan. This can affect the timing for finalisation of the design and preparation of plans for tendering for the building works contracts.

The following sections provide details on each of the strategies in response to the benefits and challenges stated above, with support from data, feedback from stakeholders, and/or benchmarking.

4.4.1 AP-1 Develop an integrated digital submission and approval process

4.4.1.1 Description

The aim of this strategy is to develop an integrated digital submission and approval process by applying digital tools and platforms throughout the whole construction cycle to facilitate and streamline approval processes. We believe there are four initiatives that can synergise to achieve this aim:

- Encourage and facilitate submissions generated from BIM models to BD
- Develop an automated design and as-built checking tools for accelerated approval
- Adopt a full e-inspection system
- Extend spatial data requirements to the private sector.

Figure 22 illustrates key submission and application milestones, which industry stakeholders identified as the ones most likely to be associated with delay. These include 'building plan submission', 'application for consent', and 'application for occupation permit'. The proposed integrated digital submission and approval process, therefore, will mainly target to accelerate these stages, in particular.

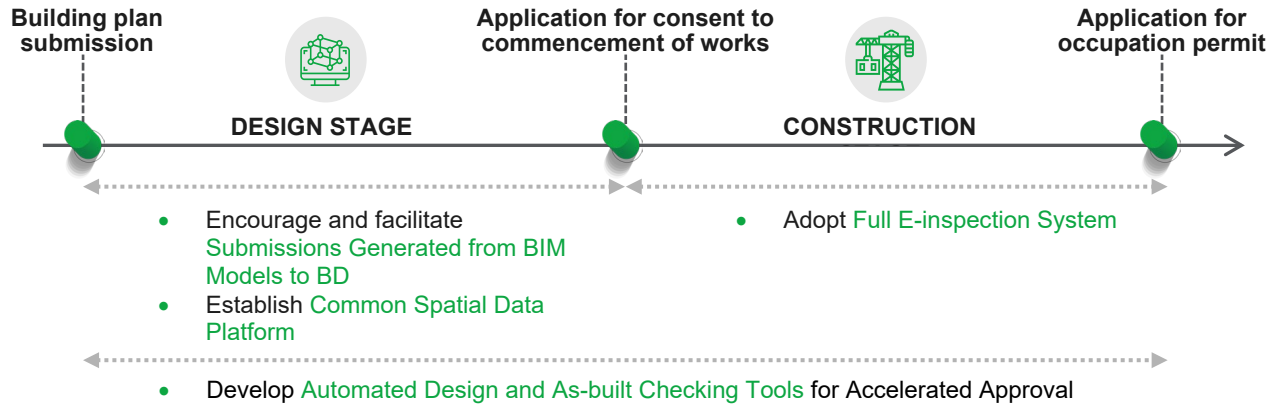


Figure 22 - Application of digital tools and platforms throughout construction cycle

This section attempts to describe the four digital tools, which are listed above, and compose this strategy. This will include current developments and application of such tools, followed by a practical action plan outlining proposed short- and medium-term actions that will consider the intended synergies amongst these tools in combination with the evidence.

I. Encourage and facilitate submissions generated from BIM models to BD

The construction industry globally is continuing to adopt BIM technology on a global scale. Industry reports estimate the market for BIM to be growing at a CAGR (compound annual growth rate) of 14% to 16% (MarketsandMarkets, 2019), and literature suggests that wide BIM adoption can improve productivity, quality, and cost effectiveness, and enhance multi-disciplinary collaboration and decision-making processes in the design, construction, and facility management. Some examples include *The next normal in construction* (Ribeirinho et al., 2020), *Building information modelling (BIM) standardization* (Poljanšek, 2017), and *Future-Ready Index* (KPMG, 2019).

Following a review and discussions with various parties on the current measures to encourage and facilitate more BIM for the public and private sectors, we propose, by way of this strategy, the enhancement of the current measures for submissions generated from BIM models to BD. This will require, a study on the appropriate requirements, uses, project types and sizes, and regulator and industry readiness. Such a study can take stock of the work done by Government and the CIC on the topic since 2017 as outlined in the next few paragraphs.

In Hong Kong, the Government has taken initiatives in driving the uptake in use of BIM. In the 2017 Policy Address, the Chief Executive stated the Government will require the adoption of this modelling technology in major government capital works projects. In 2017, DEVB issued a technical circular, DEVB TC(W) No. 7/2017, to mandate the adoption of BIM for capital works projects with project estimates of more than HKD30 million. In the 2018 to 2019 Budget Speech, the Financial Secretary stated that "starting this year, the Government will adopt

building information modelling technology in the design and construction of major government capital works projects. The CIC will formulate BIM technical standards, help equip the industry and encourage the use of such technology in private works projects", signalling the Government's aspiration to help grow the adoption of BIM in the private sector, as well. Circulars DEVB TC(W) No. 18/2018 enhanced the implementation requirements of BIM and DEVB TC(W) No. 9/2019 expanded the scope of mandatory BIM uses. DEVB TC(W) No. 12/2020 was issued to further enhance implementation requirements and further extend the scope of BIM uses. According to the circular, Works Departments shall encourage organisations entrusted with projects outside the Government (i.e., AAHK, MTR Corporation, private developers, etc.), sub-vented projects, and private projects to be handed over to the Government, to use BIM technology as far as possible.

In the private sector, BD issued Practice Note PNAP ADV-34 regarding BIM in 2016 which allowed the submission of BIM as reference materials. In addition to the requirement for hard copy submissions, this practice note encourages AP/RSE/RGE to present their building plans in BIM in a specific digital format to facilitate the submission and approval processes. In 2019, PNAP ADM-19 was revised to accept the use of BIM for calculating floor areas of buildings in general building plans. It also requires the AP to follow BD's *Guidelines for using building information modelling in general building plan submission* and use the standard BIM templates which can be downloaded from BD's website. In addition, where BIM is adopted in the preparation of general building plans by APs, the model of the completed projects will be referred to the Lands Department (LandsD) and the Planning Department (PlanD) for the development of 3D spatial data and maintenance of 3D planning and design information.

In 2014, the CIC formulated a road map to guide the strategic implementation of BIM, supported by a series of promotional activities. For instance, the CIC Task Force on BIM Standards, in collaboration with BD, prepared a document entitled *CIC BIM standards for preparation of statutory plan submissions* and published it in December 2019. In December 2020, the CIC launched a set of new/updated CIC BIM standards. This included software-specific user guides, software template, sample project models, sample drawings, and BIM object presentation summary. Based on this, practitioners can follow the CIC BIM standards to produce statutory plans, including superstructure (reinforced concrete and steel structures), foundation, demolition, excavation and lateral support, site formation, ground investigation, drainage, and curtain wall plans. BD sought comments from the Building Sub-Committee of the Land and Development Advisory Committee and the Authorized Persons, Registered Structural Engineers, and Registered Geotechnical Engineers Committee on these CIC BIM standards. The CIC will revise the CIC BIM standards in response to the comments received. When finalised, BD will promulgate them as *Guidelines for using BIM in statutory plans submission* on BD's website in the near future.

Additionally, a task force on submissions of 2D drawings generated from BIM models of pilot projects to BD was established by the CIC and the first meeting was held in January 2021. Members include the DEVB, BD, LandsD, HD, HD ICU, AAHK, MTR Corporation, HKHS, HKU and Urban Renewal Authority. The objectives are to identify projects and carry out pilot submissions with BIM to BD for approval and consent, streamline the workflow for submissions with BIM, and identify training requirements and improvements needed to the BIM standards. The work of the task force will aim to synchronise with the electronic submission hub (ESH) being developed by BD and facilitate the acceptance of BIM submissions.

By way of this strategy, we propose to **encourage and facilitate BIM submissions along with the 2D plans generated from BIM models for BD approval** by making reference to Singapore's BIM e-Submission system (see details in Section 4.4.1.3). As such, BD can still require and process 2D drawings under the Buildings Ordinance regardless of whether it is generated from BIM models, as well as the voluntary submissions of BIM models as supplementary information to facilitate BD's plan processing. We expect that drawings generated from BIM will accelerate the checking and approval process, especially if assisted by approved automated checking tools, and maximise the synergy with the efforts by LandsD and PlanD to build 3D digital maps and contribute to the next generation of city development (i.e., smart city).

To encourage submissions to BD, the Government is recommended to consider the following factors:

- **Estimated rollout of the ESH to accept submissions with BIM.** Currently, electronic submission is allowed under PNAP ADM-17 for submissions not involving voluminous documents, customised programmes, or large size drawings. To further extend the use of electronic submissions, BD commissioned a feasibility study in 2013 on the implementation of an electronic submission system of plans and documents under the Buildings Ordinance and a review on the feasibility of a full-scale electronic submission system for processing electronic plans and documents in 2017. Subsequently, in May 2020, BD awarded a consultancy contract to develop an ESH for centralised processing of electronic building plans and documents, as well as other applications under the Buildings Ordinance as an alternative to the present paper-based system to facilitate the submission and approval processes. ESH will accept electronic building plans generated from BIM in addition to other

formats (e.g., AutoCAD (Computer-Aided Design)). According to Legislative Council LC Paper No. CB (1)323/18-19(07), the proposed ESH is to be developed in three stages with final completion in Q2 2025.

Due to the COVID-19 pandemic, the launch of Stage 1 of ESH, which was originally planned for the first quarter of 2022, was rescheduled, as detailed in Table 14.

Stage 1	For plans not requiring cross-department referral	Q1 2022 *(rescheduled)*
	• For first submissions of plans	May 2022
	• For amendment submissions, resubmissions, and major revisions	June 2022
Stage 2	For plans requiring referrals to works departments only	Q1 2022–4 2023
Stage 3	For all types of plans	Q4 2023-Q2 2025

Table 14 - Proposed schedule for the development of the electronic submission hub

- **Estimated rollout of automated checking of BIM models.** We are cognisant of the fact that LandsD in collaboration with BD, issued a tender for development of automatic checking tools for GFA and other area calculations from BIM models. The contract includes the upgrade of BIM templates and amendments to the guidelines. The development of the checking tools for LandsD and BD are targeted to be completed on the first 12 months and 24 months after contract award, respectively. In parallel, we noted that BD engaged with a consultant in January 2021 to explore the plug-in development of auto-checking functions in BIM and PDF software for structural submissions. When approved automatic checking tools are available, the use of AutoCAD-generated drawings by the industry may be reduced and 2D plans generated from BIM models will be submitted as an alternative.
- **A well-defined sharable BIM standard.** CEDD undertook a study entitled *BIM horizontal harmonization for BIM/GIS integration*. With the aim to formulate an aligned BIM guideline for the works departments under DEVB, this study developed a conversion engine for BIM/GIS integration by converting the BIM models to shareable ones in open BIM and GIS formats. The study was scheduled for completion in 2021. When the sharable BIM standard becomes available, this will reduce the concern on using particular commercial software.
- **Readiness of the supply chain.** The CIC developed a Centre of Excellence for BIM that supports the industry in five key aspects: adoption, training, standards and guidelines, certification and accreditation, and BIM-related R&D and funding support. As the CIC continues to collaborate with industry stakeholders to promote the uptake of BIM, facilitate provision of funding subsidies for purchase of BIM hardware and software and BIM manpower development using CITF, and provide BIM training, the capability of the supply side becomes an important factor. Taking into account stakeholders' feedback, the CIC is continuing to spend significant effort in developing BIM capability in the industry by collaborating with external training providers. Consideration could be given to rolling out the mandating of BIM submissions for sizeable building projects in the first phase.
- **Regulatory readiness.** To encourage and facilitate submissions with BIM, regulatory procedures may require changes. Industry stakeholders are hoping that simultaneous reviews and identification of issues could be facilitated by submitting BIM models — with the right level of information needed at different project stages aligning with the project life cycle — concurrently to BD and different government departments. This will allow quick resolutions using the same BIM dataset. For time and cost improvements to be materialise, relevant authorities need to agree on accepting essential information they require related to their respective areas of concern, e.g., those items to be included in the building plan to demonstrate fulfilment of the land lease conditions.
- **Capability building for regulatory staff.** To facilitate the implementation of BIM in the regulatory control work, in addition to providing training to the practitioners in different sectors of the industry, the CIC has been discussing with some regulatory departments, including BD and the FSD, with regard to the training required to facilitate the handling/processing of building plans using BIM. Training will be conducted in phases to align with the rollout schedule of mandating BIM submissions to BD.
- **Availability of full sets of BIM software templates for all plans production.** To promote the use of BIM in preparing statutory plans by industry practitioners, the CIC provided two sample software templates to demonstrate how software can meet the required BIM standards. As there are existing and new BIM software

products in the market the CIC could encourage software developers to provide their own software templates that align to CIC's BIM standards.

II. Develop automated design and as-built checking tools for accelerated approval

BD is leading a number of policy-enabling initiatives to improve BIM readiness. As mentioned, an ESH will serve as a digital platform for collaborative submission and processing of plans under the BO. Based on the latest schedule of ESH development, the ESH will be ready to accept all types of plans by 2025.

In conjunction with these digital efforts, **we propose to develop more automated checking tools, serving as a first screening of design submissions to rapidly check through the plan submission and objectively identify major deficiencies, errors, or non-compliance items**, e.g., GFA calculations or individual unit calculations in buildings. Additionally, public access to such automated checking tools could be considered to also allow self-checking by designers before submission to enhance the quality of submissions, reduce approval processing time, and alleviate possible peaks in demand.

Some ground has been covered in this direction in Hong Kong. The CIC R&D Fund has supported an R&D project on 'BIM-automation of gross floor area calculation, fire safety, and prescribed checking for general building plans preparation' which was completed in Q4 2021. This serves as a showcase on using automated tools for checking against the requirements in building codes and regulations. This is being developed by a solution provider. In the long term, it is suggested that BD, as the authority, can consider undertaking such development work where there is benefit to reduce the time and resources for checking and regulatory approval.

On 16 October 2020, LandsD, in collaboration with BD, also invited a tender for 'Provision of services for the implementation of tools for facilitating automated checking process on electronic building plans to the Lands Department and the Buildings Department'. The tools are intended to develop BIM plug-in tools for two BIM software to check and retrieve the computation of GFA, site coverage, usable floor area, and usable floor space from BIM models for demonstrating compliance with the provisions of the BO and lease conditions. Besides, BD also commissioned a feasibility study on the plug-in development of auto-checking functions in BIM and pdf software for structural submissions in January 2021.

III. Adopt a full e-inspection system

The proposed e-inspection system will use digital technologies — such as 360 camera, scanners, mobile applications, and platforms — to facilitate automatic capture of images, video, and data required in inspections. It will allow remote acceptance of prefabricated products, payment certifications, and contract and regulatory acceptance for both on-site construction and off-site manufacturing processes.

Traditionally, on-site inspection is typically required to carry out quality assurance, quality control, and approvals of construction materials and workmanship in construction contracts in Hong Kong. However, this generates high peaks of manpower demand on inspection personnel, involving layers of personnel from subcontractor, main contractor, resident site staff, and client representatives. Carrying out inspections across the boundary, e.g., in the GBA, can further add to cost and time requirements due to travel to pre-fabrication sites. Since the outbreak of the COVID-19 pandemic, BD has adopted a pragmatic and flexible approach to accept alternative arrangements for meeting the requirements of supervision and audit checks in the precast concrete factories and MiC prefabrication factories in the Mainland. Videotelephony[8] is employed by the AS and supervisory personnel of each functional stream to conduct the required supervision under the approval conditions.

Currently for capital works contracts in the public sector, with a pre-tender estimate exceeding HKD300 million, the adoption of a web-based centralised portal — Digital Works Supervision System (DWSS) — is required. The DWSS, as a portal for collecting construction works information and managing the workflows of site activities that is operated on computers and mobile devices, aims to promote digitalisation of the supervision system and enhance efficiency, safety, and quality performance. Trials in pilot projects were conducted to enhance the standard and efficiency of works supervision. Under DEVB TC(W) No. 3/2020, contractors are required to submit a DWSS proposal for the client's endorsement and the DWSS will be handed over to the client for record and future operation upon completion of the works (Hong Kong SAR Development Bureau, 2020). Moreover, to echo with the implementation of DWSS, BD has plans to develop a common digital platform for site supervision (CDPSS). BD has commissioned an IT project for developing a pilot system which will pave the way for the development of a full scale CDPSS. The CDPSS will be able to store and maintain digitalised site records for private building sites required under the BO on a centralised common platform. The uploaded site records can be

[8] Videotelephony means two-way simultaneous communication with both audio and video in real time through telephone or computer network connections. The video should be recorded in colour with resolution of not less than 480p.

viewed and retrieved by all users including BD and Geotechnical Engineering Office (GEO) of the CEDD. It is targeted that the pilot system of the CDPSS will be ready in October 2022 and will be put on trial for various types of building works in different construction sites. The CPDSS will enable system compatibility and interfaces with other IT systems in BD (e.g., electronic submission hub) and other customised systems for the DWSS to facilitate data exchange between the systems.

Under this strategy we propose a system similar to the DWSS which will also utilise e-inspection and, could be developed to cover private building projects, in particular, following regulatory (e.g., BD, EMSD, FSD, WSD, etc.) approval requirements. Such a system has the potential to generate efficiencies by reducing the time spent on arranging and conducting inspections and obtaining contract and regulatory approvals.

There are many processes that this system could be used for. Two examples are given below:

- **Proof tests on foundation works**: In an application for consent to the commencement and carrying out of building works, approval is granted when site tests at critical stages of building works meet the standards required by the Buildings Ordinance. Currently, a BD officer is required on-site to witness the proof tests on foundation works required to determine the performance of foundations under loads. By utilising a robust e-inspection system, this process could be done remotely or recorded for regulatory acceptance. It is noted that BD has started pilot trials on the streamlined arrangement for witnessing foundation proof test (e.g., pile loading test) which is carried out by a laboratory accredited by the Hong Kong Laboratory Accreditation System (HOKLAS), through videotelephony by BD staff and supplemented with video recording taken by a technically competent person of the registered structural engineer's stream. The trials are primarily targeted at large building sites with a relatively large number of proof tests to be conducted for the completed foundation units. BD will carry out an audit site inspection on conducting the proof tests under the streamlined arrangement. A review will be conducted to formalise the streamlining measure for promulgation through a practice note.
- **Quality audit (rebound hammer test)**: To verify the quality of building works, BD will check the quality control documentation for the materials used, including the testing reports and conduct site tests to ascertain the quality of the completed works. As part of the quality audit process, rebound hammer tests will be carried out. A BD officer must calibrate the rebound hammer each time before conducting the test to ensure the readings taken are accurate. When an independent third-party specialist is involved in conducting on-site calibration/verification of the accuracy of the rebound hammer, e-inspection could be utilised to enable remote inspection by BD officers.

Through engagement with BD, it is our understanding that the development of an e-inspection system covering its own processes is within the department's goals and that BD is in the process of procuring and appointing a consultant to develop an appropriate system. It is also our understanding that BD has piloted some inspections on foundation works remotely through the use of videotelephony during the COVID-19 pandemic and intends to expand the adoption of this method.

The following considerations should be taken into account when developing requirements for an e-inspection system:

- Electronic mobile devices for e-inspection would be needed in project management, particularly in alignment with the paperless future trend.
- Different contractors have different systems, which causes challenges with the operation by the client's representatives and resident site staff. Some clients have adopted their own preferred systems. Unified data requirements by regulators for different types of inspection and test, unified data definition and data structure for feeding the acquired records to regulators, and preferably common user interfaces, would be needed to achieve industry-wide implementation of an e-inspection system in Hong Kong.
- Consideration should be given to issues relating to data storage — whether the process should be done on a cloud server within or outside Hong Kong — and data access rights.

From a systems perspective, the e-inspection system synergises with the intended outcomes of:

- ID-4 –Improve contract terms by utilising e-inspection for off-site manufacturing
- AP-3 – Assess and expedite the efficiency of the approval processes to facilitate the suggestion on accepting on-site testing to be carried out by laboratories accredited by HOKLAS for the issuance of HOKLAS-endorsed test certificates and witnessed by AP/RGE/RSE, and to reduce the workload of BD

IV. Extend spatial data requirements to the private sector

Digitalisation is a key enabler to unlocking the challenges associated with bottlenecks in the design and approval processes. Following a review of the current process of obtaining and processing spatial data in submissions, it is noted that the spatial data in Hong Kong is scattered and maintained by various individual stakeholders, and there is no centralised platform or common protocol to share the spatial data to facilitate the processes (Construction Industry Council, 2020). Moreover, the format of the spatial data may not be consistent or readily available in a digital format for further processing in submissions and approvals. As a consequence, additional time and resource are required to obtain, digitise, verify, and process available spatial data, adding an extra time and cost burden to the development process.

More importantly, lack of and uncertainty in the information related to underground utilities can often lead to major delays in the construction stage due to prolonged period in resolving the conflicts associated with uncharted underground utilities.

In connection to this, the CIC commissioned a study on *3D spatial and BIM data use case requirements of the Hong Kong construction industry for the development of digital Hong Kong* and consolidated a top 10 wish list, with recommendations for implementation to facilitate project development and enhance project quality.

Some examples of the use of spatial data are extracted below for reference:

Data required	Data held by	Remarks
Ground investigation report	GEO	• Some in AGS, some in PDF • GI conducted by private developments are not available online.
Installation of utilities	Government regulators and utility owners	• Scattered information from multiple utility owners resulted in excessive effort for coordination in obtaining the information • Information in PDF is not effective for data extraction, retrieval, and processing.
EIA data (noise, air pollution, vehicle emission, habitat survey, vegetation map, marine ecology data, etc.)	EPD	• Data submitted by consultants is in PDF files and is not stored in a digital spatial format. • Standardisation of geospatial EIA data format for better coordination and monitoring

Table 15 - Spatial data

The 2019-20 budget earmarked HKD300 million to expedite the development of the Common Spatial Data Infrastructure (CSDI) and 3D digital map, with HKD150 million for each of the two initiatives. The Government is aiming to launch the full operation of the CSDI portal with a number of standardised spatial datasets for the public by end-2022. An alpha version of the CSDI portal, called Hong Kong Geodata Store, was released in December 2018. To facilitate wider use of spatial data, a quick-win project, named Map Application Programming Interface was launched in December 2020. Furthermore, the 2020-21 budget earmarked HKD60 million for the establishment of the first geospatial lab to encourage the public to make use of spatial data in developing mobile applications.

