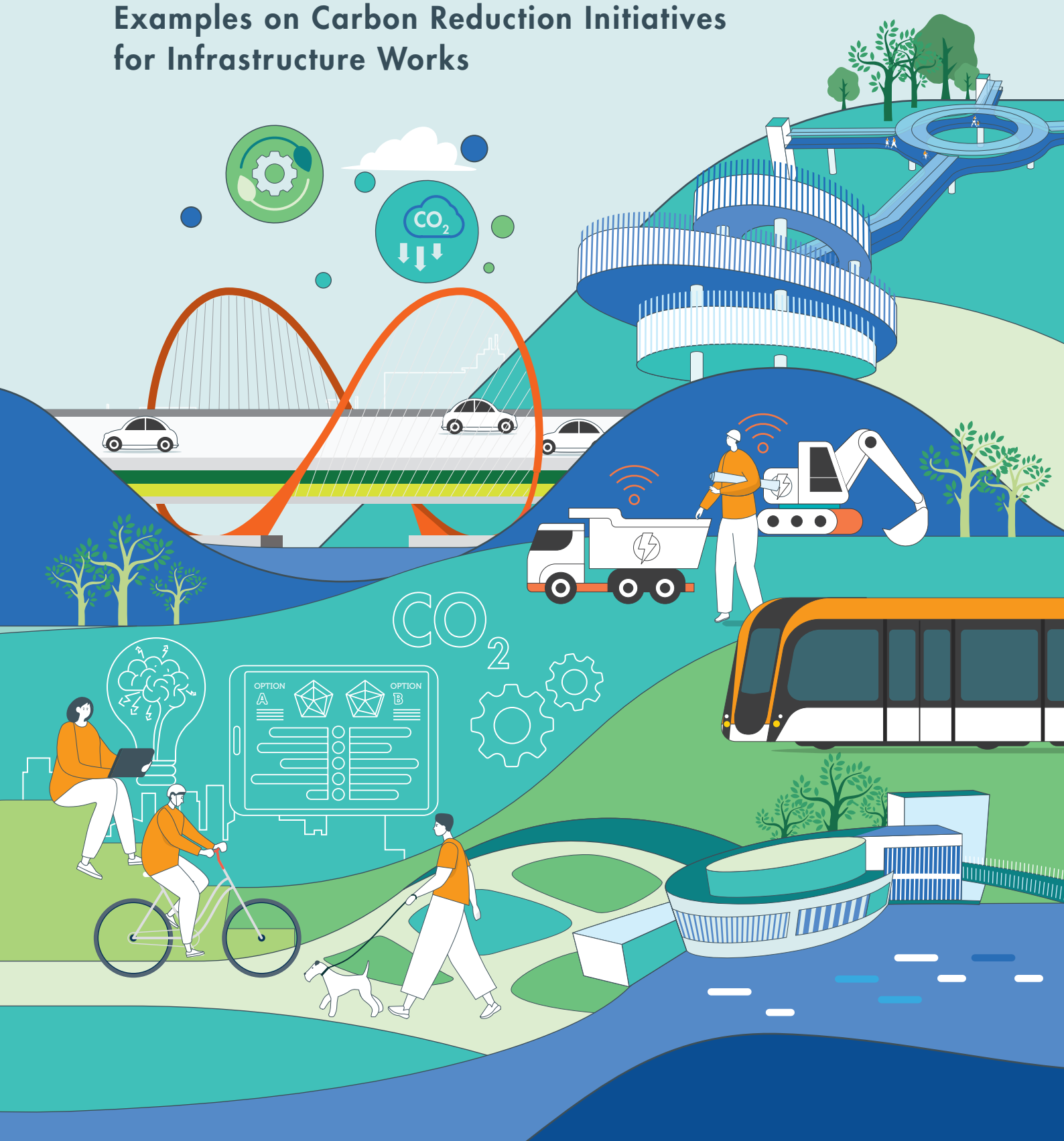
土木工程拓展署
Civil Engineering and Development Department

Playbook on Carbon Management:

Carbon Digital Platform and Successful Examples on Carbon Reduction Initiatives for Infrastructure Works



© The Government of the Hong Kong Special Administrative Region
First published, Oct 2026

Prepared and Published by:
Civil Engineering and Development Department



Table of Contents

Preface 5
Introduction 7
Purpose and Scope of Playbook 7
Structure of Playbook 9
Disclaimer 9
Acronyms 10

01 Understanding Infrastructure Carbon 12
1.1 Why Infrastructure Carbon Matters 12
1.2 Upfront Embodied Carbon in Infrastructure 14

02 Identifying Carbon Hotspots within CEDD's Work Portfolio 16
2.1 Looking Deeper: Carbon Hotspots at the Major Process and Sub-Process Level 17

03 Carbon Digital Platform 20
3.1 Overview 20
3.2 Shaping the Carbon Digital Platform 21
3.2.1 Anchoring the Platform on CEDD Core Infrastructure Works 21
3.2.2 Giving the Platform a Reliable Foundation 22
3.2.3 Setting a Practical Boundary for Assessment 23
3.3 What You Can Do with the Platform 25
3.3.1 A Connected Carbon Thread from Design to Construction 25
3.3.2 Quick Early-Stage Insight through Preset Parameters 26
3.3.3 Early Design Optioneering for Material-Driven Carbon Reduction 27
3.3.4 Tailored Design and Construction Inputs that Reflect Project Context 28
3.3.5 Broad Material Coverage across Infrastructure Site Processes 29
3.3.6 Regional Adaptability 30
3.3.7 Granular Breakdown and Meaningful Carbon Outputs 31
3.3.8 A Clearer Basis for Project-Level Carbon Performance Tracking and Prioritisation 32
3.3.9 A Stronger Basis for City-Wide Carbon Governance and Planning 33
3.3.10 A Scalable and Growing Infrastructure Carbon Database 34
3.4 How to Use the Platform 35
3.4.1 Where the Platform Fits in Practice 36
3.4.2 Design Module Workflow 36
3.4.3 Construction Module Workflow 37
3.4.4 Design Optioneering within the Platform 38
3.4.5 Illustrative Optioneering Examples 39

04 Successful Examples 46
4.1 Overview 46
4.2 Successful Examples 48

05 Conclusion 130

06 Way Forward 132

07 Acknowledgements 134

Scan the QR code to view and download the electronic version of the Playbook.





Preface



The Hong Kong SAR Government has pledged to achieve carbon neutrality before 2050, and the Civil Engineering and Development Department (CEDD) is committed to turning that vision into reality. From early design to on-site construction, we relentlessly pursue practical decarbonization measures that embed sustainability at every stage. This Playbook encompasses our efforts in pursuing greener construction technologies that are proven to be practical and effective in decarbonizing our construction sites.

Our first milestone achieved is having overcome the challenge of estimating and analyzing emissions from construction activities. Existing carbon assessment tools often rely on broad assumptions and fail to capture the complexity of different processes. To close this gap, CEDD has developed the Carbon Digital Platform (CDP), which delivers precise, activity level probing by differentiating between different common work activities of site formation and roadworks, such as piling and concreting. An innovative feature of the CDP is Optioneering, enabling engineers to compare the carbon emissions inherited in different engineering options. Engineers could now make fully informed, optimised decisions at the core of project planning.

Our ambitions extend beyond carbon emission estimation. We have curated a portfolio of proven decarbonization. Successful Examples already applied across our sites — from sustainable material selection and innovative construction methods to energy efficient system design. These Successful Examples include the deployment of Battery Energy Storage Systems (BESS), electrification of machinery. We have also pioneered the use of Ultra-High Performance Concrete and Ultra-High Strength Steel S960, which significantly reduce material quantities and the associated embodied carbon at scale. These practices establish a benchmark for industry practitioners to make reference to. Our contributions also include the publication of the Hong Kong Nature-based Solutions Design Guidelines, jointly with the Agriculture, Fisheries and Conservation Department, in March 2026. This joint publication signals our determination to lead in the realm of sustainable urban development.

The journey to a carbon neutral built environment in Hong Kong is a collective mission. I would like to acknowledge the dedication of our contractors and consultants, particularly I wish to express my gratitude to our peer institutions and organisations, for sharing their invaluable insights and examples on decarbonisation. This Playbook is more than a guide; it is a catalyst to encourage joint actions and accelerate our shared progress toward a greener and more sustainable future.

Mr. FONG Hok-shing, Michael
Director of Civil Engineering and Development

Purpose and Scope of Playbook

The CEDD is leading a locally significant initiative focused on deepening empirical understanding of carbon performance in construction activities in Hong Kong.

This Playbook has been developed as a practical guide to support carbon assessment and management of infrastructure projects in Hong Kong, with reference to local construction practices, project conditions and delivery constraints.

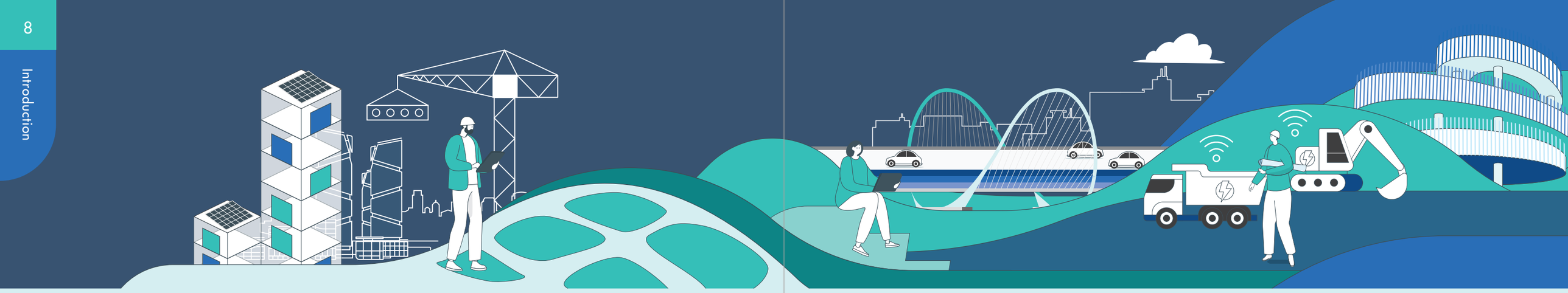
Key objectives of this Playbook include:

- **Providing a practical framework** for carbon assessment and management of infrastructure projects in Hong Kong, with reference to local construction practices, project conditions and delivery constraints.
- **Supporting the institutionalisation of carbon management within CEDD** by helping embed more consistent carbon appraisal, performance monitoring and decision-making within internal systems, processes and project delivery.
- **Filling an evidence gap in construction-stage carbon performance** by establishing a more reliable and locally grounded understanding of how carbon emissions arise in major construction activities.
- **Focusing on site formation and roadworks projects**, as two primary infrastructure types within CEDD's remit, and providing a structured basis for carbon assessment in these works.
- **Enabling more granular analysis of construction emissions** by considering carbon performance at process and activity level, including the influence of construction methods, plant usage, material quantities and site conditions.
- **Building a data ecosystem for Hong Kong's infrastructure works** to support performance evaluation, optioneering and continuous improvement through the development of a web-based Carbon Digital Platform.
- **Supporting informed decision-making and future carbon reduction efforts** across the infrastructure sector through more credible, data-driven carbon insights.

This Playbook is intended to:

- **Provide government organisations with a strong local reference** for how public sector bodies can move towards data-driven carbon governance, recognising that credible carbon emission estimations are important foundations for scalable carbon management.
- **Support designers in identifying bottom-up carbon reduction opportunities** through the Carbon Digital Platform, helping carbon emissions to be assessed in a more structured way and providing better support for decision-making.
- **Support contractors in improving construction-stage carbon data collection and record-keeping** through a more systematic approach to capture relevant project data, so that carbon calculation and reporting can be carried out on a more consistent basis.





Structure of Playbook

This Playbook is structured into the following chapters:

Section 1
Understanding Infrastructure Carbon

This section introduces infrastructure carbon and explains its significance in the context of carbon reduction commitments, setting out the key challenges and rationale for adopting a more structured approach to carbon management.

Section 2
Identifying Carbon Hotspots within CEDD's Work Portfolio

This section presents the carbon hotspot analysis across selected CEDD site formation and roadworks projects, highlighting key emission drivers at project, major process and sub-process levels to support more targeted carbon reduction opportunities.

Section 3
Introducing the Carbon Digital Platform

This section introduces the Carbon Digital Platform, a digital carbon calculation tool in supporting carbon estimation, optioneering, and construction-stage tracking across infrastructure projects. It outlines the platform's framework, key features, and practical applications.

Section 4
Successful Examples on Carbon Reduction Initiatives for Infrastructure Works

This section presents Successful Examples for carbon reduction and organises them into three categories- Material, Site Management, Design & Delivery with reference to local civil engineering projects and pilot case studies, which aims to promote sharing of methods to reduce infrastructure carbon emissions.

Section 5
Summary and Practical Next Steps

This section summarizes the content of this Playbook and outlines a practical way forward to support implementation of carbon management across the infrastructure value chain.

Disclaimer

All materials and information in this Playbook shall not be regarded as a substitute for and do not constitute part of the prevailing guidelines, practice notes, relevant contract provisions, etc. In the event of any inconsistency or conflict between this Playbook and the prevailing guidelines, practice notes, relevant contract provisions etc., the latter takes precedence. This Playbook is produced for information and experience sharing purpose. It does not constitute, nor should it be construed or relied upon as any legal, contractual, or professional advice.

Acronyms

Acronyms used in this Playbook are as follows:

ASR	Alkali-Silica Reaction
BESS	Battery Energy Storage System
BF-BOF	Blast Furnace - Basic Oxygen Furnace (steelmaking route)
CEDD	Civil Engineering and Development Department
CEF	Carbon Emission Factor
CSF	Condensed Silica Fume
EAF	Electric Arc Furnace
EMSD	Electrical and Mechanical Services Department
EPD	Environmental Protection Department
GGBS	Ground Granulated Blast-furnace Slag
HVO	Hydrotreated Vegetable Oil
$kgCO_2e$	Kilogram of Carbon Dioxide Equivalent
LCA	Life Cycle Analysis
LD-ECC	Low-density Engineered Cementitious Composites
OPC	Ordinary Portland Cement
PFA	Pulverised Fuel Ash
PV	Photovoltaic
R20	Renewable Diesel (20% renewable blend)
RC	Reinforced Concrete
RFI	Request for Information
SCM	Supplementary Cementitious Materials
UCO	Used Cooking Oil
UHPC	Ultra-High Performance Concrete
UTBM	U-shaped Tunnel Boring Machine
VRSC	Vibration Resistant Sprayed Concrete



1. Understanding Infrastructure Carbon

1.1 Why Infrastructure Carbon Matters

Hong Kong has an ambitious plan to reduce its carbon intensity by 65 to 70% by 2030 compared to a 2005 baseline[1], and to be a carbon neutral city by 2050[2]. Nationally, the direction is to peak CO_2 emissions before 2030 and achieve carbon neutrality before 2060. The 15th Five-Year Plan strengthens the action plan for carbon peaking and promotes the gradual establishment of dual-control system for both total carbon emissions and intensity.

As the civil landscape of our city continues to grow sustainably, carbon emissions associated with the construction, operation, and decommissioning of our built environment have become an important focus to align with carbon reduction goals. In particular, the WorldGBC[3] is calling for a 40% reduction in embodied carbon by 2030 and net zero embodied carbon by 2050 across buildings, infrastructure, and renovations alike, pertaining to the construction phase of built projects[3]. To date, significant progress has been made in addressing carbon emissions within the public and private building sectors, particularly through the adoption of sustainability assessment frameworks leading to holistic reduction of operational and embodied carbon.

1 Hong Kong's Climate Action Plan 2030+
2 Hong Kong's Climate Action Plan 2050
3 The Circular Built Environment Playbook (WorldGBC)

Despite this, infrastructure projects have received comparatively less attention than buildings in public carbon discussions. This focus is understandable, given that approximately 66% of Hong Kong's carbon emissions are associated with power generation, with around 90% of electricity consumption attributable to the operations of our buildings[2]. In comparison, typical infrastructure works, such as site formation and roadworks, require significantly less resources to operate and maintain. However, infrastructure works are inherently material- and resource-intensive, and rely heavily on concrete, steel, large-scale earthworks, and fuel-driven construction activities. As such, they represent a significant source of embodied and construction stage carbon emissions.

In Hong Kong, CEDD is one of the key parties in delivering infrastructure, whose responsibilities range from site formation, reclamation, seawalls and breakwaters, geotechnical works (including earthworks and slope works), and other enabling infrastructure such as roadworks, tunnels, and bridges. With major development initiatives such as the Northern Metropolis, CEDD's role and correspondingly the carbon implications of its works, continues to expand.

A robust understanding of the carbon emission performance of infrastructure projects lays important groundwork for the pursuit of low-carbon infrastructure. However, at present there is no localised carbon assessment or management framework tailored specifically to infrastructure works in Hong Kong. While good practices and technological advancements do exist, these are often fragmented and lack systematic recognition or guidance for consistent application. As a government body with influence across public works, CEDD is framing this broader initiative around the longer-term institutionalisation of carbon management within infrastructure delivery, rather than treating carbon assessment as a one-off exercise. The Carbon Digital Platform and the Successful Examples discussed in the later sections of this Playbook are intended not only to support understanding of infrastructure carbon, but also to help translate that understanding into more practical and consistent carbon management through a structured database, design optioneering, and reduction-focused practices.



1.2 Upfront Embodied Carbon in Infrastructure

Building on the importance of infrastructure carbon outlined in the previous section, it is important to understand where emissions arise within project delivery. While infrastructure carbon can be considered across a full life cycle, the majority of measurable emissions are expected to occur during the manufacturing and construction stages (A1–A5).

Focusing on upfront stages provides a practical and high-impact starting point for carbon management. These stages capture the emissions associated with material supply and construction activities. Decisions such as design parameters, material quantities, and construction methods, therefore have a direct impact on project's carbon assessment results.

Upfront carbon refers to the greenhouse gas emissions associated with material production, transport, and construction activities up to project completion:

- A1–A3: Raw material supply and manufacturing, and associated transport
- A4: Transport to construction site
- A5: Construction and installation

Together, these stages represent the embodied and construction-stage emissions incurred before the asset becomes operational, forming a defined and measurable boundary for infrastructure carbon assessment.

A1 **Raw materials supply**



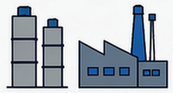
Extraction and processing of raw materials

A2 **Transport to manufacturing plant**



Transportation of raw materials to manufacturing plant by road, sea or rail

A3 **Manufacturing**



Manufacture of construction products and components (e.g. concrete, steel, asphalt)

A4 **Transport to project site**



Transportation of finished products and prefabricated components to construction site

A5 **Construction and installation process**



On-site construction activities and installation of materials and components

CO_2e

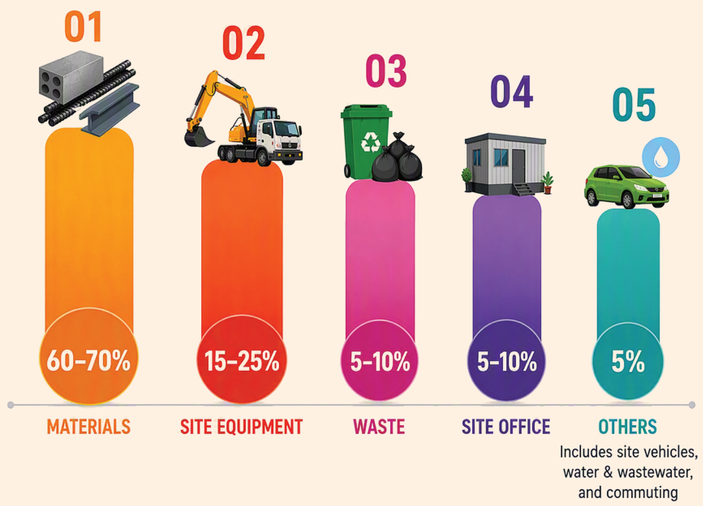
CO_2e (carbon dioxide equivalent) emissions arise across the key upfront stages from material supply to construction (A1-A5)



2. Identifying Carbon Hotspots within CEDD's Work Portfolio

To establish a more grounded and practical understanding of where carbon emissions arise within CEDD's infrastructure work portfolio, a carbon assessment was carried out across 10 selected site formation and roadworks projects. This exercise focused on construction-stage emissions within the A1–A5 boundary, with the aim of identifying consistent patterns, key drivers, and areas of relatively higher carbon intensity across CEDD's two core infrastructure work types—site formation and roadworks. Based on the carbon assessment results, the upfront carbon intensity for site formation[1] typically ranges from 30 to 380 $kgCO_2e/m^2$, while that for roadworks[2] typically ranges from 160 to 1,600 $kgCO_2e/m^2$.

A breakdown of emissions by site activities, including site equipment, site offices, site vehicles, materials, waste, water and wastewater, and daily commuting, indicates that material-related emissions are the dominant contributor, which accounts for approximately 60% to 70% of total upfront carbon emissions across the assessed projects. This is followed by emissions associated with fuel-driven construction activities (i.e. site equipment), which typically account for around 15% to 25%.



This observation reinforces that, within the A1–A5 boundary where material production and construction activities are captured, a dominant portion of carbon emissions are significantly influenced by material demand and usage, with construction energy use acting as a secondary contributor.

1 The area denominator for site formation is defined as the total site formation area of the project. The high carbon intensity is due to some sites being inclusive of areas where the intensity of work is high (e.g. hilly terrain with many slope works and retaining structures).

2 The area denominator for roadworks is defined as the total road area of a project. The high carbon intensity is due to the need to build many elevated roads and underpass, which are material intensive.

2.1 Looking Deeper: Carbon Hotspots at the Major Process and Sub-process Level

The carbon assessment focuses on the construction-stage carbon performance of two core infrastructure work types under CEDD – site formation and roadworks. Key construction activities have been systematically broken down into measurable components, based on project-controlled activities, rather than those governed by third parties, such as utility companies.

The typical site formation and roadworks processes are identified below:

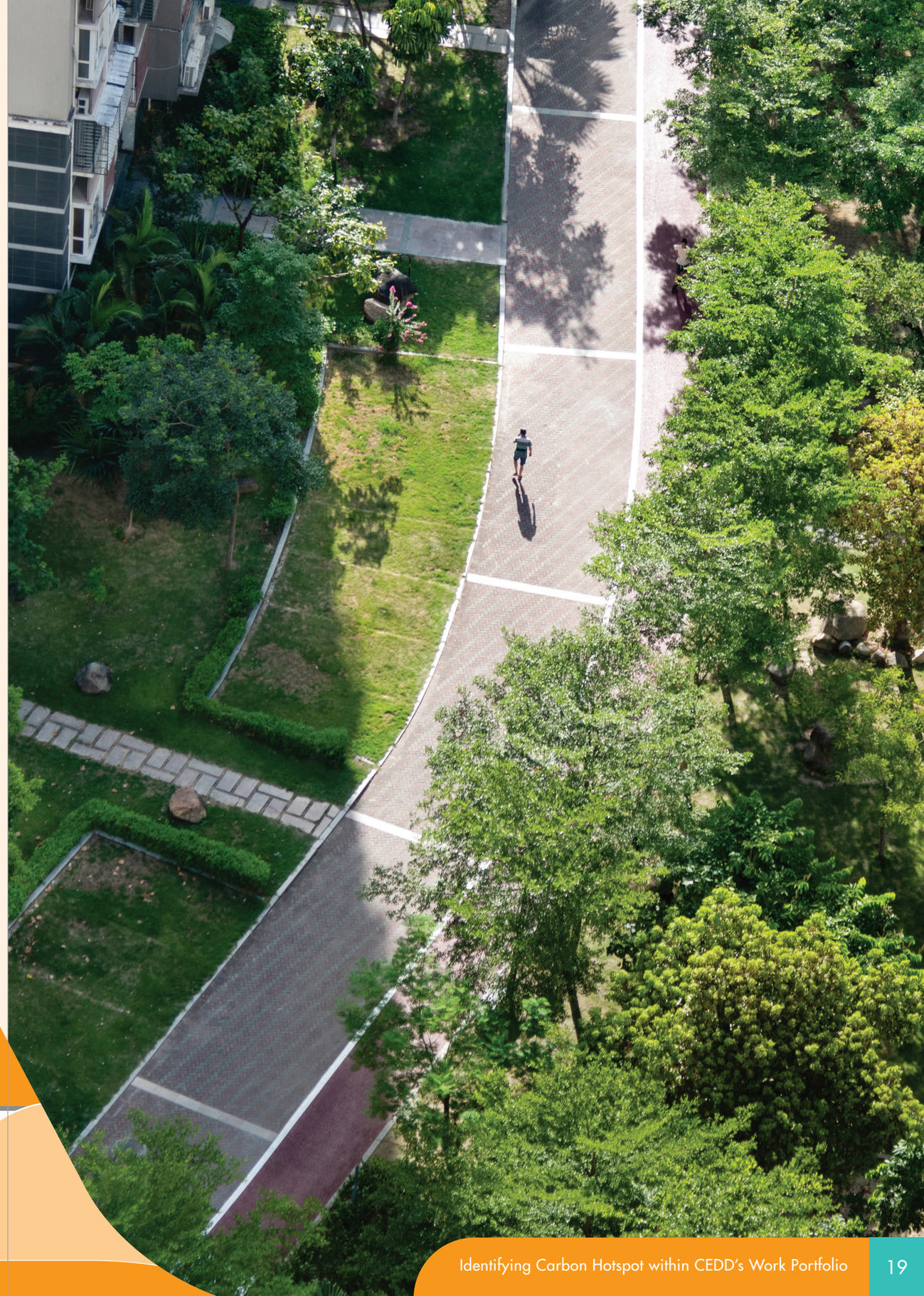
Major Processes	Typical sub-processes
Site Clearance	• General site clearance & haul road construction • Ground investigation • Tree felling & demolition of existing structure • Site hoarding & fencing • Land decontamination
Retaining Structure Works	• Bored pile wall (soil and rock), skin wall & capping beam • Soldier pile wall (soil only), skin wall & capping beam • Adding tie back to bored pile/soldier pile wall • Retaining structures/reinforced-earth wall
Road Structure	• Retaining structures • Box culvert/underpass • Abutment/pier
Earth works, Slope works & Ground Improvement	• Excavation & filling • Soil nail • Rock cut slope • Ground improvement works
Utilities	• Water mains • Drainage works (drainage pipe/U-channel) • Others
Pavement	• Subgrade/sub-base/base layer/surfacing • Paving block
Landscaping	• Transplanting/trees planting • Hydroseeding
Natural Terrain Hazard Measures	• Rigid/flexible barrier
Others	• Road furniture • Traffic management & safety system

Through this more granular lens, it is observed that most carbon-intensive sub-processes typically align with those exhibiting the highest material intensity. Taking one of the assessed site formation projects as an example, retaining structure works contribute the majority of emissions, largely driven by sub-processes such as bored pile wall construction, where substantial quantities of concrete and reinforcement bar are required for each pile. In contrast, other processes, such as site clearance, involve relatively lower overall emissions.

The assessment confirms that materials remain the primary driver of project emissions, followed by site equipment and fuel consumption, reinforcing the importance of day-to-day site management. Efficient plant usage, energy consumption and site practices also play a vital role in shaping overall emissions. This suggests prioritizing material optimization and efficient equipment management, which together offer the highest potential for carbon reduction.

By recognising that emissions are concentrated in material-intensive and site equipment related sub-processes, more robust design optioneering can be enabled by a careful selection of options for materials and equipment (i.e. fuel-related). These insights contribute to how both the Carbon Digital Platform and Successful Examples (carbon reduction initiatives) in the later sections of this Playbook are shaped.





3. Carbon Digital Platform

3.1 Overview

A Carbon Digital Platform, which is a digital carbon calculation tool, has been developed to provide a structured and scalable approach to infrastructure carbon management in Hong Kong. It establishes a connected carbon thread from design through construction, integrating project-level data collection with platform-wide aggregation and analytics so that carbon information can be systematically managed, calculated, compared and refined, strengthening the basis for informed decision-making.

While the Carbon Digital Platform has been developed, more field data is currently being collected from projects of CEDD to enrich its database. The Carbon Digital Platform will be expanded to cover more infrastructure work types.

Key functions include:

- **Connected carbon thread:** links design-stage estimation with construction-stage accounting using real project data, ensuring consistent carbon tracking and carbon traceability throughout the project life cycle.
- **Early-stage estimation:** provides rapid carbon insights using preset parameters and minimal inputs, enabling early identification of carbon hotspots when detailed design information is limited.
- **Design optioneering:** integrates carbon considerations into early design option assessment by comparing alternatives and highlighting opportunities for carbon reduction.
- **Tailored project inputs:** reflects project-specific assumptions and data inputs rather than generic comparisons, supporting more meaningful carbon evaluation and informed decision-making.
- **Broad material coverage:** supports a wide range of locally relevant and user-defined materials across infrastructure processes to enable more realistic basis for more informed low-carbon decisions.
- **Regional adaptability:** reflects local supply chains, material origins, and transport conditions to deliver more credible and regionally relevant carbon assessments.
- **Granular carbon outputs:** provides process-level and activity-level carbon breakdowns to reveal emission hotspots and inform improvement opportunities.
- **Performance tracking and prioritisation:** monitors project-level carbon performance and identifies high-impact processes, materials, and activities to prioritise carbon reduction efforts.
- **City-wide carbon governance and planning:** aggregates project-level carbon data to enable trend monitoring and inform carbon governance across public works projects.
- **Scalable carbon database:** develops an evolving carbon data ecosystem by aggregating project-level information into a structured and reusable knowledge database.

3.2 Shaping the Carbon Digital Platform

3.2.1 Anchoring the Platform on CEDD Core Infrastructure Works

CEDD delivers a wide range of civil infrastructure works that underpin Hong Kong's long-term development. To establish a practical and focused starting point, the Carbon Digital Platform prioritises site formation and roadworks as its initial scope. These two infrastructure types represent a significant portion of CEDD's construction portfolio and are closely associated with major sources of carbon emissions.

The platform adopts a structured assessment boundary that captures the key carbon-intensive activities and construction processes relevant to these works, enabling consistent and practical carbon evaluation at the project level.

This focused scope provides a strong foundation for the progressive institutionalisation of carbon management within CEDD, while allowing flexibility to expand to other infrastructure work types as the framework and the platform mature.