In October 2020, the DEVB formed a Common Spatial Data Advisory Committee to advise the Government on the development of the CSDI. The first term of the committee is for three years from October 2020. The terms of reference of the committee are:

To advise the Government, through the Common Spatial Data Steering Committee, on the development of the CSDI in Hong Kong including the following:

a) Leading industry and international practices, know-how, standards, and trends for the development of spatial data infrastructure
b) Initiatives for opening up and sharing of spatial data in the society
c) Potential applications of spatial data under CSDI and supporting innovation with spatial data
d) Formulation of engagement plans for relevant stakeholders and the public.

At present, different government departments and individual public and private organisations collect and maintain their own sets of spatial data, despite some of the data being available for public use. It has been recognised that

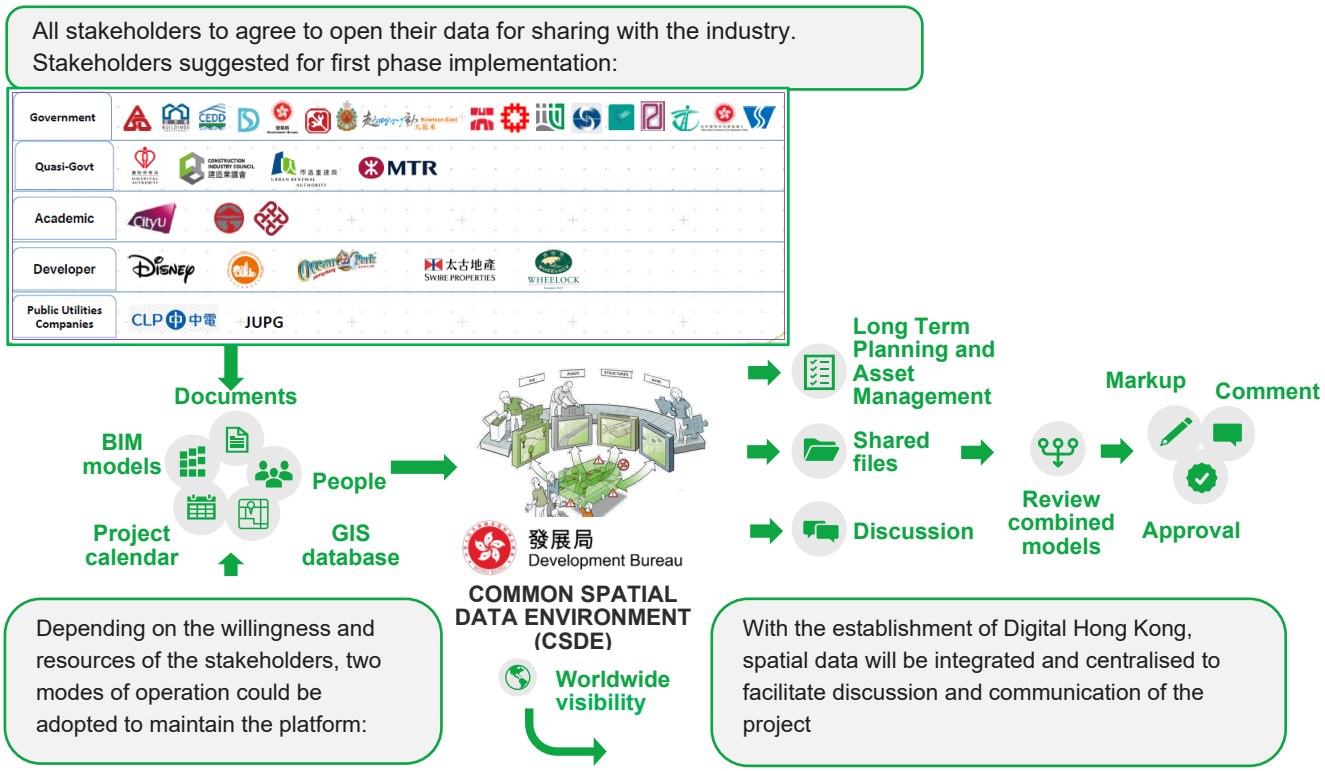
the Spatial Data Office of DEVB is developing the CSDI portal (beta version), a single integrated platform, for the storage of all important data from various sources to improve the efficiency and reliability of design and approval (GovHK, 2020). It shall require collaboration from concerned government departments and communication with respective departments to identify sharing data (Construction Industry Council, 2020). For instance, upon its formal launch in Q3 2022, BD will upload and share spatial data to the public through the CSDI portal. According to the CSDI website, the CSDI platform will contain about 320 datasets covering different B/Ds both within and outside the regime of DEVB by end-2022, which will facilitate the use by the general public and improve efficiency of city management.

To further enhance the efficiency of the collection and maintenance of spatial data on the CSDI, DEVB has plans to enforce an active provision of spatial data collected during project development to the platform for better data sharing by taking the successful experience of the catalogue of slopes maintained by the GEO. For private development projects, BD will make use of the data of projects already available in BD publication and website to contribute to the CSDI. Besides, PNAP ADM-19 was amended in September 2019 to enable the Lands Department and the Planning Department to extract from submitted BIM models simplified BIM data and BIM geo-spatial information, respectively. These will be used to update 3D spatial data and other 3D maps and upkeep 3D planning and design information. Through the coordinated submission of data (e.g., building model from developer) by project teams, the approval units shall hold sufficient confidence of the data stored on the platform and recognise the reliability of data from this source of data in plan submissions. Together with the adoption of other aforementioned digital tools (ESH, automated design checking tools, and e-inspection platform), this could eventually reduce the processing time by both project proponents and approval units, reduce uncertainty on the spatial data especially for those related to underground utilities, and enhance the predictability of project programmes.

In addition to the benefits of the application in the approval processes, the CSDI can also facilitate the availability of spatial data for government, business, academia, and the general public. Potential applications benefiting the government could be Smart Living and Smart Government. For the wider community, the examples shall extend to Smart Mobility, Smart Environment, and Smart Economy (Shiu, 2020).

With reference to the experience of Virtual Singapore (see details in Section 4.4.1.3), the system enables collaboration between departments, public sector, academia, and citizens for policy and business analysis, decision-making, test-bedding of innovations, community collaboration, and other activities that require information. For instance, by using the data and system capabilities, the platform leverages various government initiatives (i.e., Smart Nation, Nationwide Sensor Network, GeoSpace, etc.). For the private sector, businesses can deploy the data and information for business analysis, resource planning, and management.

One should note that building stakeholders may have confidentiality and copyright related concerns with reference to providing BIM models in their submission. This possibility should be examined and taken into account in decision-making.



Active pushing force

- Stakeholders to upload open data to the CSDE for sharing

Passive pulling force

- Platform owner to request for information regularly for updating

Project proponent

- Reduced time for obtaining the information from scattered sources and for resolving conflicts with the stakeholders
- GIS data can be leveraged to determine delivery routes and hence improve the planning and design process or projects adopting DfMA or MiC

Approving unit

- More confidence on the data to reduce the workload for coordinating and verifying the information in submission

General public

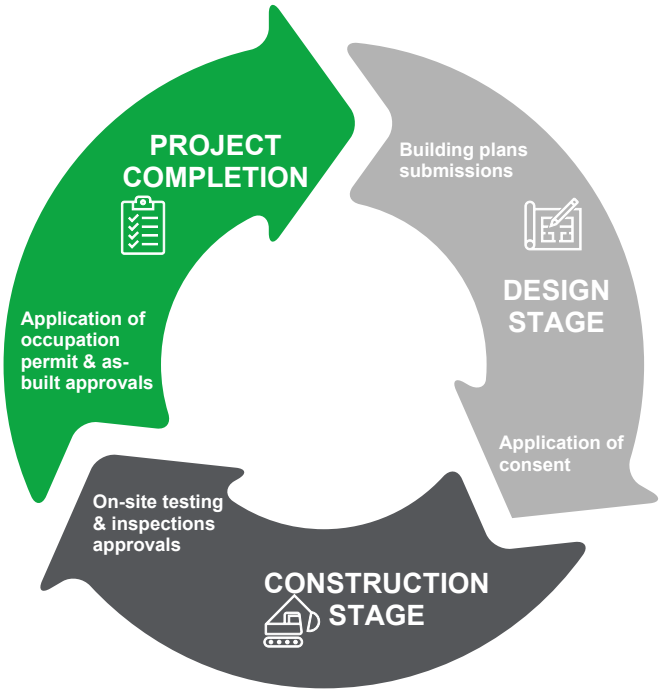
- Able to be engaged in long term development of the city, reducing occurrence of late objection to the project, which leads to major delay

Figure 23 - Functions and major contributing parties of Common Spatial Data Platform

4.4.1.2 Practical action plan

As an integrated digital submission process, the four digital tools (BIM, automated design checking tools, e-inspection platform, and common spatial data platform) are interlinked throughout the whole design and construction submission processes, serving different functions. We recommend reviewing the submission processes, identifying the action plans for each digital tool, and exploring the synergistic effect between the tools to maximise the benefit of these digital tools and ultimately streamline the approval processes by means of digitalisation and the formation of a digital ecosystem. Figure 24 illustrates the potential interrelationship of the digital tools in the project development cycle.

- **BIM submission to bd** for completion stage approvals with **automated design checking tools** and **e-inspection platform**
- Project data collected to be fed into the **common spatial data platform** and **project collaboration platform (pm-1)** in a pre-determined format



- **Common spatial data Platform** enables submitters to obtain data through an integrated platform, speeding up the submission preparation processes and avoiding unforeseeable risks due to unavailability of information (e.g. underground utilities)
- **BIM submissions to BD** with **automated design checking tools** as first screening of submissions

- **BIM submission to BD** for construction stage approvals with **automated design checking tools**
- **E-inspection platform** to collect data and records of construction progress, and facilitate submission preparation

Figure 24 - Interrelationship of the digital tools in the project development cycle

The table overleaf outlines a proposed action plan for the development of these four digital tools in the short- and medium-term.

	Develop an Integrated Digital Submission and Approval Process			
	Encourage and Facilitate Submissions Generated from BIM Models to BD	**Develop Automated Design and As-built Checking Tools for Accelerated Approval**	**Adopt Full E-inspection System**	**Extend Spatial Data Requirements to the Private Sector**
Short Term	• **CIC's Taskforce on BIM Submissions to BD** to conduct a study to define the requirements for BIM submissions to BD. The development of the requirements should collect the views of the industry, BD, and quasi-government clients, e.g., HKHA, HKHS, MTR, AAHK, URA, Hospital Authority, and WKCDA. • **CIC** supports **BD**, in consultation with the Task Force on BIM Submissions to BD, to identify and develop, as appropriate, an implementation plan, in line with their current plan on ESH implementation and rollout; prepare guidance notes on best practices for reference by the industry, and update PNAP ADV-34 to cover standards and implementation of BIM submissions in a gradual approach, if necessary, like in the case of the BCA in Singapore (see details in Section 4.4.1.3).	• **CITF** to continue to provide funding support and incentives for the private sector to adopt / develop automated checking tools • **CIC** supports BD to continue to review the current plan processing and as-built records checking mechanism and establish a list of items for suitable automated checking. • **CIC** supports BD to continue to procure services from private application service providers to develop suitable automated checking tools	Development of e-inspection system: • **Government** to consider conducting a feasibility study for the e-inspection system • **CIC** supports BD to continue to explore an e-inspection platform for site monitoring, if appropriate (e.g., CDPSS) Implementation of an e-inspection system for on-site processes and off-site manufacturing: • **BD** to consider exploring procedures and update the practice notes on how the e-inspection system could be incorporated into regulatory control, as appropriate	• **Government** to consider exploring data requirements (to be compatible with CSDI) and method of collection, storage, and updating in the private sector • **Government** to consider the appropriate security levels for data updating and retrieval

	Develop an Integrated Digital Submission and Approval Process			
	Encourage and Facilitate Submissions Generated from BIM Models to BD	**Develop Automated Design and As-built Checking Tools for Accelerated Approval**	**Adopt Full E-inspection System**	**Extend Spatial Data Requirements to the Private Sector**
Medium Term	• **CIC's Taskforce on BIM Submissions to BD**, to engage industry stakeholders, and rollout a BIM capability building plan for government staff in line with the development of BIM submissions, and to consider expanding the provider pool for BIM training to external educational institutions to expedite city-wide capability building • **BD** to consider measures to encourage BIM submissions for sizeable projects • **BD** to consider making use of automated checking tools as first screening on BIM submissions. • **BD** to consider reviewing the effectiveness of the BIM submissions and automated checking tools to identify improvement areas and assess whether expansion of functions is required with consideration of industry feedback and opinions on a regular basis	• **BD** to consider reviewing the effectiveness of the automated checking tools to identify improvement areas and assess whether expansion of functions is required with consideration of industry feedback and opinions on a regular basis • **BD** to review and consider, as appropriate, accepting other automatic checking tools developed by solution providers	Review and continuous development of e-inspection: • **BD** to consider reviewing the performance of the e-inspection system and identify improvement areas, as appropriate • **BD** to explore, as appropriate, if any suitable type or scale of projects for implementation of the e-inspection system	-
Potentially streamlined submissions	Design stage: • Statutory plan submissions	Design, construction, and completion (OP) stage: • Statutory plan submissions • Application for consent • Application for occupation permit • As-built approvals	Construction stage: • Application of consent • Application of occupation permit	Design, construction and, completion stage: • Statutory plan submissions
Reference to evidence	• Singapore's e-submission and CORENET	• Singapore's CORENET	• Existing e-inspection platforms in Hong Kong	• Virtual Singapore

	Develop an Integrated Digital Submission and Approval Process			
	Encourage and Facilitate Submissions Generated from BIM Models to BD	**Develop Automated Design and As-built Checking Tools for Accelerated Approval**	**Adopt Full E-inspection System**	**Extend Spatial Data Requirements to the Private Sector**
	(Construction and Real Estate Network) • Hong Kong Housing Authority's HePlan		• Russia's State of Drugs and Good Practices	

Table 16 - Practical action plan for developing an integrated digital submission and approval process

4.4.1.3 Evidence

This section provides international and local examples related to the four digital tools as referenced in the practical action plan above. Examples include Singapore's BIM e-submission, Construction and Real Estate Network (CORENET), and Virtual Singapore; Housing Authority's Housing Electronic Submission Plan (HePlan) and existing e-inspection platforms in Hong Kong; and Russia's State of Drugs and Good Practices.

Singapore's BIM e-submission

To reduce the number of foreign workers and to improve the productivity in Singapore's construction industry, the BCA introduced the BIM Roadmap in 2010 with the aim of achieving an 80% level of BIM usage in the construction industry by 2015. In relation to this, the BCA published *Singapore BIM Guide 2012* to provide clarity on the requirements of BIM usage at different stages of a projects and *BIM Essential Guide for BIM Execution Plan 2013* to provide a BIM execution plan template.

As the BCA understands the challenges that businesses face in considering the application of a new technology in their operations, BIM e-submission was introduced and mandated in a phased approach (see Figure 25). It is also important to note that when the BCA mandated BIM submissions in 2013, there was no amendment made to the existing ordinance. A few years later, hard copies and AutoCAD-generated 2D drawing submission were no longer acceptable.

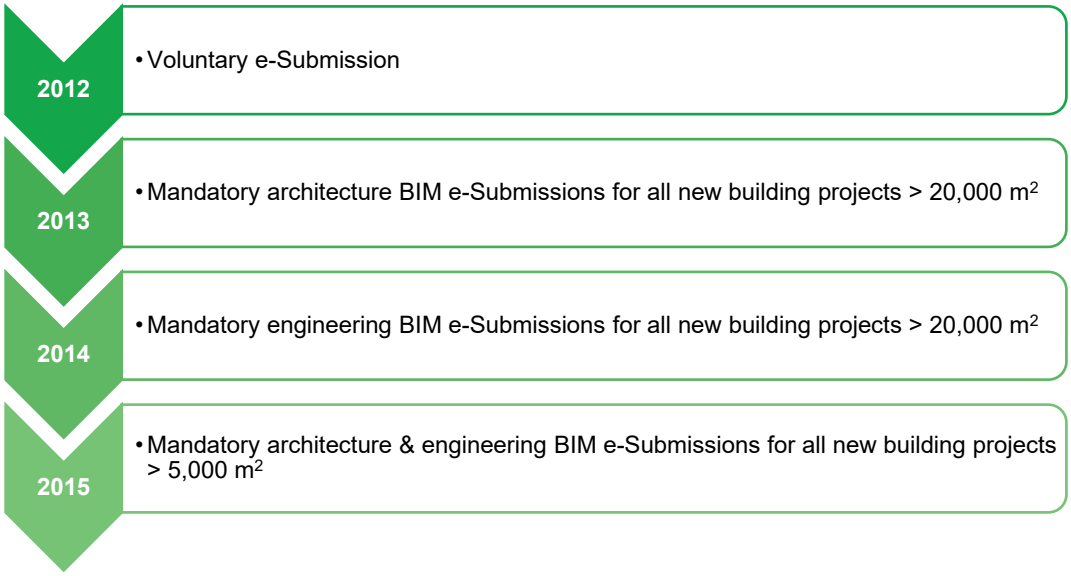


Figure 25 - Schedule of BIM submission for regulatory approval in Singapore

Currently, BIM e-submissions are done in lightweight file formats which are compressed versions of native files in order to manage the file size[9]. The challenge associated with BIM processing is that the industry has to reinstate 2D annotations manually onto 2D plans to supplement the plan for regulatory submission. To address this, the BCA has been accepting voluntary BIM e-submissions in native BIM format since October 2016 (for architectural plans) and October 2017 (for civil and structural submissions/MEP engineering plans). In parallel, the BCA has been working with industry stakeholders to explore the feasibility of BIM submissions in open BIM format.

Regarding the requirements of BIM submission, the BCA issued Codes of Practice which set out the requirements and guidelines on the creation of models with specific object types, associated properties, and presentation format for regulatory BIM e-submission. Once the models are submitted to CORENET, the respective regulatory agencies will conduct compliance checks on the 2D and 3D views (in lightweight compressed BIM formats such as 3D .pdf or Autodesk. dwf) generated from Revit/Archicad and other original BIM software formats submitted under the BIM e-submission requirements. BIM e-submission is now fully rolled out in Singapore regulations. Over the years, the BCA has provided a realistic transition period before BIM submission was mandated. This phased

[9] Architectural submissions: native file format (.rvt, .pla, .dgn) or lightweight file format (.dwf, .pdf, .bimx); civil and structural submissions: native file format (.rvt, .db1, .dmp, .dgn, .pla) or lightweight file format (.dwf, .pdf, .bimx); MEP submissions: native file format (.rvt, .pla, .dgn) or lightweight file format (.dwf, .pdf, .bimx)
*Architectural reference file can be submitted in .pdf or .dwf format.

implementation plan has given industry practitioners adequate time to build up their capability and allowed the industry to understand and buy into the benefits of BIM technology.

In an effort to fully take advantage of BIM systems and streamline approval processes, the BCA Academy[10] developed a training framework to accelerate the BIM adoption process. Particularly, the Academy launched BIM reviewer courses for government officers to ramp up BIM capability within the government.

Singapore e-government initiative — Construction and Real Estate Network

CORENET was first introduced in 2001, serving as the main submission system for building works approval. This e-submission system (eSS) enables automated conformance checking and facilitated approval on applications made to over 16 government agencies from nine different ministries, covering planning approvals, structural approvals, building approvals, certificate of statutory completion (CSC), temporary occupation permit (TOP) and fire safety certificate (FSC).

The BCA outsourced the implementation, management, and operation of the system to a third-party operator for approximately SGD4.8 million for over a contractual period of five years with an option to further extend for five years (Nova Group, 2007).

Outcomes of eSS highlighted:

- The eSS reduces time in securing construction or related permits by 80%. The eSS also reduces the number of application forms by 73% from 845 to 231 and facilitates a shift from physical submissions to electronic submissions (Nova Group, 2017).
- The eSS results in operational savings of USD150 million per year and other savings of USD1 billion per year related to investor risk and capital.
- The 'total construction permitting time' is shortened from 102 days to 38 days between 2008 and 2009 (Asia-Pacific Economic Cooperation, 2012).

The centralised digital platform streamlined the approval process for building applications with a significant reduction in process time and savings on operational expenses. Functions of the digital platform can also be applied to Hong Kong's development of an electronic submission hub.

Housing Electronic Submission Plan, Hong Kong Housing Authority

Developed by the Independent Checking Unit (ICU) under the Office of the Permanent Secretary for Transport and Housing, HePlan is a digital system which facilitates a transition from hardcopy submission to electronic submission for HKHA's new development projects and A&A projects (Chung, 2017). The system also enables ICU to conduct record management, filing and its internal workflow.

Application of HePlan:

HePlan is part of a wider effort including that of the HKHA to enhance productivity through integration of a series of **digital tools** (e.g., Semi-Automated Foundation Design in 2017 and BIM in 2014) (Hong Kong Housing Authority, 2020).

HePlan receives submissions using **BIM** Technology. Future versions of the system will enable download of plans onto mobile platforms, thereby facilitating digitalisation of site-monitoring works.

AP/RSE/RGE/AS of contractor registered in BD are eligible to register as users and access the system upon obtaining a personal or organisational **e-cert**. The AP can assign representatives as users who must also obtain an e-cert (Hong Kong Housing Authority, 2017).