Scan the QR code to visit the Carbon Digital Platform

Desktop access



3.2.2 Giving the Platform a Reliable Foundation

Recognised standards and guidance play an important role in providing the Carbon Digital Platform with a credible methodological foundation, helping ensure that its outputs are systematic, reliable, and suitable for learning and decision-making over time.

Three widely referenced international guidelines relevant to infrastructure carbon assessment and management are summarised in the table below.

Key Standards and Guidance	Description
PAS 2080:2023 – Carbon management in buildings and infrastructure (with guidance document)	A governance-focused framework that enables value-chain stakeholders to collaboratively decarbonise projects by identifying emissions and removals within their control and influence. The standard emphasises leadership, collaboration, and early decision-making across the infrastructure life cycle.
BS EN 17472:2022 – Sustainability assessment of civil engineering works: Calculation methods	A modular, LCA-based framework providing specific methods, scenarios, and criteria for the assessment of whole-life environmental performance of civil engineering works, including infrastructure assets.
Greenhouse Gas Protocol – Corporate Accounting and Reporting Standard (GHG Protocol)	A globally adopted framework that defines standardised methods for measuring and reporting greenhouse gas emissions at an organisational level, including the classification of emissions into Scope 1, Scope 2, and Scope 3.

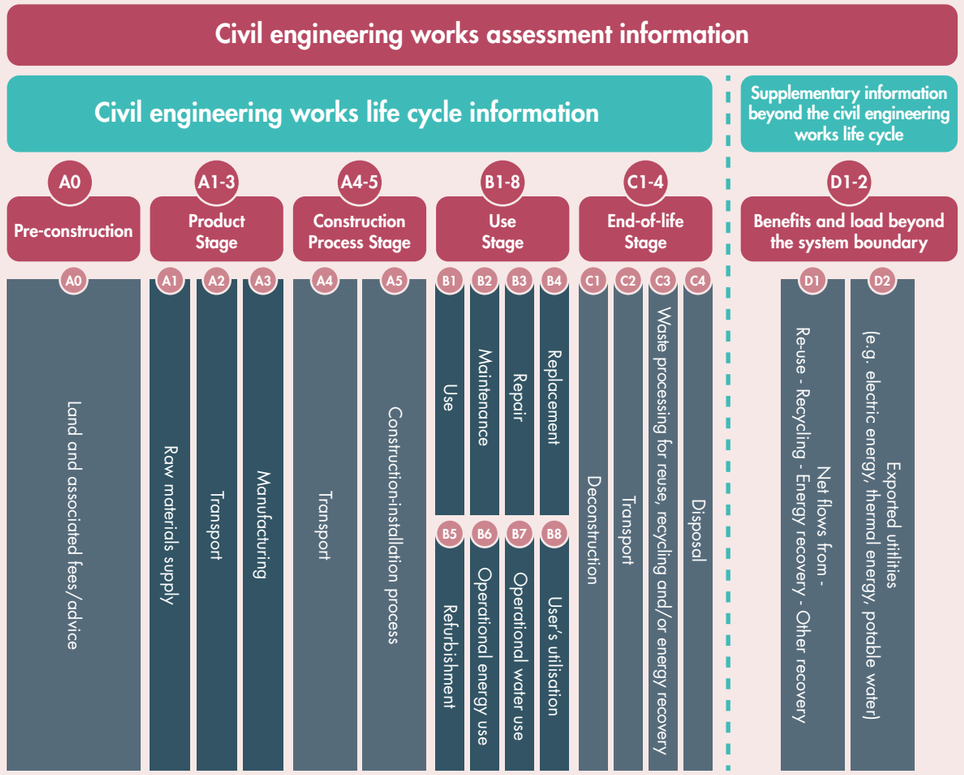
However, when applied as a practical digital carbon management tool at the local or project delivery level, particularly for specific works such as site formation and roadworks, these references present several limitations that should be recognised:

1. **Limited Local Applicability:** Local context and project-specific challenges are not explicitly addressed, including differences in construction practices, contractual arrangements, and regulatory environments.
2. **Lack of Prioritisation for Decision-Making:** Limited guidance on prioritising actions is provided based on carbon significance, making it difficult to focus effort on the most impactful emission sources.
3. **Insufficient Practical Guidance:** The implementation approach is often overly broad, with limited clarity on "how", particularly in relation to construction-stage data collection, allocation of site activities, and the interpretation and application of results.

To address these gaps from a local delivery perspective, the carbon management approach and tools developed, as set out in this Playbook, are designed to provide a locally relevant, practical, and decision-oriented framework.

3.2.3 Setting a Practical Boundary for Assessment

When assessing the carbon emissions of an infrastructure project, a whole life cycle approach is often seen as most appropriate, consisting of stages A through D in the diagram below.



Source: BS EN 17472:2022

BS EN 17472:2022 defines the life cycle structure for civil engineering works, while PAS 2080 complements this by providing a carbon management framework that considers both the asset's life cycle and its wider impact on the built environment.

Life Cycle Stages

Stage A – Product & Construction: Covers raw material supply, transport, manufacturing, delivery to site, and construction activities. This stage typically accounts for most upfront embodied carbon, driven by material quantities, production processes, transport, and plant use.

Stage B – Use: Includes operation, maintenance, repair, and replacement during the asset's service life, with stronger focus on long-term performance and maintenance strategy.

Stage C – End-of-Life: Encompasses deconstruction, waste transport, processing, and disposal, determining how materials are dismantled and treated at the end of life.

Stage D – Beyond Project Boundary: Considers the potential benefits of circular economy strategies, arising from the reuse, recovery, and recycling of materials, and the export of energy and other utilities beyond the system boundary, system boundary. These would minimize uses of resources and energy consumption in the future.

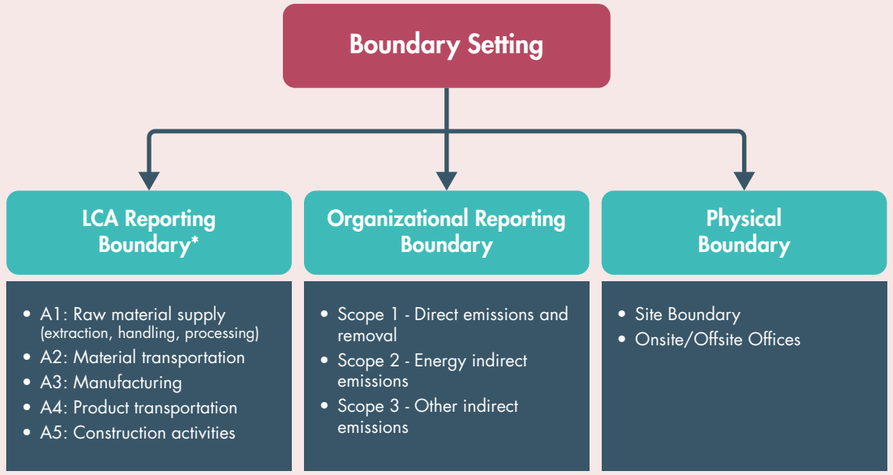
Together, these stages provide a whole-life view of infrastructure carbon, essential for long-term carbon management.

Platform Focus

The Carbon Digital Platform provides a practical starting point for decarbonizing infrastructures in Hong Kong by focusing on Stage A (A1–A5, Product and Construction Process Stage), where emissions are most measurable and directly linked to material use, construction activities, and plant operation. This matches CEDD's core business to carry out construction works for site formation and roadworks projects.

In contrast, the associated carbon emissions for operation, maintenance, and decommissioning under Stage B and C are more difficult to be quantified with significant data limitations, and these activities are not CEDD's core business. Stage A1–A5 remains a clearer and more workable boundary for carbon management.

In addition to Life Cycle Assessment (LCA) reporting boundary, two complementary boundaries should be considered – the organizational reporting boundary and the physical boundary, as shown in the diagram below:



* A1 to A5 are inclusive in this study without considering the operation and end of life stage of the project.

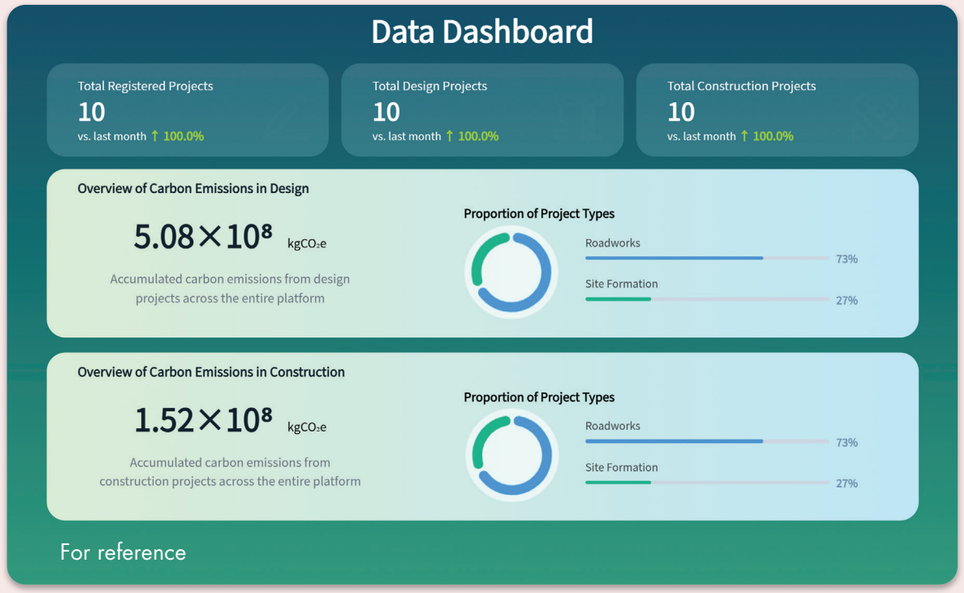
The organisational reporting boundary defines how emissions are attributed according to reporting responsibility, including Scope 1 – direct emissions and removal, Scope 2 – energy indirect emissions, and Scope 3 – other indirect emissions. This boundary helps project teams understand what emissions are assessed and how they are classified.

The physical boundary defines the area covered by the assessment. In line with the GHG Protocol and Guidelines to Account for and Report on Greenhouse Gas Emissions and Removals for Buildings (Commercial, Residential or Institutional Purposes) in Hong Kong, it includes both construction sites and site offices. This boundary ensures that carbon calculations reflect actual site conditions, helping to prevent omissions or double counting.

Together, these boundaries define not only what is counted, but also how emissions are allocated, interpreted and managed in the process of infrastructure delivery.

3.3 What You Can Do with the Platform

3.3.1 A Connected Carbon Thread from Design to Construction

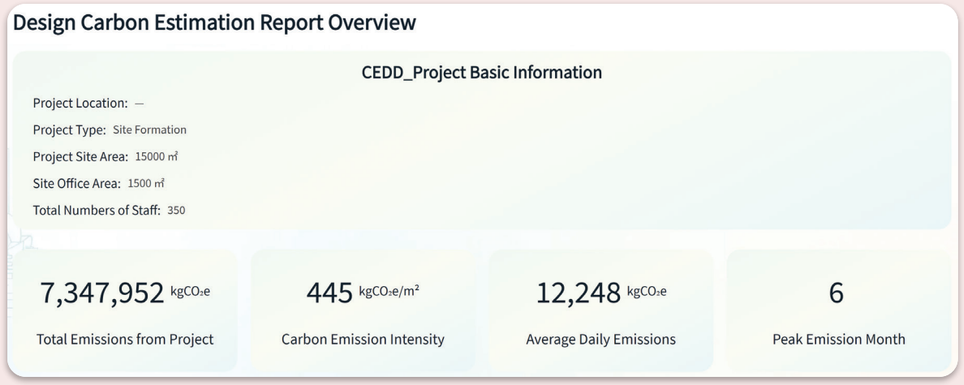


The platform establishes a continuous carbon management thread from design through construction. It integrates design-stage estimation with construction-stage accounting, ensuring consistent carbon assessment methodology from concept to delivery, where actual data is incorporated. This enables carbon considerations to remain active across the full project life cycle.

The platform closes the gap between estimated and actual carbon performance. During design, it supports high-level carbon estimation based on early-stage design parameters. During construction, it tracks emissions using real project data (e.g. fuel use, site records), enabling validation and adjustment of projections to reflect actual conditions. This provides a clearer, evidence-based view of how carbon evolves from design intent to delivery.

By linking stages, the platform enhances traceability of carbon throughout the project. Early assumptions are assessed alongside actual inputs, creating a consistent and grounded understanding of emissions over time. It functions not only as a calculation tool, but as a continuity framework that supports structured, practical carbon management from planning to implementation.

3.3.2 Quick Early-Stage Insight Through Preset Parameters

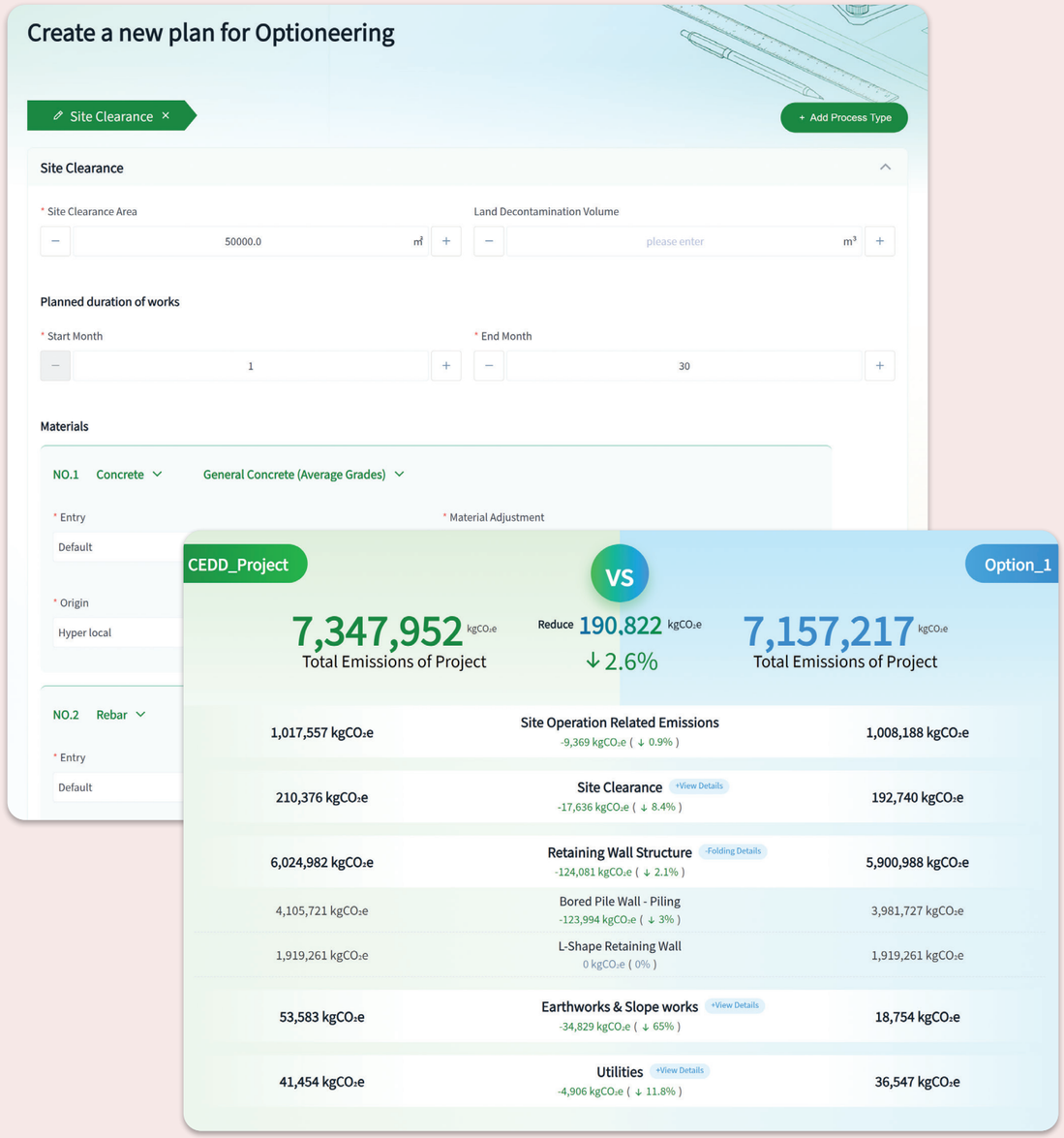


A key challenge in early-stage carbon estimation is the uncertainty and limited availability of design information such as material quantities, construction methodologies, and temporary works required, making it difficult to assess carbon impacts during development of design options.

To address this, the platform provides rapid, high-level carbon insights through the use of preset parameters. Default conditions are assigned to major processes and sub-processes, representing typical material and equipment consumption profiles. This allows designers to generate indicative carbon estimates with minimal input when detailed design data are not yet available.

Despite its simplicity, the platform maintains sufficient granularity to support meaningful analysis. Carbon impacts are broken down across key processes and sub-processes, enabling designers to understand overall project performance in respect of carbon emission while identifying carbon hotspots. This makes carbon-intensive elements more visible, even at an early stage, and highlights where emissions are most concentrated. As a result, designers are better equipped to optimize the design and can focus efforts on areas with the greatest potential for carbon reduction.

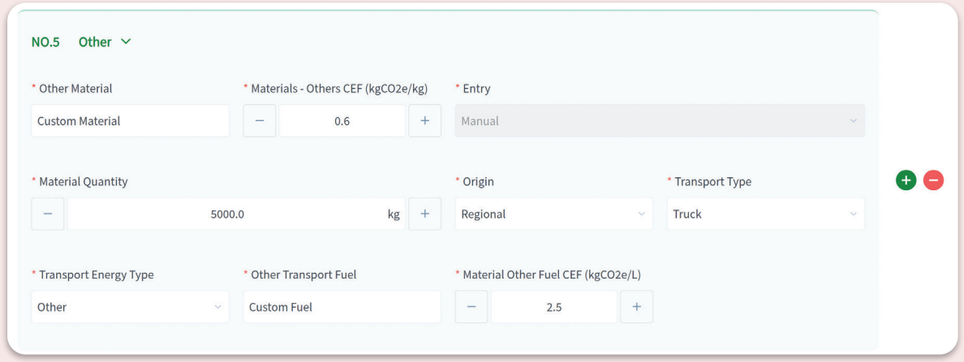
3.3.3 Early Design Optioneering for Material-Driven Carbon Reduction



At the early design stage, the platform supports optioneering when opportunities to reduce carbon emissions arise. By enabling designers to input design parameters and compare the carbon emissions of different technically viable options, optioneering is now enabled.

Through the optioneering function, designers can compare possible options in terms of their carbon emissions, not only allowing them to obtain a clearer understanding of how different material selections may affect projected carbon performance, but also identifying the carbon hotspots within the project.

3.3.4 Tailored Design and Construction Inputs that Reflect Project Context



Rather than relying solely on pre-defined database parameters, the platform enables tailored inputs that can more accurately reflect specific project conditions. Across both Design and Construction Modules, users can choose not to follow default assumptions, but adopting custom materials, construction methods, equipment, and fuel types, together with project-specific carbon factors. This flexibility allows carbon estimation to align more closely with the actual design intent and construction approach under consideration, making the platform adaptable to both design development and construction planning needs.

At the design stage, the platform supports detailed, project-specific inputs such as:

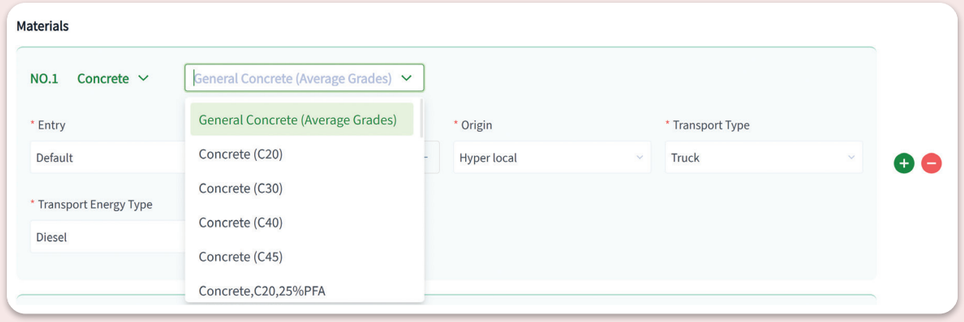
- Refined quantity take-offs linked to evolving design geometry
- Alternative structural systems (e.g. precast vs in-situ, modular solutions)

At the construction stage, the platform allows contractors to input actual site-related data, including:

- Plant and equipment types with project-specific utilisation rates
- Fuel types and corresponding emission factors (e.g. diesel vs electric plant)

By incorporating tailored inputs across both stages, the platform enables more meaningful carbon evaluation. Designers and contractors are informed not only by generic comparisons, but by the actual materials, methods, and constraints of the project, supporting a more accurate carbon emission assessment with a view to improving carbon management decision-making alongside cost, programme, and constructability considerations.

3.3.5 Broad Material Coverage Across Infrastructure Site Processes



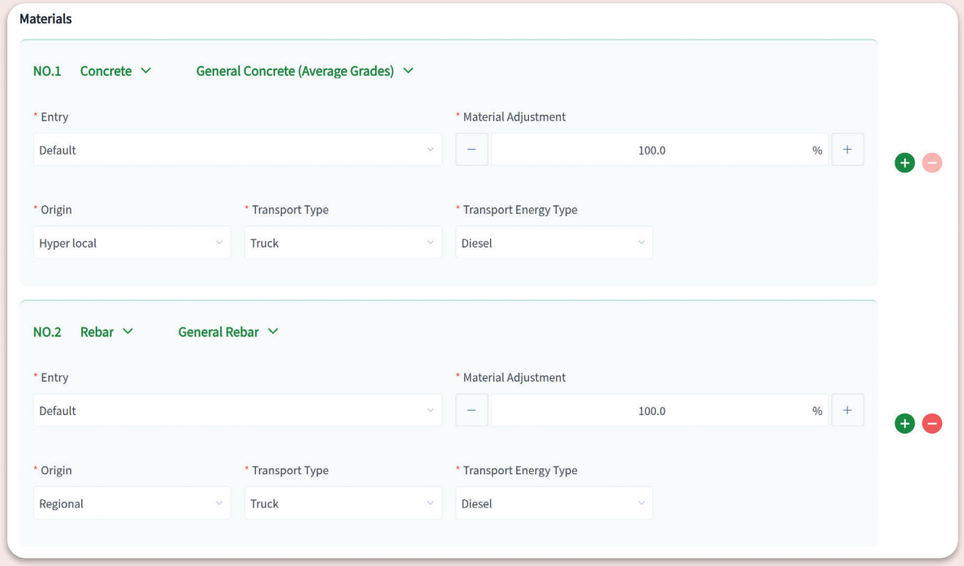
The platform offers an extensive material library that covers a wide selection of locally supplied materials for different construction activities. It also supports manual input of carbon emissions from specific materials. Rather than applying a generic material assumption across all processes, material inputs are linked to the specific processes or sub-processes. This allows carbon estimation to better reflect how different works are actually designed and delivered.

This process-specific input structure is supported by a locally relevant material library with broad material coverage, developed with reference to carbon assessments of actual CEDD projects as well as CIC Carbon Assessment Tool database[1]. The library provides a broad selection of materials commonly used in local infrastructure works, giving users a practical starting point for carbon estimation and option comparison. Where the required material is not available in the library, the platform allows users to specify materials with relevant carbon-related information, enabling project-specific assumptions, material sources and emerging alternatives to be incorporated.

By adopting a structured material library with the flexibility to add self-defined materials, the platform provides a wider and more realistic basis for design optioneering. Designers can explore a broader range of material choices and compare their carbon emissions within the relevant major processes or sub-processes, rather than relying on pre-defined assumptions. This enhances the usefulness of the platform during early project development, supporting a more informed low-carbon option selection.

1 Construction Industry Council (CIC), CIC Carbon Assessment Tool. [ONLINE]. Available at: https://cat.cic.hk/ [Accessed July 2026]

3.3.6 Regional Adaptability

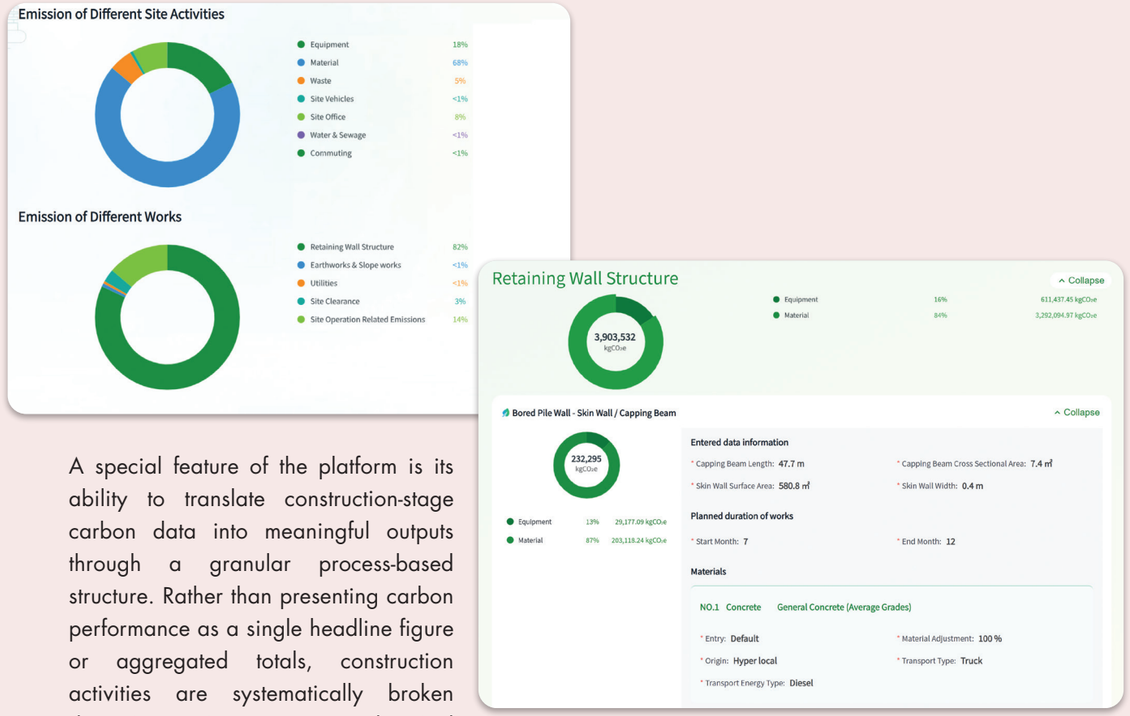


In Hong Kong, local construction material production capacity is limited, and projects rely heavily on imported materials or external sources of manufacture. The platform is developed with a strong focus on regional adaptability, recognising that infrastructure carbon emissions relate closely to local supply chain conditions, material sourcing arrangements, and construction practices.

Existing local carbon tools often rely on standardised datasets that may not reflect local realities. A key limitation is the insufficient representation of location-specific variables such as material origin, transport distances, and production methods, creating a gap between calculated emissions and actual project performance.

The platform incorporates localised, project-level data and allows continuously expansion of its database with time, thus reducing reliance on assumptions that may not hold locally. As more data are captured, carbon assessments become more representative, taking cognisance of the actual supply chains and site conditions. Instead of considering transportation as a standard component, the platform allows users to define material origin, transport type and fuel, and assign multiple transport scenarios to a single material. This enables a more granular and realistic representation of transport-related emissions, strengthening the relevance of the outputs.

3.3.7 Granular Breakdown and Meaningful Carbon Outputs



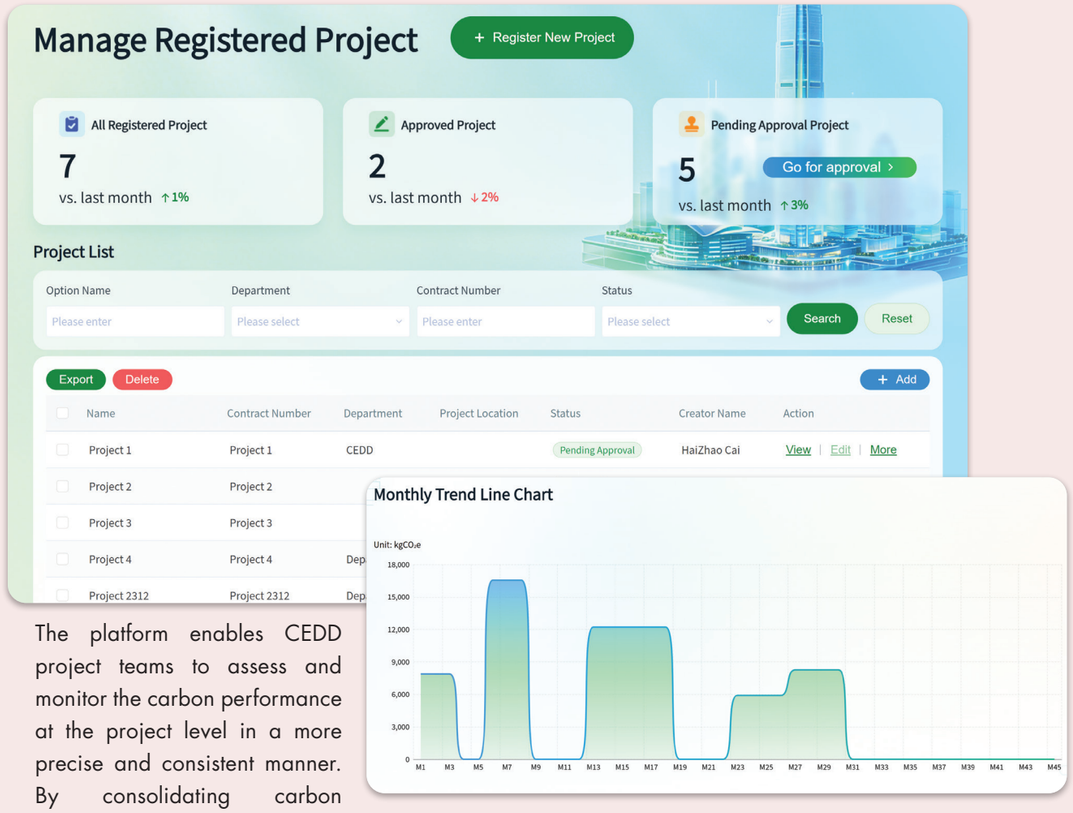
A special feature of the platform is its ability to translate construction-stage carbon data into meaningful outputs through a granular process-based structure. Rather than presenting carbon performance as a single headline figure or aggregated totals, construction activities are systematically broken down into major processes and typical sub-processes, allowing emissions to be linked more directly to actual site activities and project-specific considerations.

Focusing on site formation and roadworks, the platform provides structured breakdowns of common processes such as site clearance, earthworks, retaining structures, and utilities, which are further sub-divided into measurable sub-processes. The level of detail is underpinned by project-specific carbon studies drawing on data such as fuel consumption records, material delivery logs and site diaries. For example, retaining structures can be differentiated into bored pile walls, soldier pile walls, L-shaped walls and other types, with bored pile walls typically identified as a major contributor due to intensive concrete and reinforcement use.

Building on this structural framework, the platform generates meaningful outputs such as total emissions alongside detailed breakdowns by site processes and activities, including energy, materials and equipment usage. Activity types can be further disaggregated, such as waste emissions being separated into inert, non-inert and general waste. The platform also supports comparison between different input options, helping users to understand how changes in materials, fuel types or construction approaches may affect overall carbon performance.

Supported by carbon dashboards and visualisations, these outputs help users interpret results in details. They provide a clearer basis for identifying emission-intensive processes, comparing options and prioritising targeted carbon reduction opportunities at major process and sub-process levels.

3.3.8 A Clearer Basis for Project-Level Carbon Performance Tracking and Prioritization



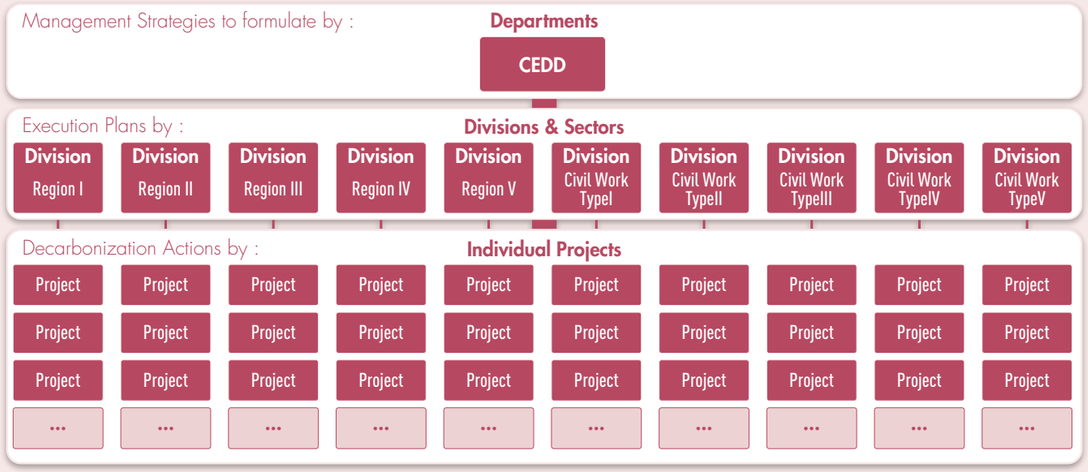
The platform enables CEDD project teams to assess and monitor the carbon performance at the project level in a more precise and consistent manner. By consolidating carbon information from individual projects into structured reporting outputs, the platform allows project teams to review, compare and monitor performance in a more systematic way.

Building on the granular outputs described in the previous sections, the platform enables users to interpret where emissions are concentrated across works, site activity types and sub-processes. This allows relatively carbon-intensive processes or activities to be identified more readily and followed up during design development or construction delivery.

The transparency in emission data supports more targeted prioritisation of carbon reduction efforts. Rather than applying measures uniformly across all parts of a project, project teams can use the platform outputs to focus attention on materials, equipment or site activities that have significant impact on overall carbon performance. This provides a more practical basis for selecting suitable carbon reduction measures, reviewing their potential impact and monitoring whether the overall performance is improving with time.

This provides CEDD project teams with a more informed approach for reviewing carbon results consistently across projects, identifying high-impact areas, tracking changes between design-stage estimates and construction-stage records, and determining where further guidance and intervention may be needed.

3.3.9 A Stronger Basis for City-Wide Carbon Governance and Planning



At a broader level, the platform supports CEDD in strengthening its role in carbon governance by providing a more robust and structured basis on the carbon impact of public works across Hong Kong. By systematically capturing and organising carbon data from individual projects, the platform enables CEDD to build a clearer, more comprehensive understanding of infrastructure carbon at a portfolio level.

This aggregated view is important in supporting city-wide planning and longer-term carbon management. It allows CEDD to observe how carbon emissions are distributed across different types of infrastructure works, and how carbon performance evolves over time as more project data are incorporated. At the same time, the structured nature of the data enables comparison of carbon performance across projects, work types, and key construction activities, providing a clearer basis for comparing relative performance and identifying recurring patterns. Such insights help move from project-specific carbon performance understanding towards a stronger and wider understanding of how infrastructure carbon performance is evolving.

3.3.10 A Scalable and Growing Infrastructure Carbon Database

Beyond its role in project-level assessment, the platform is also designed as a scalable and growing database of infrastructure construction emissions data. It is developed to support a platform-enabled approach in which carbon information from individual projects can be aggregated into a structured dataset over time, allowing project inputs to be systematically captured within this centralised system. The platform therefore functions not only as a tool for immediate management, but also as part of an evolving carbon data ecosystem.

Developed to grow organically through continuous data input and feedback, the platform gradually builds an organisation-level carbon database that strengthens in coverage and reliability over time. This centralised data ecosystem brings together carbon emission data of different projects, enabling more consistent data management and creating a more reliable foundation for design optioneering.

By structuring project-level data into a standardised format, the platform fosters an integrated, early-stage ecosystem for carbon accounting, performance evaluation, and continuous improvement. This creates a foundation for future application across design, construction, procurement, and even the supply chain, supporting progressively more coordinated and informed carbon management over time.

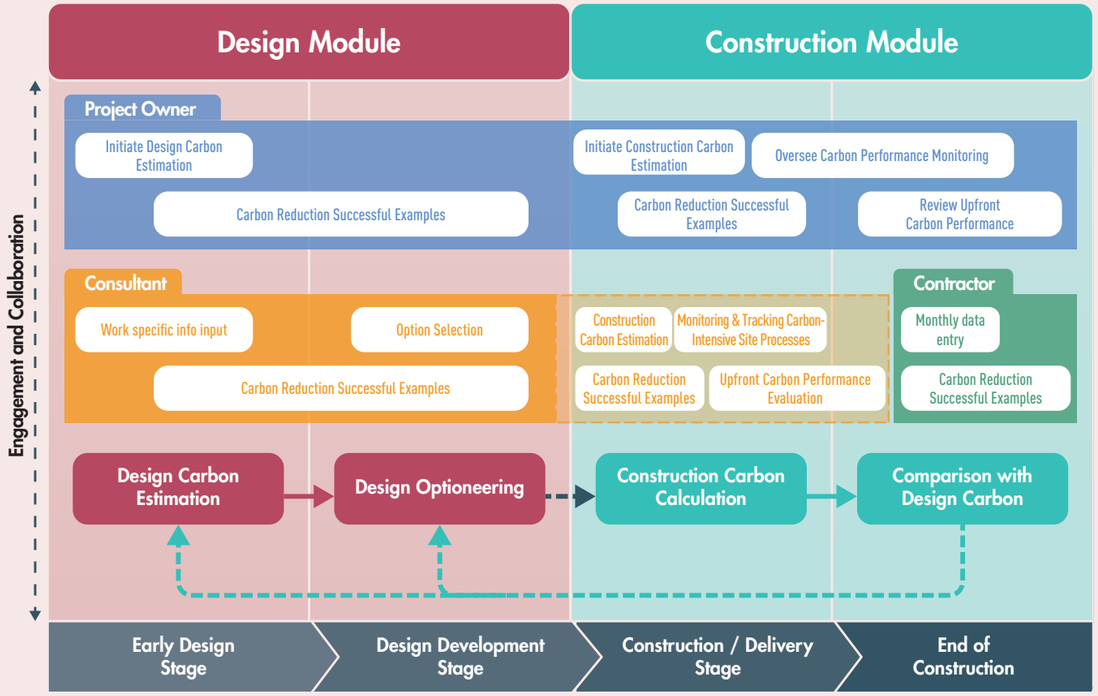


3.4 How to Use the Platform

The Carbon Digital Platform is intended to support carbon estimation, tracking and decision-making from design to construction, within the A1–A5 assessment boundary adopted for the platform. Through the platform, all key stakeholders (e.g. project teams, consultants, contractors) should contribute relevant information according to their stage of work, in return benefiting from outputs that support carbon estimation, design optioneering, carbon monitoring and performance improvement.

The platform is composed of two major connected parts: the Design Module and the Construction Module. The Design Module supports the estimation of carbon emissions during the design stage and helps design teams explore lower-carbon design options before key decisions are made. The Construction Module supports the structured collection of construction-stage information so that carbon performance can be systemically monitored, recorded and reviewed. Together, these modules provide a more consistent basis for understanding carbon performance across different stages of a construction project.

Journey to Decarbonization in Infrastructure Works



Note: In a typical consultant-designed project, consultants are involved as the Designer during the design stage and as the Resident Site Staff (RSS) during construction stage.

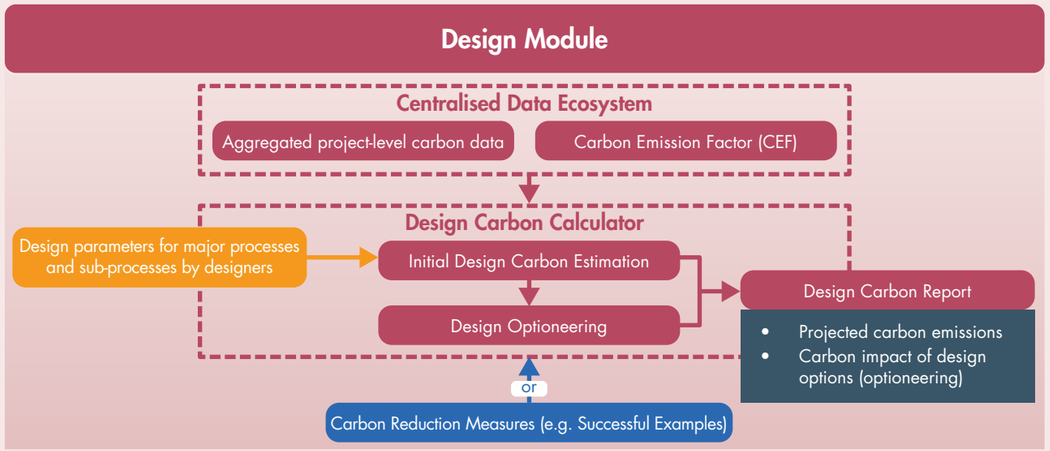
3.4.1 Where the Platform Fits in Practice

The platform is designed so that different stakeholders engage at different points. CEDD, as project owner, initiates and oversees the use of the platform, supporting carbon emissions tracking and performance evaluation. Consultants engaged as designers shall input work-specific design information, review estimated carbon emissions, and compare design alternatives through the Design Module. During construction, contractors engaged shall provide regular construction-stage data inputs through the Construction Module, allowing carbon performance during delivery to be systematically recorded and reviewed against earlier design-stage estimates. Resident site staff (RSS) shall review and validate construction-stage data input by contractors.

Through this connected workflow across the defined work stages in scope, stakeholders should know how and where to contribute. This supports a more joined-up approach to support more systematic carbon management, allowing more informed decision-making and performance evaluation throughout the work stages.

3.4.2 Design Module Workflow

The Design Module begins with the input of design parameters for major processes and sub-processes by designers. These inputs are used to generate an initial estimate of projected carbon emissions associated with the proposed design. This provides a starting point for understanding the carbon implications of key design options, and then followed by assessment of carbon reduction measures (e.g. Successful Examples).



From there, the Design Module supports design optioneering. Once an initial estimate has been established, alternative design approaches or selections can be explored and compared. This enables carbon information to be considered as part of design option assessment, rather than being reviewed only at the end of the process. The platform therefore supports not only the estimation of projected emissions, but also an assessment of how the total carbon emissions may be reduced when different options are introduced.

The Design Module is supported by a centralised data ecosystem, drawing on aggregated project-level carbon data[1] and carbon emission factors (CEF)[2] as the basis for backend calculations. The outputs are presented through a Design Carbon Report, which provides details of projected carbon emissions and the implication of different design options on carbon emissions. For designers, the main point of engagement is at the input and option-testing stage. For CEDD project teams, the output offers a clearer basis for reviewing projected carbon performance and identifying reduction opportunities at an earlier stage.

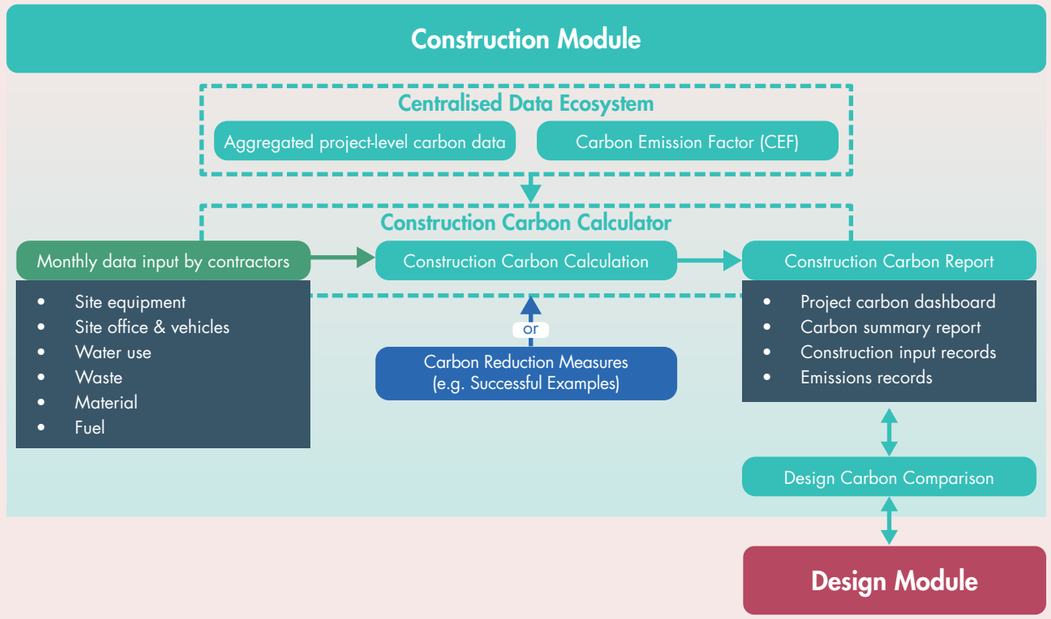
1 Aggregated project-level carbon data consolidates carbon information from relevant infrastructure projects.
2 CEFs represent the amount of carbon emissions associated with a unit of material, fuel or activity.

3.4.3 Construction Module Workflow

The Construction Module supports the structured capture of construction-stage carbon information through regular data entry. In the workflow shown below, contractors provide regular records of items such as site equipment, site office and vehicles, water use, waste, materials, and fuel. These records form the basis for construction-stage carbon calculation and ongoing project-level tracking during delivery.

These records are processed through the Construction Carbon Calculator, supported by the same broader centralised data ecosystem of aggregated project-level carbon data and CEF. The outputs are presented through a Construction Carbon Report, including dashboard-style views, summary reporting, input records and emissions records, thereby supporting a more consistent and structured approach to conduct a review of carbon emission in construction stage.

A key feature of the Construction Module is the ability to support comparison with the Design Module, creating a link between the projected carbon emissions developed during design stage and the actual carbon information recorded during construction stage. This provides CEDD project teams with a clearer basis for reviewing carbon performance across different project stages.



3.4.4 Design Optioneering within the Platform

Within the Design Module, optioneering is intended to assist designers in assessing how changes in selectable design inputs may affect the projected carbon emissions. Rather than producing only a single estimate, the platform is intended to support comparison between alternative selections to show how different design options affect carbon emissions at both overall project and individual process levels.

This design optioneering, in practice, is intended to allow designers to review the carbon implications of changes based on the available selections within the system. At this stage, types of changes for design optioneering include:

Types of Changes for Optioneering	Description
Change fuel type	Changing between different types of fuel used in equipment and on-site vehicles
Change material types	Changing the type of material (e.g. changes to concrete may include OPC, different ratios for PFA mix, different ratios for GGBS mix)
Change material origin	Changing the proximity of origin
Change material quantity	Adjusting the material reduction percentage
Use of renewable energy	Reduce the site office's fuel and electricity consumption by generating electricity from renewable energy sources

The expected outcome for designers is therefore not only an initial carbon estimation, but also a clearer basis for comparing different options and identifying where and how changes will lead to lower projected carbon emissions. In this way, optioneering helps position carbon information as a practical input to design development, rather than as a retrospective check undertaken after finalising the selected option. Worked examples to demonstrate how different selections may influence outputs and how those outputs may be interpreted within project decision-making are given in the following section.

3.4.5 Illustrative Optioneering Examples

This section provides two illustrative scenarios of how the platform may be used to support design optioneering. By showing how alternative design selections can influence projected carbon emissions, the examples help demonstrate how the platform may be applied in practice to support option comparison and more informed design decisions.

Scenario 1

Optioneering Strategy	Use of Cantilever Soldier Pile Wall with tie-back (outside site boundary) instead of Cantilever Bored Pile Retaining Wall

A deep excavation is proposed for an infrastructure project in an urban area of Hong Kong, requiring a retaining wall to ensure stability and minimise impact on surrounding facilities. The initial design adopts approximately 240m of conventional Cantilever Bored Pile Retaining Wall, which is commonly used due to its ability to provide a fully self-contained system within the site boundary. However, it typically requires larger construction plant and higher construction cost for large bored piles.

Given the growing emphasis on reducing embodied carbon in infrastructure works, particularly from material-intensive elements such as retaining structures, there is a need to explore whether alternative design approaches could achieve comparable performance with lower material usage. This creates an opportunity for optioneering to assess and compare viable retaining wall systems at the early design stage. Therefore, Cantilever Soldier Pile Wall with tie-back could be considered as an alternative to Cantilever Bored Pile Wall to stabilize the excavation if extension of tie-backs beyond site boundary is permissible.

Baseline Option: *Cantilever Bored Pile Wall*

- Cantilever bored pile wall, with pile diameter of 3m and reinforcement ratio of 2.93%

Input Parameters		
Skin Wall & Capping Beam	Capping Beam Length (m)	47.7
	Capping Beam Cross Sectional Area per unit length (m2/m)	7.4
	Skin Wall Surface Area (m2)	580.8
	Skin Wall Thickness (m)	0.4
Piling	Pile Diameter (m)	Ø 2.8-3.3m
	Number of Piles	16
	Soil Depth (m)	18.0
	Rock Socket Depth (m)	10.3

Proposed Option: *Cantilever Soldier Pile Wall with Tie-back (outside site boundary)*

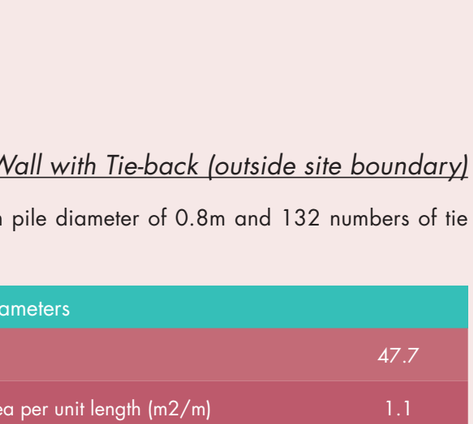
- Cantilever soldier pile wall with tie-back, with pile diameter of 0.8m and 132 numbers of tie back

Input Parameters		
Skin Wall & Capping Beam	Capping Beam Length (m)	47.7
	Capping Beam Cross Sectional Area per unit length (m2/m)	1.1
	Skin Wall Surface Area (m2)	595.3
	Skin Wall Thickness (m)	0.4
Piling	Average Pile Diameter (m)	0.8
	Number of Piles	44
	Average Soil Depth (m)	22.8
	Average Rock Socket Depth (m)	0

Baseline Option
Cantilever Bored Pile Retaining Wall



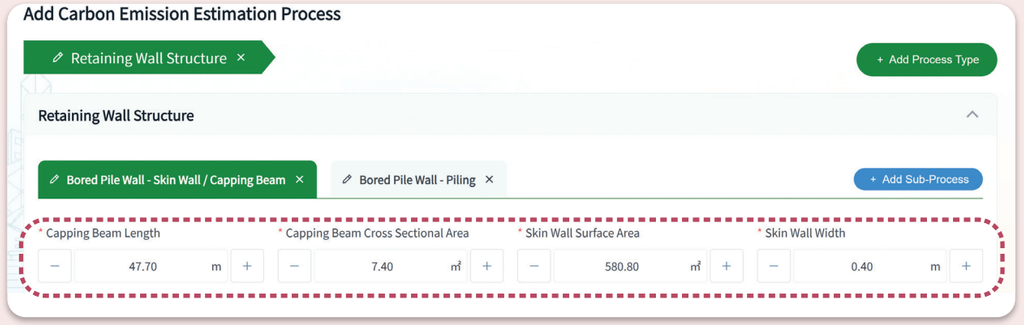
Proposed Option
Cantilever Soldier Pile Wall with Tie-back

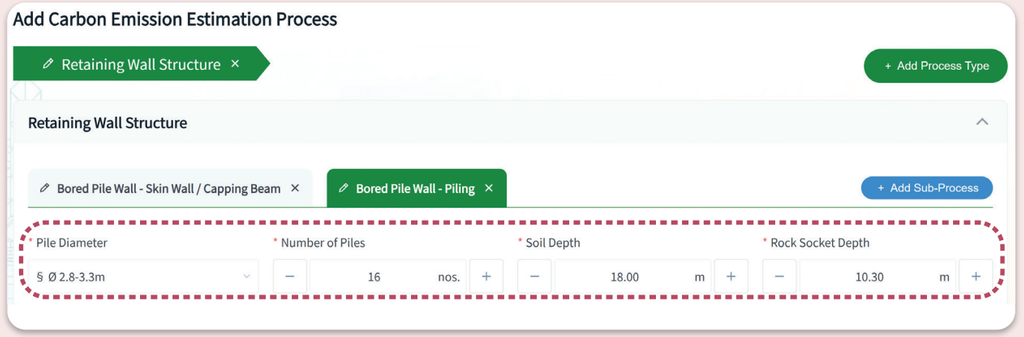


On the Platform

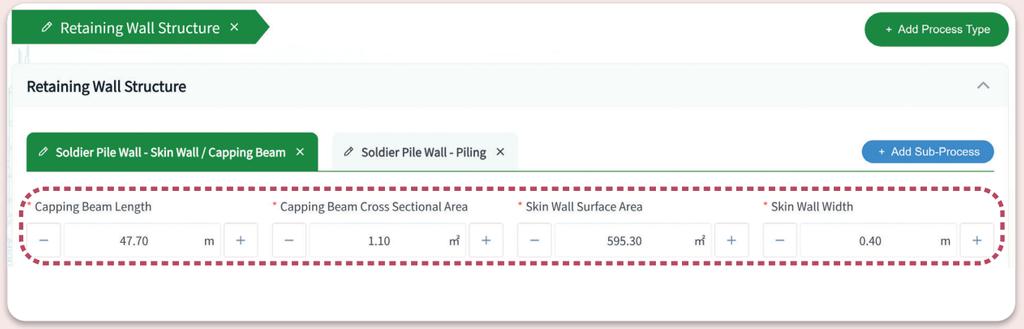
Designers are required to input work-specific design information for applicable sub-processes under both baseline and design options. The sub-processes “Bored Pile Wall” and “soldier Pile Wall” under the major process of “Retaining Wall Structure”, require separate parameter input for its skin wall/ capping beam and piling:

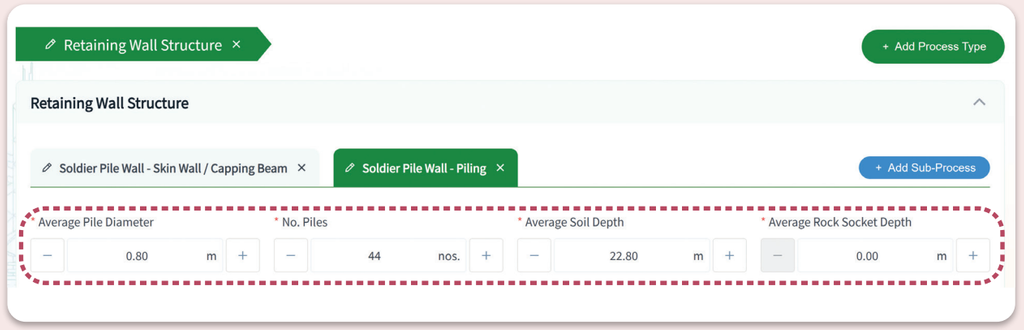
Baseline Option:



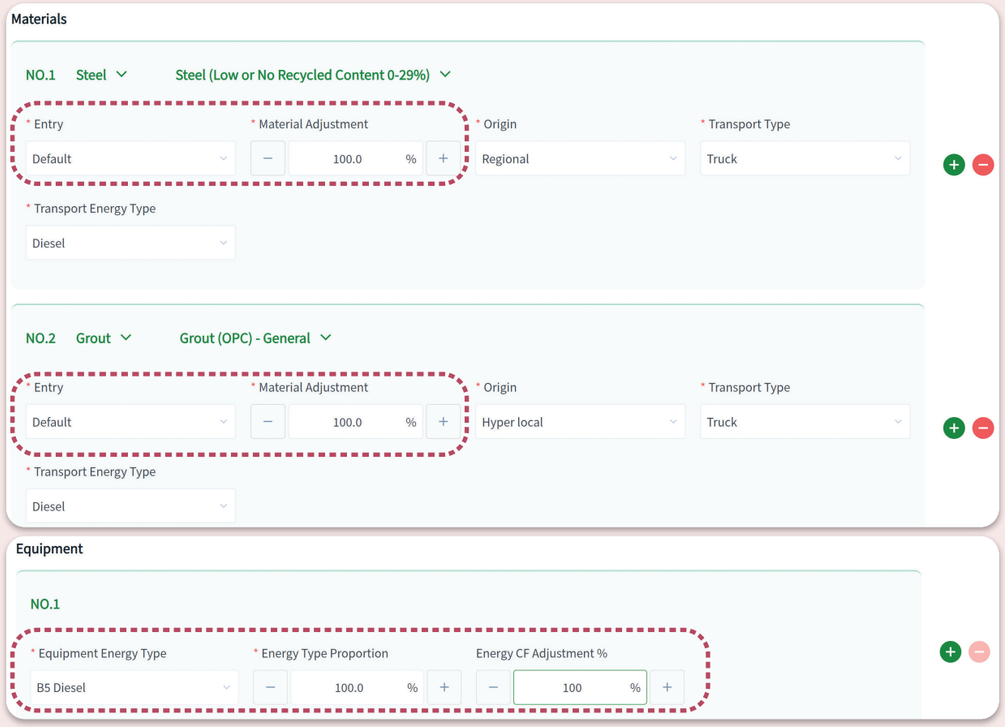


Design Option:





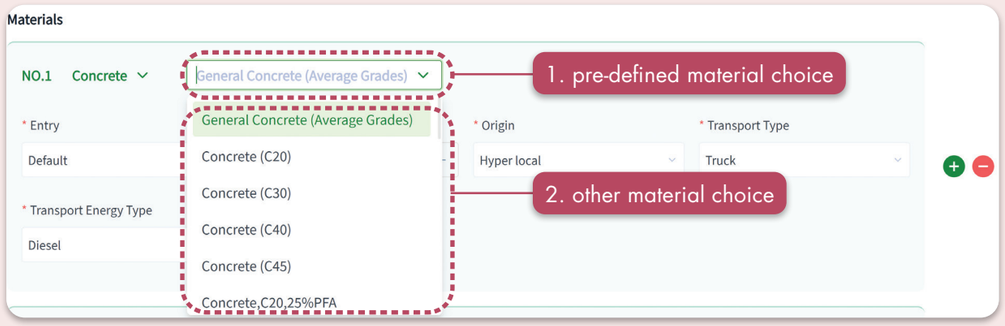
At early design stages, when key design parameters are still developing, the project team can use preset default profiles for each process and sub-process, reflecting typical material and equipment consumption.

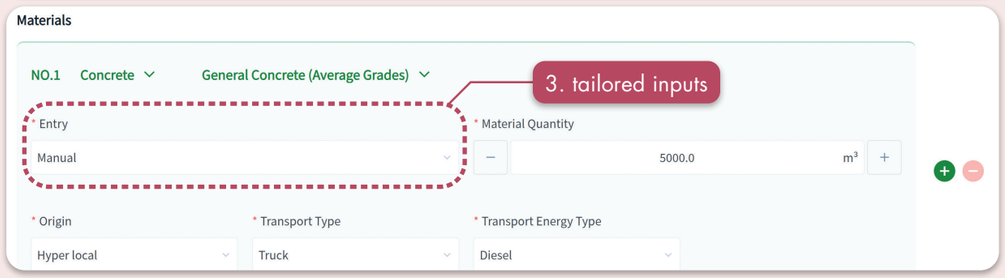


Each sub-process is assigned with pre-defined material composition. For retaining wall, the pre-defined material composition includes concrete, rebar, steel and grout. In this virtual scenario, the pre-defined material composition for soldier pile wall includes steel and grout.