HePlan is the first electronic submission system for building control and the first government system in Hong Kong which applies digital signature with digital certificate to facilitate long-term documentation of plans. The system attained ISO9001 and ISO27001 certifications on its quality management system and security management system. HePlan streamlines the approval process for submissions from contractors to the HKHA. Consultation with HKHA is needed to better understand the development of the system and whether it could be extended to the proposed electronic submission hub for BD submissions.

[10] BCA Academy is the education and training institution of the Building and Construction Authority, Singapore.

Existing digital platforms for e-inspection in Hong Kong

There are similar systems pre-approved by the CITF for funding subsidy for use in both public and private sectors, including e-inspection, but the systems also serve a wider purpose such as site monitoring. However, there is currently no standardised e-inspection system defined by the regulatory bodies for the purpose of statutory inspections, particularly for off-site factory manufacturing outside of Hong Kong.

Examples of digital platform developments include ESIA (BEX Solutions Limited, 2019), InfoSMART (Infotronic 2020), and SmartWorks (SmarTone Mobile Communications Limited, 2020). The Logistics and Supply Chain MultiTech R&D Centre (2020) also partnered with the Hong Kong Polytechnic University to develop Project Eye.

Figure 26 shows how data and inspection reports are created in the digital platform via e-inspection.

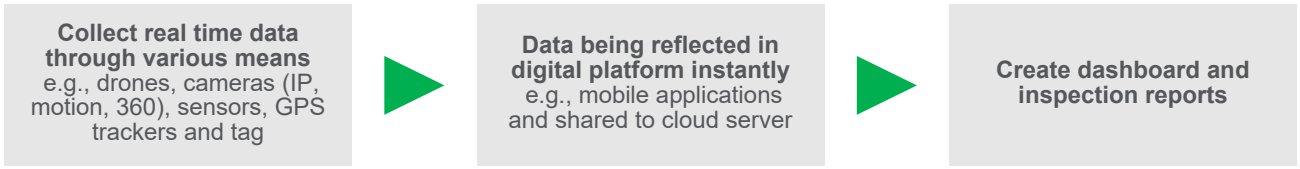


Figure 26 - E-inspection procedure

One of the existing digital platforms, InfoSMART, provides Smart Inspection Records in the format of a detailed site report as shown in Figure 27.

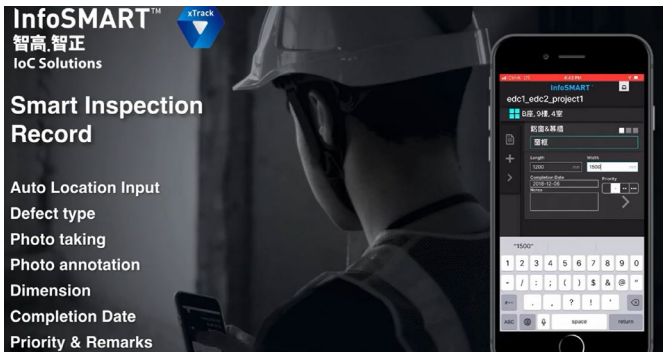


Figure 27 - InfoSMART smart inspection record

Russia's State of Drugs and Good Practices: Remote good manufacturing practices inspection

This benchmark provides a valuable reference for off-site process management for e-inspection platforms.

Amidst COVID-19, staffing for on-site good manufacturing practice (GMP) inspections are limited for pharmaceutical manufacturers. Consequently, GMP inspections were postponed or completely discontinued by some regulatory agencies. As a result, regulators including the Geneva-based Pharmaceutical Inspection Co-operation Scheme and the US Food and Drug Administration proposed off-site inspection methods as an alternative.

Russia's State Institute of Drugs and Good Practices (SID&GP) published its experience on its first remote GMP inspection of an international pharmaceutical company on the Parental Drug Association Letter (Shestakov, 2020). SID&GP adopted a risk-based approach for remote inspection, taking into account a variety of factors including results from previous inspections, criticality of the concerned products, and complexity of the inspection site. Before such inspection was carried out, an approval was sought from the regulator. If the GMP certificate is awarded in a previous inspection, the manufacturer will be approved for a remote inspection with favourable conditions. If, however, a repeat inspection is conducted concerning the corrective actions and other attributes that result in censure, further agreement from the manufacturing site needs to be sought for the remote inspection.

Procedures of the off-site inspection process are summarised as follows:

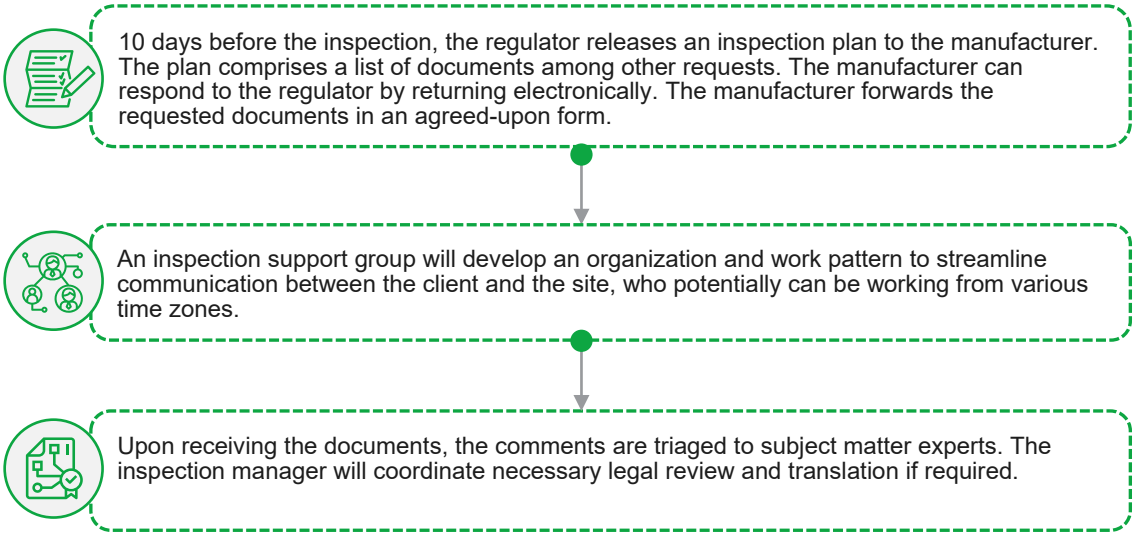


Figure 28 - Procedures of off-site inspection process

Some limitations were identified by the off-site inspection process. For example, the inspection process can take up to two to three times longer due to the remote nature of such inspections. Nonetheless, the case provided confidence to remote inspection for some of the most critical products. In the context of construction, this case provides valuable reference for regulatory processes of relevant agencies that are required for using proposed e-inspection process in DfMA or MiC projects where such products may be used outside of Hong Kong.

Virtual Singapore

Virtual Singapore is a 3D digital model of Singapore developed through a collaborative effort between local government agencies, universities, and partners. The interface is developed by the Singapore National Research Foundation of the Prime Minister's Office, Singapore Land Authority, and Government Technology Agency of Singapore, which respectively contribute to project management, operations, and technological development (Singapore National Research Foundation, 2018). First launched in 2014, Virtual Singapore was estimated to cost SDG73 million and was targeted to complete in 2020 (Stone, 2017).

The 3D model comprises detailed information on the environment, including material representation of geometrical objects, terrain attributes such as water bodies and vegetation, and granular components of buildings such as facades and ceilings (Singapore National Research Foundation, 2018). The data repertoire is based on static, dynamic, and real-time data from multiple sources including public agencies and geospatial and non-geospatial platforms such as OneMap and Business Hub.

Virtual Singapore offers four major capabilities, including:

- **Virtual experimentation:** For example, the 3D city model can be used to examine coverage areas of telecom networks.
- **Virtual test-bedding:** Virtual Singapore can be used for validating the provision of services. For example, a facility can leverage the semantic information of the 3D model to simulate crowd dispersion to establish emergency procedures.
- **Planning and decision-making:** The city model supports analytical applications such as analyses of transport flow and pedestrian movement. For example, urban planners can perform fluid analysis on the virtual environment to inform urban planning process and architectural design (Chaturvedi, 2019).
- **Research and development:** The data environment provides opportunities for researchers to develop new technologies and capabilities.

By leveraging rich data, Virtual Singapore is expected to enable different stakeholders of Singapore, including government agencies, citizens and residents, businesses, and the research community, to augment their analytic, decision-making, innovation, and collaboration capabilities. Some examples of the digital models are shown in Figure 29:

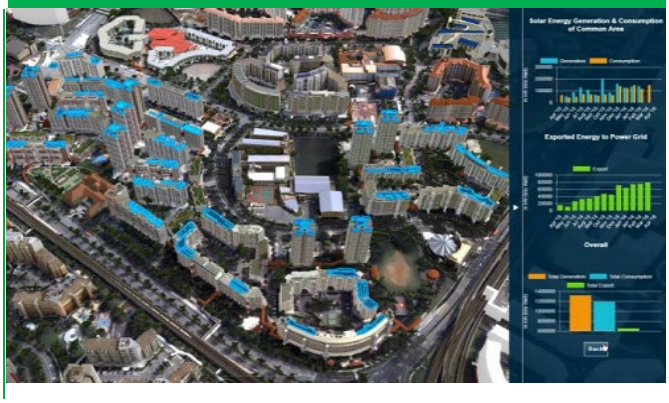
Wind Simulation	Solar Analysis
	
Researchers/urban planners can use the 3D model to perform fluid analysis. As illustrated, wind flow and urban heat island effects are tested to inform urban planning process and architectural design (Chaturvedi, 2019).	Urban planners can make use of the virtual environment to analyse the buildings to understand their potential for solar energy production and hence optimise the location for the installation of solar panels (Stone, 2017).

Figure 29 - Examples of digital models of Virtual Singapore

4.4.2 AP-2 Extend the list of minor works exempted from BD design submission

4.4.2.1 Description

The Minor Works Control System (MWCS) was introduced on 31 December 2010 to facilitate building owners and occupants in carrying out small-scale building works lawfully through simplified requirements without the need to obtain from BD prior approval of plans and consent to commence works. Minor works are classified into three classes according to their nature, scale and complexity, and the risk to building safety that they posed (see Table 17).

BD formed a Technical Committee on the Minor Works Control System (TCMWCS) comprising building stakeholders and relevant government departments.

The terms of reference of TCMWCS are:

e) To collect views and consider any comments from the building industry arising from the use of the Technical Guidelines and implementation of the MWCS and Validation Scheme for Prescribed Buildings and Building Works including the related legislative proposals
f) To advise and make recommendations to the Director of Buildings from time to time on the appropriate measures to be taken in response to item (a) above.

As part of its regular review on the MWCS, BD gathers views from industry stakeholders — via TCMWCS and the APSEC — and reviews and proposes to extend the scope of the MWCS (from 126 to 187 minor work items), with additional designated exempted works items (from 15 to 30 items).

Subsequently, the amendments to the subsidiary legislations of the Buildings Ordinance, viz. the Building (Minor Works) (Amendment) Regulation 2020 (Amendment Regulation) and the Building (Planning) (Amendment) Regulation 2020 (B(P)(A)R), were gazetted in May 2020 and came into effect on 1 September 2020.

To ensure a smooth transition for the commencement of the Building (Minor Works) Amendment Regulation (Amendment Regulation), BD set up a Working Group under APSEC.

The terms of reference of the Working Group are as follows:

a) To collect views on arrangements in handling minor works items associated with the proposed Amendment Regulation that may be carried out concurrently under the development projects or A&A (alterations& additions) projects after the coming into effect of the proposed Amendment Regulation
b) To formulate a set of practical guidelines for item (a) above for consideration by the Director of Buildings
c) To collect views on other matters associated with the commencement of the proposed Amendment Regulation.

	Class I	Class II	Class III
Complexity and level of risk	High	Medium	Low
Minor works items	58 items	68 items	61 items
Appointed person to prepare and sign prescribed plans	Prescribed building professional and prescribed registered contractor	Prescribed registered contractor	Prescribed registered contractor
Submit documents before commencement of works	Minimum 7 days	Minimum 7 days	Not required
Submit documents after completion of works	Within 14 days	Within 14 days	Within 14 days

Table 17 - Minor works three classes

During the stakeholder engagement, this recommendation received support from the private sector. By making reference to the Singapore system, they noted that government checks should focus on major issues or innovative ideas. Minor and traditional submission items were left to the Singapore Qualified Persons equivalent of the AP/RSE to approve.

In the short term, we propose to extend the list of minor works.

4.4.2.2 Practical action plan

We suggest that, in the short term, BD may consider extending the list of minor works items and to cover additional building works items, where appropriate. The following steps and responsible parties are recommended:

Short Term

- **APSEC** to consider communicating with practitioners regularly and collect a priority list for extension
- **CIC** supports BD/APSEC to continue to review and revise, as necessary, the list of minor works items to be extended.
- **CIC** supports DEVB to continue to review the list and prepare a gazette for public consultation, as necessary.
- **BD** to consider publishing, as necessary, the revised list of minor works
- **BD/APSEC** to consider carrying out briefing sessions to enhance industry awareness of the revised list of minor works items

4.4.2.3 Evidence

There are numerous benchmarks where similar self-regulatory systems are in effect. The section below describes three of them, specifically the systems in the UK, Victoria State in Australia, and Singapore:

The Building Regulations 2010, UK

As statutory instruments, building regulations play an important role in ensuring that the policies set out in the relevant legislation are undertaken. Under the Building Act 1984, the building regulations have been periodically updated, rewritten or consolidated.

With the latest version being the Building Regulations 2010, the UK Government mandates that building works, as defined in Regulation 3, must comply with the applicable requirements contained in the Regulation (UK Building Regulation, 2010). The term 'building works' is defined to include:

- The erection of a new building
- The extension or alteration of an existing building
- The material alteration of a building
- Provision of services or fittings in a building.

The prescribed building works must meet the applicable technical requirements in the building regulations. In the case that such works contravene the regulations, the person carrying out the work will be subject to prosecution for imposition of an unlimited fine, up to two years after the completion of the offending work under section 35A of the Building Act 1984. In addition, the alteration or removal of work may be required as the local authority enforces section 36 of the 1984 Act. If any work fails to comply with the regulations, the authority may require the owner to pull it down.

Some works are exempt from all regulations, with some others exempt from certain aspects. However, planning permission may still be required even if the work is exempt from the regulations. The exemption is determined by two approaches:

- Compliance parts A to K and M to Q are judged against seven classes of works
- Part L (conservation of fuel and power) is evaluated against the criteria provided in Regulation 21. Part L requirements apply to buildings, extensions of such buildings, or parts that are in connection with the buildings.

Exemptions for Classes 1 to 7			
Class of work is exempt from need to comply with these parts	A-K, M, N and Q	L	P
Class 1 (buildings controlled under legislation)	Exempt	Part L may apply	Exempt
Class 2 (buildings not frequented by people)	Exempt	Part L may apply	Exempt
Class 3 (greenhouses)	Exempt	Part L may apply	Exempt
Class 4 (temporary buildings)	Exempt	Part L may apply	Exempt
Class 5 (ancillary buildings)	Exempt	Part L may apply	Exempt
Class 6 (small-detached buildings)	Exempt	Part L may apply	Not exempt
Class 7 (extensions)	Exempt	Exempt	Not exempt

Table 18 - Exemptions for classes 1 to 7

The UK regulations on obtaining approvals provide a list of works that are exempted from the authority's approvals, which can be a reference for BD when considering extension to list of minor works.

4.4.3 AP-3 Assess and expedite the efficiency of the approval processes

4.4.3.1 Description

With the aim of improving government services involving applications and approvals in the construction industry, we consulted industry stakeholders on the efficiency of the existing processes. Particularly, the private sector expressed concerns and opinions with PlanD, BD, and LandsD in handling building plans submissions.

In response to the challenges raised during the stakeholder engagement, this strategy examines the opportunities to streamline the existing approval processes across three areas which include:

- Reviewing existing approval systems to promote fast-track processing and setting KPIs with a shortened approval time
- Enhancing communication between the government regulators, and consulted departments, and the industry
- Establishing comprehensive KPI's for all government departments.

I. Review and streamline existing approval for fast-track processing

Instead of a 'facilitator' and a 'promoter', industry stakeholders expressed that the Government is a 'controller' exercising too much control and scrutiny over the submissions and approvals, which leads to prolonged regulatory review time. The lengthened approval processes of which have intensified the cost pressure for private developers. The high cost will eventually be passed onto the end users. Upon review of current government approval processes, it is noted that some of these processes can be streamlined to improve productivity without compromising public safety and quality of the project. This could be achieved through adopting different strategies including:

- Parallelisation of existing processes
- Reduction of assessment timeframes based on complexity
- Expanding testing of materials to certified laboratories on-site testing carried out by certified laboratories and witnessed by AP/RGE/RSE
- Greater adoption of digital site records for off-site inspection / approvals.

Below are three observations on actions directed towards streamlining:

1. We are cognisant of the revised PNAP ADM-19 that BD issued in February 2021. The updated practice note sets out the streamlined procedures for fast-track processing for repair works to curtain wall, window wall, and cladding, and processing plans submissions for erection of fire damper in ventilation system, supporting frame for suspending air-conditioning plant or mechanical ventilation plant, and large metal ventilation duct or associated supporting frame inside building. It is expected that **with the development of an ESH, following the adoption of reliable automated design checking tools in the future and based on the experience gained, the feasibility of reducing the processing time should be explored**. Careful consideration should be given to the reduction of the review pledge time to ensure it is realistic. AP-3(ii) below, on performing data-driven review of response times, further elaborates the idea of control over pledge time of government departments with reference to submission approvals.
2. Potential to **accept on-site testing carried out by HOKLAS-accredited laboratories for the test** that declares no real or perceived conflict of interest and witnessed by the AP/RGE/RSE or their TCP (relevant level and with relevant experience), and with the test result sent to BD directly, to reduce workload of BD and time required for the arrangement. BD is currently running pilot trials to push forward this approach. This suggestion could be facilitated by the e-inspection system, DWSS, and CDPSS as elaborated in point three below.
3. Potential to make use of **digital cameras and scanners for producing site records** (e.g., piling works) and as a mean for off-site inspection/approval. BD is carrying out pilot tests on the application of videotelephony for witnessing loading test on completed piles instead of having BD officers present at the site. Furthermore, upon the issuance of DEVB TC(W) No. 3/2020 on DWSS, capital works contracts under the Capital Works Programme with pre-tender estimate exceeding HKD300 million shall adopt DWSS in the contract to enhance the standard and efficiency of works supervision, as well as the quality and safety. For the private sector, BD commissioned an IT project to develop a pilot system on CDPSS. The platform will also include provisions for data exchange with other IT systems in BD (e.g., ESH).

Adoption of an e-inspection system in private development projects could reduce the time for documentation of site records, allowing early submission and easy handling of numerous site records for mega-projects, and enhance the quality and safety.

Apart from these observations, some other potential areas to **streamline the review, approval, and vetting processes** are listed below. We recognise that action may have already been taken in these areas or that there may be limited opportunities for streamlining therein. However, we are listing these as potential areas for examination by relevant stakeholders:

- Tree preservation and removal by LandsD
- Temporary land allocation by LandsD
- Excavation permit by HyD
- Temporary traffic arrangements by Transport Department
- Fire services installation inspections by FSD.

The abovementioned suggestions are examples from the discussions with professionals and stakeholders and are not intended to be exhaustive, neither are they intended to be definitive. Studies would be needed to understand the opportunities, if any, for fast tracking processes and reducing the time required and cost of projects.

II. Perform data-driven review of response times by consulted departments

In our stakeholder engagement exercise, industry stakeholders supported the idea of setting up KPIs for response times by consulted departments which could better facilitate an 'open and transparent' submission approval system. Regarding the Centralised Processing System (CPS) of building plans under the Buildings Ordinance, there are more than 30 interested government departments as listed in PNAP ADM-2, and not all of them have a clear pledge time for the public to follow with. The establishment of KPIs or clear pledges can, under the right circumstances and with due consideration to the characteristics of government agencies in terms of roles, goals, policies and positions, drive the right behaviours.

We understand that under PNAP ADM-2, BD facilitates building professionals in the approval process whilst ensuring safety and health. For other comments relating to matters not governed by the Buildings Ordinance, AP/RSE/RGE may approach relevant government departments directly. In the event of divergent or conflicting requirements from different government departments, BD will typically organise meetings with the parties concerned to resolve the problem.

At the time of writing this report, there is not enough structured data on response times by consulted departments under CPS to form a view on the feasibility of, or benefits from, creating such KPIs. The planned implementation of the ESH, provides an opportunity to collect data on response times by consulted departments, which can help identify areas for improvement and possible development of clear pledges or KPIs where required. We recommend that after the establishment of ESH, and after a sufficient volume of data is collected, a periodic review is performed on response times from the consulted departments under the CPS to identify improvement opportunities for better management of the submission and approval processes.

After such a review is complete, **the relevant bureau (i.e., DEVB) can take the lead in terms of guiding consulted CPS departments to provide their responses within reasonable timeframes. Priority can be given to those processes which, based on data, are found to require a long period of consultation before obtaining approval**.

Figure 30 shows the flow of building plan submissions under circumstances where KPI on response time is suggested to be established in the processes.