For each material type, designer can either go with:

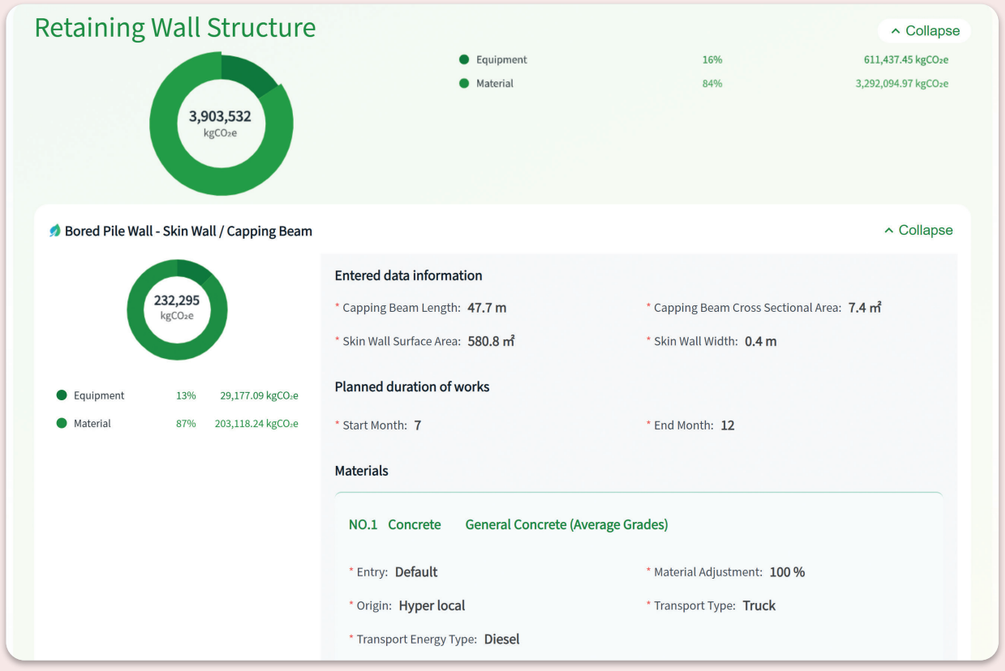
1. pre-defined material choice; or
2. other material choice from the platform's material library; or
3. tailored inputs that reflect actual project context

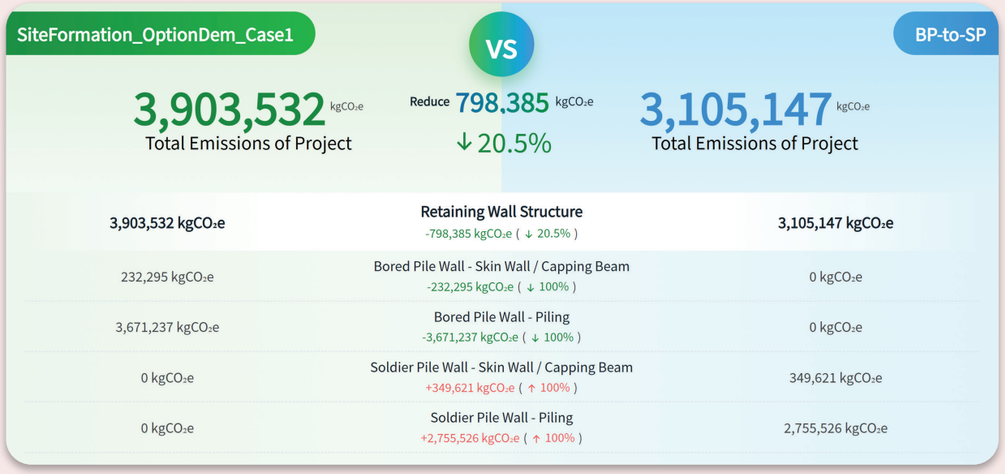




Upon completion of parameter input, the platform will perform the calculation, and the carbon emission estimates will be generated and available for review in a detailed breakdown.

The platform enables side-by-side evaluation of both options by comparing the associated carbon emissions under different major processes and sub-processes.





This virtual scenario demonstrates how the tie-back system can achieve comparable structural performance with smaller pile sizes and reduced concrete usage. Based on the carbon emissions calculation, the optioneering results are as follows:

Overall carbon emission reduction
-20.5%

Scenario 2

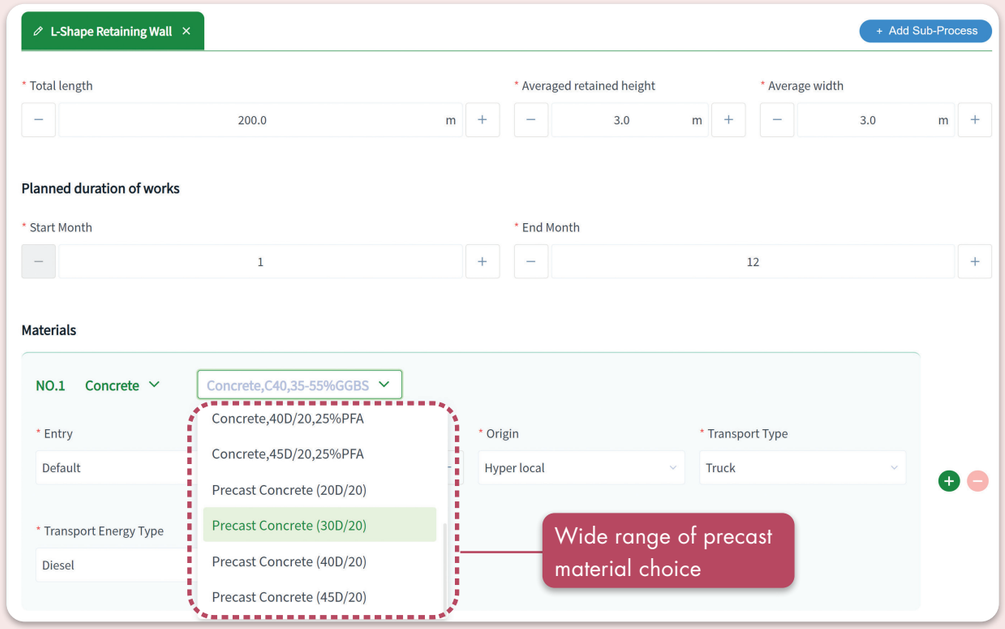
Optioneering Strategy	Use of Modular Prefabricated Block for L-shaped Retaining Wall Construction

A retaining wall is required for a local infrastructure project, where an L-shaped reinforced concrete retaining wall is proposed to provide earth retention along the alignment. The baseline design adopts a conventional cast in-situ solution, which typically involves extensive formwork, reinforcement fixing, and on-site concreting works.

Given the repetitive nature of the wall geometry and increasing focus on improving construction efficiency and reducing embodied carbon, there is a need to explore whether alternative construction approaches could reduce site activities and material wastage. This presents an opportunity for optioneering to assess the feasibility of modular prefabricated block systems as an alternative solution.

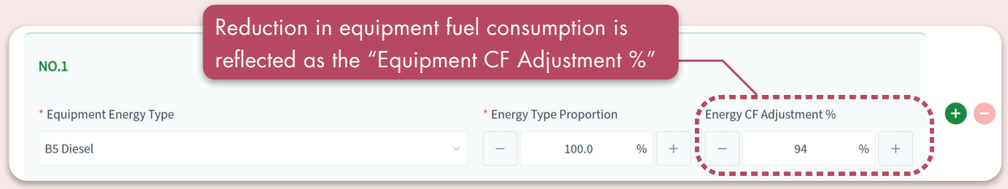
Input Parameters for L-shaped Retaining Wall	
Total wall length (m)	200
Average retained height (m)	3
Average width (m)	3

To reflect the carbon impacts due to the use of modular prefabricated component, the designer can change material type from "ready-mix" to "precast", the equipment consumption factor, as well as material origin (if any). Under this scenario, due to concrete pump being no longer necessary for precast concrete use, 6% reduction[1] in overall equipment use can be achieved, so the "Equipment CF Adjustment %", reflecting the equipment usage rate, is reduced to 94% to reflect this adjustment.



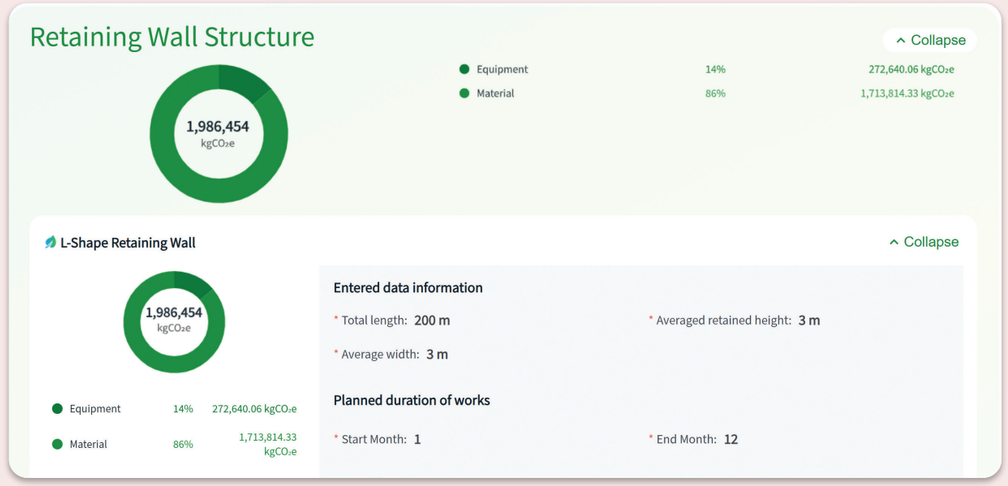
1 Based on data collected from the assessed projects, concrete-related works are estimated to account for approximately 6% of total site equipment fuel consumption.

This virtual scenario demonstrates how the use of modular prefabricated material contributes to the overall carbon emissions reduction in the project. Based on the carbon emissions calculation, the optioneering results are as follows:

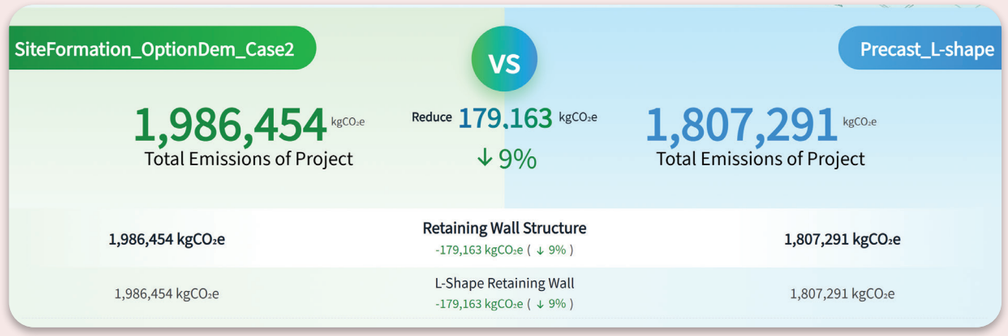


Overall carbon emission reduction
-9%

Upon completion of parameter input, the platform will perform the calculation, and the carbon emission estimates will be generated and available for review in a detailed breakdown.



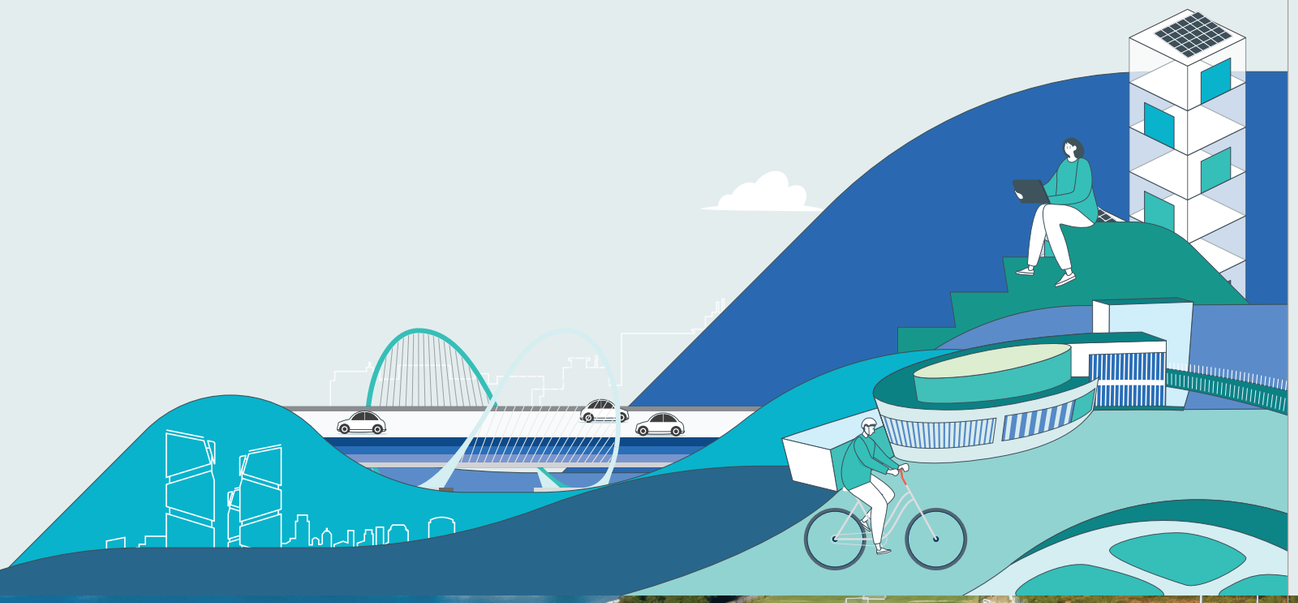
The platform enables side-by-side evaluation of both options by comparing the associated carbon emissions under different major processes and sub-processes.



4. Successful Examples

4.1 Overview

The Successful Examples presented in this section are organized into three categories: Material, Site Management, Design & Delivery. The guiding principles on how to identify carbon reduction opportunities for key emission sources are explained for each category.



MATERIALS

Design Out Carbon Intensive Materials is the guiding principle to focus on reducing embodied carbon at source by minimising materials demand and selecting lower-carbon alternative materials. Applying this principle encourages project teams to avoid unnecessary materials use, reduce over-specification, improve material efficiency, eliminate waste and pollution, and consider opportunities for carbon sequestration in materials where technically appropriate and verifiable.

SITE MANAGEMENT

Control Over Site Energy and Equipment is the guiding principle most closely aligned with site management, while also linking to construction methods where equipment selection, plant utilisation and sequencing affect energy demand. It focuses on reducing construction-phase emissions through efficient energy use, lower-carbon energy supply and active monitoring. This matters because fuel-driven plant, temporary works, logistics and site operations can represent a notable share of construction-stage emissions. Applying this principle encourages project teams to improve plant efficiency, reduce idling and unnecessary fuel use, integrate alternative and low-carbon energy sources where feasible, and track stock, fuel and equipment records to support more informed site management.

DESIGN & CONSTRUCTION DELIVERY

Embrace Innovation in Design and Construction Delivery is the guiding principle most closely aligned with design optimisation and effective delivery of construction work. Through early coordination, smarter planning and the adoption of innovative technologies, project teams can achieve substantial reductions in carbon emissions. This principle is important because incremental improvements alone may be insufficient to address the carbon impacts arising from conventional design approaches, inefficient sequencing, duplicated activities and resource-intensive construction practices. By streamlining site operations, integrating design and construction decisions at an earlier stage, adopting efficient construction methodologies, reducing waste and rework, and leveraging low-carbon technologies, project teams can embed innovation into project delivery and unlock more meaningful carbon reductions.



The selected examples illustrate how these guiding principles can be translated into practical applications for local infrastructure projects. Rather than prescribing a single solution, they provide reference points for practitioners to identify potential carbon reduction opportunities and consider suitable measures alongside technical feasibility, safety, cost, programme, statutory requirements, procurement arrangements and supply chain availability. When used together with the Carbon Digital Platform, these Successful Examples can help project teams move from identifying carbon hotspots to applying practical reduction measures at the appropriate stage of project delivery.





Biochar-enhanced Precast Concrete Panels



CarbonCure Concrete



Engineered Structural Bamboo



Ground Granulated Blastfurnace Slag (GGBS) Concrete



GGBS as Substitute for Cement in Grouting of Soil Nails



Green Electric Arc Furnace (EAF) Steel



Low-density Engineered Cementitious Composites (LD-ECC)



S960 Ultra High-Strength Steel



Ultra-High Performance Concrete (UHPC)



Vibration Resistant Sprayed Concrete (VRSC) Single-layer Lining for Hard Rock Tunnels and Caverns





Battery Energy Storage System (BESS)



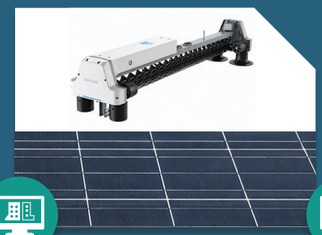
Electric Heavy Goods Vehicles



Electrification of Construction Machinery



Hydrogen-Powered Construction Plant and Vehicles



PV Performance Enhancement through Self-Cleaning Coating and Rail-Guided Mechanism



R20 Renewable Diesel



Smart Metering and Digital Monitoring for Construction Equipment



Construction of Box Culverts by Adoption of U-shaped Tunnel Boring Machine (UTBM) Method



Innovative Modular System for Excavation and Lateral Support (ELS) Construction



Green and Cost-effective Land Decontamination Method

Biochar-enhanced Precast Concrete Panels

Biochar-enhanced precast lightweight concrete panels reduce cladding weight of building envelope, lowering structural demands on roof trusses, columns and foundations. The precast approach also supports efficient off-site manufacturing and installation. This is achieved by replacing a portion of the fine aggregate (e.g. sand) with biochar, which is significantly lighter than conventional aggregates. With 25-30% replacement of fine aggregate, the concrete density can be reduced by approximately 3%, resulting in lighter panels that are easier to transport, handle and install.

In addition to reducing weight, biochar is produced from plant-based biomass that has absorbed CO_2 during growth. When incorporated into concrete panels, this biogenic carbon can be stored for the long term, helping to reduce upfront embodied carbon.



Possible Applications

Various application location for infrastructure projects

- **Current non-structural application with future structural potential:** Current applications are primary for non-structural elements, such as pavers and partition wall blocks. However, ongoing collaboration among contractors, material suppliers and academic institutions is driving further research and market development, with the aim of exploring wider adoption including structural elements in the future.

Project Info

Project Name
CEDD - Civil Engineering Office Community Liaison Centre for Civil Engineering Office of CEDD at Ma Liu Shui Promenade

Project Location
Ma Liu Shui Pak Shek Kok Promenade, Science Park Road, Shatin

Project Year
Project commencement in 2025

Extent of Strategy Application
Biochar-enhanced lightweight precast concrete panels were adopted for the façade, using biochar produced from yard waste collected and converted into biochar at EcoPark as a partial replacement for fine aggregate.

Project Description
The circular building design is mainly reflected in two fundamental cycles. The first is the biological loop. It pursues the principle that building materials should be taken from and returned to nature. For example, renewable and biodegradable engineered bamboo was used to replace conventional building materials as the building's structural framework. The second cycle is the technical loop, which leaves the possibility of giving each primary structural component a second life. This allows the building's life cycle to extend beyond a single location, enabling resources to circulate continuously.



Overall Benefits

Potential Carbon Reductions

- Biochar contains carbon originally absorbed by plants during growth. When used in concrete, this biogenic carbon can be retained within the concrete product as long-term carbon storage, helping to reduce the product's upfront embodied carbon.
- Based on biochar carbon content analysis, biochar can sequester approximately 2.347 $kgCO_2e$ per kg. In this project, the biochar-enhanced concrete achieved a carbon footprint of approximately –126.32 $kgCO_2e/m^3$ based on assessment using the CIC Green Product Certification (CIC GPC) tool, indicating that the carbon stored within the product exceeds the associated carbon emissions in the production process. A total of 6 m^3 of biochar-enhanced lightweight concrete was used in the precast panels, resulting in an estimated net carbon sequestration of 762 $kgCO_2e$.
- Biochar is significantly lighter than conventional fine aggregate. Replacing approximately 25-30% of the fine aggregate with biochar can reduce concrete density by 3%. The resulting reduction in panel self-weight can reduce loads on supporting elements such as roof trusses, columns and foundations, thereby reducing structural material quantities and associated embodied carbon.

sequester approximately

2.347 kg CO_2e

per kg of biochar

Cost/Time/Manpower Reduction

1 Reduced foundation/supporting-structure demand:

- Replacing a portion of the aggregate with biochar can reduce fresh concrete density by 3%, resulting in lighter cladding panels. The lowered dead load may reduce loads transferred to supporting elements such as roof trusses, columns and foundations compared with conventional concrete cladding panels. Subject to structural design requirements, this may lead to a smaller size of the supporting elements.

2 Reduced lifting needs and crane size:

- The reduced panel weight may allow the use of smaller crane capacities and fewer heavy lifting operations. This can simplify lifting logistics, reduce crane operating time and potentially lower construction costs, as crane hire is often influenced by crane size and lifting requirements.

3 Faster installation through off-site precast approach:

- The precast approach supports off-site fabrication. Compared with in-situ concrete works, this can reduce on-site work, shorten installation programmes and lower on-site labour requirements.

4 Good thermal and acoustic performance:

- Pilot-scale thermal monitoring and acoustic testing have demonstrated that biochar-enhanced concrete products, including partition blocks and porous pavers, can provide better thermal insulation and sound insulation performance than conventional concrete, contributing to improved building comfort and environmental quality.

Other Opportunities

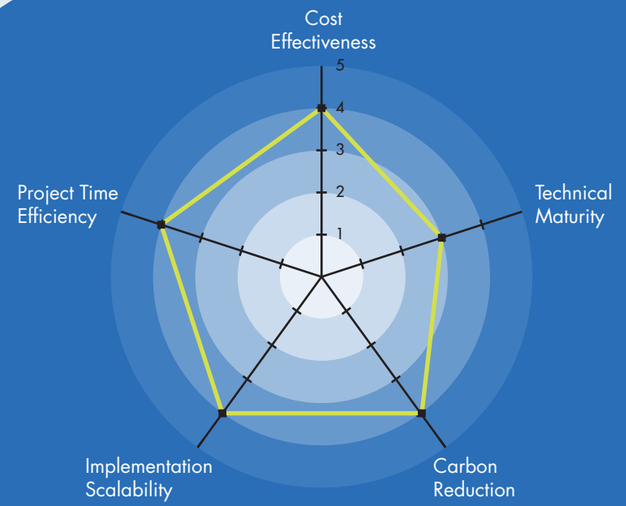
1 Circularity

- Yard waste and other biomass waste can be converted into biochar (e.g. through facilities such as EcoPark) and subsequently used as a raw material for concrete production. This transforms waste into a useful construction resource and supports circular economy principles.

Recommendations for Optimisation

- The supply of biochar is expected to improve as local processing capacity and supply networks expand, supporting its use on an even larger scale. Early planning and engagement with biochar suppliers are recommended to secure a consistent supply of biochar for your projects.





Source:

Tsang, D. C. W. (2025). Biochar-enhanced Construction Materials for Sustainable Waste Management and Decarbonisation. Final research report presentation, Ref. No. GTF202020153. The Hong Kong University of Science and Technology.

CarbonCure Concrete

CarbonCure concrete captures CO_2 into fresh concrete during mixing, where it reacts with calcium ions to quickly turns into tiny limestone-like solids inside the mix. This mineralisation process permanently stores a portion of CO_2 within the concrete mix (i.e. CO_2 become locked into the concrete).

This can enable optimisation of the concrete mix design to achieve the required performance with a lower cementitious material content, thereby reducing embodied carbon. The combination of cement reduction and permanent CO_2 storage provides dual carbon benefits, contributing to lower-carbon concrete production.



Possible Applications

Various application location for infrastructure projects

- **Replace cast-in-place structural elements:** CarbonCure concrete can be applied beyond footings to other cast-in-place structural elements that use ready-mixed concrete, such as walls, slabs, beams and columns.

Project Info

Project Name
CEDD - Civil Engineering Office Community Liaison Centre for Civil Engineering Office of CEDD at Ma Liu Shui Promenade

Project Location
Ma Liu Shui Pak Shek Kok Promenade, Science Park Road, Shatin

Project Year
Project commencement in 2025

Extent of Strategy Application
CarbonCure concrete with 40% GGBS cement replacement was used in the project's foundation works. The concrete was supplied from a local ready-mix supply chain that includes Hong Kong's first concrete plant implementing CO_2 injection during concrete manufacturing.

Project Description
The Civil Engineering Office Community Liaison Centre (CLC) at Ma Liu Shui Promenade is developed by taking demountability, adaptability, material recovery, future material reuse into consideration, thus reducing the generation of construction waste across the building life cycle.



Overall Benefits

Potential Carbon Reductions

The use of CarbonCure concrete reduces carbon emissions, through:

- Reducing the cementitious content in the concrete mix while maintaining the required concrete strength, thereby lowering emissions associated with cement production
- Permanent CO_2 storage via mineralisation of injected CO_2 into a stable carbonate compound within the concrete.

Based on the manufacturer's carbon assessment and X-ray diffraction (XRD) verification, the project achieved carbon savings through both cement reduction and permanent CO_2 storage. With a 5% reduction in cementitious material content and CO_2 injection at 0.1% of cement weight (assuming 90% CO_2 uptake efficiency), a total saving of 7.37 $kgCO_2e/m^3$ of concrete was achieved, comprising:

- 7.15 $kgCO_2e/m^3$ from reduced cementitious material content; and
- 0.22 $kgCO_2e/m^3$ from permanent CO_2 mineralisation within the concrete.

A total of 97.5 cubic metre concrete was used in this project, resulting in 697 $kgCO_2e$ avoided due to cement reduction and 21 $kgCO_2e$ permanently stored through CO_2 mineralisation

(Note*: The calculated savings were based on concrete mix containing 40% GGBS replacement. The reported savings therefore represent the additional benefit of the CarbonCure technology when applied to a 40% GGBS concrete mix, rather than a conventional 100% OPC concrete mix)

7.37 kg CO_2e/m^3

of concrete saved through cement reduction and permanent CO_2mineralisation"

Cost/Time/Manpower Reduction

1 Improved compressive strength:

- In this project, dedicated test results and optimized mix design indicated that CarbonCure mixes can perform on par with conventional OPC concrete. Carbon mineralisation helps improve compressive strength and early strength development of the concrete mix. This can shorten the time required for the concrete to gain early strength, which is beneficial for projects with tight construction programme.

Other Opportunities

1 Circularity:

- The strategy makes beneficial use of captured waste CO_2 from industrial processes (e.g. power plant) by injecting it into fresh concrete for permanent storage in a stable mineral form. This supports the circular use of an industrial by-product that would otherwise be released to the atmosphere, while contributing to lower-carbon concrete production.

2 Proven environmental performance:

- CarbonCure Concrete has attained the Platinum rating under the CIC Green Product Certification. This independently verified recognition provides assurance of CarbonCure Concrete's environmental performance and makes this innovative concrete solution readily specifiable to support low-carbon targets in future projects.

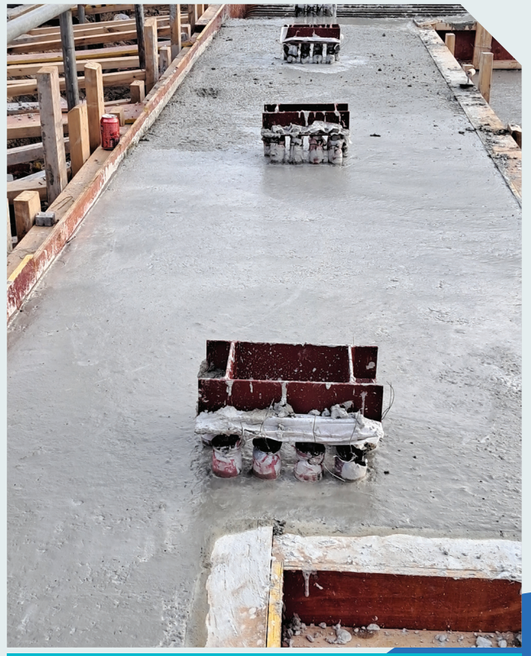
Recommendations for Optimisation

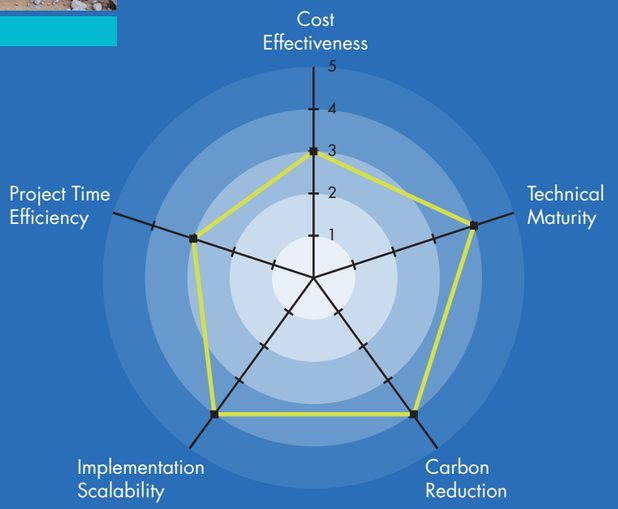
1 Mix-specific CO_2 dosage

- It is recommended to undertake carbon uptake tests during concrete mix trials with a view to establishing the optimum CO_2 dosage range for each specific mix design.

2 Batching plant integration and initial investment

- While implementation requires specialised CO_2 storage and controlled injection equipment to ensure accurate dosing, the initial investment and maintenance costs are relatively small when compared to the plant's overall operating costs. Furthermore, this system introduces significant financial upside by leveraging active carbon capture and unlocking potential new revenue through carbon trading.





Engineered Structural Bamboo

Engineered structural bamboo is a bio-based material that can be used in lightweight, modular structural systems. The use of engineered bamboo to replace structural steel can reduce total dead load, thus minimising foundation requirements and heavy lifting needs. Replacing structural steel with engineered bamboo also lowers embodied carbon, as bamboo stores biogenic carbon and can achieve a net-negative carbon profile even after manufacturing.

Bolted connections support Design for Manufacturing and Assembly (DfMA) and Design for Disassembly (DfD), enabling efficient construction and future reuse. Embedding scrap steel in connection plates can further reduce total carbon emission by avoiding new steel production.

Reducing
carbon by over
100%
compared with
conventional structural steel



Possible Applications

Various application location for infrastructure projects

- **Primary structural applications:** Engineered bamboo can be used as a load-bearing structural material for primary structural elements, including beams, columns and trusses.
- **Lightweight roof structures:** The material is well suited to lightweight roof structures, such as pavilions, canopies and other roof features. In particular, its low self-weight supports modular construction approaches.
- **Nature-based design:** As a bio-based material, engineered bamboo is well aligned with nature-based design principle, where its natural appearance and lower embodied carbon support better integration with landscape.

Project Info

Project Name
CEDD - Civil Engineering Office Community Liaison Centre for Civil Engineering Office of CEDD at Ma Liu Shui Promenade

Project Location
Ma Liu Shui Pak Shek Kok Promenade, Science Park Road, Shatin

Project Year
Project commencement in 2025

Extent of Strategy Application
The project utilised approximately 25,000 kg of engineered structural bamboo (laminated structural bamboo) as the primary structural system, including columns, beams and bracings. The lightweight structural system incorporates demountable bolted connections.

Project Description
The Civil Engineering Office Community Liaison Centre (CLC) at Ma Liu Shui Promenade is developed by taking demountability, adaptability, material recovery, future material reuse into consideration, thus reducing the generation of construction waste across the building life cycle.





Overall Benefits

Potential Carbon Reductions

- Engineered structural bamboo delivers a net-negative upfront carbon footprint by sequestering biogenic carbon during growth, sequestering approximately 21,050 kgCO_2e in the project based on the product Environmental Product Declaration data [1] and achieving over 100% carbon reduction compared with structural steel.
- In contrast, conventional structural steel has a positive embodied carbon footprint typically ranging from 1.4 to 2.23 kg CO_2e/kg, depending on the production method, based on industry-average Environmental Product Declaration for structural steel.
- The lightweight and fully bolted bamboo system reduces installation-stage emissions by around 20% through lighter lifting, smaller crane, and elimination of on-site welding, with similar benefits during deconstruction as the reversible bolted connection system facilitates efficient dismantling and component recovery.

Cost/Time/Manpower Reduction

1 Reduced foundation demand:

- Engineered structural bamboo is significantly lighter than structural steel and reinforced concrete (RC), with a density of approximately 600 kg/m³ in this project. Its lower self-weight reduces structural dead loads and foundation requirements, enabling smaller and lighter foundation systems. This can reduce excavation, concrete and steel consumption, as well as associated plant and labour requirements, resulting in lower embodied carbon, improved construction efficiency and potential cost savings.

2 Reduced lifting needs and crane size:

- The lightweight modular bamboo system can reduce crane size requirements and the heavy lifting operations, lowering equipment fuel consumption and plant-related costs, including crane hire, mobilisation and set-up.

3 Faster installation through bolted modular assembly:

- The fully bolted bamboo system supports DfMA, enabling rapid installation with small crews, with no on-site welding or hot works required. The absence of welding, post-weld inspection and curing processes helps shorten the construction programme, reduce specialist labour requirements, and improve overall site productivity when compared with welded structural steel construction.

Other Opportunities

1 Circularity – enabling design for disassembly, reuse and waste reduction:

- Design for Disassembly (DfD) is exhibited through the use of reversible bolted connections to enable non-destructive dismantling and direct reuse of structural components. Reuse rates up to 90% have been reported.
- The use of reversible bolted connection makes it easier to separate, recover and redeploy bamboo modules during refurbishment or at end-of-life, reducing waste generation and improving material recovery rates to lower whole-life carbon impact.

2 Proven environmental performance:

- The engineered bamboo product used in this project has attained the Platinum rating under the CIC Green Product Certification. This independently verified recognition provides assurance of market-available engineered structural bamboo products' environmental performance and supports its specification as low-carbon material in future projects.

1 According to the product Environmental Production Declaration of the bamboo specified for the project case, the bamboo sequesters 1.81 kg CO_2e/kg during growth and achieves a net upfront carbon footprint of approximately –0.84 kg CO_2e/kg after accounting for manufacturing and transportation emissions.

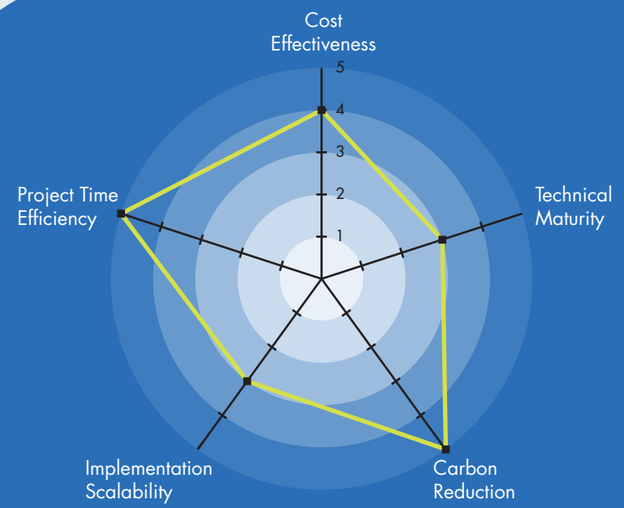
Recommendations for Optimisation

1 Local adoption

- Early engagement with design teams and authorities is recommended to clarify submission requirements and fire protection needs. To support the long-term growth of engineered structural bamboo, it is highly desirable to establish dedicated local design standards as project experience increases.

2 Early procurement planning

- Reliable supplies are available across neighboring regions such as Jiangxi and Fujian Provinces, located just hours away from Guangdong by truck. For larger-scale or repeated adoption, early procurement planning and/or framework supply agreements are highly recommended to secure capacity and ensure pricing certainty.



Ground Granulated Blastfurnace Slag (GGBS) Concrete

Among the various Secondary Cementitious Materials (SCMs), pulverised fuel ash (PFA) is the one most commonly used in Hong Kong, but its production is diminishing due to reduced use of coal for power generation. Facing the anticipated PFA shortage, Ground Granulated Blast-furnace Slag (GGBS) has emerged as viable alternative.

GGBS is a by-product from the iron and steel manufacturing. By replacing a portion of ordinary Portland cement (OPC) with GGBS, the concrete mix can achieve significant reductions in embodied carbon emissions, as cement is the dominant contributor to the overall whole-life cycle carbon footprint of concrete.

Given that GGBS concrete provides enhanced concrete durability due to its promising material properties, it is expected to play an increasingly important role in sustainable construction.

Carbon reduction achieved by **50%** GGBS C45 concrete compared with OPC concrete of the same grade



Possible Applications

Various application location for infrastructure projects

- **Mass concrete (e.g. Thick walls)**
- **Foundation**
- **Substructures**
- **Base slabs**

> **"GGBS concrete significantly reduces carbon emissions while improving the long-term durability.**

Project Info

Project Name
CEDD - Site Formation and Infrastructure Works for Police Facilities in Kong Nga Po (Contract No: ND/2018/01)

Project Location
Kong Nga Po, New Territories

Project Year
Construction commenced in 2019

Extent of Strategy Application
The use of GGBS concrete for construction of stormwater storage tank, retaining walls, and the bridge, due to its high workability, ability to withstand chloride attack and mitigate thermal cracks.

Project Description
The project involves the site formation of about 19 hectares of land at Kong Nga Po to support the development of new police facilities. The major works include upgrading roughly 1.7 kilometres of Kong Nga Po Road to a 7.3-metre-wide single two-lane carriageway and constructing a new vehicular bridge of about 100 metres to enhance site accessibility. The works further comprise associated infrastructure works, including road works, waterworks, drainage and sewerage works, geotechnical works, landscaping works, environmental mitigation measures, and other ancillary works.





Overall Benefits

Potential Carbon Reductions

- Cement represents approximately 10% of the mass of typical concrete, yet it contributes more than 70% of the concrete's overall carbon emissions.
- Approximately 50% of carbon reduction when compared with Ordinary Portland Cement (OPC) concrete of same grade. Example of different grading as below:
- Reduction of carbon footprint when compared with OPC concrete of same grade:

Grade 45

47.4% by addition of GGBS

24.7% by addition of PFA

Cement replacement of concrete are 50% with GGBS and 35% with PFA respectively

Cost/Time/Manpower Reduction

1 No cost premium for GGBS

- Concrete incorporating 35-75% GGBS has been widely adopted in projects with no significant cost premium as compared to OPC concrete. In contrast, an estimated 6-10% premium is carried for PFA-blended concrete while GGBS-blended concrete is generally cost-neutral relative to OPC concrete

Other Opportunities

1 Reduced Drying Shrinkage

- All concrete shrinks as it dries, however GGBS concrete exhibits significantly lower drying shrinkage, with around 20-30% lower shrinkage strain than OPC and PFA concrete. This reduces shrinkage-related cracking as well as volume change, hence enhanced concrete durability and extend the service life of concrete structure.

2 Superior Resistance to Chloride Penetration

- Rapid Chloride Permeability Tests (RCPT) show that the GGBS concrete achieved low chloride permeability, which is 50% lower than typical OPC concrete.
- The reduced chloride permeability limits the ingress of water, chlorides, salt and other aggressive substances into the concrete, providing enhanced protection to embedded steel reinforcement against corrosion

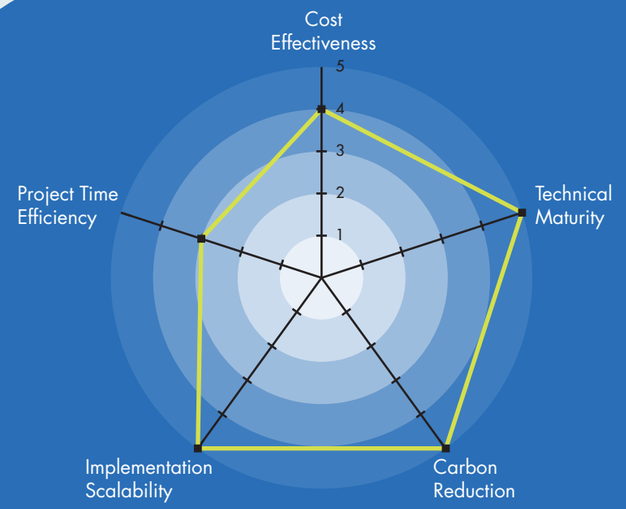
3 More consistent concrete appearance:

- GGBS concrete generally has a lighter and more uniform colour than PFA concrete. It helps to reduce the visibility of surface discolouration and efflorescence, contributing to a more consistent aesthetic appearance over time.

Recommendations for Optimisation

- Utilizing finely ground GGBS increases the particle surface area and accelerates the hydration process, enabling early-strength development comparable to conventional OPC concrete. Consequently, concerns regarding the weak early-strength development of GGBS concrete are no longer applicable, as it will not prolong the construction cycle of building works.





GGBS as Substitute for Cement in Grouting of Soil Nails

A recent CEDD study demonstrated that GGBS is a practical and cost-effective cement replacement for soil nail grouting mix, with virtually no adverse impact on site operation, programme and cost.

Conventional soil nail grout relies on Ordinary Portland Cement (OPC) which is associated with a relatively high carbon footprint. Replacing a proportion of OPC with GGBS can significantly reduce embodied carbon while also beneficially reuse the steel-making industry by-product.

Using locally available pre-bagged GGBS, the grout can be produced using conventinal mixing practices for OPC with only minor adjustments to site operations. This provides a practical and readily deployable low-carbon solution for Landslip Prevention and Mitigation (LPMit) works.

Up to
69%
carbon reduction achieved through **75%** GGBS cement replacement.



Possible Applications

Various application location for infrastructure projects

1. **Widespread application of strategy in soil nailing for LPMit works**

   This study has demonstrated that it is practically feasible to substitute cement with GGBS for soil nailing works under the LPMit Programme. A total of 22 grout mix trials were conducted, all of which complied with the relevant General Specification for Civil Engineering Works (GS).

   Building on these findings, from the fourth quarter of 2025 onwards, all LPMit works contracts are targeted to adopt GGBS-cement grout in soil nailing works at two or more sites per each works contract, where practicable. This approach will facilitate wider implementation while enabling LPMitP project teams to gain valuable hands-on experience under diverse site conditions.

2. **Further adoption in rock dowels**

   Apart from soil nailing works, GGBS-cement grout has the potential to be adopted in rock dowels for structural support of rock slopes, provided that site trials are conducted to study and prove the bond performance between GGBS-Cement grout and the rock mass fulfilling the design requirement and compliance to current GS.

Project Info

Project Name
Landslip Prevention and Mitigation Programme, 2021, Package H

Project Location
Kau Wah Keng Pilot Site (Study Area – 11NW-A/HPSA2B)

Project Year
2024

Extent of Strategy Application:
A total no. of 417 soil nails had been grouted by GGBS-Cement grout.

Project Description
Following successful laboratory testing and site trials using bulk GGBS, a pilot site was identified to further evaluate the practical implementation of GGBS-cement grout in soil nailing works. The pilot aimed to simulate typical site operations, including batch-by-batch mixing and continuous grouting, in a manner comparable to conventional cement grout practices.

With the collaboration of a local GGBS manufacturer, pre-bagged GGBS was made available, enabling the pilot application to proceed under realistic site conditions. This arrangement facilitated better handling, storage, and dosing of GGBS at the pilot application.

The primary objective of this study is to review and optimize the workflow for incorporating pre-bagged GGBS in grout mixes for grouting works of soil nails through site trials. It also aims to establish appropriate technical specifications and practical guidelines for pilot implementation, with a view to supporting long-term adoption in LPMit sites.



Overall Benefits

Potential Carbon Reductions

- GGBS, a by-product of steel manufacturing, has a significantly lower embodied carbon than Ordinary Portland Cement (OPC). Replacing 60–75% of cement with GGBS can reduce cradle-to-gate carbon emissions by approximately 45–69%, equivalent to 703–888 $kgCO_2e/m^3$ for grout containing around 1,350 kg of cement per m^3.

Cost/Time/Manpower Reduction

1 Similar or reduced material costs due to lower unit cost of GGBS

- The cost implication of pre-bagged GGBS has been evaluated through a fair cost comparison between conventional cement grout and GGBS-cement grout. The findings from the pilot application indicate that GGBS-cement grout is approximately 2% more economical per unit volume than conventional cement grout, as the lower unit cost of GGBS outweighs the additional admixture (i.e. superplasticiser) required in the mix. Transportation costs for GGBS were not included; however any additional transport cost is expected to be minimal as the material is locally sourced.

2 Pre-bagged GGBS eliminates the need for time-consuming on-site measurement associated with bulk handling

- The use of pre-bagged GGBS eliminates the need for time-consuming on-site measurement associated with bulk handling. Early small-scale site trials found that weighing bulk-delivered GGBS prior to mixing was labor-intensive and inefficient. Using pre-bagged GGBS simplifies handling, eliminates on-site weighing, and allows grout mixes to be defined by bag quantities, resulting in time savings and improved consistency. This approach also aligns with conventional bagged cement practices, thereby supporting smoother implementation and adoption on-site.

Other Opportunities

In addition to the performance benefits outlined in the "Other Opportunities" section for GGBS Concrete, such as reduced thermal cracks by limiting cure temperature of concrete, enhanced durability against chemical attacks and reduced drying shrinkage etc., the pre-bagged GGBS provides a distinct practical and implementation advantage as follows.

1 Pre-bagged GGBS provides greater flexibility for material transport and storage across a wider range of site temperature and humidity conditions.

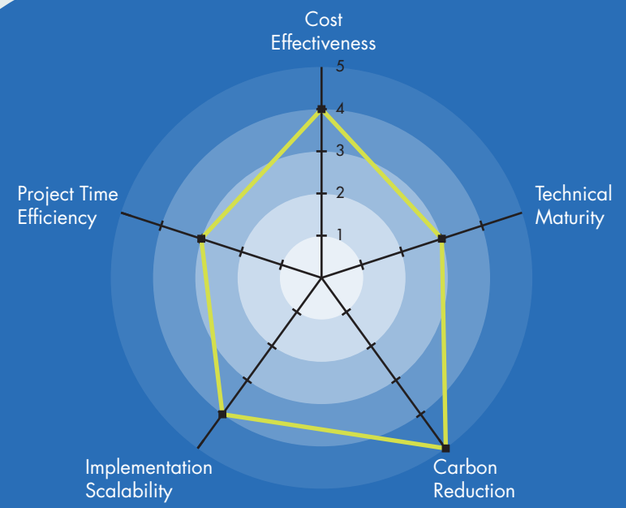
- While the GS does not specify storage requirements for pre-bagged GGBS, pilot studies confirmed that it can be stored in environments comparable to those for bagged cement. GGBS stored on-site for up to 14 weeks under uncontrolled temperature (8–27°C) and humidity (55–97% RH) conditions exhibited no observable deterioration in GGBS-cement grout performance. This demonstrates robust storage tolerance, reducing logistical constraints and enabling more flexible procurement and delivery planning.

2 Improved Operational Efficiency with Pre-blended Materials

- In addition to the availability of locally supplied pre-bagged GGBS, contractors can readily prepare GGBS-cement grout by adding cement, pre-bagged GGBS and admixtures into mixers in accordance with the specified grout mix design. This process is comparable to the conventional preparation of cement grout and can be implemented smoothly on-site.
- Furthermore, the availability of pre-blended products in a single bag can significantly enhance operational efficiency. With advancements in the packaging of cementitious materials by local suppliers, such pre-blended GGBS-cement products are now commercially available. These products typically contain 60% to 68% GGBS, combined with cement and admixtures in a single bag. Their use simplifies batching and eliminates the need for separate material dosing, resulting in a grouting process that is operationally comparable to the conventional cement grout in soil nailing works.
- In addition, some of these pre-blended materials are supplied in 25kg bags, which are lighter than conventional 45kg cement bags. This improves occupational health and safety by reducing manual handling risks during lifting and transportation.

Recommendations for Optimisation

- Beyond traditional soil nail installations, GGBS cement grout is highly viable for broader general grouting and ground improvement works. Deploying this low-carbon grout in a pre-bagged format significantly enhances its feasibility for on-site applications.



Green Electric Arc Furnace (EAF) Steel

Green steel (e.g. Electric Arc Furnace (EAF) steel) is produced by melting recycled steel scrap using electricity, rather than making steel from iron ore in a coal-based blast furnace route. This production method can significantly reduce the embodied carbon of steel because it enables the manufacture of steel products from recycled steel scrap rather than the virgin raw materials. In addition, the supply of electricity could potentially come from renewable sources.

Achieve

50%

carbon reduction by green energy produced EAF steel, compared to conventional BF-BOF steel



Possible Applications

Various applications for infrastructure projects

- **Reinforcement steel (rebar)**
- **Structural steel**

Project Info

Project Name

Several pilot building projects in Hong Kong

Extent of Strategy Application:

Approximately 5,200 tonnes of green rebar was adopted, representing around 80% of superstructure rebar consumption

Project Description

A joint-venture commercial office development at Causeway Bay with a GFA over 100,000m2, comprising three mid-rise Grade-A office towers and social welfare facilities, together with urban park, landscape connection, and cultural spaces. The works also include a five-storey basement and the retention of two Grade-3 historic masonry walls and two old and valuable trees.



Overall Benefits

Potential Carbon Reductions

- **Achieving over 50% carbon reduction** compared to conventional Blast Furnace - Basic Oxygen Furnace ("BF-BOF") steel.
- Conventional coal-based BF-BOF steelmaking relies on coal as a reactant and energy source, which results in high process emissions in addition to fuel consumption. In contrast, EAF steelmaking melts recycled steel scrap using electricity to produce new steel. Because the feedstock is already metallic iron/steel (scrap), the process generally does not require the same coal-based conversion of iron ore into iron, which is a major source of emissions in BF-BOF steelmaking.
- **Recycled content drives major embodied carbon savings.** EAF steel can typically achieve very high recycled content - an average recycled content of 90% for EAF, compared with around ~30% recycled content in traditional BF-BOF in practical terms. Using scrap as the main feedstock reduces reliance on primary ore-based steel production and supports circular economy outcomes in keeping steel in circulation rather than producing new virgin steel.
- **Greater reduction potential when renewable / lower-carbon electricity is used.** Because EAF steelmaking is electricity-based, its carbon performance improves as the electricity supply decarbonises. Using electricity (instead of coal) enables grid decarbonisation and renewable energy to contribute to the reduction potential, meaning EAF steel has greater potential for further embodied-carbon reduction when powered by renewable or lower-carbon electricity sources.

Cost/Time/Manpower Reduction

1 Cost-effectiveness despite premium:

- Based on the Technical Procurement Guideline published by Hong Kong PropTech Alliance, while EAF steel may attract an indicative 20–25% price premium.
- Despite this premium, EAF steel can be a high-leverage embodied carbon reduction measure, as alternative carbon reduction measures or carbon offsetting initiatives for carbon-conscious projects pursuing ambitious decarbonisation targets may require substantially higher investment. As such, adopting EAF steel can provide a cost-effective means of achieving upfront embodied carbon reductions, delivering favourable carbon savings relative to the additional investment required.

Other Opportunities

1 Circularity

- High recycled content supports circularity. EAF steel is produced primarily from recycled steel scrap, keeping materials in circulation and reducing reliance on virgin raw materials, thereby supporting circular economy outcomes.

Recommendations for Optimisation

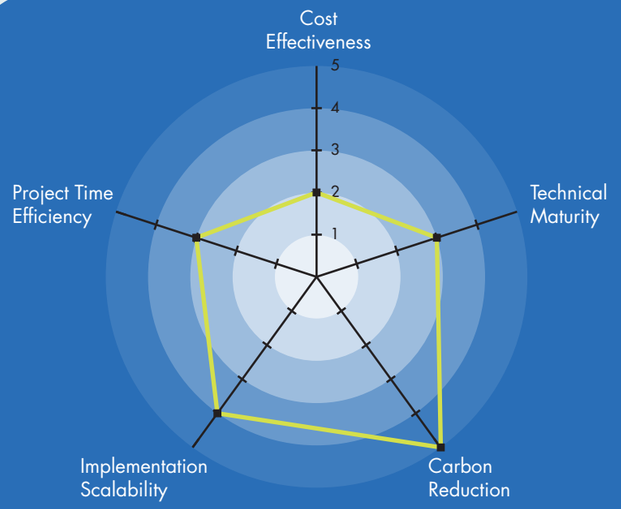
1 Regional market availability

- The growing regional capacity and maturity of EAF low-carbon steel production unlock more flexible sourcing options, enabling procurement strategies to align dynamically with evolving supply chain conditions and project deliverables.

2 Early engagement with suppliers

- With EAF steel suppliers increasingly adopting internationally recognised Environmental Product Declarations (EPDs), early engagement is critical to proactively obtain the data required to verify and compare the embodied carbon performance of different products.





Source:
Hong Kong PropTech Alliance and RESET Carbon (2024). Technical Procurement Guideline on Low Embodied Carbon Construction. Low Carbon Construction Solutions Working Group.

Low-density Engineered Cementitious Composites (LD-ECC)

Low-density Engineered Cementitious Composites (LD-ECC) is a locally developed, high-performance lightweight cementitious material intended for infrastructure works where reduced self-weight and robust in-service performance are needed. Compared with conventional foamed lightweight soil, it offers higher strength and lower permeability which can help enhance long-term stability under varying environmental conditions.

In addition, LD-ECC can also contribute to embodied carbon reduction by enabling an alternative embankment solution to conventional reinforced concrete (RC) box culvert systems. The LD-ECC system typically uses precast concrete panels with limited steel reinforcement and connection components, reducing reliance on the rebar-intensive construction associated with traditional RC box culverts.

Approximately

71 tCO_2e

carbon reduction, equivalent to the annual carbon sequestration of around

3,200 trees



Possible Applications

Various applications for infrastructure projects

- **Road embankment**
- **Remedial works for slope erosion**
- **Low-noise overlay for areas with lighter traffic** (e.g., residential villages or hospital surroundings)

Project Info

Project Name
CEDD - Site Formation and Infrastructure Works for Yuen Long South First Phase Development (Contract 2) in Yuen Long Sourh New Development Area (Contract No: YL/2021/04)

Project Location
Yuen Long South, New Territories

Project Year
Project construction commenced in 2022

Extent of Strategy Application:
The use of LD-ECC for the road embankment works of new Slip Road S2 in this project, as an innovative cementitious material developed in Hong Kong.

Project Description
The works form part of the Yuen Long South First Phase development. Major works include site clearance and formation (including land decontamination works), nullah deckings at various locations, and construction of new roads (Road D1, Road D2, Road L1A, Road L1B) and a slip road (Slip Road S2) at the existing Shap Pat Heung Interchange, together with improvement works to sections of the surrounding road network. Slip Road S2 is introduced to help improve traffic movement around the Shap Pat Heung Interchange by providing a direct left-turn connection that bypasses the interchange and streamlines traffic towards the Pok Oi Interchange.



Overall Benefits

Potential Carbon Reductions

- The LD-ECC embankment method achieved carbon reduction mainly by avoiding the reinforcement-intensive RC box culvert arrangement, thereby significantly reducing the demand for ordinary steel reinforcement and associated formwork materials.
- The conventional RC box culvert option required substantial steel reinforcement, contributing approximately 717 tCO_2e, whereas the LD-ECC option utilised only limited steel components for precast panels and connections, contributing approximately 67 tCO_2e, with no ordinary rebar required.
- As steel is a major contributor to the embodied carbon footprint of the RC box culvert, the significant reduction in steel-related emissions more than offsets the higher cementitious-material emissions associated with LD-ECC
- Based on the project's carbon footprint assessment comparing the two construction approaches, the LD-ECC embankment method achieved an overall embodied carbon reduction of approximately 71 tCO_2e (6.0%), equivalent to the annual carbon sequestration of around 3,200 trees.

Cost/Time/Manpower Reduction

1 Shorter construction programme:

- The LD-ECC embankment method reduced construction duration by approximately 50% compared with the conventional RC box culvert and retaining wall approach, based on a programme comparison of 5 months for LD-ECC versus 10 months for the RC solution.
- The programme savings were achieved through reduced on-site material handling and temporary works, a faster construction cycle enabled by the material's high early strength, and the elimination of time-intensive on-site reinforcement fixing required for conventional reinforced concrete construction.

Other Opportunities

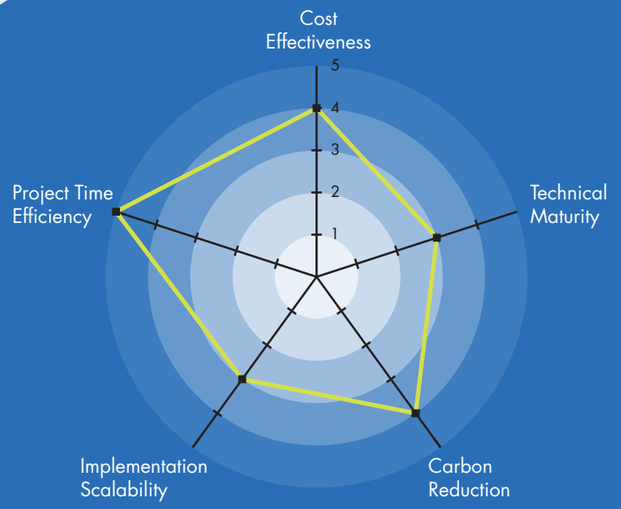
1 Safety & Interface Risk Reduction:

- Compared with conventional reinforced OPC concrete construction for RC box culverts and retaining walls, the LD-ECC embankment method simplifies the construction process by minimising on-site material lifting, reducing temporary works, and eliminating the need for permanent reinforcement fixing on-site.
- The simplified construction approach helps reduce health and safety risks associated with working at height, heavy lifting operations, people-plant interfaces, and confined space activities, while also improving overall construction efficiency.

Recommendations for Optimisation

- Although the material cost of LD-ECC is about 30-40% higher than the conventional OPC concrete, this premium is offset by reduced requirements for temporary formwork and heavy lifting activities, and shortened construction duration. Project case study indicates that the overall construction cost remains fully comparable to traditional reinforced concrete construction.
- Further cost savings are achievable on larger projects, where economies of scale from mass production and greater reductions in on-site formwork and reinforcement works can improve overall cost efficiency.





Source:

Qiu, J. Application of Engineered Cementitious Composites (ECC) in Precast Ultrathin White-Topping (PUWT): A Field Demonstration on Jurong Island, Singapore. Presentation slides. Department of Civil Engineering, The Hong Kong University of Science and Technology.

S960 Ultra-High Strength Steel

Compared with traditional in-situ reinforced concrete construction, which is heavier and requires more extensive foundations and on-site work, ultra-high strength steel provides an alternative by offering a structural material with significantly higher yield strength thereby allowing slimmer sections with lower foundation demands and reducing structural self-weight. Although ultra-high strength steel typically commands a price premium, its ability to achieve the required structural performance with less material can help offset the additional cost. This combination of material efficiency, weight reduction and embodied carbon savings is expected to support its wider adoption in future construction projects.

Approximately

65%

Carbon Reduction

compared with conventional concrete footbridges construction



Possible Applications

Various applications for infrastructure projects

- **Bridge superstructure**

Project Info

Project Name

CEDD - Two Footbridges in Fanling North New Development Area, Phase 1: Fanling Bypass Eastern Section (Shek Wu San Tsuen North to Lung Yeuk Tau) (Contract No.: ND/2019/04)

Project Location

Fanling North New Development Area (FLN NDA), covering:

- Lung Yeuk Tau Interchange; and
- Across Ng Tung River connecting Fanling North New Development Area and Siu Hang San Tsuen

Project Year

Works contract commenced in 2019

Adoption of S960 ultra-high strength steel commenced in 2023

Two footbridges completed in 2026

Extent of Strategy Application

S960 ultra-high strength steel was adopted in the superstructure of the two footbridges in lieu of reinforced and prestressed concrete for reducing the structural weight and maximising off-site fabrication.

Project Description

The project mainly comprises construction of an approximately 2-kilometre-long dual two-lane Fanling Bypass Eastern Section between Shek Wu San Tsuen North and Lung Yeuk Tau, including:

- Footbridge F4 across Ng Tung River; and
- Footbridge F6 at Lung Yeuk Tau Interchange comprising a vehicular underpass of the Fanling Bypass Eastern Section, an at-grade roundabout connecting Fanling Bypass Eastern Section with existing Sha Tau Kok Road – Lung Yeuk Tau, and a cycle track cum footbridge



Overall Benefits

Potential Carbon Reductions

- Prefabrication of S960 ultra-high strength steel components minimizes on-site construction activities, reducing machinery use and associated emissions in the overall construction process.
- Off-site modular fabrication reduces on-site temporary works and repeated handling, and the resulting minimal on-site assembly helps achieve approximately 65% carbon reduction compared with conventional concrete footbridges construction.
- Carbon reduction is mainly due to significant reduction in on-site construction works.