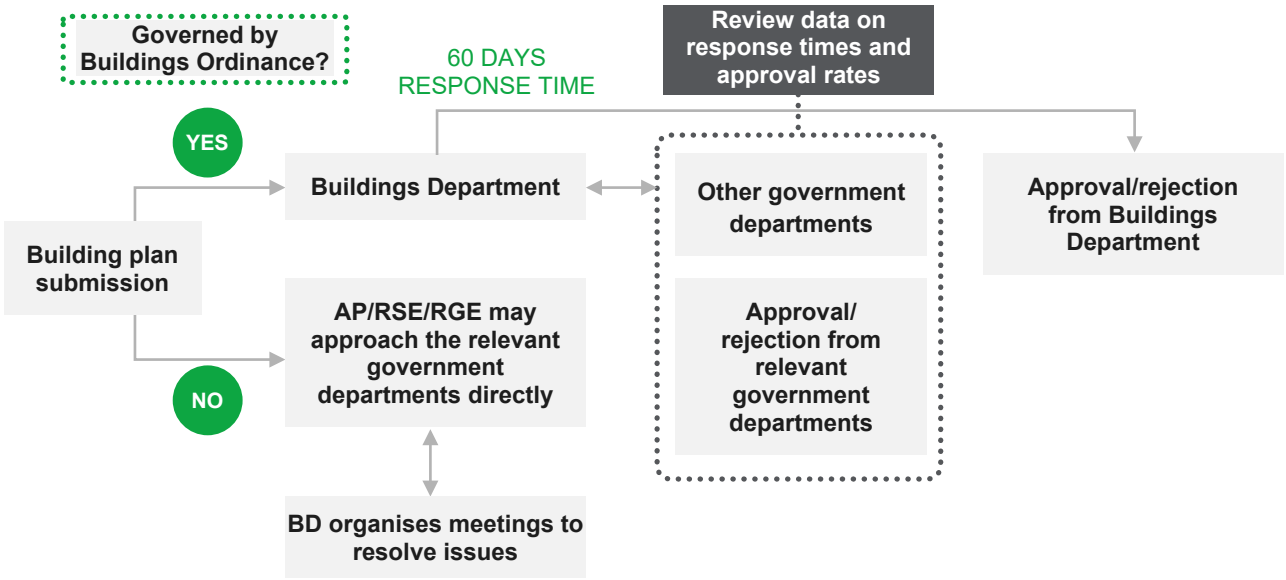


Figure 30 - Flow of submission in relation to response time

III. Improve communication amongst BD and other regulatory departments, APSEC and the industry

Currently, APSEC acts as the main communication channel to BD and practitioners via the APSEC members (Hong Kong SAR Buildings Department, 2020). The latest composition of APSEC includes six official members from BD, GEO, and LandsD and 10 non-official members from HKIA, HKIE, HKIS and AAP (see Figure 31). The communication channel relies heavily on the effectiveness of representation of a relatively small group of non-official APSEC members.

Industry stakeholders believed a more effective mechanism is needed to support communication. Specifically, the mechanism should capture and document senior government officers' decisions and ensure that these are cascaded down to all operational junior officers in government departments for them to follow.

For the communication of latest practices for design and construction works, BD will prepare, update, and issue PNAP on its official website for adoption by the industry (Hong Kong SAR Buildings Department, 2020). It is noted that BD and some other regulators (e.g., FSD) are starting to use webinars to reach out to practitioners. Apart from the benefit to regulators being able to convey clearly the intent of their new procedures and regulatory requirements, such a mechanism/channel should be welcomed by the industry as they could offer views and suggestions for improvement.

A preliminary review on the communication channel revealed that communication between non-official APSEC members and their corresponding members is mostly one-way. Announcements of discussion notes in APSEC meetings via emails or the website may not capture the wider industry's views and may limit the opportunity for further timely engagement and consultation.

The communication mechanism is recommended to be reviewed to ensure clear and direct reporting channels are in place for the resolution of industry issues. Also, it is suggested to improve transparency of the resolution process to gain better support from the industry.

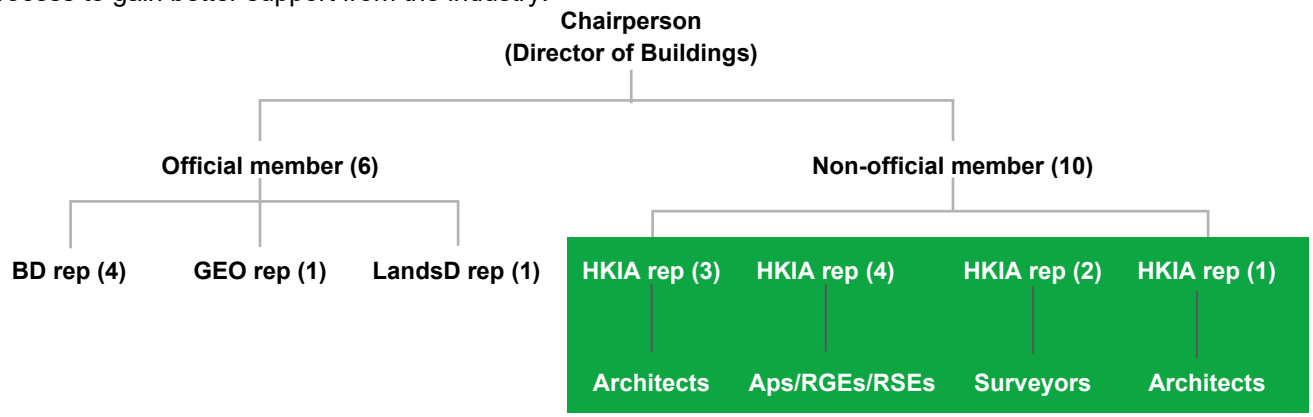


Figure 31 - Current organisation of structure of APSEC

4.4.3.2 Practical action plan

Table 19 illustrates the action plan for the three recommendations in short and medium terms.

	Assess and Expedite the Efficiency of the Approval Processes		
	Review and Streamline Existing Approval for Fast Track Processing	**Perform Data-Driven Review of Response Times by Consulted Departments**	**Improve Communication Mechanism amongst BD and Other Regulatory Departments, APSEC and the Industry**
Short Term	• **Government** to continue to collect stakeholders' feedback for streamlining approval processes	• **Government** to explore if there is suitable type of data that will be periodically reviewed in the ESH with relation to response times of consulted departments, as well the review time intervals and parties to be involved in the review	• **APSEC** members to propose an effective means of communication and workflow with practitioners to collect feedback on their concerns (e.g., requirements in codes and standards that significantly affect productivity, time, cost, quality, and sustainability performance) • **APSEC** members to disseminate the latest agreement with and information from BD to all practitioners in a timely manner, such as within one week of receiving BD's meeting notes, and organise regular open forums or co-organise them with BD and/or other regulators
Medium Term	• **Government** to consider setting up or utilising existing mechanism (potentially, Steering Group on Streamlining Development Control) to review approval processes on an ongoing basis to identify areas for further streamlining. Figure 32 illustrates the mechanism and its role.	• **Government** to review the data on these approval processes and prepare proposals that will improve efficiency, convenience, and transparency of services, with consideration to the different characteristics of government agencies in terms of statutory roles, goals, policies, and positions • **DEVB** may seek feedback from relevant CPS departments and industry practitioners, as appropriate, on proposed response time improvements. ○ Consideration would need to be given to how to best manage the consultation with a large number of parties involved (36 No.) and would require clear governance and decision-making authority. Priority on critical items with long	• **Professional bodies** to consider standardising and establishing the communication channel with their members, APSEC members, and the Joint Sub-committee on Streamlining Development Control • **BD** to consider continuing to supplement the outcomes of APSEC meetings with practices notes and amended clauses of relevant codes of practice regularly

		approval time is recommended. • **DEVB/BD and other consulted departments** to consider carrying out periodic reviews of ESH data on these approval process times • **BD** to consider embedding the improvements in the ESH if appropriate • **DEVB** to consider the feasibility of or benefits from creating KPIs on response time after the establishment of ESH when sufficient volume of data is collected	
Reference to Evidence	-	2016 Building Control Performance Standards, the UK	-

Table 19 - Short- and medium-term action plans for assess and expedite the efficiency of the approval processes

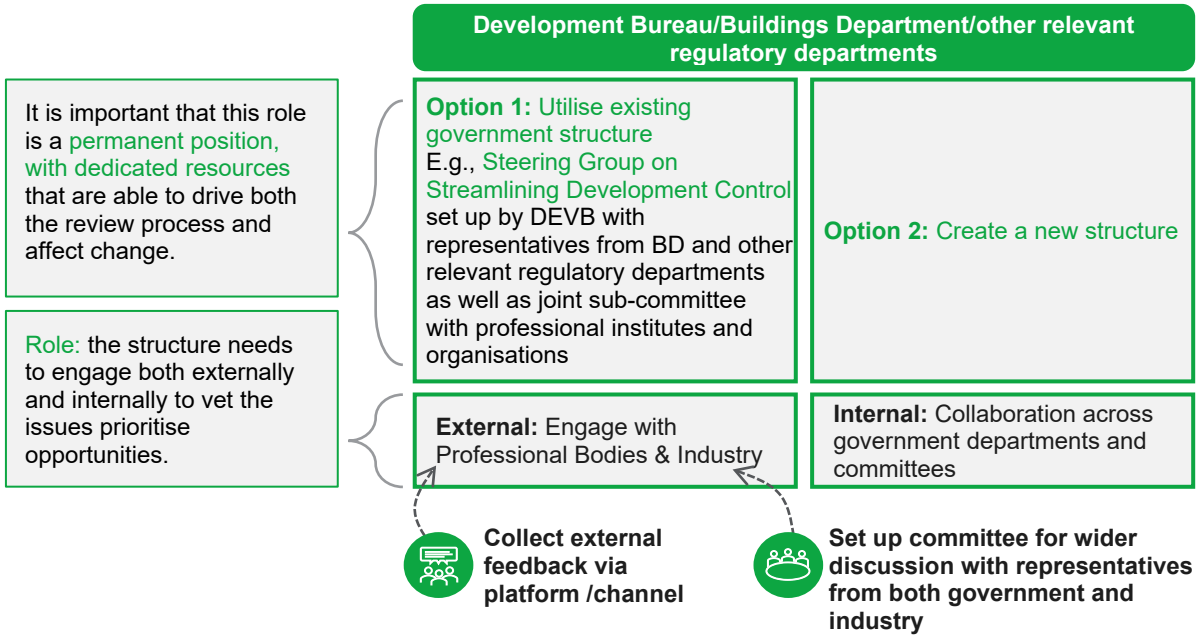


Figure 32 - Proposed mechanism for streamlining approval processes

4.4.3.3 Evidence

2016 Building Control Performance Standards, the UK

Led by the Building Control Performance Standards Advisory Group and the Department for Communities and Local Government, a revised guide to Building Control Performance Standards (the Standards) was published in 2006, providing protocols for local authorities and approved inspectors in England and Wales to follow and monitor the quality of services. Initially, the Standards were drawn up by a steering group comprised of the Local Government Association and the Association of Consultant. The document acknowledged the difficulties in measuring the success of building control in precise terms and suggested qualitative analysis should have a role in assessing the performance against performance indicators for continuous improvement. The document provided standards and guidance notes for nine attributes (see Table 20).

Attributes	Standards
Policy, performance, and management systems	Every building control body should create and publish a business policy for and have a formal documented quality management system for compliance to the standards and evidence of its performance.
Resources	Building control bodies should allocate sufficient resources and sufficient experienced and qualified staff to discharge their duties.
Consultation	Building control bodies should undertake statutory consultations in a timely manner and all comments should be communicated clearly to the client.
Pre-application contact and provision of advice	Building control bodies should establish a single point of contact for service. Early involvement is encouraged.
Assessment of plans	Communications with the client should be clear regarding compliance with regulations, views of statutory consultees, pertinent conditions, and solutions in event of a dispute. Records should be kept for future reference and control.
Site inspection	Site inspection plans should be matched to client needs. Contraventions in the event of non-compliance and relevant mechanisms for appealing should be communicated clearly to the responsible person.
Communications and records	Building control bodies should communicate in writing. All records should be stored in a retrievable format for a minimum of 15 years.
Business and professional ethics	When delivering services, the principle and building control functions should not be comprised. Building control bodies and supporting consultants should always observe best practice and professional standards.
Complaints procedure	Building control bodies should publish and maintain an appropriate procedure for complaints, where comments made by the person can be received and independently audited.

Table 20 - Standards and guidance for building

In reference to the experience of the UK and existing local practice of performance pledges, regulatory agencies in Hong Kong can provide high-level direction to continually monitor and improve the practice of service standards.

4.5 Enhancing project management and procurement

Following our review of best practices overseas and their suitability for the Hong Kong construction industry, a series of enhancements in project management (PM) and procurement strategies related to project collaboration platforms, professional qualification assurance, material testing methodology, and project management training are proposed. The strategies brought forward in this focus area aim to reduce construction time and project cost and enhance project quality by:

- Improving collaboration among clients, consultants, contractors and specialists
- Developing a centrally managed, consistent data platform for refined diagnosis and long-term improvement in Project Management and Procurement
- Assuring the qualifications for professionals
- Reducing time for on-site testing and supervision
- Equipping project managers with improved skills through training.

Associated challenges to the proposed strategies include:

- Increased complexity through the use of multiple project collaboration platforms
- Potential cost and time overrun issues due to the lack of Project Management capability
- Establishing and adopting new material testing methodology.

Table 21 illustrates how each strategy contributes to improvements on time, cost, and quality:

STRATEGY	TIME	COST	QUALITY
PM-1 **Development of Integrated Project Digital Platform**	AI and big data analysis could improve accuracy of initial estimates of project time and cost, and facilitate correct allocation of budget, time, and contingencies based on asset class and characteristics of the project.		A big data-enabled alert system for the project manager could help improve project management action times from the identification of issues.
PM-2 **Establish a Framework for Enhancing Project Management Skills**	N/A	N/A	Will improve the quality of project leaders by elevating the personnel standards, with enhanced levels of training and competencies.
PM-3 **Launch Product Certification for Construction Materials**	Will reduce time on on-site sampling, testing, and approval in project	N/A	N/A
PM-4 **Adopt Early Contractor Involvement (ECI) in Projects**	Could reduce time and cost through contractor's earlier engagement in the design stage		• Will encourage adoption of innovation • Will allow buildability of the design and construction risks to be reviewed and mitigated at an earlier stage of the project

Table 21 - Time, cost and quality impact of high-priority enhancing project management and procurement strategies

The following sections provide details on each of the strategies in response to the benefits and challenges stated above, with support from research and feedback from stakeholders.

4.5.1 PM-1 Development of integrated project digital platform

4.5.1.1 Description

Big data collection is not a new topic to the construction industry. With the production of millions of data in one single project, the key question is how this data can be effectively stored, used, and analysed to deliver better project control and planning. The strategy proposes that the Government should be the party that provides a centrally managed platform to be used in LegCo-funded projects on defined project types and enhanced with AI to make strategic decisions, standardise the workflow, and facilitate project collaboration and project planning.

We understand that the Government is focused on promoting digitalisation of public works project delivery. In the 2020-2021 Budget Speech, the Financial Secretary announced that HKD100 million would be allocated to develop an integrated digital platform for data integration and information exchange for the Government to collect real-time data on the progress and performance of public works projects. We understand from DEVB that the integrated digital platform for public works projects will be implemented in phases starting from 2022.

The aim of such an inter-departmental capital works project management system is to enable integration and analysis of data gathered from different works projects. The desired outcome is for the project personnel and departmental management to be equipped with the latest progress of the projects and to facilitate informed decision-making and effective project planning, ultimately reducing the possibility of cost overspend or delay.

4.5.1.2 Practical action plan

As the Government is currently in the progress of developing the platform and several associated initiatives have been planned or undertaken by DEVB, the following proposed actions may be supplementary or additional to the current planning for consideration.

Short Term

- **CIC** to support the development of the project digital platform if required, e.g., provision of information on labour return
- **CIC** to consider conducting a study to understand the fundamental needs and criteria for an integrated project platform and develop a list of service providers. Specifically, it is recommended to:
    - Research the existing project management/data platforms adopted in the industry, including the purpose, function, accessibility, and type of data stored.
    - Consult with relevant parties to leverage existing data sources (e.g., as CIC's CWRS and levy data or data in the CSDI), collect their requirements on functionality and data format, and understand expectations as to how this platform will be used to support their organisational objectives.
    - Gauge interest, ambitions, and requirements from the private sector and understand the private sector's willingness to make use of project data from such a platform, as well as benefit from resulting insights; consult with the private sector to understand privacy and confidentiality concerns to define the limits of what can be reasonably expected to be input by the private sector, and what the expected worthwhile trade-off can be.
    - Understand how the system works from implementation and data analysis through to operation, maintenance, and updates.
    - Identify any risk to the platform and the solutions.

Medium Term

- Riding on the project digital platform developed in the public sector, **CIC** to encourage stakeholders in the private sector to develop and adopt a similar digital platform

Relevant industry stakeholders should take into account the following considerations when developing the 'client requirements':

- Scale and scope of projects to be delivered using the platform, such as large-scale projects, capital works, repair, maintenance, additions, and alterations
- Customisation of the platform required to fit different project nature and asset types
- Engagement model, such as acquiring license from existing providers for tailored platform or development of a bespoke platform
- Training requirements for government departments
- Data management, including who will provide data, have access to it, how will it be interrogated, and what will be done with the learning
- Long-term maintenance and ongoing improvement based on market needs; the ability of the platform to expand with new modules that can connect and work with pre-existing data
- Data security
- Ability to combine with other existing platform/tools, such as digital supervision tool and BIM.

The proposed platform should allow and require key project participants to utilise the system and provide data. Without the input of data from external project parties, the data collected would be less comprehensive, impacting the potential for insights when undertaking analysis for project planning. As per the information gained during the stakeholder interviews, there are already companies in the private and quasi-government sectors that have adopted platforms to store data for analysis.

Figure 33 shows the operation cycle of the platform.

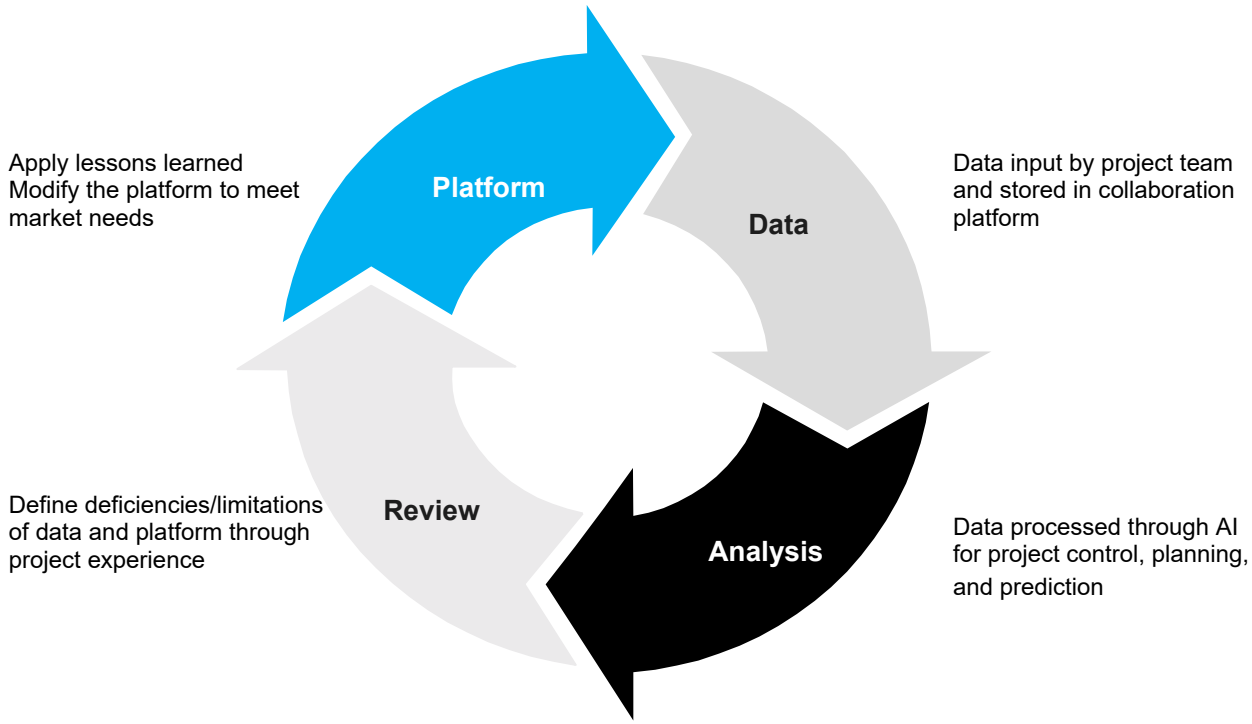


Figure 33 - Operation cycle for integrated project digital platform

4.5.1.3 Evidence

The government developed Electronic Project Management Platform (ePM) in the US and the private sector-developed nPlan from the UK provided the benchmarking for this strategy.

ePM platform by the Public Building Services of the US General Services Administration

The ePM platform hosted by Public Building Services (PBS) of the US General Services Administration (GSA) is a web-based tool that creates a collaborative work environment for PBS-sponsored design and construction projects. It allows project teams to consolidate planning, design, procurement, and construction into a single, collaborative system. ePM is being used for projects with values between USD25,000 and USD100 million. ePM features customised screens and tools to make navigating to information quick and easy, and the GSA

encourages all appointed contractors to adopt it for PBS projects (US General Services Administration 2019). Figure 34 shows the user interface of ePM.

Figure 34 - User interface of PBS ePM

Benefits of ePM include:

- Communicate instantly and securely with government teams: ePM provides a secure workspace to enable collaboration with project team members.
- Increase project efficiency: Design and construction stakeholders can develop schedules, manage budgets, collaborate online, manage contracts, and securely store drawings, photos, and other project-related documents through a single platform. Since the information is input to a centralised repository, duplication of data entry is minimised.
- Standardise technology and processes: ePM uses commercial-off-the-shelf software, increasing its compatibility with industry advances in project delivery.
- Learn best practices: Project teams can analyse data and trends across portfolios, programmes, and projects to optimise 'lessons learned' and value-engineering opportunities.

ePM demonstrates benefits of storing data in one single platform which allows collaboration among project teams. With big data embedded in the platform, project forecasting and planning can be enhanced. Hong Kong could take ePM as a reference to develop a similar accessible platform for storing and analysing project data.

nPlan, the UK

nPlan is a project management platform with machine learning technology which processes project data through AI and algorithms to better predict, plan, and schedule construction projects. Funded by Innovate UK (Great Britain, 2019), nPlan has been collaborating with a number of major clients and contractors, such as Atkins, Heathrow Airport, and Shell Oil Company (Atkins, 2020). Figure 35 shows how nPlan works:

Figure 35 - How nPlan works

Benefits of nPlan include:

- Increase transparency: Project risk and latest end date estimates can be accurately communicated through the platform.
- Enhance project planning: Greater certainty of time and cost based on AI analysis.