Cost/Time/Manpower Reduction

- Shortens the construction period by 40% in comparison to traditional construction processes. This is enabled by off-site modular fabrication, reduced on-site assembly requirements, and faster groundwork resulting from smaller and lighter foundation systems
- Ultra-high strength steel offers strong cost-effectiveness, as the increase in material cost is generally lower than the proportional increase in yield strength. The higher strength capacity allows for reduced steel quantities and more efficient structural designs, helping to offset the price premium while delivering material and carbon savings

Other Opportunities

1 Reduced use of materials and resources:

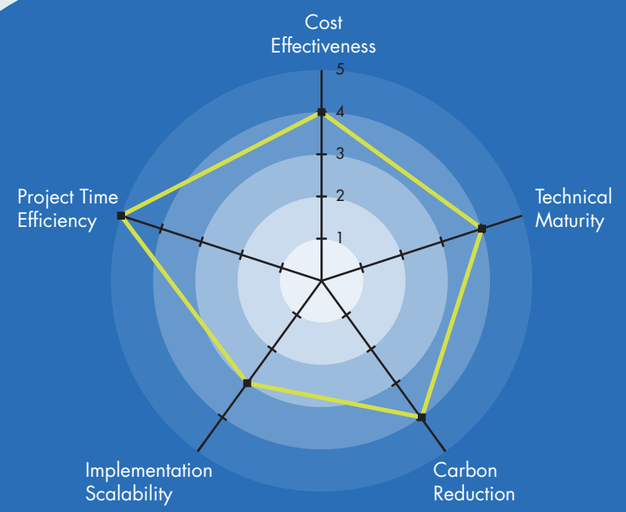
- Ultra-high strength steel enables lighter and more efficient bridge designs, reducing material consumption and foundation requirements.
- The lower self-weight decreases demand for construction materials in both the bridge structure and foundations, contributing to improved resource efficiency and lower embodied carbon.



Recommendations for Optimisation

- The application of S960 ultra-high strength steel creates a vital opportunity to cultivate highly skilled welders with specialised, high-quality fabrication capabilities. To achieve this, a comprehensive training programme for site welding of S960 ultra-high strength steel, in collaboration with the Chinese National Engineering Research Centre for Steel Construction (Hong Kong Branch) at the Hong Kong Polytechnic University (CNERC), was successfully implemented. Local steel welders were trained in the course for on-site assembly of S960 ultra-high strength steel for the construction of the S960 footbridge under ND/2019/04, strengthening local expertise in ultra-high strength steel applications.
- Robotic welding can be deployed to enhance both welding quality and productivity by utilizing precise heat input control to ensure structural consistency.





Source:

Civil Engineering and Development Department (2026). Innovative Use of Ultra-High Strength S960 Steel in Bridge Structures. Hong Kong Engineer, Vol. 54, January 2026.

Chung, K. F. (2022). Effective Use of High Strength S690 to S960 Steel in Construction. Hong Kong Engineer, Vol. 50, May 2022.

Ultra-High Performance Concrete (UHPC)

Ultra-high performance concrete (UHPC) is a cementitious composite that delivers compressive strength exceeding 120 MPa and often reaching up to 200MPa or higher, with direct tensile strength not less than 5MPa. Its ultra high strength is achieved through an optimized gradation of granular constituents, a very low water-to-cementitious materials ratio (typically <0.25) and the incorporation of high volume of discontinuous short steel fibres in concrete matrix.

The densely packed particles and low water content create a highly compact concrete matrix with very low porosity, while the fibres help maintain tensile capacity and crack resistance after cracking occurs. The resulting dense, crack-resistant structure significantly reduces permeability and liquid ingress, delivering superior durability compared with conventional HPC.

Notes on strength classes:

1. **Normal concrete is typically ≤50 MPa;**
2. **High-performance concrete categories include:**
   - high strength: 55–80 MPa
   - very high strength: 85–120 MPa
   - UHPC: >120 MPa.

UHPC achieves up to

50%

Carbon Reduction

compared with the conventional concrete



Possible Applications

Various applications for infrastructure projects

- **Vehicular bridges:** Applicable to bridge works where enhanced strength/durability are advantageous; UHPC can also be used for deck-level connections between prefabricated bridge elements (e.g., closure pours/grout).
- **Footbridges:** Applicable to footbridge works where slender/lighter structural solutions and durability performance may be desirable.
- **Permanent precast formwork:** Applicable to works incorporating prefabricated or precast elements produced under controlled manufacturing conditions.

Project Info

Project Name
CEDD - Site Formation and Infrastructure Works For Yuen Long South First Phase Development - Contract 3 (YL/2022/01)

Project Location
Yuen Long South, New Territories

Project Year
Construction commenced in December 2022

Extent of Strategy Application
UHPC was adopted for vehicular bridges, footbridges and permanent precast formwork for bridge pier. Its dense microstructure limits water ingress, enhances durability and supports efficient precast bridge connections (e.g. closure pours and grouted joints) by improving constructability.

Project Description
The works form part of the Yuen Long South First Phase Development. Major works include site clearance and formation (including land decontamination), reconstruction of Tong Yan San Tsuen Interchange, and improvement to sections of existing Shan Ha Road, Long Hon Road and Tong Tai Road, and associated infrastructure works (e.g. drainage, utilities, subways, cycle tracks)



Overall Benefits

Potential Carbon Reductions

- UHPC achieves up to 50% carbon reduction compared with the conventional concrete.
- UHPC reduces carbon emissions primarily by enabling material efficiency and longer service life. Its high compressive and tensile strengths allow structural elements to be redesigned and optimized, meeting the same performance with less material, such as thinner and lighter concrete sections and, in some applications, reduced reinforcement demand (e.g., reduced need for shear stirrups).
- In parallel, UHPC's discontinuous pore structure reduces liquid ingress and improves durability compared with conventional and high-performance concretes, which can extend design life and reduce the frequency of repair or replacement-related emissions. By reducing concrete volume and reinforcing steel, UHPC reduces the upfront embodied carbon associated with material production and delivery, while durability-driven reductions in maintenance further lower whole-life impacts.

Cost/Time/Manpower Reduction

1 Reduced structural elements size and self-weight

- In this project's bridge piers, the use of UHPC achieves up to 70% weight reduction in comparison with conventional concrete pier, with up to 53% reduction in reinforcement steel use, shrinking foundation works and improving cost and programme efficiency.
- Its higher strength allows smaller cross-sections for the same performance, cutting superstructure dead load and then smaller foundation size, material cost, and associated excavation time. Hence, the associated material cost can be reduced as well as the time spending on larger scale of foundation work can be reduced.

2 Faster construction through prefabrication and simpler connections

- UHPC is compatible with prefabrication to accelerate construction. It has been used as field-cast closure pours of grout, simplifying connection detailing and improving on-site constructability.
- The prefabrication of UHPC enables thinner, more durable, and lower-maintenance structural elements; it is also adopted as the permanent formwork for bridge piers in this project. This approach reduced the construction period by 1.5 months, and allowed higher cost effectiveness by reallocating the cost originally intended for temporary timber or steel formwork towards higher-quality permanent solution.

3 Improved durability with lower maintenance demand

- UHPC's dense matrix with discontinuous pores reduces liquid ingress, which significantly enhances durability compared with conventional and high-performance concretes. By limiting the penetration of moisture and aggressive agents such as chlorides, UHPC can extend service life, reduce frequency of repair/maintenance interventions and associated operational disruption.

Other Opportunities

1 Enhanced construction site safety

- By using UHPC permanent formwork integrated into the bridge pier structure, formwork removal and manual handling at height can be completely eliminated, as the formwork becomes part of the permanent works.
- This approach significantly reduces high-risk site activities associated with conventional in-situ concrete bridge pier construction, thereby improving construction safety and efficiency.

2 Aesthetic / Enhanced forms

- UHPC can deliver superior aesthetics by enabling thinner, lighter, and more delicate visible elements than conventional concrete. It is due to the fact that its high strength allows slimmer sections while still meeting structural demands.

Recommendations for Optimisation

1 Developing local production capability and industry experience

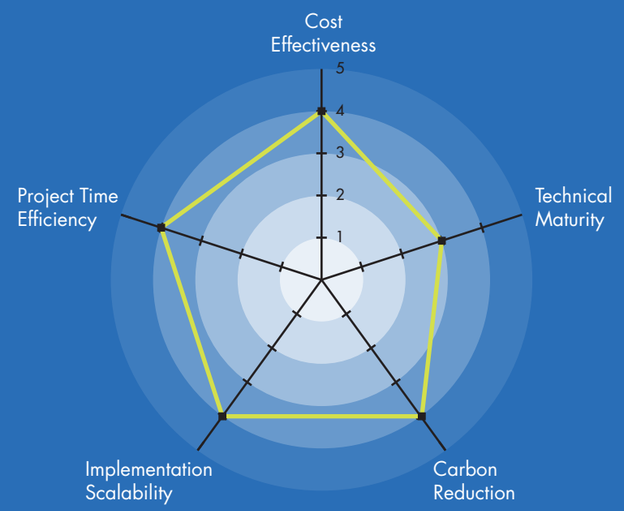
- The production of UHPC requires specialized equipment to be set up at the concrete batching plant, which is not commonly available in Hong Kong. However, the initial set up cost can be offset by wider future application or scaled-up production.

2 Stringent control in production and placement

- UHPC typically requires higher mixing energy and longer mixing time due to very low water content and reduced/eliminated coarse aggregate. Therefore, its performance is more sensitive to casting/curing controls, such as managing fiber behaviour during placement and ensuring the immediate sealing of exposed surfaces to prevent early-age cracking.

3 Potential cost optimisation

- Although UHPC carries a higher unit cost than conventional concrete, its cost-effectiveness should be evaluated holistically. The initial premium can be balanced against opportunities for structural design optimisation, reduced material consumption and enhanced long-term asset performance driven by UHPC's exceptionally high strength and durability characteristics.



Source:

Civil Engineering and Development Department and Building Technology Research Institute (2025). Technical Guidelines for Structural Use of Ultra-High Performance Concrete. Hong Kong: Government of the Hong Kong Special Administrative Region.

Graybeal, B. (2011). Ultra-High Performance Concrete. Technical Note FHWA-HRT-11-038. McLean, Virginia: Federal Highway Administration, Turner-Fairbank Highway Research Center.

Vibration Resistant Sprayed Concrete (VRSC) Single-layer Lining for Hard Rock Tunnels and Caverns

Developed jointly by the Geotechnical Engineering Office (GEO) and Applied Science and Technology Research Institute (ASTRI), formerly known as Nano and Advanced Material Institute (NAMI), Vibration Resistant Sprayed Concrete (VRSC) is a kind of polymer-modified, fibre-reinforced sprayed concrete. By leveraging advanced chemical bonding, three VRSC mixes (one steel fibre- and two synthetic polymer fibre (SPF)-reinforced) were formulated by NAMI, delivering enhanced dynamic bond strength capable of resisting near-field blast-induced vibrations.

Alongside the material development, the project established an analytical framework—combining dynamic impact testing with 3D numerical simulations—to assess dynamic mechanical behaviours. This enables project teams to evaluate blast-induced vibrations and tailor the VRSC mix design to meet specific functional requirements.

Ultimately, when combined with rock reinforcement design approaches, the use of VRSC enables the conventional double-layer lining system in hard rock tunnels and caverns to be replaced by a single-layer lining. Such optimisation reduces overall lining thickness, leading to substantial carbon reductions and overall savings in construction time, cost and logistic of works within the confined space.

Possible Applications

Various applications for infrastructure projects

1. **Road and Railway Tunnels:**
   - When integrated with rock reinforcement design approaches, the application of VRSC could potentially extend to major transportation infrastructure, which are currently dominated by cast-in-place linings.
   - While VRSC offers structural and operational benefits, its adoption for active road and railway tunnels requires careful consideration and comprehensive overall risk management. This involves evaluating its long-term durability, waterproofing integration, and performance under stringent public transit safety standards before full-scale implementation.

Substantial carbon savings through

30% Reduction
in shotcrete volume usage



Project Info

Project Name
CEDD – Joint Cavern Development at Anderson Road Quarry Site (Contract No. GE/2022/14)

Project Location
Anderson Road Quarry Site

Project Year
Construction commenced in 2023; Pilot application (SPF-C40/50 VRSC mix) in January-February 2026

Extent of Strategy Application
As a pilot application, a synthetic polymer fibre reinforced SPF-C40/50 VRSC mix was applied to the tunnel adit crown and wall (length: 55 m), which replaced the originally designed double-layer sprayed concrete lining.

Project Description
The Joint Cavern Development (JCD) project is located at the Anderson Road Quarry Site. The project involves the excavation of four large-span caverns (32 to 36 metres wide and 28 metres tall) within Strategic Cavern Area (SCVA) No. 28, and the construction of CEDD's Public Works Central Laboratory (PWCL) and Government Records Service's Government Records Building (GRB) inside the caverns.

The project adopted innovative construction technologies including the use of prefabricated components to construct the buildings, which can improve site safety and shorten the construction period. The PWCL and GRB will also adopt automated systems to enhance their service efficiency.

2. **Public Works Cavern Developments:**
   - Direct application in future hard rock cavern projects.
   - Given its successful pilot applications, the prescribed VRSC mixes are highly suitable as a permanent, single-layer lining for underground utility, storage, and environmental facilities, optimizing both space and construction time.

Overall Benefits

Potential Carbon Reductions

1 Reduced material use through structural optimisation

- Due to structural optimisation made possible by the new VRSC mixes, conventional two-layer linings can merged into a single thinner layer, which substantially lowers the project's embodied carbon footprint due to a significant reduction in overall concrete volume and lining thickness.
- In the project case, the substitution of a traditional two-layer sprayed concrete design with a single-pass VRSC lining results in approximately 30% reduction in shotcrete volume usage.

2 Use of low-carbon cementitious replacements

- The use of supplementary cementitious materials (SCM), such as pulverised fuel ash (PFA) and ground granulated blast-furance slag (GGBS) is relatively uncommon in sprayed concrete, primarily due to the stringent requirement of early-age (< 1 day) strength and the compatible use of accelerating admixtures. This means most sprayed concrete mixes are purely Portland-cement based (CEM I, under EN 197-1). The developed VRSC mixes, however, incorporates PFA and condensed silica fume (CSF) to improve performance while reducing embodied carbon emissions.
- For the prescribed VRSC mix (C40/50) in the pilot application, PFA and CSF were at 12% and 8% by total cement weight respectively. The emission reduction can be calculated using the CO_2e intensity values of OPC and the SCMs from the Carbon Label Quantification Tool for Ready Mixed Concrete developed by the Construction Industry Council (CIC). In the project case, for every 1m^3 of shotcrete, the replacement of OPC by SCM (e.g. PFA, CSF) leads to approximately 19% carbon emission reduction in the cement used in the concrete mix.

3 Reduced demolition / excavation volume due to thinner reinforcement lining:

- Because the VRSC single-layer lining is thinner, the initial excavation profile can be reduced while maintaining the required internal space. This reduction directly lowers the quantity of explosives required and minimises the volume of excavated rock, further lowering the overall carbon emission associated with rock excavation, mucking out, transport, and spoil disposal.

Cost/Time/Manpower Reduction

1 Overall cost reduction:

- An approximate material cost saving of 10% to 15% for lining construction is achieved in the project case, driven by the reduced material volume enabled by the thinner reinforcement lining. While the use of Ethylene-vinyl Acetate (EVA) polymer modifier results in a higher unit cost, this can be offset by the overall material reduction. Additional benefits from lower material quantities, such as reduced logistics demands and shorter construction duration, further contribute to reductions in both construction and operational costs.

2 Improved construction efficiency:

- Effective construction logistics are critical for construction within a confined space. The space constraint necessitates frequent relocations of construction plants and unplanned or redundant movements would not only extend the construction duration but also increase the cost.
- By elimination of the secondary lining layer, at least one to two construction procedures can be omitted, thus reducing the number of relocations required, saving time and manpower as well as direct carbon emissions.
- Furthermore, improved construction efficiency leads to a direct reduction of the overall construction time and savings in the costs of maintaining the working environment (i.e. lighting, ventilation, drainage, etc.), and an indirect reduction in carbon emissions.

Other Opportunities

1 Optimization of rock reinforcement design / construction approach in hard rock tunnels and caverns:

- When integrated with the use of rock reinforcement design approaches, application of VRSC fundamentally optimises the construction of hard rock tunnels and caverns. By replacing the conventional double-layer lining by a single-layer system, it eliminates the need for a secondary structural lining by utilising the enhanced, vibration-resistant properties of the initial VRSC layer. This is made possible by the enhanced adhesion of the VRSC mix, from the chemical bonding between the Ethylene-vinyl Acetate (EVA) and the rock substrate.
- As an example, typical functional double-layer lining system yields a thickness of 200 mm to 500 mm in a hard rock tunnel/cavern, comprising the initial temporary lining (sprayed) of 50 mm to 150 mm thick and the secondary permanent lining (either sprayed or cast in-situ) of 150 mm to 350 mm thick. The use of VRSC likely induces a 30% to 40% reduction to the overall thickness.

Case Example:

- At the JCD project, the thickness of the sprayed lining depends on the size of the excavation and the geological conditions.
- For a typical 10-metre wide construction adit excavated in fair geological conditions, the thickness of temporary and permanent lining are 55 mm and 135 mm, respectively.
- In the pilot application, the temporary lining was omitted and a 135 mm thick permanent VRSC lining was applied. This led to a 30% saving in sprayed concrete volume and subsequent reduction in carbon footprint.

2 Enhanced rock adhesion and vibration resistance

- The enhancement of vibration resistance comes from the enhanced early-age adhesion (bond strength) between the shotcrete and the rock under dynamic loading. Mechanical debonding is the primary failure model concerning sprayed concrete lining. With this enhancement, and with proper mixing, spraying techniques and workmanship, the durability of the lining as well as overall underground stability are directly enhanced. This further expedites the excavation progress through shortening the time required in each blast cycle.

3 Potential improvement of water impermeability of the layer

- In tunnel waterproofing, EVA emulsions are widely utilized as spray-applied waterproofing membranes due to their excellent substrate adhesion and hydrophobic properties. Theoretically, the introduction of EVA polymer modifiers into cementitious systems like the VRSC can significantly reduce water permeability by forming a continuous polymer film within the matrix pores. However, no specific tests were carried out as it is not a requirement in most hard rock tunnels and caverns, where there are separate provisions of drainage and waterproofing. Further testing should be carried out to validate this theoretical enhancement in water impermeability.

4 Reduction of Heat of Hydration through SCMs

- The exothermic reaction between cement and water to form calcium silicate hydrate gel (C-S-H) is necessary for development of concrete strength. However, this can cause high heat release, leading to thermal cracking. The replacement of cement with SCM in the new VRSC mix reduces the reaction rate, in return reducing the amount of the heat released.

Recommendations for Optimisation

1 Developing market supply of polymer modifiers

- The VRSC mix relies on Vinyl Acetate-Ethylene (VAE) re-dispersible polymer powder (RPP) to absorb energy and mitigate crack propagation. While liquid EVA emulsions are standard in waterproofing membranes, securing bulk dry-form RPP for structural sprayed concrete requires a specialised procurement strategy.

2 Developing local application experiences

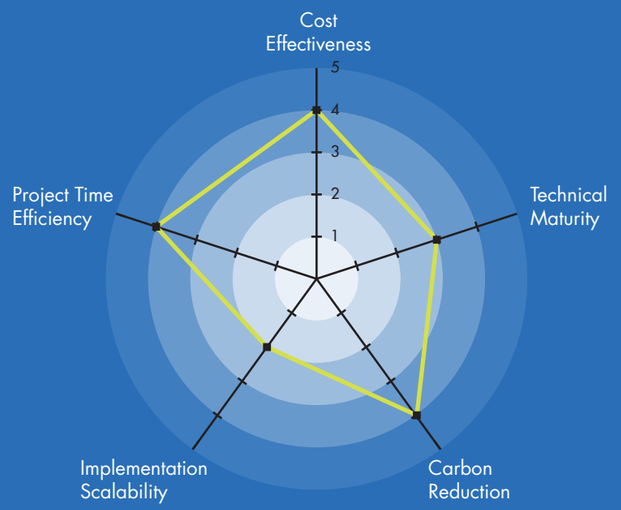
- The structural performance of VRSC is highly sensitive to its chemical interaction with admixtures, as well as the skill of mixing and spraying operations. Consequently, specialised training for nozzlemen is essential to ensure consistent material blending and application on-site.
- VRSC is generally applicable to drill-and-blast tunnelling with a Maximum Instantaneous Charge (MiC) up to 10kg/delay and total charge of 1000 kg per advance. Should the MiC or total charge mass exceed these limits, a specialised mix design must be formulated and supplemented by advanced dynamic testing alongside complex 3D numerical simulations to evaluate dynamic bond strength against model-predicted, blast-induced tensile stresses.
- Local laboratory capacities should be enhanced to support the routine execution of advanced dynamic testing.



3 Applying VRSC for hard rock only

- The engineering rationale behind using VRSC as a single-layer lining is rooted strictly in hard rock reinforcement principles. It is fundamentally not suitable for soft soil or mixed-ground tunnelling, where entirely different ground support and lining design approaches are required.





Battery Energy Storage System (BESS)

Battery Energy Storage System (BESS) provides temporary site power using stored electrical energy, reducing reliance on continuously operating diesel generators. By lowering generator run-time and avoiding unnecessary idling, BESS can reduce diesel consumption and associated carbon emissions.

BESS can also improve the site environment by reducing generator noise and exhaust emissions. The technology is particularly suitable for applications with high peak or rapidly fluctuating power demand, such as tower cranes. Sometimes grid electricity may be insufficient to accommodate short-term peak loads

Up to
90%
Carbon Reduction
achieved by replacing diesel generators with BESS



Possible Applications

Various applications for infrastructure projects

- **BESS is most suitable for equipment with large and rapid load fluctuations, such as a tower crane.**
- **Sites where grid supply may not be able to accommodate high peak loading or sudden load changes, BESS is particularly useful to manage the peak electicity demand, subject to the equipment power rating and site configuration.**

Project Info

Project Name
Kwu Tung North New Development Area, Phase 1: Site Formation and Infrastructure Works (Contract no.: ND/2019/01)

Project Location
Kwu Tung North (KTN) New Development Area (NDA)

Project Year
Project construction commenced in 2019

Extent of Strategy Application
One set of BESS was deployed to provide temporary power to 42 newly installed LED streetlights along the pedestrian pathways at Kwu Tung North Road, Heung Tsz Road, and Kwu Chun Street prior to grid connection. The use of BESS supports reliable temporary illumination while helping reduce reliance on diesel generators.

Project Description
The project forms part of the first phase development of the KTN/FLN NDAs. Major works include site formation of land under the First Phase of KTN NDA. Major road and associated works are also included, covering carriageways and supporting pedestrian and cycle facilities, as well as subways and junction improvements. The scope further comprises district cooling system pipeworks, slope works and landscaping works.



Overall Benefits

Potential Carbon Reductions

- The carbon reduction is primarily achieved by reducing diesel generator operating hours and fuel consumption through the use of BESS to meet part of the temporary power demand while maintaining the same level of service.
- In this project, a like-for-like comparison for temporary street lighting operating 12 hours per night indicated that diesel consumption could be reduced from approximately 480 L to 50 L when a fully charged BESS was used to provide the same service.
- Based on the emission reference from the Guidelines to Account for and Report on Greenhouse Gas Emissions and Removals for Buildings in Hong Kong (2008 Edition) issued by EPD and EMSD, this corresponds to an estimated carbon reduction of up to 90%.

Cost/Time/Manpower Reduction

1 Cost benefit – operating cost savings & indicative payback:

- BESS operation can have lower operating costs than generator-led operation, driven by reduced fuel demand and improved energy efficiency.
- Indicative payback period examples based on General Guideline on BESS adoption for construction sites (February 2025) issued by CLP Power Hong Kong Limited (CLPe):
  1. Purchasing 1 set of 380A BESS to replace a 400kVA diesel generator (rental): 4.1 years
  2. Purchasing 1 set of 660A BESS to replace 2 nos. of 300kVA diesel generators (rental): 3.6 years

Notes on BESS sizing (based on General Guideline on BESS adoption for construction sites (February 2025) issued by CLPe):

1 set of 380A BESS is recommended for:

- 1 no. of mid-size (24 tons) tower crane (~300A) + 2 nos. of hoist (~40A); or
- 5 nos. of welders (~60A)

1 set of 660A BESS is recommended for:

- 1 no. of large size (64 tons) tower crane (~600A); or
- 2 nos. of mid-size (24 tons) tower crane (~300A)

Other Opportunities

1 Noise and air quality improvement:

- BESS operates at a lower noise level than a diesel generator. Based on the supplier's information, typically, the BESS operation can achieve very low noise operation under 90dB(A), much lower than that of a diesel generator.
- Due to its low noise operation, the use of BESS can failitate CNP (Construction Noise Permit) applications, particularly for works during restricted hours or near noise sensitive receivers.
- BESS operates without on-site fuel combustion and generates no direct exhaust emissions, improving local air quality and eliminating diesel-related odour, fumes, and fuel spill risks on construction sites.

Recommendations for Optimisation

1 Battery State-of-Charge (SoC) management

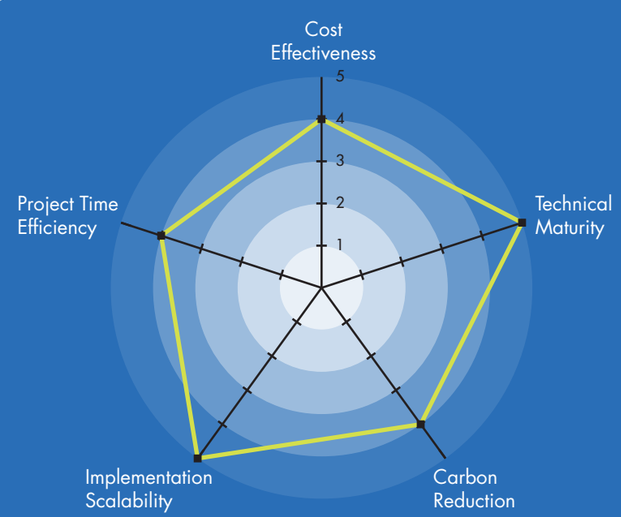
- To maintain battery health and prolong its service life, the SoC should generally not fall below 10%. For continuous operation, the SoC should preferably be maintained at 50% or above, where practicable, to provide sufficient operational reserve. The BESS can support charging and discharging operations without dedicated downtime, provided that the charging and discharging cycles are properly managed in accordance with the manufacturer's recommended operating limits.

2 Hybrid deployment

- Depending on the site power arrangement and required duty, BESS is commonly deployed as part of a hybrid setup in conjunction with diesel generators. This approach provides a more resilient and controllable temporary power supply solution, rather than relying solely on BESS as a standalone power source.

3 Site planning and space requirements

- BESS units are typically container-sized and require a dedicated footprint on site. Considering the BESS placement early in the construction site layout design helps ensure sufficient space is allocated. Where site space is limited, exploring layout options and positioning the unit strategically can help accommodate its footprint effectively.



Source:
CLP Power Hong Kong Limited (2025). General Guideline on BESS Adoption for Construction Sites. Revised February 2025. CLP Power Hong Kong Limited.

Electric Heavy Goods Vehicles

The use of electric heavy goods vehicles instead of conventional diesel-powered vehicles to transport excavated materials within or outside of a construction site can reduce tailpipe emissions and the embodied carbon from energy consumption.

Four electric dump trucks have been successfully implemented in a pilot at Lam Tei Quarry as part of its ongoing rehabilitation works, supporting continued quarrying activities. Enabled by two on-site charging stations sourced from the grid, the current implementation is calculated to result in reduction in net carbon emissions compared to existing diesel powered trucks.

Up to
74%
Carbon Reduction
through electric dump truck deployment

Possible Applications

Various applications for infrastructure projects

1. **Usage of electric dump trucks within site for movement of excavated waste**
   - Beyond transport of quarried materials, electric dump trucks can be used for internal site transfers of waste or various excavation material arising from site formation or roadworks projects.
2. **Extend to external transportation from sites to fillbanks or disposal areas**
   - The current project refers to “articulated” dump trucks used for internal site transfers only. However, electric HGVs are also available in the market for off-site transportation.

Project Info

Project Name
The Rehabilitation of Lam Tei Quarry – Extended Works

Project Location
Lam Tei

Project Year
2015 – Now

Extent of Strategy Application
4 electric dumpers with payload ranging between 60 to 70t. Two charging stations to support operation.

Project Description
The Rehabilitation of Lam Tei Quarry – Extended Works mainly comprises of design and build for the final landform of Lam Tei Quarry, including quarrying works, slope stabilization works, drainage works and landscape works. The Contract commenced in 2015 and is scheduled for completion in 2026.



Overall Benefits

Potential Carbon Reductions

1 Reduced carbon emissions by avoiding use of diesel and replacement by electric grid energy:

- Electric dump trucks use energy more efficiently than diesel trucks, resulting in lower energy demand and emissions per unit of haulage. They also offer long-term decarbonisation benefits as the electricity grid continues to shift towards renewable energy.
- The magnitude of carbon reduction can be estimated based on past operational consumption data of diesel and electric dump trucks from the pilot site. Using the latest CLP electricity and diesel carbon emission factors from the EPD/EMSD, switching from diesel dump trucks to electric dump trucks is expected to lead to a net reduction of 0.214 $kgCO_2e$/ton of quarried rock production, representing approximately 74% reduction in carbon emissions for the same material output.

Cost/Time/Manpower Reduction

1 Reduced capital expenditure due to lower cost of truck:

- Compared to diesel dump trucks with similar carrying capacities (such as the Bell BE45E), the electric dump trucks used in the pilot site at Lam Tei Quarry are approximately half the cost (excluding charging infrastructure). This significantly reduces the capital expenditure (CAPEX) of sites, should the dump trucks be purchased.

2 Reduced operational expenditure from replacing diesel with electricity use and more efficient work conversion of energy

- The cost of using electric dump trucks to haul quarried rock is over 70% lower than conventional diesel dump trucks, significantly reducing the operating expenditure (OPEX) of sites. As an example, for a production month of 68,460 tonnes of quarried rock, switching from diesel to electric can lead to over HK$50,000 in cost savings per month.

Other Opportunities

1 Zero tailpipe emissions leading to improved site air quality (refer to site electric machinery successful example)

- Direct exhaust emissions are avoided by switching to electric dump trucks, which contributes to a cleaner working environment and improved local air quality in the vicinity.