- Reduce contingency budget and claims: Risks are identified early in the project, reducing the incidence of time and cost claims due to uncertainty.

Compared to ePM which demonstrated a centralised platform to store and manage multiple projects, nPlan focuses on processing data for individual projects through AI from a database nPlan owns.

4.5.2 PM-2 Establish a framework for enhancing project management skills

4.5.2.1 Description

This strategy aims to bridge the knowledge gap between entry level practitioners, including those with limited or no experience who primarily learn 'on the job', and more experienced professionals from different construction disciplines (e.g., quantity surveying or engineering) who have transitioned into project management roles but are lacking core project management skills, and the various degree level and above academic courses available in Hong Kong. In addition, there is the opportunity to link up with project management professional bodies, their core competencies, and professional accreditations to deliver a cohesive career project management development path which can cater to different experience/qualification backgrounds.

The industry stakeholders expressed support for this strategy and highlighted the following issues relating to project management delivery in Hong Kong:

- No clear framework that outlines the competencies and capabilities required for project managers across different sectors
- Lack of specific training programmes and qualification standards dedicated to project management
- Lack of consistent professionalism across the industry for project managers.

One of the potential arrangements is that the project management framework will be set up and managed by the public sector in collaboration with educational institutions and professional bodies locally and internationally. For instance, DEVB established the Centre of Excellence for Major Project Leaders in July 2019 and launched its flagship project: Major Projects Leadership Programme (MPLP). Bearing similarities to the Major Projects Leadership Academy delivered by the Infrastructure and Projects Authority UK, DEVB created the MPLP with Oxford Said Business School to equip leaders with a more innovative minds and contemporary leadership skills. The MPLP will also involve project leaders from public organisations and private sector. Moreover, in the 2021-22 Budget Speech, the Financial Secretary reserved HKD6 million to enhance the professional skills of mid-tier managers in the Government and uplift their project delivery capability through provision of systematic training in the next three years, ensuring more effective use of public resources (Hong Kong SAR Government, 2021).

Improving the project manager's capabilities would potentially bring positive impacts to time and cost through the application of tried and tested project management processes consistently taught in line with industry best practices. The qualifications and accreditations obtained through the proposed framework may be worthwhile for the Government to refer to while considering the selection criteria for project manager roles during procurement.

Construction or project management training programmes are mainly offered by educational institutions in Hong Kong, while professional bodies in other countries can additionally offer this option. The Evidence Section explains how project management training programmes are developed elsewhere, with examples from the UK and Singapore. An overview of the programmes shows a range from diploma and bachelor's degree to master's degree level and is listed in Table 22. The programmes generally cover similar topics related to project management and are accredited by local and/or international professional bodies. The programmes are not designed for entry level, as the applicant must have already attained a certain level of educational qualification. For example, the BSc in Construction Management offered by the Vocational Training Council (VTC) has the lowest entry requirement amongst its peers; however, minimum of a higher diploma is expected for entry levels.

In Hong Kong, there are two professional bodies for construction/project management, namely the Hong Kong Institute of Construction Managers (HKICM) and the Hong Kong Institute of Project Managers (HKIPM). Neither of which offers structured project management training programmes.

In summary, there are currently limited project management training programmes offered by the Government[11] or local professional bodies, and the programmes run by higher educational institutions have minimum entry level

[11] For example, the Major Projects Leadership Programme and Project Delivery Capability Programme are under the Centre of Excellence for Major Project Leaders.

requirements. This means that there is a disconnect between experienced professionals from different disciplines who require a 'top-up' qualification or training that provides core project management skills and those who do not have a degree (or other minimum qualification or training requirement) but are now in a position where project management skills are required in their day-to-day role.

Institutions / Course name	Syllabus	General Entry Requirement	Accreditation
City University of Hong Kong PgD (Postgraduate Diploma)/MSc (Master of Science) in Construction Management	• Management principles • Financial management • Law and contract • Construction technology • Economics	Holder of a bachelor's degree or equivalent qualification	RICS
City University of Hong Kong SCOPE BSc in Construction Management	• Construction technology • Economics • Construction planning and programming, • Contract • Sustainability	Holder of associate degree/higher diploma in building-related disciplines or equivalent qualifications and meets English language requirement	• CIOB • HKICM • RICS • Quantity Surveyors International (QSi)
The University of Hong Kong SPACE Professional Diploma in Construction Project Management	• Construction planning and programming • Cost planning • Construction law • Technology • Project management practices	Holder of advanced certificate or equivalent qualification in construction or aged 23 years or above with minimum 3 years of relevant work experience	Professional Diploma in Construction Project Management Award issued by University of Hong Kong Space
The University of Hong Kong MSc in Construction Project Management	• Construction economics • Law and contracts • Project management practices • Health and safety • Procurement • Construction technology • Construction planning and programming	Holder of a bachelor's degree	• RICS • Major in Quantity Surveying (QS) is accredited by HKIS (QS) and Pacific Association of Quantity Surveyors (PAQS)
Hong Kong Continuous Professional Education Centre BSc in Construction Project Management	• Construction economics • Project management practices • Contracts • Civil engineering • Bid strategy	Higher diploma, associate degree, or professional diploma, or holder of relevant qualification with substantial work experience	• Chartered Association of Building Engineers (CABE) • CIOB • HKICM • The Hong Kong Institute of Clerks of Works (HKICW) • HKIPM • RICS

The Hong Kong Polytechnic University PgD/MSc in Project Management	• Construction economics • Law and contracts • Project management practices • Real estate • Construction technology • Construction planning and programming	Holder of a bachelor's degree preferably with 2 years of relevant work experience	• CIOB • HKIPM • RICS
Vocational Training Council SHAPE BSc (Hons) Construction Management (Offered by the Coventry University, UK)	• Contract management • Sustainability and innovation • Construction resource and quality management	• Graduate of the following VTC Higher Diploma programmes • Professional diploma programmes awarded with either merit or distinction	• HKICM • HKIPM • CIOB

Table 22 - Construction/project management programmes offered by major local educational institutions

4.5.2.2 Practical action plan

Short Term

- **CIC** to conduct a feasibility study on needs, extent and operating model of project management framework, options to be considered:
  1. Solely set up and operated by the public sector (e.g., CIC, VTC)
  2. Set up and operated by an appropriate industry organisation with collaboration with existing educational institutions (e.g., universities)
  3. Conduct further engagement with relevant trade bodies to identify and define the below:
     - The core competencies of project management by referencing other governments and professional bodies
     - The target group of participants
     - Mode of study
     - Programme curriculum.

Table 23 summarises the short-term action plan for the project management framework. Each of the items are linked with the relevant benchmarks and references discussed in the following section.

	Action Plan	Relevant Benchmarking
SHORT TERM	**CIC to conduct a feasibility study needs, extent and operating model of project management framework,** options to be considered:	-
	• Solely set up and operated by the public sector	Singapore Skills Framework
	• Set up and operated by an appropriate industry organisation with collaboration with existing educational institutions (e.g., universities)	Business and Technology Education Council (BETC) qualifications accepted by Universities as entry requirement
	• Conduct further engagement with relevant trade bodies to identify and define: ○ The core competencies of project management by referencing other governments and professional bodies ○ The target group of participants ○ Mode of study ○ Programme curriculum	• Singapore Skills Framework • RICS • BETC • Certification: Projects IN Controlled Environments (PRINCE2)/Association for Project Management (APM)/RICS/PMI (Project Management Institute)

Table 23 - Short-term action plan to establish a framework for enhancing project management skills

Role of project manager

As the roles (e.g., site supervisor and project manager) and sectors (e.g., developer, consultant, contractor) become diverse, each position may require specific project management skills in addition to the core competencies all project managers will need to possess, such as project planning, procurement, risk and financial management, contract administration, and team leadership. These 'specialist competencies' could include the following:

- Planning and design
- Land acquisition
- Commercial management
- Tendering and Contract management
- Site supervision
- Sub-contractors coordination
- Dispute resolution
- Legal compliance
- Asset and maintenance management.

Taking 'land acquisition' as an example, it is a skill that is more relevant to a developer project manager than a contractor project manager, as the former will be more focused in managing projects related to land purchase and sale procedures while the latter will focus more on construction-related/technical activities.

Core competencies

The project manager competencies are key to the framework. With reference to the benchmark in the Skills Framework (SFw) used in Singapore, which is discussed in Section 4.5.2.3, Table 24 lists some examples of core competencies for project managers that could be taken into consideration which can be identified in the short term (Royal Institute of Chartered Surveyors, 2017). Each competency should be measured with levels of achievement to demonstrate the understanding of context for that particular competency. As mentioned above, a different project manager role may require a different set of competencies, and some of the competencies may have been achieved by the person at different levels when obtaining professional qualifications. A gap analysis is required to identify training needs.

Digital and BIM skills will continue to develop as a core competency for project managers. This is reflected in the latest technical circular from DEVB (No.12/2020) which outlines the aim for developing BIM technical capacity across project teams and contractors/consultants to support the wider adoption of BIM in capital works projects.

Examples of Core Competencies	
People management	Commercial management and business negotiation
Communication and negotiation	Construction technology and environmental services
Rules, ethics and professional practice	Contract practice and dispute resolution
Risk management	Procurement and tendering
Programming and planning	Sustainability
Project administration	Value engineering
Health and safety	Project evaluation
Data management	Integrated digital delivery application such as BIM
Project cost management	Construction site management
Regulatory submission and clearance	Asset management and maintenance

Table 24 - Examples of core competencies for project managers

Training programmes and target group of participants

With the identified existing project management-related training programmes and the suggested competencies and roles for project managers, it is proposed that the training programmes should be designed based on the competencies defined, including the levels of knowledge and skills required in each competency. These would fit the different roles and levels of project management, with a review to be done to look at how existing training programmes offered can fit the defined competencies.

The target group of participants should cover all levels and roles of project management, as well as new entrants with limited project management knowledge who wish to join the field:

- New entrants: equipping new entrants with skills and knowledge for a specific job role in the sector at their respective entry level
- In-service employees: those who aspire to take on more challenging roles at work; training programmes for in-service personnel to broaden or deepen specific skills and knowledge for various job roles in the sector

Qualification obtained as to government projects

Through the qualification obtained in structured training (e.g., a professional training certificate by a recognised or accredited training institute like NEC accreditation), it is proposed that the Government should consider including the qualification as one of the criteria in the procurement process.

DEVB implemented a similar requirement for public works projects using NEC ECC which requires that the relevant key people of the contractor should possess a minimum number of years of experience managing NEC contracts or be an accredited project manager or supervisor (DEVB Practice Notes for NEC ECC for Public Works Projects in Hong Kong, October 2016). The CIC currently promotes accreditation courses with the NEC UK so that construction professionals can obtain the necessary NEC3/4 project manager and supervisor qualifications. The NEC (as part of the ICE) maintains a record of all accredited practitioners globally.

4.5.2.3 Evidence

International benchmarking for project management framework is described in this section according to the operational standards (public/private) and the curriculum offered. An example from the Government is SFw in Singapore as illustrated below. From the private sector, this section examines the project management training programmes offered by relevant professional bodies (e.g., APM, PMI, RICS).

Skills Framework in Singapore

SFw was jointly developed by SkillsFuture Singapore, Workforce Singapore, and the Building and Construction Authority (BCA) together with industry associations, training providers, organisations, and unions to provide information relating to the construction sector. It provides

information on career pathways, training programmes, occupation, and job roles with level of qualifications and core competencies clearly identified in each role throughout the project manager pathway (SkillsFuture Singapore, 2020). SFw is for those who wish to join the construction industry to assess their career interest, identify relevant training programmes to upgrade their skills, and prepare for desired job roles. SFw covers various occupations including project manager. Core competencies are defined into two areas:

- Technical skills: dispute resolution, project management, project risk management, and regulatory submissions and clearance
- Critical core skills: 16 core skills under three categories being thinking critically, interacting with others, and staying relevant (SkillsFuture Singapore, 2020).

Built upon the work functions, a set of technical skills and competencies are defined as qualifications of a project manager. Different ranks of project managers (assistant project manager, project manager, senior project manager, project director, etc.) require different levels of attainment against the competencies. Table 25 shows the levels needed by a senior project manager.

Technical Skills and Competencies			
BIM application	Level 4	People management	Level 4
Business negotiation	Level 4	Procurement coordination and policy development	Level 4
Condition-based assets monitoring management	Level 4	Project cost	Level 4
Construction technology	Level 4	Project feasibility assessment	Level 4
Continuous improvement management	Level 4	Project management	Level 5
Critical thinking	Level 4	Project risk management	Level 4
Data collection and analysis	Level 5	Quality system management	Level 4
Design for maintainability	Level 2	Regulatory submission and clearance	Level 4
DfMA	Level 4	Stakeholder management	Level 5
Design for safety	Level 3	Technical writing	Level 3
Dispute resolution	Level 4	Technology application	Level 4
Emergency response management	Level 4	Technology scanning	Level 4
Engineering contract management	Level 4	Value engineering	Level 3
Green building strategy implementation	Level 4	Workflow management	Level 4
Incident and accident investigation	Level 3	Workplace safety and health culture development	Level 4
Integrated digital delivery application	Level 3	Workplace safety and health framework development	Level 4
Manpower planning	Level 4		

Table 25 - Technical competencies of senior project manager

Workforce Skills Qualifications in Singapore

The Singapore Workforce Skills Qualifications (WSQ) is a national credential system that trains, develops, assesses, and certifies skills and competencies for project management roles in the workforce. Training programmes developed under the WSQ system are based on skills and competencies validated by employers, unions, and professional bodies. This process ensures existing and emerging skills and competencies that are in demand are used to inform training and development under WSQ (SkillsFuture Singapore, 2018). Benefits for WSQ include:

- For individuals, career mobility and certifications of skill sets for future project management job opportunities
- For employers, quality assured and industry-relevant training choices for their employees
- For project managers, career stream becomes more attractive.

The two benchmarks from Singapore provide a sample structure of a national qualification framework and definition of core competencies that standardises the qualification of project managers and provides a clear career pathway.

Business and Technology Education Council qualification in the UK

The Business and Technology Education Council (BTEC) developed the Vocational Qualification for school leavers who wish to proceed with further study as an entry route to higher education or develop in a particular

career or sector. In the UK, more than 95% of UK universities and colleges accept students with BTEC qualifications, including universities from the Russell Group (Pearson Education Ltd, 2020). BTEC qualifications cover a wide range of levels which are equivalent to other academic qualifications in the UK:

- BTEC Firsts, also known as BTEC Level 2 qualification, are equivalent to General Certificate of Secondary Education.
- BTEC Nationals, also known as BTEC Level 3 qualification, are equivalent to A levels.
- BTEC Higher Nationals, also known as BTEC Level 4 or Level 5 qualification, are equivalent to the first year or first and second year of an undergraduate degree.

In each level, BTEC provides Extended Diploma, Diploma, or Extended Certificate to further classify the levels of each qualification. BTEC qualifications focus on practical training with employers' involvement, including apprenticeships and on-the-job training; therefore, students have the opportunity to learn first-hand from practicing professionals and real employment environments. Figure 36 shows the construction-related courses at BTEC Level 3.

Suite	Qualification Number	Title
Pearson BTEC Level 3 Nationals (QCF)	500/7138/5	Certificate in Construction and the Built Environment
	500/7140/3	Subsidiary Diploma in Construction and the Built Environment (QCF)
	601/1095/8	90-credit Diploma in Construction and the Built Environment (QCF)
	500/7137/3	Diploma in Construction and the Built Environment (QCF)
	500/7139/7	Extended Diploma in Construction and the Built Environment (QCF)
Pearson BTEC Level 3 Nationals (QCF)	603/0862/X	Extended Certificate in Construction and the Built Environment
	603/0863/1	Foundation Diploma in Construction and the Built Environment
	603/0864/3	Diploma in Construction and the Built Environment
	603/1218/X	Diploma in Building Services Engineering
	603/1217/8	Diploma in Civil Engineering
	603/0861/8	Extended Diploma in in Construction and the Built Environment
	603/1219/1	Extended Diploma in Building Services Engineering
	603/1216/6	Extended Diploma in Civil Engineering

Figure 36 - BTEC Level 3 construction related course

The BTEC qualifications can be a useful reference for the project management framework in terms of setting the level equivalent to local academic qualifications, as well as the training mode which will allow active participation of employers and professionals.

Project management training and programmes by international professional bodies

Relevant international project management professional bodies are identified in the list below.

Association for Project Management (APM), the UK

- APM (2020) is a chartered body for project management professionals, providing levels of training leading to Project Fundamentals Qualification, Project Management Qualification, and Project Professional Qualification.
- A variety of certificates for experienced project managers are also available from the APM, such as Certified Associate in Project Management and Project and Program Management Professional.
- APM qualifications offer a clear route to achieving both the Chartered Project Professional and the APM Registered Project Professional standards.

Project Management Institute (PMI), the US

- PMI (2020) is a global professional organisation for project management which offers a project management curriculum, including a wide range of modules.
- The modules cover different levels, from foundation levels to more advanced levels (PM1 to PM12).
- It provides various certifications upon completion of training for different areas of expertise, such as PMP, CAMP, and PgMP.

Royal Institution of Chartered Surveyors (RICS)

- RICS is a globally recognised professional body which includes a route for professional chartership in project management.
- RICS (2020) provides training in project management, including Certificate in Construction Project Management.

Project management certification — PRINCE2 in the UK

PRINCE2 is a process-based method for effective project management providing fundamental skills to become a successful project manager (ILX Group, 2020). The certification is split into two levels:

- Foundation: an introduction to PRINCE2 principles, themes, and processes to consistently deliver projects on time and within budget, manage risk, and mitigate perceived problems.
- Practitioner: applies and tailors PRINCE2 appropriately to address the needs and problems of a specific project scenario.

Major Projects Leadership Academy by the UK Government and University of Oxford

Major Projects Leadership Academy (MPLA) was developed by the Infrastructure and Projects Authority in the UK and is run in partnership with the Saïd Business School, University of Oxford. The academy builds the skills of senior project leaders across government, making it easier to carry out complex projects effectively. No one is able to lead a major government project without completing the academy programme (University of Oxford, 2015). MPLA deploys teaching and learning approaches that are appropriate for the profile of the people who make up the UK Government's project leader community. MPLA is endorsed by the APM.

Competency Domain	Description
Leadership of self	Distinguishing the self-knowledge to allow leaders to know how to maximise their leadership impact on projects
Leadership of major projects	Distinguishing those leadership attributes which are most germane to major projects ('temporary organisations'), compared to the leadership of ongoing operations
Commercial leadership	The competency to provide commercial leadership and exert effective control over the 'extended delivery team' across organisational boundaries
Technical leadership	The competency of appropriately applying the principles, disciplines, and tools to programme and project management to support the leadership of project

Table 26 - Competency defined in MPLA

MPLA is supported by a competency framework and a curriculum. The competency framework describes the qualities/characteristics major project leaders should possess to conduct their project leadership role effectively as shown in Table 26. The curriculum was designed to link up with the competencies. Table 27 illustrates one of the modules connected with the competencies.

Module 1: Breaking Away: from 'managing projects' to 'leading temporary organisations'			
Leadership of Self	**Leadership of Major Projects**	**Commercial Leadership**	**Technical Leadership**
Embracing the challenge of leading major projects, questioning existing ideas and approaches, and	*Being the leader of 'temporary organization', not manager of a scaled-up project; engaging and leading internal and*	*Comprehending the historical performance of major projects, which is poor and not improving*	*Examining whether conventional approaches to project management are fit for purpose in a major project environment;*

Module 1: Breaking Away: from 'managing projects' to 'leading temporary organisations'			
contributing to finding new ways through engaging	*external stakeholders through vision*		*understanding organisation design theory and practice*

Table 27 - Curriculum linked with the competency defined in MPLA

The main purpose and direction for MPLA is to act as a training school for project managers who are or will be working on major government projects and develop them to be senior project leaders qualified in the core competencies set. MPLA is an example of collaboration between the Government and an educational institution with accreditation by professional bodies, focusing on enhancing project management standards in government projects.

4.5.3 PM-3 Introduce product certification scheme for construction materials

4.5.3.1 Description

In Hong Kong, some construction materials will need to be sampled on delivery to site and tested and approved for acceptance in the contract. Taking steel reinforcing bars as an example, they are to be sampled and tested after delivery from the QA manufacturer to the site and then accepted or rejected. The site approval process takes one month on average, including approximately one week for the QA stockist to receive and certify the steel reinforcing bars and about two to three weeks to be tested and approved on-site. Due to the volume of steel reinforcing bars needed, this process would need to be done by batches, resulting in a prolonged process. Figure 37 illustrates the existing mechanism for steel reinforcing bars sampling, testing, and approval.

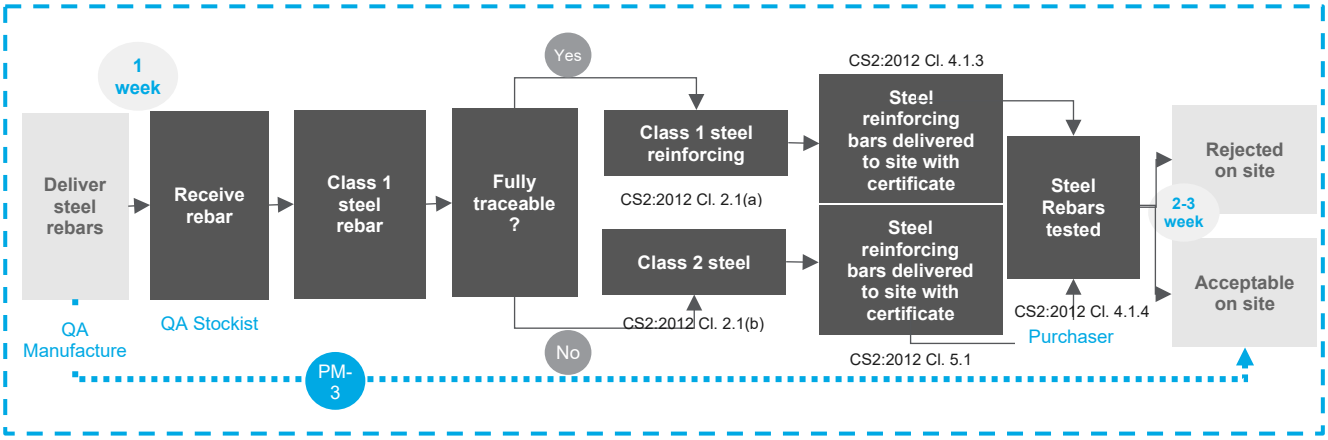


Figure 37 - Existing mechanism for steel reinforcing bars testing and approval process in Hong Kong

Before the steel reinforcing bars are delivered to site, they have to be tested in a laboratory accredited under the HOKLAS to obtain certification (Hong Kong SAR Innovation and Technology Commission, 2020). Such practice is required by government departments as noted in the General Specification for Building Works by the Architectural Services Department (2017) and Construction Standard (CS2) by the Civil Engineering and Development Department (2012). Apart from HOKLAS, The Hong Kong Quality Assurance Agency (HKQAA), and the Hong Kong Certification Body Accreditation Scheme (HKCAS) carry out quality assessment and assurance services which cover construction materials. However, this currently does not include steel reinforcing bars.

During the stakeholder engagement, it was noted that steel produced in the same batch and tested by the approved laboratory would need to be tested again for different projects. In this instance, the view was that there should be a universal rebar criterion and approval system among government departments, whereby when one batch is approved and certified, it should be applied to all projects to minimise time.

An open and transparent system maintained by the Government that fosters a large pool of certified manufacturers, especially based in the Greater Bay Area, who meet the local standards is encouraged. Supported by the proximity to Mainland China, the reliance on a handful of manufacturers can be avoided by an abundance of suppliers for reinforced steel. Details on how the system works and whether this could be developed on top of the existing accreditation services such as HOKLAS, HKQAA, and HKCAS are outlined in the following section.

In addition to the time saving benefits, it has been demonstrated internationally by the Certification Authority for Reinforcing Steels (CARES) programme in the UK that a certification system can bring cost reductions while ensuring quality through a robust continuous review, monitoring, and verification mechanism. A proposal completed by CARES on the Hong Kong Product Certification Scheme in 2019 stated the benefits of the certification system relating to time and cost (CARES Hong Kong Limited, 2019):

- Testing reduced to a minimum of 45 days
- Removal of project-specific product test fees which significantly lead to a saving of around HKD100,000 for a lot size of 3,500 tonnes. With rebar demand of 1.4 million tonnes per year in Hong Kong, the projected annual saving could reach HKD40 million. In addition, the annual cost of wasted reinforcing steel will be reduced by at least HKD52.5 million.

In the 2009 Policy Address, testing and certification services was as one of the six key industries for driving Hong Kong towards a knowledge-based economy. During the same year, the Government appointed the Hong Kong Council for Testing and Certification to formulate a market-oriented development plan for the testing and certification industry, and selected four trades in the development plan, including Chinese medicine, food, jewellery, and construction materials.

In light of this, the Hong Kong Housing Authority (HKHA) has implemented product certification in its construction projects in 12 types of building and building services materials since 2010 as illustrated in Table 28.

Building Product (Year of Rollout)	Product Conformity Certification Scheme Owner
Timber doorsets (fire resistance) (2010)	Hong Kong Institute of Steel Construction
Panel walls (fire resistance) (2010)	
Cement products (2010)	Hong Kong Concrete Institute
Tile adhesives (2010)	
Ceramic tiles (2010)	
Repair mortars (2010)	
Aluminum windows and 4-bar hinges assembly (2011)	Hong Kong Institute of Steel Construction
uPVC drainage pipes and fittings (2013)	Hong Kong Institution of Plumbing and Drainage
Close-couple water closet suites (2013)	
Mesh reinforcement (2013)	Hong Kong Concrete Institute
LED lighting products (2016)	Hong Kong Electronic Industries Association
Paint products (2017)	Hong Kong Association for Testing, Inspection and Certification

Table 28 - HKHA's product conformity certification scheme

The benefits associated with HKHA's product conformity certification scheme include:

- Promoting industrial quality through upstream control
- Continuous surveillance of production process in factory to ensure consistent production quality
- Greater confidence on product quality to recognised standards
- Enhancement of product reputation (product certification mark), hence, business opportunities and competitiveness.

However, on-site sampling and additional laboratory testing for products with product certification are still required to check compliance with standards/contract requirements.

Currently CEDD is maintaining two lists of quality assured stockists for supplying steel rebars to public works projects in Hong Kong — the lists are for CS2:2012 and CS2:1995 —where these manufacturers are not required to go through the submission of material specifications for approval. However, on-site sampling and laboratory testing are still required even when rebars are supplied by the on-the-list quality assured manufacturers.

We understand that DEVB is developing a product certification scheme for steel reinforcing bars for public works projects and has conducted a feasibility study on the adoption of PCS for rebars covering the whole supply chain, including manufacturers, stockists, and rebar prefabrication yards. DEVB is collaborating with CEDD to appoint a suitable party to develop the PCS and supporting central data repository. At this time, the Government has no plan to implement the PCS for other construction materials.

To strengthen the benefits, this strategy suggests **putting forward the steel reinforcing bars product certification scheme proposal to the private sector and expanding the scheme to include other widely**

used construction materials that may require further sampling and testing before contract acceptance and use. The process will be subject to demonstration of robustness in the supply process to ensure traceability of the materials delivered on-site to QA manufacturers to shorten the approval time.

This strategy can further link with AP-1 on e-inspection system to facilitate the inspection process and the traceability of steel and other off-site manufactured materials by the use of bar code, RFID, or QR code to enhance the robustness of ensuring quality materials are being used in construction.

4.5.3.2 Practical action plan

The Hong Kong Accreditation Service (HKAS) administers the operation of HOKLAS, HKCAS, and the Hong Kong Inspection Body Accreditation Scheme. HKAS offers accreditation to laboratories under HOKLAS and certification bodies under HKCAS. Application for accreditation is open to any laboratory or certification body which provides a third-party testing or product certification service for specific construction materials and products. Earning accreditation is a recognition of a laboratory's or certification body's capability to perform specific activities to meet certain accreditation criteria and does not guarantee individual results or equate with product certification.

For contract and regulatory compliance, reinforcing steel bars are currently required to be tested by laboratories accredited by HOKLAS for them to be issued HOKLAS-endorsed test certificates for a particular accredited test. HKCAS will accredit certification bodies, such as HKQAA, to provide third-party product certification service for construction materials, including reinforcing steel bars, concrete, mortars, pipes, and tiles.

However, the practice focuses on **conducting contract-based sampling and testing on manufacturers' products rather than certifying the quality of the products from manufacturing sources (factories) and ensuring the robustness of the processes of product supply to sites**. Testing has to be conducted each time before steel is delivered to site. With reference to the international benchmarking of UK CARES in the following section, it is recommended to look into the possibility of allowing certification of products from manufacturers and suppliers. Short- and medium-term action plans include:

Short Term

- **CIC** to reference the practice learned from UK CARES in reinforcing steel bars certification system, the experience of Singapore Civil Defence Force in regulating fire safety products and materials, and the approach taken by HKHA in certifying construction products. CIC to also consider conducting a feasibility study to define which widely used construction materials require long on-site sampling, testing, and approval processes to be included in product certification schemes that will be set up if there are benefits to do so. The study should include the following considerations:
    - Which widely used construction materials in Hong Kong require sampling, testing, and approval in the contracts and what are their existing sampling, testing, and approval procedures?
    - Are there construction delays due to the time required for testing and approval of such materials?
    - What is the supply chain of the identified construction materials? Understand the market of their manufacturers/suppliers in Hong Kong, Mainland China, and other international regions.
    - Can the accreditation agencies (HOKLAS and HKCAS) and certification bodies (e.g., HKQAA) be utilised and what changes in the industry are required to support the roll out of the product certification scheme? Can other international assessment bodies be accepted to provide third-party testing/inspection or product certification service?
    - Can scheme owners be found for the product certification scheme? Potential conflict of interest, fairness, or capability should be considered when selecting scheme owners.
    - If feasible, **CIC** to outline some potential ideas on product certification for other widely used construction materials. This may include the development of a digital platform to operate the scheme, covering the QR code and RFID components.
        - In reference to Singapore Civil Defence Force's experience of regulating fire safety products and materials (see details in Section 4.5.3.3), it is recommended to develop a product risk classification system based on product risks factors (e.g., quantities of use, past quality performance, and consequence of deficiency). Products in different risk levels could be regulated under the schemes with different surveillance methods.

Medium Term

- **CIC** to extend and promote the steel reinforcing bars certification scheme to the private sector
- **CIC** to review the performance of the certification scheme, including time, cost and quality performance
- **CIC** to promote the scheme to the construction industry and explore the maturity of developing other similar schemes.

4.5.3.3 Evidence

The CARES programme in the UK and Product Listing Scheme in Singapore provide the benchmarking for this strategy.

UK Certification Authority for Reinforcing Steels

CARES is an independent body that offers certification to companies that produce materials and components or provide services within the reinforced concrete industry. CARES' scheme for the reinforced steel market in the UK has a technical approval process for companies to register on their system and become a CARES-certified steel rebar supplier (UK Certification Authority for Reinforcing Steels, n.d.). The process is open and transparent and allows any qualified global company to be a CARES-certified supplier if approval is granted. Product conformity certification for reinforcing steel is based on continuous monitoring and verification of product performance against recognised standards. CARES operates a thorough regime of regular product testing at independent laboratories that reflects the critical nature of the products. Approvals and certifications are gained by manufacturers only after demonstrating that their quality systems meet the requirements of ISO 9001:2008 and any additional product-specific CARES requirements (UK Certification Authority for Reinforcing Steels, 2011).

The CARES technical approval system was structured to ensure the highest possible technical integrity for the benefit of product end users. All CARES technical approvals are covered by the UK Accreditation Service, which is an independent verification of the integrity and transparency of the scheme.

CARES issues six different certificate types to ensure that the product type, process, and size are included in the certificate and that the certificate is of the relevant type (UK Certification Authority for Reinforcing Steels, n.d.):

- Management System Certification
- Product Conformity Certification
- Product Installation Certification: for specialist post-tensioning contractors and covers the installation of post-tensioning systems
- Technical Approval Certification: for non-standard products
- Sustainable Reinforcing Steel Certification
- Construction Products Directive Certification: CARES may issue two certificates related to this — a Certificate of Factory Production and an EU Certificate of Conformity — depending on the applicable system of attestation required by the technical specification for the product (i.e., those relating to factory production control certification and those relating to product certification).

CARES has proven the success of a steel reinforcement certification system with its transparent approval process and a large pool of companies that meet stipulated standards to be registered as a CARES-certified manufacturer. As of 2020, more than 300 global manufacturers have been registered and approved into the CARES system (UK Certification Authority for Reinforcing Steels, 2020).

Although there is concern that with the effect of Brexit, quota and tariffs may be imposed in the UK for steel rebar imports from EU countries which will potentially lead to monopoly problem as the UK has one sole domestic rebar producer, Celsa, which owns 40%–50% of the country's downstream fabricators. The monopoly issue would not be a risk in Hong Kong due to two reasons: Hong Kong's geographical location and tariff policy (Great Britain Office of Fair Trading, 2009).

Located close to Mainland China, there is an abundance of suppliers for reinforcing steel where promotion of a certification system should encourage a large pool of manufacturers to meet standards and join the certification database. With such a large pool, reliance on a handful manufacturers could be avoided.

In terms of policy, Hong Kong would have less of a potential tariff and quota issue with importing from Mainland China or India compared to the UK due to domestic laws, meaning a monopolistic situation can be avoided.

Product Listing Scheme for fire safety products in Singapore

Singapore's Fire Safety and Shelter Department (FSSD) issued a list of regulated fire safety products. Any material that is intended for fire safety works would be deemed acceptable to FSSD if listed under the Product Listing Scheme (PLS), and its use is in compliance with the requirements specified in the Fire Code. (SCDF, Fire Code 2018 2018)

The listed products are categorized into three certification schemes complying with the requirements stipulated in ISO/IEC 17067:2013 (Conformity assessment — fundamentals of product certification and guidelines for product certification schemes)[12]:

Scheme Type 1b

Scheme Type 1b consists of type testing of a sample of a production and subsequent batch inspection. Every subsequent batch shall also be tested or inspected. Regulated fire safety products certified under this scheme type are issued with a Declaration of Compliance (DoC) or product labels which are displayed on the products. Some examples include auditorium sets, fire damper, and fire shutter/fire curtain.

Scheme Type 2

Scheme Type 2 consists of type testing of a sample during initial certification and market surveillance (i.e., warehouse, project site, etc.). Market surveillance is conducted, and samples of the product from the market are assessed for ongoing conformity. The products under this scheme type are issued with a Certificate of Conformity (CoC). Some examples are home fire alarm device, material for wall/ceiling/floor construction, and roof covering material.

Scheme Type 5

Scheme Type 5 consists of testing, factory inspection, and ongoing assessment of the quality management system, including auditing the production process and management system. Surveillance of the quality system is conducted either from the market or at the point of production, or both, to ensure that products meet the requirements. Regulated fire safety products certified under Scheme Type 5 are issued with product labels or a DoC. Some examples are fire pump, fire-rated partition, and fire-rated duct system.

The regulated fire safety products under PLS are regulated by Singapore Civil Defence Force. These products are tested by laboratories accredited under the Singapore Accreditation Council's laboratory accreditation scheme or recognised under the International Laboratory Accreditation Cooperation Mutual Recognition Agreement/Arrangement between Singapore and other countries. To enhance accountability and traceability, the certification bodies will issue product labels with unique serial numbers that allow tracing of these products to their CoC and the installation location of each product.

With a classified product certification system, the PLS supports the industry in fulfilling regulatory requirements and ensures that regulated fire safety products conform to safety, reliability, and performance standards. This scheme provides a reference for Hong Kong to develop a product certification scheme for the steel reinforcing bars or other potential construction materials.

4.5.4 PM-4 Promotion of benefits of early contractor involvement in projects

4.5.4.1 Description

Early contractor involvement (ECI) is an approach whereby contractors, design teams, and key supply chain (e.g., material suppliers and logistics service providers) are integrated early in the project life cycle. The aim is to improve teamwork, innovation, and planning that ultimately results in clear definition of values to the client and

[12] ISO/IEC 17067:2013 is intended for use by all with an interest in product certification and, especially, by certification scheme owners. It describes the fundamentals of product certification and provides guidelines for understanding, developing, operating, or maintaining certification schemes for products, processes, and services.

financial and time efficiencies. It also brings high quality input/innovation from contractors and their supply chain at an earlier stage in a project's life cycle.

From the stakeholder engagement, there were mixed views on the benefits of adopting ECI, with the client side supporting the idea of adopting ECI while contractors voiced a number of reservations. On the client side it was stated that ECI can help identify early risk items and develop appropriate design solutions during the ECI period. However, contractors highlighted that ECI could result in additional cost and effort which are frequently not compensated.

In the context of new engineering contract (NEC), ECI is stated under NEC4 as a secondary option X22 and only used with main option C (target contract with activity schedule) and main option E (cost reimbursable contract), or an additional Z-clause under NEC3 which involves two stages (Institution of Civil Engineers, 2019):

- Stage 1 allows a contractor to be appointed to assist/lead the design development before details of what is to be constructed have been fully developed and priced.
- Stage 2 provides the opportunity for the client to decide whether or not to proceed with the Stage 2 (construction stage) with the original contractor.

A typical procedure of ECI is illustrated in Figure 38.

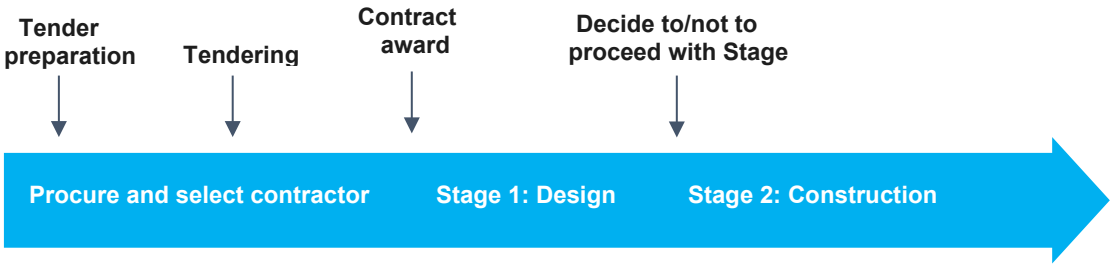


Figure 38 - Typical procedure of ECI

In this proposed strategy, **ECI is not limited to the NEC framework. Instead, it is proposed to adopt and promote ECI in all forms of contracts,** such as general conditions of contract and NEC, for appropriate project types and scales. Figure 39 demonstrates the options for adoption of ECI in different forms of contracts.

In Hong Kong, the DEVB established the Inter-departmental Working Group on NEC Pilot Projects and the Steering Committee on NEC Pilot Projects to drive the wider application of ECI for public works projects. The Steering Committee is currently identifying suitable public works projects to trial different ECI models (not limited to Secondary Clause X22 of the NEC4).

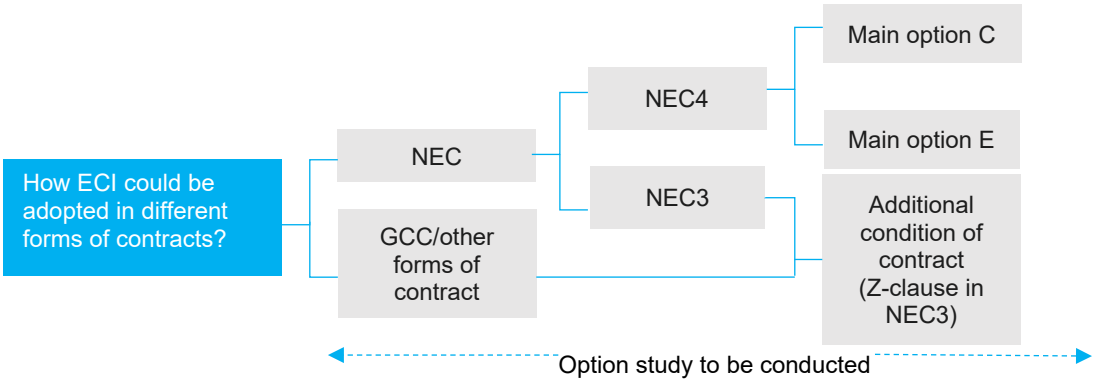


Figure 39 - ECI adoption in different forms of contracts

4.5.4.2 Practical action pan

Short Term

- **CIC** to conduct a thorough study on the applicability, benefits and challenges in the adoption of ECI in the private sector.

Medium Term

- Subject to the findings of the study mentioned in short-term action, **CIC** set up a working group to promote the adoption of ECI in the private sector. The working group may serve the following functions:
  - Develop a selection mechanism for ECI projects in the private sector, including the following steps:
    I. Conduct a feasibility study to define/set out the types and scale of projects suitable for adopting ECI in the private sector. Factors to consider:
       - Is the design complex, and are there high risks which could affect time, cost, and quality?
       - Is fast-track design and construction process required for major elements?
       - Are the scope of works and the 'designer' poorly defined or undefined?

    II. Conduct a procurement options analysis to match the different project types to the right form of contract in the private sector. This includes the consideration on adopting NEC or other form of contract, and a comparison of the mechanisms adopted.
  - Conduct a **joint study with contract professionals** to identify the risk of adopting ECI in the private sector, such as a potential conflict of interest or fairness for a contractor who has been involved in Stage 1 (detailed design, buildability and risk assessments, and development of risk control and mitigation measures) being at an advantage in Stage 2 (tendering). Amendment / additional rules may have to be introduced to ensure full compliance with the high standards of corruption prevention as required by the Independent Commission Against Corruption (ICAC). Reference can be made to the ICAC assignment study (2013) on the payment system for target cost contracts and NEC Practice Notes (2016).
  - Recommend pilot projects in private sector to opt for ECI based on the selection mechanism.
  - Review and measure the performance of pilot projects in the private sector that are examined in terms of time, cost, and quality.
  - Review the ECI contract terms on provisions allowed for lost tenderers for their designs and ideas contributions at Stage 1 to encourage contractors' involvements in the private sector
  - Share experiences and views from the current public works of the Steering Committee on NEC Pilot Projects through a structured working group forum.
- **Working group on ECI** to review the performance of ECI projects in terms of time, cost, and quality performance, and to modify the selection mechanism in the private sector.

Concern on conflict of interest and unfairness

As raised during the stakeholder engagement and feedback in the MTR Corporation case study in the section below, there is a concern on fairness in competition for tenderers involved in Stage 1 design, having an advantage of early access to project information given they participated in the concept design development. However, this does not necessarily mean that they will be able to provide the best and cheapest tender. It is critical to clearly define the award criteria by the client when tendering for Stage 2, as well as allowing other tenderers reasonable time to prepare and open transparent communication (i.e., all tenderers receive the same tender package, responses to tender queries are copied to all tenderers, and clear tender briefings are provided to all). Therefore, it is suggested in the short term to conduct a joint study with contract professionals to review how the contract terms and tender arrangements can be improved.

4.5.4.3 Evidence

This section includes examples of ECI adoption in Hong Kong, the UK and Australia, demonstrating the benefits and examining how ECI could be adopted. Currently, there are a number of projects that have been carried out in the public sector using NEC option C or E, in particular by the Drainage Services Department. However, ECI was not adopted on all of these projects meaning that there is limited data.