2 Energy recovery through regenerative braking

- The use of electric dump trucks with regenerative braking functionality allows the trucks to re-charge during downslope driving. As the trucks decelerate, regenerative braking captures kinetic energy that would otherwise be dissipated as heat and converts it into electrical energy, which is then stored in the battery for future use.

3 Evolving Battery and Charging Solutions

- Improved battery capacity and efficiency may extend operating time and support wider heavy-duty haulage applications. BESS-integrated and mobile charging systems may also provide more flexible charging at temporary or remote locations.

4 Greater charging flexibility

- Some flexible charging solutions, such as BESS-integrated chargers and mobile charging units robots, can support the use of electric construction HGVs at site with limited grid capacity or fixed charging infrastructure.
- BESS-integrated charger combines battery storage with dedicated charging equipment for electric vehicles and machinery. It can store electricity when power is available and deliver it through the charger when needed, helping manage high charging demand where grid capacity is limited.
- Mobile charging robots can provide further flexibility by bringing the charging equipment directly to the vehicle or machinery location.

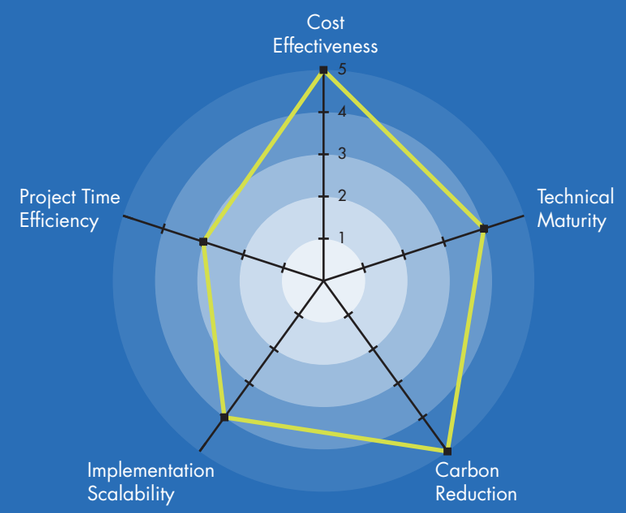
5 Government funding support

- The Construction Innovation and Technology Fund (CITF) supports the adoption of eligible technologies, including machinery and equipment that enhance environmental performance. Electric construction vehicles and equipment may be eligible, subject to the prevailing funding scope, application requirements and approval.

Recommendations for Optimisation

1 Site charging arrangements

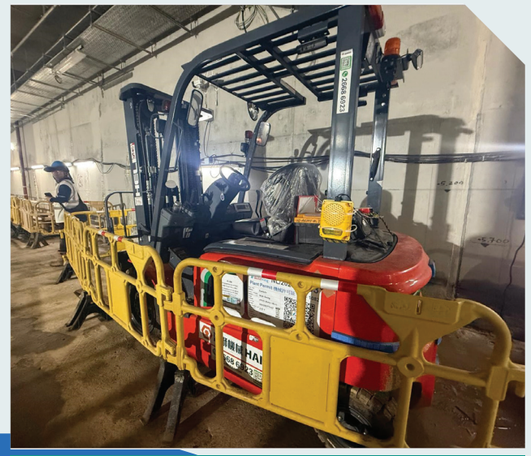
- As electric heavy goods vehicles become more widely adopted, grid electricity supply and charging infrastructure warrant early attention given the growing charging demand. Planning charging schedules and charging stations in advance can optimise electricity usage and support efficient site logistics.



Electrification of Construction Machinery

Electrification of construction machinery replaces diesel-powered plant (e.g., excavators, site lifts, forklifts and other small plant) with electric alternatives powered by grid charging and/or onboard batteries. This reduces direct on-site fuel combustion and associated exhaust emissions during operation, particularly where diesel equipment would otherwise idle frequently. In addition to carbon benefits, removing on-site emissions during operation (i.e. tailpipe emissions released from vehicle during operation) can help improve local air quality and working conditions on construction sites, especially in enclosed or underground areas.

Up to
74%
Reduction
in operational carbon emissions through electrification of machinery



Possible Applications

Various application location for infrastructure projects

Common electrified machinery on construction sites:

- Electric forklifts
- Electric excavators
- Site electric lifts (temporary vertical transport / access)
- Battery-electric hand-held tools

Project Info

Project Name
CEDD - Tung Chung New Town Extension – Major Infrastructure Works in Tung Chung East (Contract no.: NL/2020/03)

Project Location
Tung Chung East, Lantau Island

Project Year
Project construction commenced in 2021

Extent of Strategy Application
Three electric forklifts were deployed for on-site material handling and logistics, supplemented by one diesel forklift to ensure operational flexibility. The use of electrified equipment reduces reliance on diesel and minimizes direct exhaust emissions during operations.

Project Description
The contract forms part of the Tung Chung New Town Extension (TCNTE) works in Tung Chung East, delivering major engineering infrastructure to support the TCNTE development. Major works include drainage and sewerage works (including two sewage pumping stations), waterworks, roadworks (including carriageways, footpaths, cycle tracks and junction improvements), common utility tunnels and landscaping.

Overall Benefits

Potential Carbon Reductions

- Carbon reduction is achieved primarily by reducing diesel consumption and replacing it with electricity use (from grid charging / batteries). In operational terms, the CO_2e intensity of electricity used for charging can be lower than burning diesel for comparable activity, and electric plant also avoids direct on-site exhaust emissions during use.
- Based on project's weekly operational data and assumptions as per Guidelines to Account for and Report on Greenhouse Gas Emissions and Removals for Buildings (Commercial, Residential or Institutional Purposes) in Hong Kong 2008 Edition issued by Environmental Protection Department (EPD) and Electrical and Mechanical Services Department (EMSD), the comparison between diesel forklift and electric forklift was prepared. The comparison indicates **approximately 74%** reduction in **operational carbon emissions** for electric forklift use compared with diesel forklift, assuming comparable work output/usage.

Cost/Time/Manpower Reduction

1 Lowering operating cost (reduced non-productive energy consumption):

- In Hong Kong, operating energy cost is influenced by both the local diesel pump price (i.e. paid per litre at the pump) and tariff-based electricity pricing (i.e. charged by kWh under a published tariff).
- For diesel forklifts, idling still requires the engine to run, so the equipment continues to burn diesel even when not moving or lifting, which adds "non-productive" fuel consumption to operating cost.
- Electric forklifts do not require continuous combustion during standby or diesel idling. Hence, when using electric machinery, the operating energy spend can be more closely linked to actual equipment use patterns, whereas diesel machinery can incur "non-productive" material fuel cost during waiting/standby periods.

Other Opportunities

1 Improved local site environment:

- By replacing diesel-powered equipment with electric alternatives, the strategy reduces on-site diesel combustion and associated exhaust emissions during operation, while also achieving significantly lower noise levels. This is particularly beneficial where diesel plant would otherwise run for extended periods or idle intermittently, supporting a cleaner, quieter working environment and improved local air quality within the work area.

2 Suitability for enclosed operations:

- Electric machinery can be advantageous for confined / underground working areas (e.g., tunnel, cavern), as electrification eliminates direct exhaust emissions during operation, which can help support better local air quality and working conditions within the confined work zone.

3 Evolving Battery and Charging Solutions

- Improved battery capacity and efficiency may extend operating time and support wider range of construction machinery applications. BESS-integrated and mobile charging systems may also provide more flexible charging at temporary or remote locations.

4 Greater charging flexibility

- Some flexible charging solutions, such as BESS-integrated chargers and mobile charging units robots, can support the use of electric construction machinery at site with limited grid capacity or fixed charging infrastructure.
- BESS-integrated charger combines battery storage with dedicated charging equipment for electric vehicles and machinery. It can store electricity when power is available and deliver it through the charger when needed, helping manage high charging demand where grid capacity is limited.
- Mobile charging robots can provide further flexibility by bringing the charging equipment directly to the vehicle or machinery location.

5 Government funding support

- The Construction Innovation and Technology Fund (CITF) supports the adoption of eligible technologies, including machinery and equipment that enhance environmental performance. Electric construction vehicles and equipment may be eligible, subject to the prevailing funding scope, application requirements and approval.

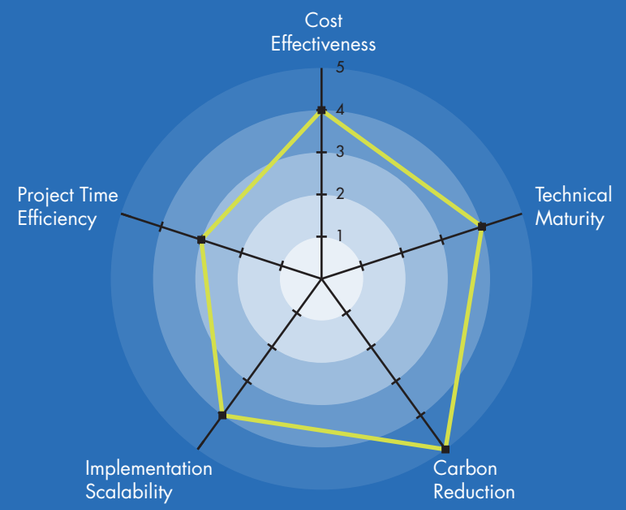
Recommendations for Optimisation

1 Charging and runtime planning

- To ensure operational continuity, electric machinery requires structured charging schedules aligned with site work programme. This involves planning charging windows within permitted operational hours alongside robust standby measures, such as optimised task sequencing and the deployment of backup machinery.

2 Developing market and upfront investment

- Unlike heavy or high-duty equipment (e.g. large cranes and excavators), a wider array of electric options is readily available for small-to-medium plant, including forklifts. Selecting electric-powered machinery requires careful consideration of upfront purchase or rental costs, as well as the financial implications associated with standard off-the-shelf configurations.



Hydrogen-Powered Construction Plant and Vehicles

Hydrogen generators are adopted to provide temporary site electricity as a cleaner alternative to conventional diesel generators. Using hydrogen as the energy source, the generators generate electricity without fuel combustion and produce zero direct carbon emissions during operation, with only water as the primary by-product.

This helps reduce on-site exhaust emissions and air pollutants, improving air quality within construction site. In addition, they typically operate at lower noise levels than conventional diesel generators, which help minimise disturbance to workers and nearby sensitive receivers in neighbourhoods.

Up to

77%

Carbon Reduction

Achieved through the use of hydrogen generators compared with diesel generators



Possible Applications

Various application location for infrastructure projects

Construction sites with strict noise and emission constraints.

Project Info

Project Name
Batch 1A Development of Hong Kong-Shenzhen Innovation and Technology Park (HSITP) site project

Project Location
The Loop

Project Year
Project construction commenced in 2021

Extent of Strategy Application
Multiple hydrogen energy applications were implemented, including hydrogen generators, hydrogen forklifts, and hydrogen vehicles. One 45kW hydrogen generator was deployed to replace a conventional diesel generator.

Project Description
HSITP is a major innovation and technology development at the Lok Ma Chau Loop, covering about 87 hectares and planned in two phases. This project forms part of Phase 1 (i.e. Batch 1), which is planned to provide an estimated total floor area of 1 million m^2, comprising a mix of Research and Development (R&D) buildings (including wet-lab / advanced manufacturing and dry-lab / office space) as well as academic and industry buildings.



Overall Benefits

Potential Carbon Reductions

- Unlike diesel, which releases carbon dioxide during combustion, hydrogen produces no direct carbon emissions during electricity generation with water vapour as primary by-product. Based on emissions data provided by the hydrogen supplier, the hydrogen generator can achieve approximately 77% lower carbon emissions than an equivalent diesel generator. A 45 kW unit operating for 10 hours per day is estimated to reduce emissions by approximately 118 tCO_2e per year, equivalent to the annual carbon sequestration of around 5,140 trees, based on the EPD/EMSD Hong Kong GHG Accounting Guidelines (2008).
- In this project, hydrogen was supplied from Chinese Mainland. Looking ahead, Hong Kong is developing local hydrogen supply infrastructure, including the public hydrogen filling station at Au Tau, Yuen Long, which has adopted a staged supply pathway - with initial supply via cross-boundary delivery from the Greater Bay Area, and longer-term development including on-site pressure swing adsorption (PSA) hydrogen production, and PV green-electricity hydrogen production.
- The overall carbon performance of hydrogen generators depends on the hydrogen source. While on-site emissions are eliminated, upstream emissions may arise from hydrogen production, compression, storage and transportation. The carbon reduction potential can therefore be further enhanced through the use of green hydrogen produced using renewable energy sources such as solar or wind power.

Cost/Time/Manpower Reduction

1 Sustainability-led Choice for Low-carbon Construction Practices:

- Noting that current rental and hydrogen costs may be higher, the adoption of hydrogen generators is primarily driven by project decarbonisation targets and the need to reduce carbon emissions from construction activities.
- In this project, no delays or adverse impacts on construction programme were identified during implementation, demonstrating that hydrogen generators can be integrated into site operations without affecting project delivery while improving environmental performance.

Other Opportunities

1 Higher fuel utilization efficiency:

- Hydrogen generators can achieve fuel utilisation efficiencies of approximately 40-60%, compared with 20-40% for conventional combustion-engine generators. The higher efficiency enables more useful energy to be delivered from the same fuel input, reducing energy losses and improving overall system performance.

2 Zero direct carbon emissions during operation:

- Hydrogen-powered generators produce no direct carbon emissions during electricity generation, with water vapour as the primary by-product.

3 Significantly lower noise levels:

- Hydrogen generators typically operate at around 60-65 dB, approximately 10-20 dB quieter than conventional diesel generators. The lower noise output can reduce disturbance to nearby sensitive receivers, such as residential developments, schools and hospitals.

4 Improved suitability for urban and residential environments:

- Owing to their low noise and zero on-site emissions, hydrogen-powered generators are well-suited for use in urban and residential areas. They can support overnight construction activities without the need for additional acoustic enclosures or noise mitigation measures.

Recommendations for Optimisation

1 Operational cost and environmental benefits

- Compared to conventional diesel generators, hydrogen-powered plant and vehicles involve higher rental and fuel costs despite their significant carbon-reduction potential. More importantly, the true environmental benefits of this technology are dictated by the supply chain, differing vastly between green and grey hydrogen.

2 Safety and regulatory controls

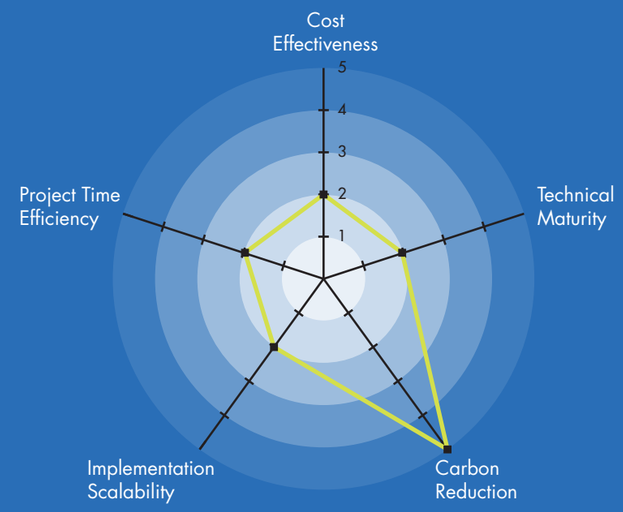
- Utilising hydrogen generators requires rigorous safety controls and regulatory oversight across storage, refueling and risk mitigation protocols. However, as the technology evolves and gains wider application both locally and in Chinese Mainland, initial capital expenditures and compliance costs are expected to fall.

Source:

Zhou, Y., Zhang, Z. and Li, Y. (2022). Life-Cycle Analysis of Greenhouse Gas Emissions of Hydrogen, and Recommendations for China. White Paper. Washington, DC: International Council on Clean Transportation.

Electrical and Mechanical Services Department (2024). Code of Practice for Hydrogen Filling Stations. Issue 0. Hong Kong: Government of the Hong Kong Special Administrative Region, February 2024.

Environment and Ecology Bureau (2024). The Strategy of Hydrogen Development in Hong Kong. Hong Kong: Government of the Hong Kong Special Administrative Region, June 2024.



PV Performance Enhancement through Self-Cleaning Coatings and Railed-guided Mechanisms

Construction sites are often characterised by harsh, dusty environments that accelerate soiling of photovoltaic (PV) panels, reducing energy generation and increasing maintenance requirements. This strategy seeks to maintain long- term PV performance through the use of self-cleaning Titanium Dioxide (TiO_2) coatings and automated cleaning systems.

Self cleaning coatings in the context of PV panels typically refer to a thin layer of TiO_2 applied on the glass surface. The self-cleaning characteristics of TiO_2 coatings comes from a combination of the photocatalytic and photo-induced hydrophilicity. The photocatalytic properties of TiO_2 decomposes organic dirt into small quantities of carbon dioxide and water under sunlight. The hydrophilic properties further disperses and flattens water (e.g rain) on the PV panel surface in a "sheet-like" manner, leading to more effective rinsing of dirt and debris.

These coatings can be complemented by automated cleaning mechanisms, such as railed mechanisms or cleaning robots, which allows automated dry or wet cleaning cycles to be performed on a more frequent basis than manual cleaning.

These cleaning mechanisms aim to maintain optimal panel efficiency to ensure energy generation is maximised over the system's lifespan, particularly in uncontrolled environments prone to soiling such as construction sites. Compared to manual human cleaning intervals, automated systems may additionally benefit from reduced manpower costs and cleaning times, making this strategy particularly suitable to large-scale PV farms. By sustaining high generation efficiencies, this strategy effectively reduces carbon emissions by maximising the displacement of grid power by PV renewables.

Possible Applications

Various applications for infrastructure projects

Photovoltaic systems could be more widely adopted in various infrastructures and facilities that are anticipated to have adequate exposure to sunlight, which can reduce carbon emission and electricity costs throughout their serviceable life.

PV panels can be placed close to dust generating works if integrated cleaning solutions are included.

Existing cleaning requirements under dusty site conditions will be reduced by self-cleaning coatings and robotic cleaning, making the implementation more cost effective and save more cleaning labour time.

Project Info

Project Name
Improvement Works at Kau Shat Wan Government Explosives Depot (Contract No. GE/2025/30)

Project Location
Kau Shat Wan Government Explosives Depot, Lantau Island

Project Year
Construction to commence in 2026. As a "new trial", understanding of cleaning performance and levels of efficiency gains shall be obtained after commissioning of the PV farm.

Extent of Strategy Application
A project involving the installation of a photovoltaic farm system (about 5200 sq.m) at the Kau Shat Wan Government Explosives Depot is being implemented. Under normal circumstances, the electricity generated by this system would fully meet the electricity demand of the Depot from both daytime and nightime activities, without any consumption from the existing grid.

Project Description
A photovoltic (PV) farm is proposed to be installed at the Kau Shat Wan Government Explosives Depot on Lantau Island. The project would be the largest PV farm equipped with a battery system at any Hong Kong Government facility which fully supports onsite electricity demand. In addition to the proposed 560 kW capacity PV panel system, the project also involves the construction of a battery system, energy management system, MiC plant rooms, and other ancillary works. This project adopts off-site fabrication and on-site installation construction techniques to strengthen the quality, safety and environmental control, as well as to promote better works progress. In particular, this project specifies the use of a self-cleaning coating PV panels that promotes decomposition of organic grime. A railed cleaning mechanism will be installed to clean the PV panels. Both initiatives would strengthen the cleaning efficiency and optimise the electricity generation of the system.

Approximately
130 tCO_2e
annual carbon reduction achieved, equivalent to the annual carbon sequestration of around
5,800 trees



Overall Benefits

Potential Carbon Reductions

1 Estimated carbon reduction of the system as a whole is approximately 130 tonnes of CO_2 per year

- Equivalent to the electricity consumption of approximately 120 households or annual carbon sequestration of approximately 5800 trees. This carbon emission figure is calculated from the yearly grid electricity demand by the depot, under the assumption that the generation from the PV farm will fully offset this demand. As an explosive depot primarily for storage, energy demands generally arise from MEP services in offices, ventilation fans, dehumidifers in magazines, and charging of electric forklifts and other equipment.

2 Ensure renewable energy generation target is met in order to avoid unnecessary indirect emissions from the grid

- Energy generation from PV panels is driven by the amount of solar irradiation (i.e sunlight) that reaches the surface. Soiled PV panels by dust or organic matter such as bird droppings reduce the intensity of sunlight that reaches the photocells. If soiled PV panels are not cleaned in time, generation efficiency can be reduced requiring surplus electricity to be fed in from the grid and leading to additional indirect carbon emissions.

Cost/Time/Manpower Reduction

1 Cost Saving

- This project saves the electricity cost of about HK$600,000 per year.

2 Reduced Manpower Costs and Resources by Application of Self-Cleaning Coating and Cleaning Mechanisms

- By applying a durable TiO_2 coating to the PV panel surfaces, organic grime can be decomposed through the photocatalytic effect with sunlight, preventing accumulation of organic grime. Combined with super-hydrophilic qualities to ensure rapid water spread and effective self-cleaning, the coating reduces the rate of soiling and therefore extends cleaning intervals to reduce manpower costs and resources such as water and electricity, whilst maximizing generation efficiency.

3 Reduced Manpower Use and Improved Cleaning Efficiency from Robotic Railed Cleaning System

- An automated railed cleaning mechanism mounted on the PV frame keeps the PV panels consistently clean, significantly reducing the reliance on manual labour and thus operational costs.

Other Opportunities

1 Raising Public Awareness of Renewable Energy

- This project can raise public awareness of the Government's use of sustainable energy.

2 Building Experience in Renewable Energy Adoption

- This project enables the Government to gain experience in adopting renewable energy technologies with battery storage system, to promote more extensive use in other facilities.

3 Reduced risk of injury of workers during manual cleaning works

- Minimizes risks of injury of workers during manual cleaning works.

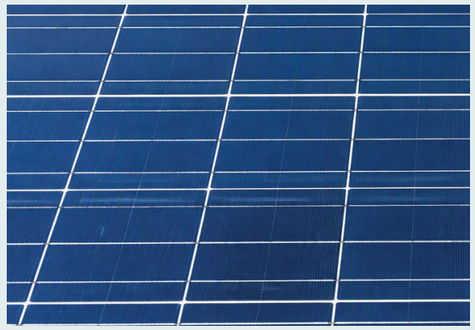
Recommendations for Optimisation

1 Handling heavy soiling and debris

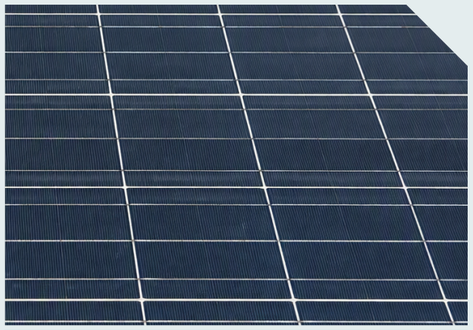
- While a 'dry wipe' system is highly resource-efficient due to its waterless operation, a polybutylene terephthalate (PBT) brush alone is less effective against stubborn contaminants that extend beyond dry dust and particulates. To enhance overall cleaning performance, the implementation of higher cleaning frequencies combined with an organic grime-neutralizing hydrophilic surface coating is essential.

2 Coating durability and maintenance

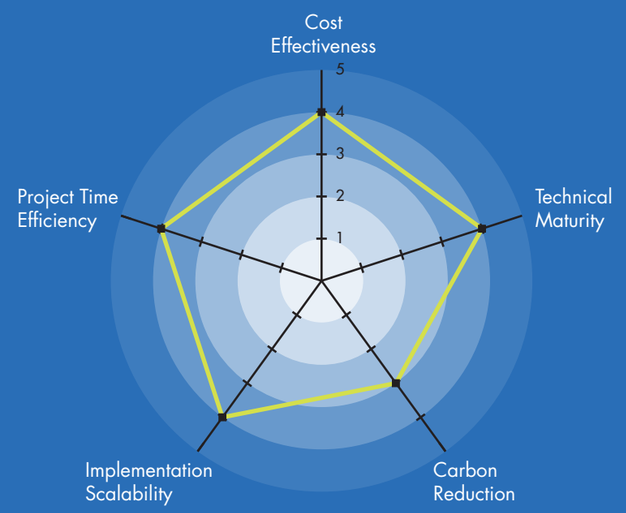
- Repetitive mechanical motions can cause abrasive wear via entrapped particulate matter, thereby accelerating coating degradation and delamination. Further research is essential to evaluate the long-term durability and super-hydrophilic properties of these catalytic coatings, particularly under daily dry-wipe cleansing cycles.



with Coating



without Coating



R20 Renewable Diesel

Renewable diesel (R20) is a low-carbon alternative fuel produced from hydrotreated vegetable oil (HVO) refined from used cooking oil and renewable feedstocks such as waste oils and fats. Chemically similar to conventional fossil diesel, it delivers comparable performance and can be used as a direct drop-in replacement in existing diesel engines and infrastructure without modification.

By applying renewable diesel in a hard-to-abate construction sector, the strategy demonstrates both its practical feasibility and immediate emissions-reduction potential while maintaining operational reliability.

Achieve up to

15%

Carbon Reduction

compared with conventional diesel



Possible Applications

Various applications for infrastructure projects

Fuel-powered construction equipment, such as excavators, loaders, cranes, generators and other diesel-powered plant.

Project Info

Project Name

CEDD - Civil Engineering Office Community Liaison Centre for Civil Engineering Office of CEDD at Ma Liu Shui Promenade

Project Location

Ma Liu Shui Pak Shek Kok Promenade, Science Park Road, Shatin

Project Year

Project commencement in 2025

Extent of Strategy Application

R20 renewable diesel is adopted for construction machinery and equipment due to its drop-in compatibility with existing diesel engines and infrastructure. This is the first application of HVO-blended renewable diesel (R20) at a local construction site in Hong Kong.

Project Description

The Civil Engineering Office Community Liaison Centre (CEO CLC) at Ma Liu Shui Promenade is developed as a demonstration of circular building design in Hong Kong. It demonstrates circular building design by prioritising demountability, adaptability and material recovery, supporting future material reuse while reducing resource use and construction waste across the building life cycle.



Overall Benefits

Potential Carbon Reductions

- Achieve up to 15% carbon reduction compared with conventional diesel, i.e. EN590 B0 (ultra-low sulfur) diesel.
- R20 contains 20% renewable content, produced from hydrotreated vegetable oil (HVO) refined from used cooking oil (UCO) and other waste feedstocks such as animal fats, and is sourced from an ISCC-EU-certified supplier. ISCC-EU scheme is a certification recognised under the EU Renewable Energy Directive (RED III) that confirms renewable fuels are responsibly sourced, traceable through the supply chain, and proven to reduce carbon emissions.
- The renewable content has lower upstream carbon intensity than conventional diesel, as it is made from waste-based feedstocks and does not rely on crude oil extraction and refining.

Cost/Time/Manpower Reduction

Reduced engine wear due to cleaner combustion of renewable diesel R20

- R20 has pure chemical compositions, so it burns more completely and cleanly than conventional fossil diesel. During combustion, R20 produces less soot, carbon deposits, and unburned residues that can accumulate in engines and contribute to engine wear.
- Reduced deposit build-up helps minimise engine wear, keeping components cleaner, extending service intervals, reducing maintenance frequency, and lowering the risk of unplanned downtime compared with conventional diesel operation.

Other Opportunities

1 Improved combustion quality and fuel stability:

- R20 has a higher cetane number than conventional biodiesel, resulting in more efficient and stable combustion. This supports improved engine performance and fuel efficiency, while also reducing the likelihood of microbial growth during fuel storage.

2 Enhanced oxidation stability and storage reliability:

- Renewable diesel exhibits superior oxidation stability compared with conventional biodiesel, giving R20 a longer shelf life and making it more suitable for storage and long-term use, especially where fuel may sit unused for a while. This reduces the risk of fuel degradation over time.

3 Drop-in compatibility with existing diesel equipment:

- R20 can be used exactly like conventional diesel. It is fully compatible with all diesel engines and most diesel generators without requiring engine modifications, unlike higher biodiesel blends (e.g., B20–B100), which may have engine compatibility issue.

4 Cleaner exhaust emissions:

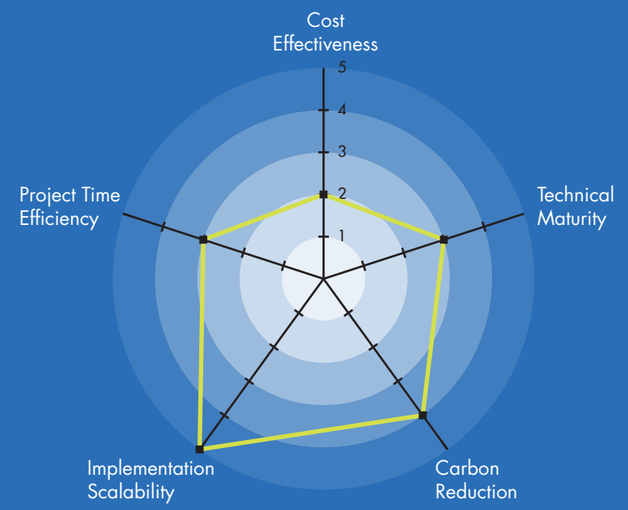
- The use of R20 results in cleaner combustion and lower harmful emissions of regulated air pollutants, including nitrogen oxides (NO_2), particulate matter (PM), carbon monoxide (CO), and unburnt hydrocarbons (HC), contributing to improved local air quality.

5 Potential reduction in engine noise and smoother operation:

- Due to more even and consistent combustion, R20 enables smoother engine operation, which contributes to reduced engine noise compared with conventional diesel.

Recommendations for Optimisation

- Based on "Assessing Demand-Side Readiness for Decarbonisation" published by Business Environmental Council (BEC), the cost of R20 renewable diesel is reported to be three to four times higher than that of regular diesel. However, as the Chinese Mainland is the world's largest exporter of Used Cooking Oil (UCO), which is the primary feedstock for renewable diesel, expanding supply channels from this region is expected to steadily drive down market prices over time.



Smart Metering and Digital Monitoring for Construction Equipment

Construction plant and equipment are often operated inefficiently on-site, with issues including prolonged idling, underutilization of machinery and suboptimal deployment leading to unnecessary fuel consumption, carbon emissions, operating costs.

Digital sensors provide a data-driven approach to address these inefficiencies, shifting equipment management from experience-based decision-making to data-informed optimisation. Sensors are installed on major plant and equipment, such as piling rigs, crawler cranes, generators, air compressors, and power packs, to capture key real-time operation parameters including operating hours, fuel consumption, engine condition, and idle versus active status.

This information is transmitted to online dashboard, allowing project teams to monitor equipment performance in near real time. With improved visibility, contractors can better manage asset utilisation, minimise idle time, optimise equipment sizing, and coordinate timely mobilisation and demobilisation.

Digital monitoring and optimisation of construction plant achieved an estimated

35%
Carbon Reduction

Possible Applications

Various applications for infrastructure projects

Digital sensor can be applied across a wide range of construction plant to optimise fuel use and operational efficiency.

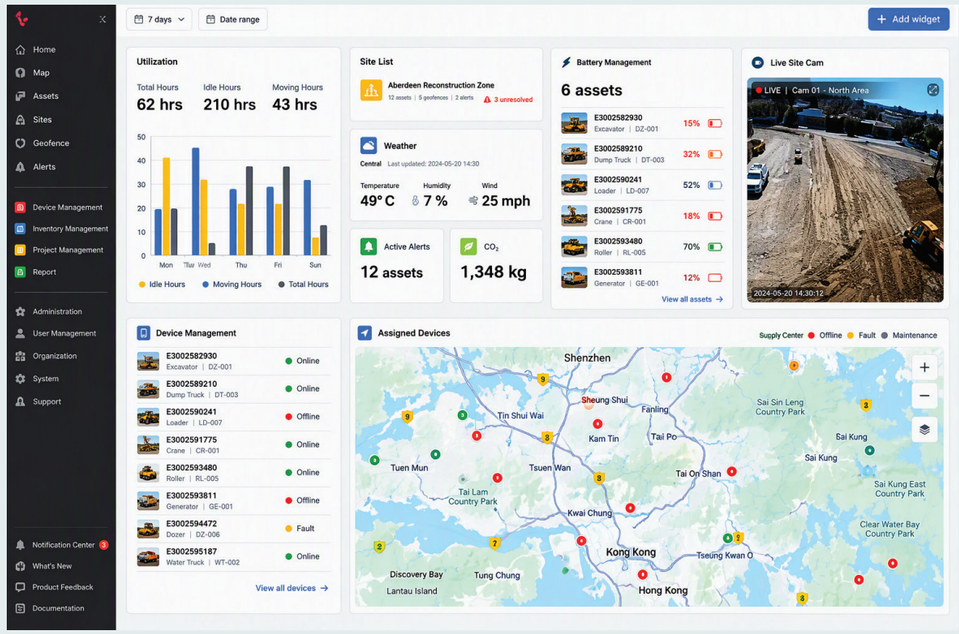
- One potential application is in monitoring the performance and utilisation of Battery Energy Storage Systems (BESS), where real-time data can support more efficient energy management and integration with site power demands.

Project Info

Project Name
Some pilot infrastructure and building projects across Hong Kong

Project Location
Hong Kong

Extent of Strategy Application
Deployment of smart sensor systems across approximately 130 generators installed in various infrastructure and building projects throughout Hong Kong, enabling real-time monitoring and data-driven optimisation of generator performance.



Overall Benefits

Potential Carbon Reductions

- Carbon reduction is achieved primarily through improved equipment efficiency and reduced fuel consumption of construction plants. Digital sensors enable continuous monitoring of equipment performance, enabling project teams to identify underutilised, oversized or inefficiently operated plant and take corrective actions.
- In the project case, the tracking of generator performance by digital sensor and optimisation achieved an estimated carbon reduction of approximately 35%.
- Generators generally achieve their best fuel efficiency and operating performance when running at loads above 75% of their rated capacity. Operating at lower loads results in disproportionately higher fuel consumption per unit of output. By tracking real-time loading conditions by sensors, contractors can identify when generators are consistently operating below 50% load and take corrective actions, such as right-size equipment, optimise deployment or reduce the number of generators in service. Through such optimisation measures, fuel use is reduced and directly cut the associated carbon emissions.

Cost/Time/Manpower Reduction

1 Lower plant and fuel costs through optimisation

- Improved visibility of equipment usage enables the identification of underutilised or oversized plant. In project case, digital sensors allow contractors to optimise deployment by reducing the number or capacity of machines, thereby lowering the overall cost by approximately one-third.

2 Improve manpower efficiency

- Real-time utilisation data improves resource planning and reduces over-allocation of manpower and equipment. Greater visibility of idling and operational inefficiencies allows project teams to optimise operator deployment and reduce unnecessary standby time, ultimately improving workforce productivity and equipment utilisation.

Other Opportunities

1 Enhance productivity by minimising inefficient utilization

- The integration of sensors, data analytics, and digital platforms enhances planning and coordination. By making equipment performance and utilisation transparent, project teams can better align resources with actual demand, reducing waste and improving overall productivity.

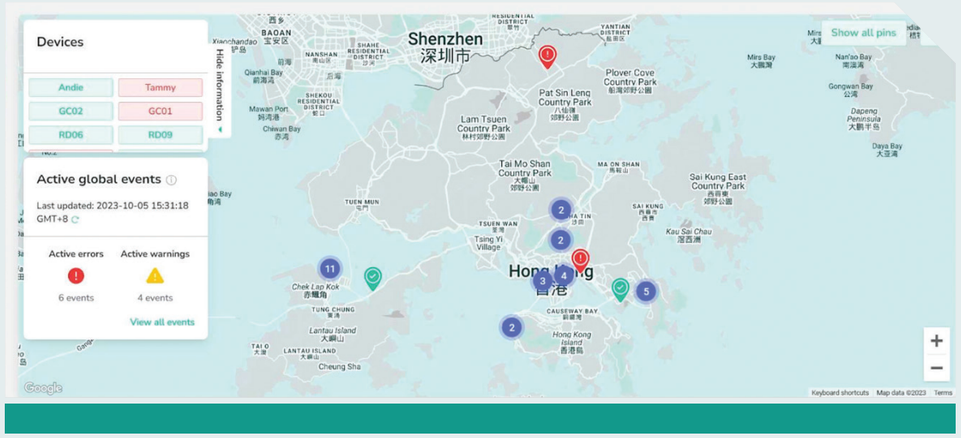
Recommendations for Optimisation

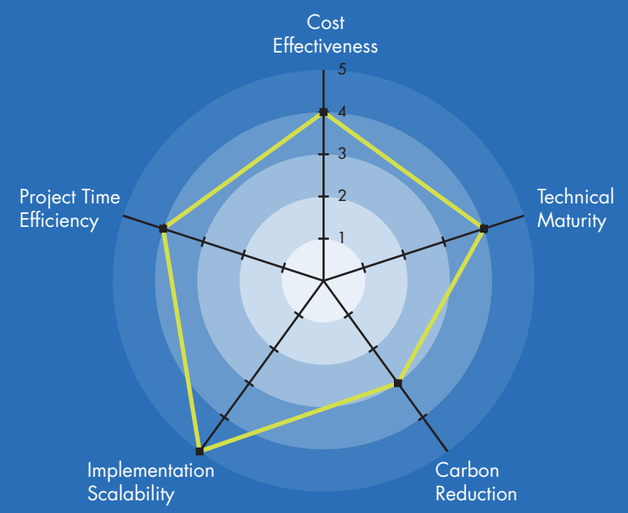
1 Installation challenges for hired plant or machinery

- Since construction machinery in Hong Kong rarely features pre-installed sensors, making early arrangements with equipment owners is critical for successful deployment, especially when dealing with hired plant.
- Developing clear procedures for sensor installation, calibration and decommissioning helps minimize disruptions to site operations and protects machine warranties.

2 Equipment-specific utilization indicators

- Digital sensors capture essential parameters like fuel use, load, and running hours, but utilization patterns still fluctuate based on site conditions and machine allocation. Rather than relying on a single, generic metric across all equipment types, machine performance should be evaluated against its intended operating profile and site-specific constraints,
- Regular calibration of utilisation indicators is essential to ensure that collected data provide a meaningful assessment of operational efficiency and drive informed optimisation decisions.





Construction of Box Culverts by adoption of U-shaped Tunnel Boring Machine (UTBM) Method

The Yuen Long South project is a paradigm of sustainable construction, leveraging the innovative U-shaped Tunnel Boring Machine (UTBM) to drive deep carbon reduction. The integrated function of UTBM eliminates resource-intensive temporary works, while automated systems largely reduce material overuse. A smart hybrid power system uses daytime excess energy to charge batteries, enabling silent, emission-free nighttime operations and saving diesel.

This holistic approach slashes the project's overall carbon footprint by an estimated 30-40%. Further initiatives like noise-reducing enclosures and optimized logistics protect the local environment and community. This project establishes a replicable blueprint for building low-carbon, sustainable infrastructure in dense urban settings.

Approximately
30-40%
Carbon Reduction
and **80-90% Reduction** in material wastage

Possible Applications

The UTBM technology can be applied to a wide range of infrastructure projects, particularly those involving drainage and flood resilience improvements.

1. **Box culverts along live water passages**: Highly suitable for constructing box culverts along existing nullahs, rivers, or drainage channels where water flow must be maintained throughout construction, and it can also be used for upgrading urban drainage systems with limited working space.
2. **Road widening without closures**: UTBM enables road widening projects where new carriageways are built over box culverts or utility tunnels, allowing traffic to continue on adjacent lanes without full road closure. It can also be applied to the construction of underpasses and box shaped structures, where traditional ELS methods would cause unfavorable disruption.

Project Info

Project Name
Contract No. YL/2021/04 - Site Formation and Infrastructure Works for Yuen Long South First Phase Development – Contract 2

Project Location
Yuen Long, New Territories

Project Year
The contract commenced in 2022

Extent of Strategy Application
UTBM applies to underground precast box shaped structure construction in urban infrastructure projects. It is suitable for congested roadways and high ground water tables. UTBM replaces conventional Excavation and Lateral Support (ELS) methods, reducing ground disturbance and carbon emissions – ideal for large-scale infrastructure projects like Yuen Long South.

Project Description
The Yuen Long South New Development Area (YLS NDA) is the southern extension of Yuen Long New Town. It will be one of the main sources of future land supply for housing in the Northern Metropolis. Through comprehensive planning and upgrading of infrastructure, the underutilised rural land and inefficient brownfields in the area will be transformed to more suitable uses to improve the environment. YLS NDA will become a green and liveable residential community.

3. **Common utility tunnels (CUT):** For utility tunnels, UTBM offers an efficient solution for installing common utility tunnel along narrow road corridors, as it eliminates repeated trenching by different utility companies.
4. **Deployment in high-density cities facing soft ground conditions:** Beyond Hong Kong, UTBM can be deployed in any coastal or high-density city facing soft ground conditions, a high water table, and congested urban layouts—examples include Singapore, Shenzhen, Bangkok, and Mumbai.

Overall Benefits

Potential Carbon Reductions

1 Construction process optimization:

- The elimination of double-handling processes for temporary support materials and the optimization of precast segment production in controlled yard conditions contribute to an estimated 30-40% reduction in the overall construction of BC04 (box culvert 04) carbon footprint.

2 Material efficiency:

- Material efficiency has been substantially improved through the UTBM approach. The replacement of traditional timber formwork with reusable steel systems has dramatically reduced construction waste. Precise automated material application systems have demonstrated 80-90% reduction in material overuse, while the implementation of just-in-time delivery protocols has optimized logistics.

Cost/Time/Manpower Reduction

1 Streamlined construction procedures

- By integrating excavation, segment installation and backfilling into a single continuous mechanized process, UTBM streamlines construction and eliminates multiple sequential activities, thereby reducing overall project duration. The system advances at approximately 6 metres per day, compared to the 0.6 metres per day typical of traditional methods, enabling completion of the box culvert up to about 2 years earlier and compresses work that would otherwise take several years into a much shorter timeframe.

2 Reduced manpower and offset construction cost

- Automation and prefabrication reduce labour requirements by around 30%, minimising reliance on manual and high-risk operations while enhancing productivity. The construction cost for box culvert by UTBM can be fully offset by the saving in people and administration cost for its advantages of continuous construction.

3 Potential social and economic savings

- A huge sum of saving due to potential social and economic costs arising from safety enhancement, minimized traffic disruption and public nuisance is anticipated. The use of reusable steel formwork and standardized temporary works also lowers material wastage and long-term project costs.

Other Opportunities

1 Reduced safety hazards and risk to public

- UTBM eliminates hazardous activities including sheet piling, open trench excavation and conventional ELS works alongside heavy traffic road. This reduces risks of collapse, falls and plant-related incidents affecting both workers and the public. Automated processes, including laser-guided screeding, reduce workers' exposure to dangerous zones, while real-time video monitoring at the front shield improves situational awareness and enables immediate response to changing ground conditions.

2 Enhanced climate resilience allowing year-round operation across wet and dry seasons

- The system also enhances climate resilience by enabling year-round construction. Critical equipment such as generators, hydraulic systems, and control panels are elevated above predicted water levels, and dedicated drainage pathways prevent water accumulation. As a result, UTBM can operate continuously at Yuen Long Nullah during the wet season and dry season, whereas conventional methods at Yuen Long Nullah are typically limited to approximately five dry months per year.

3 Reduced social impacts by maintaining traffic and minimizing noise

- UTBM substantially reduces disruption to nearby communities and road users. UTBM maintains two-lane-two-way traffic for certain portion of Kung Um Road, avoiding the prolonged one-lane-two-way arrangements that would otherwise last for three years. Noise reduction by 5 – 10 dB is achieved through acoustic barriers, EU compliant generator, power bank and hydraulic jacks. These benefits improve public acceptance and have been recognised by industry organizations including Construction Industry Council and the Hong Kong Institution of Engineers.

4 "Super connector" to connect engineering solutions from the Chinese Mainland to the global market

- As the first application of successful UTBM technology in Hong Kong, it serves as a "super connector" to export innovative Chinese Mainland engineering solutions to reach global markets. The system establishes a replicable, low-carbon, high-productivity template that can be adopted in future infrastructure projects facing similar space and environmental constraints.

Recommendations for Optimisation

1 Project-specific equipment design

- Soft alluvial clay and high groundwater demand continuous dewatering and specialized eccentric load balancing. To maintain proper sliding resistance, the UTBM's dead weight must be perfectly balanced against the bearing capacity of the soil formation.

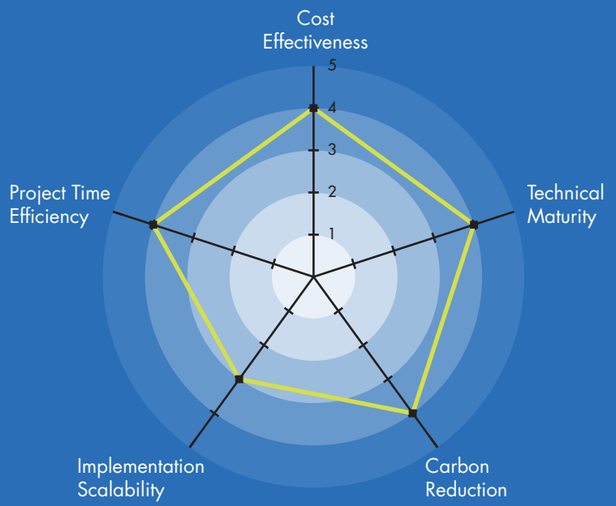
2 Grouting under unfavorable ground conditions

- Installing a grout curtain is necessary to prevent seepage under adverse ground conditions. Should additional sections necessitate grouting, the associated financial and schedule impacts must be considered in the project planning stage.

3 Precast segments delivery planning

- Precast segments require just-in-time delivery utilising heavy transport. Proactively managing transit routes and arrival windows is essential to minimize disruptions to local traffic and neighboring road users.





Source:

Civil Engineering and Development Department (2026). CEDD Innovation Series: U-Shaped Tunnel Boring Machine. Hong Kong: Government of the Hong Kong Special Administrative Region.

Innovative Modular System for Excavation and Lateral Support (ELS) Construction

An Innovative Modular System for Excavation and Lateral Support (ELS) Construction is a modular solution using high-strength steel tubes and proprietary connection components assembled mainly by bolt-and-nut installation, rather than conventional on-site welding and fabrication. Modular delivery and rapid bolt-up installation can shorten the delivery-to-installation cycle and reduce labour input for strut installation. The system is designed for quick assembly and disassembly, allowing components to be recovered and reused across excavation stages (and potentially across projects), which can reduce demand for newly fabricated temporary steelwork.

> **"Reduced new steel demand, maximised component reuse and eliminated fabrication wastage through modular temporary works."**

Possible Applications

1. **Applicable to projects where temporary ELS is needed,** subject to project-specific design and engineering assessments.
2. **Can be adopted as alternative or partial replacement for conventional strutting systems,** demonstrating a flexible hybrid solution that can be integrated with conventional ELS arrangements where appropriate.

Project Info

Project Name
CEDD - Advance Site Formation and Engineering Infrastructure Works at Kwu Tung North and Fanling North New Development Area (Contract no.: ND/2019/01)

Project Location
Kwu Tung North (KTN) New Development Area (NDA)

Project Year
Project construction commenced in 2019

Extent of Strategy Application
Modular system was adopted as the temporary ELS system for extensive deep drainage trench works, covering approximately 7 km in length. The system is fully modular, achieving 100% reuse of shoring components, with pinned joints allowing rapid adjustment using standard equipment to suit linear and varying trench alignments, enabling efficient installation.

Project Description
The major work includes site formation (including soil treatment work) and construction of engineering infrastructures, including temporary sewage treatment facilities, a fresh water service reservoir, a flushing water service reservoir, and associated plumbing, drainage and sewage pipeworks. The project also covers roadworks (including carriageways, footpaths, cycle tracks, a subway and junction improvements), district cooling system pipeworks, as well as slope and landscaping works.



Overall Benefits

Potential Carbon Reductions

1 Material optimisation (reduced new temporary steel demand):

- The modular high-strength steel tube system enables rational structural member sizing and avoids the need for bespoke welded and cut-to-fit steelwork. By using fewer and smaller members to achieve the required support capacity (e.g. fewer king posts and tie beams in the project case), the system can reduce temporary steel consumption and the associated embodied carbon from steel production.

2 Reuse of components across stages (and potentially across projects):

- The bolted modular system allows components to be easily dismantled, recovered and reused across different excavation stages and potentially future projects. Despite it is subject to design requirements and component condition, such design literally reduces demand for newly fabricated temporary steelwork and lowers associated embodied carbon and transportation impacts.

3 Reduced fabrication wastage (less steel purchased for the same function):

- Unlike conventional ELS systems that often require on-site cutting and modification, the modular system minimises steel wastage through standardised components and configurable layouts. In the project case, the modular system was configured based on the as-built perimeter wall for ease of installation, resulting in no wastage on the main struts, reducing the carbon emissions of wasted steel.

Cost/Time/Manpower Reduction

1 Programme reduction (installation cycle):

In the project case, the approach of modular system for ELS allows a two-third reduction in construction time. This is attributed to:

i. elimination of on-site hot works: Traditional ELS method requires cutting, fitting, and welding steel members on-site, whereas the modular system uses a bolt-and-nut installation for all proprietary components, enabling fast installation.

ii. rapid preloading via integral (built-in) hydraulic ram: The built-in ram eliminates the need for manual preloading method such as steel shims, wedges or jacking. As preloading is a key hold point before excavation can proceed to the next level, the faster pressurisation and lock-off process helps shorten the transition time between excavation stages and improve construction efficiency.

2 Operational Cost and Manpower reduction:

- In the project case, the labour input for the 30m ELS work was reduced from 18 man-days to 12 man-days under the modular approach as no welder is needed. This allows approximately 33% manpower reduction and reduced reliance on specialist trades and shortening installation time, contributing an estimated 35% reduction in operational costs through lower labour input and improved installation efficiency.

3 Reduced internal handling during manufacturing:

- Unlike the traditional ELS approach, which requires the internal transportation across multiple fabrication and handling steps for built-up members. The modular struts arrive ready to assemble and install by bolt-up on-site, reducing intermediate fabrication handling and re-handling of long built-up members.

Other Opportunities

1 Circularity and repeat use potential:

- In the project case, 100% of the modular struts and braces were reused. The pinned-joint connection system and use of standard lifting equipment enabled easy assembly and disassembly, allowing rapid adaptation to changing trench alignments, improving construction efficiency.
- The system is designed for repeated use, subject to geometry, load requirements and component condition. This reduces demand for newly fabricated steelwork and promotes circular resource use.

2 Enhanced construction safety:

- By adopting modular system, high-risk site activities associated with conventional ELS construction method, such as cutting, fitting, and welding steel members, are eliminated during excavation

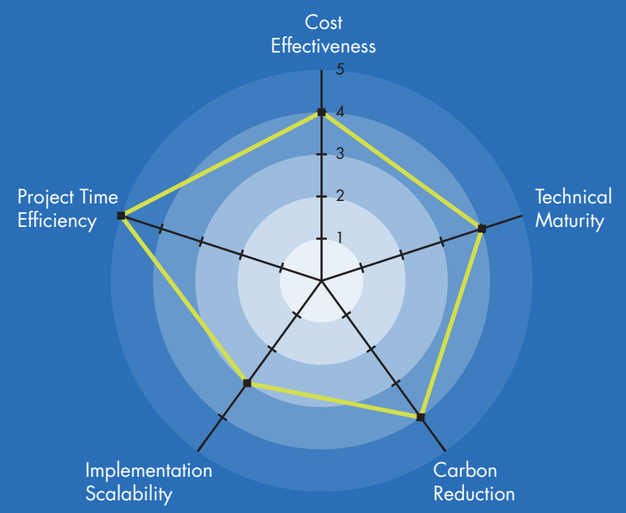
Recommendations for Optimisation

1 Initial cost and procurement

- Although the upfront capital expenditure for the Innovative Modular System exceeds that of conventional ELS system, this premium is often offset by the significant cost savings of a faster construction program. Early procurement planning and engagement of suppliers can facilitate more efficient and timely procurement, delivery and installation of components.

2 Flexibility on design modifications

- Compared with conventional ELS methods, tolerances for on-site design modifications are more stringent due to the utilisation of standardised components.



Green and Cost-effective Land Decontamination Method

The project, commissioned by the Civil Engineering and Development Department (CEDD) and conducted by the Building Technology Research Institute (BTRi) with support from HKUST, aims to evaluate the feasibility and performance of using Biochar and GGBS as solidification or stabilization (S/S) materials for the remediation of land contaminated by heavy metals & hydrocarbon chemicals.

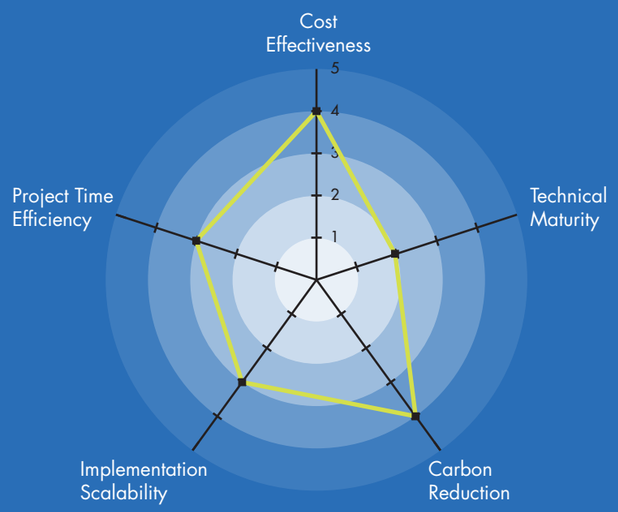
Up to
75%
potential carbon reduction
through GGBS-biochar systems

Project Info

Collaboration between CEDD, BTRi and HKUST

Possible Applications

Contaminated land – particularly those contaminated by both heavy metals or organic pollutants (hydrocarbons).



Overall Benefits

Potential Carbon Reductions

- HKUST's study concludes that GGBS-biochar systems instead of OPC for S/S can reduce embodied CO_2 by 30-75%. Overall demand of virgin material is reduced, and use of biochar (a carbon-negative material) further sequesters CO_2.
- The primary carbon reduction stems from replacing OPC with GGBS. Although it is primarily imported from the Chinese Mainland, the supply is stable and can reduce emissions by at least 650 kg CO_2e per ton of OPC replaced under local logistics and energy conditions.

Cost/Time/Manpower Reduction

1 Use of biochar for soil remediation is more cost-effective than conventional treatment methods per ton of soil, particularly for organic contaminants

- Waste is converted into biochar through pyrolysis rather than being sent to landfill, helping to avoid landfill disposal fees, resulting in significantly lower costs than methods such as excavation and thermal desorption.

2 Use of GGBS over OPC is more cost effective in the long run

- ~22% lower costs when used as partial replacement of OPC in buildings as it requires less energy, uses less raw materials, and increases durability (thus less maintenance). However, this is dependent on sourcing origin.

Other Opportunities

1 Increased decontamination efficacy compared to OPC cement S/S

- Biochar enhances adsorption capacity, while GGBS provides pozzolanic reactivity, effectively co-immobilizing heavy metals and organic pollutants
- This addresses a critical limitation of traditional cement-based S/S treatments, which often struggle with organic contaminants.

Recommendations for Optimisation

1 Regulatory alignment

- Risk-Based Remediation Goals (RBRGs) are defined by total contaminant concentrations, whereas biochar and GGBS mitigate bioavailability through adsorption and solidification, representing fundamentally different remediation mechanisms. Also, the application ratios of biochar and GGBS can be optimised for varying site-specific conditions and contaminant profiles.

2 Space and equipment arrangements

- Biochar blending requires uniform incorporation into the soil at a ratio of 5% to 20%, a process that typically necessitates large-scale earthmoving machinery. On compact treatment sites (<1,000 m^2) adjacent to active infrastructure, specialised equipment selection and optimised sequencing are essential to operate safely within a confined spatial footprint.

5. Conclusion

This Playbook has set out a practical starting point for strengthening carbon management across CEDD's infrastructure works. By focusing initially on site formation and roadworks, and by adopting a clear A1–A5 assessment boundary, it provides a structured basis for understanding where construction-stage carbon emissions arise, how they can be measured more consistently, and where reduction efforts may be most effectively directed.

The development of the Carbon Digital Platform marks an important step in moving from one-off carbon assessments towards a more systematic and reusable carbon data ecosystem. Through its connected Design and Construction Modules, granular process-level structure, localised data inputs, and reporting functions, the platform helps carbon information become more transparent, traceable, and useful throughout project development and delivery. It enables project teams to compare options earlier, monitor construction-stage performance more consistently, and build a stronger evidence base for future decision-making.

At the same time, the Playbook recognises that meaningful carbon reduction is not just calculation alone. It requires a shared understanding of carbon hotspots, practical Successful Examples, early collaboration across the value chain, and the progressive embedding of carbon considerations into design, procurement, construction planning, site management and reporting. To support this, the Playbook showcases carbon reduction initiatives across three categories: Material, Site Management, Design & Delivery. The Successful Examples provide practical reference points for translating carbon insights into action, helping practitioners consider suitable reduction measures for local infrastructure projects while allowing flexibility for project-specific conditions and professional judgement.

As CEDD continues to expand the use of the platform and refine its carbon management approach, the knowledge generated from individual projects can be brought together to support wider organisational learning and city-wide infrastructure planning. Over time, this will help establish a more credible, locally grounded and continuously improving basis for low-carbon infrastructure delivery in Hong Kong.

This Playbook should therefore be viewed not as a final destination, but as a foundation for continued development. By combining structured carbon data, practical digital tools, and reduction-focused Successful Examples, it supports CEDD and the wider infrastructure value chain in taking more informed, consistent and collaborative steps towards lower-carbon public works delivery.





6. Way Forward

Looking ahead, the next stage of carbon management should focus on turning the framework, platform and Successful Examples set out in this Playbook into a progressively embedded way of working. The Carbon Digital Platform provides a foundation for consistent carbon assessment and reporting, and its value will continue to grow in the long term as more data is collected and stakeholders work together across the infrastructure value chain.

A key way forward is to apply the platform on more projects within the current scope of site formation and roadworks. Wider and repeated application will help test the workflow under different project conditions, improve familiarity among project teams, and generate a broader set of carbon data for more informed decision-making in the future. As more projects are added, the platform can become more useful not only for individual project assessment, but also for identifying recurring carbon hotspots and informing portfolio-level prioritisation.

Continued improvement of data quality will also be important. Project teams should be encouraged to collect construction-stage information in a more systematic and transparent manner, including material quantities, transport assumptions, fuel use, equipment records and other relevant site data. Over time, this will help strengthen the reliability of carbon calculations, reduce reliance on generic assumptions, and build a more locally grounded infrastructure carbon database for Hong Kong.

Carbon considerations should also be progressively brought earlier into project planning and design. The greatest opportunity to influence carbon often arises before key design and construction decisions are fixed. By using the platform to compare options, review material choices, and understand process-level carbon drivers, project teams can consider carbon performance alongside other established project requirements such as cost, programme, safety, buildability and technical performance.

In parallel, the Successful Examples identified in this Playbook should be kept under review and expanded as further project experience becomes available. New examples, lessons learnt and proven reduction measures can be incorporated into future updates, allowing the Playbook to remain practical, relevant and responsive to evolving construction methods, material technologies, procurement approaches and policy expectations.

In the longer term, there is potential to extend the platform beyond the current focus on site formation and roadworks, subject to data availability, project needs and methodological refinement. This may include broader infrastructure work types, more detailed comparative analysis functions, and closer alignment with future whole-life carbon assessment approaches. Such expansion should be pursued progressively, building on the practical foundation already established under the current framework.

Ultimately, the way forward is to treat carbon management as an ongoing process of learning, application and refinement. By continuing to apply the platform, improve data quality, share lessons across projects and embed carbon thinking into everyday project decisions, CEDD and its project partners can strengthen the practical delivery of lower-carbon infrastructure and contribute to Hong Kong's wider transition towards carbon neutrality.

Acknowledgements

We extend our sincere appreciation to the following project consultant and contributors, whose expertise, practical experience and valuable insights have been instrumental in shaping this Playbook. Their contributions include, but are not limited to:

Project Consultant

Ove Arup & Partners Hong Kong Limited

Contributors

AECOM Asia Company Limited

Build King Construction Limited

China State Construction Engineering (Hong Kong) Limited

Gammon Construction Limited

The Hong Kong Institution of Engineers




A
B
CO_2