In the private sector, case studies adopting ECI have been taken from the UK, Australia, and Hong Kong.

Shatin to Central Link Contract SCL1121 Cross Harbour Tunnels, Hong Kong

The Shatin to Central Link (SCL) is part of the Hong Kong Government's Railway Development Strategy 2000 and is a major infrastructure project connecting the New Territories and Hong Kong Island and crossing the Victoria Harbour by an undersea tunnel. The project was managed by the MTR Corporation and the scope included a 1.75km immersed tube tunnel with a contract value of HKD4.3 billion (Penta-Ocean Construction Ltd., 2015) under construction Contract SCL1121. Contract SCL1121 commenced in 2012 and was planned to be completed by end 2020.

ECI was adopted in the first stage of tendering for a technical assessment of the contract. With the involvement of the contractor, this step was aimed at assessing the buildability and identifying the potential changes to design and specification. Subsequently, the focus of the second stage was to develop the tender which would include the technical assessment with time and cost implications based on the result/findings from the first stage.

Figure 40 indicates the project timeline with ECI and the subsequent achievements at various stages.

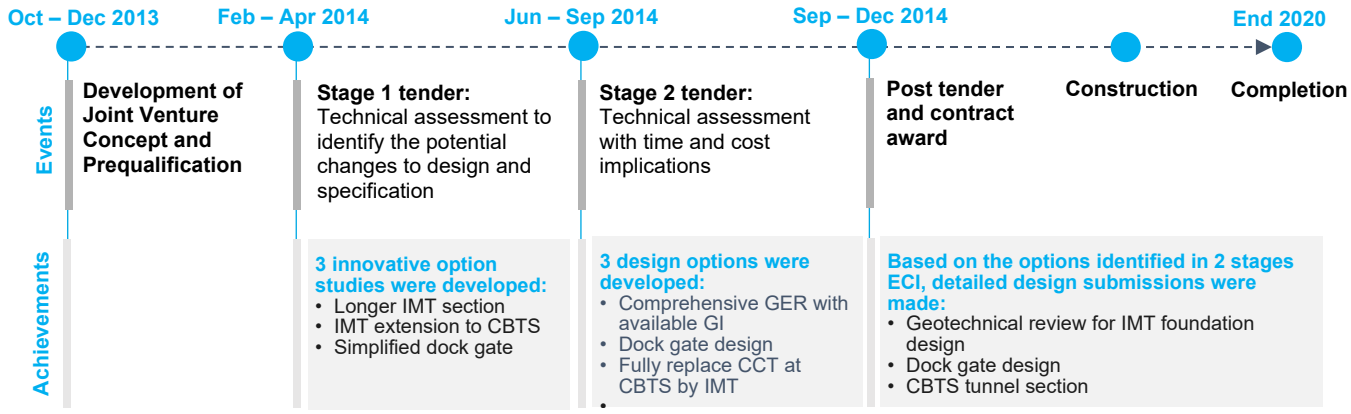


Figure 40 - Project timeline for Contract SCL 1121 with achievements on ECI adoption

There were three key benefits identified from the adoption of the ECI approach based on feedback from our stakeholder engagement:

- ECI provided an effective approach to explore alternative design and technical solutions which facilitates constructive discussions between MTR Corporation and relevant government departments during the early stage.
- ECI allowed an integrated team to gain a comprehensive understanding of the project and contract requirements, develop innovative solutions, plan and mobilise resources, and manage risks to achieve project delivery and control costs.
- From a client perspective, the risk premium was a fair trade-off for fewer retained risks (e.g., design) and greater time and budget certainty.

We note that the SCL case also demonstrated that there are opportunities for improvement in some elements of the ECI approach. Specifically:

- Bidding costs were considered high by losing tenderers.
- Some tenderers were uncertain about elements of the award process, e.g., clarity on the number of contractors to be prequalified at Stage 1.

Alternative forms of contract, such as NEC, could be considered to enable the contractor to take part in the design development and construction planning stage of a project. Specifically, NEC developed an additional clause to be included in the NEC3 engineering and construction contract (ECC) options C and E where an ECI approach is required. The additional clause focusses on promoting collaboration through the whole construction process and sharing the benefits gained.

Hong Kong Academy, Hong Kong

Hong Kong Academy was the first private sector NEC project to incorporate ECI in Asia. The project scope included the construction of a new 20,000m^2, five-storey campus, featuring classrooms, learning support facilities, international standard gymnasium, and a multiuse performance space containing a 350-seat auditorium.

The contract used was NEC3 ECC option C with a target contract value of HKD365 million (Institution of Civil Engineers, n.d.).

Benefits of ECI highlighted:

- ECI provided greater certainty of delivery on time and provided some ability to accommodate design development during construction while managing within a fixed budget.
- Transparency of the contractor's costs and implications of changes allowed the client to evaluate in real time if design changes could be afforded or needed to be adjusted.

Bank Station capacity upgrade, the UK

London Underground undertook a major capital project to expand Bank Station to support its network capacity upgrade. The work to enlarge the station consisted of major civil engineering, including moving the Southbound Northern Line tunnel approximately 20m westward. The works involved specialist tunnelling, civil engineering, high-voltage power engineering, communications systems, lift and escalator works, as well as building and M&E work. A two-stage approach was adopted, with the first stage of procuring a contractor to work alongside the project team during feasibility and concept design stages allowing constructability and programme advice to be given. The output of this stage was a compliant scheme design which was then used as the basis for the second stage, a tender for the construction works (Institution of Civil Engineers, 2015).

Benefits of ECI highlighted:

- Demonstrated GBP63 million cost saving, which is >10% of the total project sum
- Ideas and input from the contractor in the first stage were paid even if they were not incorporated into Stage 2.
- Built trust between the client, contractor, and supply chain, reducing miscommunications and misunderstandings at an early stage.

However, the Bank Station case revealed issues arising from ECI:

- The contractor that provided input in the first stage was incentivised to hold back ideas that could deliver major cost savings, as those can provide commercial advantage for their bid for the next stage.
- Some contractors feared that major savings ideas were taken and added to the compliant design for all contractors to bid against in the second stage.

To tackle the issues, London Underground developed and implemented the Innovative Contractor Engagement approach for Stage 1. Tenderers involved in Stage 1 entered a 'confidential engagement' where London Underground engaged with each tenderer for ideas development. Ideas were not shared across tenderers. Validated ideas were then taken forward into the tender at Stage 2. All tenderers were paid for participating in the confidential engagement stage and unsuccessful tenderers were paid for the subsequent use of their innovative ideas.

Bruce Highway, Australia

ECI was adopted in two of the Bruce Highway upgrade projects, namely Bruce Highway upgrade — Caloundra Road to Sunshine Motorway and Bruce Highway duplication to increase capacity and traffic flow.

Bruce Highway upgrade—Caloundra Road to Sunshine Motorway

With a project sum of AUD1.13 billion, the project included upgrades to the Caloundra Road and Sunshine Motorway interchanges to replace the existing at-grade ramp intersections. Two stages of ECI approach were taken with two tenderers shortlisted to engage in Stage 1 on design development with the project team (Australia Queensland Government Department of Transport and Main Roads, 2015).

Benefits of ECI highlighted:

- Gathered ideas from two tenderers at Stage 1
- Created an interactive process by participating in design, risk, and cost planning workshops between project teams and contractor
- Developed innovative solutions
- Gained early acknowledgement of project risks and details.

Bruce Highway duplication

The Bruce Highway duplication project included widening the highway from two to four lanes, constructing a four-lane bridge and an off-road cycle path, with a budget ranging from AUD394.8 million to AUD481 million (Australian Government Department of Infrastructure, Transport, Regional Development and Communications, 2020). Similar to the Bruce Highway upgrade project, ECI was adopted with the involvement of two tenderers in the preliminary design process. A major benefit highlighted by the Queensland Minister for Transport and Main Roads of using ECI was the opportunity to consider design alternatives from tenderers which provided balance between functionality, project cost, and construction impacts, as well as better integration of innovative construction methods into the design (Australian Government The Hon Michael McCormack MP, 2018).

To summarise the ideas from the five example projects above, ECI allows early risk identification, so potential delay could be foreseen and mitigated. It enhances the relationships between the project manager, client, and contractors, encouraging collaboration and transparency. It can also deliver improved project outcomes in terms of time, cost, and quality.

05
Conclusion

5 CONCLUSION

The purpose of this report is to provide suggestions for consideration which may be complementary or additional to current planning. This consultancy study made reference to the Phase 1 Study, *Improving time, cost, and quality performance of the Hong Kong construction industry,* from a few years ago to further deepen the understanding and to translate the diagnostics into practical impactful plans through a stakeholder engagement with industry leaders and consultations through industry forums. As such, we developed 13 high-priority initiatives in four focus areas — shifting to high-productivity construction, driving innovation, streamlining approval processes, and enhancing project management and procurement — which have significant potential to improve the time, cost, and quality performance of the construction industry in Hong Kong. Table 29 illustrates, in a qualitative manner, the expected improvements in time, cost, and quality performance.

It is noted that the Government has implemented initiatives to streamline existing policies and procedures/processes or introduced new ones. The various CIC boards and committees (in particular, CITAC Board and the BIM, Productivity, and Construction Business Development Committees) also have strategies and initiatives in their respective areas. An example is the recently completed review on the quality site supervision practices of the Hong Kong construction industry which resulted in eight recommendations for improving the current site supervision standards by advancing the professionalism of key parties and maximising the use of digital technologies. Many of these strategies and initiatives will produce outcomes that could help enhance the time, cost, and quality performance of the construction industry. The high-priority initiatives in the four focus areas proposed under this study will be complementary to these efforts, which are not all mentioned in this report.

Most if not all of the proposed initiatives will require common will, consensus, and collaboration amongst various industry stakeholders to successfully achieve a transformation in the construction industry. Furthermore, the impact of the synergistic effect of the different initiatives has the potential to multiply measurable improvements. For example, improving contract terms to promote wider adoption of MiC and MiMEP can also involve adoption of e-inspection tools as in AP-1. As such, we wish to stress that the key relevant parties and individual players will want to consider their participation and be actively and collaboratively engaged, as the goal of improving the efficiency of our industry is common and benefits all.

Shifting to High Productivity Construction			
STRATEGY	TIME	COST	QUALITY
ID-1 **Development of Digital Library to Facilitate MiC and MiMEP**	• Off-site construction provides improvement across construction cost, design, and built quality, and in productivity, safety, and sustainability performance. • Promotion of supply chain integration with the Greater Bay Area will enable performance improvement through provision of scale.		
ID-2 **Support and promote MiC and MiMEP**	N/A	Advocacy initiatives and, possibly, other incentives will address the initial cost barriers associated with adopting MiC and MiMEP.	Use of an assessment tool will help measure industrialisation efforts of the different construction sectors and, ultimately, will progressively drive improvements in construction quality.
ID-3 **Build up Industry's Capability on MiC and MiMEP**	N/A	N/A	Expansion of MiC Resources Centre will drive industry-wide improvements in implementation quality of MiC and MiMEP by offering technical standards, professional consultation, and training services.
ID-4 **Improve Contract Terms to Promote Wider Adoption of MiC and MiMEP**	Introduction of suitable contract terms and provision of payment mechanisms for off-site manufacturing will facilitate the adoption of MiC and MiMEP.		

Driving Innovation			
STRATEGY	**TIME**	**COST**	**QUALITY**
I-1 **Establish a Construction Innovation Platform**	The CIP will shorten the cycle of innovation from R&D through to prototyping and commercialisation.	N/A	N/A
	The platform will identify more innovative technology solutions to be developed and applied to address time, cost, and quality issues.		
I-2 **Generate Eco-system for Innovation through Tendering**	The strategy is believed to be one of the potential measures in encouraging development and implementation of innovative methods and technologies that can improve time, cost, and quality and achieve additional value for the project.		
Streamlining Approval Processes			
STRATEGY	**TIME**	**COST**	**QUALITY**
AP-1 **Develop an Integrated Digital Submission and Approval Process** [13]	<u>i. Encourage and Facilitate Submissions Generated from BIM Models to BD</u>		
	Will reduce processing time by: • Omitting circulation of hard copy submissions • Will enhance efficiency of overall submission process	N/A	BIM could effectively screen out major deficiencies, errors, and non-compliance items.
	<u>ii. Develop Automated Design and As-built Checking Tools for Accelerated Approval</u>		
	• Automated tools could effectively and objectively screen out major deficiencies, errors, and non-compliance items. • Will improve the quality of submissions so as to facilitate approval and may reduce processing time		
	<u>iii. Adopt a Full E-inspection System</u>		
	Will enhance the efficiency of the inspection approval process by reducing time for arranging on-site inspections and audits involving a lot of parties	Will save cost and manpower travelling to sites and/or factories	Will allow for quality check through e-inspection anytime anywhere
	<u>iv. Extend Spatial Data Requirements to the Private Sector</u>		
	Will reduce time for obtaining information from scattered sources and for resolving conflicts with the stakeholders	N/A	N/A

[13] For "Streamlining Approval Processes", the salient components of each strategy are provided, followed by the time, cost, and quality impacts underneath.

	Will enhance the predictability of the project programme, which may impact on-time performance and the quality of work and offer opportunity for exploring cost and time savings and alternative designs or project delivery options		
AP-2 **Extend the List of Minor Works Exempted from BD Design Submission**	Reduce approval time by decreasing the workload of regulatory bodies	N/A	N/A
AP-3 **Assess and Expedite the Efficiency of the Approval Processes**	**i. Review and Streamline Existing Approval for Fast Track Processing**		
	Need review to further streamline the approval processes and explore the potentials to further reduce the impact of approval time on project delivery programme	N/A	N/A
	ii. Perform Data-Driven Review of Response Times by Consulted Departments		
	KPI on response time could provide an objective basis for an increase in the productivity of the approval process.	N/A	N/A
	iii. Improve Communication Amongst BD and other consulted departments, APSEC and the Industry		
	Enhanced communication amongst BD and other consulted departments, APSEC, and industry practitioners could increase the overall efficiency and quality of the projects	N/A	Enhanced communication amongst BD, APSEC, and industry practitioners could increase the overall efficiency and quality of the projects
Enhancing Project Management and Procurement			
STRATEGY	**TIME**	**COST**	**QUALITY**
PM-1 **Development of Integrated Project Digital Platform**	AI and big data analysis could improve accuracy of initial estimates of project time and cost, and facilitate correct allocation of budget, time, and contingencies based on asset class and characteristics of the project.		A big data-enabled alert system to the project manager could help improve project management action times from the identification of issues.
PM-2 **Establish a Framework for Enhancing Project Management Skills**	N/A	N/A	Will improve the quality of project leaders/managers by elevating personnel standards, with enhanced levels of training and competencies.

PM-3 **Introduce Product Certification Scheme for Construction Materials**	Will reduce time on on-site sampling, testing, and approval in projects	N/A	N/A
PM-4 **Promotion of Benefits of Early Contractor Involvement in Projects**	Could reduce time and cost through contractor's earlier involvement in the design stage		• Will encourage adoption of innovation • Will allow buildability of the design and construction risks to be reviewed and mitigated at an earlier stage of the project

Table 29 - Summary of 13 strategies over four focus areas with improvements to time, cost and quality performance of the construction industry

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Appendices

APPENDIX A — TEN ROOT CAUSES

The Phase 1 Study identified 10 root causes that have significantly impacted the industry's time, cost, and quality performance. These were presented across six distinct phases in a project's life cycle: i) project approval, ii) procurement strategy, iii) delivery strategy, iv) detailed design, v) design approval, vi) project delivery and close-out.

We recognise that the Phase 1 Study did not explicitly distinguish amongst the three key sectors in Hong Kong, i.e., public, quasi-government, and private sector. This is addressed in Section 4 where the Description and Action Plans sections provide further clarity and make direct reference to the relevant affected sectors. For example, under Root Cause 4, the key issue of 'awarded to lowest price rather than best value' is more relevant to some projects in the private sector, as the government has implemented value-for-money-based procurement that requires evaluation of both technical and price competitiveness.

In addition, we recognise that since the Phase 1 Study was issued in 2017, there have been a number of developments within government and the industry that changed the past practices. As above, we looked to address this disparity in Section 4 of the report whereby we reference recent initiatives in Hong Kong and internationally. For example, under Root Cause 5 'unrealised benefits of BIM and prefabrication', it was recognised that there have been significant developments in BIM and MiC, including government initiatives such as DEVB TC(W) No. 12/2020 — where capital works projects with project estimates more than HKD30 million have to use BIM technology — and DEVB TC(W) No. 2/2020 — where MiC shall be adopted for new building works of suitable building types and accommodations.

Nevertheless, Table 30 summarises these against each stage of the aforementioned phases for completeness.

As the first work steam in the project life cycle, project approval covers the activities of the planning of a business case, including project schedule and budget.	• Industry lacking project management capability can lead to an optimistic initial budget and programme for approval, which will consequently set project underperformance. • The rate of increment in total work volume outrun the rate of increment in the labour pool and the uncertainty of new work forecast. The industry has experienced a steep growth in the gross value of construction work since 2007, while the unmatched skilled labour pool not only affects construction cost but also time. In addition, delays in the funding approval process generate uncertainty for the business planning of stakeholders to deploy the resources to satisfy the increased new project volume.
Procurement strategy is developed during the planning phase of the procurement life cycle, and it relates to the process for considering and deciding the most appropriate delivery model and approach to the market for a specific project.	• Preference on the use of design-bid-build with fixed-price lump sum procurement. Design-bid-build is the most common delivery method in Hong Kong where the owner looks for bids from contractors to perform the work after the designer completes the design documents. This linear process leads to less collaboration between designers and contractors and obstructs the use of innovative methodologies while ensuring lower costs. • Design-bid-build procurement in Hong Kong does not allow sufficient time for tenderers to propose their solutions during the tender stage. Project team and tenderers have no time to evaluate and control the risks associated with the contractor's proposal. It leads tenderers to take up all the risks on their own, as the project designers will not have time or are less willing to collaborate with the tenderers especially on matters related to the statutory approval or major change of the whole scheme or layout which has not been explored previously.
Delivery strategy is defined as the sequence of construction phases; development of innovation, standards of site management, and control; and the efficient input of resources.	• No incentive to implement innovation. Driven by the lowest-cost mindset, owners often have less consideration of construction methodologies to be adopted during the construction phase.

Detailed design involves preparation of detailed design and specifications to support tender and construction phases.	• There were three root causes identified under this stage in the Phase 1 Study, but none of those were recognised as most impactful under Appendix F of the Phase 1 Study.
Design approval involves the preparation and submission of different types of prescribed design documents to a statutory body for approval.	• Conservative approval and stringency on compliance. Statutory bodies in Hong Kong tend to focus on procedural compliance rather than encouraging innovation.
Project delivery and project close out will finalise the project team and acquire all essential resources needed to accomplish the tasks laid out in the planning documentation. This phase will create the tangible product or service and verify the success or failure of the project in terms of time, cost, and quality.	• Lack of appeal to new entrants. The industry is perceived as being dangerous, dull, and dirty. The poor image and social status of the industry have discouraged young people from joining the workforce. • Limited labour pool. The increase in work volume of the industry can result in a labour shortage compounded by an ageing workforce. • Tradition of labour-intensive methods. The industry is still based on outdated labour-intensive practices, and there is a finite incentive to adopt innovative construction methods referring to off-site fabrication. • Challenging natural and congested urban environment for construction. Hong Kong's subtropical climate, hilly and mountainous terrain, and compact urban land create challenging site conditions for construction.

Table 30 - 10 most impactful root causes identified in the Phase 1 Study

APPENDIX B — ROOT CAUSES AND KEY ISSUES AFFECTING TIME, COST, AND QUALITY PERFORMANCE

Similar to Appendix A, Table 31 combines the root causes, key issues, and identified impact on time, cost, and quality criteria for completeness.

Root Causes		Proposed Strategies that Diagnosed the Root Causes	Key Issues	Identified Impact		
				Time	Cost	Quality
1	**Industry lacking project management capability**	PM-2	Unjustified design work and contractor scope to cater for public requests	Construction schedule overrun Claim for extension of time Prolonged final accounts settlement	Claim for additional works	Insufficient resources at project closing stage
2	**Optimistic initial budget and programme for approval**	PM-1, PM-4, AP-1	Optimistic programme leads to overruns and poor quality	Construction schedule overrun Claim for extension of time Prolonged final accounts settlement	Claim for additional works	Unrealistic programme leads to poor construction quality
			Client's changes			Insufficient resources at project closing stage
3	**Rate of increment in total work volume outruns rate of increment in the labour pool and uncertainty of new work forecast**	ID-1, PM-1	Shortage of labour and skilled professionals	N/A	High construction costs	N/A
			Design consultants are under-resourced and design staff lack experience.		High level of material wastage and disposal costs	Poor design and submission quality
			Delivery effort diverted to completing the design		High supervision and administration costs	N/A
4	**Preference on the use of design-bid-build with fixed price lump sum procurement**	I-2, PM-4	Awarded to lowest price rather than best value	N/A	High supervision and administration costs	Bids are tailored to lowest price Lost opportunity to specify methodology Lack of attention to buildability Outdated labour-intensive practice
			Inflexible payment mechanisms and unhealthy cashflows	Uncertainty in time required for statutory inspections resulting in prolonged final accounts settlement		
			Ineffective implementation of QA and control	Low fee claims conscious behaviour, resulting in prolonged final	Low fee claims conscious behaviour, resulting in extensive claim resolution	QA system not guaranteeing quality Large number of defects and slow defect rectification

Root Causes		Proposed Strategies that Diagnosed the Root Causes	Key Issues	Identified Impact		
				Time	Cost	Quality
				accounts settlement		Insufficient resources at project closing stage
			Insufficient design fee and period which restrict optimisation opportunities to be evaluated sufficiently during the tender process with very limited duration allowed for the contractor to come up with effective design proposals that could benefit the whole project	N/A	Delivery effort diverted to completing the design, resulting in high supervision and administration costs	Poor design and submission quality
			Inappropriate risks allocation and risk control measures	N/A	High construction cost due to uncertainty	N/A
5	**No incentive to implement innovation**	ID-2, ID-3, ID-4, I-2	Unrealised benefits of BIM and prefabrication	N/A	High level of material wastage and disposal costs	Lack of attention to buildability Outdated labour-intensive practice
6	**Conservative approval and stringent on compliance**	I-1, PM-3, AP-1, AP-2, AP-3	Approvals are taking longer and with less certainty	Potential impact on tight programme due to prolonged approval process hindering innovation	N/A	Case officers often place more emphasis on procedural compliance rather than practicality or fostering innovation
			Procedural burden in obtaining approvals from multiple departments	Potential overruns Construction schedule overrun	Potential overruns Claim for additional works	Insufficient resources at project closing stage
			Congested utilities, including some uncharted ones, and	Claim for extension of time Prolonged final accounts settlement	High construction costs Claim for additional works	N/A

Root Causes		Proposed Strategies that Diagnosed the Root Causes	Key Issues	Identified Impact		
				Time	Cost	Quality
			traffic congestion			
7	**Lack of appeal to new entrants**	PM-2	Ageing workforce Limited labour pool	N/A	High construction costs	Shortage of labour and skilled professionals
8	**Tradition of labour-intensive methods**	I-1, I-2	Reluctant to change and be exposed to unnecessary risk Adopted new technologies without proper guidance or customisation which reduces efficiency and financial viability No obligation or client requirement imposed in the contract for adoption of new technology	Outdated labour-intensive practice	Outdated labour-intensive practice High level of material wastage and disposal costs High supervision and administration costs High construction costs	N/A
9	**Limited labour pool**	PM-2	N/A	Inadequate labours to progress site works	High construction costs	Shortage of Labouré and skilled professionals
10	**Challenging natural and congested urban environment for construction**	N/A	Uncertain and lengthy approval process to meet the prescriptive and stringent acceptance criteria, such as ground settlement value, stipulated by regulatory bodies	Construction schedule overrun	Cost and time claim Prolong final accounts settlement High construction costs	N/A

Table 31 - Root causes and keys issues effecting time, cost and quality identified in the Phase 1 Study

APPENDIX C — STAKEHOLDER ENGAGEMENT QUESTIONNAIRE

Four focus areas of the study

1. Do you find the four focus areas all-encompassing in terms of improving the construction industry in Hong Kong?
2. Which of these four focus areas do you feel is the most impactful in improving the construction industry in Hong Kong?

Strategy discussion — standard questions for each strategy

3. Do you believe this strategy is impactful in improving the time, cost and quality performance of construction industry in Hong Kong?
4. Are there any challenges/ difficulties you anticipate for the implementation of this proposed strategy? If so, what are they? Possibilities could be:
    - Regulatory
    - Industry readiness
    - Appetite or inertia
    - Special interests
5. What do you think are possible solutions to these challenges?
6. Who do you see as the natural owner of such an initiative? Beyond the owner, which industry stakeholders do you feel should be involved in the process? (Note: Arcadis to refer to the individual strategies and check the parties involved in the 'HOW' section)
7. Please assess the strategies under your allocated focus area according to its impact on time, cost, and quality and practicality/feasibility.

Impact on TCQ

Practicality	Not Significant	Moderate	High
Very Feasible	Medium Priority	High Priority	High Priority
Somewhat Feasible	Low Priority	Medium Priority	High Priority
Not Feasible	Low Priority	Low Priority	Medium Priority

8. Are there any other strategies beyond what we have identified that will achieve the objectives of this focus area? Any other strategies you wish to discuss?

Specific points for discussion for each strategy

Shifting to High-Productivity Construction	
I-1 Development of P-DfMA	• Is there synergy between P-DfMA and CIC's BIM library? • Is there economy of scale for the wide adoption of P-DfMA? • Would the Government be supportive of developing the • platform? • Would mass manufacture reduce cost, and what is the critical mass? • Is there adequate capacity with the manufacturers? • Would a P-DfMA platform need regulatory change? • Would the industry be inclined to using P-DfMA? • Is there enough demand in Hong Kong, or should this be a joint effort with the Greater Bay Area?
I-2 Support DfMA applications through government incentives	• Can the current GFA concession amount be applied to DfMA adoption (i.e., similar to the current 6% of MiC floor area)? • Would the Government be supportive of updating existing scoring mechanism and widening of the funding scope? • Is there a need in the industry for land requirements to drive DfMA (i.e., setting aside land for prefabrication yards)?
1-3 Package of measures to strengthen DfMA supply chain	• Would the industry welcome these measures, and will they use them? • Would the Government be supportive of developing these guidebooks/training programmes? • Is there a need in the industry for land requirements to drive DfMA (i.e., setting aside land for prefabrication yards)?
1-4 Establish DfMA excellence centre with technical experts	• Is there synergy between this proposed DfMA excellence centre and DfMA Alliance? • Is there enough demand for DfMA consultancy support from the industry? • Would the Government be supportive of this excellence centre and provide funding? • Is there a demand for this in Hong Kong, or should this be a joint effort with the Greater Bay Area?
Driving Innovation	
ID-1 Establish innovation advisory board (IAB)	• Would the Government be supportive in leading the formation of an advisory board? • Would the Government and CITAC be supportive of the two core functions of this advisory board? • Would the advisory board require regulatory change?
ID-2 Establish construction innovation platform (CIP)	• Would the Government be supportive of the platform and be willing to co-fund it? • Is there synergy between existing organisations (e.g., CITAC) and the proposed platform? • Would the industry be willing to join the platform and work collaboratively? • Would the industry be supportive of the proposed approach of commercialisation of innovation?
ID-3 Adopt innovation and creativity screening (ICS) in tender phase	• Would the industry welcome the idea of ICS? • Would the Government be supportive of ICS?
ID-4 Expand performance report to include innovation	• Would the Government be supportive of updating the current assessment criteria and in taking the lead to develop incentive mechanisms? • Is there synergy between the proposed strategy and the current core system of Module 5 of BES(E) where innovation of a project is assessed?
ID-5 Establish an overarching entity and incentive mechanism to encourage R&D investment by private sector	• Would DEVB be supportive of establishing an overarching entity? • Would the industry be supportive of developing incentive mechanisms and greater R&D involvement?
Streamlining Approval Processes	
AP-1 Establish electronic submission hub with BIM submission for streamlined design approval	• Is there synergy between the proposed system and other existing electronic submission systems (i.e., HePlan)? • Would an electronic submission hub require regulatory change (i.e., electronic transactions ordinance)? • Would the government be supportive of this strategy (i.e., standardise use of BIM)?

AP-2 Standardise and provide training for BD officers on scope of checking, approval criteria, and use of BIM	• Would the government be supportive of this strategy?
AP-3 Review and streamline existing approval for fast-track processing	• Would the government be supportive of streamlining existing approval process? • Would the industry be supportive of these identified opportunities for streamlining approvals? • Is this in line with the Government's latest development regarding streamlining approval process?
AP-4 Review of communication mechanism and channel between BD, APSEC, and the industry	• Would BD accept this reporting channel? • Would the industry welcome this reporting channel? • Would the professional bodies agree on the standard communication channel?
AP-5 Establish key performance indicator on response time for consulted departments	• Would the government be supportive of establishing a key performance indicator on response time?
AP-6 Incentivise the use of a centralised registration of technically competent persons (TCPs)	• Would the Government hold and maintain the TCP Registration System? • Would a centralised system require regulatory change? • Would the industry welcome this centralised system?
AP-7 Develop automated design checking tools for accelerated approval	• Would the Government be willing to own the automated design checking tools? • Would the implementation of the tools require regulatory change? • Would the industry welcome the tools? • Would function of the tools be expanding in future?
Enhancing Project Management and Procurement	
PM-1 Shift ownership of project collaboration platform to the Government	• Would government take ownership of the project collaboration platform? • Are there any regulatory constraints that would hinder the government's ability to take ownership of the project collaboration platform? • Can budget be found for this? • Could it act as add-on to DWSS?
PM-2 Establish project management qualification standards for project leaders	• Does this improve the standard of project delivery, in particular for leaders of complex projects?
PM-3 Drive consultant fee assessment practice that doesn't result to 'race to bottom'	• Are there any regulatory constraints that would prevent elimination of lowest and highest bids prior to evaluation?
PM-4 Introduce a mandatory steel reinforcement certification system	• Are there any regulatory constraints that would prevent the introduction of a mandatory steel certification system?

APPENDIX D — R&D EXPENDITURE AND INNOVATION PERFORMANCE IN HONG KONG

In 2018, the gross domestic expenditure on R&D (GERD)[14] of Hong Kong reached HKD24.497 billion. Historical figures for public sector expenditure on R&D expenditure between 2000 and 2018 are illustrated in Figure 41 (Hong Kong SAR Census and Statistics Department, 2019). Public sector expenditure, including the higher education and government sectors, on R&D directly demonstrates government efforts in driving innovation and technology development. In contrast, the R&D spending by the private sector indicates that a firm is proactive about exploring and generating new ideas to develop new or improved products, systems, or applications.

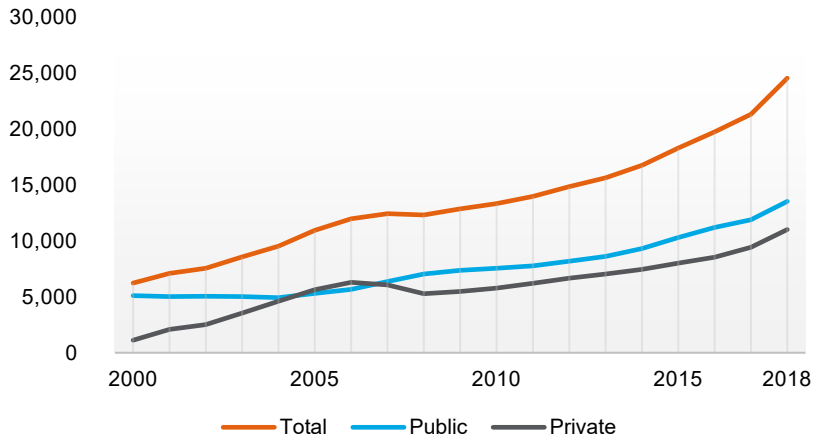

Figure 41 - R&D expenditure in Hong Kong by sectors (HKD million)

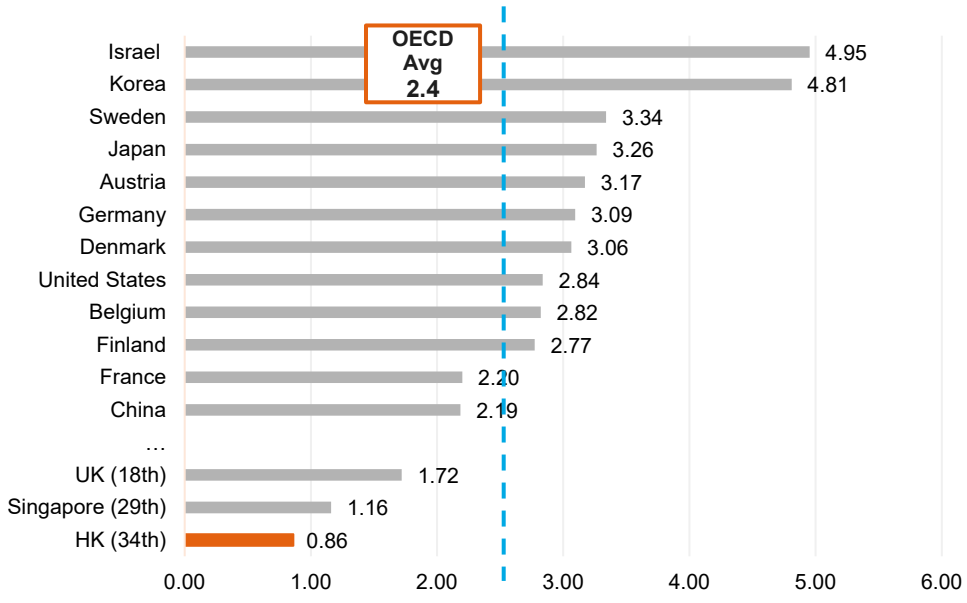

Figure 42 - World R&D expenditure (% of GDP) rankings and average R&D expenditure (% of GDP) in OECD countries in 2018

[14] R&D expenditure refers to the gross domestic expenditure on R&D (GERD). According to the OECD (n.d.), GERD is defined as the total in-house expenditure on R&D performed in a national territory during a given period. R&D activities are 'creative work undertaken on a systematic basis in order to increase the stock of human knowledge and to devise new applications based upon it'. The GERD index provides a comprehensive measure of R&D activities carried out by all resident firms, research institutes, academic bodies, government laboratories, etc., within a country or region.

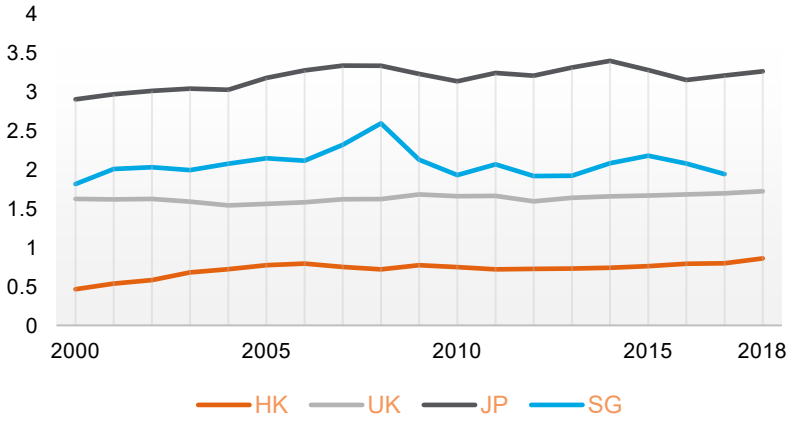

Figure 43 - R&D expenditure of Hong Kong remains the lowest of all benchmarked countries since 2000

APPENDIX E — AREAS FOR FURTHER RESEARCH

This appendix lists other proposed strategies that have not been covered in this report and the relevant feedback from the stakeholder engagement on which further research is recommended.

Driving Innovation

- **Establish Innovation Advisory Board**

Description

Regulatory bodies tend to be cautious when reviewing innovative designs submitted for approval, particularly those that relate to safety. For example, if an innovative solution relates to fire services, the proposal for it has to be circulated to relevant departments for review and comment, which can take up to six months according to stakeholders' feedback. To facilitate innovation for adoption in the private sector, it is proposed that the Construction Innovation and Technology Fund Steering Committee under DEVB implement an innovation advisory board (IAB). The IAB's role is to assist member organisations of the CIP in expediting the multi-agency evaluation of innovative construction methods, materials, and technologies. This can be done by streamlining the approval process for the development of innovation practice notes through pre-submission enquiry and conference in the Buildings Department (BD). Once a submission has been accepted, members of IAB will take the lead in resolving outstanding issues between the applicant and concerned government departments and, subsequently, facilitate the approval process in BD. The evaluation process of IAB and BD is illustrated in Table 32:

EVALTUATION PROCESS		
	**STEP 1**	Applicant submits proposal to **IAB** for evaluation.
	STEP 2	**AIB** members conduct internal meetings to pre-screen submissions.
	STEP 3	**IAB** members organise a meeting with key government departments and collect comments.
	STEP 4	Applicant addresses the comments, if any.
	**STEP 5**	**AIB** facilitates **BD** to hold **pre-submission enquiry and conference** with applicant and invite representatives of concerned **government departments** to discuss and examine the issues and principle involved.
	STEP 6	**BD** reviews the effectiveness of the innovation and provides a determination on the matters involved in the form of a **'letter of assurance'**, normally within 45 days.
	STEP 7	Applicant submits supplementary information to BD, if any.
	STEP 8	BD approves the innovation proposal and releases an **innovation practice note.**
	STEP 9	**BD** keeps a **databank** of approved innovative solutions, and a list of suppliers/manufacturers who are granted in **IPA** is published on BD's website

Table 32 - Evaluation process of innovation advisory board and pre-submission enquiry mechanism of BD

Evidence - Building Innovation Panel by the Building and Construction Authority

To improve the built environment and meet Singapore's Construction Industry Transformation Map (CITM) objectives, the Building Innovation Panel (BIP) was set up as an inter-agency to help firms fast track the assessment of innovative construction methods/processes (Singapore Building and Construction Authority, 2020). The BIP also assists firms in acquiring regulatory clearance to apply innovative proposals in their current projects.

Specifically, the BIP helps the industry in:

- Conducting focus group discussions to identify trends and promote the adoption of innovations
- Supporting the value chain from upstream research to technology deployment, through practices such as matching vendors of new construction innovation with a builder/developer, to enable actual implementation in projects and eventually across the industry
- Streamlining the approval process through the setup of a platform for multi-agency regulatory approval
- Guiding the adoption of innovation in practice and ensuring alignment with CITM objectives through the establishment of a steering committee

- Leading an evaluation process for the use of construction-related innovative solutions and expedite the resolution of outstanding issues between the applicant and respective authorities
- Publishing the list of approved innovative solutions and granted suppliers/manufacturers.

The panel's evaluation process is led by a BIP Secretariat, who will take a central coordinating role to resolve outstanding issues between the applicant and respective regulatory agencies.

The workflow of the BIP Secretariat is shown in the diagram in Figure 44:

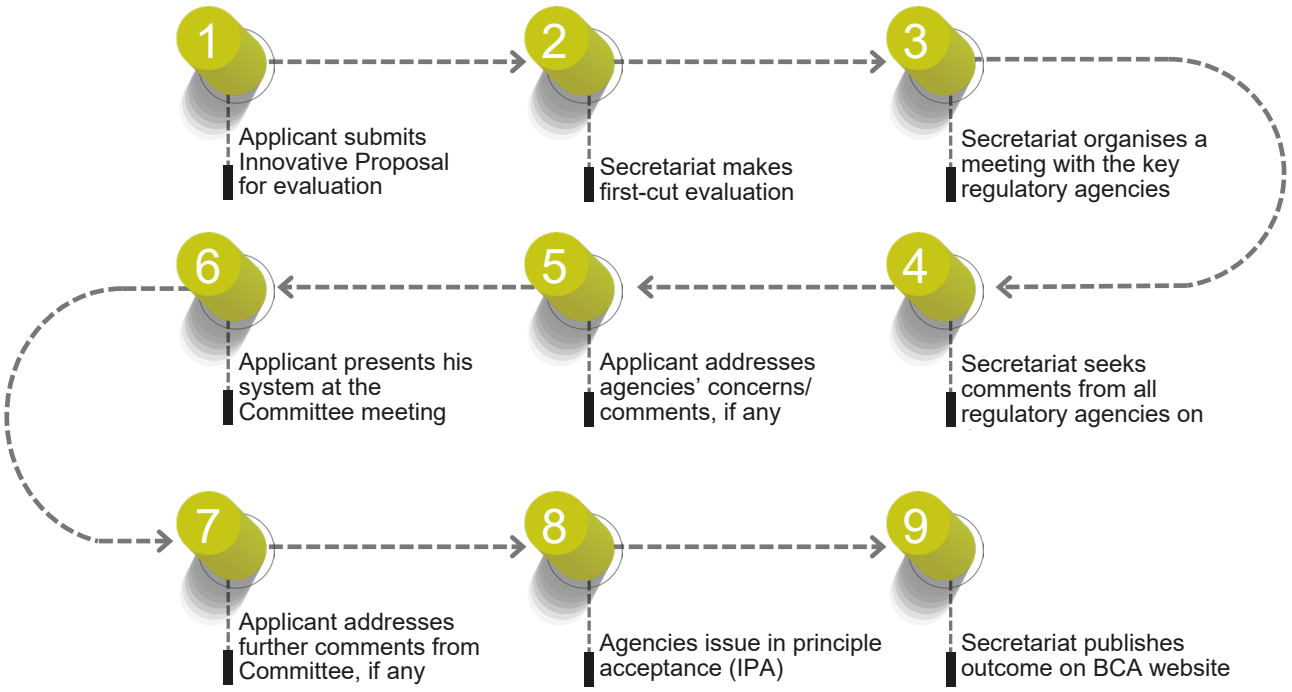

Figure 44 - The evaluation process of BIP

Since BIP was established in 2011, 86 suppliers and three major innovative solutions have been granted in-principle acceptance for use in Singapore projects, namely in the areas of prefabricated prefinished volumetric construction system, prefabricated bathroom units, and mass-engineered timber. The success of BIP provides a good example for the proposed strategy to fast track the approval of innovative solutions in Hong Kong.

Input from stakeholder engagement

Feedback from the stakeholder engagement was mostly concerned with the issue of a lack of regulatory readiness, with comments towards the strategy as follows:

- A mechanism was already in place under PNAP ADM-19 for pre-submission enquiry regarding new theories, materials or systems, sophisticated designs, and unconventional construction methods, so there is no need for an IAB. The role and functions of an IAB need to be adjusted to be complementary to existing mechanisms under BD, such as (i) initiating new ideas or taking up ideas from the industry for following up with BD for pre-approval, bearing the cost of the process and testing; and (ii) supporting BD by providing technical expertise for the vetting of new proposals.
- To make use of the existing mechanism (pre-submission enquiry) by BD instead of having a new approval unit which creates an additional layer of administration
- Inconsistencies in government policies lead to delays and uncertainties in approval processes.
- The IAB should have members from multiple regulatory departments, such as the BD, FSD, and WSD.
- Lack of incentive for the private sector to invest effort (time and costs for obtaining data to support innovations) to submit innovative proposals.
- The interviewees believed that the fundamental problem in articulating construction innovation is the lack of hard empirical evidence on the economic gains associated with this activity.